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INITIAL CONTRIBUTIONS TO A LEGAL PROTECTION OF ECOSYSTEM SERVICES

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ABSTRACT

This article aims to analyze the main aspects of ecosystem services. From a multidisciplinary analysis, these services will be demonstrated on the ecological, geographic and economic scope and then demonstrate their legal aspect. To analyze this last aspect, we will present two forms of protection of the ecosystem services: the payment for ecosystem services and the use of green infrastructure to mitigate environmental disasters. After, will be shown the J. B. Ruhl's eight principles that assist in the creation and development of ecosystem services policies. This research was conducted through analysis of national and international doctrine,Brazilian legislation and judicial decisions.

Keywords: Ecosystem services; Law; Green infrastructure; Payment for ecosystem services; Multidisciplinarity.

APORTES INICIAIS PARA UMA PROTEÇÃO JURÍDICA DOS SERVIÇOS ECOSSISTÊMICOS

RESUMO

O presente artigo tem por objetivo analisar os principais aspectos dos serviços ecossistêmicos. A partir de uma análise multidisciplinar, serão demonstrados esses serviços sob o âmbito ecológico, geográfico e econômico para, então, demonstrar o seu aspecto jurídico. Para analisar este último aspecto, iremos apresentar duas formas de proteção dos serviços ecossistêmicos: o pagamento por serviços ambientais e a infraestrutura verde no enfrentamento de desastres ambientais. Após, serão demonstrados os oito princípios elaborados por J. B. Ruhl que auxiliam na criação e elaboração de políticas que preservem esses serviços. A pesquisa foi realizada por meio de análise doutrinária nacional e internacional, de legislação e de julgados brasileiros.

Palavras-chave: *Serviços Ecossistêmicos; Direito; Infraestrutura Verde; Pagamento por serviços ambientais; Multidisciplinaridade.*

INTRODUCTION

This paper aims to demonstrate the importance of ecosystem services and how they are protected by the legal system. Analyzing the complexity involved in the matter, it will be verified how ecosystem services can be integrated into the legal system.

The first part will analyze the matter from three perspectives: the biological, highlighting the importance of recognizing the existence of ecosystem services and the benefits produced by humanity; the geographical, that delimits the origin, the way crossed and the beneficiaries of the services; and the economic, that tries to elaborate methods of valuation of the ecosystem services

In the second part, the legal scope of these services will be analyzed. For this, two specific cases will be considered: payment for environmental services and the notion of green infrastructure for reducing the risk of environmental disasters.

Finally, the eight principles created by J. B. Ruhl that intend to stipulate some criteria to be used when creating policies for the protection and maintenance of ecosystem services will be analyzed.

1 ECOSYSTEM SERVICES: CONCEPTS AND COMPLEXITY

Ecosystem services are the "[...] benefits people derive from ecosystems" (MILLENNIUM ECOSYSTEM ASSESSMENT, 2005, p. v). This concept has its origin in studies of environmental economics (CONSTANZA, 1997; DAILY, 1997), which draw attention to the importance of the maintenance and preservation of ecosystems since they are responsible for producing several essential services for human sustainability[1].

Classically, it is understood that ecosystems are goods of the common use of the people, protected by the Federal Constitution[2]. The concept of ecosystem services brings a new perspective to this idea, demonstrating that ecosystems are capable of producing goods and products for humanity,

1 Robert Constanza (1997) pointed out that the average value of 17 ecosystem services stipulated at the time was almost twice the world GDP of 1994.

2 Article 225 of the Federal Constitution: "Everyone has the right to an ecologically balanced environment, a common use of the people and essential to a healthy quality of life, imposing on the Government and the community the duty to defend it and preserve it for present and future generations. "

contributing to their development (CARVALHO, 2015). To identify, delimit and protect ecosystem services, a multidisciplinary approach involving science, law, economics, and politics is required (DAILY, 2009). In this sense, a deepening of the complexities surrounding the theme is necessary in order to make it possible to recognize the presuppositions required for the protection of ecosystem services.

1. 1 Ecosystems, ecological function, natural capital and ecosystem services

In order to describe what ecosystem services are, it is necessary to initially approach the place where they are located, as well as to differentiate them from ecosystems and natural capital. Thus, it will be explained, from an ecological perspective, how the ecosystem services are formed.

Ecosystems are considered complex systems, formed by several components in relation to which the actions of one "[...] can affect many others, including the agent itself" (RUHL, KRAFT, LANT, 2007, p. 18). Due to the intense and continuous flow of components (which may or may not generate ecosystem services), it is practically impossible to analyze every ecosystem by separating the respective elements that compose it. In view of this difficulty of analyzing complex systems[3], scholars point out that the systems operate aiming at equilibrium and, in the case of ecological systems (ecosystems), the balance is due to their *resistance* (resisting external disturbances) and *resilience*[4] (ability to recover from disturbances).

Because of its "open" feature - which includes the absorption of components external to the ecosystem, such as sunlight; internal processing, such as photosynthesis; and the production of new external components, such as oxygen - there is a challenge of defining what would be scientifically and politically useful for establishing ecosystem boundaries.

3 Quoting Constanza, the authors Ruhl, Kraft and Lant point out four characteristics of complex systems: 1) strong interaction, not always linear, between its components; 2) difficulty in distinguishing cause and effect; 3) significant temporal and local discontinuities; and 4) impossibility to consider that the aggregation of a given component to the system will have an expected result (RUHL, KRAFT, LANT, 2007, pp. 18-19).

4 On resilience, see: CARVALHO, Délton Winter de; DAMACENA, Fernanda Dalla Libera. **Direito dos desastres**. Porto Alegre: Livraria do Advogado, 2013, p. 59-63. Also: IPCC. **Managing the risks of extreme events and disasters to advance climate change adaptation.** A special report of working group I and II of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press, 2012, p. 34.

According to Ruhl, Kraft, and Lant, there are four main problems offered by the "open nature" of ecosystems to define boundaries (RUHL; KRAFT; LANT, 2007, p. 21)

> 1) several smaller ecosystems may exist within a larger one; 2) ecosystems are interconnected and often difficult to separate; 3) limits of ecosystems expand and contract over time, due to natural and anthropogenic influences; and 4) ecosystems are defined ecologically rather than defined by legislation or administration[5].

