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Natural capital and bioeconomy: challenges and opportunities for forestry

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Abstract - Over the last decades, the stock of natural capital has been globally reduced by human-induced effects such as climate change, and land use and cover modifications. In particular, the continuous flow of goods and services from ecosystems to people is currently under threat if the current human activities still remain unsustainable. The recent bioeconomy strategy is an important opportunity to halt the loss of biodiversity and the reduction of services provision, from global to local scale. In this framework, forest sector plays a fundamental role in further enhancing the sustainable development and the green growth in degraded environments, such as marginal and rural areas. This paper provides an overview of the bioeconomy-based natural resources management (with a focus on forest ecosystems), by analyzing the related challenges and opportunities, from international to national perspective, as in Italy. At first, the role of forest sector in addressing the purposes of green growth is analyzed. Secondly, the most suitable tools to monitor and assess natural capital changes are described. Finally, the most important research contributions within the bioeconomy context are reported. To create the suitable conditions for bioeconomy and green growth, the following insights have to be denoted: (i) a deeper understanding of natural capital and related changes; (ii) the improvement of public participation in decision-making processes, especially at landscape scale; (iii) the effective integration of ecological, socio-cultural, and economic dimensions while managing natural resources.

Keywords - Natural capital, bioeconomy, forest ecosystems, ecosystem services, land use and cover change

The need for bioeconomy-based natural resources management

The concepts of "green-growth" and "bioeconomy" have been developed on the consciousness that population is expected to rapidly raise in the next 40 years (Rosegrant et al. 2012). This trend most probably will cause an increase of pressures on natural resources use and a growing inequality for their distribution among people, especially with regards to wild and seminatural ecosystems, soil, water resources, and croplands, and, as a consequence, an erosion of the largest part of the Ecosystem Services (ES) strictly related to Land Use and Cover Change (LUCC), the main driver of global change.

Overcoming these situations specifically requires responsibility in subsidiarity and innovation in order to achieve concerted changes in lifestyles and resource use, across all levels of society and economy (EU 2012). There are a number of key-drivers for the development of a green economy, as follows (Rosegrant et al. 2012): (i) the demand for renewable biological resources and bioprocesses; (ii) the need for improving the management and the sustainable use of renewable resources; (iii) facing substantial challenges, such as e.g. energy and food security, in the context of increasing unpleasant social phenomena like the neocolonialism (i.e. "land grabbing") or the prevalence of export-driven cropping systems, and several constraints on water, productive lands and carbon emissions (e.g. Sheppard et al. 2011); (iv) the rapid uptake of biotechnologies in agricultural productions; and (v) the opportunity to reduce environmental degradation through more sustainable production procedures. Other important challenges derive by the fact that the bioeconomy proposal is not about protecting the environment, but instead it is about promoting the economy – in spite of clear indications of the harmful impacts that are already resulting from massive new demand for biomass, including soil loss (a long-term renewable resource), biodiversity at gene, species, stand and landscape level, as well as escalating hunger and conflict (Hall et al. 2012).

Taking under consideration the past human-induced changes and their consequences on the increasing depletion of nature, the current stock of natural capital is almost compromised and is passing through several safety thresholds of planetary boundaries (Hughes et al. 2013), such as the CO2 atmospheric composition, i.e. gaining 395 ppm in 2013, despite a tipping point of 350 ppm (Hansen et al. 2013). But also soil and forests and water are strongly threatened. The key necessary condition for

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achieving sustainability lies at least on the constancy of the natural capital stock over the time (Pearce et al. 1990). In this way, natural capital properly refers to "a stock that yields a flow of valuable goods and services into the future" and can be differentiated into "renewable natural capital (active and self-maintaining using solar energy, such as forest growing as known since the XVIII century) and non-renewable natural capital (passive)" (Costanza and Daly 1992). For instance, to sufficiently unravel the past anthropogenic effects on natural resources and the more recent shifting from Holocene to Anthropocene era, Ellis and Ramankutty (2008) globally identified and mapped the "Anthromes", namely Anthropogenic Biomes. In this way, the evaluation of ecosystem functioning (including biodiversity as main supporting element; see e.g. Cardinale 2013) is extremely important to globally reduce the impacts of the main drivers of change. For this purpose, monitoring the land use changes (one of the most accelerators of human-induced environmental modifications; Foley et al. 2005) is useful to orient the current overexploitation of natural resources towards a more "resilience-based" trajectory (e.g. Ellis et al. 2013).

