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## AN ECOLOGICAL ECONOMIC PARADIGM FOR SUSTAINABLE FORESTRY DEVELOPMENT

The forest as a natural phenomenon is an ecological economic system meets economic, ecological and social needs, i.e. contributes to the achievement of the sustainable development goals. The main function of a forest ecological system is carbon dioxide absorption, oxygen production, climate and water regulation and the production of other useful public goods, i.e. "ecosystem services". The ecological economic paradigm for sustaining forestry is a component of broader paradigm and a step towards establishing national and global green economies. It makes necessary to replace the traditional criterion of maximizing profit with the integral criterion of ecological economic efficiency. The article deals with the physical nature of a forest, its economic, ecological and social functions, principles of management and the criterion of ecological economic efficiency of economic activity. It is proved that an ecological economic paradigm ensures the formation of close to nature forestry and should become categorically imperative for forestry practices throughout the world.

**Keywords:** physical essence of the forest; economic, ecological and social functions; principles of management; efficiency criterion

### Introduction

The presentation entitled "Ecological-economic problems of forestry development" represented Ukraine at the XVIII World Congress of the International Union of Forest Research Organizations (IUFRO) held in 1986 in Ljubljana, the capital of Slovenia (former Yugoslavia).

The presentation sparked a lively discussion at the Congress and was published in its entirety by the University of Oregon Publishing House, USA, 1987 (Tunytsya, 1987).

At the XXI IUFRO World Congress (Kuala Lumpur, Malaysia, 2000) we, the authors of this paper, further developed that concept by highlighting the issue of the ecological economic doctrine formation as a key factor for the sustainable development of forestry in transition economies (Tunytsya & Tunytsya, 2000).

Taking into account the large number of high quality scientific studies about this problem published during the last 30 years throughout the world, the completed outline of an ecological economic paradigm as the scientific foundation of modern forestry emerged.

The IUFRO structure includes working group on ecological economics in forestry. The International Society for Ecological Economics holds biennial conferences that consider the problems of sustainable forestry development as of particular importance.

While there is progress, there still remains the problem for people and future generations to save the planetary forests from deforestation, degradation and large-scale illegal logging. In addition this paradigm can only be successful when going beyond the narrow sectoral borders and finally dominating the development of global economy. Moreover, this is *conditio sine qua non* for surviving and sustainable development of civilization.

Within this context it would seem that an ecological economics paradigm of sustainable forest management should become a categorical imperative in forestry practice. However, forestry is still practiced in many countries on the basis of traditional market and often primitive mercantile criteria, hampering sustainable development and contradicting the societal interests.

An example of such primitive mercantilism in reforming of forest sector is the proposal of the Ukrainian Ministry of Economic Development and Trade about the transition of 333 state forestry enterprises to the concession, submitted to the Cabinet of Ministers of Ukraine. It indicates that authorities ignore scientific recommendations. Such proposals contradict the public interests (especially the long-term ones), the Constitution of Ukraine, the current Forest Code, the Law of Ukraine "On Concessions" and other legislative acts. Institutional reforms should be under the strict public control and pass scientific expertise.

Secondly, is a big surprise that in the Association Agreement of Ukraine with the European Union, that came into force on September 1, 2017, the whole forestry sector is embedded within two lines under Article 294 "Trade in fo-



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rest products". In similar Agreements between the European Union and other countries, the forestry sector have had much broader representation. For example, in the Association Agreement signed by Moldova and EU Article 369 "Sustainable management of forests and trade in forest products" (International agreements, 2014), it acknowledges many more aspects within the forestry sector. Analysis of this failed approach deserves a separate study and relevant political assessments.

Thirty years is a long enough period for understanding the true role of forests in the integral development of society and related practices. Unfortunately, an ecological economic paradigm in forestry has not found yet an adequate practical implementation. Therefore, this paradigm is becoming even more urgent today, and the problem of the exploitation, protection and reproduction of forest ecosystems becomes pressing as never before.

Let's take a look at the main foundations of the ecological economics paradigm for sustainable forestry development in the context of modern challenges.

**The physical nature of forest as a natural phenomenon.** Scientific research has verified that forests give more than 50 % of atmospheric oxygen produced by the vegetation of the entire planet. Additionally, other functions of forests such as its influence on the water regime, climate, soil protection etc. prove that forests from seedlings to maturity have a real economic value as well as ecological value for society as a whole.

