AMAZALERT Delivery Report

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First author	Graciela Tejada-Pinell
Co-authors	Alex Ovando-Leyton; Daniel M. Larrea
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Abstract

The ecosystem services concept has been widely used in the last years; however, there is still a wide scientific debate about its interpretations, definition, classification systems, framework, and use at different scales. Over the AMAZALERT kick-off workshop results and literature review, we intend to identify and contrast ecosystem services definitions and how these have been used, interpreted, or differentiated. In addition, we aim to distinguish between the provisioning and regulating ecosystem services and the benefits they provide at different scales and how they are perceived by local and global stakeholders. We highlight the main ecosystem services in the Amazon and the potential impacts of the drivers of change (mainly deforestation and climate change) on these ecosystems. Furthermore, the role of protected areas and indigenous territories in the preservation of the Amazon ecosystem is highlighted.

Key Words: Ecosystem services, Amazon Basin, benefits**,** stakeholders, drivers of change, deforestation.

1. Introduction.

The ecosystem services concept has been widely disseminated in the last years (Balvanera & Cotler 2007; Fisher et al. 2009; Menzel & Teng 2010). Nonetheless, there is still a wide scientific debate about its interpretations, definition, classification schemes, framework, and use at different scales (Hein et al. 2006; Fisher et al. 2009). The most commonly accepted definition is one that recognizes the links between human well-being and ecosystem conservation (Hein et al. 2006; Boyd & Banzhaf 2007; Fisher & Turner 2008, Carpenter et al. 2009, CDB 2009). On the other hand, trying to get units of account of ecosystem services, some authors have made an interesting distinction between ecosystem services and the benefits that come from them; ecosystem services are ecological in nature and differ from benefits because the latter require other forms of capital (e.g., human, etc.) (Boyd & Banzhaf 2007; Fisher & Turner 2008; Fisher et al. 2008, 2009). This distinction has been poorly analyzed in the Amazon, one of the world's major biomes, and very little studies have been conducted on changes in provision of ecosystem services.

Due to deforestation and climate change, Amazon ecosystems (mainly forests) and the services and benefits that come from them are at risk (Betts et al. 2008, ESPA-AA 2008). Land use change through road expansion and large scale agriculture that comes with intensive use of fire presents a big threat to Amazon ecosystems (Barreto et al. 2006; Nepstad et al. 2008; Müller et al. 2011a, 2011b; Davidson et al. 2012). In the same way, severe droughts and forest die-back are emerging threats of climate change (Betts et al. 2008; Philips et al. 2010; Davidson et al. 2012). How do these drivers of change affect ecosystem services and benefits provided by the Amazon? This is still an open question.

Here, our purpose is to identify and contrast ecosystem services definitions and how these have been used, interpreted, or differentiated when it comes to the Amazon. In addition, we aim to distinguish between the ecosystem services and the benefits they provide, considering both local and regional stakeholders (i.e., considering different scales). We highlight the main ecosystem services of the Amazon and identify the sort of threats associated with them selected from published papers and AMAZALERT´s team perception. Finally, as a relevant tool to preserve the Amazon ecosystem services, we set out the relevance of protected areas and indigenous territories.

2. Relevance of the ecosystem services concept and classification.

The ecosystem services concept encompasses ecosystems, policies, stakeholders, and financial resources for biodiversity conservation (Chapin III et al. 2000; Chan et al. 2006; Balvanera & Cotler 2007; Nahuelhual & Nuñez 2011). The other direction of research points to the relationship between ecosystem services and human well-being and comes from the 60´s when the environmental movements started to draw attention to environmental problems and the link between human well-being and the conservation of the basic earth functions (Balvanera & Cotler 2007). The role of ecosystems in the maintenance of life support and its direct or indirect relationship with human well-being has been also highlighted (Constanza & Folke. 1997; Haines-Young & Potschin 2009; Menzel & Teng 2010). Nonetheless, the term environmental service, which is often used as a synonym of ecosystem service, can be different according to the context in which it is used, and refers more to the decision making context putting emphasis on the environment (Balvanera & Cotler 2007; Nahuelhual & Nuñez 2011). Even though recognition of the relevance of ecosystem services has been increasing in the last decade, there are still many incorrect interpretations of their definition, framework, and use.

The definition of ecosystem services has to be clear in considering the decision context in which it is being mobilized and its resulting classification scheme. The concept of ecosystem services outlined by Daily (1997) mention that "ecosystem services are the conditions and processes through which natural ecosystems and species that make them up sustain and fulfill human life". De Groot et al. (2002) prepared a classification scheme based on functions, trying to capture the relationships between ecosystem processes and components and goods and services. Today, the most used and known ecosystem classification schemes is from the Millennium Ecosystem Assessment (MA 2005), which defines ecosystem services as the benefits people obtain from ecosystems, including provisioning, regulating, and cultural services (each underpinned by biodiversity) that directly affect people and the supporting services needed to maintain other services. The MA assessment is based on the interactions that exist between people, biodiversity, and ecosystems, putting special attention on biodiversity conservation and human welfare. Wallace (2007) also has a classification scheme that considers human values, that seems to suggest the regrouping of services around preferred end-states of existence. Therefore, there are many different definitions of the ecosystem service concept; this suggests different levels of perception and levels of opinion about the concept (e.g., Costanza et al. 1997; Brown et al. 2007; Fisher & Turner 2008; Fisher et al. 2009; Costanza 2008; Haines-Young & Potschin 2009; TEEB 2010). Table 1 shows a brief comparison among the classification schemes mentioned above.