Green economy and natural resources: the role of forest sector

Beside these general considerations, in forestry the green economy benefit starts when and occurs through management tools and investments that could limit trade-off effects of traditional multi-functionality and expand the ES availability for the society with a scope of fairness within and among generations (see also Atkisson 2012). Indeed, green economy improves human well-being and social equity, and significantly reduces environmental risks and ecological scarcities (UNEP 2011a). Sustainably managed forests play an essential role in the carbon cycle and provide essential environmental and social values, and ES, beyond their contribution as a source of wood, such as biodiversity conservation, protection against erosion, watershed protection and employment in often fragile rural areas. In this perspective, in order to promote the effectiveness of green economy in managed forests, the UNECE Committee on Forests and the Forest Industry (COFFI) and the FAO European Forestry Commission (EFC) decided to take action and prepared the Rovaniemi Action Plan for the Forest Sector in a Green Economy (ECE/TIM/SP/35). This Action Plan consists of 5 pillars with their respective goals, which are: (i) sustainable production and consumption of forest products (patterns of production, consumption and trade of forest products are truly sustainable); (ii) a low carbon forest sector (the forest sector makes the best possible contribution to mitigation of, and adaptation to, climate change); (iii) decent green jobs in the forest sector (the workforce is able to implement sustainable forest management, and the forest sector contributes to achieving the social goals of the green economy by providing decent jobs); (iv). long-term provision of forest ES (forest functions are identified and valued and payments for ES - PES (Payment for Ecosystem Services)– are established, thus encouraging sustainable production and consumption patterns); (v) policy development and monitoring of the forest sector in relation to a green economy (policy-makers and institutions in the forest sector promote sustainable forest management, in a way that is adequate to mainstream the green economy in forest sector policies).

To operationalize these broad guidelines, it is recommended to follow the Ecosystem Approach (EA). EA is a method for sustaining or restoring natural systems and their functions and values. It is goal-driven approach, and is based on a collaboratively-developed vision of desired future conditions that integrates ecological, economic and social factors (Inter-Agency Ecosystem Management Force 1995). Furthermore, EA is not a static model but is a holistic process for integrating and delivering in a balanced way the three objectives of the Convention on Biological Diversity (CBD): conservation and sustainable use of biodiversity, and equitable sharing of the benefits (Maltby 2000). Therefore, only an ecosystem-based management of natural resources can halt the loss of biodiversity and the degrade of resources quality. This is exactly one of the purposes of the Bioeconomy Strategy, properly aimed at improving the knowledge base and fostering innovation to increase productivity, while ensuring sustainable resource use and alleviating stress on the environment (COM 2012).

According to the evolution of classical economic theories, the need to consider forests both as factors of production and ecological infrastructures is always stronger. In particular, the contribution of forest management and land use planning (especially in fragile forest areas, as mountain environments) in the context of green economy growth has to consider also the biodiversity of forest ecosystems and the related ES as results of complex ecological processes and interactions amongst different ecosystems in a holistic view (Ciancio and Nocentini 2004, Mace et al. 2012).

At European level, Bengtsson et al. (2000) argued that the next generation of forestry practices would need to: (i) deeper understand natural forest dynamics; (ii) analyze the role of biodiversity (i.e.

key species and functional groups) in supporting the ecosystem functionality; (iii) implement and adapt management prescriptions in accordance with natural dynamics; (iv) consider ecology, forestry, economy, and social fields in order to establish a value of the important ES from forest ecosystems. Furthermore, in line with these good practices, forest management needs to avoid the impact of disturbances (such as e.g. anthropogenic eutrophication, toxic pollution, habitat loss, disconnection from adjacent ecosystems, species invasion, climate change, etc.), which can induce long-term ecosystem changes (see e.g. Ellis et al. 2013).

