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VALUATING ECOSYSTEM SERVICES

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WYCENA USŁUG EKOSYSTEMOWYCH

STRESZCZENIE: W artykule dokonano przeglądu piśmiennictwa ekonomicznego w dziedzinie wyceny usług ekosystemowych. Jako punkt wyjścia służy znany artykuł z 1997 roku autorstwa Costanzy i współpracowników, który zapoczątkował szeroką dyskusję na ten temat. Następnie zarysowano w skrócie zakres ekonomii. Szczególną uwagę zwrócono na pomiar dobrobytu. Tak zwane zazielenienie PKB stanowi dobry przykład uwzględnienia wkładu usług ekosystemowych w tworzenie wartości ekonomicznych. Ze względu na to, że wiele spośród tych usług nie pojawia się na rynku, problem ich wyceny jest trudny. W artykule sporo miejsca poświęcono więc sposobom szacowania wartości ekonomicznej bez wykorzystania rynku. Na zakończenie przedstawiono doświadczenia zdobyte w praktyce sporządzania wycen potrzebnych właścicielom zasobów przyrodniczych, którzy chcieliby zrobić z nich jak najcenniejszy użytek.

SŁOWA KLUCZOWE: wycena ekonomiczna, zielony PKB, usługi ekosystemowe

Costanza's project

In a well-known paper published in *Nature* and reprinted in *Ecological Economics* a year later, the value of world's nature was tentatively estimated at 33 B UDS/year in 1994 dollars. This number was ridiculed by many commentators. One strain of criticism was to indicate that the number is clearly arbitrary since it is larger than the global GDP. This, however, is not a valid point since GDP measures the value of certain market transactions carried out in a year. It may well be (in fact, it is true) that some (in fact, most) of the services included in Costanza's study never show up in the market and therefore they cannot be included in the GDP.

Nevertheless the assessment is not theoretically correct which was acknowledged by its authors. First of all, not every 'monetization' of a service can be considered its value. For instance the price we pay for an orange, say, 1 EUR/kg is not necessarily the value of the natural product. For some of us the value is higher, but we take advantage of paying a lower price which is the outcome of matching demand with supply. Moreover, the price covers not only the value of the natural product, but also the value of accompanying services to pick it, transport, store etc. Thus even for market services it is not quite easy to attach a number which characterizes the economic value of an element of interest. Moreover, the number sometimes reflects an equilibrium price, but occasionally something else – like e.g. a consumer surplus, that is a difference between the (hypothetical) price and a person's willingness to pay. If sufficient information is available, then it is possible to convert consumer surpluses into prices and vice versa. This information is usually unavailable, and Costanza's team could not take advantage of it.

However, what is of paramount importance, economic analyses capture marginal values, i.e. the values of small changes introduced into systems where 'everything else' remains constant. Thus, if one concludes that the economic value of 1 m^3 of water is a certain number of euros, this does not mean that the total value of water is this number times the amount of water. Consequently the 'value of nature' – whatever is the number resulting from economic analyses – can be treated only metaphorically. In the same vein, GDP does not inform about the value of what we trade in markets; nevertheless its changes inform about directions the economy is moving into.

Language of economics

Services provided by natural systems are routinely assessed from several points of view. They can be seen as inputs into the energy, food and fibre production, they can be considered an important factor of man's economic well-being,

Biome	Ecosystem services (1994 USD ha-1 year-1)																			
	Area (ha x 106)	1 Gas regulation	2 Climate regulation	3 Disturbance regulation	4 Water regulation	5 Water supply	6 Erosion control	7 Soil formation	8 Nutrient cycling	9 Waste treatment	10 Pollination	11 Biological control	12 Habitat/ refugia	13 Food production	14 Raw materials	15 Genetic resources	16 Recreation	17 Cultural	Total value per ha ($ ha-1yr-1)	Total global flow value ($ yr -1 x 109)
Marine	36,302																		577	20,949
Open ocean	33,200	38							118			5		15	0			76	252	8,381
Coastal	3,102			88					3,677			38	8	93	4		82	62	4,052	12,568
Estuaries	180			567					21,100			78	131	521	25		381	29	22,832	4,110
Seagrass/ algae beds	200								19,002						2				19,004	3,801
Coral reefs	62			2,750						58		5	7	220	27		3,008	1	6,075	375
Shell	2,660								1,431			39		68	2			70	1,610	4,283
Terrestrial	16,323																		804	12,319
Forest	4,855		141	2	2	3	96	10	361	87		2		43	138	16	66	2	969	4,706
Tropical	1,900		223	5	6	8	245	10	922	87				32	315	41	112	2	2,007	3,813
Temperate/boreal	2,955		88		0			10		87		4		50	25		36	2	302	894
Grass/rangelands	3,896	7	0		3		29	1		87	25	23		67		0	2		232	906
Wetlands	330	133		4,539	15	3,800		?		4,777			304	256	106		574	881	14,785	4,879
Tidal marsh/mangroves	165			1,839						6,696			169	456	162		658		9,990	1,648
Swamps/ floodplains	165	265		7,240	30	7,600				1,659			439	47	49		491	1,761	19,580	3,231
Lakes/rivers	200				5,445	2,117				665				41			230		8,498	1,700
Desert	1,925																			
Tundra	743																			
Ice/rock	1,640																			
Cropland	1,400										14	24		54					92	128
Urban	332																			
Total	51,625	1,341	684	1,779	1,115	1,692	576	53	17,075	2,277	117	417	124	1,386	721	79	815	3,015		33,268

and they can also be regarded as phenomena whose value reflects the grandeur of the universe rather than anything linked to human activities. A particular point of view adopted thus implies particular types of values. To ecosystem services, people can attach material, sentimental, religious or other values. Of course, the economic ones are important, but they do not necessarily exhaust what people may have in mind when they care for such services.

Economic values are particularly useful, since they are independent from a specific worldview or a specific set of beliefs. According to a current definition of economics, this is a study of how people make choices when their resources are too scarce to satisfy all the needs[1]. Scarcity and alternative uses are the focal points of economic inquiry. If there were no scarcity, there would have been no economics.

Let us see how the overwhelming scarcity determines our decisions. Time is an example of a scarce resource that all of us have to allocate between alternative uses. Assuming that a person likes both popular and classical music, if one listens to a pop music, one cannot take advantage of a classical recital and vice versa. Hence the necessity to choose. If a hectare of land is devoted to rye cultivation, it cannot be forested. If I spend all my spare money on food, I cannot afford buying a book. And so on, and so forth.