Many environmental economists are trying to define units of account to measure the contribution of nature to human welfare. According to Boyd & Banzhaf (2007), "final ecosystem services are components of nature, directly enjoyed, consumed, or used to yield human well-being". The concept used by Fisher & Turner (2008) refers to ecosystem services "as the aspects of the ecosystems utilized actively or passively to produce human well-being", which considers that the different points of view in the definition and classification schemes of ecosystem services are founded on the specific context in which they are being used. Both authors agree on an important point; they separate the concept of ecosystem services from benefits. Recently, Haines-Young and Potschin (2009) developed the concept of “service cascade”, which labels the benefits, services, functions, and structures and processes.

Table 1. Some of the most known and used classification schemes.

Daily (1997) - List of ecosystem services (without classification)	De Groot et al. (2002) - Classification and list of ecosystem services	Millennium Ecosystem Assessment (2005) - Classification and list of ecosystem services	Wallace (2007) - Classification and list of ecosystem services
- Purification of air and water. - Mitigation of floods and droughts. - Detoxification and decomposition of wastes. - Generation and renewal of soil and soil fertility. - Pollination of crops and natural vegetation. - Control of the vast majority of potential agricultural pests. - Dispersal of seeds and translocation of nutrients. - Maintenance of biodiversity, from which humanity has derived key elements of its agricultural, medicinal, and industrial enterprise. - Protection from the sun´s ultraviolet rays - Partial stabilization of climate. - Moderation of temperature extremes and the force of winds and waves. - Support of diverse human cultures - Provision of aesthetic beauty and intellectual stimulation that lift the human spirit	- *Production*: Food, raw materials, genetic resources, medicinal resources, ornamental resources. - *Regulation*: Gas regulation, climate regulation, disturbance prevention, water regulation, water supply, soil retention, soil information, nutrient regulation, waste treatment, pollination and biological control. - *Information*: Aesthetic functions; recreation, cultural, and artistic information; spiritual and historic information; science and education. - *Habitat*: Refugium function, nursery function.	- *Provision*: Food, water, wood and fiber, fuel, natural medicines. - *Regulation*: Climate regulation, water, flood, erosion, pest, and disease control, and pollination. - *Cultural*: Aesthetic, spiritual, educational, recreational, and cultural values, ecotourism - *Supporting*: Nutrient cycling, soil conservation and formation, primary production, and water cycling.	- *Adequate resources*: Food, oxygen, water (potable), energy (e.g., for cooking–warming), dispersal aids (transport). - *Protection from predators/disease/parasites*: Protection from predation, protection from disease and parasites - *Benign physical and chemical environment*: Benign environmental regimes of temperature moisture, light and chemicals. - *Socio-cultural fulfillment*: Access to resources for: spiritual/philosophical contentment, benign social group, recreation/leisure, meaningful occupation, aesthetics, opportunity values, capacity for cultural and biological evolution, knowledge/education, genetic resources.

Many studies have investigated the relationship between ecosystem services and biodiversity (e.g., MA 2005, Mertz et al. 2007; Thompson et al. 2009; Haines-Young & Potschin 2009; TEEB 2010), trying to understand the role of biodiversity in providing "environmental services"; however, until now this interface is still not at all clear, even though there are studies that have tried to address this (Diaz et al. 2003, 2007a, 2007b, Mertz et al. 2007). Provision of ecosystem services could depend on biodiversity, and the associated ecosystem functioning of ecosystems is linked to it. Thus, higher biodiversity could allow higher levels of ecosystem services (Mertz et al. 2007). There is also growing evidence that relevant ecosystems have been degraded to such an extent that they are nearing critical "thresholds" or "tipping points", beyond which their capacity to provide useful services may be considerably reduced (Diaz et al. 2007a, 2007b; TEEB 2010; FAO-FRA 2010). Certainly, there is little hard evidence and high uncertainty (especially from tropical environments such as the Amazon forests) to address the role of biodiversity in maintaining ecosystem services, and how biodiversity loss can affect the existence of ecosystem services as ecosystems may have different species that carry out similar functions among other properties.

Some studies assert that there is a relationship between biodiversity and resilience of ecosystem services (MA 2005; Díaz et al. 2003, 2007*a*, 2007*b*; Thompson et al. 2009); the resilience of ecosystems is higher according to their state of conservation. For example, primary tropical forest (with high biodiversity) is more resilient to climate change than secondary forest (less biodiversity) (Thompson et al. 2009). Functional diversity has been suggested as the main biotic driver that links the services with the ecosystem processes (Diaz et al. 2003, 2007a, 2007b). The cascading effects related to the loss of functional diversity, the loss of ecosystem services and, therefore, the loss of benefits derived from them are unknown. According to the MA (2005) report, 15 ecosystem services from 24 that were examined have been degraded. What ecosystem services and benefits have been lost with these degraded ecosystems? This is still an open question.