Although natural resources have an intrinsic value for improving sustainability, the vision of the natural capital has become the subject of ethical and conceptual discussion and debate, especially in conservation topics. This led to divisions between those who intend the conservation of nature as such, by virtue of its intrinsic or existence value with an assessment meaning (Soulé 2013), and those, instead, who intend it as an element of supporting for human well-being (e.g. Reid et al. 2006, Kareiva and Marvier 2012, Toledo and Barrera-Bassols 2014), translatable, therefore, in an instrumental value. Nevertheless, in recent years, the concept that the integration of different views and philosophies underlies the conservation, protection and restoration of natural resources has been clarified (Tallis and Lubchenko 2014). Therefore, it is important to remind that the value of a stock of natural resources, such as in particular a forest, is more than the sum of various functions that are assigned to that forest from time to time, which means recognizing that forest has intrinsic value (Ciancio and Nocentini 2004).

In order to further improve the contribution of the forest sector and its intrinsic awareness for a responsible green economy, it is essential to assess (EFI 2014): (i) the forest products market changes and, in particular, the C substitution rate stored in forest products (in general throughout the whole production chain, including the entire Life Cycle Assessment - LCA), and its trade-offs with other ES; (ii) the changes in cultural and non-marketed ES, which are difficult to price, such as tourism and recreation, and aesthetic, historical and cultural values, etc.; (iii) the current and future investments in the business sector related to forests and timber production, taking into account the enhancement of multi-functionality and a responsible and sustainable management; (iv) the changes in the ownership of the forest and the enterprise sector, considering the participation as a strong element of identity, belonging, proximity and protection of the territory; (v) the global demand for expertise services in forest governance, forest administration, inventory and information systems, as well as in forest education. Therefore, the major challenges for the forest sector in the context of the green economy partly refer to land use change and market failures, or to forest policy and planning. The socio-economic processes play a key role in ecosystem modifications, thus directly influencing human welfare (Ellis et al. 2013). For example, all the forestry activities are increasingly knowledge-intensive and address challenges, such as those related to natural resources assessment and monitoring in a context of global change (EFI 2014). In a context of change, the preservation of intrinsic and utilitarian values of natural capital has to be encouraged, as it is a key element for the reconciliation and the building of a sustainable, responsible and resilient human-nature relationships.

Linking natural and cultural capital

The need of a strong interconnection between the natural and cultural capital assets is well expressed in the “Chart of Rome” (CoR, Presidenza Italiana del Consiglio dell’Unione Europea 2014), whose aim is to broaden the scope of nature and biodiversity policy without changing it, but rather mainstreaming it into other policies related to the territory and the economy. Although the main target groups of CoR are scientists, stakeholders and policy-makers, its message is also for citizens. It is a European initiative and develops on the EU cornerstones of Natura 2000 and the EU Biodiversity Strategy to 2020. The primary role is the promotion of a better conservation and valorization of the natural and cultural diversity. Moreover, the CoR acts as a platform for further collaborations on biodiversity in general, and in particular on ES, as well as on their societal implications (i.e. climate mitigation, clean water, clean air, protection against floods and erosion).

Furthermore, it finds its roots in the CBD, specifically with regards to protecting and encouraging the customary use of biological resources in accordance with the traditional cultural practices that are compatible with conservation or sustainable use requirements (UNEP 1992). CoR is strongly connected also with the Convention for the Safeguarding of Intangible Cultural Heritage, because communities and groups are able to constantly recreate their intangible cultural heritage, since it is the product of the interaction between nature and history, and it is transmitted from throughout generations, according to the environment they live in. In this way, people enhance their own sense of identity and continuity, and, as a consequence, promote the respect for cultural diversity and human creativity (UNESCO 2003). Another bridge built by the CoR with the EU biodiversity-related policies is the Green Employment Initiative (COM/2014/446). This initiative aims at indicating the way for job creation potential in the green economy sector with reference to skills, education and training, green public procurement, promotion of entrepreneurship, increasing of data quality (including statistical definition of employment in the environmental sector) and promotion of social dialogue.

CoR is strongly related to the adaptive capacity of human populations to deal with and modify the natural environment (Berkes and Folke 1992), the natural capital, which is composed by the ecosystems. Therefore, healthy and resilient ecosystems can provide society with a full range of economically valuable goods and services. To maintain healthy ecosystems, the following responsible actions are needed (Presidenza Italiana del Consiglio dell'Unione Europea 2014): (i) making use of good knowledge and data on biodiversity, ecosystems, their structures and functions, and on links with ES and associated benefits; (ii) maintaining, restoring and enhancing capacities to provide a range of goods and services and associated benefits; (iii) exploring natural capital as a solution to major challenges such as those related to urban areas, climate change and adaptation, agriculture and soil, forestry, hydrological risks, tourism and recreation. In this sense, good knowledge, research and data gathering on biodiversity and ecosystems are essential, because they make the knowledge base accessible to citizens and decision-makers, thus ensuring that policy-makers continue to understand and consider complex environmental state and dynamics.