The components responsible for structuring and maintaining ecosystems are called *ecological functions. According to Constanza, ecological functions are responsible* for maintaining the natural habitat and for the structure of an ecosystem (CONSTANZA et al, 1997). Events that degrade the structure of an ecosystem (such as predatory fishing, for example) end up negatively affecting the ecological functions that maintain the ecosystem's sustainability, hampering ecosystem services and, respectively, human development. (RUHL, KRAFT, LANT, 2007).

Several authors characterize the processes, flows and functions within ecosystems as *natural capital* (GRETCHEN, 2015; RUHL, KRAFT, LANT, 2007; CONSTANZA, 1997, 2014). That is natural capital structures ecosystems and can generate ecosystem services.

Thus, in a very succinct way, it is perceived that ecosystems are extremely complex systems, in relation to which several processes occurring in their interior are realized to sustain them, creating stability. From these processes, the process flows occurring in ecosystems (natural capital) can generate ecosystem services. However, due to a lack of linearity in ecosystems (complexity in identifying services), drawing their limits (to establish environmental policies, for example) becomes a very difficult task (RUHL, KRAFT, LATN, 2007), requiring a great deal of effort and cooperation from various areas (DAILY, 2009).

Ecosystem services are produced from processes that occur within ecosystems. It can be said that when there are ecosystem *benefits* for mankind, *ecosystem services are in the forefront*. Among the concepts existing in the literature on ecosystem services, we can mention that these are classified

5 Portuguese translation: "1) diversos ecossistemas menores podem existir dentro de um maior; 2) ecossistemas são interligados e frequentemente difíceis de se separar; 3) limites dos ecossistemas expandem e contraem ao longo do tempo, por conta de influências naturais e antropogênicas; e 4) ecossistemas são definidos ecologicamente em vez de serem definidos por legislação ou pela administração"

as benefits for people originating from ecosystems (CONSTANZA, 1997), or "[...] the conditions and processes that ecosystems generate - or help generate "- that benefit people" (DAILY, 2015) and also "... the benefits people derive from ecosystems" (MILLENNIUM ECOSYSTEM ASSESSMENT, 2005, p. v).

It should be noted that when it comes to ecosystem services, it should be clear that the *human component* is present. There are only ecosystem services when there is in the beneficiaries of these services (some person, a community, a country etc.), in this case, humanity. In the words of Ruhl, Kraft and Lant (2007, p. 27) "ecological processes and functions do not generate ecosystem services until they *are used by people* " (emphasis added)!

In order to know how natural capital (components generated by functions and processes within ecosystems) can generate ecosystem services and how these services are essential for mankind, a multidisciplinary examination is required that tries describe: i) the use made by the service; ii) the importance (and perception) of these services by service providers and beneficiaries; (iii) what modes are available to protect services; iv) as institutions responsible for environmental protection must act (DAILY, et al, 2009, pp. 24-27). That is, ecosystem services are as complex as the ecosystem's own notion and its use demands a *new perception* by the collectivity of its importance, its formation (since they are results of several processes and functions of one or more ecosystems) and its conservation form[6].

Because of the wide range of ecosystem services, they are usually divided into categories, according to their respective benefits to human well-being. Among the various existing categories[7], the best known is that done by the *Millennium Ecosystem Assessment*, which divided ecosystem services into four categories: *provision, regulation, culture and support*

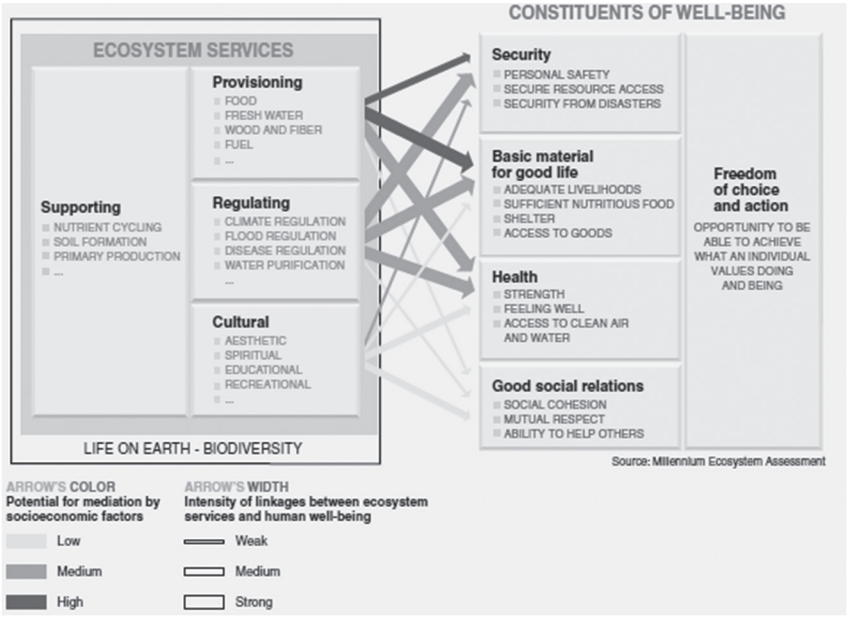
6 In the words of Ruhl, Kraft and Lant, these services are much less flexible than marketed services. They " are where they are and are what they are unless the processes of their formation are altered" and changing their processes can be detrimental not only in the provision of a particular ecosystem service, but also in other services, known or not, generated by ecosystems interconnected with the altered one (RUHL; KRAFT; LANT, 2011, 32).

7 Gretchen Daily, for example, classifies them into five categories: production of goods; regeneration processes; stabilization processes; life processes; and preservation options. Other authors, such as Holmund and Hammer, classify ecosystem services into two main categories: key services for humanity and ecosystems; and demand-derived services (which satisfy human desires) (RUHL; KRAFT; LANT, 2011, p. 25-26).

services (Millennium Ecosystem Assessment, 2005, p. 40, 50).

