METHODS OF VALUATION OF NATURE'S FUNCTIONS AND SERVICES

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BRIEF HISTORY OF ECONOMICS AND NATURAL RESOURCE PRICING

1.1. Economics, natural and environmental resources

1.2. Brief history of economics and natural resource pricing

1.3. Welfare economics and environment

1.4. Environment, ethics and discounting the future

The aim of this course is to:

describe and explain the methods for valuing the environment and complex relations between economy and the environment. The unifying theme (axiom or paradigm) of this course is the explicit recognition that the economic system (economy) is a subset of the global ecosystem (biosphere). Any decision about environment must respect the constraints that exist among natural environment and economic systems.

Over the world you can find dozens of textbooks on economics and on environment. But only few of them are addressing the problem of integrating the economy and environment from the viewpoint of practical decision-making processes. The economy, society and the environment are linked together in an evolutionary network. Real integration of economic systems with environment can be based on the real market and non-market valuations of natural and environmental resources.

This course intends to give you basic knowledge about using the market and non-market valuation methods.

Economics (economic science)
Relies on valuations; generally is understood as the study of how to allocate (production, distribution, trade, consumption) limited (scarce) resources to satisfy human needs, wants and desires.

Resources
The term resources is used synonymously with the factors of production = production factors (inputs without which the production could not take place).

For any given state of technology, the relation between some quantity of production and some quantities of economic resources can be expressed by a production function as a mathematical relationship between these two entities

$$Q = f(X1, X2, \ldots Xn) \qquad (1.1)$$

where *Q* = maximised quantity of output flow for given values of the arguments of production function and given quantities of *n* productive inputs or factors *X*.

Production factors:
labour (L), capital (C) and land (R). In applied empirical analyses sometimes a fourth factor energy (E) is applied.
These production factors enter into production function either as flows of services over some period of time, or as stocks employed at some point in time. Production function can then be formalised as

$$Q = f(L, C, R, E) \qquad (1.2)$$

example: (Cobb-Douglas PF: $Q = A\, L^{\alpha}\, C^{\beta}\, R^{\gamma}$)

<u>Land</u> (R):
sometimes only a space or territory is understood, sometimes soil fertility from the viewpoint of agricultural or forest production (to satisfy basic human needs: food, shelter). Increasingly also as a life-supporting environment. These life-supporting functions or services of the environment and its ecosystems (clean air, water etc.) were and often as yet are used as free, zero priced services by people.

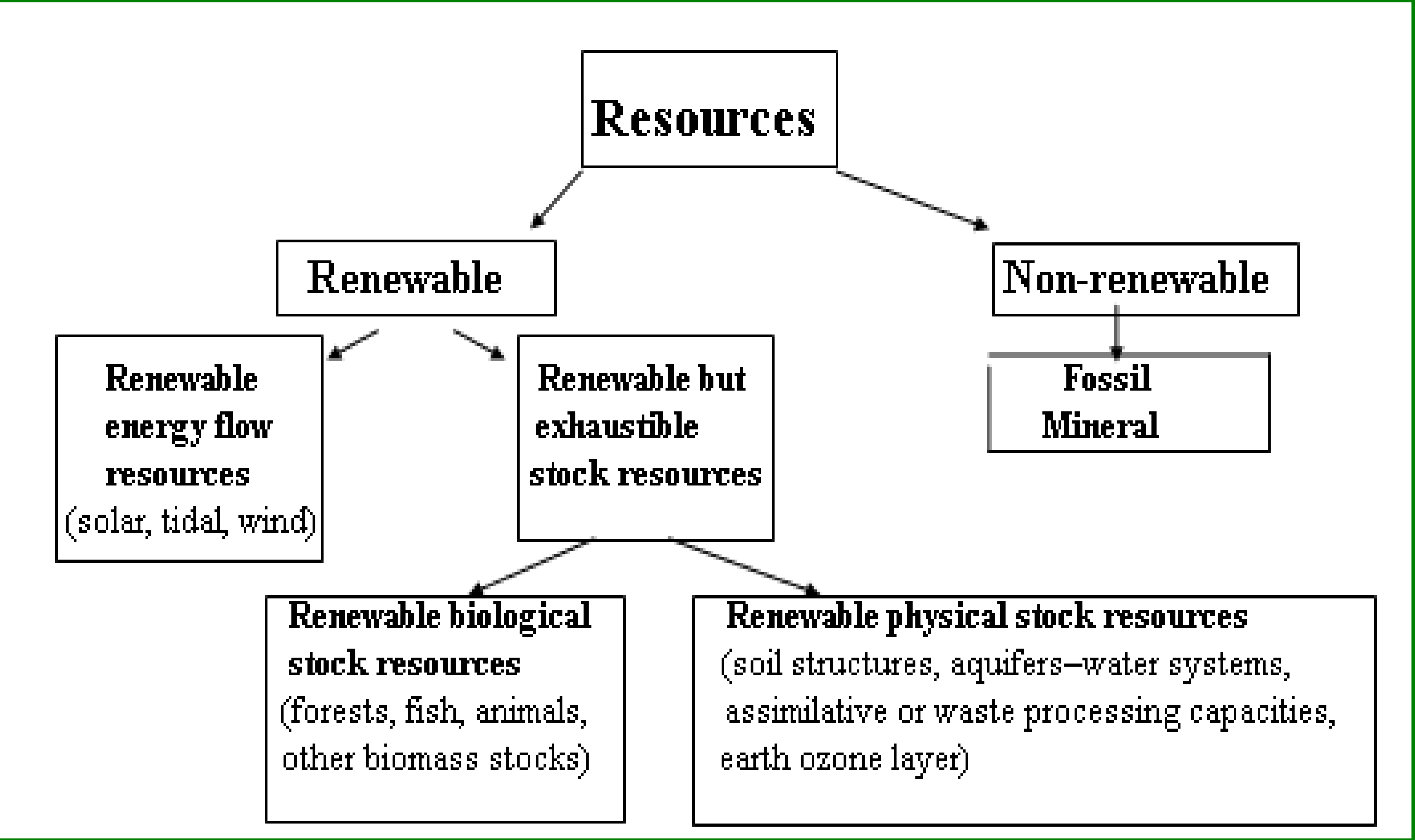
In general, land or environment serves as:

1. **Natural resources - direct provision of economic services and goods with direct *use value* (production of food, wood, fibres, extraction of fossil fuels etc.)**
2. **human and industrial waste assimilation by natural ecosystems**
3. **direct provision of environmental goods (such as clean air and water, landscape amenities, aesthetical values)**
4. **support of life – ecosystem functions and services (Natural ecosystems provide food, fresh water, wood, fibre and fuel (<u>provisioning services</u>), but also form fertile soil, cycle nutrients and purify air and water (<u>supporting services</u>), protect against harmful cosmic radiation, continually control the composition of atmosphere, mitigate climate extremes, maintain biodiversity, control diseases, decompose organic waste, (<u>regulating services</u>), are source of aesthetic, spiritual, educational, recreational values (<u>cultural services</u>) etc.).**

The main global problem is: people abuse the first two economic functions of environment at the expense of other two ecological functions, which are decisive for sustaining the life.

One of the main axioms or principles of economic theory says that resources are scarce (in other words, resources are limited).
The scarcity of resources means that the resource demand outstrips (=is higher than) supply (insufficient availability of a resource to satisfy human wants).
The scarcity of resources implies that their use is costly, they have a positive price. The use of a scarce resource has an opportunity cost in the form of an alternative foregone (=lost) benefit. In those cases where a resource user directly incurs this opportunity cost, the cost is known as private cost. However, in many cases opportunity cost is borne by other persons – costs are transferred onto others (for example in the case of polluting emissions). These costs are known as external costs (externalities, see Pigou, 1920).
One of the main problems of present economic theory is that by the scarce resources it understands only those natural resources with direct benefits for users (owners).

A classification of natural and environmental resources



The interest in economics, i.e. the interest in how people are ensuring their basic economic needs (food, shelter, clothing), and wants (food, shelter, clothing but also cigarettes, other drugs, illegal guns etc.) is as old as the human civilisation itself. It is possible to say that since a long time ago people have been mainly pricing those natural resources that had brought them some direct economic benefit. Primarily it was the space alone, the territory and its parts – grounds for construction, agricultural lands, forests, water resources and deposits of mineral sources.

Economics started to be formed systematically at the beginning of the industrial revolution approximately two hundred years ago under the influence of the depletion of traditional natural resources.

The advent (=start) of the industrial revolution (which put an end to the several hundred years history of the feudal system), tied with spreading the freedom of a human individual, brought a change to the ethical-institutional system of values, which meant a radical turn in the moral rules for economic activities.

The ancient and medieval value systems of European nations originated in:

- **the idea of the holiness (saintship) of natural world,**
- **the moral barriers against money lending for interest,**
- **the conviction that personal profit and accumulation should be hampered (banned),**
- **the conviction (belief) that his/her work is devoted to the benefit of a group (collective, community),**
- **the conviction that the trade is substantiated only for the renewal of abundance for community (society) and that the real rewards are awaiting in the other world.**

In all early societies, the principle of household economy, from the Greek *oikonomia*, played a substantial role. Private property was substantiated only to the extent that served the welfare of whole community. The word "private" comes from the Latin *privare* (rob,deprive or relieve sb of sth), which shows an enlarged medieval opinion that property should be first and foremost common (F. Capra, The Turning point, Flamingo,1983).

A turning point in the moral codex for economic activities, (abandonment of the moral duty of an individual toward his/her community and toward common property and founding the new, self-interested orientation of individuals) was expressed in the work of Adam Smith (1723-1790) - considered the father of modern economics and the founder of classical political economy. Adam Smith introduced the ideas of self-interest and of an invisible hand, i.e. the ideas that an economic system that relies on a free market and on free self-interested individuals tends to a natural state of ultimate welfare (maximal prosperity).
In his major work "An Inquiry into the Nature and Causes of the Wealth of Nations" (1776), Smith expressed and confirmed the belief in the predestined harmony of interests in the conditions of a free competition and the belief in the efficiency of invisible hand (i.e. the market mechanism) that regulates economic activities in a way leading to a state of general equilibrium among demand and supply: „*By pursuing his own interest he frequently promotes that of society more effectively than when he really intends to promote it*" (Smith, 1776, Book IV, Chapter 2, page 477).

Because land and other natural resources were understood as factors of production, it was natural to appreciate their economic utility stemming from the services which these factors could bring in production and consumption. The evaluation of natural resources according to the flow of their future services (benefits) has been the original and the most natural pricing method.

It was not a natural resource itself which has been valued, but the sum of economic effects (services) from its exploitation. According to the original Judao-Christian teaching, God entrusted (granted) people with nature to their usage. According to some other cultures, man does not stand above nature, but is a part of nature.

Early classical economists (A. Smith, D. Ricardo, T. Malthus, J.S. Mill) took land as fixed and, due to the law of diminishing returns, they saw bad prospects for the future generations. This thesis was most strongly argued by Thomas Malthus (1766-1834).

Given a fixed land quantity and an assumed continual positive population growth, the diminishing returns in agriculture imply a tendency for the output per capita to fall over time. That is why Thomas Malthus was sceptical in a long-run tendency for living standards. At the same time this English priest and thinker supposed that before the exhaustion the limit of natural resources does not enter into economic decision-making processes.

As for the <u>theory of economic value</u>, *classical school* (classical English political economy) came from the so called <u>Labour Theory of Value</u> (supply-side concept of value). They supposed that level of <u>value</u> was <u>derived from the necessary costs of production</u>, i.e. from the amount of labour and other inputs (raw-materials, machines, building, energy etc.).

Such cost level was in practice controlled by the demand (consumers). You could sell your products only if their price was derived from the so called "socially necessary costs", i.e. if the costs were comparatively low enough within the existing level of technological development.

Labour theory of value governed during the end of 18th and most of 19th century. In 1870s *neoclassical school* emerged that came from subjective, personal marginal utility as a basis of economic value.

The modern views on scarcity of natural resources have their roots in the work of David Ricardo (1772-1823), who approached the problem of scarce sources differently compared to Malthus, because he started from the assumption that the highest quality sources are exploited first, and gradually the interest passes to the less high quality sources. Such gradation entails that from the beginning, scarce resources enter in his considerations.

Ricardo's theory of rent creates probably the most important part of his main economic work, "Principles of Political Economy and Taxation" (1817). The statement that the problem of land use (use of natural resources) was the central for Ricardo is proved in the text of his main work, which starts by the following (Ricardo, 1956, p. 7): ***"The produce of the earth – all that is derived from its surface by the united application of labour, machinery, and capital, is divided among three classes of the community; But in different stages of the society, the proportions of the whole produce of the earth which will be allotted to each of these classes, under the name of rent, profit and wages will be essentially different; depending mainly on the actual fertility of the soil, on the accumulation of the capital and population, and on the skill, ingenuity, and instruments employed in the agriculture. To determine the laws that regulate this distribution, is the principal problem in Political Economy."***

In Ricardo's theory, there are two reasons for rent: unequal fertility and scarcity of land.

Differences in fertility were the inspiration for his *differential rent* ("If all land were equally fertile there would be no rent. Rent is not the result of the generosity of nature but of her niggardliness") (=shortness).

The second reason for rent was the scarcity of land. If land was homogenous in quality, the limitations of supply would create only *scarcity rents* (Hubacek, K., van der Bergh, J.C.J.M., Ecol. Econ. 56 (2006), p. 9).

John Stuart Mill (1806-1873) was the last classical economist who forecasted (predicted) increasing relative importance of land and its multifunctional role. In addition to agricultural and extractive uses of land he underlined the importance of land as a source of amenity values (green beauty of landscape for ecological and recreational reasons).

While classical political economy saw economic value as arising from the labour power embodied (directly or indirectly) in output (i.e. it was concentrated on the supply side only) (known in economics as “labour theory of value”), <u>neoclassical economics</u> (that creates the economic theory of western civilisation) <u>envisaged value as being determined in exchange by the utility or scarcity of resources</u> (saw the price from the demand side).

Neoclassical economics that was formed since the 1870s [S. Jevons (1835-1882), K. Menger (1840-1921), L. Walras (1834-1910), A. Marshall (1842-1924)] introduced a new <u>subjective concept of value as an expression of marginal utility for individual</u>. This paved the way for the development of welfare economics, in which values could be measured in terms of consumer preferences. This school assessed the problem of using natural resources as a part of a general system of using scarce resources. The classical problem of absolute scarcity was replaced by a relative concept of scarcity. <u>Exhaustion of natural resources was not treated for a long period as a serious economic problem</u> (and many economists in market economics hold the similar approach up to now), because, with the growing resource scarcity the price is growing as well, which stimulates looking for cheaper substitutes.

The paradigm of neoclassical system (especially welfare economics), upon which the current natural resource economics is based, *is individual utilitarianism and libertarianism*, i.e. an approach to human individual as a free and rationally acting individual (with undisturbness of her/his individual rights and liberties) who maximizes her/his own self-interest. The basic neoclassical libertarian approaches *come from the axiom of minimal* state, i.e. they want the state to intervene on free markets only in the cases of a market failure, i.e. when a market does not ensure an optimal allocation of resources.

Neoclassical theory came from the conception of A. Smith who understood economics as a study of demand and supply that governs the distribution of scarce resources by free markets without any regulating interventions. While English classical political economy was understood by the representatives as a historical science (economic laws are changing with changes of economic system), neoclassicists ceased to respect the historical basis and started to explain neoclassical principles as universally valid timeless concepts. Due to this approach, neoclassical economics became only a formal framework (e.g. Walras theory of general equilibrium) that has been unable to reflect real problems of real economy.

Only during the 20th century economists revealed that markets (as allocators) can assure optimal (efficient) allocation of resources just in the very specific conditions of perfect competition that are characterized by the following institutional arrangements:

1) markets exist for all goods and services,
2) all markets are perfectly competitive,
3) no externalities exist,
4) all goods and services are private goods, there are no public goods,
5) property rights are fully assigned,
6) all transactions have perfect information,
7) all firms are profit maximizers and all individuals utility maximizers,
8) long-run average costs are non-decreasing,
9) transactions costs are zero,
10) all relevant functions satisfy convexity conditions

(Perman, Ma, McGilvray, 1996, p. 93).