In addition, cultural and economic scientists (e.g. Throsby 1999) contributed to identify cultural capital as a set of three main features, such as (Sukhdev et al. 2014): (i) knowledge, including traditional and scientific dimensions; (ii) capacities, as the way knowledge is retained, increased, elaborated and developed; and (iii) practices and human activities producing tangible and intangible flows of goods and services.

In order to maintain a positive link between cultural and natural capital, the following goals have to be reached (Presidenza Italiana del Consiglio dell'Unione Europea 2014): (i) taking into account social and cultural dimension of ecosystem management; (ii) promoting locally adapted knowledge, capacities and activities with positive impacts on natural capital; and (iii) connecting benefits, goods and services from ecosystems (supply) with patterns of culture, society and economy (demand). Moreover, green infrastructures can contribute to these goals, since they connect natural and seminatural areas with urban and rural areas. They are also drivers of a transition towards a green economy and are able to guarantee many natural, cultural, social and economic linkages. In Italy, the recent report concerning the socio-economic assessment and monitoring of natural capital and Protected Areas (PA) is the first attempt to contribute to the pillars of green economy at national level (MATTM and Unioncamere 2014). The report results mainly reveal what is the current condition about biodiversity conservation, what ES are correlated to cultural capital and local communities, and how sustainable practices effectively contribute to the green economy concerns.

Even green economy-related contributions are increasing, the concepts of natural capital, ES, and cultural capital require further operational definition and understanding. A knowledge-based improvement of the concept and its operationalization are in line with the EU nature and biodiversity strategies, directives and overall policies, which are expected to enhance and promote biodiversity conservation, the sustainable use of natural resources, while improving communication, mainstreaming and policy consideration in a wide societal and political context.

Monitoring changes of natural capital: land use and ecosystem services relationship

An important issue in many debates concerning the policies and the governance of the landscape is the ES assessment. Public interest in ES assessment has been starting since the milestone work on the economic assessment of natural resources made by Costanza et al. (1997). Mostly after the CBD (UNEP 1992), biodiversity and ES in general were placed at the base of the most important global, European and national processes focusing on the enhancement and preservation of natural resources and ecosystems as sources for multiple services and benefits for the society (see European Biodiversity Strategy to 2020 (EP 2011/2307(INI) and the Italian Biodiversity Strategy (MATTM, Decree 6 June 2011)).

Although the ES concept is already central in conservation policies and environmental impact assessments (Burkhard et al. 2010), useful methodologies for its practical application are still needed, in order to support the sustainability in natural resources management. Following the needful for quantifying the natural capital and ES, both biophysical and economic aspects have to be considered. If the goal is to measure the efficiency of natural resources management as a whole, then the quantification of benefits from ecosystems is necessary, especially to preserve the stocks of natural capital useful to generate ES. Indeed, the approach of the Millennium Ecosystem Assessment (2005) is based on the notion that the resource management involves the study of the relations between the ES and their quantitative estimation. As a consequence, there is nowadays a considerable interest to establish innovative approaches to calculate ES at different spatial and temporal scales.

Among terrestrial ecosystems, forests (including other wooded lands) are one of the most important sources of services and benefits for the entire humanity. Forests (Vizzarri et al. 2013): (i) protect biodiversity, providing habitats to more than half of the plant and animal known species; (ii) play a significant role in regulating biogeochemical cycles and, consequently, in the mitigation of climate change at different spatial scales; (iii) generate a large set of goods and products (timber and non-timber); (iv) host and protect sources and catchment areas accessible to man, often characterized by high quality water; (v) protect the traditional, cultural and spiritual values of many societies in the world.

In particular, considering the provisioning services, forests can assure the availability of wood for building, firewood and other non-timber forest products (e.g. cork, tannin, mushrooms, truffles, berries, etc.), which represent important economic components for the economies of many Countries. In addition, forest soil and topsoil have an enormous capacity to filter out most of the chemical components of pollutants and to reduce the surface runoff, thus preventing and reducing the risk of erosion and slope instability. In many cases, the presence of forest areas reduces the need of treatment (and, therefore, of the related costs) for the production of drinking water available to the local population, as shown in several case study around the world (Dudley and Stolton 2003).