The ***i)*** **provision of services** are those that directly contribute to the survival of human beings by offering products essential to life, such as food, water, wood, and energy source; ***ii)*** **regulating services** are those benefits that come from ecosystem's very own regulatory processes. This is the case of biological processes that regulate air quality, climate, control erosion, floods and natural disasters; ***iii)*** **cultural services** are intangible services of the environment as sources of reflection, recreation and aesthetic experiences - issues such as local perception, social values, and hereditary are some examples; and ***iv)*** **support services** are services that are not directly perceived because they help in the formation of other services, such as soil formation, photosynthesis and primary forming of certain products[8]. They correspond to the so-called *natural capital*.

Ecosystem services interact with human well-being in a variety of ways and at different intensities. These are therefore of great importance for human well-being, since they act in an extremely diversified way, as shown in the figure below:

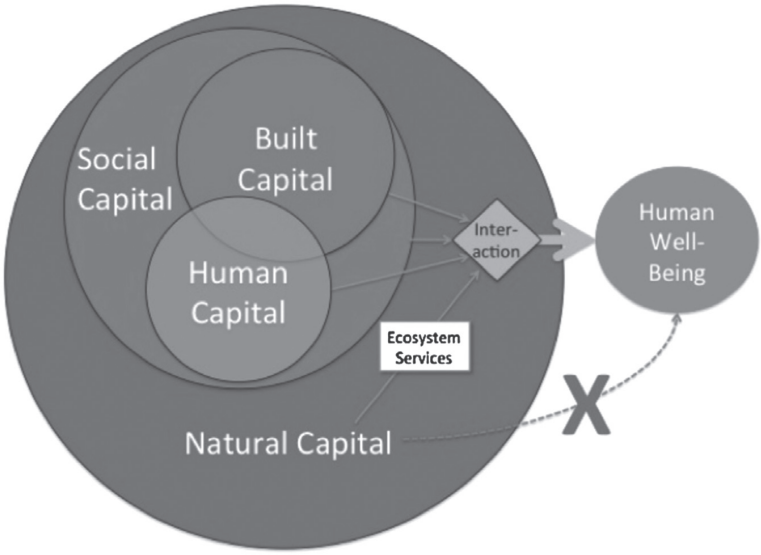


Source: Millennium Ecosystem Assessment, 2005.

8 Erosion process can be both an ecosystem service of support, and regulation, according to the observation that is made, when taking into account the time and the impact.

In this way, ecosystem services have been shown to have enormous ecological importance for humanity. Also, it is noted that they are very complex to define the relationship between the origin of services (natural capital) and the entire range of beneficiaries (humanity, in various ways). The recent increase in interest and the consequent deepening of the studies on the subject may serve to assist in the description of these services, helping in the elaboration of several environmental policies. However, ecological knowledge is not enough to establish public policies for the protection and promotion of ecosystem services. Ecosystem services should be studied in a multidisciplinary way, involving other areas of knowledge (such as Geography, Economics, and Law, for example) in order to have effective protection (RUHL; KRAFT; LANT, 2007).

In a recent study, Constanza (2014) identified that ecosystem services are not used directly by humanity, from natural capital. What happens, in fact, is a *process of integration* between human capital (existence of people), social capital (the community to which people belong) and constructed capital (community-built environment) to ecosystem services, generating well-being as shown in the image below:



Source: CONSTANZA, 2014

In this way, it can be seen that ecosystem services have enormous relevance for humanity because they offer services and products that are

essential to human life. However, these are also marked by complexity as regards their causal description, identification of beneficiaries, remuneration of providers and quantification of benefits, for example. Besides the difficulty in recognizing the existing services, another question is posed to the decision makers responsible for the demands of ecosystems and their services: their geographical and temporal delimitation. This is because identifying the area of coverage where services are produced and the way services are perpetuated temporarily is essential for preserving the ecosystems and their services.

1. 2 Difficulties in the delimitation of ecosystem services: geographical and temporal scales

While the ecology of ecosystem services seeks to identify what services are and how they reflect on human well-being, the geography of ecosystem services attempts to delimit and understand i) the source of the service, ii) the way it is distributed, and iii) where/to whom services are distributed. These components assume different characteristics, according to the spatial and temporal patterns analyzed (RUHL; KRAFT; LANT, 2007).

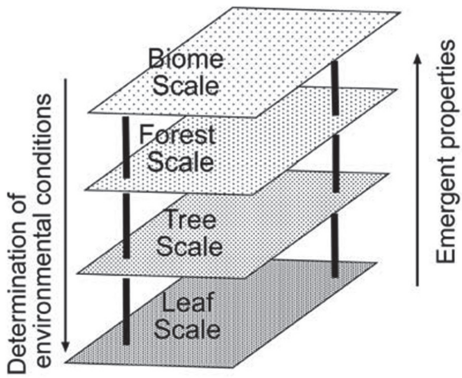
The complexity of ecosystem services shows that these are generated at *spatial and temporal scales* not always similar to those in which ecological processes and ecological functions occur in an ecosystem. That is, the corresponding ecosystem service may exist elsewhere and at another time.

The scales matter for the formulation of policies to protect ecosystem services, as well as for determining aspects related to the legal protection of these services. Scales can be spatial and temporal. According to the choice of *the spatial scale* used for the ecosystem service, the interaction will also be perceived at different social, political and economic levels. This would be the case, for example, of analyzing the ecosystem services of a river basin (regional scale), its suppliers and beneficiaries, thus covering the entire region benefiting from ecosystem services in this basin. In this illustrative case, one would analyze the economy of each region and its various social and political aspects. Similarly, analyzing ecosystem services on a local scale (for example, a flood), the questions

about the municipality and its social, economic and political characteristics (RUHL; KRAFT; LANT, 2007).

It is attentive to the fact that *there is no hierarchy between the scales*. A scale that considers ecosystem services at a federal level, for example, is no more important than a scale that would consider the local scope of services. And, as for the complexity of ecosystems and their services, managing them without considering the other levels of scales impairs the optimization of services. This is because ecosystem services are dynamically related, involving several different spatial scales for the provision of a specific service. Therefore, an analysis of ecosystem services for the formulation of preservationist and conservation policies should take into account the multiscale interaction, showing the consequences and the distribution of the services in the most diverse possible spatial levels (RUHL; KRAFT; LANT, 2007).

