COST Action Workshop

FORESTS AND ABUNDANCE OF WATER –
FOCUS ON BOREAL FORESTS AND PEATLANDS

Forest—Water Interactions: A Reply to the Water Yield Debate

SYKE, HELSINKI

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Comments Welcome
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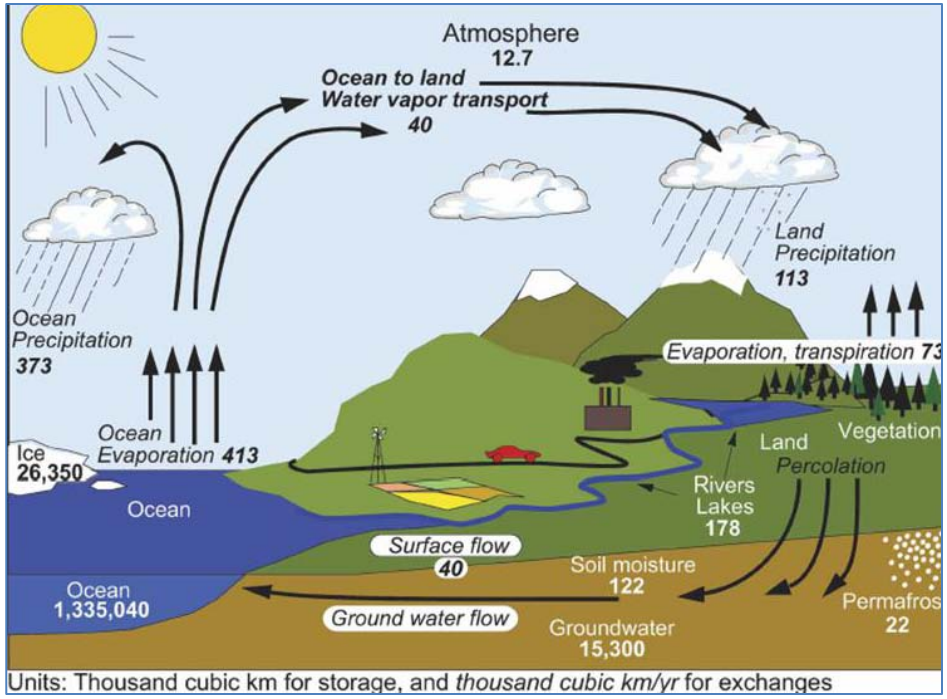
“if mitigation is about energy,
then adaptation is about water”
(Copenhagen Climate Council)

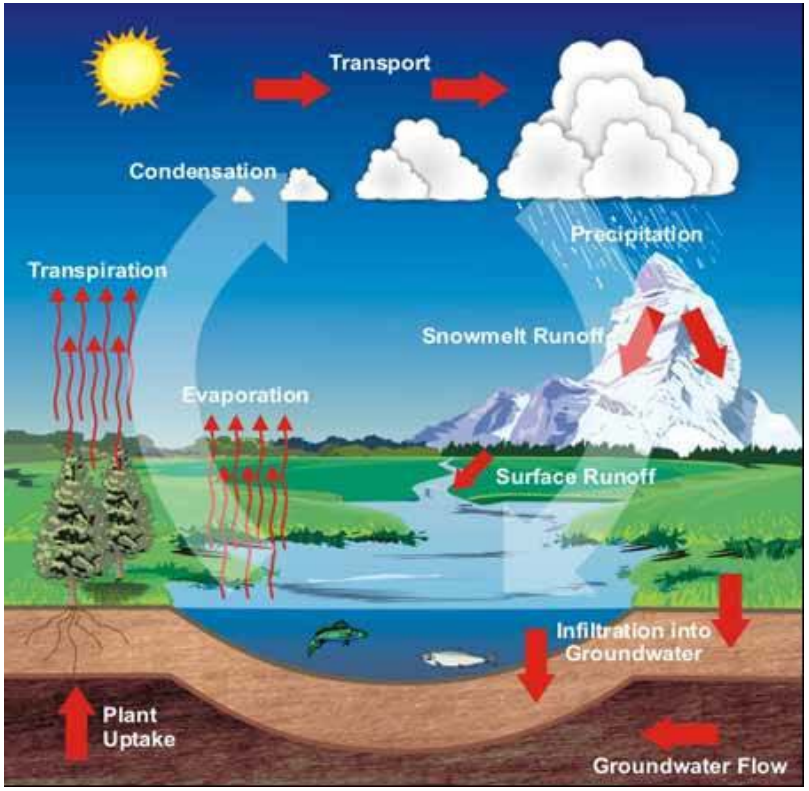
“…the supply of water is finite.
The world will have no more of it in 2025, or 2050,
or when the cows come home,
than it has today,
or when it lapped at the sides of Noah’s ark.
This is because the law of conservation of mass says, broadly,
that however you use it, you cannot destroy the stuff.
Neither can you readily make it.”
(The Economist)

The Hydrologic Cycle

Is this enough?