Amongst the regulation services, forests are integrated in climate mitigation processes. In particular, forest stands have a threefold relationship in the face of climate change, as follows: they are adapting themselves to the effects of climate change, but at the same time, are subject of the general causes (emission source, from deforestation) and of the solution (major terrestrial sink). Indeed, among the different contributions of forests to climate change mitigation, there is the absorption of carbon from the atmosphere. Especially in "fragile" landscapes (such as mountain areas), forests are of primary importance to protect infrastructures and buildings from disasters, like avalanches, landslides, debris flows, rolling stones, and erosion processes in general. The vegetation strongly affects the water supply to the ground directly intercepting rainfall, attenuating the incident solar radiation and by controlling the evapotranspiration rate.

Supporting services are considered intermediate services as predisposing conditions so that a final service can be provided. In this case, forest biodiversity is the key element to support the provision of all other services, as it directly affects the properties of self-regulation and adaptation of forest ecosystems, and the capacity of a forest to produce timber or to be resilient and resistant against natural or anthropogenic disturbances. In this context, the role of biodiversity is essential for enabling to the availability of other services, because it (Vizzarri et al. 2013): (i) supports ecosystems in the structural, compositional, and functional diversification; (ii) influences the productivity, stability and resilience of ecosystems; (iii) increases the cultural and aesthetic value due to the presence of particular organisms and habitats; (iv) indirectly provides diversified products for rural populations (food, fiber, etc.).

Around the forest ES provision, forest landscapes have also intrinsic traditional, cultural and spiritual values, because they result from a profound historical interaction between man, its activities, and the surrounding nature. In addition, forest landscapes offer unique experiences, such as combinations of suggestive images (e.g. the colors of the vegetation, the behavior of wildlife, remote and unspoiled landscapes, etc.), echoing sounds (e.g. the birds chirping, the hum of insects, superior animal sounds, etc.) and strong scents (e.g. the smell of flowers or berries, etc.).

Considering forests as natural integrated systems, inside and outside ecological processes play a key role in governing the energy and material flows between ecosystems and man. Therefore, the potential of "supply" of services by a forest ecosystem is closely linked to its "health", namely the balance of its resilience characteristics, durability, low vulnerability and stability over time. The analysis and quantification of forest ES may be in conflict with an economic approach, because the intrinsic values that people attribute to ecosystem structures and processes are often not corresponded by economic "market" value (Farber et al. 2002). Consequently, the quantification and economic evaluation of forest ES must take into account the following critical issues: (i) how to separate "stocks" from "flows"; (ii) counting for potential beneficiaries of a given service, as well as its durability and availability in time; (iii) distinguishing the production of the service that may potentially be used with the one that is currently being consumed. The use of indicators can be an effective strategy to "quantitatively" measure and monitor complex phenomena such as ecological ones. In the ES assessment, indicators should be as inclusive as possible and properly selected on the basis of ecosystem properties and structures. They should also be easy to understand, allowing easy communication between institutions, technicians, professionals, and stakeholders at the local scale (Vizzarri et al. 2013).

While analyzing and evaluating forest ES, the anthropogenic impact on ecosystem functioning and, therefore, its ability to provide a set of services (and, consequently, benefits) must be considered. During the evolutionary history, humans excelled due to their ability to model ecosystems throughout the use of tools and techniques, which are beyond the capabilities of other living organisms (Smith 2007). Therefore, the importance of the "human factor" is essential: currently more than 75% of the land in the world shows disturbance caused by human action, with less than a quarter remained as wild land, able to support only 11% of the net terrestrial primary productivity (Ellis and Ramankutty 2008). Consistently, some scientific theories define Anthropocene as the current time that the Earth is living (Zalasiewicz et al. 2008). Lambin et al. (2001) stated that LUCC: (i) has an heavy impact on biodiversity at a global scale; (ii) contributes to climate change at the local and regional level; (iii) represents the main source of soil degradation and water depletion; (iv) alters ES and affects the capacity of natural systems to support human needs. There is indisputable evidence linking changes in the use / land cover to the loss of ES, especially in cases of services as carbon sink, hydrological processes and climate change. A complete ES assessment must be considered as spatially explicit, because it serves as a basis to implement LUCC (and therefore the human impact), as well as to provide a complete overview of offered services, including their current availability and future-oriented simulation (modeled according to various hypothetical scenarios). Furthermore, mapping ES can facilitate the economic evaluation, and provide the balance (trade-off) amongst multiple ES, which is necessary to support decision-making and landscape planning processes (Chirici et al. 2014).