Scarcity affects every society and every man. Even a rich person in a rich country cannot meet the expense of satisfying all the needs that come to his or her mind (although some of these needs may be considered frivolous by somebody else). Thus scarcity forces us to make choices. Poor people make choices as well. Perhaps some of us may think that poor persons, who can hardly make the ends meet, do not really choose anything since they are in fact compelled to get what they need in order to survive. But this is not true. Even the poorest person is free to choose, although the space of his or her choice is indeed constrained severely.

While making choices people trade off one good or service for another one. Somebody may be willing to forego an opportunity to see a theatrical performance in exchange for two kilograms of tomatoes. Somebody else prefers to give up some of her leisure and to work an extra hour in order to earn money to be spent on a charity. A boy may prefer buying a watch over buying a jack-knife as his budget does not allow to have them both.

Trade offs revealed in voluntary decisions inform about the weight people attach to what they prefer and what they do not. For instance, it may turn out that – when given a choice – they are willing to exchange one kilogram of pears for two kilograms of apples; or to swap a one-week holiday at an attractive location for a two-week holiday at a less spectacular place; or they pay money equivalent to a one-day salary for a seat at a rock-concert. In each of the examples above, one can claim that people's choices revealed relative values they attach to certain goods or services. Two kilograms of apples are worth one kilogram of pears; an attractive holiday is worth twice as much as the less attractive alternative; and

[1] L. C. Robbins, *An Essay on Nature and Significance of Economics*, Macmillan, London 1932.

a seat at the rock concert is worth the daily salary. If the choices are repeated many times, typical ratios may emerge.

Experience shows that people tend to be quite coherent in their choices (at least when circumstances do not change), so that a consistent system of ratios emerges. For example, if a typical ratio of pears to apples is two, and if a typical ratio of walnuts to pears is three, then one may expect that if the walnuts are to be swapped for apples, the ratio will be six. It is practical to select one specific good or service as the common reference for these ratios. In some societies this was one ounce of gold, but it can well be a monthly salary of a worker, a litre of petrol, a hectare of an average productive land, or anything else, as long as its characteristics are measurable and well understood. This common reference is called money and values are typically quantified in monetary terms.

It should be stressed that monetary valuation reflects choices of ordinary people, not necessarily of those who are good and clever. This is the key element of economic valuation that is often misunderstood by e.g. environmentalists, or academics. Environmentalists, for instance, expect that the value of a rare species will be high – higher than an average person is willing to pay in order to save it. They argue that the species is important and it will be lost for ever if extinction comes. Likewise, some people may say that an idiotic computer game is absolutely worthless; and yet there are people who are willing to pay for it some money. While it should be acknowledged that education or upbringing may influence the values people attach to goods and services, economics is about actual people's behaviour. If one wishes to change values, one needs to approach educators or politicians rather than economists.

Eighteen and nineteen century economists fought fierce battles over where economic values come from. The number of candidates was, however, small. There were two important hypotheses. According to Francis Quesnay[2], the land (or – in contemporary language – the environment) was the ultimate source of values. Karl Marx[3] was perhaps the best known economist who claimed that the value is determined by the amount of labour necessary to produce a good or a service. Twentieth century economists largely lost interest in such philosophical disputes. Instead, they adopt a view that the values are determined not in the process of production, but in the process of consumption. The values – reflecting choices people make – indicate how a given good or service satisfies human needs directly or indirectly. In the case of consumer goods, the relationship is straightforward. In the case of goods used to produce consumer goods, their values are derived from the latter (using so-called imputation or *Zurechnung* technique developed by Eugene von Böhm-Bawerk[4]). In the case of goods used

[2] F. Quesnay, *Tableau économique,* 1759 (3d ed. reprint. Edited by M. Kuczynski and R. Meek, Macmillan, London 1972).

[3] K. Marx, *Das Kapital. Kritique von Politischen Oekonomie. Erster Band*, Verlag von Otto Meissner, Hamburg 1867, (English on-line translation: http://www.marxists.org/archive/marx/works/1867-c1/index.htm) [Date of entry: 17-07-2009].

[4] E. Böhm-Bawerk, von 1884-89, *Kapital und Kapitalszins*, Innsbruck (Vol. 1-2).

to produce the former ones, economists iterate the same procedure. Ultimately the number of iterations can be high, but the basic principle remains the same: the value reflects the usefulness of a good rather than the amount of effort applied in the course of its production.

Economic valuation – like the contemporary economics itself – is thus anthropocentric. Nevertheless it does not have to be materialistic. Human needs do not confine to food and shelter. Men care not only for the material consumption, but for other things as well. They may derive satisfaction from music, from seeing an animal or sometimes from the mere existence of a species. All their preferences are studied by economics, and the values their choices imply are calculated. Thus economists are ready to calculate the values of goods and services as far from anything material as a song sang by a bird. This does not mean that such values are easy to measure or that they are not controversial, but they are definitely within the domain of economics.

"Greening" the GDP

As mentioned before, GDP measures the value of certain market transactions carried out over a year. Critics say that it counts what does not count, and does not count what counts. Indeed, if there is an environmental improvement such as a more effective enforcement of forest protection, our welfare increases. At the same time, GDP is likely to decrease as a result of less intensive logging. On the contrary, an oil spill decreases welfare. Despite that, it is likely that GDP will go up as a result of increased rescue activities.

Disappointment with GDP has led to the emergence of alternative welfare indicators such as *Human Development Index*, HDI. These do reflect environmental changes, but – unlike GDP – they are entirely arbitrary in picking or ignoring their potential elements and choosing their relative weights. A more promising strategy seems to be that of greening and 'netting' GDP in order to take the environment into account and to subtract replacement values, i.e. expenditures aimed at merely substituting what was consumed or worn out.

A greened and 'netted' GDP is defined as:

Consumption of marketed goods
\+ Public expenditures
– Flow of environmental damages
\+ The value of the net change of real capital
\+ The value of the net change of human capital
\+ The value of the net increase in the environmental resource base (– if the net change is negative).

This definition reflects the assertion adopted by many contemporary economists that the capital, i.e. our base for production, consists of three parts called, respectively: real capital, human capital, and natural capital. The last one does not show in markets and for that reason its value is difficult to assess.