Assumptions for efficient resource allocation (perfect competition)

1. Homogenous product
2. Many buyers and sellers
3. Perfect mobility of resources (free entry and exit)
4. Perfect information

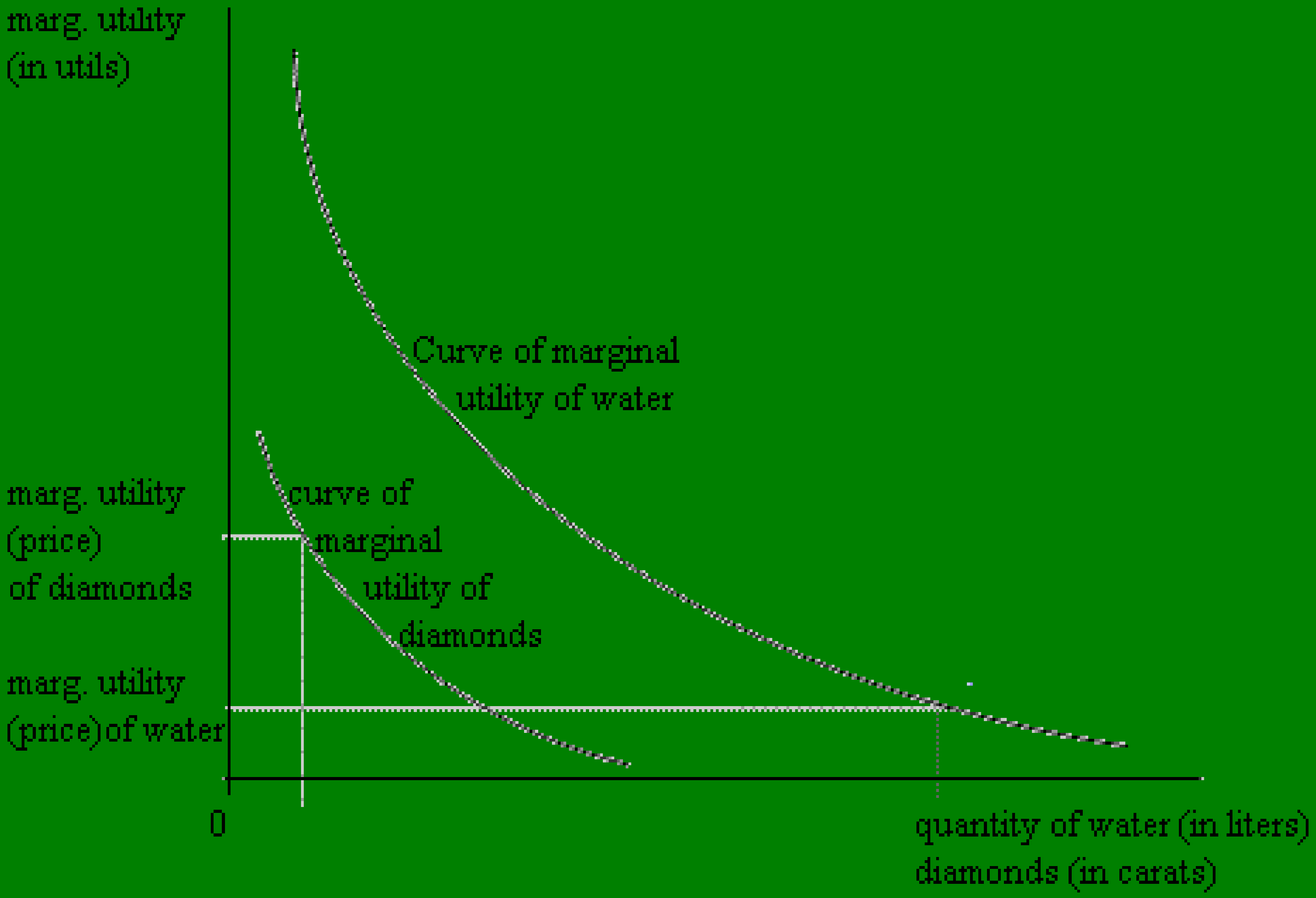
Major implication: firm is a price taker; i.e., all firms face the same, constant price.

It seems to be very unlikely that any conceivable economy could ever exist in which all these institutional arrangements are satisfied.

On the basis of the above quoted institutional arrangements (that originally were implicit) and on the basis of marginal utility theory, neoclassical economics resolved the paradox of price and value which puzzled classical economists. This paradox can be expressed by the following question: Why should the price of diamonds exceed the price of water, if water is more valuable? Should it not therefore command a higher price? Adam Smith for this reason differentiated between use value and exchange value. Neoclassicists resolved the hundred year dilemma by the concepts of total and marginal utility. In standard neoclassical textbooks we can obtain the following explanation:

"The key to the puzzle is scarcity and how it affects marginal utility. Water is cheap because it is so abundant. Another gallon provides little additional utility. Therefore, consumers are willing to pay very little for the extra water. In contrast to water, the supply of diamonds is extremely limited. Because the value or utility of an additional diamond is high, consumers are prepared to pay a high price for it. Of course, the degree of scarcity may change over time and, as it does, so will marginal utility of an additional unit. Other things equal, a scarcer a good becomes, the higher its marginal utility and therefore its market price" **(Ragan, Thomas, 1993, p. 589).**

Relation among marginal utility and quantity of water and diamonds consumed



Some elementary concepts (categories) from the field of valuation

value

The central concept that expresses relative worth or importance. It has many meanings in different human activities and professions. Generally it means something valuable or desirable (socially, ethically, economically) and expresses some criteria for valuation (normative activity).

economic value

Economic value is a value expressed in monetary terms. It is explained differently by different economic schools. Generally, subjective and objective concepts of economic value can be distinguished. The subjective value is determined by an individual's preferences (utility) that subjective economics accepts as exclusively economic. The objective value is determined as a relation between individual and group preferences on one side and necessary costs for satisfying some human wants. Both approaches are anthropogenic in the sense that positive value is determined exclusively by utility for humans. Economic values are useful to consider when making economic choices – choices that involve tradeoffs in allocating resources.

Use and non-use values

- **Use value** is defined as the value derived from the actual use of a good or service, such as hunting, fishing, birdwatching, or hiking. Use values may also include indirect uses. For example, an Alaskan wilderness area provides direct use values to the people who visit the area. Other people might enjoy watching a television show about the area and its wildlife, thus receiving indirect use values. People may also receive indirect use values from an input that helps to produce something else that people use directly. For example, the lower organisms on the aquatic food chain provide indirect use values to recreational anglers who catch the fish that eat them.
- **Option value** is the value that people place on having the option to enjoy something in the future, although they may not currently use it. Thus, it is a type of use value. For example, a person may hope to visit the Alaskan wilderness area sometime in the future, and thus would be willing to pay something to preserve the area in order to maintain that option.
- **Bequest value** is the value that people place on knowing that future generations will have the option to enjoy something. Thus, bequest value is measured by peoples' willingness to pay to preserve the natural environment for future generations. For example, a person may be willing to pay to protect the Alaskan wilderness area so that future generations will have the opportunity to enjoy it.
- **Non-use values**, also referred to as "passive use" values, are values that are not associated with actual use, or even the option to use a good or service. Existence value is the non-use value that people place on simply knowing that something exists, even if they will never see it or use it. For example, a person might be willing to pay to protect the Alaskan wilderness area, even though he or she never expects or even wants to go there, but simply because he or she values the fact that it exists.
- It is clear that a single person may benefit in more than one way from the same ecosystem. Thus, **total economic value is the sum of all the relevant use and non-use values for a good or service**.

Market value

Market value is a synonym with a common or standard price in a given space and time.

Market price

Market price is a specific result of market transactions among a seller and a buyer. Prices are means for transferring all goods and services on the common measuring basis.

Cash flow

Cash flow means a revenue or expenditure. Revenues are positive (incoming) cash flows, expenditures are negative (outgoing) cash flows.

Opportunity costs

is what people would be willing to pay for the alternative they go without because a particular project or policy is chosen.

Intrinsic (primary) value of nature

Intrinsic value is a product of belief that nature and its resources have an inherent value as an environment for life, independently on humans and their preferences.

Conventional economists argue: values in economic system are primary values

Ecologists and ecological economists argue: only nature has and contains primary values and all values in economic system are the secondary values (derived from nature)

Time

Time *t* refers to a precise point in time, normally in relation to the present, or the time at which a series of cash flows is expected to begin. Thus 15.00 on 8th Sept. 2016 is referred to as *t* = 10, if the present time is 15.00 on Sept. 8, 2006.

Natural resources

Natural resources are those sources and powers of nature that are or can be used by human individuals for production or consumption. The term resources is used synonymously with factors of production. There are many classifications of natural resources. One fundamental property concerns the reproducibility of a resource stock, the extent to which a resource exhibits economically significant rates of regeneration. Where the rate of resource regeneration is significant we describe the resource as being renewable; otherwise the resource is non-renewable (deposits of fossil or mineral resources).

By natural resources in economics, generally the marketed parts of environment are understood, while by environmental resources the non-marketed sources of environment are understood.

Environmental resources

Environmental resources provide a broader set of services than is recognised in economic analysis; environmental resources play a multifunctional role. These are all resources that create ecosystems and that had and have a decisive meaning for the life on the Earth. While natural resources cover only one out of the four main functions of the environment, environmental resources cover all four functions (source of natural resources, landscape, sink, life-supporting role). Ecosystem means a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit (Convention on Biological Diversity, 1992). Ecosystems not only are the source of desired materials (food, wood, fish production, renewable resources), but of utmost importance are their life-supporting services (natural ecosystems control temperatures, supply clean air, clean water, rainfall, ocean productivity, fertile soil, waste processing, protect against dangerous cosmic radiation, buffering against the extremes of weather, regeneration of atmosphere).

Definitions of concepts (categories) in expert valuation of nature

By which categories we can systemically describe national environment?

Most aggregated description can be given by

Corine Land Cover classes (Co-**or**dination of **In**formation on the **E**nvironment)

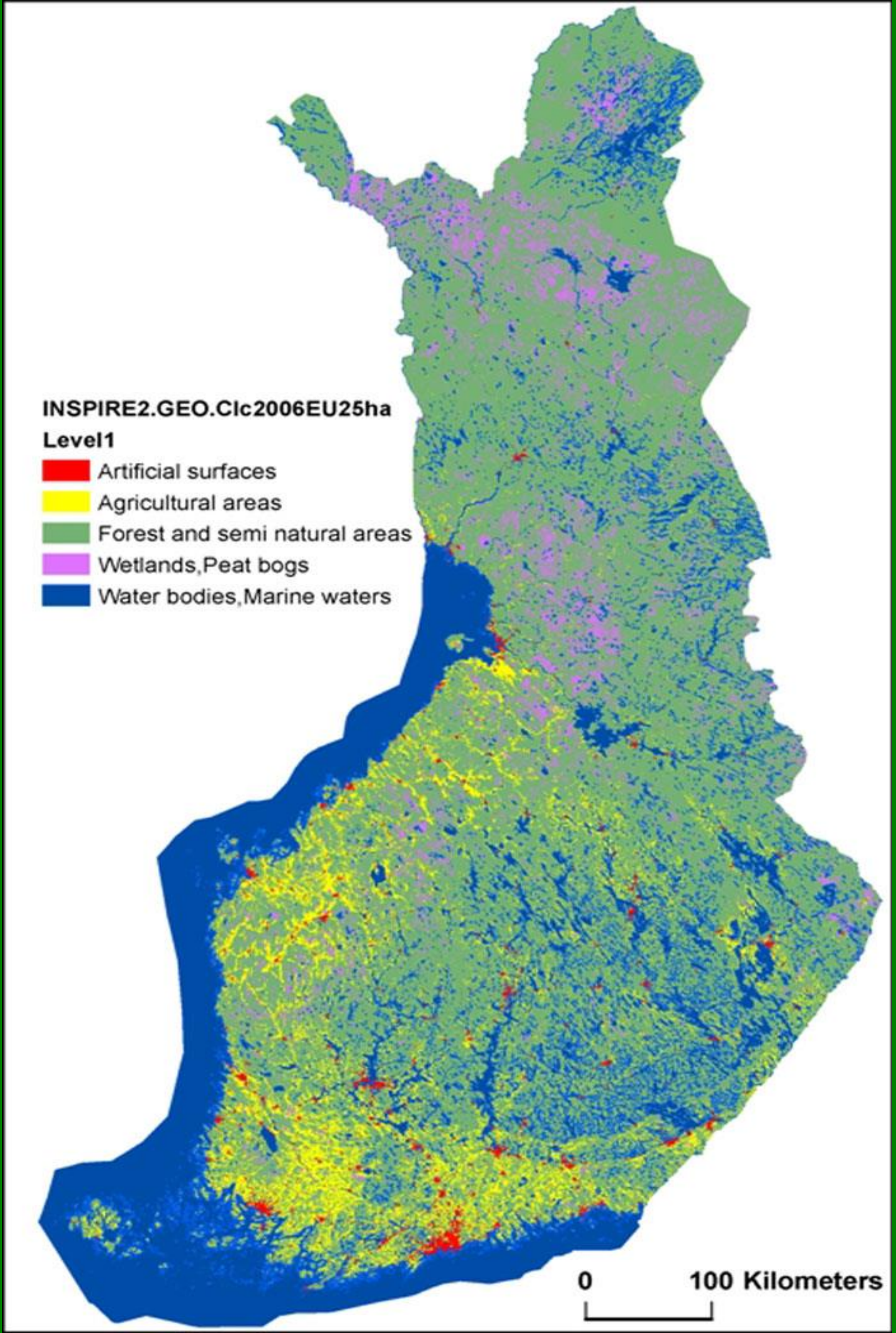
The first level (5 classes) corresponds to the main categories of the land cover/land use (artificial areas, agricultural land, forests and semi-natural areas, wetlands, water surfaces). The second level (15 classes) covers physical and physiognomic entities at a higher level of detail (urban zones, forests, lakes, etc), finally level 3 is composed of 44 classes.

More detailed description of nature can be given by the category of Biotopes

Biotope : (almost synonymous with the term habitat, but while the subject of a habitat is a species or a population, the subject of a biotope is a biological community) a small area with uniform biological conditions such as climate, soil or altitude (http://www.science-dictionary.com). A complex of all abiotic and biotic factors which, mutually effecting, form the environment of a certain individual, species, population, or community. A biotope is such local environment which meets the requirements characteristic of plant and animal species (Czech Act no. 114/1992 Coll. on the Nature and Landscape Protection).

Ecosystem: "a community of organisms and their physical environment interacting as an ecological unit" (Lincoln et al., 1982). However, this structural view does not describe the substance of the term. The term 'ecosystem' evolved to describe mainly the functional relations inside ecosystems and within their network creating the biosphere of the Earth. Natural ecosystem may be viewed as an active element with processes and structure, configuring itself to capture and degrade as much available solar energy as possible (Schneider, Sagan 2005, p. 226).

Finland: total area is 337,030 km2. The sixth largest country in Europe after France, Ukraine, Spain, Sweden, and Germany. Of this area 10% is water, 69% forest, 8% cultivated land and 13% other.



Portugal: total area is 92,390 km^2.

