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Water for Forests and People in the Mediterranean Region

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Foreword: Based on presentations at the Second Mediterranean Forest Week in Avignon, the present article aims at briefly highlighting a few topics drawn from the book: "Water for forest and people in the Mediterranean Region". The original text has been published in EFI-News (n°2, vol. 19, June 2011) and is reproduced here thanks to the kind permission of the European Forest Institute.

The Mediterranean region is faced with water scarcity due to limited and irregular rainfall patterns and increasing water demand as a result of population growth and the expansion of irrigated areas. Expected climate change will further reduce water availability through a decrease in rainfall and runoff. It will adversely impact the resilience and even survival of woodland ecosystems as a result of higher aridity and more frequent extreme events (heat waves, dry spells). This, in turn, will affect the provision of ecosystem goods and services to society.

Mediterranean countries are home to 60% the world's "waterpoor" populations with less than 1000 m³/inhabitant/year. By 2025, 63 million people in the Mediterranean will be in the need of water (with less than 500 m³/inhabitant/year).

The interactions between forest cover and hydrology are rather complex – with regard to variables such as low and high flows, water yield and quality – and depend also on many site-specific parameters. However, as these water-forest relationships are poorly perceived because of persisting "*clichés*", closing the gap between science and public perception is urgently needed. Mediterranean woodlands, for instance, cover large areas and they often occupy the upper part of watershed in mountainous areas, where they play a crucial role in protecting soil and influencing water regime. Given the interconnected nature of forests and water, water cycle and water budget should be considered in an integrated manner, addressing both the blue water (i.e. the liquid form, used for the human needs or flowing to the oceans) and the green water (i.e. the vapour form, resulting from evaporation and transpiration processes).

Innovative knowledge-based policies and strategies should look at both green and blue water, and balance water for people and nature through a real socio-eco- hydrological approach, founded on an integrated land/water/ecosystem management. This requires joint efforts from the scientific community (hydrologists/ ecologists/foresters/economists) for organizing and structuring the available knowledge in a comprehensive manner. This was the motivation and aim of the book "Water for Forests and People in the Mediterranean – A Challenging Balance" which EFIMED compiled as the first volume of the new EFI series "What Science Can Tell Us" targeting decision/policy makers, managers and society in general [1].

1 - Please visit www.efi.int/portal/virtual_library/publications/what_science_can_tell_us/ for a free download of Water for Forests and People in the Mediterranean – A Challenging Balance. What Science Can Tell Us 1, 2011 by Yves Birot, Carlos Gracia and Marc Palahi (editors). The book is also available in French and will be translated into Spanish by the end of 2011. See also *Forêt Méditerranéenne*, T. XXXII, n°3, sept. 2011, p. 335.

Blue and Green Water: What Trade-offs?

Life in the Mediterranean region is constrained by the water available to living beings. In a broad view precipitation is, in average, around 450 mm while the potential evapotranspiration reach mean values of around 1000 mm. This means that Mediterranean ecosystems — particularly forests — have to deal with an almost permanent shortage of water. In the Mediterranean climate, this shortage is more severe during the dry summer periods when the vapour pressure deficit (VPD) of the atmosphere is higher.

Fig. 1: The artificial lake of La Môle in a fully forested watershed dominated by cork oak, supplying water to the tourist town of Saint-Tropez, Var, France. It is interesting to note that the water company is paying annual fees to the local forest owners (public and private) for maintaining the fuel break network, and thus limiting the risk of wildfires, whose impact on dam siltation and water quality can be huge. *Photo by C. Birot.*

While boreal and most temperate forests are "energy limited" and transpire an amount of water which is limited by the available solar radiation, Mediterranean forests are most of the time "water limited". This means that the water transpired is as much as the root systems can reach. A dense cover of e.g. holm oak (*Quercus ilex*) can turn back to the atmosphere as much as 90% of the annual precipitation. Of course this is not water lost: it keeps the trees alive, can be re-used after precipitation – usually far from the areas where it was transpired – and helps to control soil erosion among many other beneficial effects.