Types of economic values

In modern economics, the *Total Economic Value* (TEV) consists of several elements, some of which may relate to less tangible non-material characteristics that are nevertheless measurable[5]. In broad terms, TEV consists of *Use Value* (UV) and *Non-Use Value* (NUV), the latter being sometimes referred to as „Passive Use Value". *Use Values* are divided into *Direct Use Values* (DUV) and *Indirect Use Values* (IUV). An example of DUV is the value derived from swimming in a lake, while an example of IUV is provided by stabilizing a local water table as a result of protecting the lake. Often DUV is linked to the physical consumption of a good, but – like swimming in a lake – it is not a prerequisite. John Krutilla[6] observed that what people are willing to pay for a good or a service may not be exhausted by UV in any sense. Thus he introduced the concept of NUV as a measure of the residual. The NUV is often divided into *Existence Value* (EV) and *Bequest Value* (BV). The former is linked to what people may attach to the mere existence of a good, while the latter represents the value from handing over the good to next generations.

The formula TEV = UV + NUV = DUV + IUV + EV + BV is not universally accepted. Some economists argue that there are yet additional elements not captured in the list above. An example of such a concept is a *vicarious value* that people attach to goods or services which are meaningless for themselves but may meet some needs of somebody else. For instance, someone may be willing to pay for the protection of a species that is used or appreciated by somebody else. However, other economists argue that vicarious values are already included in NUV, and a new category is unnecessary.

Another example is *Option Value* (OV)[7]. Burton Weisbrod defined it as a value that people attach to something in order to keep future options open. For instance, a future discovery can make a species valuable as a source of a pharmaceutical, even though such benefits are not known today. Consequently the general formula reads TEV = UV+NUV+OV. However, some critics argue that OV does not exist, since its components are included either in UV or NUV, if future (uncertain) benefits are properly accounted for.

Even though the labour theory of value does not belong to modern economics, there are a number of similar approaches that are used in applications. Two of them are particularly popular. These are the energy and land theories of value. The former is based on the assumption that exchange ratios tend to reflect the

[5] D. Dziegielewska, T. Tietenberg, S. Niggol, *Total economic value,* "Encyclopedia of Earth", C. J. Cleveland, Washington D.C. Environmental Information Coalition, National Council for Science and the Environment 2007, http://www.eoearth.org/article/Total_economic_value [Date of entry: 17-07-2009].

[6] J. V. Krutilla, *Conservation Reconsidered*, "The American Economic Review" 1967 Vol. 57, No. 4, p. 777-786.

[7] B. A. Weisbrod, *Collective Consumption Services of Individual Consumption Goods*, "Quarterly Journal of Economics" 1964 Vol. 77, p. 71-77.

amount of energy used – directly and indirectly – to produce a good. The latter posits that the ratios should depend on the amount of land used – directly and indirectly – to produce a good. Values calculated according to the former are denominated in calories or joules, while the values calculated according to the latter are denominated in hectares. Actual choices involve monetary valuations which means that everything should be converted into money. Nevertheless some analysts claim that there are goods which do not allow for monetary valuations.

Statistical life is an example of a good that is thought of by many as impossible to put a price tag on. This, however, depends on how the good is defined. First of all, statistical life has nothing to do the life of a concrete person; for many people this is simply sacred and priceless, and economists do not pretend that they can contribute to a debate on human life. Even though sometimes the life can be exchanged for money (for instance, a murderer kills somebody for a small amount of money, or somebody else rescues a relative from death by paying a large bounty), economists explain that these are not routine transactions reflecting people's preferences. Instead, economists analyze how people choose when they have an opportunity to change (either increase or decrease) a small probability of death. Based on such choices, it is possible to infer about their preferences with respect to saving lives in large populations, reflected in the so-called *Value of Statistical Life* (VSL), which is a finite number. It is then an easy exercise to calculate the so-called *Value of Life Year* (VOLY) gained or lost, for example, as a result of a policy programme.

Nevertheless some analysts insist that even a statistical life cannot be priced. But they admit that a person whose life is saved may not be in perfect health. Hence the concept of *Quality Adjusted Life Years* (QALY) which captures the fact that a life year gained may be perceived as less valuable if the person affected enjoys imperfect health. Advocates of the QALY concept argue that everything that affects humans – be it air pollution, noise, landscape, recreation opportunities etc. – ultimately translates into QALY.

A similar approach can be taken with respect to non-human life. The equivalent of a „person-year" is a „hectare-year". Additionally, if a hectare enjoys natural biological diversity, it is calculated as a full hectare. If, on the contrary, the field is affected by impaired diversity, it is calculated as a fraction of the actual area. Hence the concept of *Biodiversity Adjusted Hectare Years* (BAHY). Its advocates argue that everything that affects non-humans – be it air pollution, noise, climate etc. – ultimately translates into BAHY[8].

Nevertheless, if there is a trade-off between QALY and BAHY, and obviously some programmes are oriented towards human well-being rather than nature, then the question remains how to translate QALYs into BAHYs and *vice versa*. Therefore money equivalents of everything are called for, despite efforts to free environmental improvements from economic values. It is improper to simply multiply physical units – e.g. QALY or BAHY – by fixed „prices" attached to

[8] B. P. Weidema, *Using the budget constraint to monetarise impact assessment results*, "Ecological Economics" 2008 Vol. 68, p. 1591-1598.

these units. Analysts should always strive to understand the trade-offs people actually make when they take decisions.

The approach making a strict difference between humans and nature (not to be valued in money terms), and non-living resources (that can be valued in money terms without much hesitation) is questionable also on theoretical grounds. Changes that affect non-living resources – leading e.g. to cheaper computers – may ultimately save people's lives and hence contribute to QALYs. Attempts to free value assessments from money considerations can never be successful. Economics is about how people make choices which – by their very nature – are complex and multifaceted.

Economic values are thus very diverse and they call for appropriate measurement techniques. In their attempts to capture values implied by people's choices, economists must understand what specific needs are served by what they analyze.

Valuation techniques

Economic values exist whenever people make choices, irrespective of whether they buy and sell in competitive markets. Therefore economic values existed in feudal and in centrally planned economies. In a market economy they are simply more visible and easier to capture, but even there they are not always effortlessly available to a researcher.

Economists distinguish between private and public goods. The former can be easily bought and sold in markets. The latter comply with two principles: non-exclusion and non-rivalry. The first means that if a good is provided, it is impossible to exclude anybody from using it. The second means that if a unit of a good is used by somebody, the same unit can be used by somebody else without adversely affecting the original user. A lighthouse and an air defence system are textbook examples of public goods, but there are more interesting examples studied in environmental management.