Corine land cover classes

1. Artificial surfaces

1.1 Urban fabric

- 1.1.1. Continious urban fabric
- 1.1.2. Discontinuous urban fabric

1.2 Industrial, comercial and transport units

- 1.2.1. Industrial or commercial units
- 1.2.2. Road and railnetworks and associated land
- 1.2.3. Port areas
- 1.2.4. Airports

1.3 Mine, dump and construction sites

- 1.3.1. Mineral extraction sites
- 1.3.2. Dump sites
- 1.3.3. Construction sites

1.4 Artificial, non-agricultural vegetated areas

- 1.4.1. Green urban areas
- 1.4.2. Sport and leisure facilities

2. Agricultural areas

2.1 Arable land

- 2.1.1. Non-irrigated arable land
- 2.1.2. Permanently irrigated land
- 2.1.3. Rice fields
- 2.2.1. Vineyards

2.2 Permanent crops

- 2.2.2. Fruit trees and berry plantations
- 2.2.3. Olive growes

2.3 Pastures

- 2.3.1. Pastures

2.4 Heterogeneous agricultural areas

- 2.4.1. Annual crops associated with permanent crops
- 2.4.2. Complex cultivation patterns
- 2.4.3. Land principally occupied by agriculture
- 2.4.4. Agro-forestry areas

3. Forest and seminatural areas

3.1 Forests

- 3.1.1. Broad-leaved forest
- 3.1.2. Coniferous forest
- 3.1.3. Mixed forest

3.2 Scrub and/or herbaceous vegetation associations

- 3.2.1. Natural grassland
- 3.2.2. Moors and heathland
- 3.2.3. Sclerophyllous vegetation
- 3.2.4. Transitionazl woodland-shrub

3.3 Open spaces with little or no vegetation

- 3.3.1. Beaches
- 3.3.2. Bare rock
- 3.3.3. Sparsely vegetated areas
- 3.3.4. Burnt areas
- 3.3.5. Glaciers and perpetual snow

4. Wetlands

4.1 Inland wetlands

- 4.1.1. Inland marshes
- 4.1.2. Peatbogs

4.2 Maritime wetlands

- 4.2.1. Salt-marshes
- 4.2.2. Salines
- 4.2.3. Intertidal flats

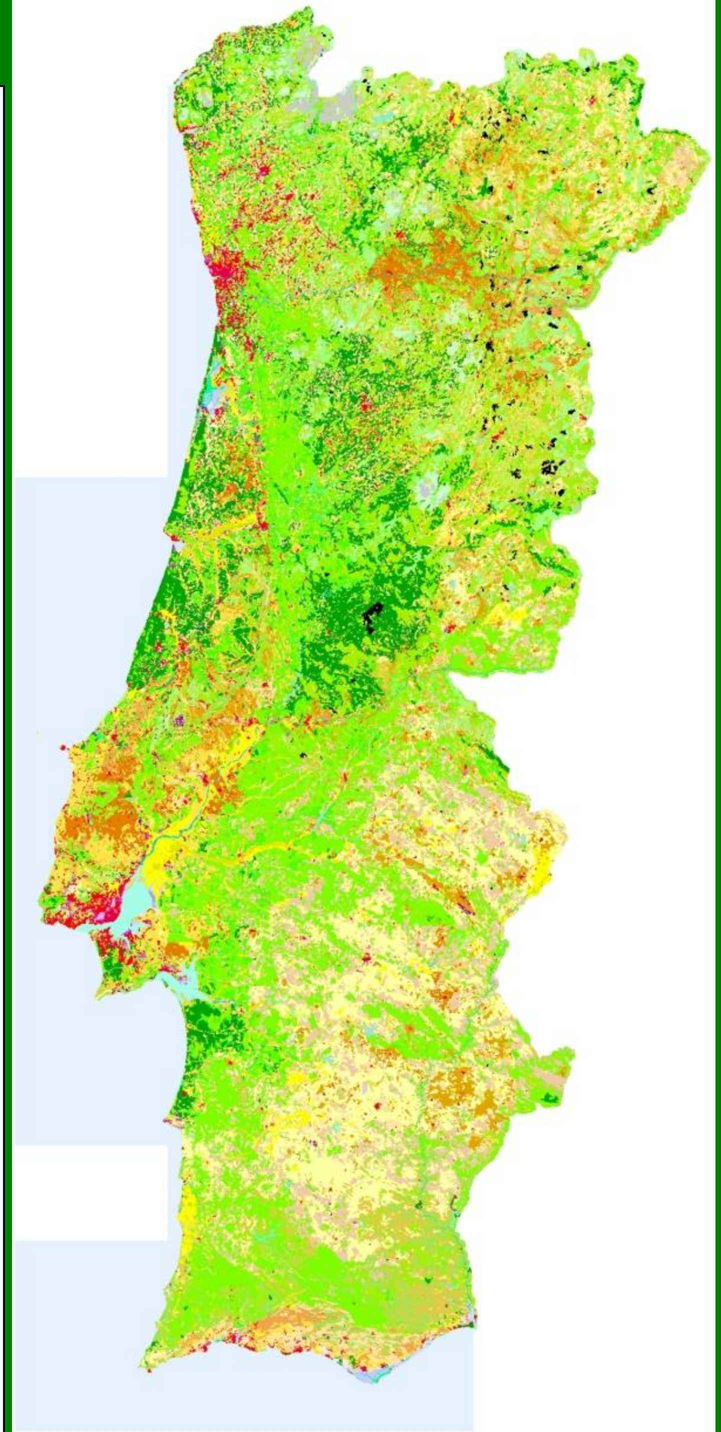
5. Water bodies

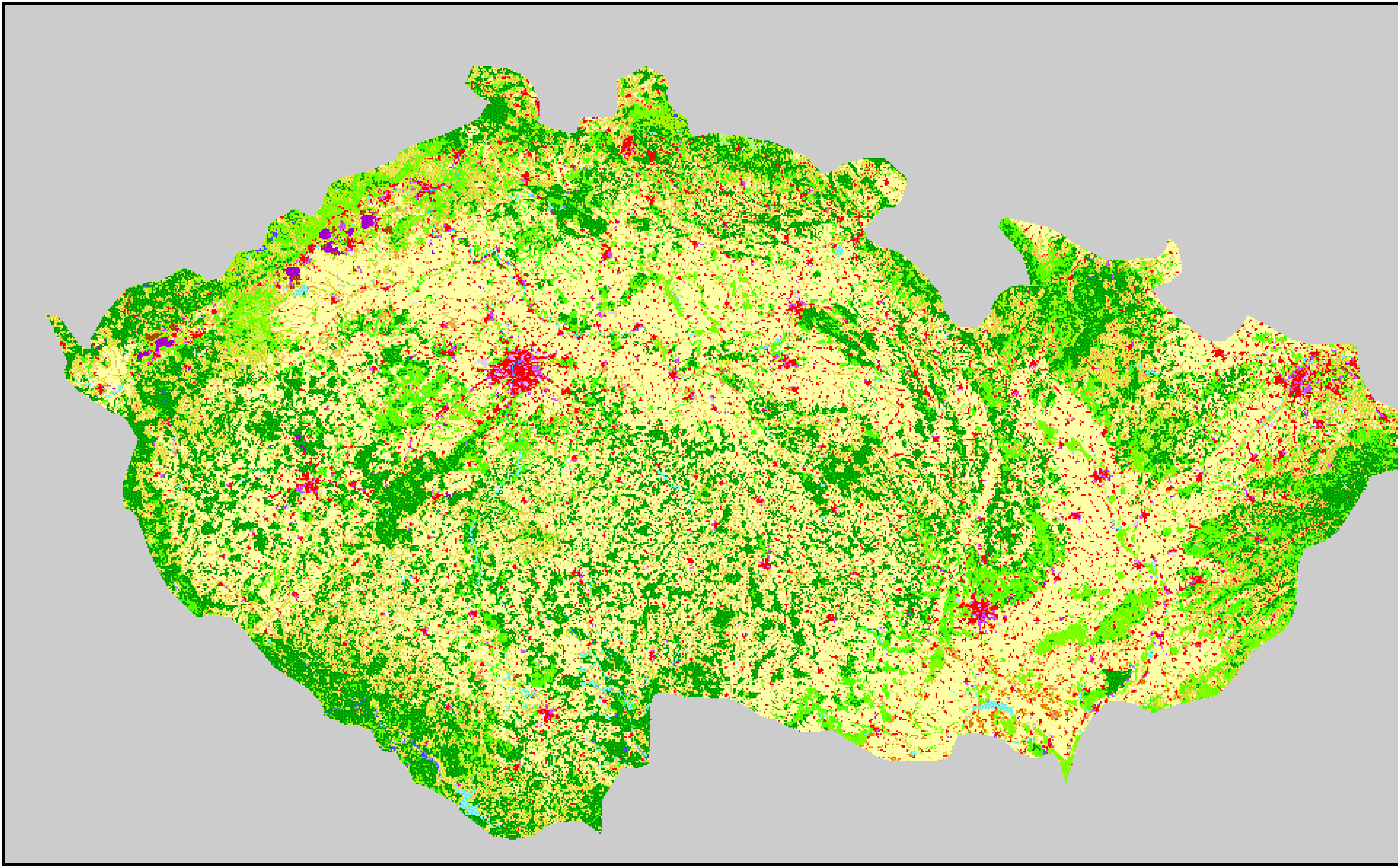
5.1 Inland waters

- 5.1.1. Water courses
- 5.1.2. Water bodies

5.2 Marine waters

- 5.2.1. Coastal lagoons
- 5.2.2. Estuaries
- 5.2.3. Sea and ocean





Non-market valuation approaches

1. demand curve (preference, WTP) methods

People traditionally value only those parts of nature that provide them some direct benefits (utility). Anthropocentric utilitarian approaches to valuation of natural resources were elaborated already during 19th century (Faustmann 1849). In all cases values were derived as sums of net benefits from their utilization.

At the end of 20th century, within utilitarian approach, scientists started to develop hypothetical markets for valuation of non-market benefits of nature, like biotopes or supporting, regulating and cultural services of ecosystems, asking people (consumers) what they are willing to pay for such biotopes or ecosystem services, or what they are willing to accept for the loss of such biotopes or services.

All these utilitarian, demand side approaches (revealed and stated <u>preference methods</u>, like TCM, CVM, hedonic etc.) <u>suffer toward environment with one substantial defect. Valuations are done by individual consumers who are far from integrating such hidden „intermediary“ benefits of biotopes as specific environment for specific living species or benefits of individual ecosystem services into their value systems</u>.

Rate of underestimation by demand curve methods

- Currently, a well-known example of first ecosystem service monetary valuation on the global level is e.g. the article by Costanza et al. (1997). The team of authors estimated the total annual value of 17 ecosystem services of 16 world biomes at the range of USD16-54 trillion (trillion=10^{12}) with an average of USD 33 trillion per year, which was approximately double of (1.8-fold) of annual world GDP (USD 18 trillion).
- Using the experiment Biosphere 2, we can assess the rate of underestimation in Costanza article. As known, Biosphere 2 was the most ambitious project ever undertaken by 8 people to survive in a 3.15 acre sealed greenhouse for two years within an artificially created ecosystem. This $200 million Biosphere 2 experiment in Arizona discovered that it was (after about five months) unable to maintain life-supporting oxygen levels for people living inside.
- If Biosphere 2 needed $200 million investment for eight people, then the natural capital of the global ecosystem could thus be estimated at least at the value level of $165 quadrillion (165 x 10^{15}). By using 5% discount rate, we achieve annual ecosystem services $8 quadrillion (8 x 10^{15}), which means five hundred-fold of the annual world GDP.

Biosphere 2 sealed greenhouse

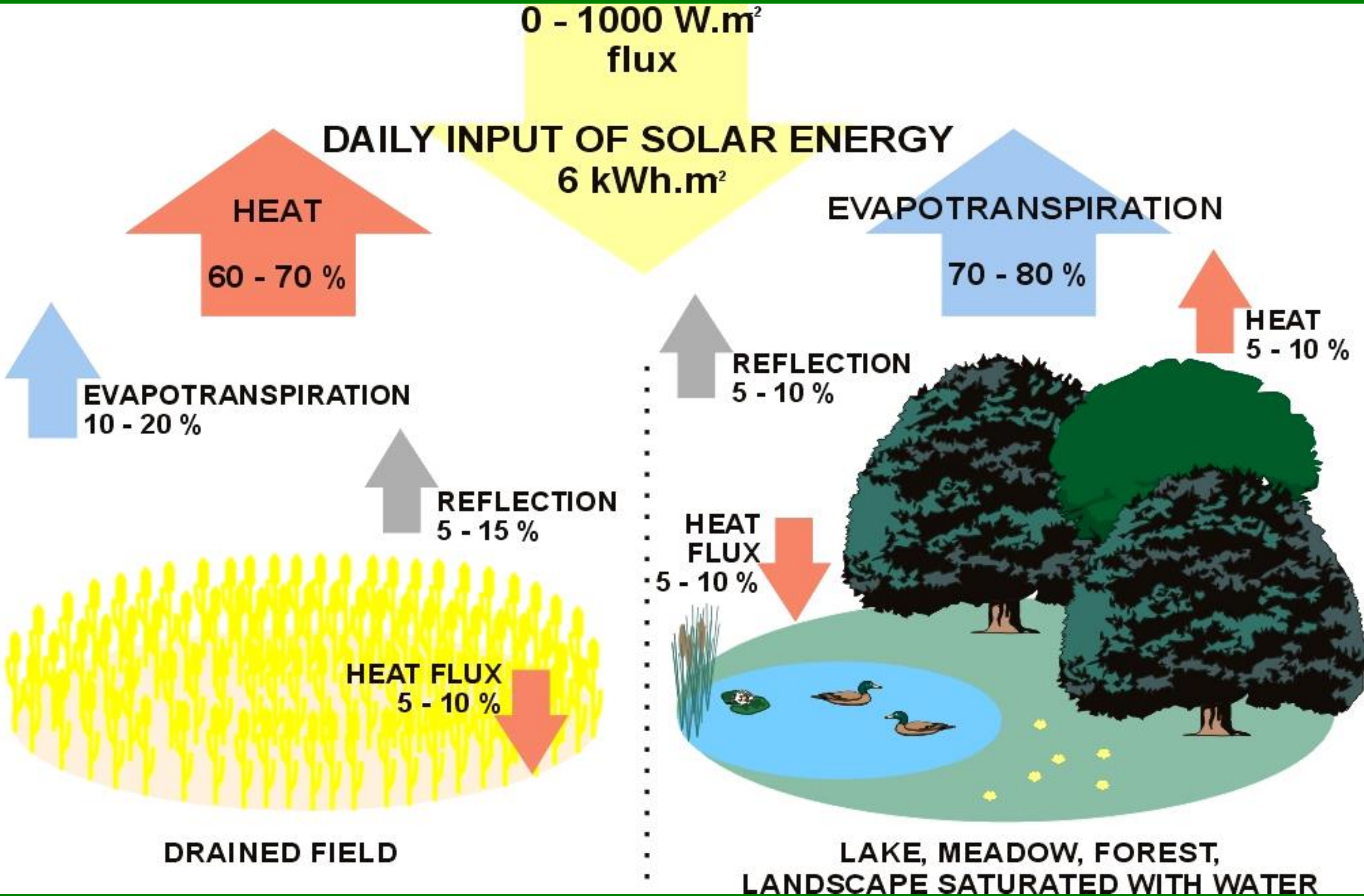
Biosphere 2 food production

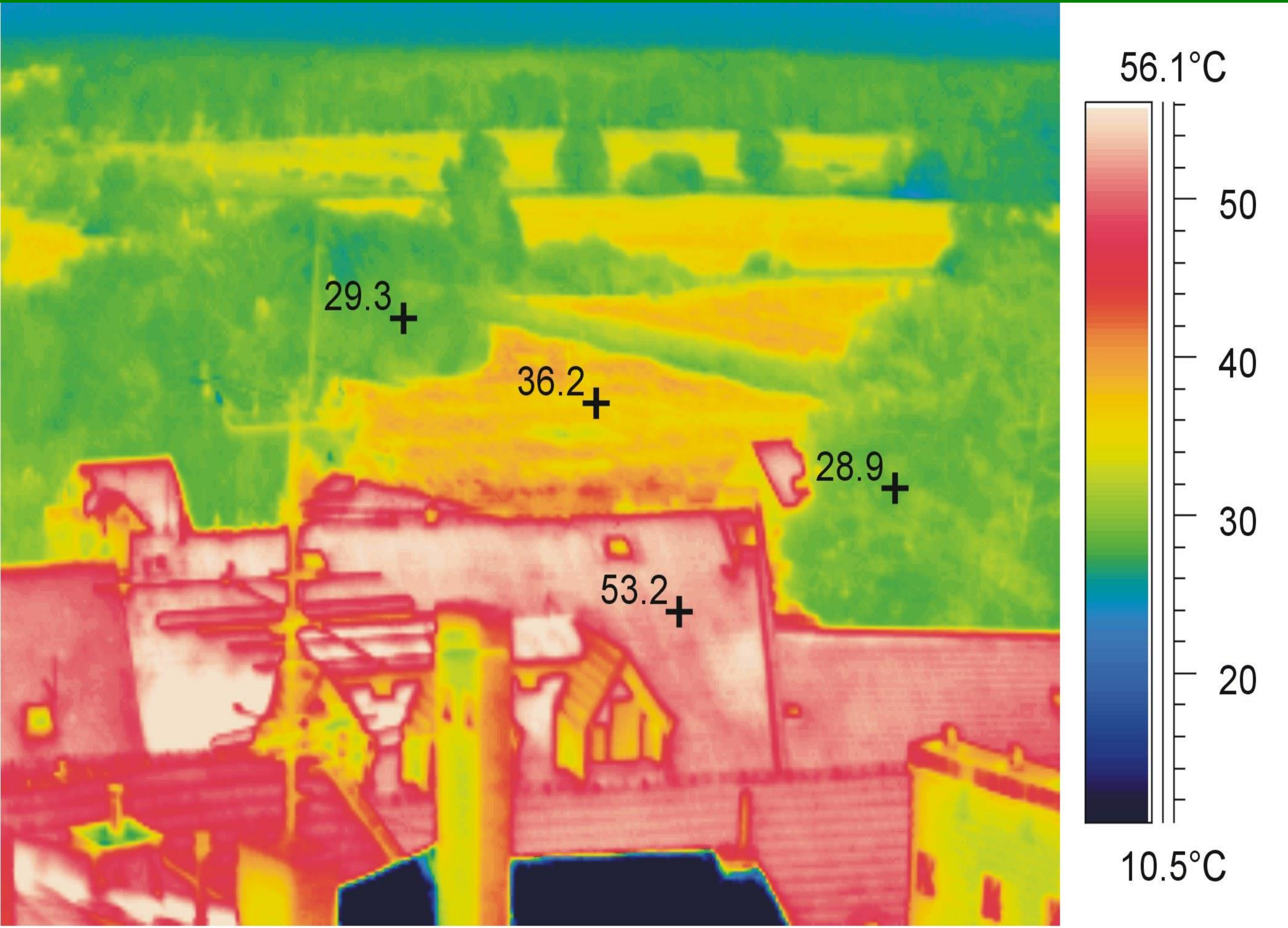
Behaviour of ecosystems

- **Self-organized development in natural ecosystems increases cyclic processes while reducing loss processes (Ripl 1995, 2003).**