The proper management of any system, including ecosystems, requires thorough knowledge of its functional traits. In order to avoid management errors based on misconceptions about water and forests, it is important to understand how much water a tree uses and how it uses that water. While there is an open debate about if forests attract rainfall, there is no doubt that forests are water consumers and reduce the stream flow significantly.

Life is very expensive in terms of water. To fix one gram of carbon that will be transformed e.g. in corn grain, pine needles or wood in our trees, a plant uses a huge amount of water. The efficiency with which the plants use water is very low. Most common values are around 500 grams of water to fix 1 g of carbon. Obviously in these conditions forests use huge amounts of blue water (precipitation which feeds our stream flows) to capture carbon in the gas exchange process, returning this water to the atmosphere as green water. The result is that to produce 1 m^3 of wood, some tree species uses up to near 3000 m^3 of water, which is the so called water foot print of wood. The crucial point is that this enormous amount of water depends on the tree species, of course, but also on the management regime of the forest, as illustrated in the table 1.

While optimizing the forest management of our forests to improve the water use efficiency does not affect the carbon fixed by the forest severely, it is crucial to incorporate the water as a key factor to our management conceptual models. There are a lot of advantages beside the water savings in optimizing the use of water: a water-centered forest management regime can represent in the Mediterranean region enormous ecological and social advantages in relation to the current carbon-centered management concepts which very often misuse the most precious environmental factor: water.

New Approaches to Evaluate Water-Related Ecosystem Services

Unsustainable water consumption patterns and the impacts of climate change are making the water scarcity problem worse in the Mediterranean. This will most likely aggravate conflicts between upstream and downstream users and rural and urban areas. Furthermore, since forests are major consumers of water, it can be expected that the discussion about the trade-off between reduced water availability and the ecosystem services provided by them will receive increased attention. Sustainable solutions require the integration of different interests and the collaboration of all stakeholders involved. For example, a drastic reduction of the forest area might increase the availability of water, but would negatively influence the provision of ecosystem goods and services. Integrating ecohydrological and socio-economic aspects is a key approach towards sustainable management of water resources, ensuring balanced and continued provision of sufficient water resources and other environmental services. A myriad of new tools for trade-off analysis and land management optimization are becoming available that could help to achieve optimal decisions.

The integration of water with other ecosystem services should be based on a better understanding of how ecosystem services interact with each other.

Green water flow sustains main ecosystem functions, and therefore should receive increased attention. The blue water paradigm is based on the evaluation of blue water resources available for human purposes, as related to the effects of forests and other land uses and management. The integrated evaluation of green and blue water flows can be achieved through hydrological models, as well as through policy relevant indicators.

Soil depth (cm)	Optimal management (m^3)	Non optimal management (m^3)
50	584	782
150	739	1263

Table 1:
Water footprint of Scots pine (*Pinus sylvestris*) (m^3 of water used to produce 1 m^3 of wood) growing in two contrasting soils under an optimal management compared to a management regime non optimize for the use of water. Soil depth cm optimal management non optimal management

The challenge of integrating upstream and downstream interests, including terrestrial and aquatic ecosystems, can be met through reconciling the blue and green water paradigm. This can be practically achieved by using specific methods.

To explore the economic dimension of the implementation of water-related policies, we would have to quantify the value of water and the effects of these policies on the provision of environmental goods and services and their value. When considering the value of water, we should distinguish at least two concepts, namely, the value and the price of water. The actual price of water in most Mediterranean countries is based on the supply cost, only including operational and management costs of water supply. The recommended approach would be to define the water price on the basis of the full-cost, which includes opportunity and economic costs, and environmental externalities. Appropriate water pricing would be one of the key elements of more efficient use and management of water.

Do Forest Areas Influence Rainfall Regime?