Environmental quality is an example of public good. If it is low then everybody is adversely affected, and the gravity of individual damages does not depend on the number of victims. If – on the contrary – one makes an investment to improve it, then everybody will benefit and the level of individual gains will not depend on the number beneficiaries. Also biodiversity possesses characteristics of a public good. Its benefits can be enjoyed by everybody and – at least within certain limits – an additional user does not affect adversely previous ones.

Private goods can be exchanged in markets and their values can be derived from their prices. Public goods are a different story. Market behaviour is distorted as a result of the non-exclusion principle. People understand that if a public good is provided, then nobody can be excluded from using it. Therefore some take advantage of this fact by being 'free-riders', i.e. they use the good while pretending that they do not care for it and consequently they do not finance its

provision. Economists demonstrate that the market supply of a public good is lower than justified by social preferences. An alternative is to supply it through a political process (outside the market), but this requires that public authorities are able to measure how much of the good is demanded by the society. Putting it in economics language, they should know how much are people willing to pay jointly in order to have the good provided.

Until the 1940s there were no methods to valuate public goods. For instance, people felt that a unique landscape might have a value, but thought that this was beyond economics. Harold Hotelling[9] was the first economist to suggest that the value of a scenic site visited by tourists (a public good) can be derived from the cost they incur in order to get to the place (travel is a private good). Robert Davis[10] was the first to demonstrate that if the good is not private (and hence it does not have a market price), its value could be determined by simply asking people how much they are willing to pay in order to use it. These two ideas started a whole new domain of economics devoted to the valuation of non-market goods.

Economic values can be best reflected in competitive market prices. If the market is a non-competitive one, then prices are distorted by strategic behaviour of its agents, and consequently they do not necessarily inform about people's preferences well. However, if there is no market – as in the case of public goods – there are no market prices to rely on at all. Typical environmental goods and services belong in this category.

There are two valuation techniques developed for non-market goods: indirect and direct ones. The former derive economic values from so-called surrogate markets where people buy and sell goods that are complementary to the one in question. The latter refer to a hypothetical market where the good in question could be bought and sold; economists ask people directly how much they would be willing to pay (WTP) for what they do not have, or how much they would be willing to accept (WTA) for being dispossessed of what they have. Of course, both types of questions are hypothetical and there is no guarantee that answers truthfully reveal people's preferences. Nevertheless there were great efforts undertaken (especially over the last two decades) to make the direct methods credible.

Indirect valuation techniques are considered by economists more reliable, since they are based on actually revealed preferences. The prime example of this approach is the Travel Cost Method (TCM) first suggested by Harold Hotelling. The idea is very simple. The more people visit the place, the more valuable it is. Also when they travel longer distances or pay higher costs, the goal of their journey must be more valuable. The idea is quite simple, yet its implementation is not. The same records of visitations can be interpreted in several ways. Even the cost incurred by an individual visitor is problematic. There are no definitive

[9] H. Hotelling, *An Economic Study of the Monetary Valuation of Recreation in the National Parks*, Washington, DC: U.S. Department of the Interior, National Park Service and Recreational Planning Division 1949.

[10] R. K. Davis, *The Value of Outdoor Recreation: An Economic Study of the Maine Woods*, Ph.D. dissertation, Harvard University, Cambridge, USA, 1963.

solutions to how to account for the travel time. Many economists argue that the time spent in travel has its value reflected by earnings lost. But as it is difficult to practically assess these earnings, some researchers simply do not include them in the travel cost. Another unsolved issue is how to allocate the cost of multipurpose trips. Some analysts exclude such trips while others try to allocate the cost according to the weight attached to any of the purposes as declared by visitors themselves. Of course, either way is questionable.

If the costs of individual travels are somehow determined, then it is by far not obvious what conclusions can be drawn from these observations. Economic theory implies that the value people attach to the visit should not be lower than the travel cost. But for some visitors it can be higher. Moreover, the analysis typically captures only a fraction of those who are actually visiting the place. There are very sophisticated econometric techniques to reveal demand functions based on the observed distribution of travel costs. Unfortunately the results are sensitive to assumptions regarding theoretical distributions these observed ones are sampled from.

Despite theoretical problems, TCM proved to be a powerful instrument of environmental protection. Valuable places are sometimes subject to a pressure to destroy them in order to provide some economic benefits. For instance, a canyon can be destroyed by constructing a water retention reservoir to produce hydroelectricity. The benefit from destruction is the net value (i.e. after subtracting production costs) of 'clean' electricity. The alternative use of the canyon is tourist recreation. If TCM demonstrates that this alternative is more valuable than the electricity, then the dam does not make economic sense. Similarly, a wetland can be destroyed by draining it in order to enhance agricultural production. If TCM demonstrates that the wetland provides sufficiently high tourist recreation benefits then its drainage loses its economic justification.

Another example of indirect approach is provided by so-called Hedonic Price Method (HPM). Let us look at the case of silence. This is a typical non-market public good. It can be neither bought nor sold. However, there is a complementary private good, namely real estate. If there are two identical houses, one of which is located in a silent place while the other one in a noisy neighbourhood, it can be expected that the former will get a higher price. If everything else is the same, then the price difference can be attributed to the silence. In other words, the difference indicates how much are people willing to pay for silence. Of course, it would be unrealistic to find two almost identical estates so that the price difference can be attributed to a single cause. In practical applications, researchers analyze a large number of transactions and look for correlations of prices with many attributes that may possibly affect the price. Based on econometric modelling, they can determine to what extent a specific cause – like, for instance, silence – changes the price. The number found can then be interpreted as the value of the attribute that *per se* was not a market good.

There are also other techniques aimed at analyzing people's revealed preferences in order to estimate values of non-market goods. The one that can also be used to estimate e.g. the value of silence is Avertive Behaviour Method (ABM).

Again the intuitive justification is quite straightforward. People are willing to pay for noise-proof windows more than what they pay for 'normal' ones. Therefore the difference can be attributed to how much they value silence. Like before, practical inference is based not on a single comparison, but rather on a large data set where prices of windows are correlated with many attributes, one of which is a window's ability to reduce the noise.

If a surrogate market cannot be easily identified, the value of a non-market good has to be assessed directly, by asking people about their WTP or WTA in a hypothetical market. The first technique developed for this purpose is so-called Contingent Valuation Method (CVM). It owes its name to the fact that a respondent is presented with a hypothetical scenario of the provision of the good in question, and his or her answers are made contingent upon acceptance of this scenario. There are two basic formats of CVM. The WTP/WTA question can be open-ended, OE (e.g. *How much are you willing to pay for ...?*), and respondent are expected to quote a number. Alternatively, respondents can be presented with a number and asked if they were WTP/WTA for the scenario shown. They are supposed to answer *yes* or *no*.