The use of monitoring tools, such as Land use / Land Cover Inventories (Inventario dell'Uso delle Terre in Italy – IUTI, Corona et al. 2012) allows to identify and quantify in a quick way and at low cost the key dynamics characterizing the landscape changes, as well as the monitoring of their impact in ecological and functional terms (Sallustio et al. 2013, Marchetti et al. 2012b, Corona et al. 2012). As an example, for the period 1990-2008 in Italy the following important changes have been identified: (i) the forest area has increased of about 500,000 ha. At that time, the urban areas have expanded of the same amount, especially to the detriment of agricultural land, which recorded a loss of about 800,000 ha; and (ii) the registered urban sprawl can be mainly referred to the downhill and plain territories, and correlated to the increasing pressure on already fragmented and degraded ecosystems. The recovery of human-modified landscapes is necessary to create a socio-economic cohesion between urban and forest area. Furthermore, recreating the lost agricultural fabric offers enormous ecological potential, including e.g. the reduction of fragmentation and degradation (especially of soil), a significant increase of biodiversity (creation of corridors and ecological niches) and the recovery of an important band transition having the function of mitigation systems between natural and manmade assets (vacant land or derelict land; Marchetti and Sallustio 2012). Delivering and keeping the identity to the rural landscape increases the awareness about the primary sources location of power and energy in urban areas, thus enhancing processes of historical and cultural identity, and improving health and social welfare.

It is important to note that the trends observed at the national level in Italy are not very different from those observed within the National Parks, both for land cover modifications and services provided (Marchetti et al. 2012a, Marchetti et al. 2013a). This trend directly reflects on the landscape planning development, especially taking into account the problem of maintaining grasslands, pastures and agricultural activities of extensive type, which are important for the historical, economic and cultural landscapes heritage, and are essential elements for the conservation of the environmental mosaic, which is typical of the Italian peninsula and of its biodiversity (Marchetti et al. 2013b). Taking apart how the urban sprawl develops over the time, it is important to deeper understand in which way policy instruments and regulations are currently used and implemented in these areas (also within PA- Protected Areas). For instance, the abandonment of silvicultural practices within National Parks and High Conservation Value Forests (HCVFs; Maesano et al. 2011) can reduce the forests growth and productivity, making them less resilient while facing natural disturbances (pest outbreaks, forest fires, etc.).

While contrasting the urban sprawl phenomena, agriculture represents a key activity, because it is able of recreating a balanced landscape by preserving areas which are not built-up and, where possible, by restoring ecological integrity of degraded and fragmented environments (i.e. mountain areas). Farming is the essential and long-lasting territorialization factor, as well as the energy basis of the life cycle in the country. However, it can become central to a regenerative vision of the landscape only if integrated with the ecological characteristics. The productive function of the countryside must be flanked by the importance of the concept of its capacity to be a producer of social cohesion, of a good and healthy environment where people can live a quality lifestyle, feeling a sense of belonging. By the contrary, from the urban point of view, there is mainly the problem of defining, perceiving and recognizing the countryside as an area where food and energy come from, according to conceptual models which focus on the ecological footprint (Wackernagel and Rees 2004, Iacoponi 2001).

Moreover, the participatory aspect is necessary in order to carry out one of the founding principles of the European Landscape Convention (Council of Europe 2000), as well as that of the Italian Constitution, which underlines the fundamental need of enabling local participation in decision-making processes at landscape level (articles 3 and 9). Participation has not to be considered as a simple accessory to democracy, but as a real possibility that local communities have, on different levels, to influence and orient the decision-making processes within a given area, irrespective of their individual, specific interests (Settis 2010). Indeed, the engagement of stakeholders may increase the likelihood that environmental decisions are perceived as holistic and fair, accounting for a diversity of values and needs and recognising the complexity of human-environmental interactions (Richards et al. 2004). Furthermore, in a shared management strategy of the landscape, which takes local interests and concerns into account primarily at an early stage, it may be possible to inform the project design with a variety of ideas and perspectives. In this way, public participation increases the likelihood that local needs and priorities are successfully met (Reed 2008). By establishing common ground and trust between stakeholders, participatory processes have the capacity to transform adversarial relationships and find new ways for participants to work together (Stringer et al. 2006). This may lead to a sense of ownership over the process and outcomes, thus enhancing long-term support and active implementation of decisions (Richards et al. 2004).