- **Continental landscape thus develops toward climax vegetation (naturally created) that maximizes efficiency of solar energy use, mitigating most effectively the temperature and climatic extremes and maximizing water and nutrients retention inside the ecosystems.**

EVAPOTRANSPIRATION




29.3
36.2
28.9
53.2
56.1°C
50
40
30
20
10.5°C

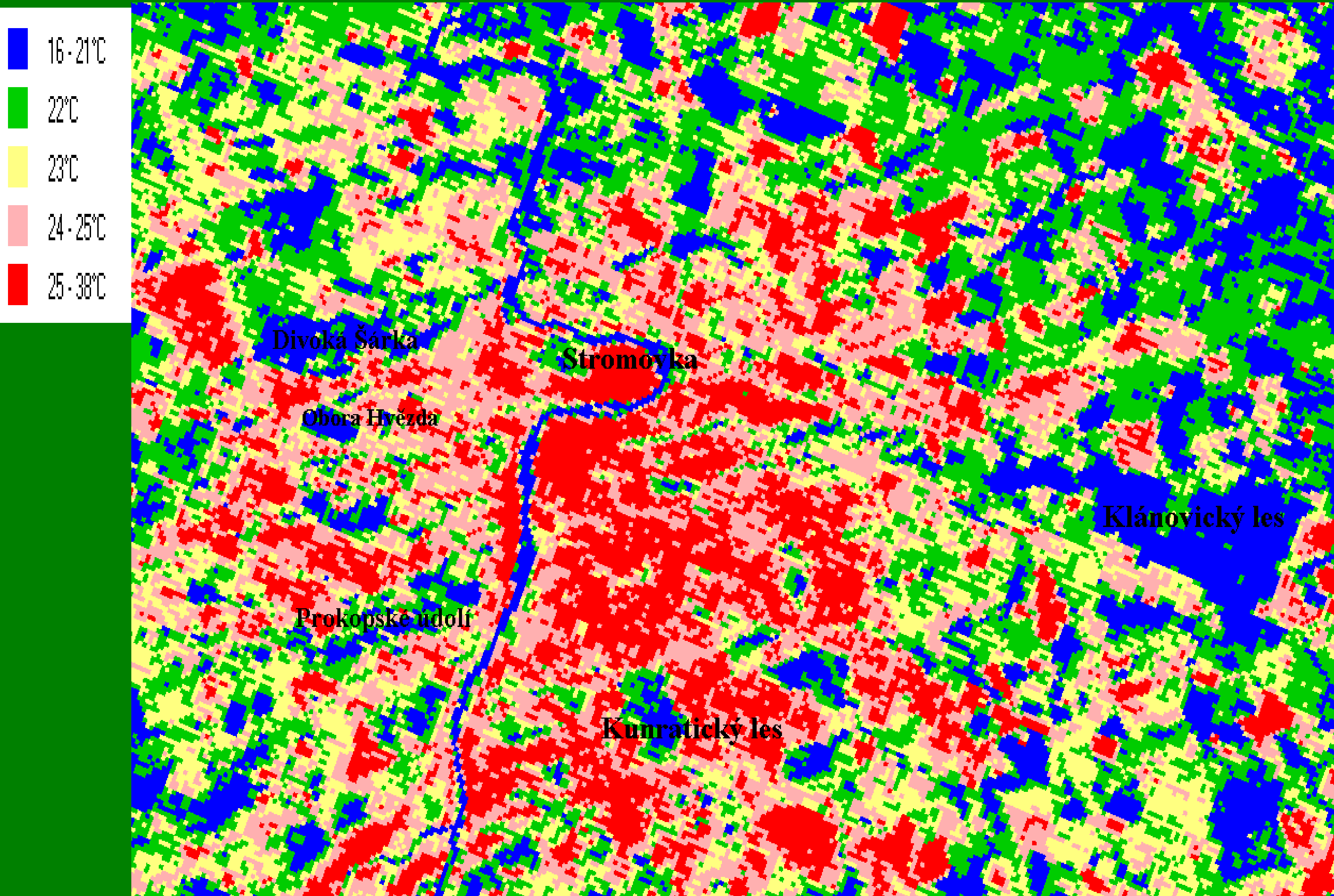
Behaviour of human species

- Humans in their economic activities of industrial period proceed in completely opposite way. By deforesting and dewatering the landscape, they "develop the land", thus maximizing their rent seeking, their economic self-interest from the unit of land (very often by corrupting political parties).

- When valuing land and other natural resources, economists and businesses are not valuing nature, but only future rents (benefits) that can be extracted from the territory. Schizophrenia of territorial planning and landscape planning dominates, supported even by independent ministries (in the CR). Results can be seen on thermal satellite map of Prague.

Prague land cover temperatures, July 28, 2005, 9.30, 23x34 km,

(multispectral and thermal remote sensing data from Landsat TM and ETM+)



Who depends on who

- But it is not the biosphere that depends on humans while the opposite is true.
- Only recently scientists started to realize that humans are multilaterally dependent on natural ecosystems.
- Natural ecosystems not only provide traditional natural resources (food, wood, water, etc.), but also protect against harmful cosmic radiation, continually control the composition of atmosphere, produce fertile soil and biomass, clear air and water, mitigate climate and temperature extremes, maintain biodiversity, decompose organic waste etc.

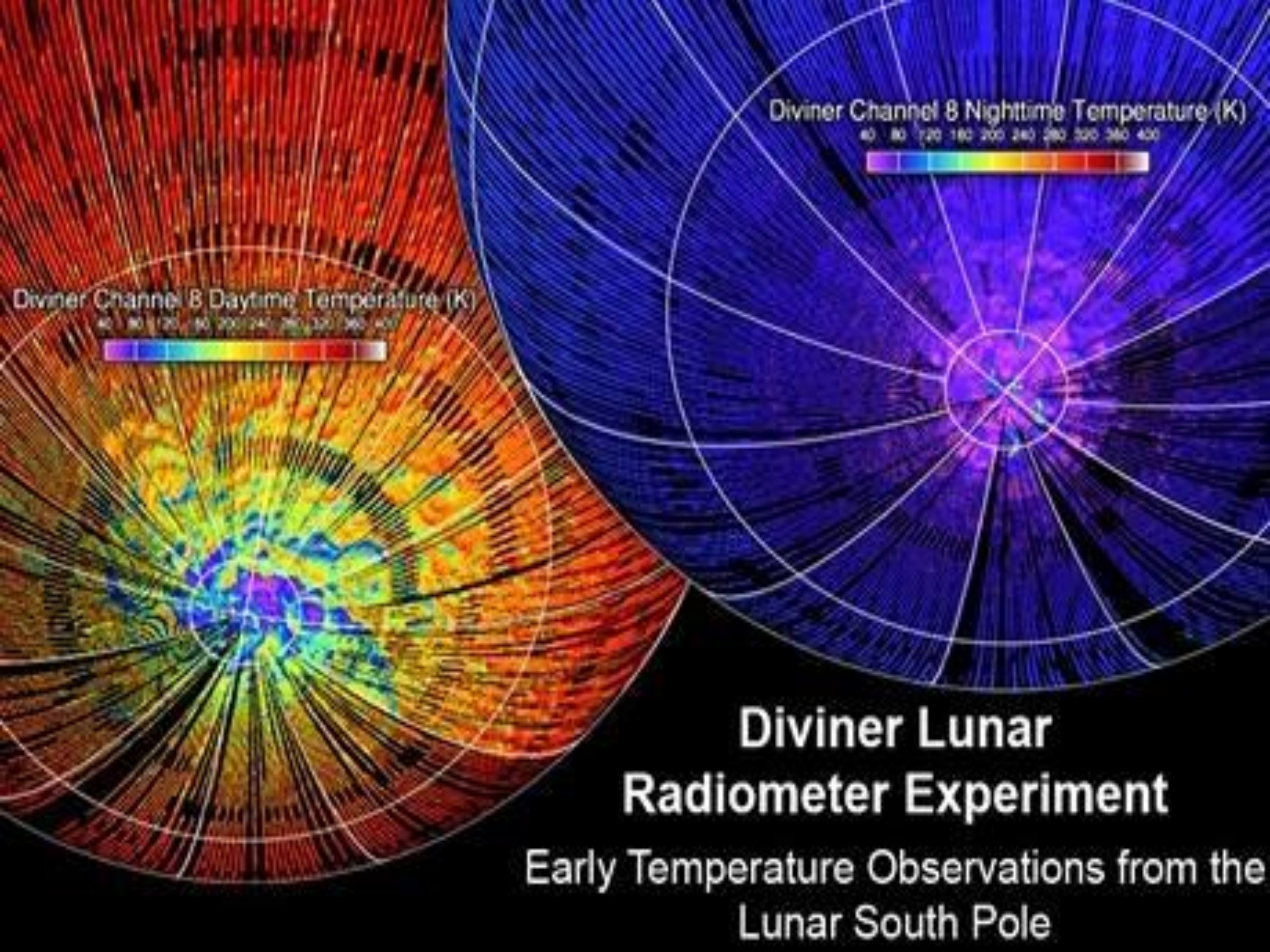
Humans depend on ecosystem services

Human societies and their economies decisively depend on the life supporting functions and services of Earth's ecosystems (MEA 2005).

1. provisioning services: natural ecosystems provide food, fresh water, wood, fibre and fuel, but also

2. supporting services: form fertile soil, cycle and purify air and water,
3. regulating services: protect against harmful cosmic radiation, continually control the composition of atmosphere, mitigate climate extremes, maintain biodiversity, control diseases, decompose organic waste,
4. cultural services: are source of aesthetic, spiritual, educational, recreational values etc.

Only provisioning services are marketed and valued by humans. It is more and more clear that humans decisively depend on non-market supporting and regulating services. They are not intermediary but primary for maintaining the life of humans and other heterotrophs.


Diviner Channel 8 Daytime Temperature (K)
Diviner Channel 8 Nighttime Temperature (K)
40 80 120 160 200 240 280 320 360 400
Diviner Lunar
Radiometer Experiment
Early Temperature Observations from the
Lunar South Pole

Non-market valuation approaches

2. biophysical, cost-based methods

Alternative theoretical concept for valuing non-market ecosystem services comes from the replacement value. This approach considers the cost of providing a substitute service that would perform a similar function to an ecosystem (for example, flood protection service of wetland may be valued on the basis of the costs of building man-made flood defences).

Taking into account that major part of decisive life-supporting ecosystem services have not yet entered into the value system of human individuals, the replacement cost approach and the values derived seem to be more efficient way for revealing the decisive existential importance of ecosystem services for human species.

As Costanza et al. write: "*In fact, one additional way to think about the value of ecosystem services is to determine what it would cost to replicate them in a technologically produced, artificial biosphere.*" (Costanza et al. 1997, p. 255).

Non-market valuation approaches

3. emergy valuations

Third important approach to ecosystem valuation is the emergy analysis, i.e. analysis of energy embodied in ecosystems. Emergy (embodied energy; e*nergy* is the ability to make some work) measures both the work of nature and that of humans in generating products and services. Emergy is defined as available energy of one kind previously required directly and indirectly to make a service or product (units: emjoules).

Emergy theory comes from the axiom that all the real wealth of the environment comes from the work of the geobiosphere (Odum H.T. 1996, p. 35). The sun, the tides, and the heat sources deep in the earth are three main energy sources, each of a different energy form (sunlight insolation: 42 %, tidal energy: 15%, and deep heat inside the earth: 43 %).

Emergy analysis identifies full energy inputs and reflects the supply (full cost) curve approach (broader then the labour theory).

Valuation approaches we are using

In project called „*Explaining interactions among ecosystems and environment in conditions of climate change*" for valuing ecosystem services we used the replacement cost approach combined with biophysical Energy-water-vegetation model (EWVM): monitored data on solar energy flows and water latent changes (Ripl 2003, Sejak et al. 2009).

In conditions of prevailing absence of ecosystem service values in the value system of many human individuals, we count these approaches as efficient way to show how costly humans are in replacing some ecosystem services (benefits) by anthropogenic, technological way.

Moreover, this approach organically integrates already elaborated Biotope valuation method that reflects an average costs for restoring individual biotopes as environments for specific plant and animal species (Seják, Dejmal et al. 2003; fzp.ujep.cz/projekty/bvm/bvm.pdf).

Biotope valuation method (BVM)

1) biotope matureness (points acc. to phylogenetic age of species)
2) biotope naturalness (6 p. to completely natural, 1 point to anthropogenic)
3) diversity of biotope structures (6 p. to all vegetation layers)
4) diversity of biotope species (points acc. to nr. of autochthonic species)
5) rareness of biotope (points acc. geographical and climatic uniqueness, scarcity, frequency and extent)
6) rareness of species of biotope (points acc. to nr. of rare and red list species)
7) sensitivity (vulnerability) of biotope (points acc. rate of vulnerability through the change of habitat conditions)
8) threat to number and quality of biotope (points acc. to dependency on the change of rate of anthropogenic activities and conditions)

- The sum of points achieved in the first four characteristics was multiplied by the sum of points achieved in the four remaining characteristics. The figure obtained was divided by the maximum of points (576) and multiplied by 100.

  [((1 + 2 + 3 + 4) * (5 + 6 + 7 + 8)) / 576] * 100 = nr. of points (3-100)

The point value of respective biotope type shows its relative ecological significance compared to other biotopes. Based on eight of the above mentioned ecological characteristics, a complete list of biotope types for the territory of the CR was created (currently including NATURA 2000 biotopes, extended by underground water biotopes) with their respective point values, showing the ranking of biotopes according to their ecological importance (biotope’s life-supporting potential). The list of biotope types can be found at http://fzp.ujep.cz/projekty/bvm/bvm.pdf (point values are related to 1 m^2 of respective biotope).

Financial evaluation

Typological evaluation of a biotope type (which is corrected by the coefficient based on individual characteristics) gives only a relative value expressed by an amount of given points. **It is necessary to find the financial value of one point in order to be able to express the value of a biotope in monetary terms.**
For this purpose, **projects of nature and countryside restoration were analysed**. We assessed what long-term ecological effects (valued by points) can countryside revitalisations bring and we compared these effects with their costs. This enabled us to count the average cost that Czech society spends for 1 point increase of ecological quality.

136 nature restoration projects have been analysed that had already been implemented during last 5 years in different parts of the Czech Republic and which brought the increase of point value of the area. The financial value of one point was counted for one revitalisation as a sum of its costs divided by a sum of the point increase. Presently (2016), the **average value of one point is set at 0,592 Euro**.

The method's usefulness for maximising the BD benefit

The results obtained on the basis of this Czech-Hessian method are important and stimulating in several ways:

1. The results can be used for **implementing economic instruments (fees)** for activities affecting nature and the environment. New economic instruments **can create nation-wide market for protecting biodiversity and thus help to bring about a more sustainable behaviour by economic actors**.