This format is called dichotomous choice (DC), since the choice respondents have – like in a referendum – is a dichotomous one.

Economists debate which of the two formats – OE or DC – is better. In most applications the DC is preferred since it is common for people to look at a price and then to decide (*yes* or *no*) about the transaction. Some analysts apply so-called double-bounded dichotomous choice. It starts with a DC question and then, based on the answer received, it either doubles the bid (if the answer was *yes*) or halves it (if the answer was *no*). The second DC question is followed by the final OE question. Theoretically the series of three answers gives a more accurate description of respondents' preferences. In reality, however, people tend to see the first bid as a 'reference', and their answers to the final OE question are highly correlated with it. In economists' jargon, the first bid 'anchors' respondents' thinking about the problem, so that the seemingly increased accuracy of estimates is disputable.

Initially the development o CVM was rather slow. A radical change was triggered by a massive oil-spill near the coast of Alaska in 1989 (the *Exxon-Valdez* disaster). The catastrophe was unprecedented both in terms of the amount of oil leaked and in terms of damages to the natural environment. All the same, there were apparently no economic losses, since nobody suffered and no property was destroyed (the area was not inhabited). Nevertheless the government of Alaska sued Exxon for 3 billion dollars for damages that American citizens suffered as a result of the catastrophe. The amount of money was determined in a CVM survey where respondents were asked about their WTP for avoiding such a disaster in the future.

Exxon, the world's largest corporation at that time, did not want to pay such a fine and tried to ridicule the CVM as a non-reliable technique. To this end they commissioned three CVM surveys about people's WTP for saving ducks migrating from Alaska to Latin America. In one survey they asked about WTP for

saving 10,000 ducks and the average answer was roughly UDS 20. In the second survey they asked about 100,000 ducks and the average answer was USD 20 again. In the third one they asked about 1,000,000 ducks and the answer was more or less the same. Hence the conclusion was that the method yielded inconsistent results, as the average value of a duck saved was like 100:1, depending on how they phrased the question.

Experts noted, however, that the question was misleading, since a typical respondent thought of saving the seasonal migration process rather than a specific number of birds. Thus the answers were consistent, but it was unjustified to relate them to specific numbers quoted. The Exxon exercise showed that CVM can be abused, but it did not prove that it was not credible. The war over the *Exxon-Valdez* case resulted in establishing by the US President a special panel – co-chaired by two Nobel laureates, Kenneth Arrow and Robert Solow – to determine if the CVM is reliable as a technique of estimating values of non-market goods.

The Arrow-Solow Panel concluded that, if properly designed, the CVM is reliable and it can be used to assess environmental values. The findings of the Panel[11] were published in the *Federal Register* and they have been binding for the American justice system. The Panel developed a protocol that a good CVM survey should follow in order to prevent inconsistent results like in the Exxon study. The protocol is now commonly referred to by researchers whenever they apply CVM. The Panel also indicated WTP rather than WTA, and DC rather than OE as preferred formats of surveys.

The 1993 marked the launch of a new era in the development of CVM. The number of applications became large, and every year economists improve the method by solving problems encountered in earlier cases.

The success of CVM has not stopped the search for alternative methods of soliciting people's preferences for non-market goods. The technique which is now becoming more and more popular is called Choice Experiment (CE). It differs from CVM in that it is not confined to a single WTP/WTA question. Like in CVM, respondents are presented with a scenario of the possible provision of a public good to be evaluated. The good is characterized by several attributes and each of the attributes can be measured at several levels. For instance, there was a CE study carried out in Poland[12] aimed at estimating people's WTP for enhanced biodiversity protection in the Bialowieza Primeval Forest (at the border of Poland and Belarus). Biodiversity was characterized by three attributes such as: (1) natural ecological processes, (2) rare species, and (3) ecosystem components. Each of the attributes was contemplated at three possible levels: (a) *status quo*, i.e. no improvement, (b) partial improvement, and (c) significant improve-

[11] K. J. Arrow et al., *Report of the NOAA Panel on Contingent Valuation*, "Federal Register" 1993 Vol. 58 No. 10, p. 4601-4614.

[12] M. Czajkowski, M. Buszko-Briggs, *Valuing changes in forest biodiversity. The application of a CE approach to Białowieża forest in Poland*, paper presented at the Annual Conference of the *European Association of Environmental and Resource Economists*, Gothenburg 2008, http://www.webmeets.com/files/papers/EAERE/2008/449/Valuing%20Changes%20in%20Forest%20Biodiversity%20-%20blind.pdf [Date of entry: 17-07-2012]

ment. All types of improvements were carefully explained and quantified. The fourth attribute that was presented to respondents was a financial contribution, defined as a tax to be paid for 10 years (also in several variants, including no tax at all – linked to the *status quo* variants). Every respondent was given several options to choose from (hence the name 'choice experiment'). His or her choices were then analyzed in order to determine what was the (implicit) WTP for a specific change in biodiversity. The advantage of CE is that each respondent gives many statistical observations instead of a single one, as in the classical CVM. Consequently, CE surveys lead to better statistical estimates at a fraction of the cost required by CVM ones.

Valuation results

The second half of the 20th century, and especially its last decade brought an eruption of valuation studies relevant for environmental protection and management. Perhaps the best known example is the exercise compiled by Robert Costanza. The numbers aggregated for given ecosystems multiplied by their areas gave the total value of the world's ecosystem services.

As indicated before, there are important reasons to question the correctness of this valuation. First, the studies used by the team could be simply inaccurate. In fact, it would be very strange if all of the studies were error-free. Second, it is likely that the values calculated were not always comparable. The authors admitted that some of them were gross and some were net, even though all of them should have been net ones (the difference between gross and net values is the cost of provision which should be subtracted, if the result is to be comparable with GDP). Third, the numbers were coarse aggregates. For instance, there was only one number used to characterize the value of pollination provided by grasslands, even though there are of course many types of grasslands, and the value of pollination services depends on many aspects that cannot be accounted for in this approach. Finally, most of the entries in the matrix were based on single studies, and it is unlikely that these studies were fully representative for all ecosystems and all services they stood for.

Despite these limitations, the survey of Costanza et al.[13] serves as a useful reference. It would be inappropriate to pick rates from the Costanza matrix and multiply them by the number of hectares in order to establish the value of a given site. However, it is fair to argue that – irrespective of what may possibly come out from specific site surveys – the per hectare value of ecosystem services provided by a wetland is likely to be an order of magnitude higher than the respective value of a forest (the matrix implies the ratio of 49). Looking at the matrix gives a rough approximation of what can be expected from a site-specific survey.

