Water footprint and forest biomass

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Suggested reading

EffFibre WP4 Task2 Subproject 3: Water Footprint

Samuli Launiainen, Metla, Helena Wessman, Katri Behm, VTT

One starting point of the study was Water Footprint Network's (WFN) research result:

- water footprint for one A4 sheet is 10 litres (2000 m3/t)
- similar sensational results also for many other biomass based materials
- water consumption comes mainly from growing of biomass, green drops in the graph on the right
- in Finland it makes some 500 m3 of water per 1 m3 of industrial wood

Main targets of the study was

- to take an active role in ISO water footprint standardization process
- to produce scientific material comncerning water footprint applied in Nordic forestry
- to find the effects of forestry/logging to hydrologic cycle of forests
- to provide basic data on water impacts of fibre production to be used in life cycle impact assessment

As a result it was found that

- WFN's result for forestry products have severe limitations what comes to measuring sustainability impacts
- volumetric water use inventories are potentially misleading if used to compare water use efficiency of products
- water footprint should take into account local conditions and it should measure the activity's impact to water availability
- measuring vaporized water as consumed or 'lost' is questionable because water delay in atmosphere is very short

Water Footprint

easy to market, a bit difficult to define

Everyone knows how much is one litre of water
but what litres should be included – and for what audience

Water Footprint:

Was born as the younger sister of Carbon Footprint
Was expected to follow in her sister's footprints to global success
Was dressed in her sister's used clothes
Was not approved as her own - different to her sister

Different approaches to water problems

Is it water consumption, water footprint or is it something else they want to know?

Drivers to water discussion

1. Increased use of water especially for agricultural needs in regions where irrigation is needed
2. Lack of good quality ground water also in regions with not so limited surface water availability
3. Water pollution limiting the use of available water resources

Two kind of answers to satisfy information needs

1. Water consumption approach
   product/production chain oriented
2. Water management approach
   organisation/site oriented

Different approaches to water problems

Is it water consumption, water balance or is it something else they want to know?

Measuring water status

1. The core is quantification of actual water consumption, water balance and/or water use impacts
   - How much is consumed
   - What kind of water is consumed (surface/ground, fresh/brackish/salt)
   - How it is used, as household/process/cooling water
   - From local use to footprint accounting, virtual water (supply chain effects)
   - Breaking consumption into pieces, withdrawal, recycling, returned/discharged
   - System input-output balance
   - Water use impact, availability/scarcity, flows from one resevoir to another, pollution

2. The shell around this core consists of all possible activities around water use, water management
   - Future targets
   - Compliance
   - Business risks/opportunities
   - Stakeholeder engegament
   - Policy/strategy

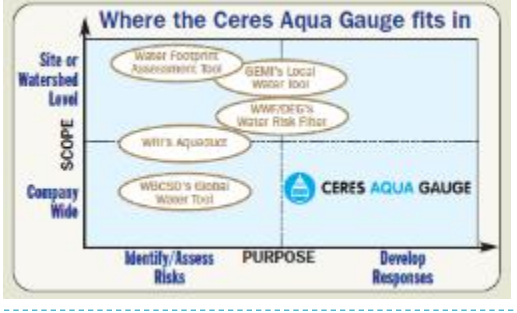

Approaches

Water initiatives 1

Water Footprint Network (WFN)
- Dutch non-profit organisation *'to promote the transition towards sustainable, fair and efficient use of fresh water resources*'
- Roots in prof. Arjen Hoekstra's national virtual water trade studies in UNESCO
- Now more concentrated on product level footprints with the same methodology

CDP Water Disclosure (CDP = Carbon Disclosure Project)
- Investor and water risk (to business) oriented approach
- Follows the organisation's carbon activity = collects quantitative and qaulitative data concerning the company's carbon/water management

CERES
- Exxon Valdes catalysed organisation, water is one of its five issue areas
- Aqua Gauge assesment tool: data gathering, risk assessment, governance, policies and standards, business planning and stakeholder engagement



Water initiatives 2

Three organisations in close cooperation

GEMI (Global Environmental Management Initiative)

- GEMI Local Water Tool: water use, business risks/opportunities, strategy/goals, development/implementation

WBCSD (World Business Council to Sustainable Development)

- Global Water Tool: concentrates on water use for GRI, CDP, Bloomberg and Dow Jones water data needs
- Global Water Tool for Power Utilities:
- India Water Tool:

IPIECA (Global Oil and Gas Industry Association for Environmental and social Issues)

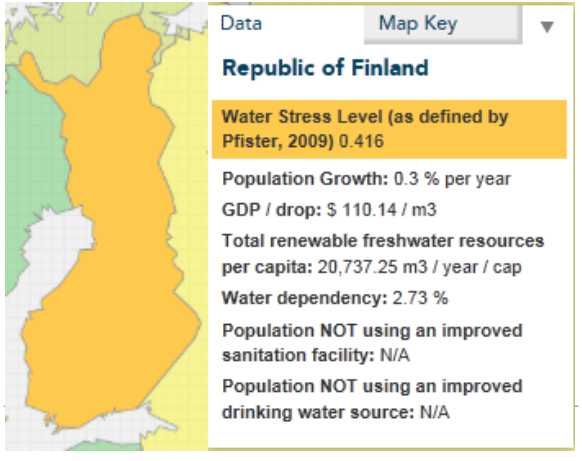
- Global Water Tool for Oil and Gas:

Water initiatives 3

WRI (World Resource Institute)
- Has lauched Aqueduct, a global map tool to identify water risk areas

CEO Water Mandate
- Calls for business leaders to commit to six principles of the mandate: direct operations, supply chain and watershed management, collective action, public policy community engagement and transparency

Growing Blue water impact index
- Organised jointly by other water initiatives
- Global map tool for water availability and use



Water initiatives 4

WWF Fresh Water Program

- Water stewardship (mangement and strategy)
- Water security (secure water to everyone)
- Habitat protection
- Ecosystem services
- Climate change adaptation
- Water governance

WWF Water Risk Assesment

- Physical risk (scarcity, pollution, impact on ecosystems, supplier's risk)
- Regulatory risk
- Reputational risk

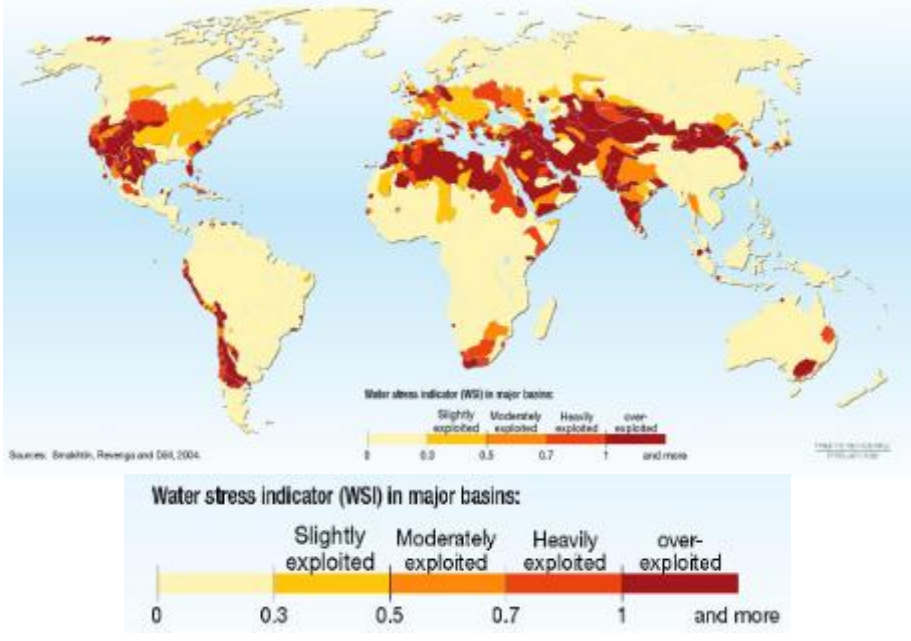
Water scarcity and water stress indicator

Water scarcity index measures the water stress resulting from water overuse

Local water scarcity index can be used as a factor to show the impact used water volumes

There are several methods to define indexes for water scarcity/stress based on

- human need, m3/capita/year
- hydrology, withdrawal/consumption per resources
- and combination of hydrologic, environmental, human need and policy indicator



Case Water Footprint Network (WFN)

Measures blue, green and grey water consumption or ’freshwater appropriation by humans’ and tells **How much is consumed?**

1. Blue water consumption means use of fresh (surface or ground) water by
   - transfering water from one ’catchment area’ to another,
   - evaporating it
   - incorporating it into the product

2. Green water consumption means using rain water
   - through plant transpiration and other growing area evaporation
   - by incorporating it into the product

3. Grey water consumption means the volume of (virtual) clean water needed to dilute waste water emissions to harmless concentration (alters kilograms to cubic meters)

Case Water Footprint Network (WFN)

Forest growth causes green water consumption.