Is this enough?



What do we Learn/Know about the Following?

What is the role of evapotranspiration (ET) in the hydrologic cycle?

What is ET's relative impact on precipitation?

How does the hydrologic cycle extend across terrestrial space?

How are the *oceanic* and the *terrestrial* cycles connected?

Are they connected?

Forest – Water Interactions: the Water Yield Debate

Supply-side and *Demand-side* Schools:

Supply-side:

- Increasing forest cover *positively* impacts precipitation and runoff
- Sometimes labeled the "*romantic*" view
- Also labeled as "*mythology*"
- Limited empirical evidence

Demand-side:

- Increasing forest cover *negatively* impacts precipitation and runoff
- Ecosystems and the services they provide (biomass, CS, etc) represent a *subtraction* from the water budget
- Observations based on very large number of paired-catchment basin studies
- Typically measured on a very small scale (<2 km^2)

Deforestation literature

Consistently/increasingly finds evidence for declining precipitation and increasing low flow events in deforested areas

- What is being missed by the demand-side school?

Where do Ecosystems Really Belong?

On the *demand-side* or the *supply-side*?

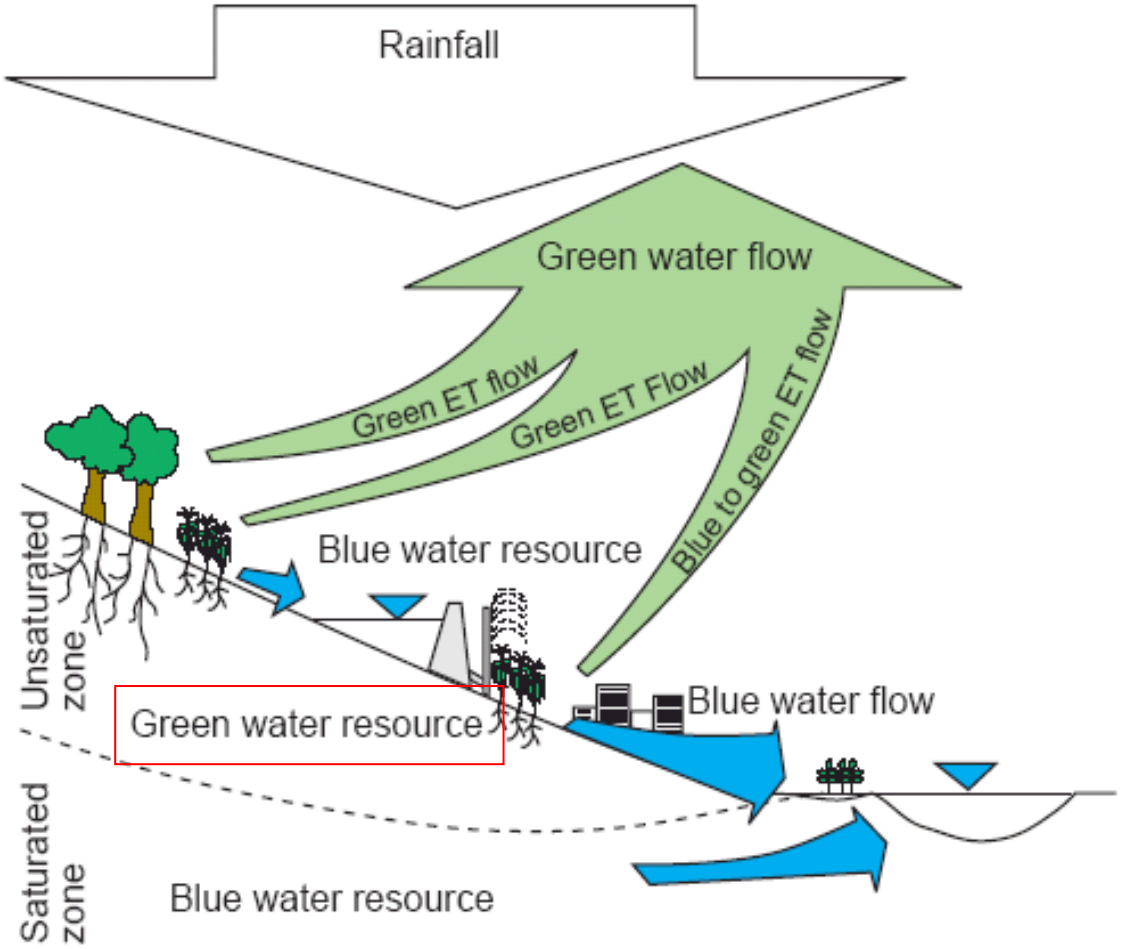
Should we view ET as a *subtraction from* or a *contribution to* precipitation and river runoff?