Many concepts of ecosystem services have been proposed (some more than others). However, it is necessary to differentiate between ecosystem services and benefits and how the direct or indirect drivers of change could have an impact on their existence. For example, if deforestation reduces the carbon sequestration of an area, this could have a chain effect and affect the ecosystem services and, therefore, reduce their benefits. Clearly, the first step is to identify these benefits at different scales (local to regional). Further studies should analyze the dynamic relationships between biodiversity, ecosystem processes and services, and benefits, as well as determining what could be the geographical distribution of the impacts of global and regional drivers of change about their geographical patterns. There is also an interesting scientific discussion on the effects of sustainable use of ecosystem services (i.e., natural capital) and trade-offs arising from exploiting ecosystem services differently or selectively non-sustainable (i.e. TEEB 2010, Golstein et al. 2012, among others).

3. Distinction between ecosystem services and benefits

The approaches of Boyd and Banzhaf (2007), Fisher & Turner (2008) and Fisher et al. (2009) agree on an important point; they separate the concept of ecosystem services from benefits. Boyd & Banzhaf (2007) make the distinction between **end-products or final services,** intermediate products or components, and benefits. Final services or end products of nature are not benefits or final products consumed because they need one or more ecosystem services and production factors (infrastructure, information, etc.) to generate the benefit. Along with Boyd & Banzhaf (2007), Fisher & Turner (2008) and Fisher et al. (2009) make the distinction between final and intermediate ecosystem services, considering also that ecosystem services and benefits are not the same. Whether the ecosystem service is considered final or intermediate [or the intermediate component as in Boyd & Banzhaf (2007)] will depend on what is being valued, monitored or measured, as well as what are the benefits and who are the beneficiaries. On the other hand, the main difference between Boyd & Banzhaf (2007), Fisher & Turner (2008), and Fisher et al. (2009) is the service view. The first authors see services as ecological components (things you can count such as lakes, forest and wild life species population, among others). By contrast, Fisher & Turner (2008) and Fisher et al. (2009) see services as the processes of ecosystems as long as there are beneficiaries that derive benefits from them (see Fig. 1). One commonality among the three points of view is that they all consider ecosystem services as an integral part of to be ecological an integral part of in nature. In this sense, aesthetic values, cultural contentment, and recreation are not ecosystem services, but benefits, as they are a pre-condition for human capital and an ecosystem service (or function). Other authors considered non-ecological compartments to be ecosystems services and not benefits (De Groot 2002; MA 2005; Wallace 2007). Separating these chains of ecosystem service provision, its use (i.e., when the provision becomes a service), and the benefit are important to avoid double counting in economic valuation (see Boyd & Banzhaf 2007 for more details).

There are two main points to consider when it comes to units of account (economics): (1) Ecosystem services are ecological in nature and (2) they correspond to the aspects of ecosystems from which humans derive welfare. **In the same way, ecosystem services differ from benefits because the latter require other forms of capital (human, social, and others) (e.g., Boyd & Banzhaf 2007; Fisher & Turner 2008; Fisher et al. 2009).** Figure 1 shows an example based on the water cycle to make the distinction between ecosystem services, intermediate processes and benefits (e.g., drinking water). For the key regulation of ecosystem services of the Amazon (water, soil and climate), it will be crucial to try to make this distinction, considering also the perception of the different stakeholders at different scales, such as regional (basin scale) or sub-regional (sub-basin), and at local scales (i.e., strategic sites such as protected areas or indigenous territories). It is widely recognized that ecosystem services and the benefits they provide should be explicitly and systematically integrated in decision-making processes. However, the majority of studies have been carried out at a regional or global level, thus limiting their utility at smaller scales. Practically there are no studies on the benefits derived from ecosystem services (considering Boyd & Banzhaf (2007)'s, Fisher & Turner (2008)'s and Fisher et al. (2009)'s view) at the local scale. This is particularly true for the Amazon, even though the region is recognized as strategically important for the local services and benefits it provides.