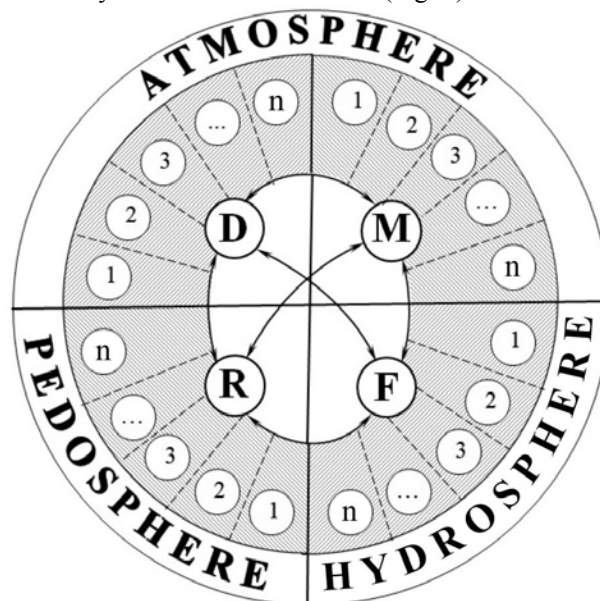
It should be emphasized that the Paris Climate Agreement 2015, adopted by most countries of the world, reflects the key role of forests in greenhouse gases absorbing and climate change mitigation. One of the 17 global sustainable development goals (UN *SDG15*), adopted by the UN Summit in 2015, also underlines the importance of the forest management processes. The UN *Sustainable Development Goal 15 (SDG15)* is aimed on "Sustainably manage[ing] forests, combat[ing] desertification, halt[ing] and reverse[ing] land degradation, halt biodiversity loss".

Thus, current forestry should be considered, on the one hand, as an organizationally formed independent sector of material production and, on the other hand, as socially significant phenomenon and integral part of national economy as a whole. Unity of these two aspects of forestry has a principal methodological value for understanding the essence of ecological economic paradigm and finding ways to solve the sustainable development problems of this sector.

The cumulative effect of investments into forestry can be divided into a traditional economic effect within the forestry sector and related industries that consume forest products and the ecological effect consumed by many sectors that seem to be far away from forestry as well as directly by the people. In other words, the ecological effect of forests in terms of ecosystem services comes at the disposal of the whole society. This part of forests' effect is implicitly present as a result of other sectors' activities. Forests provide a type of free service by creating and maintaining favorable environmental conditions necessary for their existence.

As an independent structural component of the biosphere and an object of the economy, forests produce a huge amount of benefits for society which are connected both among themselves and with the external environment.

Despite the diversity and complexity of the forest ecosystem components, its structure in general can be represented by the formula PHDMFRA (Fig. 1).



**Figure 1.** Forest as the ecological-economic system (PHDMFRA) of potential products and services that are interrelated and related with external environment

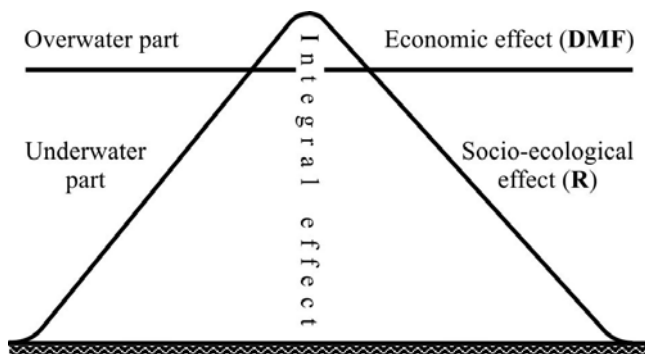
where: P – pedosphere; H – hydrosphere; D – raw materials of wood origin; M – resources of non-wood vegetable origin; F – resources of animal; R – multilateral use functions (services) of the forest; A – atmosphere.

The forest stand is the main component and major link within the forest ecosystem. The forest stand (D), as well as all other components such climatic, geographical and other natural conditions, of the physical structure of the forest, cannot be considered apart from the system. The forest stand, in turn, affects species composition, location and livelihoods of organisms that inhabit the forest. That is, it is necessary to take into account the feedback between the individual components of the forest ecosystem and the external environment.

