F O R E S T S A N D W A T E R / L E S Y A V O D A

A close relationships between forests and water was known from ancient times. A great traveler Christopher Columbus mentioned in his diary, that when they visited naturally forested islands, it rained there almost every hour. When the forests were cut down (with increasing civilization), rainfalls and even fog dramatically decreased. Despite considerable research, the mechanism determining global climate remain poorly understood. However this situation started to change dramatically, when new ideas of global as well as local water movements were analyzed by teams of physicists – climatologists introducing a new explanation of observed facts and new term of "Biopump" (Gorshkov and Makarieva from 2006-2014). They were shortly followed by specialists from other countries (Berresford et al. 2009, Sheil and Murdiyarso 2009 and others).

Atmospheric moisture originates from oceanic and terrestrial evaporation, Rain derived from terrestrial sources and contributing to local rainfall is termed "recycled". The proportion of recycled rain (a measure dependent on the extent of the area considered) shows little consistent differences between wet and dry regions. What is puzzling about wet regions is the question, what drives the inward flows of atmosphere moisture required to replace amounts of water what flows out through rivers (Savenije 1996). Conventional theory offers no clear explanation. Makarieva and Gorshkov (2008) described another elegant explanation, which is based on huge atmospheric volume and pressure changes caused by evaporation of liquid water and condensation of water vapor. They also demonstrated, that regardless on location, forest-free transects on a continental level (deserts, fields, low vegetation) show a near-exponential reduction in annual rainfall with increasing distance from the coast. However, well-forested transect show no such reduction (but even a slight increase).

Forests evaporate more moisture than other vegetation, typically exceeding flux from herbaceous cover by a factor of 10 (Calder 2005). Closed tropical forests evaporate annually more than one or up to two meters of water (Gordon et al. 2005, Loescher et al. 2005). Large tropical trees can transpire several hundreds liters of water per day (Goldstein et al. 1998). However similar amount of water can transpire trees from well water supplied central European (especially floodplain forests – large oaks up to 600 liters per day). Solitary growing trees even more - willows up to 1000 liters per day; 35 such trees transpire the same amount of water like grass on the whole hectare (Čermák et al. 1984, 2001). Forest evapotranspiration benefits from canopy height and roughness, which leads to turbulent airflows. This has been termed the "clothesline effect", as it is the same reason why laundry dries more quickly on a line, than when laid flat on the ground (Calder 2005). Water reserves are important. Trees with high stem volume allow transpiration to outstrip root uptake as stem water reserves are depleted by day and replenished by night (Čermak et al. 1982, 2007, Goldstein et al. 1998). Trees and forest lianas typically have deep roots than other vegetation and can thus access subterranean moisture during droughts (Jeník

1957, Calder et al. 1986, Čermák and Kučera 1990). Individually deeper develop spruce roots help to defend trees against bark beetle attack (Alexandr and Čermak 2011).

Winds always flow from areas with lower evaporation (where is less water vapor, which condensation i.e., 1250 x shrinking causes only small air pressure drops) to areas with high evaporation (where large volume of evaporated water vapor condense causing much larger pressure drops). Clearing enough forest within the larger forest zone may switch net moisture transport from ocean-to-land to land-to-ocean, leaving any forest remnants to be desiccated. Similarly clearing a band of forest near the coast may suffice to dry out a wet continental interior.

In response to your questions:
(a) How large should be a forest to start working as the biotic pump: even a single tree contributes to enhancing a water cycle on land by enhancing condensation via evapotranspiration and in this sense works as a biotic pump. However, this enhancement diffuses over a larger territory and benefits the local tree insignificantly. The real question is thus how large a forest should be in order that the enhancement of the water cycle that it produces (i.e., increased water vapor import from the ocean) actually covers its own needs in water. Several points are clear. First, large forests (about 1000 x 1000 km) are self-sustainable. Second, coastal forests that are close to the ocean can be self-sustainable, even if they form a narrow belt. The same narrow belts grown far in the dry continental interior, would be unsustainable. Third, if there is a moisture flow ensured by a large forest (e.g., the Eurasian forest belt), any small patch situated not very far from it (within a few hundred kilometers) could be self-sustainable. For this patch the larger forest will play a role of the ocean. That is why we believe, that the fragmented forests in Western Europe ARE valuable for the regional climate.
(b) How do work this way dry (e.g., pine) and relatively low transpiring forests. They work as less efficient biotic pumps, but still work. Actually pine forests at least in our boreal zone are successional forests that if everything goes normally are gradually replaced by spruces. So as succession goes normally, are gradually replaced by spruces. So as the succession goes on, the efficiency of the biotic pump increases.

Jestliže je na Šumavě většina lesů nemocných (tj. stejnověké monokultury), samotné aktivity přírodních procesů povedou k desertifikaci plochy. **Obnovu přírodních lesů** lze docílit jen **jemnými metodami** a teprve pak spoléhat na jejich samoregulaci. Jinak dojde ke **kompletní degradaci lesů** (Gorshkov a Makarieva 2013, Odd klimatologie, Ústav nukleární fyziky Akademie věd, Petrohrad)**.**

Ekosystémy se umí obnovovat samy, ale to je otázka **velkých ploch** (cca 20 x větších než ČR) a **luxusu času**. Přírodní procesy se obnovují za tisíce, genetická struktura populací možná až za 10 tisíc let. Ideální přírodní les se o sebe dokáže postarat, **umělé kulturní lesy** ale nikoli, těm **musíme pomoci** (prof. .... Univ. Britská Kolumbie).