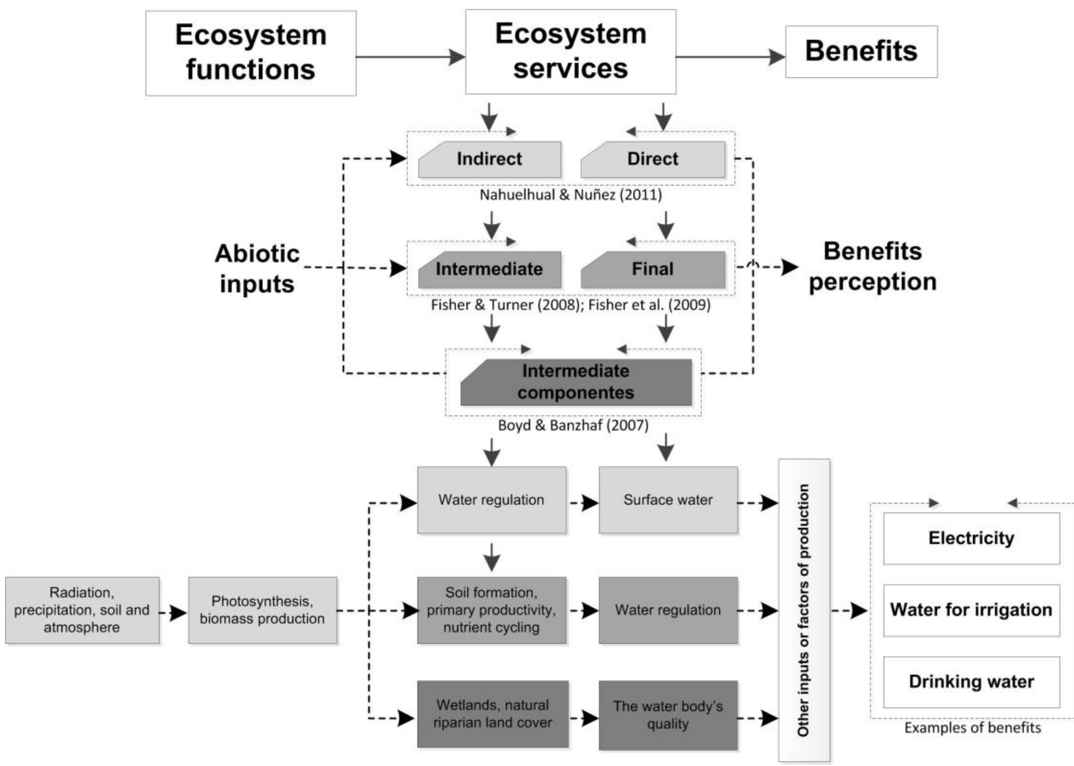

Figure 1. Different approaches to ecosystem functions, ecosystem services and their benefits.

4. Local scale ecosystem services and benefits perception

The concept of ecosystem services has evolved towards more operational definitions for decision making. This conceptual evolution has made it possible to differentiate between ecosystem services and benefits (see section above). The benefits materialize at the moment when human well-being becomes directly affected and can result from one or a combination of ecosystem services and different production factors. The Amazon has been recognized as a key region for the provision of globally-important ecosystem services. However, the benefits associated with other ecosystem services need to be seen at much smaller spatial scales, such as that of indigenous territories or protected areas.

Perception of the benefits of ecosystem services could be different when taking into account local, biophysical, and ecological conditions, as well as the social, economic, and cultural context (Hein et al. 2006; ESPA-AA 2008; Fisher & Turner 2008). For example, international demand for timber from the Amazonia may lead to a regional loss of forest cover, which increases flood extent along a local stretch of a river affecting local communities (MA 2005). Likewise, how the benefits of ecosystem services are perceived by local stakeholders, such as the indigenous groups and citizens that live directly from the natural ecosystems, will be different from how they are perceived by groups of scientists and urban people. The benefits in which they are interested will dictate their understanding of what an ecosystem service is. Taking the carbon sequestration service of the Amazon forests as an example, local stakeholders would perceive the benefit of biomass for fuel because this is their urgent need, while scientist and urban people may perceive the benefit of climate regulation rather than biomass for fuel (see Boyd & Banzhaf 2007).

Amazonian indigenous groups would identify the benefit of water as river transportation and consumptive use; the farmers inhabiting the same place would perceive the benefit of water as consumption for agriculture, and people from a nearby town would perceive the construction of a hydropower plant as the main benefit. Through their subsistence activities (hunting and fishing) and small scale production (the harvest of forest products and non-timber forest products), the indigenous people who inhabit these territories can act as a driving force for conserving the landscape, protecting different ecosystem services, and facilitating their benefits. It can causes land conflicts and trade-offs in ecosystem services, where new hydropower plants impact indigenous livelihoods. Therefore, when addressing the ecosystem services of a region, it is crucial to take into account their benefits at local scales. Thus, our understanding of the relationships between ecosystem services and their benefits requires studies with a multi-scale approach. A trade-off analysis of ecosystem services that have their specific importance at either local, regional or global scale have to take into account the different perceptions of the different stakeholders at different scales to be closer to the real social processes (see Aguiar et al. 2007).

5. Main ecosystem services in the Amazonia

There are several classifications schemes of ecosystem services, and when it comes to prioritize main ecosystems in the Amazonia it is difficult to make definitive conclusions, because they vary according to the scale of perception and the classification scheme that is being used (Hein et al. 2006; ESPA-AA 2008; Fisher & Turner 2008). In fact, there are some studies that try to address the main ecosystem services in the Amazonia, taking into account different stakeholder's views and the Amazon environment (i.e., ESPA-AA 2008). Within AMAZALERT, we tried to identified priority amazon ecosystem and their drivers of change considering the perception of the AMAZALERT´s specialist in a workshop and literature review:

a) **Main ecosystem services and driver of change (Kick-off workshop results):** The project held an inaugural meeting from 3-5th October in Sao Paulo, Brazil. During the third day of the workshop, we identified and prioritized the most important large-scale Amazonian ecosystem services and its drivers of change. The original idea was that there would be 10-15 stakeholders, but there were only 3; however, the workshop was carried out anyway to get the perception of the AMAZALERT team and stakeholder's suggestions for future connections. In total twenty persons completed the questionnaire, from different organizations: Alterra / WUR (Wageningen University); EMBRAPA (Empresa Brasileira de Pesquisa Agropecuaria Brazil, Brazilian Agricultural Research Corporation); INPE (National Institute for Space Research); JR (Joanneum Research); FAN (Fundación Amigos de la Naturaleza); PIK (Potsdam Institute for Climate Impact Research) and University Gent (Belgium). As a result, seven ecosystems services were selected as the most relevant (see deliverable D 1.1 and Figure 2): ***consumptive use, carbon storage in intact forests and soils, maintenance of favorable climate, subsistence agriculture, fishing, providing living space to wild plants and animals, and protection of biodiversity***. Among these, ***protection of biodiversity*** is the service with the highest value for the AMAZALERT consortium.