As an illustration, Ruhl, Kraft, and Lant (2007) demonstrate the multiscale interaction that exists in a forest, ranging from the level of the leaf to that of the biome that belongs to this ecosystem. From the most comprehensive to the most specific scale, there is the determination of environmental conditions, that is, establishing the environmental characteristics of the environment that allow the existence of these components. On the contrary, from the most specific to the most comprehensive level, the structure that supports the ecosystem under analysis (called *emergent properties*) is being created. The figure below illustrates the interaction between the scales:



Source: RUHL; KRAFT; LANT, 2007.

In addition to spatial scale, the *time scale* is also important for analyzing ecosystem services. The temporal analysis is necessary, since ecological processes occur at different speeds, according to the ecosystem, its components, its climate. Rapid processes are easier to perceive than slower processes (a river's flooding period can be considered a rapid process as it is easily perceived, while the effects of erosion are slower and more noticeable in the long run). As with spatial scales, timescales must be analyzed together (both those that identify fast processes and slow processes), because long-term effects on ecosystems affect the fastest and vice versa (RUHL; KRAFT; LANT, 2011).

The geography of ecosystem services analyzes how the different scales (spatial and local at their various levels) interact with each other. By analyzing these interactions, it is possible to understand how ecosystem services are produced, the path taken and how they are made available to the population (SALZMAN, 2010).

1. 3. Valuation of ecosystem services: defining their importance or how to change nature

As already seen, ecosystem services have a very important economic value for human well-being. In the words of Constanza (1997), *the valuation of ecosystem services is inherent in the choices and environmental decisions that are made*. In the author's sense, valuation is part of any decision, for "while we are forced to make choices, we go through a process of valuation. " When making a decision, whether you like it or not, you are valuing yourself and the only choice that can not be made is whether you want to decide or remain inert!

Constanza (1997) stipulated the valuation of ecosystem services based on the changes they undergo and their impact on human activity[9]. Changes in the quality and quantity of available services both have an impact on the well-being of the human population and within the ecosystems themselves, altering the availability of natural capital. The perceptions of

9 In an illustrative way, the author attempted to value ecosystem services around the world, reaching the average abstract value of $ 33 trillion, corresponding to 1. 8 times the value of GDP at that time. The author himself admits that this value should not be taken into account as the exact value of ecosystem services, but rather to demonstrate the importance of services to mankind (CONSTANZA 1997, p. 257-259).

these changes become clearer for certain services that already have some *market*. As an example, we can mention the corals, which help in the creation and breeding of fish, an activity that has a market value due to the fishing of seafood; and forests can be mentioned, which have provision services in supplying material such as wood, an activity that has a well-established market.

A major problem of the valuation of these services is the so-called *market failures. When there is no valuation* of these services, there is a risk of not giving them the necessary protection, or not defining their limits of use (RUHL; KRAFT; LANT, 2007). This problem demonstrates the *undervaluation* (CARVALHO, 2015) of these services[10] because the absence of a market or pricing often prevents recognition of the importance of a given service. This happens especially because the services are *open* resources *(open-access resources),* giving the idea of being *free* and unlimited (RUHL; KRAFT; LANT, 2007) when they are not (ARAGÃO, 2011). Gratuity and the supposed unlimited availability of services tend to cause what Ruhl, Kraft, and Lant (2008) call the *tragedy of Ecosystem Services*[11], making scarce (even degrading completely) the services produced.

The reason for these services is that they are not easily perceived as human ecosystem services (CONSTANZA, 2014), such as the air you breathe, the climate of a particular region, or access to a particular place. It is not known that, in fact, these benefits are derived from the functions and processes of ecosystems and that they have an economic value with a certain end for the human being.

Another problem for the valuation of these services is that they

10 As for the undervaluation, is also the doctrine of Alexandra Aragon: "(...) it is known that the market value of natural resources does not correctly reflect its real value: the forest is not only valuable for the firewood, furniture or paper pulp it can produce, just as the river is not only worth for fish and for water supply. But the real value, social and ecological, of natural resources goes far beyond their market value. The real value results both from the very existence of the resource and from the natural functions performed and that are the services rendered to Man and the Planet. " {0}({/0}{1}ARAGÃO, 2011, p. 140-141). {/1}

11 Concept inspired by the *Tragedy of the Commons* by Garret Hardin (1968), in which the lack of information and control over goods ends up reducing its availability. In the case of ecosystem services, the idea of often being positive externalities (the owner of the area producing ecosystem services abroad receives no gain when others use such goods), as well as the lack of a valuation of these services and the lack of incentives and policies that help maintain services without a person's responsibility for the collective interest, can encourage the excessive exploitation of the service, leaving it unusable for the next generations (RUHL; LANT; KRAFT, 2008).

have a value and a specific importance according to the place analyzed (SALZMAN, 2010). The same service may have a value in one region, while in another it has another distinct value, due to changes in climatic, geographical and social conditions.

It is worth noting that the most common valuation method is the *monetary one* when trying to allocate a sum of money to the analyzed ecosystem service. It happens that this method encounters major problems in order to assign an economic value to ecosystem services that do not have a specific market (market failures). In view of this, there are some valuation methods that take into account certain criteria for value assignment, such as the comparison of ecosystem services with manufactured services, the importance to the community of a given ecosystem or the identification of the value that people would be willing to pay to maintain a certain service. Authors such as Ruhl, Kraft, and Lant (2007) point to existing flaws in these methods, owing to the omission of some criteria that would be important for the valuation of services. The authors emphasize that these methods hardly take into account the complexity of ecosystem services, or that they do not apply the same formula of valuations of manufactured goods in environmental services, whose characteristics are different.

This monetary valuation, in turn, could be seen as a way of *commodifying* nature (CONSTANZA, 2014), or of pricing something that has an inestimable value (the environment). However, this is not the idea, since the valuation of natural resources is already a common practice for certain ecosystem services. Wood, for example, has a known market price. We can also mention that natural resources are objects of environmental compensation processes[12], during authorization procedures for the construction of enterprises, for example.