The *demand-side school* typically places ET on the demand-side.

Yet we know that ET must also come back down somewhere.

Thus, what is ET's overall contribution to the global precipitation cycle?

Green and Blue Water Flows



Source: Falkenmark (2008: Fig. 1).

Evaporative Efficiency and the ET Multiplier

Rockstrom and Gordon (2001)		Landsurface (1000 Mm^2)	Total Evapotranspiration ($Gm^3\ y^{-1}$)	Evaporative Efficiency (m/y)
Forest & Woodlands				
	Taiga	11560		
	Coniferous	3500		
	Deciduous	8500		
	Woodland/Savannah	5200		
	Forest dry/Deciduous	7400		
	Forest wet	5300		
	Savannah/woodland dry	12700		
	Savannah/woodland wet	1300		
	Total	**55460**	**40000**	0.72
Wetland				
	Bog	651		
	Bog	488		
	Swamp	41		
	Swamp	16		
	Swamp	508		
	Total	**1704**	**1400**	0.82
Grasslands				
	Cool Grassland	6940		
	Mountainous grassland	650		
	Warm and hot grassland	17300		
	Mountainous grassland	650		
	Dry shrubland	4000		
	Total	**29540**	**15100**	0.51
Cropland				
	Total	**17600**	**6700**	0.38
Water Body Surfaces (Oki and Kanae 2006)				
	Lakes	2.7	1.3	0.48
	Oceans	391000	436500	1.12
			Geograph. Access.	**Total Blue Flows**
Total Green Flows (ET)			63200	63200
Total Blue Flows (B)			12500	40000
P			**75700**	**103200**
ET/P =			83.5%	61.2%
Green to Blue Flow Ratio:			5.06	1.58

Rockstrom and Gordon (2001)		Hubbart and Pidwirny (2010)	Marengo (2006)
Geographically Accessible	**Total**	**Total**	**Average**
Share of Green Water in Global P	**Share of Green Water in Global P**	**Share of Green Water in Terrestrial**	**Share of Green Water in Local**
ET/P = 83.5%	**ET/P = 61.2%**	**ET/P = 63.9%**	**ET/P = 61.9%**
Ratio of Green to Blue Water Flows	**Ratio of Green to Blue Water Flows**	**Ratio of Green to Blue Water Flows**	**Ratio of Green to Blue Water Flows**
5.06	**1.58**	**1.78**	**1.7**

Hubbart and Pidwirny (2010)	
ET	71000
Blue Flows	40000
Terrestrial P	111000
ET/P	0.64
Ratio G/B	1.78

Oki and Kanae (2006)			
	Area	**ET**	**Ev. Eff.**
Forest	40.1	29	0.72
Wetland	0.2	0.2	1.00
Grassland	48.9	21	0.43
Cropland	15.6	7.6	0.49
Lakes	2.7	1.3	0.48
Other	26.4	6.4	0.24

Estimated Impact of Global Change in Forest Cover

Between 2000-2005, global forest cover has declined by 3% (Hansen et al 2010)

- Would suggest a 4.7-5.3% decline in global precipitation
- We do have estimates suggesting that global precipitation has declined

- Suggests that evapotranspiration (ET) and the ecosystem services that provide it belong on the "supply-side" of the water balance equation
- Emphasizes the relative importance of ecosystem services more generally:
  - Should not think of ecosystem services as a drain on available water supply
  - Requires more balanced thinking about ecosystem impacts and the role they play in the hydrologic cycle