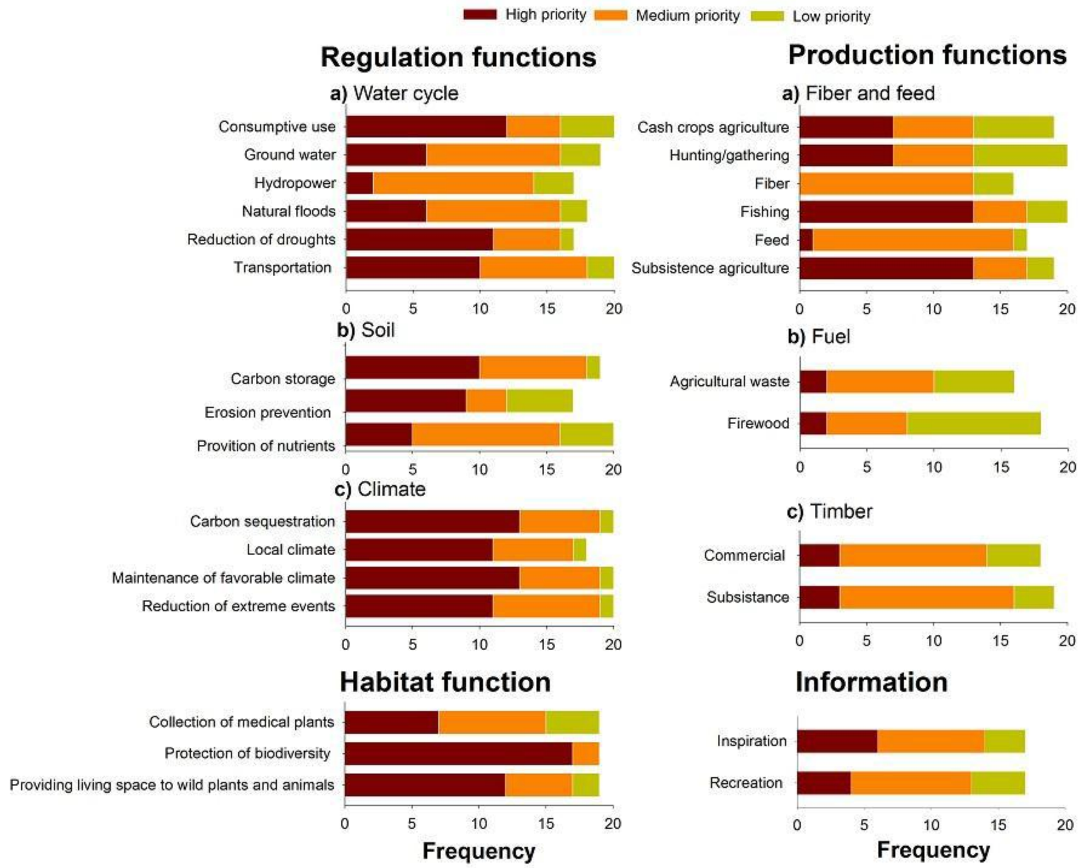

Figure.2. Amazon ecosystem services prioritization. The figure shows the results obtained to the prioritization of the regulation ecosystem services (a: water cycle, b: soil and c: climate), the production ecosystem services (a: fiber and feed, b: fuel, and c: timber), and the prioritization of the information and habitat function ecosystem services. Frequency is referred to the number of times that each person weighted each ecosystem service.

The main drivers of change were analyzed for the seven ecosystem services identified as the most relevant. The drivers of change were split in two categories, deforestation (or land use change drives) (Figure 3a, 3c) and climate change drivers (Figure 3b-3c). The key drivers of change identified were ***large scale agriculture production and infrastructure*** (river dams, roads, settlements, expansion of cities, etc.), ***following by slash and burn, wood industry*** (legal and illegal) and ***cattle ranching***.