Considering the above-mentioned issues, it is important to remark that managing the landscape is another of the many duties carried out by the agricultural establishments, with economic and labour-related repercussions, which factors that cannot be ignored in transitional periods such as that of today. The main goal is to create a new culture, which, while starting with the enterprises, can stimulate interaction amongst businesspeople, public authorities and professionals in order to shape new ways for organizing the land. This takes into account the close connections between urban areas, nature and the world of farmers to guarantee that the principles of sustainable development are fulfilled. This action way can be possible if local and scientific knowledge are integrated to provide a more comprehensive understanding of complex and dynamic natural systems and processes (Reed 2008).

Perspectives for the future implementation of bioeconomy

In this composite changing world, the availability of data and easily upgradeable models that can describe these processes are important, since they allows the creation of future scenarios supporting public and private decision makers, in planning and designing the responsible growing of green economy and its activities. The possibility to calculate uncertainty and accuracy of models being used, the substantial reduction of errors of commission and omission are common issues in the field of land use inventories and maps, especially while focusing on practical forest management (Corona 2010). The evaluation of LUCC effects on biodiversity and ES should be the main element in supporting planning processes. Even if it could appear as a choice linked to particular sensitivity or marketing issues for administrators or ordinary citizens, it is now clear that this must be the *modus operandi*, as already established at international level.

Indeed, many efforts have been made to include the evaluation of the ES within decision-making contexts. For example, in 2012 the IPBES (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services) was established, as a tool for linking the scientific community to policy makers, putting the first track on what are the needs and requirements in applied contexts (http://www.ipbes.net/). Similarly, at the European level, the Action 5 of the EU Biodiversity Strategy to 2020 requires that the Member States start to map and assess the state of ecosystems and their services within their own boundaries in order to support natural capital conservation. For the development of a knowledge framework to support the contexts and needs of different States, the Working Group "Mapping and Assessment on Ecosystems and their Services" (http://ies.jrc.ec.europa.eu/news/468/155/Mapping-and-Assessment-of-Ecosystems-and-their-Services.html) was established. At national level, the first results obtained in research projects such as the "MIMOSE" (Development of innovative models for multi scale monitoring of ES indicators in Mediterranean forests) are promising. MIMOSE specifically aims to develop an innovative monitoring approach to estimate the capacity of a given forest area to provide ES under different management scenarios (Chirici et al. 2014). Key elements of this approach are connected to an integrated set of ES indicators and methods oriented to their spatial estimation. In this perspective, the primary project purpose is to bridge the gap between the concept of ES and their operational implementation in the management of forest ecosystems and environmental planning. The results of the project are expected to provide a real contribution for the incorporation of ES in decision-making processes and the forest landscape management and planning, thus providing an opportunity to understand the trade-offs between the different forest ES. This is expected to be useful to inform local stakeholders, sensitizing them towards a certain management that maximizes net benefits from ecosystems for the society.

For the forest sector, the most important challenges are to find innovative approaches for managing forest resources, in a way that simultaneously increases wood and non-wood production, improves the food security and energy supply against poverty, and safeguards other environmental services and biodiversity (Alexandratos and Bruinsma 2012). Under the current (unsustainable) conditions, forest resources cannot continue to contribute to the natural capital flows in the future, thus reducing the transferring of important services to people, especially in degraded environments, and reducing the ecosystem capacity to sustain the green growth. As a consequence, monitoring changes in forest cover (e.g. Hansen et al. 2010) and relative attributes (e.g. Butchart et al. 2010) is extremely important to make the future-oriented management guidelines coherent with the bioeconomy bases. More recently, several authors pointed out the urgent need to put the bases for a persistent monitoring of forests and their services (Maes et al. 2012). However, further research is required to bridge the gap between ecologic and economic fields (Cardinale et al. 2012), especially considering the emerging international commitments, both at European (EP 2012) and global scale (UNEP 2011b, UNEP 2014).