Constanza (2014) understands that the attribution of monetary value to ecosystem services does not make them commodifiable or privatized since the cost is not valued for the possibility of replacing services, but rather for their *use* and *not use*. In addition, the author understands that

12 The compensatory measures authorized by the competent environmental agency, when presenting an Environmental Impact Study, during the environmental licensing, for which the impact caused by the undertaking is "within an acceptable limit [...]], **not jeopardizing the environment and the quality of life of the community** "(emphasis added) (FARIAS, 2015, p. 97). That is, highlighting which ecosystems and services will be affected and how much their compensation would be worth.

the cash valuation makes the decision more transparent, including for the recognition of existing uncertainties and limitations. Recognizing and monetarily measuring ecosystem services removes *human ingenuity* from certain concepts as studies of ecosystem services have revealed the limitations of man-made infrastructure (also called gray infrastructure and social infrastructure) that can be improved through the use of ecosystem services[13].

The main idea behind the valuation of ecosystem services already pointed out by Constanza (1997) and Daily (1997) in the 1990s or by the Millennium Ecosystem Assessment (2005), is that they have a *vital value for human well-being*. And there are social, ecological and economic criteria that must be taken into account when valuing ecosystem services. For this reason, in-depth multidisciplinary studies, pointing out the possible beneficiaries, should be carried out for the valuation of ecosystem services (RUHL; KRAFT; LANT, 2007). In addition, not only for marketing purposes, valuation can be used for multiple purposes, aiding environmental decisions regarding the maintenance of natural resources (CONSTANZA, 2014). And also, according to Daily, ecosystem services demonstrate that "[...] we do not protect what we do not value" (DAILY, 1997, p. XIX), because they offer a perception of ecosystems that are not traditionally quantified.

In addition to the economic-monetary method of valuation, other forms can be used, such as units of measures (hectares), the quantity of energy and time scales. The choice of the form of valuation becomes what "[...] best communicates to different audiences in a specific decision-making context" of environmental issues. (CONSTANZA, 2014, p. 153).

The importance of stipulating an economic value to ecosystem services lies in the fact that it is possible to compare them with other services and products in order to make a more efficient decision on the maintenance, recomposition or displacement of ecosystems. The ways

13 The author mentions studies that prove the mitigation capacity of ecosystem services (wetland) more effective than that of a dike in cases of storms in the event of a hurricane. Besides mitigate the impact of a catastrophic event, the same bathed is responsible for storing carbon, that is, it becomes much more efficient than a dam. And having this knowledge illustrates the importance of ecosystem services to mankind. Nas palavras do autor: "Pointing out that the 'horizontal levees' of coastal marshes are more cost-effective protectors against hurricanes than constructed vertical levees (Constanza et al., 2008) and that they also store carbon that would otherwise be emitted into the atmosphere (Luisetti et al., 2011) implies that **restoring or recreating them for this and other benefits is only using our intelligence and ingenuity**, not betting against it" (grifo nosso) (CONSTANZA, 2014, p. 154).

in which services *are* valued, despite being limited, can demonstrate that services *are not free* (ARAGÃO, 2011), has an important value for society (RUHL; LANT; KRAFT, 2007).

In the words of Alexandra Aragão, the importance of valuing ecosystem services is due to the fact that: "[...] the market can only guide the use to an optimal level if the price reflects its social and ecological value. " And with regard to the open characteristics of services and the possibility of the *tragedy of ecosystem services*, the author mentions: "however, n many ecosystem services are valued at zero price, which invariably leads to overuse and therefore, to an inefficient allocation of resources" (ARAGÃO, 2011, p. 7).

In the same vein, Keith Hirokawa (2015) explains that it is already possible to establish values that were previously not accounted for by ignoring or by not knowing of the functions and benefits of ecosystems for humans. For the author, the importance of knowing these values serve to be aware of the consequences that the changes resulting from the degradation of ecosystems generate in the well-being of humanity, justifying the importance of conserving services and their ecosystems avoiding future damages (shortage of food, increased occurrence of environmental disasters, etc.). The stipulation of values to ecosystem services enables the creation of *information* about these services[14] (HIROKAWA, 2015, p. 551).

The economics of ecosystem services contribute to the analysis of benefits, cost of loss and the effects of measures to protect ecosystem services (ARAGÃO, 2011). Information gained from valuing ecosystem services has a key role to play in determining which services are intended to be preserved and how services contribute to the well-being of human beings. In addition to assisting in valuation, information also contributes to the understanding of the complexities and interconnections existing between ecosystem services. (RUHL; RAFT; LANT, 2007).

14 Information on ecosystem services assists in the valuation of *lost* services, that is, it accounts for the damage caused to the environment as a result of impacts that degrade it (disasters, degradation), according to (HIROKAWA, 2011, p. 553).

2 ECOSYSTEM SERVICES AND THEIR EFFECTS ON LEGAL SYSTEMS

In this dynamic interaction, the law has a fundamental role as guarantor of a *fundamental right to a balanced environment*[15], guaranteeing the constitutional value of an *Environmental State* (CARVALHO, 2013). In this bias, ecosystem services must be thought of as an object of protection and regulation, based on intercommunication between distinct systems, helping to create legal criteria for protection (CARVALHO, 2010).

Currently, Environmental Law has used the notion of ecosystem services for regulation and environmental planning. Two specific cases will then be addressed: the issue of payments for environmental services and disaster risk management coupled with ecosystem services from the notion of green infrastructures.

2. 1 Payment for environmental services

The policy of payment for environmental services - PSA consists of a basic concept of the market: one party agrees to take certain actions to maintain the production of some ecosystem service, while another offers an incentive to do so (SALZMAN, 2010). It is about internalizing the *positive externalities* generated by ecosystem services (benefits that are not accounted for by the generators of the services and viewed as free and unlimited by the beneficiaries) by means of remuneration/incentive to the generator of the service, characterizing it as "[...] a complement to the current command and control instruments, in order to make the task of environmental preservation effective" (ALTMAN, 2011, p. 74)[16]. If there is no incentive to conserve services, they may disappear, and the *tragedy of ecosystem services* may occur (RUHL; LANT; KRAFT, 2008).