[13] R. Costanza et al., *The value of the world's ecosystem services and natural capital,* "Nature" 1997 No. 387, p. 253-260.

All techniques mentioned in section 5 were tested in Poland. Their review covering the period of 1994-1999 is included in Zylicz[14]. In particular, the book explains how CVM surveys were prepared and carried out according to the Arrow-Solow Panel guidelines. There were several CVM studies performed. WTP for reduced eutrophication of Baltic Sea was the focus of a number of these. Both DC and OE questions, and two main types of interviews – face-to-face and mail – were tested. It should also be noted that for the first time the same survey scenario was implemented in three countries. The same study was simultaneously executed in Lithuania, Poland and Sweden. The results were then used to analyze prospects for establishing a Baltic-wide cooperation programme aimed at cleaning-up the sea[15]. Apart from the Baltic studies, there were CVM surveys of WTP for improved protection of the Biebrza wetland in north-eastern Poland. Indirect valuation techniques were represented in the book by TCM applied in order to estimate the value of clean water that many people in Warsaw acquired from public Oligocene wells (the tap water was of a much lower quality, but it did not require travelling).

After 1999, there were several CVM surveys done. Other methods were tested too. CVM was used in a couple of new applications. Most notably it was used to study people's WTP for time savings[16], reduced health risks from air pollution[17], improved quality of surface water[18], improved medical care[19], as well as for reduced work accident risk[20]. An international study aimed at lake recreation was carried out in Poland, Czech Republic and Norway[21].

An HPM study of housing prices in Warsaw[22] revealed interesting characteristics of real estate market in Poland. For instance, it demonstrated that people are WTP more for less noisy locations (no surprise). At the same time, they are

[14] T. Zylicz, *Costing Nature in a Transition Economy. Case Studies in Poland*, Edward Elgar, Chelthenham 2000.

[15] A. Markowska, T. Zylicz, *Costing an international public good: The case of the Baltic Sea*, "Ecological Economics" 1999 Vol. 30, p. 301-316.

[16] A. Bartczak, *Wartosc czasu podrozy*, "Ekonomia" 2002 No. 7, p. 100-121 [en. The value of travel time].

[17] D. A. Dziegielewska, *Essays on Contingent Valuation and Air Improvement in Poland*, Ph.D. dissertation, Yale University, New Haven 2003.

[18] A. Markowska, *Koszty i korzysci wdrozenia w Polsce Dyrektywy 91/271/EWG w Sprawie Oczyszczania Sciekow Komunalnych*, Ph.D. dissertation, University of Warsaw 2004 [en. Costs and benefits of implementing in Poland the Council Directive 91/271/EEC concerning urban waste-water treatment].

[19] O. Markiewicz, *Analiza oplacalnosci programow ochrony zdrowia na podstawie wyceny statystycznego zycia i wyceny dodatkowego roku przezycia w Polsce*, Ph.D. dissertation, University of Warsaw 2008 [en. Efficiency of health protection programmes in Poland based on the Value of a Statistical Life, and the Value of a Life Year].

[20] M. Giergiczny, *Value of a Statistical Life – the Case of Poland*, "Environmental and Resource Economics" 2008 Vol. 41 No. 2, p. 209-221.

[21] M. Czajkowski et al., *Lake Water Quality Valuation-Benefit Transfer Approach vs. Empirical Evidence* „Ekonomia" 2007 No. 19, p. 156-193.

[22] M. Borkowska, M. Rozwadowska, J. Sleszynski, T. Zylicz, *Environmental Amenities on the Housing Market in Warsaw. Hedonic Price Method Research*, "Ekonomia" 2001 No. 3, p. 70-82.

WTP more for green neighbourhood unless the apartment is in a detached house; in the latter case the neighbourhood of a public park adversely affects the price. Another HPM was carried out in order to check if real estate prices were positively affected by a water retention reservoir on the lower Vistula river; they were not[23]. A variant of HPM – a so-called hedonic wage method (where wage differentials are linked to working conditions) – was performed in order to estimate people's WTP for reduced accident risk[24]. Yielding more consistent results, the study turned out to be much more credible than a simultaneous CVM survey. This confirms economists' conviction that whenever possible, indirect methods based on revealed preferences are preferred to direct methods based on stated preferences.

The recreation value of Polish forests was estimated three times using TCM and other methods. Two of these studies were focused on the Bialowieza Primeval Forest[25]. One covered ten different sites representative for Polish public forests[26]. Contrary to earlier hypotheses[27], they revealed that people's WTP for forest recreation is higher than in Western Europe, and – moreover – it is remarkably higher for the Bialowieza Primeval Forest.

The most recent studies apply the CE technique. As an alternative to CVM, it was used in Markiewicz's and Giergiczny's studies on the VOSL. As well, it was used by Czajkowski and Buszko-Briggs in order to decompose people's WTP for improved protection of the Bialowieza Primeval Forest. The latter research allowed for two important conclusions. First, people in Poland place quite a value on natural ecological processes; contrary to prior expectations, they are WTP more for these than for protecting rare and charismatic species. Second, people in Poland indicate their preference for protection measures carried out within the framework of a national park; protection scenarios that differ only in whether they are undertaken by the park imply different values with a clear preference for activities bearing the stamp of a national park.

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[23] A. Jacewicz, J. Zelazinski, T. Zylicz 2002*, Prawdy i mity o stopniu i zbiorniku wodnym we Wloclawku*, „Gospodarka Wodna" 2002 No. 8, p. 326-329 [en. Truths and myths about the Wloclawek dam].

[24] M. Giergiczny, *Value of a Statistical Life – the Case of Poland*, "Environmental and Resource Economics" 2008 Vol. 41, No. 2, p. 209-221.

[25] M. Buszko-Briggs, M. Giergiczny, J. Ziezio, T. Zylicz, *Wartość ekonomiczna Puszczy Bialowieskiej*, WWF-Polska, Warszawa 2004 [en. Economic value of the Bialowieza primeval forest]; M. Czajkowski, M. Buszko-Briggs, *Valuing changes in forest biodiversity. The application of a CE approach to Białowieża forest in Poland*, paper presented at the Annual Conference of the *European Association of Environmental and Resource Economists*, Gothenburg 2008 [http://www.webmeets.com/files/papers/EAERE/2008/449/Valuing%20 Changes%20in%20Forest%20 Biodiversity%20-%20blind.pdf [Date of entry: 17-07-2012].