2. The results can be important **for territorial (land use) planning** and decision-making. By comparing the values of environmental functions and economic functions for a particular territory we can generate relevant information for **ex ante evaluations and political decisions**.

3. They are important as an **indicator for national accounting**. By combining biotope values and the CLC (Corine Land Cover) approach, the total national value of biotopes as the **monetary value of national natural capital** (CZK 17,000 billion) can be quantified. Changes in natural capital can be monitored. Such information can be important for greening traditional national accounts, such as GDP.

Identifying the Biotope Natural Capital in the Czech Republic

By combining biotope values with the CLC (Corine Land Cover) project results, the development of total national value of biotopes as the **monetary value of national natural capital** was quantified. Changes in natural capital were monitored by comparing the areas of CLC 2000 items (17,6 trillion CZK) with the areas of CLC items 1990 (17 trillion CZK). It means that during 1990s (period of transiting from the centrally planned to market economic system) some ecologically positive changes took place; these changes were caused mainly by transferring some arable lands to meadows and pastures and by increasing the area of forests (total increase yearly by about CZK 60 billion).

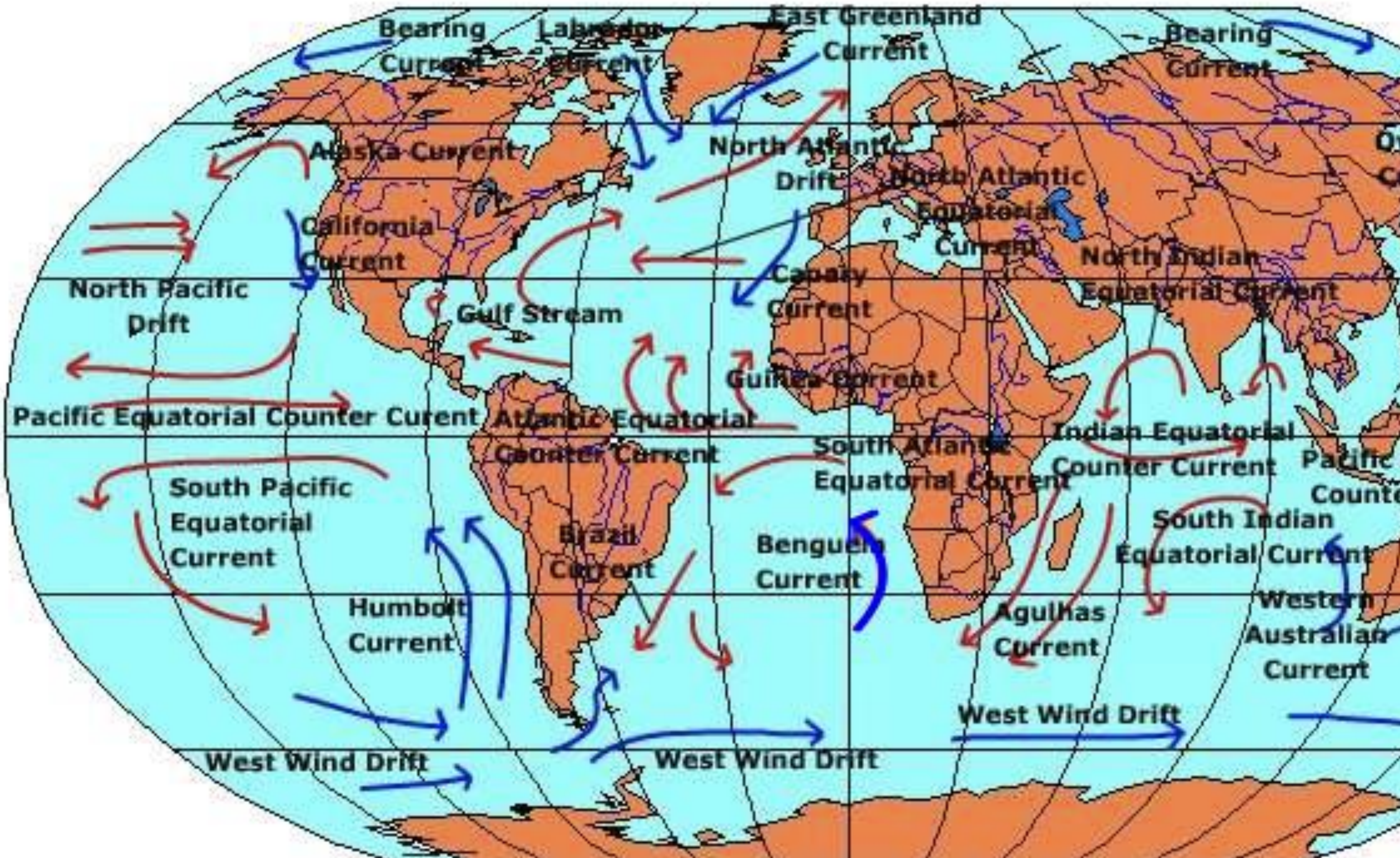
Against this positive tendency (reflected by CLC images) there was on the other hand also a negative tendency of developing industrial zones and commercial and residential areas on agricultural lands (not reflected by the CLC, being mostly less than 25 ha), reducing the ecological value of the Czech territory by approximately 10 billion CZK every year.

What can do biotope values and what ecosystems

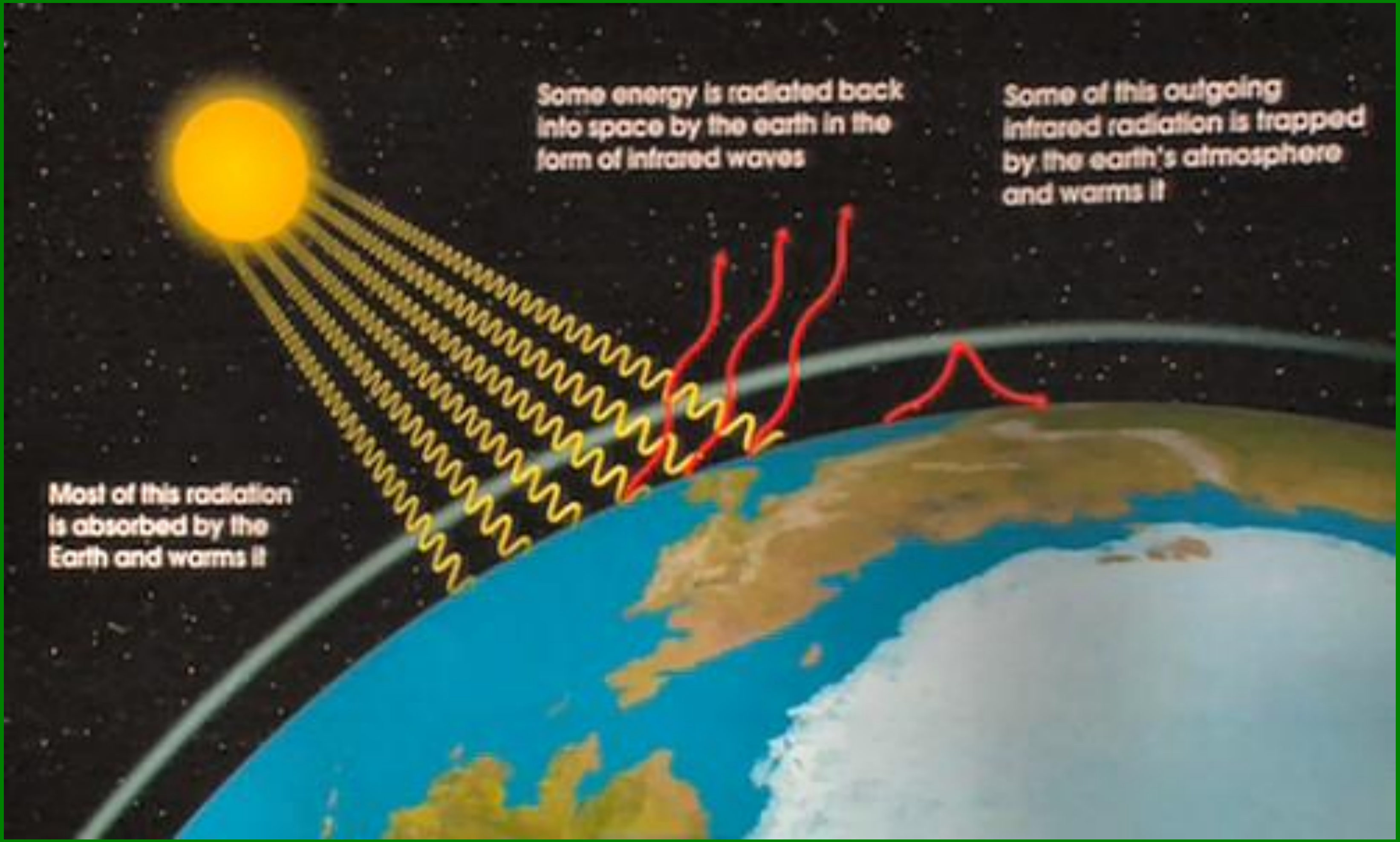
Biotope values inform on relative ecological importance of respective biotope compared to all other national or regional biotopes. Levels of biotope values come from average costs that are necessary to sustain and improve quality of biotopes (quality of nature).

Biotope values do not reflect ecological benefits that natural ecosystems produce for society as life-supporting services. Such benefits can be valued either asking people what they think such value is or can be valued on the basis of costs that society has to pay for technological substitution of individual ecosystem services (ie. flood protection of wetlands can be substituted by constructing river dam. Cost necessary for retaining 1 m3 of flood water can be used as price for valuing flood water retained by wetlands). Similarly, oxygen produced by vegetation can be valued by production costs for technical or medicinal oxygen.

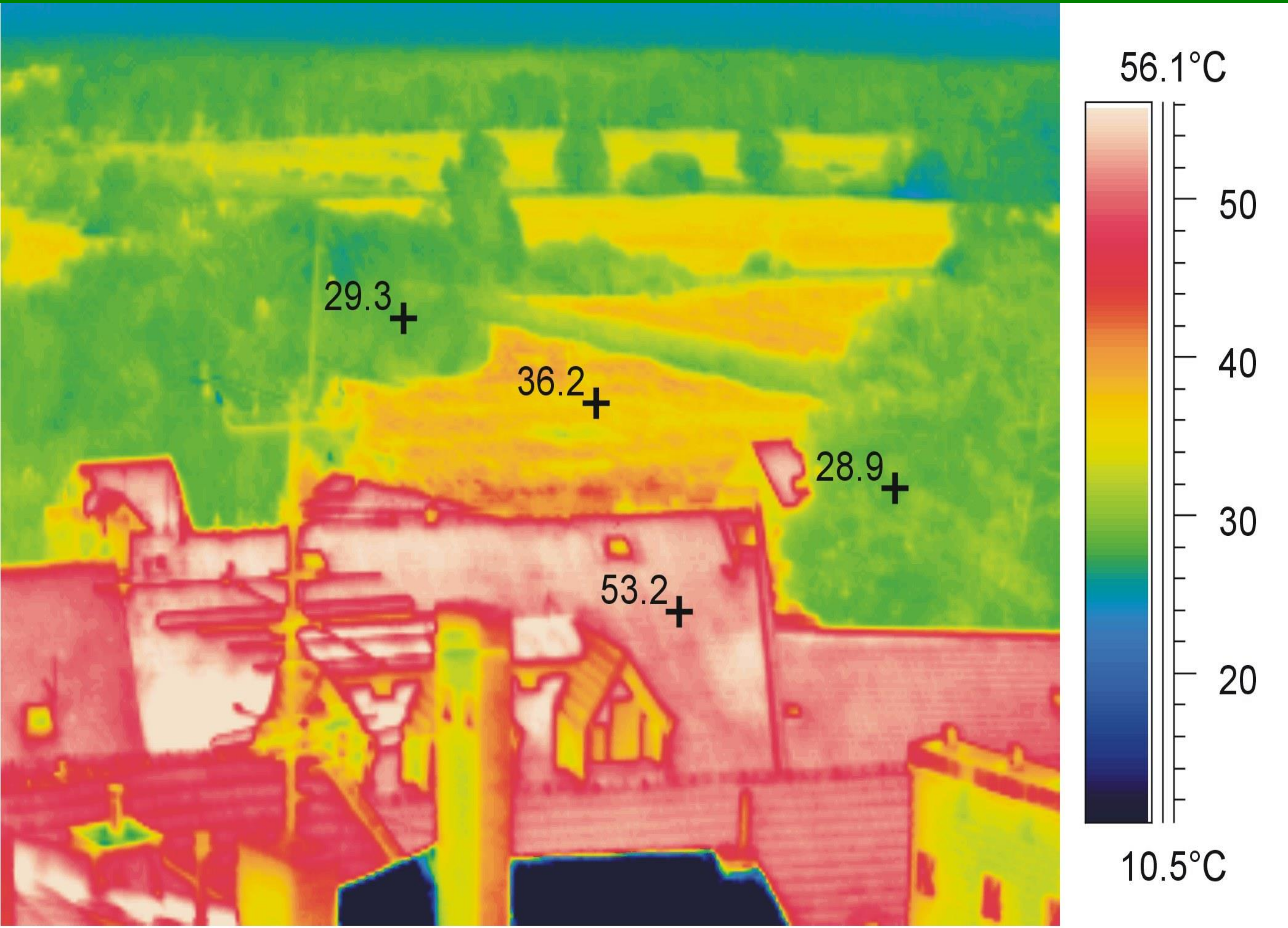
It is energy of Sun and water in liquid form that in the form of ocean streams from equator to poles warms the continents



It is energy of Sun and water as atmospheric vapour and water latent heat changes that help to control temperatures on continents in a range agreeable for sustaining the life

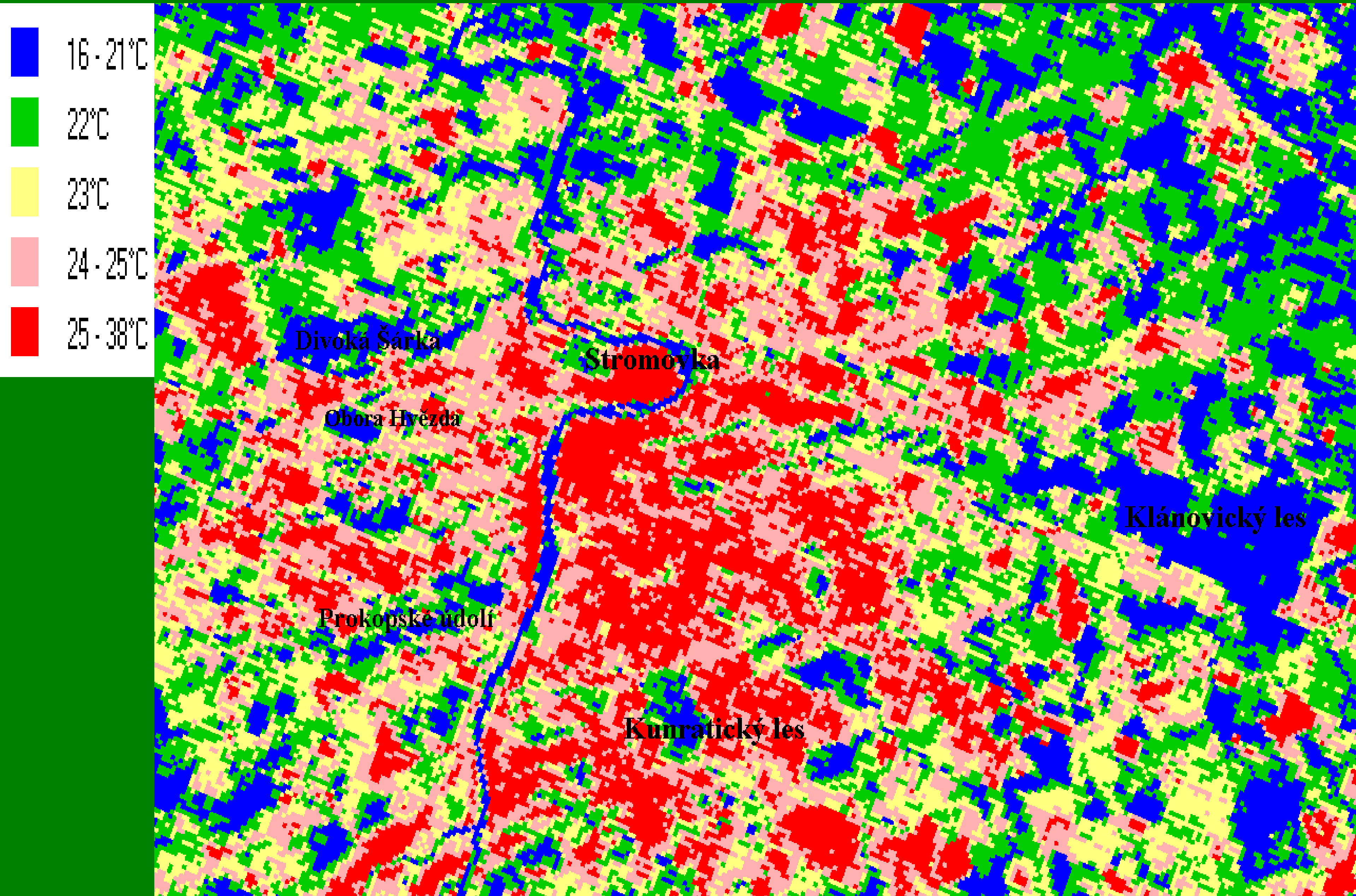


And it is symbiosis sun energy-water-vegetation that locally controls temperatures on continents in a range agreeable for sustaining the life.