It is an idea originated from the polluter-payer principle, with a

15 Article 225 of the Federal Constitution: Everyone has the right to an ecologically balanced environment, a common use of the people and essential to a healthy quality of life, imposing on the Government and the community the duty to defend and preserve it for present and future generations

16 Ecosystem services are considered positive externalities, since they are public goods of common use, for the maintenance of which there would be no way of paying for themselves (RUHL; KRAFT; LANT, 2007). In the same sense, Nusdeo (2012, p. 72) classifies positive externalities as "[...] benefits to third parties that are not recovered by the agent who produced them."

positive preservationist aspect, called the principle of the *protector-receiver* (ARAGÃO, 2011). The idea of protector-receiver follows the same logic as the polluter-payer; however, as already mentioned, *positive* externalities are internalized in the conduct of the protector, in the form of incentives or payment.

Based on the premise that those who pollute must bear the costs of environmental damage caused (negative externalities, damages caused to third parties by the polluting activity) as a way of not encouraging the continuity of activity, that preserves and generates social gains (produces *positive externalities*, that is, social gains for third parties, without receiving payment) should receive *incentives* to maintain their protectionist behavior (ARAGÃO, 2011).

The PSA contract can be made between private (owners of areas where there are ecosystem services and locations where benefits are distributed), and one or more owners requiring the *conduct* of the service provider to bind themselves to preserve it. Or, it can be done between private owners and the public power, is this the administrator or facilitator of the negotiation. PSAs can be dynamically established, varying according to the characteristic of the existing ecosystem service(s) (ALTMAN, 2011, p. 77).

The idea of paying to preserve ecosystem services is not so recent in the legal system. It can be noted that the National Environmental Policy has envisaged the use of economic instruments to promote environmental protection[17]. In this sense, Carvalho (2015, p. 59) mentions:

> Environmental services and their respective payments adhere to the legal system of the country because they are included in the notion of economic instruments, as mechanisms for implementing the National Environmental Policy (article 9, XIII, Law no. 6. 938/81).

Other federal laws also mention the possibility of creating economic incentives for environmental protection. This is the case of forests, discussed in chapter X of the Forest Code (Law 12561/2012), which provides for the "Program for Support and Incentives for the Preservation and Recovery of

17 "Article 9 - Are Instruments of the National Environmental Policy: (...)XIII - economic instruments, such as forest concession, environmental easement, environmental insurance and others".

the Environment" (Article 41) which promotes "[...] payment or incentive to environmental services as remuneration, monetary or otherwise, to the activities of conservation and improvement of ecosystems and that generate environmental services" (item I).

In the mentioned section, several conservation activities are listed which can be remunerated with monetary payment or otherwise. These are: (i) sequestration, conservation, maintenance and increase of stock and reduction of carbon flow; (ii) the conservation of natural scenic beauty; (iii) the conservation of biodiversity; (iv) the conservation of water and water services; (v) climate regulation; (vi) cultural valuation and traditional ecosystemic knowledge; (vii) soil conservation and improvement; (viii) the maintenance of Areas of Permanent Preservation, Legal Reserve and restricted use.

Although it does not specify how payments and incentives will be made[18], forestry legislation already demonstrates the intention to *encourage conservation practices* that focus on the preservation and maintenance of ecosystem services through compensation or incentives. It is perceived as a de-characterization of the preservation of the environment only by means of coercion (fines, work embargo, demolition), including the encouragement of good practices.

The PSA is a form already established in Brazil[19] to assist in the

18 For a critique of the legal provisions mentioned, see the work of Paulo de Bessa Antunes, which mentions: "(...) the set of measures verbalized in the law, without a clear indication of their cost and repercussions for the whole of society, imply a transfer of income that should be well explained, so that society would agree or disagree with it" (ANTUNES, 2014, p. 262).

19 At the federal level, Bill 792/2007, which " mandates environmental services and provides for the transfer of resources, monetary or otherwise, to those who help to produce or conserve these services is processed in the Chamber of Deputies. "The project is a report by Federal Deputy Anselmo Jesus (PT/RO) and aims to "transfer resources, monetary or non-monetary, to those who help to conserve or produce" ecosystem services (referred to here as environmental services).
The original text of the project has only four articles, in which, in the first one, environmental services are classified, similarly to the classification of the *Millennium Ecosystem Assessment*, dividing them into four categories. The second article states that anyone who employs effort to develop the services will be entitled to the payment or compensation determined. The third article establishes that it will be up to the Executive to regulate the law that disposes on ecosystem services. The fourth article only provides for the validity of the law.
The law does not provide many details of how payments will be made or who can receive them by classifying all recipients in a generic way. Not to mention that passes the responsibility of regulating the law to the Executive Branch. That is, the bill does not specify the details of the forms of protection and conservation, nor how the payments will be made.
Several municipalities have legislation establishing the payment program for environmental services. They create funds or forms of investment to pay the owners who keep the services intact. The municipalities of Campinas-SP (Municipal Law 15, 046 of July 23, 2015) and the municipality of Extrema-MG, which, since 2007, created the "Conservative Water Project", encouraging farmers to protect ecosystem services through payments and incentives, for example.

protection and regulation of ecosystem services by offering incentives (monetary or otherwise) to their protectors. This is a way of highlighting the importance of protecting these services and also trying to quantify them at a certain value that serves as a stimulus to the maintenance and preservation of ecosystems.

And Law is nowadays a *regulator and guarantor,* helping to fulfill and protect these services, either through the formulation of legislation or through coercion to enforce PSA contracts.

2. 2 The green infrastructure in disaster risk prevention

Another form of legal protection of ecosystem services is its observation as a *green infrastructure*, used, as will be seen, in the prevention and mitigation of environmental disasters, especially those resulting from extreme climatic events.

The usual concept of infrastructure is the mechanisms built by the human being, through Civil Engineering (CARVALHO; DAMACENA, 2013), such as bridges, dams, dams, runways, airports, among others, so-called gray infrastructures. Infrastructure can also be installation or building, as is the case of hospitals, schools, and prisons, social infrastructures (BENEDICT; McMAHON, 2001). All these infrastructures are constructions of the human being that facilitate and help the life of the people.

Nature, in turn, can also be considered as infrastructure, as it provides services and products that help the continuity and development of society, so-called *green infrastructures*. The green infrastructure assimilates to the built infrastructure for *providing the necessary ecosystem services for the maintenance of human life and its well-being*. Supply is provided by ecosystem services such as the provision of protein through food, medicines from biodiversity or protection against rain and flood (VERCHICK, 2012).