The role of forests in affecting microclimate, by regu- lating flows and availability of water and preventing erosion, are generally well established. The huge flux of global water vapour from annual precipitation over land, the evaporation and transpiration processes and plants represents a fundamental ecosystem service that contributes to the global water cycle and climate regulation through cloud formation. Therefore, forests sustain the hydrological cycle through evapotranspiration, which cools the climate through feedbacks with clouds and precipitation. Large-scale model simulations have routinely demonstrated biogeophysical regulation of climate by vegetation through albedo (reflectivity), turbulent fluxes, and other effects on the hydrological cycle.

Are the influences of forests on rainfall "active" processes? Recently, analysing vegetation data from terrestrial transects and precipitation fields, researchers concluded that rainfall in areas with extensive natural forests (the Amazon, Yenisey River and equatorial Africa) does not decrease as expected with increasing distance from oceans. Although, the same is not true over non-forested areas, and researchers have proposed the existence of an active "biotic pump" transporting moisture inland from the ocean to forests (Makarieva *et al.* 2009). Natural forests maintain high evaporation fluxes, which support an ascending air motion over the forests and "suck in" moist air from the ocean. However, the "evaporative force" on which the "biotic pump" theory is based has been criticised as not being supported by basic physical principles (Meesters *et al.* 2009). Other researchers have underlined the relevance of the "biotic pump" in offering new lines of investigation and transforming how we view forest loss, climate change, hydrology, and environmental services, if validated (Sheil and Murdiyarso 2009). Although the theory of "forests as a biotic pump" has not received enough confirming support yet, all researchers working on the role of forests involved in climate change agree that there should be improvement concerning weakness and uncertainties when modelling climatic responses.

Notably, land use and coverage are still not generally recognized in international assessments as having a role in precipitation that is at least as large as hat caused by the radiative effect of greenhouse gases. Forests have the ability to amplify or dampen climate change arising from anthropogenic greenhouse gas emissions through albedo, evapotranspiration, the carbon cycle, and other processes.

"The biophysical consequences of forest cover change and other co-effects can be large at regional scales and may sometimes reduce or even cancel the benefits of carbon sequestration. Biophysical interactions should therefore be factored into climate mitigation strategy in at least two ways — in designing carbon sequestration projects to achieve the greatest climate benefit and in comparing the costs and benefits of terrestrial carbon sequestration with those of other mitigation activities." (Environ. Res. Lett. 2008).

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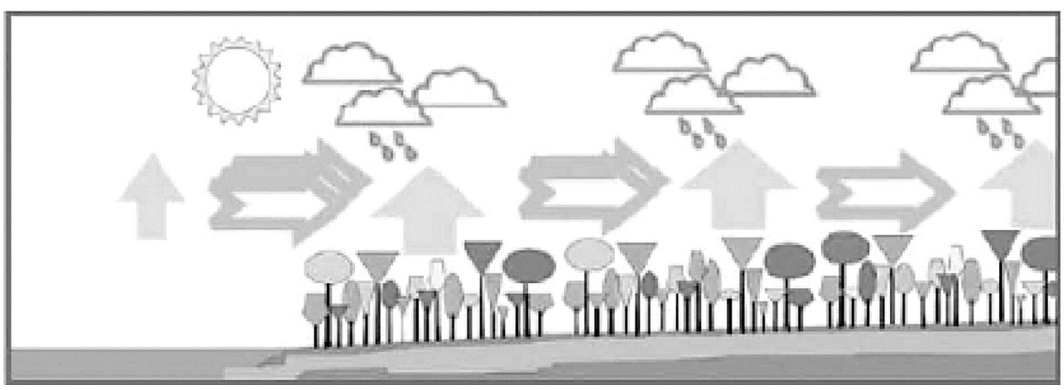

Fig. 2: Biotic pump of atmospheric moisture: transpiration fluxes regulated by natural forests exceed oceanic evaporation fluxes to the degree when the arising oceantoland fluxes of moist air become large enough to compensate losses of water to runoff in the entire river basin. Adapted from *Sheil and Murdiyarso* (2009).