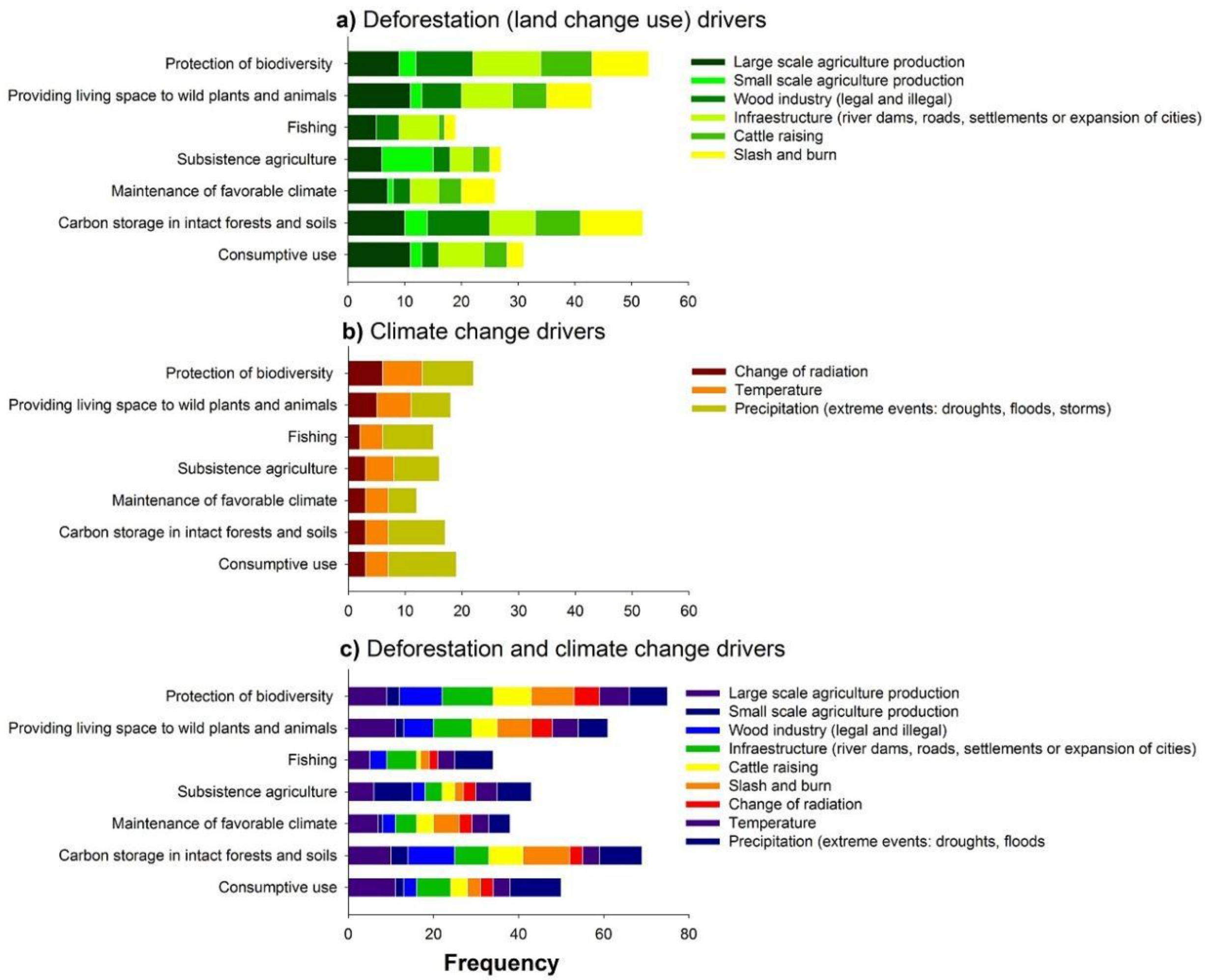

Figure 3. Amazon ecosystem services prioritization. The figure shows the results obtained to the prioritization of the regulation ecosystem services (a: water cycle, b: soil and c: climate), the production ecosystem services (a: fiber and feed, b: fuel, and c: timber), and the prioritization of the information and habitat function ecosystem services. Frequency is referred to the number of times that each person weighted each ecosystem service.

b) **Main ecosystem services and driver of change (Literature review):** Overall, the main ecosystems services in the Amazon could be water supply, fishing (that could be a benefit derived from the protection of biodiversity conservation and water supply), climate regulation, carbon sequestration, soil (related to agriculture), provision of living space to wild plants and animals, and the protection of biodiversity (including genetic resources). Climate regulation and water supply at different scales are relevant services since vegetation is closely related to energy and water fluxes between the land surface and atmosphere (Betts 2001). The role of ecosystems in energy and water regulation in the Amazon basin is highly relevant; the incoming air from the Atlantic Ocean provides two-thirds of the Amazon moisture and the process of evapotranspiration is responsible for recycling the remaining one-third of the moisture (Costa & Foley 1999). These processes are linked to energy absorption and latent and sensible heat fluxes which in turn regulates convective precipitation (Davidson et al. 2012). In mountainous areas, processes of fog interception (horizontal precipitation) occur due to montane cloud forests that favor fog interception and water condensation in vast regions of the east-oriented portions of the Andean mountain range (Mulligan & Burke 2005; Bruijnzeel 2004). Numerical models show that a reduction in precipitation is expected after deforestation, following changes in energy and water fluxes (Sampaio et al. 2007; Coe et al. 2009; Mei & Wang 2009). Ultimately, river discharge and groundwater recharge are susceptible to changes in evapotranspiration and precipitation at different scales (Davidson et al. 2012).