29.3
36.2
28.9
53.2
56.1°C
50
40
30
20
10.5°C

Praha, teploty povrchů, slunný 28. červenec 2005, 9.30, 23x34 km,
(multispektrální a termická data Landsat TM a ETM+)



EWVM: For deciduous forest ecosystem saturated with water, the estimations of services are the following:

1. **Biodiversity:** L2.3 Hardwood forests of lowland rivers are valued according to BVM by 66 points per 1 m2, per 1 ha it means 660,000 points x CZK12.36 per point = CZK 8 157 600 of stock value, with 5% discount rate it means annual service at the level **€ 16.300**
2. **Oxygen production:** In temperate zone, 1 ha of deciduous forest produces annually around 10 tons of biomass (expressed in dry mass). It corresponds to the release of 10.6 tons of oxygen. Production of oxygen has been calculated from the fundamental equation of photosynthesis where formation of one molecule of 6 carbon sugar is associated with a release of 6 molecule of oxygen, i.e. formation of 180 grams of sugar (cellulose etc.) is associated with a release of 192 grams of oxygen. From this stoichiometry follows that the production of 10 metric tons of dry mass is accompanied by the release of 10.6 metric tons of oxygen. According to Avogadro law, one gram-molecule of gas under normal atmospheric pressure and temperature 20oC has a volume of 22.4 litres, i.e., 32 grams of oxygen take up 22.4 litres. Then, mass of 1 litre of oxygen is 1.429 g, or 1kg of oxygen holds the volume of 700 litres. 10,600 kg ha-1 x 700 litres = 7,42 mil. litres x € 0,02 per litre = **€ 148.400**
3. **Climatizing (air-conditioning) service:** In temperate zone, 1 ha of deciduous forest transpires around 600 litres of water from 1m2 during vegetation season. Forest saturated with water evaporates around 5 litres of water during a sunny day from 1 m2. Whereas photosynthesis (biomass production) uses less than 1% of the incoming solar energy, by evapotranspiration (latent heat) around 80 % can be used in water saturated vegetation. Latent heat of 1 litre of water is equal to c. 0.7kWh. It is necessary to emphasize the double air-conditioning effect of evapotranspiration: first, a tree cools itself and its environment by evaporation of water (solar energy is used as latent heat), second, water vapour condensates on cool surfaces (or in cool air) and releases latent heat. Considering the double airconditioning effect (cooling during evapotranspiration and warming during water vapour condensation), the annual climatizing service of 1 ha can thus be estimated 600 l x 1.4 kWh (0.7 kWh cooling, 0.7 kWh warming) x 10,000 x €0.08 (electricity cost price)= **€ 672.000**
4. **Support of short water cycles and water retention service:** evapotranspirated 600 litres m^{-2} brings an annual service: (600 litres m^{-2}) x € 0.114 (distilled water price) x 10,000 m2 **€ 684.000**

Total annual services from 1 ha forest € 1.520.700

If the natural landscape is drained, as the following scheme of drained foothill pasture (channel straightening and recessing) shows, ecosystem services substantially decline:

- **1. <u>Biodiversity</u>:** Intensively managed or degraded mesic meadows X T.3 are valued according to BVM by 13 points per 1 m2, per 1 ha it means 130,000 points x € 0.4944 per point = € 64,272 of capital value, with 5% discount rate, annual service **€ 3.200**
- **2. <u>Oxygen production</u>:** 3.5 mil. litres O2 x CZK 0.25-0.73 per litre (CZK0.50 = € 0.02) **€ 70.000**
- **3. <u>Climatizing service</u>:** Around 300 litres of evapotranspired water from 1 m2 during vegetation season. Annual climatizing service of 1 ha can thus be estimated 300 x 1.4 kWh (0.7 kWh cooling, 0.7 kWh warming) x 10,000 x €0.08 (electricity cost price) **€ 336.000**
- **4. <u>Support of short water cycles and water retention service</u>:** evapotraspirated 300 litres of water per 1 m2 brings an annual service: (300 litres per m2) x € 0.114 (distil. water price) x 10,000 m2 = **€ 342.000**
- **<u>Total annual services from 1 ha of drained pasture € 751.200</u>**

Four ecosystem services of main functional groups of biotopes in the CR (GDP 2008 in the CR = € 147.56 bln.)

Nr.	Functional groups of biotopes	Area [km^2]	Ecosystem services [€. m^{-2}. $year^{-1}$]				Sum of ecosystem services	
			Climatizing service[1]	Short water cycle[2]	O_2 production[3]	Biodiverity service[4]	Relative value [€.m^{-2}.$year^{-1}$]	Absolute value [billion€.$year^{-1}$]
1	**Water bodies**	675	67	57	25	0	**150**	**101**
2	**Peatbogs**	23	90	74	3	1	**168**	**4**
3	**Other wetlands**	364	90	74	30	1	**195**	**71**
4	**Extensively manag. mesic meadows and pastures**	2601	67	34	16	1	**118**	**308**
5	**Intensively managed mesic meadows and pastures**	5579	56	34	21	0	**111**	**621**
6	**Degraded mesic meadows pastures and heathlands**	4609	45	20	12	0	**77**	**355**
7	**Dry dense grasslands**	40	45	11	11	1	**68**	**3**
8	**Dry open grasslands**	172	34	9	6	1	**49**	**9**
9	**Xerophilous scrubs**	426	45	17	12	1	**75**	**32**
10	**Mesic scrubs**	1959	56	34	16	1	**107**	**209**
11	**Wet scrubs**	17	67	54	17	1	**140**	**2**
12	**Dry pine forests**	298	45	26	13	1	**85**	**25**
13	**Other coniferous forests**	6050	56	46	23	1	**126**	**761**
14	**Damaged coniferous forests**	8222	45	34	19	0	**98**	**807**
15	**Deciduous forests**	6636	78	68	27	1	**175**	**1161**
16	**Degraded deciduous forests, culticenosis**	1632	56	40	19	1	**116**	**189**
17	**Alluvial forests**	924	90	80	30	1	**201**	**186**
18	**Solitery trees, alleys**	1276	56	34	21	1	**112**	**143**
19	**Arable land: biotopes of cereals and root-crops**	27605	34	9	13	0	**56**	**1541**
20	**Arable land: fodder crops and perennial plants**	141	45	20	30	0	**95**	**13**
21	**Areas without vegetation**	2938	11	3	0	0	**14**	**41**
22	**Rocks biotopes**	113	22	11	3	1	**38**	**4**
23	**Other natural and near-natural biotopes**	3780	66	50	22	1	**140**	**528**
24	**Other more anthropic affected biotopes**	2787	38	17	14	0	**70**	**196**
	Total Czech Republic	**78869**						**7310**

Biotope, ecosystem service values and official prices of territories in the CR (in € per 1 m^2)

LAND COVER 1:100000	BVM capital values	Annual ES values	ES capital values	Econom. capital values	Notes
1.1.1. Continuous urban fabric	0 - 1.20	27	535	1.4 - 90	acc. to urban site
1.1.2. Discontinuous urban fabric	5.04	78	1557	1.4 - 90	acc. to urban site
1.2.1. Industrial or commercial units	0 - 1.32	32	638	1.4 - 90	acc. to urban site
1.2.2. Road and rail networks and assoc. land	4.00	58	1156	1.4 - 90	acc. to urban site
1.2.3. Port areas	3.92	70	1398	1.4 - 90	acc. to urban site
1.2.4. Airports	5.92	80	1591	1.4 - 90	acc. to urban site
1.3.1. Mineral extraction sites	6.64	43	864	1.4 - 90	acc. to urban site
1.3.2. Dump sites	3.88	99	1981	0.04	
1.3.3. Construction sites	3.52	42	844	1.4 - 90	acc. to urban site
1.4.1. Green urban areas	9.52	106	2127	1.4 - 33	
1.4.2. Sport and leisure facilities	9.28	79	1589	0.4 - 0.6	
2.1.1. Non-irrigated arable land	5.12	62	1242	0.04 - 0.7	acc. to soil quality
2.2.1. Vineyards	7.52	88	1769	0.04 - 6.4	
2.2.2. Fruit trees and berry plantations	7.00	88	1764	0.04 - 4	
2.3.1. Pastures	10.28	102	2050	0.04 - 0.4	ann. ES €75 m
2.4.2. Complex cultivation	6.96	85	1696	0.04 - 0.4	acc. to soil quality
2.4.3. Land with agricult. & natural vegetation	10.64	100	1996	0.04 - 0.4	acc. to soil quality
3.1.1. Broad-leaved forest	20.12	156	3118	0.1 - 4.4	
3.1.2. Coniferous forest	12.96	124	2490	0.1 - 4.4	
3.1.3. Mixed forest	14.08	131	2616	0.1 - 4.4	
3.2.1. Natural grassland	16.32	109	2177	0.04	
3.2.2. Moors and heathland	26.20	129	2576	0.04	
3.2.4. Transitional woodland shrub	11.64	106	2128	0.04	
3.3.2. Bare rock	19.68	107	2144	0.04	
4.1.1. Inland marshes	16.56	159	3174	0.04	
4.1.2. Peatbogs	26.36	168	3361	0.04	
5.1.1. Water courses	11.44	139	2776	0.3	
5.1.2. Water bodies	9.24	148	2962	0.3	

Two methods of systemic landscape valuation

- By utilizing these two methods (BVM, EWVM), two systemic scales of ecological values of the Czech landscape (both as flows and stocks) have been derived.
- Biotope stock values range from zero (chemically contaminated land, impermeable surfaces) to about €40 per m2. The scale of biotope values shows the average societal costs that society has to pay in maintaining the ecological quality of landscape and its variable biotopes.

- Similarly, the scale of ecosystem services stock values starts at levels near to zero in cases of completely anthropogenized lands; however, in natural and semi-natural ecosystems the values reach even above €3000 per m2 (Sejak, Pokorny 2009). EWVM shows how costly society is in replacing the ecosystem services by technological ways. BV and EWV methods may provide land managers, public land stewards and environmentally aware land developers a means to optimize land uses properly among ecological and economic purposes.

Conclusions

1. Based on demand side methods (preference approach), Costanza et al. (1997) estimated the world annual ecosystem services as 1.8-fold of annual world GDP (USD 18 trillion).
2. Our pilot estimation of annual ecosystem service values in the CR represents four main functions and services of national ecosystems. Estimated annual ecosystem services exceed the annual GDP at least fifty times.
3. It is not the replacement cost method that tends to overestimate actual values of supporting and regulating services of ecosystems, but rather the preference methods that expressively underestimate these primary services of nature.
4. If viewed as complementary, these two methodological approaches (preference methods, replacement cost methods) show the range of ecosystem service values, from how people value these life-supporting services to what are their real abilities to replace them.
5. Due to growing environmental awareness and continuing technological progress, there is a clear convergence in future valuation results of both approaches.

Biodiversity and ecosystem services are the key conditions for preserving life on Earth, as they help to regulate the climate and other critical conditions for life.

The extraordinary significance of biodiversity and its intrinsic value has been underlined in the Convention on Biological Diversity (CBD, 1992), in which the intrinsic value of biodiversity is highlighted in the first sentence together with social, economic, scientific, educational, cultural, recreational and aesthetic values.

The "Millennium Ecosystem Assessment" report stated „the intrinsic value of biodiversity and ecosystems is no less important than the utilitarian value" (MEA 2002, ch. 6).

Humans depend on ecosystem services

- **Human societies and their economies decisively depend on the life supporting functions and services of Earth's ecosystems (MEA 2005):**

- **<u>Provisioning services:</u> natural ecosystems provide food, fresh water, wood, fibre and fuel, but also**

- **<u>Supporting services:</u> form fertile soil, cycle nutrients and purify air and water,**
- **<u>Regulating services:</u> mitigate climate and temperature extremes, protect against harmful cosmic radiation, continually control the composition of atmosphere, maintain biodiversity, control diseases, decompose organic waste,**
- **<u>Cultural services:</u> are source of aesthetic, spiritual, educational, recreational values etc.**

- **Only provisioning services are marketed and valued by humans. It is more and more clear that <u>humans decisively depend especially on non-market supporting and regulating services</u>. They are not intermediary but primary for maintaining the life of humans and other heterotrophs.**

Economic valuation methodologies for valuing non-market environmental goods have reached during two or three decades a considerable diversity, but they still remain tied in the straitjacket of individualistic utilitarian approach.

From the overview of valuation techniques it can be seen that they are based either on stated or on revealed preferences of individual consumer.

These methods are so deeply tied with satisfying human individual pleasures that for many economists any other different approach is hardly imaginable.

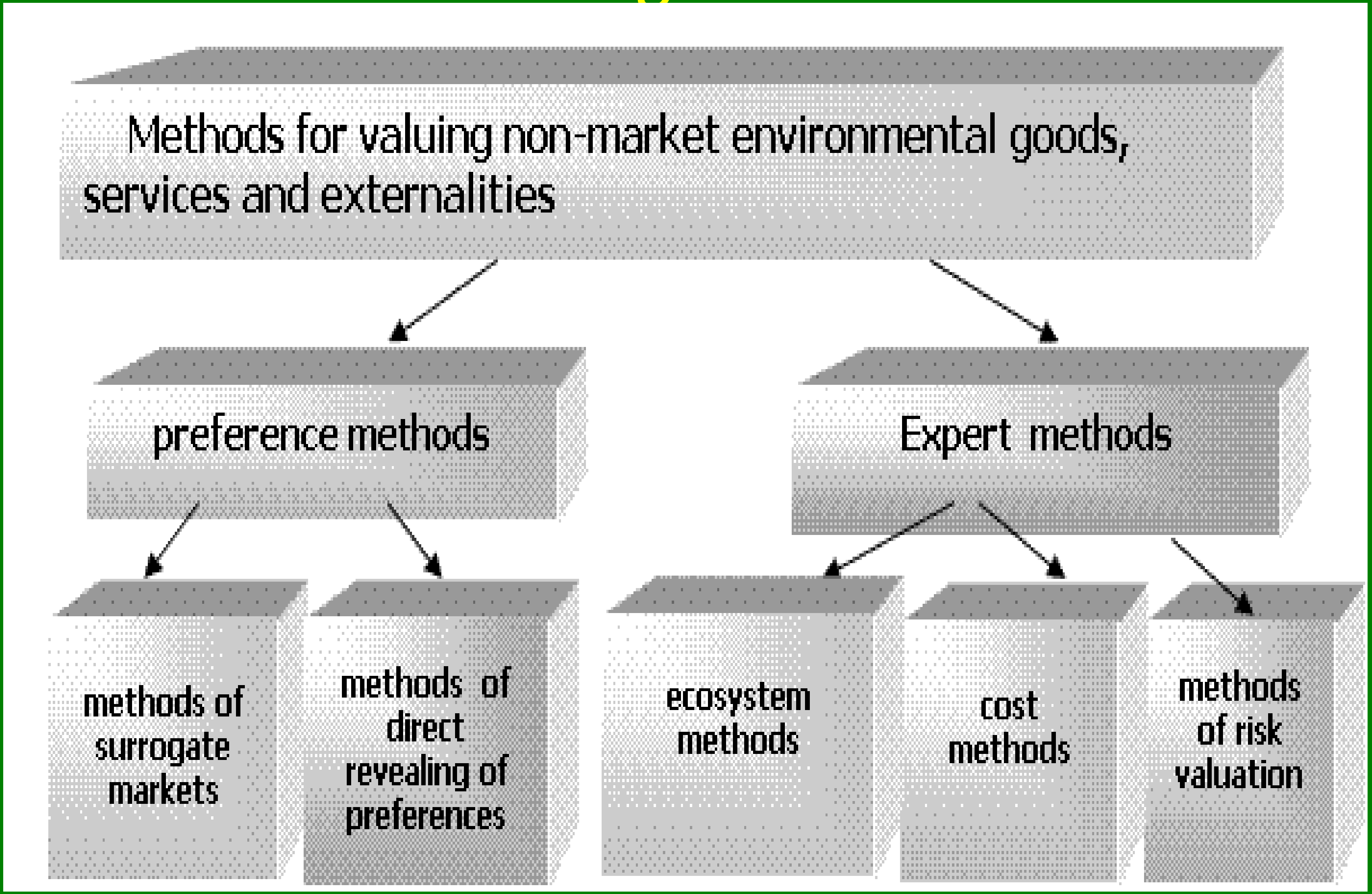
We can find the following valuation techniques

- ***Price based approaches***: use the market price of environmental goods and services.
- ***Related goods approach***: uses information on the relationship between a marketed and non-marketed good or service.
- ***Indirect approaches***: seek to elicit preferences from actual, observed market based information (e.g. the value of changes in productivity approach, the production function approach, travel cost method, hedonic pricing).
- ***Direct approaches***: are used to elicit directly consumer's willingness to pay for non-marketed environmental values.
- ***Cost-based methods***: use some estimate of the costs of providing or replacing a good or service as an approximate estimate of its benefit (e.g. opportunity cost, restoration cost, replacement cost, relocation cost, preventive expenditure).