Considering the forest as the ecological economic system, DMFRA is necessary to provide sustainable use and reproduction of the entire set of its multiple components that carry consumer value as well as take into account environmental factors. Optimal forest management options need to be searched for in the parameters of complex exploitation, protection and reproduction of the entire DMFRA system.

For the sake of clarity, the hypothetical rate of the economic (DMF) and socio-ecological (R) forest functions aimed to ensure sustainable development of society and the human wellbeing can be compared with the iceberg. The superficial part of which (DMF) reflects the traditional economic effect, and the underwater part is for the ecological effect (R), which is a multi-layered public forest ecosystem service (Fig. 2).

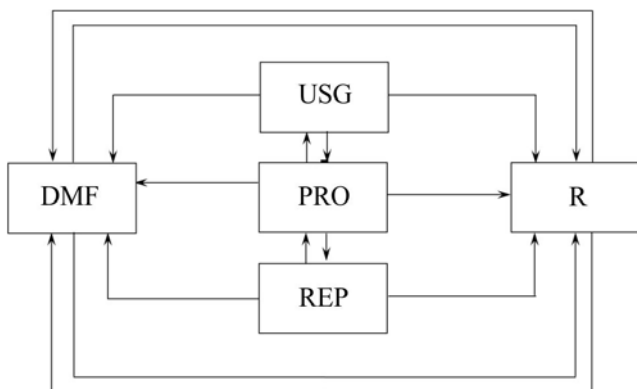
This symbolic chart shows the necessity of common efforts by all citizens of the planet dealing with exploitation, conservation and reproduction of forest ecosystems. It's high time to go beyond declarations to concrete activities. A new generation of top state forestry managers in Ukraine represented by the deputy head of State Forest Resource Agency Volodymyr Bondar are building new national strategy for forestry sector based on this innovative approach.



**Figure 2.** Hypothetical correlation between the total value of forest for the whole society (R) and traditional economic value (DMF) through comparison with an iceberg for the integral effect of functioning of forest ecological-economic system.

**Exploitation of forest ecosystems with respect to the conflict of business, sectoral and societal interests.** It should be noted that all components removed from the ecological system in the labor process (except unutilized wastes) physically pass into the economic system becoming its products. The only exception is human. Man is a participant in the economic process, the main component of the economic subsystem. At the same time, as a biological species, human beings remain an integral part of the ecological subsystem. This dual position as a biological being, on one hand, and a laborer, on the other hand, prevents comprehensive understanding of the role and functions of a human in the rational management of the forest ecosystem.

Taking into account the obvious conflict of interests of business, the forest sector and society, forest use in the context of an ecological economic paradigm should become a triple- staged process. This includes usage (USG), protection (PRO) and reproduction (REP) and of the two components of the ecological system DMFR – raw materials of wood origin (D), commodity resources of non-vegetable plant origin (M), commodity resources of animal origin (F) and multiple ecosystem services (R), that in some cases are goods for the market, and in others, are provided to the public (people) free of charge. The forest management process is shown schematically on Fig. 3.



**Figure 3.** The essence of forest exploitation in the context of ecological economic paradigm

**Principles of the ecological economic paradigm for sustainable forestry development:**

- The principle of **complexity in exploitation, protection and reproduction** of public ecosystem services of the forest (R) and raw materials of wood and non-wood origin (DMF) in one or another territory in their interrelationship;

- Principle of obligatory **account for ecological effects** of forest usage. After all, any forestry activity is accompanied not only by the economic effect, but also by the resulting ecological effect. The planting of trees or their cutting, as well as other measures that are carried out in the forestry industry, including the very visit of a forest by a person for recreational, tourist or other purposes, cause differently scaled environmental changes, called "environmental effects". Ecological effects are reflected in our Proposal (1977) of criteria for ecological and economic efficiency of forest usage, the content of which is disclosed below. According to this criterion, each production structure of the forestry sector is responsible for the environmental consequences of its activities;
- The **priority of preventive measures** for the protection and reproduction of raw and non-raw forest resources (the whole system of PHDMFRA). Preventive measures for the protection of forests and their timely restoration are always more efficient and cheaper than those implemented with delay;
- The principle of **taking into account the scarcity** of certain components of the DMFR system, including forest ecosystem services. Relatively higher ranking is given to irreplaceable, non-transactional environmental conditions and resources, as well as conditions and resources that are more scarce than others;
- The principle of **geographical (regional) differentiation for methods of organization of forest usage**, which provides a different level of assessment of qualitatively similar environmental conditions and resources (spatial estimate);
- Principle of **time lag incorporation**.