The term green infrastructure refers to an interconnected network of green areas that conserve ecosystems and their functions that assist human populations. The notion of green infrastructure is not only about an isolated unit, but about areas that are connected with it, forming an infrastructure,

but of *natural resources*. The idea of infrastructure reflects the complexity of ecosystems and their services, as already reported. Connected areas can be much more useful and complete than isolated protected areas because they can preserve native plants, animals, and ecological processes[20] in a sustainable way, in conjunction with the development of society, and not fragmented (BENEDICT; McMAHON, 2001).

As with built infrastructures, green infrastructures also need long-term planning and constant maintenance. The construction of a road, an airport, a school, or a hospital, for example, is not done without in-depth study and analysis of the costs required to complete the project. With the green infrastructure, the same happens. It takes planning, study, and information to avoid an irregular and unsustainable occupation of natural assets. The human modification of ecosystems without proper planning fragments and impoverishes the ecosystem as well as causing various harms to humanity itself. This is reflected in ecosystem services, affecting flood control capacity, the supply of building materials and food necessary for human life, as well as access to shelter and protection. The effects are also felt economically and socially, such as the costs of mitigation and disaster response and the need to make high investments to build an infrastructure to replace those lost (natural and/or built). Often, the cost of preserving and maintaining green areas is much lower than those spent compensating for damage to areas with few or no ecosystem services (BENEDICT; McMAHON, 2001).

For Verchick (2012), thinking about ecosystems as green infrastructures can help us to formulate public policies in different ways. First, this perspective highlights the many ecosystem services that ecosystems provide, facilitating and encouraging the elaboration and search for ways to protect those we most need. Recognizing which services are essential is also a form of valuation, as already said by Constanza (1997; 2014), and this helps in the construction of information for the elaboration of more efficient protection policies.

One can mention, by way of example, an excerpt from the vote

20 Art. 225. Everyone has the right to an ecologically balanced environment, a common good used by the people and essential to a healthy quality of life, imposing on the Government and the community the duty to defend and preserve it for present and future generations.
Paragraph 1 In order to ensure the effectiveness of this right, it is incumbent upon the Public Power:
I - **to preserve and restore essential ecological processes and provide for the ecological management of species and ecosystems** (emphasis added).

of Special Appeal 650. 728 - SC[21] which talks about the evolution of the mangrove protection culture, once seen as dirty and unwanted environments, and only served to procreate mosquitoes and disease development, even with the support of the Government, to destroy them. However, with ethical, scientific and legal development, it has been realized that these ecosystems have several services and functions that contribute to the development of society, as reproductive areas of diverse species; filters containing nutrients, sediments, and pollutants; areas of storm protection and coastal erosion. A source of food and traditional activities such as artisanal fishing, working also as an essential environment for the survival of traditional **communities,** the ecosystem was classified as Permanent Preservation Area by law.

In this example, knowledge of the functions and services provided by mangroves has enabled a change in the protection policy of these ecosystems. This change literally transformed what was considered dirty and unnecessary into a vitally important ecosystem in which any human intervention is forbidden.

Next, Verchick (2012) reports that the idea of infrastructure makes it clear that services are interconnected systems and perform functions together, as explained previously. This perspective revolves on the importance of not making isolated protection since other green areas and regions (such as ecological corridors, estuaries, for example) are part of the same infrastructure (problems of scales and limits, as already mentioned).

21 According to an excerpt from the Minister's vote: "Notwithstanding its relevant ecosystem-transition position between the marine, river and terrestrial environments, mangrove *lato sensu* (= mangrove *stricto sensu* and marshes) were, by mistake, disparaged, popular and legally. **As a result, for centuries the distorted cultural conception prevailing in them saw the consummate model of ugly, fetid and unhealthy, a form of ugly duckling of ecosystems or antithesis of the Garden of Eden. Hence they are considered unproductive land and no one associated with the procreation of mosquitoes transmitting serious diseases, such as malaria and yellow fever. It is a socially despicable environment, which is occupied by the humblest people, in the form of stilts, synonymous with poverty, filth and outcasts of society (areas of prostitution and illicit activities).**
As a result of the evolution of scientific knowledge and changes in the ethical posture of the human being towards Nature, **several functions are now recognized in mangroves.**
[...]
Current Brazilian legislation reflects the scientific, ethical, political and legal transformation that repositioned the mangroves, (...) the legislator attributed to them legal nature of Permanent Preservation Area "(our emphasis).
BRAZIL. SUPERIOR JUSTICE TRIBUNAL. Special Resource 650728 / SC. Applicant: H Carlos Schneider S / A Trade And Industry And Other; Defendant: Federal Public Prosecutor. Rapporteur: Minister Herman Benjamin. Brasília, October 23, 2007. Available at: < https://ww2.stj.jus.br/processo/revista/inteiroteor/?num_registro=200302217860&dt_publicacao=02/12/2009>. Accessed on: 18 Aug. 2015.

And, thirdly, the author mentions that green infrastructure has the characteristic of being opened, in common use. This view, as already mentioned, needs to be changed in order to avoid the *tragedy of ecosystem services*.

In the same sense, as regards green infrastructure, Carvalho believes that "thinking environmental services as a green infrastructure places greater emphasis on the integration between the environmental elements and those built by man. " For the author, this concept values the ecosystem services provided for human life and integrates values of "conservation, planning and planning of land occupation, growth management and planning of built infrastructure" (CARVALHO, 2015, p. 58).

The infrastructure vision also encourages a greater appreciation of the *monitoring*, *maintenance* and *recovery* of these areas" (emphasis added). As an example, the author cites flooded areas, marshes, dunes and resting compared to dams, barrages, and roads to demonstrate what are the natural infrastructures. At a time of disaster, as the author explains, these green infrastructures can handle the event in two moments. At first, "acting as a *natural blockade* to the impacts of a disaster, diminishing or diverting the forces of nature from the direction of human communities" (emphasis added). In a second moment, after the event, "the natural infrastructure will serve to *provide goods and services of fundamental importance for the economic and physical recovery of the affected place* ". In other words, at a time of disaster, the green infrastructures mentioned will aid in mitigation and prevention of damage by providing ecosystem services of regulation and, later, with provisioning services (CARVALHO, 2015, p. 61).