Local and Terrestrial Precipitation Recycling

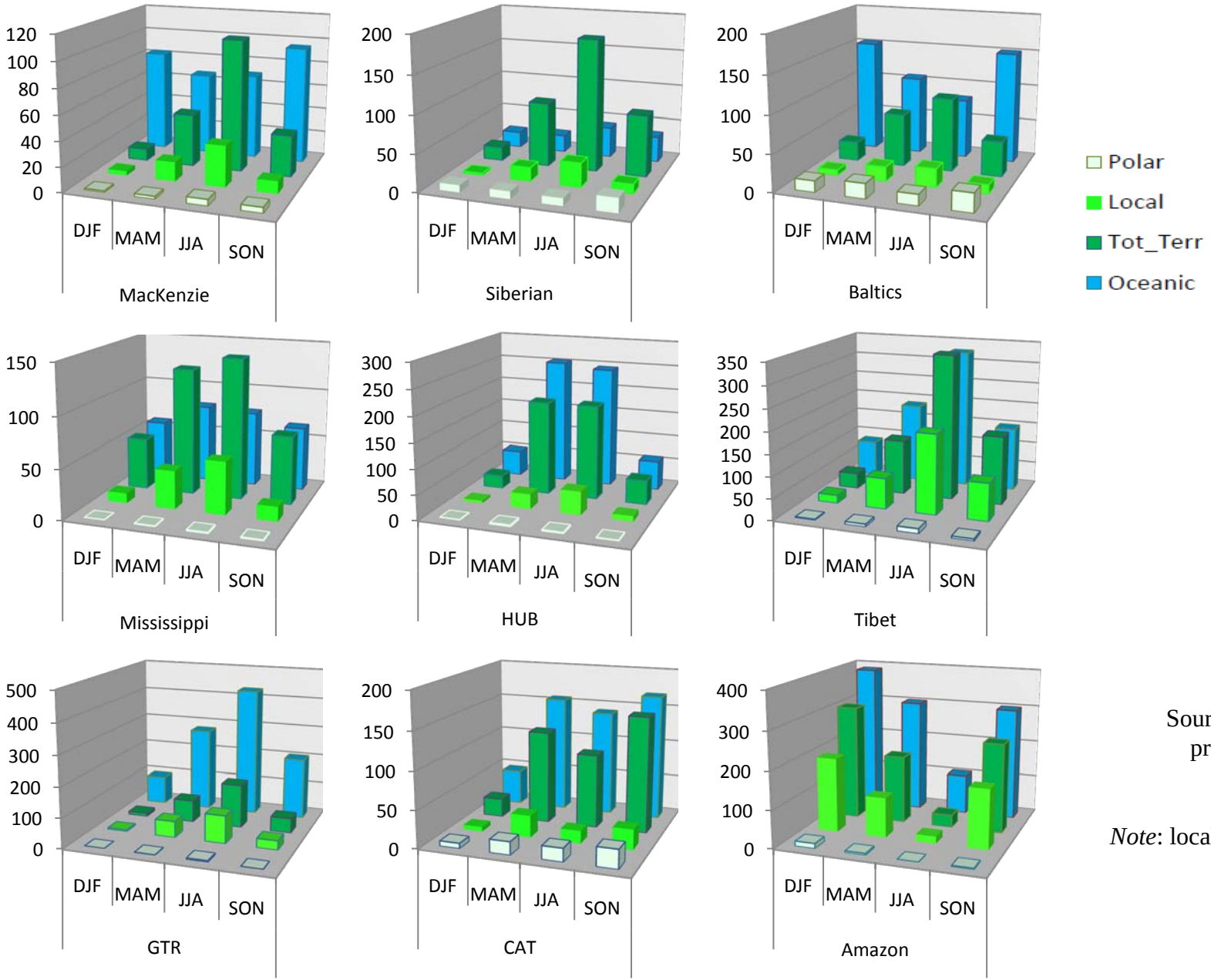
The big questions are:

- How important/large is ET/P?
  - What is the relative *intensity* of precipitation recycling?
- Where does ET fall?
  - Does ET return "locally" or at more distant locations?

Some early findings on precipitation recycling:

- Measured ET = P-R
- All ET *assumed* to be *locally* recycled
- Early measures of "*local*" precipitation recycling very high
- But it is difficult to argue against the overall logic of precipitation recycling
- The big question seems to be what is the scale on which it occurs?
- And how important is *terrestrial* precipitation recycling?

Average Estimated Precipitation in Major River Basins by Source (1948-1997)



Source data generously provided by Michael Bosilovich, *NASA*.

Note: local share ***included*** in terrestrial share.

What do we Learn from the Data?

