Supplementary information

Natural forest growth and human induced ecosystem disturbance influence water yield in forests

Zhen Yu, Xiuzhi Chen, Guoyi Zhou, Evgenios Agathokleous, Lin Li, Zhiyong Liu, Jianping Wu, Ping Zhou, Meimei Xue, Yuchan Chen, Wenting Yan, Lei Liu, Tingting Shi, Xiang Zhao

Supplementary Table 1 One sample t-test to examine the significance of the *R*/*P*s changes in the eight combinations by the two treatments

The 8 independent combinations	DECREASE		INCRESSE	
	n	*P* value	n	*P* value
P/PET<1	125	<0.000	63	0.001
P/PET<1 and Planted	66	<0.000	50	<0.000
P/PET<1 and Natural forest	59	0.027	13	0.572
P/PET>=1	91	0.002	62	0.380
P/PET>=1 and Planted	57	0.006	48	0.298
P/PET>=1 and Natural forest	34	0.098	14	0.850
Planted	123	<0.000	98	<0.000
Natural forest	93	0.005	27	0.569

P: precipitation; PET: potential evapotranspiration; DECREASE: felling and thinning treatments that directly reduce tree quantity; INCREASE: afforestation and reforestation treatments prone to increase trees.

Supplementary Table 2 Two samples t-test to examine the significance of the difference in Δ*R*/*P* between any two contrasting combinations

Two contrasting combinations		DECREASE		INCREASE	
Combination 1	Combination 2	t	*P* value	t	*P* value
P/PET<1	P/PET>=1	7.179	<0.000	-5.995	<0.000
P/PET<1 and Planted	P/PET<1 and NF	-6.664	<0.000	7.266	<0.000
P/PET>=1 and Planted	P/PET>=1 and NF	-0.387	0.700	1.796	0.077
PF	NF	-2.671	0.008	6.345	<0.000
PF and P/PET<1	PF and P/PET>=1	9.418	<0.000	-7.561	<0.000
NF and P/PET<1	NF and P/PET>=1	2.167	0.033	0.811	0.425

P: precipitation; PET: potential evapotranspiration; PF: planted forest; NF: natural forest; DECREASE: felling and thinning treatments that directly reduce tree quantity; INCREASE: afforestation and reforestation treatments prone to increase trees.

Supplementary Table 3 Net changes in runoff coefficients (Δ*R*/*P*) by the two treatments

Treatments	Δ*R*/*P* (%)	Net forest change (%)	Forest age (Pre-T) (yr)	Forest cover (Pre-T) (%)
DECREASE	15.3±13.7^{A}	-61±34^{A}	55±77^{A}	62±30^{A}
INCREASE	-8.5±10.6^{B}	81±24^{B}	60±102^{A}	65±28^{A}

Different letters in a same column indicate significant difference in values with ANOVA tests; Pre-T means pre-treatment. DECREASE: felling and thinning treatments that directly reduce tree quantity; INCREASE: afforestation and reforestation treatments prone to increase trees.

Supplementary Discussion

Coevolution of water cycling process and other ecosystem processes

We take transpiration and evaporation (soil evaporation and canopy interception), the macroscopic part of water cycling process in forest ecosystems, as an illustration to elaborate the coevolution of water cycling process and other ecosystem processes. Transpiration process is determined not only by thermodynamic environments but also by eco-physiological activities of vegetation community. With the help of transpiration process, vegetation succeeds in converting the water potential difference between phyllosphere air and rhizosphere soil into the motive power for absorbing water and nutrients. A complete transpiration process consists of four nodes (Roberts 2005): (1) water absorption by roots, (2) water storage and transportation in plant body, (3) water secretion via stoma and (4) evaporation of the secreted water on leaf surface. The four nodes of transpiration, as well as soil evaporation and canopy interception, alter with ecosystem progressive succession.

For node (1), the development of root system and the increasing soil organic carbon elevate root absorption areas and reduce the absolute values of soil matrix potential (Liu *et al* 2011), which promotes the accessibility of vegetation community to water and nutrients and decreases their dependence on transpiration tension. Through node (2), ecosystem water storage gets more with increasing biomass and varies from plane (kept only in soils) to three-dimensional (kept both in soils and in biomass) with the help of diversified spatial structure of vegetation community. In node (3), an increased water storage in plants may enhance water secretion via stoma, which, however, depends mainly on stomatal openness constrained by eco-physiological activities. For node (4), evaporation of the secreted water from leaf surface usually increases due to increasing secreted water and biomass or LAI.

However, the motive force to drive water evaporating from leaf surface generally decreases due to the decline of canopy conductance, especially for the leaves positioned in canopy and understory; only the water on leaves of the outermost layer can escape into free atmosphere (McJannet *et al* 2007, Lion *et al* 2017). Meanwhile, soil evaporation generally becomes zero or minus with closing canopy and increasing vapour in air. Canopy interception will also diminish under the circumstance of moist leaves and low canopy conductance. In short, while forest ecosystems develop from pioneer stage to climax stage, various ecosystem functional processes (e.g., biomass and soil organic carbon accumulation, community structure diversification, water cycling process) co-evolve, and the occurrence surface of evapotranspiration changes from the near surface layer to three dimensional- and multi-layers to the outermost layer (McJannet *et al* 2007, Lion *et al* 2017). Natural succession of forest ecosystems along with natural growth does not necessarily increase water consumption, on the contrary, they usually increase water yields in many situations as our results showed.

Supplementary References:

Lion M, Kosugi Y, Takanashi S, Noguchi S, Itoh M, Katsuyama M, Matsuo N and Shamsuddin S A 2017 Evapotranspiration and water source of a tropical rainforest in peninsular Malaysia *Hydrol. Process.* **31** 4338–53

Liu X, Qiao Y and Zhou G 2011 Controlling action of soil organic matter on soil moisture retention and its availability *Chinese J. Plant Ecol.* **35** 1209–18

McJannet D, Fitch P, Disher M and Wallace J 2007 Measurements of transpiration in four tropical rainforest types of north Queensland, Australia *Hydrol. Process.* **21** 3549–64

Roberts J 2005 *Encyclopedia of Hydrological Sciences*