[26] A. Bartczak, H. Lindhjem, S. Navrud, M. Zandersen, T. Zylicz, *Valuing forest recreation on the national level in a transition economy: The case of Poland*, "Forest Policy and Economics" 2008 Vol. 10, No. 7-8, p. 467-472.

[27] UNECE/FAO, *European Forest Sector Outlook Study. 1960 – 2000 – 2020*. Main report, Geneva 2005.

Benefit transfer approach

It is excellent if analysts or policy makers can afford an empirical study carried out at the location of interest. Unfortunately in many cases they do not have time or resources to do it. The idea that comes to one's mind is to extrapolate the results from a site where a study of interest was conducted to the site that needs to be analyzed. This is called „benefit transfer".

There are two major approaches to using values or coefficients that do not originate from a study of a particular site. One is based on breaking a good G into components g_1, g_2, ..., g_n, and tries to attach a value from another assessment exercise to each of these. Formally it can be explained by the following formulae:

$$G = (g_1, g_2, ..., g_n), \text{ and } TEV(G) = TEV(g_1) + TEV(g_2) + ... + TEV(g_n), \quad (1)$$

This has been routinely used in assessing gains from projects that provide multiple benefits in terms of avoided externalities. For instance, if switching from a passenger car to a bus reduces air emissions, noise and road accidents, then the overall gain can be decomposed into corresponding elements, each of which is given a value separately, based on earlier assessments. Of course, the lack of exact equivalence between the original circumstances and the project implies possible errors, but these may be considered minor compared to the effort required by a new study (which – by the way – would also be subject to uncertainty). This is how the ExternE[28] base is utilized by the European Commission for assessing benefits from alternative energy scenarios.

The second approach is based on interpreting the results of a benefit study carried out for one site from the point of view of another site. If, for instance, a good G was evaluated at site *s* (the empirical „study" site), and its value was calculated as $TEV_s(G)$, then the question is how to estimate $TEV_p(G)$, the value of the same good at the site *p* (the „policy" site).

The simplest way would be to assume that $TEV_p(G) = TEV_s(G)$. Nevertheless, for most practical purposes, this is not a satisfactory solution, since there are no convincing arguments that the actual value computed at both sites would have been the same. There are two main reasons why the numbers could be different. One reason is that the people whose preferences are to be taken into account have different incomes in both sites. If we further assume that the value they attach to the good depends on their incomes with constant elasticity of ε (i.e. $TEV_p(G)/TEV_s(G) = (Y_p/Y_s)^\varepsilon$), then

$$TEV_p(G) = TEV_s(G)(Y_p/Y_s)^\varepsilon. \quad (2)$$

This is a benefit transfer statement that is, perhaps, the most frequently used one. The elasticity ε has to be determined using some additional information.

[28] European Commission, *ExternE, Externalities of Energy. Methodology 2005 Update*, Brussels 2005: http://www.externe.info/ [Date of entry: 18-07-2012].

Often analysts assume that the elasticity is linked to a specific type of a good. For instance, a „luxury" good has elasticity higher than one ($\varepsilon>1$), while „necessity" goods are characterized by low elasticities ($\varepsilon<1$). There is no consensus on whether, by default, environmental quality is a luxury good or not. If there is no convincing argument about the level of elasticity, analysts may assume that it is equal to one. Then the formula simply reads $TEV_p(G) = TEV_s(G)(Y_p/Y_s)$.

Another way of extrapolation is to observe that not only people's incomes, but also other characteristics observed at site *s* determine $TEV_s(G)$. Analysts assume that $TEV_s(G) = f(x_s, y_s, ..., z_s)$, where $x_s, y_s, ..., z_s$ are variables observed at *s* such that $TEV_s(G)$ depends on them. The function f is called a benefit function. The result of a benefit transfer exercise is then summarized by the formula $TEV_p(G) = f(x_p, y_p, ..., z_p)$. The formula from the previous paragraph turns out to be a special case of the latter, with Y playing the role of the single relevant variable, and f(Y) defined as $TEV_s(G)\ (Y/Y_s)^{\varepsilon}$.

Some researchers assume that the more parameters estimated in the benefit function f the better. Indeed, increasing the number of explanatory variables in the definition of f increases the estimation fit at the site *s*. This does not necessarily imply that the accuracy of the transfer will be better. On the contrary, the more variables are taken into account at the site *s*, the more likely it is that some of them are specific for the data set at *s*, not necessarily for the site *p*. As a result, the benefit transfer using such a complicated function f may result in a higher error than a simple alternative based on e.g. income differentials.

Research experience, as well as theoretical arguments, suggest that benefit transfer functions f should have firm foundations in economic theory. Parsimony is a useful guide for analysts who would like to transfer conclusions from an empirical study to a site possessing apparently similar characteristics. Income is an example of a variable that economic theory heavily relies on, while neither age nor level of education seem to play the same strong role. Consequently, including income in benefit transfer functions is inevitable. At the same time, using functions that include social and demographic characteristics of stakeholders improves statistical fit to the empirical data sets at the site s, but it may prove very misleading when transferred to the site *p*[29].

Extrapolations based on the Costanza's *et al.*[30] matrix, as well as on the QALY/BAHY concept are examples of a benefit transfer method based on the formula (1). They are eagerly used in many applications, since original research would have been costly. Nevertheless one needs to appreciate that the numbers provided by them have to be regarded as first approximations rather than the

[29] I. Bateman, R. Brouwer, S. Ferrini, M. Schaafsma 2009, *Guidelines for Designing and Implementing Transferable Non-market Valuation Studies*, A Multicountry Study of Open Access Water Quality Improvements paper presented at the 17th Annual Conference of EAERE, Amsterdam 2009 http://www.webmeets.com/files/papers/EAERE/2009/945/090201%20-%20Aquamoney%20CDV%20-%20EAERE%20format%20-%20guidelines%20version%20-%20anon.pdf [Date of entry: 18-07-2012].

[30] R. Costanza et al., *The value of the world's ecosystem services and natural capital*, "Nature" 1997 No. 387, p. 253-260.

values that justify the selection or rejection of a given project. More accurate conclusions need either an original research or at least a benefit transfer exercise involving the formula (2).