**The essence of the criterion of ecological-economic efficiency for forest usage is disclosed in further terms:**

The ecological effect of forest usage is defined as any changes both spatially and temporally in the quality of the natural environment (R) conditions, as well as changes in the quantity and quality of forest resources (DMF). Such changes can have both positive and negative character – improvement or deterioration of natural living conditions, increasing or decreasing in quantity and quality of resources. The ecological effect is organically linked to the economic results of production and consumption.

The ecological economic effect is the integral ecological economic effect of the process of forest usage, which is measured by the algebraic sum (plus or minus) of the traditional economic effect (profit received) and its accompanying ecological effect (damage caused by changes in the quality of the environment as well as the quality and quantity of forest resources).

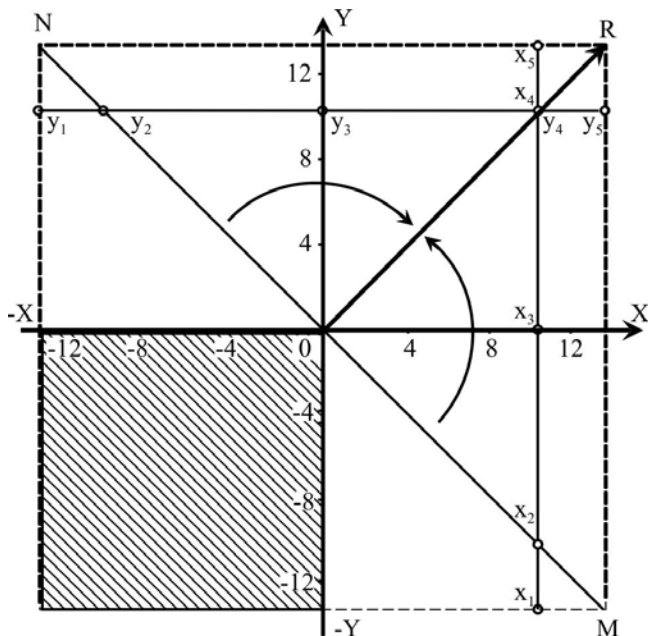
The application of the integral indicator named "ecological economic effect" assesses the effectiveness of economic activity instead of the traditional indicator of "profit". This is an important factor in the orientation of any economic system to environmentally promote production and the achievement of sustainable development goals.

The ecological economic efficiency is the ratio of total economic and environmental costs in forest management to obtain the integrated environmental and ecological effect. The category "ecological economic efficiency" reflects the inevitable interconnection between the economic and ecological effects achieved through the usage of (USG), protection (PRO) and reproduction (REP) of components "R" and "DMF" of forest ecosystems.

According to our ecological economic paradigm, the criterion for the effectiveness of forest management (in the narrow sense – forest usage) should be about maximizing the time of stable integral ecological economic effect instead of the traditional criterion of profits maximizing.

Graphic interpretation of the criterion of ecological-economic efficiency of the forest usage is shown in Fig. 4.

The training of **specialists with this new thinking** is required to implement the ecological economic paradigm in forestry. Greening of education is an important tool for training these specialists.



**Figure 4.** Graphic interpretation of the criterion of ecological-economic efficiency of the forest ecosystem functioning (forest usage process)

$X$  – scale of environmental effects;  $Y$  – scale of economic effects;  $NM$  – discriminator of positive and negative ecological and economic effect;  $OR$  – vector of optimal ecological-economic effect;  $x_{1,2,3,4,5}; y_{1,2,3,4,5}$  – variants of ecological-economic estimation of integrated use, protection and reproduction of resource and non-resource parts of forest ecosystem

The greening of education is about filling the curricula in all fields of knowledge and specialties, not only forestry education, with environmental requirements. Greening should become a key factor for creating of a new education system. Only in this way can a new person with an ecological economic view prevail and ensure the sustainable societal development in harmony with nature.

The ultimate goal for greening education is to create a transformation of public consciousness for the construction of new models of sustainable forest governance. In this way, it will be possible to gradually implement real sector reform in accordance with the sustainable development goals.