In the Handbook of Biodiversity Valuation (OECD, 2002) we can read about:

- *economic valuation methods* ***based on market prices*** (where the prices are revealed by existing markets),
- ***stated preference methods*** (markets are constructed using questionnaires),
- ***benefits transfer*** ('borrowing' of estimate of willingness to pay from one site and applying it to another).

Methods for valuing non-market environmental goods and services



Preference methods = demand side methods

(methods based on revealed preferences or on revealing the preferences)

Within the preference methods, two main approaches can be identified in current environmental literature (see e.g. OECD 1994):

- the first method is based on **already <u>revealed preferences</u>** on related markets, economists try to find a good or a service that is sold in markets and is related to or "bundled with" the non-market service, the comprise **<u>hedonic property value method</u>, hedonic wage model, <u>travel cost method</u> and averting behaviour method**;
- the second method is based on a **direct revealing the preferences**. People are asked how much they are willing to pay to have a specified environmental quality happen. This is **known as "<u>stated preferences</u>" or "<u>contingent valuation method" (CVM).</u>**

Methods of revealed preferences = methods of "**related markets**".

- **The first approach** may be called a ***methods of revealed preferences*** or a methods of "***related markets***". These are the methods of indirect valuation through the behaviour of people on related markets. The estimates are based on what people actually did and why they did it – not what people said they would do under a set of hypothetical conditions.
- These methods are sometimes called indirect methods, because they value on the basis of indirect behaviour. They contain the ***method of hedonic pricing***, where the environmental value is derived from the differences of property values in different locations (with different environmental quality).
- Some other methods, like ***the hedonic wage model, travel cost method and averting (defending) behaviour method***, will be described further. These methods are connected with accepting a set of assumptions that remains largely untested. Being derived from the real behaviour on markets, these methods reveal only direct use value.

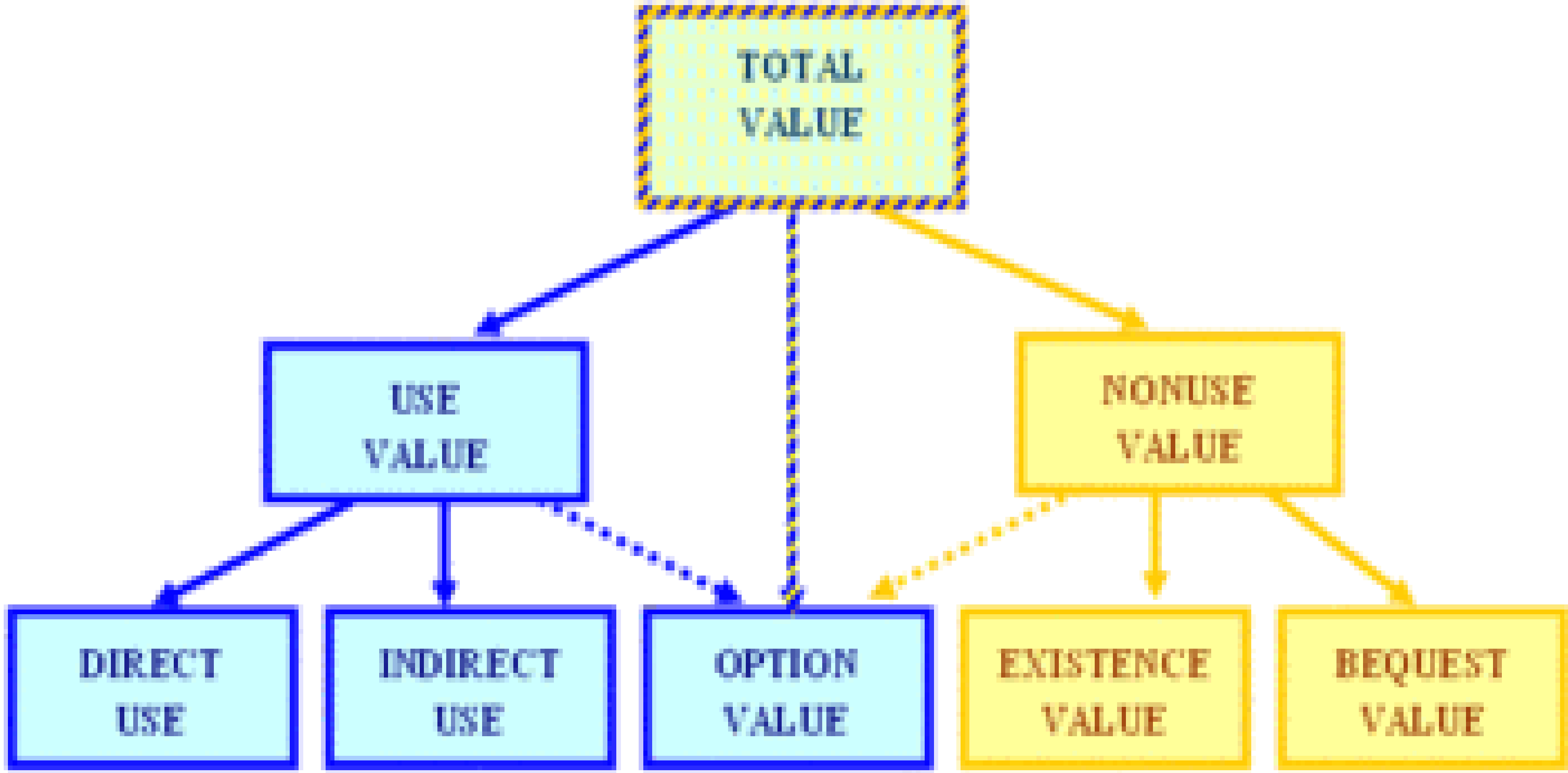
What is economic value in mainstream economics?

Economic value (EV) is a measure of the benefit that an economic actor can gain from either a good or service (Wikipedia). It is neoclassical concept of EV (comes from marginal utility for individual).

Classical school explained economic value as socially necessary costs that must be spent in order to create some good or service.

Greatest economists (A. Marshall, H. Daly) argue that both sides (costs and utility) must be taken into account to identify the economic value

Total economic value



Hedonic pricing method (HPM)

This method comes from the assumption that property market price is dependent on its use values. Given that different locations of property will have different levels of environmental attributes and that these attributes affect the stream of benefits from the property, then the variation in attributes will result in differences in property values (since property values are derived from the stream of benefits). The HPM looks for any systematic differences in property values between locations and tries to separate out the effect of environmental quality on these values.

The HPM involves the following steps:

- **Defining the market commodity (in this case property) and the environmental good or service of concern which is an attribute of the market commodity (e.g., air pollution).**
- **Specifying the functional relationship between the market price and all the relevant attributes of the market commodity (structural characteristics of housing, neighbourhood characteristics, environmental quality aspects). This is called Hedonic Price function.**
- **Cross-sectional (covering a large number of similar properties at one point in time) or time series data (covering a smaller number of similar properties over a number of years) are collected (e.g., from real estate agents).**
- **The coefficient on environmental quality $\Delta P/\Delta E$ is calculated using techniques such as <u>multiple regression analysis</u>. Such coefficient is known as the marginal implicit price of environmental quality and gives the additional amount of money that must be paid by an individual to move to an identical property with a higher environmental level. The shape of demand curve is estimated from available discrete data.**

Wage risk method

Another variant of the HPM is wage risk method which is used to place a value on the benefits of environmental improvement to human health. These improvements will consist of reduced mortality and morbidity. Benefit estimation requires that we place a monetary value on the benefits of changes in the risk of death, injury and illness. It is assumed that an individual can substitute between income and health (they can make trade-offs between income and health) with the trade-off measured by WTP. Market now being looked at is not property but the labour market.

A wage risk method involves the following steps:

- Defining the labour market commodity (in this case job and wage) and the environmental good or service of concern which is an attribute of the market commodity (e.g. risk of an accident).
- Specifying the functional relationship between the market price (wage) and all the relevant attributes of the market commodity (job related characteristics, socioeconomic characteristics of the individual, accident - death or injury – risk for the job). This is called an earnings function.
- Cross-sectional data for wage rates and the other associated characteristics are collected (e.g. from Standard Class Industry Codes).
- Multiple regression analysis is used to calculate the coefficient on accident risk, i.e., $\Delta W/\Delta R$. Such coefficient is known as the marginal implicit value of the risk of an accident and gives the additional amount of money that must be paid to an individual to move to an identical job with a higher risk of death or injury level. The shape of earning curve is estimated from available discrete data.
- The coefficient on the risk term gives the amount €X per year that must be paid to a worker to accept a job with an extra 1 in 100,000 chance of an accident occurring. For a group of 100,000 workers each with an increase of 1 in 100,000 in the risk of an accident, there would statistically be one extra death on average. €X was paid to each of the 100,000 workers to accept the statistical death of one person and so the Value of this Statistical Life is €100,000.X
- So, Value of Life = 100,000 . $\Delta W/\Delta R$.

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Travel Cost Method

The travel cost demand function is interpreted as the derived demand for a site services and depends on the ability of a site to provide the recreation activity. Only use values are therefore considered, with existence and option values being ignored.

The procedural steps involved in the TCM are as follows:

- **For the site in question, the area around is divided into concentric circles (called zones), such that the travel cost of getting to the site and back from each zone is measurable. The travel cost includes any site entrance fee, the direct money costs of getting there (petrol, etc., as well as time costs involved in getting to the site and at the site.**
- **Visitors to the site are sampled using a questionnaire to determine their: zone of origin and other demographic/attitudinal information, frequency of visits to the site in question, frequency of visits to substitute sites, trip information, e.g. length of trip, nights stayed in motel etc., travel paths, meals at restaurants, etc.**
- **Visitation rates are then found for each zone of origin using the above information (to get visitor days per capita). A measure of travel costs to and from the site is found using the above information.**
- **Statistical techniques such as multiple regression analysis are used to test the hypothesis that visitation rates depend on travel costs, i.e. visitation rates are regressed on travel costs and other socioeconomic variables such as income, education, etc. as well as the prices and distances of competing sites e.g., $V_i = a + b.TC_i + c.INC_i + d.ED_i + \ldots + f.STC_i$ where V is the number of visits to the site, TC is the total travel cost to the site, INC is the individuals income, ED is their education, STC is total travel cost to substitute sites, the subscript i denotes the respondent, and a,b,c,d,f, are the coefficients to be estimated. The coefficient b gives the change in number of visits for a change in travel cost (admission price).**
- **The observed total visitation for the site from all zones represents one point on the demand curve for the site.**
- **Assuming that any increase in travel cost has the same effect on visitation as an equivalent increase of a hypothetical admission fee, then other points on the demand curve are found by using the estimated visitation rate equation to compute visitation rates and total visits for all travel cost zones for a given increase in admission price (or rather its surrogate, travel cost). This is repeated for successive increases in admission price such that the full demand curve is found. The benefits (consumer surplus) of the site are then found from the area under the demand curve.**

Contingent valuation method (CVM)

- Application of CVM means a preparation and use of specially structured questionnaire, through which respondents (individuals or households) are asked a series of questions revealing their preferences for some specific change in environmental quality. The method is termed "contingent" because environmental quality change is not, in fact, necessarily going to be provided by research analyst: the situation respondent is asked to value is hypothetical. Due to this hypothetical character CVM can be applied universally to obtain values of private, semi-public or purely public goods and services. CVM is used especially for valuing environmental goods and services for which a conventional market does not exist.
- At first glance CVM appears similar to public opinion polling and market research techniques. Although there are similarities, there are also significant differences. CVM seeks to obtain monetary value of the change in well-being an individual (or household) would obtain from the change of environmental quality. Public opinion polls are not concerned with monetary valuations. Market researchers want to know whether people will purchase some private good while CVM typically focuses on individuals' preferences for non-market public goods.

Types of CVM interviews

- **The CVM interviews can be conducted <u>by mail, telephone, or in-person or some combination of these</u>. In-person interviews are generally considered to provide the highest quality data if surveyors are properly trained and familiar in details with valued problem. The major disadvantages are their expense and possible biases from asking the same question in different ways.**

- **In countries with extensive telephone network, telephone interviews offer several advantages. They are relatively inexpensive and random-digit dialing methods can be used to obtain a relatively representative sample of respondents. The interview is interactive but without possibility of using pictures and graphical explanations.**

- **Mail surveys also have often been successfully used, especially if respondents were compensated for completing the questionnaire. All three forms can also be combined.**

Content of questionnaire

Most CV survey instruments (questionnaires) should contain three main parts:

- **First, to explain environmental problem valued, careful description of valued problem, often with the use of pictures and diagrams, to explain how the problem is related to respondent and in which way he/she would pay, institutions responsible. Problem description should include information on such things as: when the environmental quality change will be available, how the respondent will be expected to pay for it, how much others will be expected to pay, what institutions will be responsible for the change etc. Problem description must be sufficient, but short enough.**

- **Second, the respondent is asked one or more questions how much he/she is willing to pay for the improvement of environmental quality (to accept for environmental quality loss).**
- **Unique to the CVM are the description of hypothetical market and the valuation questions. There are several ways that a respondent can indicate his/her choice or preferences. One is to answer a question as to whether or not he would want to purchase the service if it cost a specified amount. We refer to this as a YES/NO question. Another possibility is to ask a direct question about the most he/she would be willing to pay for the good or service, we refer to this as a direct or open-ended question. YES/NO questions are generally preferred and respondents may be shown a list of possible answers in the form of "payment" card.**
- **Respondent must be put into a position of buyer, must be informed that he/she has no right for the public good without paying for it. As public goods generally have the characteristics of joint consumption and non-exclusion, respondent must be informed how his/her answer will influence the project implementation (to avoid his/her free-rider behaviour).**
- **Environmental problems are the main area of CVM applications (see e.g. Braden et Kolstad, 1991; Cummings, Brookshire et Schulze, 1986 etc.), especially in cases, where no other methods can be used. CVM are able to reveal not only use values, but also optional and existence values. As showed by Greenley, Walsh et Young (1981), these non-use values can reach a half of total value.**

- **Third, CV survey usually include a series of questions about the socioeconomic and demographic characteristics of the respondent and his/her family.**

Types of errors and biases in CV surveys

Although CVM is nearly universally applicable and can value all components of economic value, revealing preferences through questions is connected with many problems.

There are three basic categories of errors: on respondent side, on surveyor side (miscommunication between surveyor and respondent), errors with aggregation of individual responses.

Respondents may not reveal their true value of the good or service:

- **- <u>strategic biases</u>: respondents can understate their true preferences for public goods in hopes of a "free ride" while others pay; if the price for public good is not tied to an individual's WTP response, but the public good provision is, respondents may over-report their true WTP, to ensure the provision of the good;**
- **- <u>biases are given by specific procedures</u> (how questions are asked, by the way of payment, information given etc.).**

Second cause of biases consists in the fact that CV researcher may not have specified the most policy-relevant hypothetical scenario for the respondent to value. People may be willing to pay for improved environmental goods and services but only hardly can distribute such hypothetical WTP into the individual environmental fields and media.