All forest evaporation included during the tree's life time => some 500 m3 water per m3 of wood.

Does not recognize regional differences in water availability or water cycle effects, all evaporation is regarded as loss (dry region view)

Contrary to ISO standard, measures only absolute cubic meters, not the impact to water flows of using biomass

ISO standard has forced WFN to create arguments to justify their approach

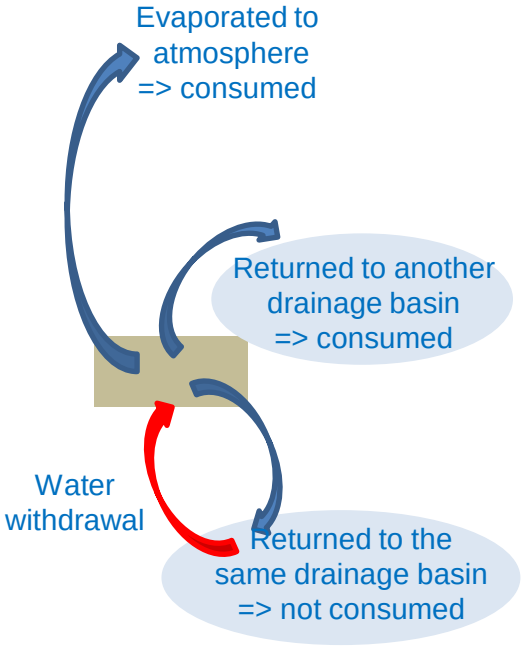
Case Water Footprint Network (WFN)

Methodological thoughts

- WFN actually measures how much water is taken from the source that is used
- Returning water to all other directions is calculated as consumption

- Evaporation is always regarded as loss
- Water cycle is not taken into account even if evaporated water is not accumulated into atmosphere but increased evaporation means increased rain with a short delay
- The process is concidered only from that one area's point of view, no matter if evaporation in wet region means more rain in some drier region

- The method does not distinguish natural flows and man made flows (or human effect to natural flows)
- The method gives higher consumption figures to processes in areas with better water availability where the impacts are smaller



Case ISO Water Footprint Standard 14046 (2014)

Gives a general frame to water footprint calculation, not clear calculation rules

Based on ISO LCA standard (14044) => consumption approach with product/organisation orientation

Emphasizes that the result of water footprint assessment is always impact
Does not define the indicators for this impact, says only that they are '*environmental issues of concern*'