The greening of education should provide the high-quality staff for sustainable development. This requires dynamic creative actions by the academic community. Principal guidelines for the activities of environmentally competent specialists should be: first, taking into account the environmental effects of production activities; second, the priority

of preventive measures in the protection of forests and in the nature protection field in general.

Therefore, the greening of education should be considered as one of the priority directions for all educational institutions activity regardless the profile of specialists training.

**Legal support for implementation of an ecological economic paradigm.** Specialists with a fundamentally new way of thinking, trained within the ideology of sustainable development, will be able to implement this ecological economic paradigm of forestry under the conditions of adequate national and international legislation. Therefore, it is necessary to conduct a large-scale highly qualified work for the national legislation improvement, first of all, the Forest Code, as well as development of the draft of International Forest Code. This will allow the national and world forestry to be managed in accordance with the modern challenges and international agreements on sustainable development adopted in recent years.

## Conclusion

The content of this ecological economic paradigm concerning forestry has been highlighted in its progress since XVIII World IUFRO Congress (1986) when we presented it for the first time and XXI IUFRO World Congress (2000) where we explicated further considerations.

Having adopted UN SDGs and Paris Climate Agreement (2015), the world community gave a paramount global significance to integral ecological economic criterion of forestry effectiveness instead of failed approach of conventional economy.

Forests are crucial for Life on Land (*SDG15 - Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss*), and therefore pure economic effect from wood and non-wood forest products is only just the tip of iceberg. Their main value for mankind is defined by multiple ecosystem functions and services for maintenance of the quality of atmosphere, hydrosphere and soils. Benefits in forestry consist both of ecological and economic effects. Their sum provides a synergy of the integral effect sustaining environment and people into the future. The principles of an ecological economic paradigm should be properly integrated into national legislations. It is high time for IUFRO to initiate the development of International Forest Code.

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## ЕКОЛОГО-ЕКОНОМІЧНА ПАРАДИГМА СТАЛОГО РОЗВИТКУ ЛІСОВОГО ГОСПОДАРСТВА

Ліс як природний феномен є одночасно еколого-економічною системою, функціонування якої задовольняє економічні, екологічні та соціальні потреби, тобто сприяє досягненню цілей сталого розвитку. Головна функція лісової екологічної системи полягає у поглинанні вуглекислого газу, продукуванні кисню, клімато- і водорегулюванні та продукуванні інших корисних загальносупільних благ, так званих "екосистемних послуг". Еколого-економічна парадигма сталого розвитку лісового господарства є компонентом ширшої парадигми та кроком до становлення національної та глобальної екологічної економіки. Вона обґрунтовує необхідність заміни традиційного критерію максимізації прибутку інтегральним критерієм еколого-економічної ефективності. Розглянуто фізичну сутність лісу, його економічні, екологічні і соціальні функції, принципи господарювання та критерій еколого-економічної ефективності господарської діяльності. Доведено, що еколого-економічна парадигма забезпечує становлення наближеного до природи лісівництва і має стати категоричним імперативом практики ведення лісового господарства у всіх країнах світу.

**Ключові слова:** фізична сутність лісу; економічні, екологічні і соціальні функції; принципи господарювання; критерій ефективності.

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Лес как природный феномен является одновременно эколого-экономической системой, функционирование которой удовлетворяет экономические, экологические и социальные потребности, то есть способствует достижению целей устойчивого развития. Главная функция лесной экологической системы заключается в поглощении углекислого газа, продуцировании кислорода, климато- и водорегулирования и выработке других полезных общественно важных благ, так называемых "экосистемных услуг". Эколого-экономическая парадигма устойчивого развития лесного хозяйства является компонентом более широкой парадигмы и шагом к становлению национальной и глобальной экологической экономики. Она обосновывает необходимость замены традиционного критерия максимизации прибыли интегральным критерием эколого-экономической эффективности. Рассмотрены физическая сущность леса, его экономические, экологические и социальные функции, принципы хозяйствования и критерий эколого-экономической эффективности хозяйственной деятельности. Доказано, что эколого-экономическая парадигма обеспечивает становление приближенного к природе лесоводства и должна стать категорическим императивом практики ведения лесного хозяйства во всех странах мира.

**Ключевые слова:** физическая сущность леса; экономические, экологические и социальные функции; принципы хозяйствования; критерий эффективности.