Terrestrial (ET) precipitation recycling plays an important role, in particular during summer

This relationship becomes more pronounced as one moves across continents

The summertime terrestrial contribution to precipitation may make ecosystem survival possible in some regions (>50%)

But even in some coastal regions, the terrestrial (ET) component is significantly large

The terrestrial component is far more important than the local component

But even the local component is quite large in some areas

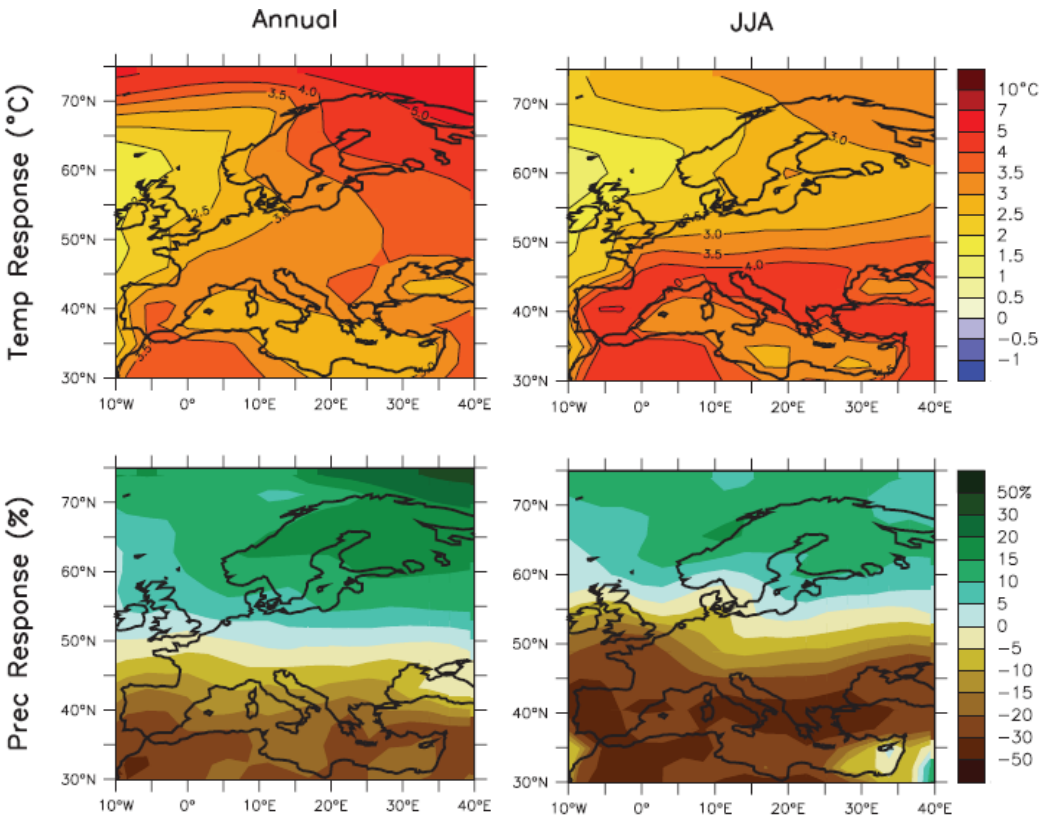
The relative importance of the local component is also a function of the relative size of the other “continental” components

On the Importance and Role of Land Use Choices

- Change in forest cover has transboundary implications
- Land conversions (forest to cropland, cropland to forest, deforestation, urbanization) require careful and thorough consideration
- Ecosystem preservation/creation should presumably be strongly linked to other EU and national level policies
  - E.g. Afforestation, WFD, CC Adaptation, etc.

Integrating Forest-Water Yield into the (EU) Policy Framework

Climate Projections for 2100



Source: IPCC, 4th Assessment report, 2007.

The Role of Forest – Water Interactions

Forest cover appears to play an important role in the global hydrologic cycle.

Increasing forest cover appears to lead to increasing precipitation and runoff.

The global impact of increasing forest cover does not rule out the local *demand-side* impact.

The transboundary impact of local decision-making must be placed at the core of planning strategies.

Forest-based ecosystems provide a ecosystem service that extends well beyond their ability to produce biomass, CS, etc.

What we Still Need to Know

- Can we influence where ET falls?
- What is the role of temperature in semi-arid regions?
  - Can the presumed impact of rising temperatures and declining precipitation be reversed, especially in the more arid regions?
- Assuming we can gather more information on the above 2 factors:
  - Where can additional forest cover be used to the best effect?
  - What is the relative scale/mass of forest cover required to have the desired effect?


Thanks for listening…
Let it Rain…!