Carbon sequestration is a global service derived from forests as they remove large quantities of atmospheric CO_2, Amazon forest (which is one of the largest forests in the world) has a potential for being an important carbon sink with relevance at regional and global scales. Even though deforestation threatens this service as many of these sequestered carbon are released back into to the atmosphere, fluctuating in the last decade in the Amazon from 692 to 901 $TgCO_2yr^{-1}$ (Aguiar et al. 2012). This shows the high uncertainty that exist in estimating carbon emissions from deforestation where biomass estimates is the largest source of uncertainty. Carbon sequestration could not have a direct impact on local stakeholder's perception other than economic incentives to preserve the forest (e.g., payment for environmental services and REDD schemes, see ESPA-AA 2008).

What is clear is that forests are more than carbon; they bring a lot of ecosystem functions and services as provision of forest products and non-forest products and provide the living space to wild plants and animals and the protection of biodiversity (including genetic resources, such as, seeds, fishing and aquatic biodiversity). Local stakeholders depend on biodiversity due to the benefits of food, subsistence agriculture and fishing, provision of medical plants, and wild meat consumption, as the global society also depends on these benefits at a global scale (i.e., food, commercial agriculture, new species for science that could lead to the cure of mortal diseases) (MA 2005; ESPA-AA 2008; TEEB 2010).

The main driver of change in the Amazon is land use change through deforestation and large-scale degradation of tropical rain forest (Nobre et al. 1991; Martino 2007; Betts et al. 2008; FAO FRA 2010). In some countries, the most visible threat is deforestation and forest degradation through road expansion and large scale agriculture that comes with intensive use of fire influenced by access to markets among others (Barreto et al. 2006; Martino 2007; Aguiar et al. 2007: Killen et al. 2007; Jarvis et al. 2009; Betts et al. 2008; Müller et al. 2011a). About 80% of the deforestation in the Amazon has occurred within 30 km of a paved road (Barreto et al. 2006), and the agriculture frontier has expanded. The so-called "arc of deforestation" shows that until 2001, 80% of the deforestation in the Amazon had occurred in Brazil (Betts et al. 2008). In the periods 1990-2000 and 2000-2010 Brazil displayed the highest net loss of forest in the world (FAO-FRA 2010). Even so, from 2000 to 2010 there has been a substantial reduction in the Brazilian deforestation rates (Betts et al. 2008; FAO-FRA 2010).

Deforestation may alter climate- and hydrology-related ecosystem services (climate regulation and water supply services) at different scales since vegetation is closely related to energy and water fluxes between the land surface and atmosphere (Betts 2001). Deforestation in upper zones of Amazonia has resulted in sediment transport and deposition with a direct relation to mobilization of pollutants and contamination-pollution problems (Forstner & Muller 1973; Akagi et al. 1995; Barbosa & Dorea 1998; Roulet et al. 1999, 2000; Cordeiro et al. 2002; Maurice-Bourgoin et al. 2003; Lacerda et al. 2004; Almeida et al. 2005; Davidson et al. 2012; Ferreira et al. 2009). Flood dynamics are also strongly linked to changes in land cover. Sediments from deforested areas in medium and upper portions of the watersheds along the Amazon are draineposited in large floodplain environments, altering the drainage capacity of the river systems and affecting ecosystems, local communities, and infrastructure (as well as the benefits such as hydropower generation and transport) (Maurice-Bourgoin et al. 2000; Martinez et al. 2006; Martinez & Le Toan 2007).

Another relevant agent of disturbance has emerged putting at risk the future of the Amazon Basin. This threat is climate change (Betts et al. 2008; Philips et al. 2010; Toledo 2010; Davidson et al. 2012), which involves the possibility of severe droughts (e.g. Betts et al. 2008; Philips et al. 2009) and forest die-back (substitution of forests by savanna, which has been projected by the Met Office Hadley Centre model), and has captured the attention of many scientists. However, deforestation poses a more direct threat, and may interact with climate change through various feedbacks as well as processes such as fire (Cochrane & Barber 2009; Marengo et al. 2011). The perception of the climate change drivers is growing. After visualizing the role of forests, it is not hard to infer the situation without them to take consciousness of the relevance of the services they provide.

c) **Variance between literature review and Kick-off workshop results.** Both sources of information settled the same ecosystem services in general (*water supply*, *fishing*, *carbon storage*, *climate regulation*, *providing living space to wild plants and animals, and protection of biodiversity*) (see Table 2); however, water supply was focused in two different scales. Literature focused on water regulation service, while the workshop focused on the water consumptive use. Biodiversity was prioritized by the workshop and literature; also, AMAZALERT team highlighted this ecosystem service as the most important. On the other hand, the subsistence agriculture service was only prioritized by AMAZALERT team.