Third group of errors can be generated by <u>sampling errors (non-random samples, non-responses) and by insufficient sample size</u>.

- **In public goods provision, biases can not be excluded, but many authors believe that biases are not fundamental. Approaches are seeked to exclude overstating the real WTP (Hoehn et Randall, 1987). Fundamental for good results is a quality of a questionnaire and its proper application.**

Guidelines for conducting CV studies

General guidelines

- **Sample Type and Size: Probability sampling is essential. The choice of sample specific design and size is a difficult technical question that requires the guidance of a professional sampling statistician.**
- **Minimize Non-responses: High nonresponse rates would make CV survey results unreliable.**
- **Personal Interview: It is unlikely that reliable estimates of values can be elicited with mail surveys. Face-to-face interviews are usually preferable, although telephone interviews have some advantages in terms of cost and centralized supervision.**
- **Pre-testing for Interviewer Effects: An important respect in which CV surveys differ from actual referendum is the presence of an interviewer (except in the case of mail surveys). It is possible that interviewers contribute to "social desirability" bias, since preserving the environment is widely viewed as something positive. In order to test this possibility, major CV studies should incorporate experiments that assess interviewer effects.**
- **Reporting: Every report of a CV study should make clear the definition of the population sampled, the sampling frame used, the sample size, the overall sample non-response rate and its components (e.g., refusals), and item non-response on all important questions. The report should also reproduce the exact wording and sequence of the questionnaire and of other communications to respondents (e.g., advance letters). All data from the study should be archived and made available to interested parties.**
- **Careful Pre-testing of a CV questionnaire: Respondents in a CV survey are ordinarily presented with a good deal of a new and often technical information, well beyond what is typical in most surveys. This requires very careful pilot work and pre-testing, plus evidence from the final survey that respondents understood and accepted the description of the good or service offered and the questioning reasonably well.**

Guidelines for conducting CV studies

Guidelines for Value Elicitation Surveys

- **Conservative design: When aspects of the survey design and the analysis of the responses are ambiguous, the option that tends to underestimate willingness to pay is generally preferred. A conservative design increases the reliability of the estimate by eliminating extreme responses that can enlarge estimated values wildly and implausibly.**
- **Elicitation Format: The willingness-to-pay format should be used instead of compensation required because the former is the conservative choice.**
- **Referendum Format: The valuation question generally should be posed as a vote on a referendum.**
- **Accurate Description of the Program or Policy: Adequate information must be provided to respondents about environmental program that is offered.**
- **Pre-testing of Photographs: The effects of photographs on subjects must be carefully explored.**
- **Reminder of Substitute Commodities: Respondents must be reminded of substitute commodities. This reminder should be introduced forcefully and directly prior to the main valuation to assure that the respondents have the alternatives clearly in mind.**
- **Temporal Averaging: Time dependent measurement noise should be reduced by averaging across independently drawn samples taken at different points in time. A clear and substantial time trend in the responses would cast doubt on the "reliability" of the value information obtained from a CV survey.**
- **"No-answer" Option: A "non-answer" option should be explicitly allowed in the addition to the "yes" and "no" vote options on the main valuation (referendum) question. Respondents who choose the "no-answer" option should be asked to explain their choice.**
- **Yes/No Follows-ups: Yes and no responses should be followed up by the open-ended question: "Why did you vote yes/no?"**
- **Cross-tabulations: The survey should include a variety of other questions that help interpret the responses to the primary valuation question. The final report should include summaries of willingness to pay broken down by these cathegories (e.g., income, education, attitudes toward the environment).**
- **Checks on understanding and Acceptance: The survey instrument should not be so complex that it poses tasks that are beyond the ability or interest level of many participants.**

There are at least 5 doctrines of utilitarian welfare economics that prevent a faster development of economic valuations of non-market biodiversity and ecosystems:

1. doctrine of self-interested behaviour of individual
2. doctrine of utilitarianism of economic valuation,
3. doctrine of subjectivism of economic valuation,
4. doctrine of discounting the future,
5. doctrine of non-accepting the intrinsic value of nature

Doctrine of self-interested behaviour of individual

The beginning of the industrial revolution brought a fundamental change in the moral framework for an individual's behaviour. While the medieval ethical system was based on the duty of individual's work for the community, on the preference of public property to private property, on the prevention of lending money for interest and on the prevention of accumulating personal profit, the industrial revolution changed the moral framework towards self-interested behaviour of an individual and towards private property as the stock of his/her wealth (Capra, 1983).

These changes stimulated enormously the economic activities of individuals that expanded their material welfare; however, this happened at a severe price of destroying the world's ecosystems and growing economic differences between nations and inside nations.

Doctrine of utilitarianism of economic valuation

Already in the first half of the 19th century, forestry and agricultural economics were established as theories of rational use of these natural resources by human individual. According to these theories, the economic value of a natural resource is not the value of the resource alone, but the value of the sum of future net benefits for the owner from the use of such resource.

Recently, this utilitarian approach to natural resources has also been applied to non-market environmental goods. Many authors identify different services that ecosystems provide for humans. But valuing the services of ecosystems leads to more questions then answers, because the total economic value of these services is infinite. Up to now, the majority of economists have been interested mainly in those services that have direct use value for the current consumer. Moreover, there is a clear substitution (meaning also competition) between the marketed and non-marketed services of ecosystems.

Doctrine of subjectivism of economic valuation

The existing valuation techniques are focused on identifying the preferences of individual consumers. However, the sum of such individual preferences may - even substantially - differ from the social preferences for environmental quality that are generated within the parliamentary and governmental decision-making activities.

In representative democracies, government and parliament are the bodies that primarily take decisions in the field of environmental protection.

Doctrine of discounting the future

In order to obtain finite economic values of infinitely renewable resources, the principle of discounting future values has been applied since the 19th century. The conceptual basis for discounting is the fact that current consumption is valued higher than the future one. This utilitarian warrant of discounting can be found in many works, recently for example in Guidelines for Preparing Economic Analyses (EPA 2000).

However, discounting of ecosystem services by positive discount rate generally prevents from realizing that adapting the speed and direction of economic and demographic processes to the evolutionary processes of the Earth is a precondition for a sustainable future.

Obsession with the utilitarian approach to biodiversity and ecosystems and the non-acceptance of intrinsic value of environment is a contra-productive phenomenon that currently prevents a real progress towards sustainable development.

The most promising way toward biodiversity measuring is an ecosystem (= "*a dynamic complex of plant, animal and micro-organism communities and their environment, interacting as a functional unit*": CBD, 1992).

Ecosystems are spatially tied with biotopes (≈habitats). *A biotope is a local environment that meets the requirements which are characteristic for plant and animal species*.

Biotopes anchor the ecosystems to the Earth's surface. In the following part the Biotope valuation method (BVM) is described.

BVM: Ecological characteristics of biotope

http://fzp.ujep.cz/Projekty/BVM/BVM.pdf

In Germany and the Czech Republic, each biotope type has been recently valued by an interdisciplinary team of ecologists and economists of different scientific backgrounds using points according to eight ecological characteristics (each of them with the potential point value from one to six points):

1) biotope matureness (points according to phylogenetic age of species)

2) biotope naturalness (6 p. to completely natural, 1 point to anthropogenic)

3) diversity of biotope structures (6 p. to all vegetation layers)

4) diversity of biotope species (points acc. to nr. of autochthonic species)

5) rareness of biotope (points acc. geographical and climatic uniqueness, scarcity, frequency and extent)

6) rareness of species of biotope (points acc. to nr. of rare and red list species)

7) sensitivity (vulnerability) of biotope (points acc. rate of vulnerability through the change of habitat conditions)

8) threat to number and quality of biotope (points acc. to dependency on the change of rate of anthropogenic activities and conditions)

The sum of achieved points in the first four characteristics were multiplied by the sum of points achieved in the four remaining characteristics. The figure obtained was divided by the maximum of points (576) and multiplied by 100.

[((1 + 2 + 3 + 4) * (5 + 6 + 7 + 8)) / 576] * 100 = nr. of points (3-100)

The point value of a respective biotope type shows its relative ecological significance compared to other biotopes.

This methodology was farther developed for the territory of the Czech Republic. The main reason for this elaboration was the requirement of the Czech Ministry of the Environment to apply this methodology to the NATURA 2000 system of natural habitats. The list of biotope types was created, including:

1. natural and quasi-natural biotope types (acc. to NATURA 2000),

2. biotope types modified or changed by human activities (semi-natural, marked ‚X‘),

3. unnatural and abiotic biotope types (marked ‚XX‘).

Our interpretation of differentiating biotopes thus arises from the aspect of vegetation rather than from the topological aspect, which was significant for the Hessian method. In the Hessian approach, every stage (for example young stages) of certain biotope type is considered to create a biotope unit. Our conception, incorporating the NATURA 2000 system of biotopes, counts with the ideal and fully developed (typical) stage of biotope type. For this reason it was necessary to define the additional criteria for evaluating a specific biotope at a specific environment and time, which will correct the first level of valuation (biotope type as one item for a national territory). These additional criteria take into account the ontogenetic development of biotope, its integrity in the countryside, anthropogenic disturbance and fullness of the functions of biotope's ecosystems.

Financial evaluation

Typological evaluation of a biotope type (which is corrected by the coefficient based on individual characteristics) gives only a relative value expressed by an amount of given points. It is necessary to find the financial value of one point in order to be able to express the value of a biotope in monetary terms.
For this purpose, projects of nature and countryside restoration were analysed. We assessed what long-term ecological effects (valued by points) can countryside revitalisations bring and we compared these effects with their costs. This enabled us to count the average cost that Czech society spends for 1 point increase of ecological quality.

136 nature restoration projects have been analysed that had already been implemented during last 5 years in different parts of the Czech Republic and which brought the increase of point value of the area. The financial value of one point was counted for one revitalisation as a sum of its costs divided by a sum of the point increase. Presently, the average value of one point is set at 0,50 Euro.

The method's usefulness for maximising the BD benefit

The results obtained on the basis of this Czech-Hessian method are important and stimulating in several ways:

1. The results can be used for implementing economic instruments (fees) for activities affecting nature and the environment. New economic instruments can create nation-wide market for protecting biodiversity and thus help to bring about a more sustainable behaviour by economic actors.

2. The results can be important for territorial (land use) planning and decision-making. By comparing the values of environmental functions and economic functions for a particular territory we can generate relevant information for ex ante evaluations and political decisions.

3. They are important as an indicator for national accounting. By combining biotope values and the CLC (Corine Land Cover) approach, the total national value of biotopes as the monetary value of national natural capital (CZK 17,000 billion) can be quantified. Changes in natural capital can be monitored. Such information can be important for greening traditional national accounts, such as GDP.

Identifying the Natural Capital in the Czech Republic

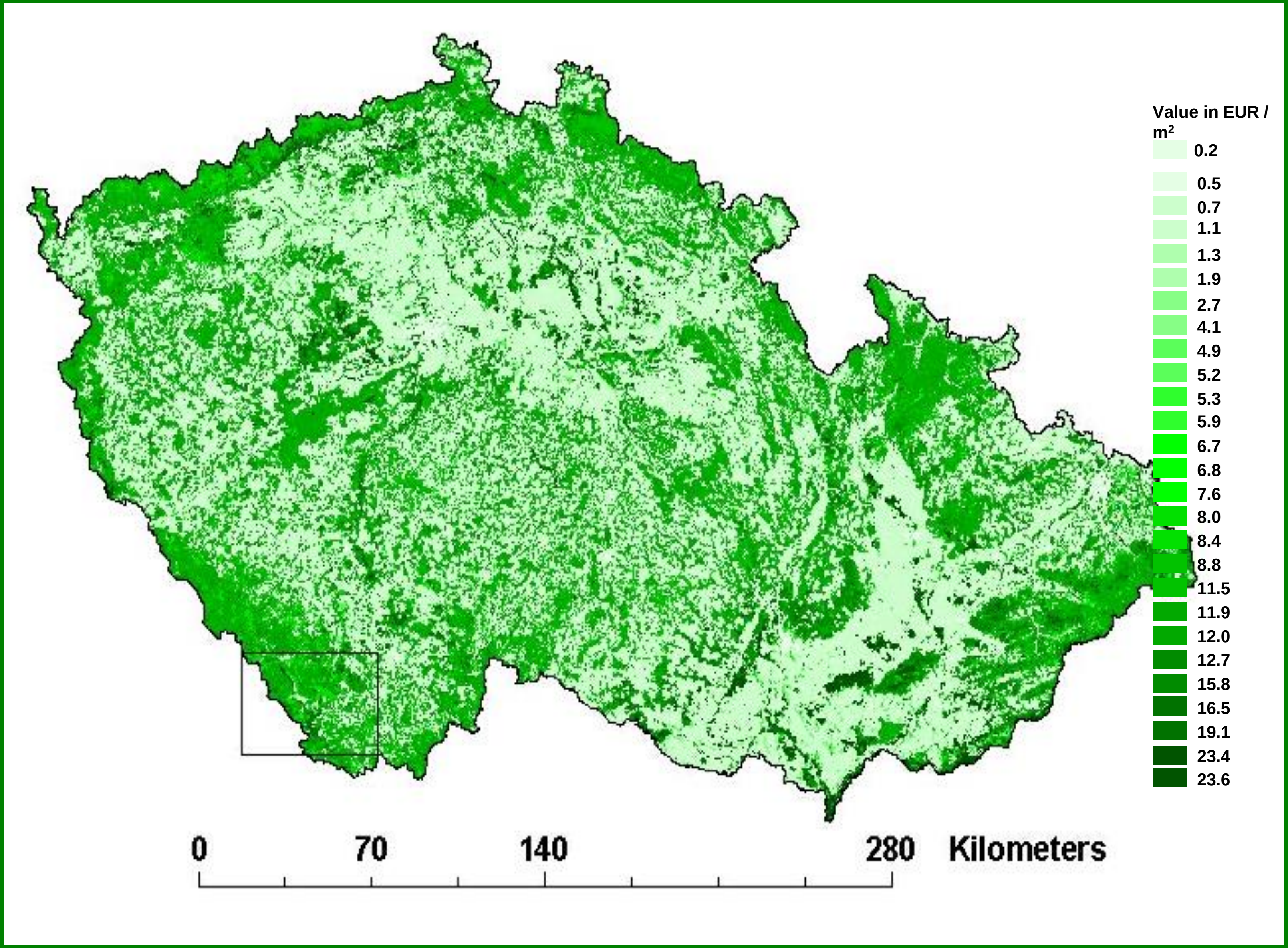
By combining biotope values with the CLC (Corine Land Cover) project results, the development of total national value of biotopes as the monetary value of national natural capital was quantified. Changes in natural capital were monitored by comparing the areas of CLC 2000 items (17,6 trillion CZK) with the areas of CLC items 1990 (17 trillion CZK). It means that during 1990s (period of transiting from the centrally planned to market economic system) some ecologically positive changes took place; these changes were caused mainly by transferring some arable lands to meadows and pastures and by increasing the area of forests (total increase yearly by about CZK 60 billion).

Against this positive tendency (reflected by CLC images) there was on the other hand also a negative tendency of developing industrial zones and commercial and residential areas on agricultural lands (not reflected by the CLC, being mostly less than 25 ha), reducing the ecological value of the Czech territory by approximately 10 billion CZK every year.

Conclusions

1. Identifying the problems of biodiversity, the main limits are given by the fragmentary knowledge of this concept. If BD is defined as variability among living organisms, measured at the level of genes, species and ecosystems, then the existing knowledge about all these three levels is very limited up to now.
2. At the same time, it is repeatedly proved that biodiversity is declining, due to human impacts, much faster than the natural rate of species reproduction. In this situation, application of precautionary principle is the only responsible approach.
3. Precautionary principle can best be implemented through the spatial approach to biodiversity. In order to halt the biodiversity decline (the most stringent goal of 6 EAP), it is necessary to start with valuing the Earth's surface as an environment for living organisms.
4. That is why the Czech researchers propose to apply the extended Hessian method as an effective economic instrument for biodiversity conservation which will stimulate the protection of life not only in protected areas, but at a nation-wide or the EU levels.

1.Value Map of the CLC Items in the Czech Republic



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