In this perspective, the nodal points lie in the efficiency evaluation of conservation strategies, in the assessment and monitoring of ES, and in the ability to translate these measures in estimating the cost implications. Similarly, the analysis of ES shall provide an integrated and holistic approach, which has to be able to grasp the complexity of functional processes For this purpose, there are several tools available for orienting conservation policies, such as e.g. the use of biophysical indicators (e.g. Noss 1999), the mapping of natural resources and habitats (e.g. Weiers et al. 2004), and the implementation of economic instruments for the market of "natural products" (e.g. Engel et al. 2008). Time and spatial scales (at which conservation strategies are planned and the effects assessed) are also key issues in mapping ES and related changes. It should be always kept in mind how the resilience of natural systems and their adaptability and susceptibility to change go far beyond the administrative limits or times of programming and planning. Indeed, there is also a “resilience thinking”, which describes the collective use of a group of concepts to address the dynamics and development of complex socio-ecological systems (Folke et al. 2010). This implies a profound reflection on how, where and who has to deal with conservation, preferring detailed, solid and shared strategies to "niche" policies (Pressey et al. 2007).

Furthermore, the economic evaluation, despite much closer to a utilitarian view of natural resources, is currently the most effective tool to persuade and influence the people choices, especially waiting for the consolidation of a collective consciousness, more sensitive to the issue of conservation and use of natural resources in general. In this perspective, it is therefore also necessary to review the strategic role of PA. It is no longer enough to establish new PA or expand the existing ones, but it is necessary to strengthen and make more efficient and effective the management in existing ones (Watson et al. 2014). PA must be not only "Shrines of Nature", but real laboratories in which testing the best practices to enhance the natural and cultural capital can be to be exported and implemented in heavily populated surrounding matrix.

The forest sector can offer many opportunities in the context of bioeconomy, such as: (i) the proper and effective implementation of Criteria and Indicators for Sustainable Forest Management, (C&I-SFM; see also EFI 2013); (ii) the expansion of PA network; (iii) the development of initiatives related to projects for reducing global emissions (e.g., Reducing Emissions from Deforestation and forest Degradation, REDD+; http://www.un-redd.org/); (iv) the acceptance of PES in the current economic and productive systems; (v) the implementation of policies aiming to more active management and sustainable conservation of natural capital. Within this context, the research is essential to (Vizzarri et al. 2013): (i) analyze the degree of complexity, the value and quality of forest ES through innovative tools that can simulate the complexity of ecosystems themselves (process-based modelling and mapping); (ii) collect the most complete set of available information relating to the health and resilience of forest ecosystems (new techniques for monitoring and detection); (iii) consider the active involvement of stakeholders in planning decisions and forest management through statistical analysis multi-criteria techniques (agent-based techniques); (iv) reduce the uncertainty associated with estimating the value of ES, as well as reducing the gap between ecological and socio-economic research.

By the other hand, among the critical issues currently found in scientific research in the context of the bioeconomy applied to forest resources, worthy of mention are: (i) the limited availability of spatialized data on a national scale; (ii) the deficient multidisciplinarity in analyzing forest ES; (iii) the absence of widespread and consistent use of models, quantitative analysis and evaluation of ecological, economic, and socio-cultural indicators related to the provision of services delivered by forest ecosystems; (iv) the lack of implementation of EU policies at the local level.

In order to determine, and subsequently improve the competitiveness and the role of the forest sector in relation to other productive sectors as part of the bioeconomy, governments, public administrations, and sector managers need a complete picture of the stock, streams, and balance of costs and benefits of services provided by forest ecosystems.

Therefore, investments have to be oriented towards the improvement of management practices in existing forests and agroforestry systems, in order to ensure the continuous supply of the widest range of services provided. In this context, the development of new methods for supporting planning processes and especially to improve the ability to transfer the skills and knowledge to policymakers are essential elements for implementing the pillars of bioeconomy and green growth, also in the forest sector.

At conclusion, the future-oriented research is expected to be interdisciplinary and multi-purpose, and able to translate theories and concepts in models and methods particularly suitable for analyzing the *status quo* and the potential impact of different policy scenarios and management on ecosystem resilience. In the frame of bioeconomy, research is called to provide scientific bases, models and decision support tools for implementing sustainable growth and local development, which have their roots on paradigms less anthropocentric and more focused on coupling human and natural systems.

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