Table 2. Ecosystem services prioritized by literature and the kick off workshop

ECOSYSTEM SERVICES PRIORITIZED	
Literature review	**Kick-off workshop**
- Water supply	- Water consumptive use
- Fishing	- Fishing
- Climate regulation	- Maintenance favorable climate
- Carbon sequestration, soil	- Carbon storage, in intact forest
- Provision of living space to wild animal and plants	- Providing living space to wild plant and animals
- Protection of biodiversity	- Protection of biodiversity
	- Subsistence agriculture

6. The role of protected areas and indigenous territories in the preservation of the Amazon ecosystem services

The perception of protected areas and the role of indigenous cultures within them had evolved in such a motivating way. At the beginning of the 19th century the protected areas were conceived as hunting reserves or reserved forest arrogated to the state in benefit for future generations. This model of conservation, reflected first in the USA with the creation of National Parks and then expanded worldwide, generally excludes local residents and denies indigenous rights (Colchester 2004). During the 20th century, international bodies like The World Conservation Union (IUCN), International Labour Organization (ILO) and Convention on Biological Diversity (CBD) had achieved a general framework that promotes conservation in a more equitable and sustainable way. The advent of today´s concept of conservation implies also the recognition of indigenous rights, culture, knowledge and furthermore their governance. In the case of Amazonia, those indigenous rights are now supported by specific laws or constitutions. Although the concepts of conservation and the indigenous rights have developed widely, there are many threats affecting indigenous rights and their territories (agriculture and cattle expansion, gold mining, oil companies, etc.) (Borrini-Feyerabend et al. 2004; Colchester 2004; Barreto et al. 2006).

Deforestation is the most evident impact and brings tremendous consequences for the conservation of Amazonia's ecosystem services. Local people (e.g., indigenous and rural inhabitants) are the most vulnerable to changes in the provision of ecosystem services, due to the high interdependency between them and the natural ecosystems (Finer et al. 2008, ESPA-AA 2008). Thus, conservation for indigenous people is a challenging task involving external factors and particular views or paradigms of development (Schwartzman & Zimmerman 2005). If ecosystem services benefits are perceived at a local scale (indigenous communities), protected areas and indigenous territories can play a fundamental role on their conservation. The extension of indigenous territories (2,144,412 km) and protected areas (1,696,529 km) represents almost 45% of Amazonia (21.8 and 27.5%, respectively, RAISG 2012). At the same time, at a global level, indigenous territories and protected areas could be the last reservoirs of pristine forests (and the benefits that comes with them) as well as refugees for biodiversity threatened by accelerated land use change. Many other initiatives involving indigenous peoples and the Amazon imply both conservation of a common benefit or service and development for local people (Posey 1985; Gadgil et al. 1999; De Jong 2001; Schwartzman & Zimmerman 2005; Coria & Calfucura 2012).

Protected areas are mitigating the impacts of ecosystems fragmentation (Ferraz et al. 2007; Martino 2007); moreover, the growth rate of unofficial roads is three times lower inside them (Barreto et al. 2006) and their population densities are particularly low (ESPA-AA 2008). Indigenous territories occupy much more territory than national parks or other categories of protected areas and, in general, are located in the proximity of intense intervened areas. Thus, indigenous territories are functioning as the main barrier to deforestation in Amazonia (Nepstad et al. 2006). Recent research in the Brazilian Amazon shows that in the states of Pará, Rondônia, and MatoGrosso, indigenous territories barred deforestation in high-pressure areas (Espindola et al. 2011).

Ecosystems conservation in indigenous territories and protected areas is fundamental as they constitute a geographic space that guaranties the continuity of most of the ecosystem functions and services and its benefits across the Amazon. However, the weak governance at different scales (municipal, regional, national), the lack of specific institutional and legal frameworks allowing indigenous participation in conservation policies or the systematic violations of laws regarding protected areas and indigenous rights are relevant constraints to be taken into account.

7. Remarks and conclusions.

The most recognized and used definition and classification of ecosystem services is that proposed by the Millennium Ecosystem Assessment, which covers ecosystem goods and services. However, since 2005 the concept of ecosystem services has evolved towards more operational definitions for decision making.

Today, this conceptual evolution has made it possible to differentiate between ecosystem services and benefits. The benefits materialize at moment when human well-being becomes directly affected. They can result from one or a combination of ecosystem services and different production factors. For example, drinking water, electricity, and water for irrigation are benefits derived from hydrological ecosystem services (an indirect service) along with other inputs and factors of production, such as infrastructure, labor, and information.

Differentiating between ecosystem services and benefits could help in the intention of bringing together the economic and the natural sciences. However, the perception of the ecosystem services and benefits can be different when taking into account local, biophysical, and ecological conditions, as well as the social, economic, and cultural context (Hein et al. 2006; ESPA-AA 2008; Fisher & Turner 2008). This work rescues information from literature and AMAZALERT team opinion. However, it is important to emphasize that these may have a regional perspective, perhaps if the questionnaire would have been filled by local stakeholders, they would have identified more urgent services such as food, fuel or water.

At the regional scale (Amazon Basin), it is difficult to identify the main ecosystem services, as they can vary depending on the point of view of people benefiting from them and the specific context of the study or project (and the data availability), the stakeholders consulted and the classification scheme. Nevertheless, with the main ecosystem services presented in this review, we aimed to link the ecosystem services with their benefit perception according to different stakeholders and the main impacts that land use change and climate change will have on them. In this sense, the key variables recommended for future modeling were: a) carbon storage and fixation, b) water regulation and c) biodiversity. This last will be modeling by the ROBIN project (see http://robinproject.info/home for more details). In addition, we wished to highlight the role of protected areas and indigenous territories in the effective conservation of Amazon ecosystem services.

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