The notion of green infrastructure requires a more careful view of land management and use. In this case, the prominence of the municipalities stands out so that this management is determined, according to the Federal Constitution (art. 30, VIII) (CARVALHO, 2015, pp. 78-79). With a view to reducing disaster risk, the inclusion of ecosystem services is an environmentally safer and cheaper alternative to do so.

3. GROUNDING FOR LEGAL PROTECTION OF ECOSYSTEM SERVICES: THE EIGHT PRINCIPLES OF J. B. RUHL AND THEIR APPLICATIONS

As shown, the Brazilian legal context already presents some alternatives to protect ecosystem services. However, to help develop new forms of protection (or improve existing ones), the eight principles created by J. B. Ruhl will be used to help elaborate a scope for managing ecosystem services (RUHL, 2015). They are:

Principle 1 - Ecosystem services must always create human well-being: as already mentioned, when talking about ecosystem services, it is strictly speaking that there is a correspondence in the human component. When creating measures of use (PSA) and protection of ecosystem services, one should always emphasize **what they do for humanity**.

When there is not a person or a community that benefits from a product originating from ecosystems, one will be talking about natural capital, or the ecosystem itself, but not on ecosystem services. Ruhl, Kraft, and Lant (2007), as well as Constanza (1997) and Gretchen (1997) already said that ecosystem services will exist only when their respective *human benefits* exist.

Principle two - to define property rights and an equitable distribution of impacts: in this case, it should be stressed how natural capital generators and beneficiaries of ecosystem services can be encouraged or obliged to take certain actions. This principle is of vital importance to the PSA, since it must be determined when a given landlord can receive maintenance of ecosystem services and which area of their property should be protected (and thus prevented from being used for other purposes).

Hirokawa (2011), in the same vein, believes that, in regulating ecosystem services, ownership will inevitably be attained and must be adapted. New questions about how to define who would have the legitimacy to compel another owner to maintain and preserve a particular ecosystem (since it is a provider of ecosystem services) in a distinct location should be addressed by law (RUHL; KRAFT; LANT, 2007).

Principle three - to integrate the notion of ecosystem services

with other environmental policies: policies for the protection and preservation of ecosystem services must be created in a complementary way to other existing preservation policies. Existing policies should also include the notion of these services in their programs.

The very notion of ecosystem services requires a multidisciplinary approach in several areas in order to have the necessary information for those who will decide. In this sense, a wide range of forms of protection of ecosystem services and ecosystems opens up, integrating the perspective of ecosystem services (CARVALHO, 2015) with several environmental policies (DAILY, 2009).

Principle four - Pricing is ideal, but not always necessary: some ecosystem services do not need to be valued monetarily. This is the case with services that have invaluable values (for historical and cultural reasons, for example). However, if there is any way to value and price the services, it is always good to keep them in mind in order to have better options for the decision regarding the use and preservation of these services.

As already mentioned, there are several ways of valuing ecosystem services, each specific to the intended purpose (CONSTANZA, 2014). However, monetarization allows one to understand how much one would be losing economically by failing to preserve ecosystem services (CONSTANZA, 1994).

Principle five - The values should be explicit: whenever a decision involving ecosystem services has to be made, the values referring to the knowledge of these services should *always* be *presented.* The importance of information on the values and measures taken to support the environmental decision must always be clear and judicious. This is justified even to present possible uncertainties by which the valuation process has passed (CONSTANZA, 2014).

Principle six - To include ecosystem services in Environmental Impact Studies: Given the importance of ecosystem services for human well-being, development policies (eg buildings and works) should present in their Environmental Impact Studies what ecosystem services will be and how they will be compensated. Again, the role of information. Checking which ecosystem services will be affected and which compensatory measures will be taken assists in making more judicious measures, as well

as being made within an acceptable limit (FARIAS, 2015).

Principle seven - to include information on ecosystem services in environmental decisions: Whenever possible, when decisions have to be taken that involve ecosystems (whether preservation or compensation), the consequences of human well-being should be informed.

Principle eight - to carefully designate any action to be taken on ecosystem services: when taking any decision that takes ecosystem services into account, use reliable technical criteria as well as perform effective maintenance so that there is no harm to the parties.

Finally, these two principles can be analyzed together, since they demonstrate the importance of multidisciplinarity in the decisions to be taken (DAILY, 2009), as well as the impact that the decisions taken can have on ecosystem services and, consequently, on human well-being (CONSTANZA, 1994; MILLENNIUM ECOSYSTEM ASSESSMENT, 2005). In other words, addressing ecosystem services in environmental decisions is a complex issue, inherent in the subject itself, which will require changes in the legal system that, if not taken, could cause the *tragedy of ecosystem services* (RUHL, 2008).

CONCLUSION

Ecosystem services are services and products originated from ecosystems that aid in human well-being. The study of this subject addresses complex issues, which require a multidisciplinary approach in several areas. In this work, the importance of addressing ecosystem services in some of these areas was emphasized.

From an ecological perspective, it is sought to recognize what ecosystem services exist in a given place, how it is formed and the benefits produced. The geographical perspective allows establishing the territorial and temporal limits of ecosystem services, demonstrating the origin, path, and destination of services. The geography of ecosystem services contributes to the understanding that ecosystem services can be observed through different scales (geographical and temporal). As for the economics of ecosystem services, it can be seen that there are several ways of valuing services, highlighting their importance for human well-being. Valuation

should not be seen as a pricing of services or of nature itself, since it demonstrates the value of the use and non-use of ecosystems, aiding in the foundation of the protection of ecosystem services.

It is of paramount importance for the legal system this multidisciplinary perspective of ecosystem services since it provides the *information* necessary to have the proper preservation of ecosystems and their services. In the present work, we analyze the way to regulate (payment of environmental services) and to use ecosystem services as instruments of quantification and weighting on the risks of disasters (green infrastructure). These are just some models of legal protection of ecosystem services. However, as the analyzed matter itself, the use of ecosystem services by the legal system goes through a complex analysis of diverse information. In view of this, eight key principles were presented for the elaboration of a policy of efficient protection and its use, so that adequate foundations for the protection of these services exist.

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