Kuik et al.[31] provide an interesting review of wetland valuation studies. The authors, however, do not attempt a benefit transfer. Instead they perform a „meta-analysis" of the existing empirical studies in order to explain the differences in money values by geographical and social circumstances. The difference between a benefit transfer based on formula (2) and meta-analysis is that the former is based on a single site valuation study while the latter estimates a value function based on several site valuation studies. The corresponding regression model reads:

$$TEV(G_s) = f(x_s, y_s, ..., z_s);\ s = 1,...,k. \quad (3)$$

Hence the function f estimated as a result of such an exercise depends not only on a single site, but rather on an array of sites 1,...,*k*, each of which has a different value but also different characteristics.

A practical application

In 2010 the Director of a National Park in Poland realized that market prices do not reflect the value of ecosystem services provided by the land he administers. A commercial enterprise leased a narrow strip of land (to operate a gas pipeline) paying the rental price of 244 EUR/ha per year. The park director requested that the price be increased in order to reflect ecosystem services compromised as a result of the enterprise activities.

Warsaw Ecological Economics Center was asked to assess the value of ecosystem services such as O_2 production, CO_2 sequestration, water retention, protection against erosion, wind etc, provision of natural habitats, and landscape amenity – not included the 244 EUR/ha price. Neither the time suggested, nor the unusual shape of the land (a very narrow strip) allowed for original field studies. Thus the Warsaw University team decided to browse earlier studies in order to recommend per hectare numbers as proxies for the value of ecosystem services lost.

According to a widespread belief, 'forests produce oxygen'. Hence constraints on forestry activities lead to a decrease in O_2 production. This is not correct. Oxygen is produced by a young ecosystem only. A mature forest consumes as much oxygen as it produces, but an old one – where decay processes dominate over photosynthesis – consumes more than produces. Thus – following

[31] O. Kuik et al., *The Value of Wetland Ecosystem Services in Europe: An Application of GIS and Meta-analysis for Value Transfer*, paper presented at the 17th Annual Conference of EAERE, Amsterdam 2009 http://www.webmeets.com/files/papers/EAERE/2009/448/Value_transfer_and_GIS_EAERE.pdf [Date of entry: 18-07-2012].

e.g. Colinvaux[32] – we concluded that O_2 production should not be taken into account.

Carbon sequestration is a different story. As long as the forest exists, it stores carbon. Assuming that a Polish forest grows at the pace of 3 m^3/ha per annum, i.e. roughly 2 tonnes/ha, one can assume that this corresponds to the amount of carbon dioxide not sequestrated if there is no forest. Taking into account the CO_2 to C ratio of 3.67, 1 hectare of forest captures 7.34 tonnes of carbon dioxide per annum. At the European price of 15 EUR/tonne this corresponds to 110 EUR/ha approximately.

An atypical geometry of the land studied suggests that a per hectare value of water retention is simply copied from the literature. Costanza et al[33]. estimate it at 5 USD(1994)/ha. Taking into account inflation and exchange rates, this corresponds to 9 EUR/ha, and this is what was adopted in our assessment.

Protection against erosion, wind etc calls for separate analyses. Again, because of an atypical geometry of the land, its wind protection role is negligible. However, even a very tiny filed may play a role in soil protection and formation. Costanza et al. estimate it at 96+10 USD(1994)/ha per annum. Like before, taking into account inflation and exchange rates this corresponds to 190 EUR/ha.

The last two types of ecosystem services referred to a number of Polish studies. Removing forest cover implies losing natural habitats. Moreover these are habitats protected under a national park regime which adds to their value, as empirical analyses indicate. Recent Polish studies demonstrate that the 'trademark' of a national park increases the value people attach to a natural habitat[34]. In a separate study[35] the total value of forest habitats was estimated at 570-970 EUR(2005)/ha. This, however, covers two elements of the Total Economic Value of a forested hectare, i.e. natural habitats and recreational (landscape) amenity. It was based on a national survey which includes both frequently visited forests and areas considered less attractive as tourist destinations but of a high natural importance. Taking into account the specific geographical location of the park, we made an arbitrary assumption to understand 50% of the lower bound as a proxy for the first element and 50% of the higher bound as a proxy for the second one. Allowing for inflation, this implies 310 EUR/ha for the former and 528 EUR/ha for the latter.

As before, let us compare these numbers with entries in Costanza et al. The is no equivalent of the 'value of natural habitats' there. A similar scope is cover by two entries: nutrient cycling (361 USD(1994)/ha), and genetic resources (16 USD (1994)/ha), 367 in total. Allowing for inflation and using appropriate exchange

[32] P. A. Colinvaux, *Why big fierce animals are rare: an ecologist's perspective*, Princeton University Press 1979.

[33] R. Costanza et al., *The value of the world's ecosystem services and natural capital*, "Nature" 1997 No. 387, p. 253-260.

[34] M. Czajkowski, M. Buszko-Briggs, N. Hanley, *Valuing Changes in Forest Biodiversity*, "Ecological Economics" 2009 Vol. 68, p. 2910-2917.

[35] A. Bartczak, H. Lindhjem, S. Navrud, M. Zandersen, T. Zylicz, *Valuing forest recreation on the national level in a transition economy: The case of Poland*, "Forest Policy and Economics" 2008 Vol. 10 No. 7-8, p. 467-472.

rates, this is more than a double of what we estimated. Our much lower estimate results perhaps from the fact that Costanza's number reflects mainly tropical forests whose habitats are much more valuable than those located in boreal ones. In contrast, the number adopted by us for recreational (landscape) amenities is much higher than the mere 38 USD(1994)/ha used by Costanza et al. (1997). Two factors could have caused this difference. Firstly, as demonstrated by Bartczak et al. (2008), the demand for forest recreation in Poland is much higher than in Western Europe and USA where numbers adopted by Costanza's team came from. Secondly, the demand for recreation in our site – a national park – comes from wealthy urban agglomerations which adds to whatever an 'average' level may be.

These analyses can be summarized as follows:

- O_2 produced 0,
- CO_2 sequestrated 110,
- Water retention 9,
- Protection against erosion, wind etc 190,
- Provision of natural habitats 310,
- Landscape amenity 528.

This makes the total of 1147 EUR/ha (per year), i.e. much higher than the price 244 EUR/ha (which reflects 'private' benefits only). A new rental price negotiated between the park director and the enterprise takes into account ecosystem services lost.

Summary

Ecosystem services can be evaluated in economic terms. The fact that they are not included in market transactions makes the exercise more difficult, but not impossible. The number of studies is very high and still increasing. Thus there is a sufficient empirical base for decision and policy makers to take into account the economic value of nature. Owners and guardians of ecosystems seem to be gradually more aware of their assets' values. In Poland there are precedents of taking these into account in practical applications.