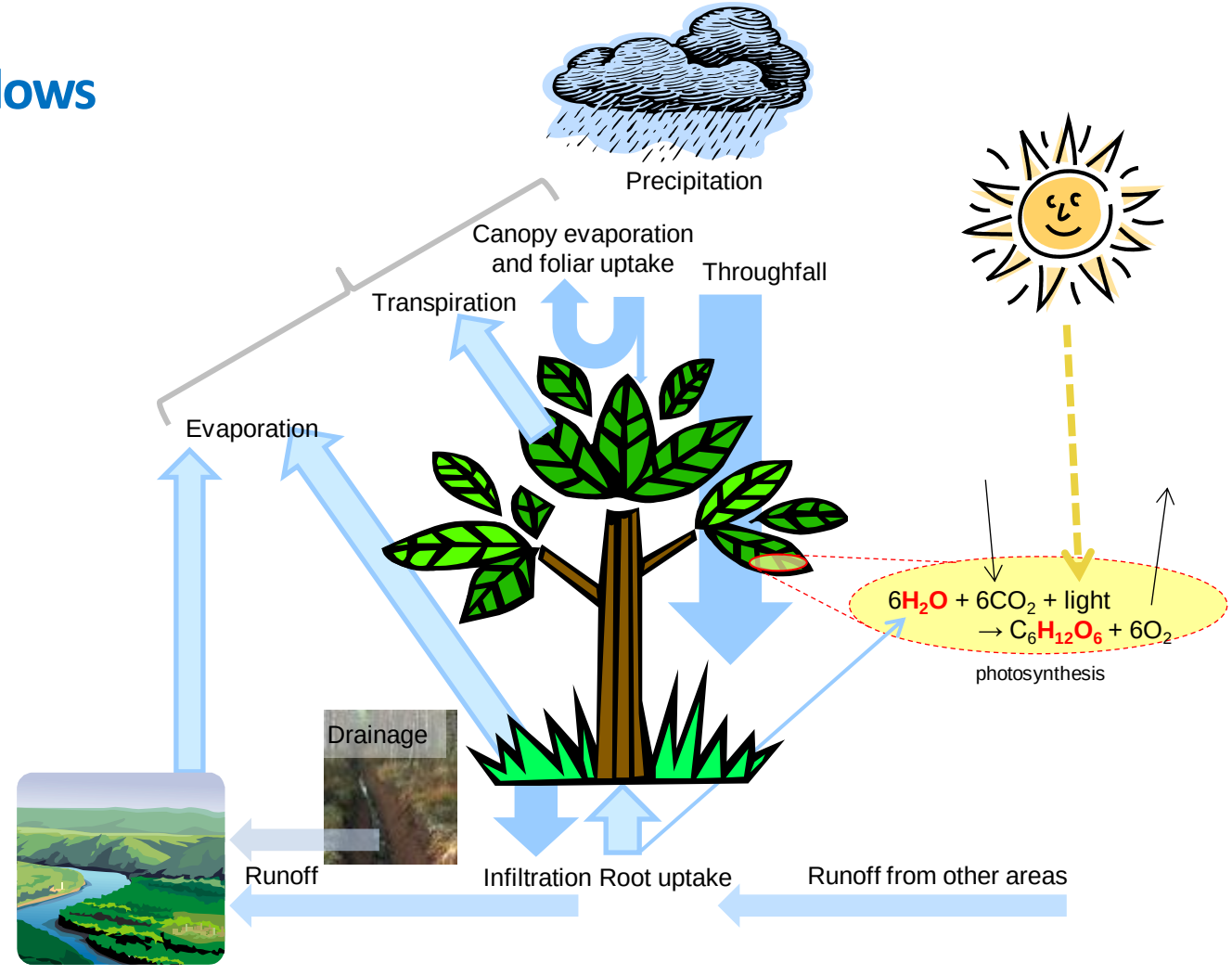
Defines water related terms, the interesting ones from forest point of view:

- *water use = use of water by human activity*
- *water withdrawal = antropogenic removal of water*, (antropogenic = human based)
- water consumtion is regarded as water removed but not returned to the same drainage basin (water source)
- w*ater footprint assessment* definition connects *water use* and human impact to water footprint by saying that the assesment *evaluates inputs, outputs and impacts related to water used or affacted by a product…* etc

The standard seems to focus on *impacts caused by human water use*, this looks not very amazing but it closes out natural water flows as such and aims on human impact on them.


What happens in the forest

Forest water flows



Sama suomeksi

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Forest Biomass and Water Outflows

A very small share of forest waterflows is finally tied to wood

- ½ of the fresh wood weight is moisture
- ½ of the dry matter (oxygen and hydrogen) can be seen as originating from water, the rest is carbon

A larger flow is vaporised from the leaves in a process called **transpiration**

The nearest flow outside the plant is **canopy evaporation** resembling the drying umbrella behaviour of the tree

Below the trees there is **understory** having similar water flows as the tree and **soil evaporation**

A part of the water is **filtered to the soil** and/or **run to watercourse**

In some forest areas water level is lowered by ditching leading to **drainage**. As the other flows above are continuous drainage causes a sudden change in water storage of the forest and is more difficult to connect to produced wood volumes.

Forest Biomass and Water Outflows

1. Photosynthesis has locked some 200 litres or
   - **0,2 m^3** of water into 1 m3 of wood.

2. If 2/3 of all growing wood material is used as industrial wood the water volume increases to 300 litres or
   - **0,3 m^3** of water per 1 m3 of industrial wood

3. Including the **moisture** in the industrial wood increases the amount by 400 litres or
   - **0,4 m^3** of water per 1 m3 of industrial wood.

4. During the growth of that wood water flow through the tree (transpiration) plus evaporation in the forest elsewhere makes together (**evapotransipiration**) some
   - **500 m^3** of water per 1 m3 of industrial wood.

Forest Water Flows

An example of relative flow volumes
in spruce intensive forest area
Koivusalo, Lauren
Metsätieteen aikakauskirja 4/2011

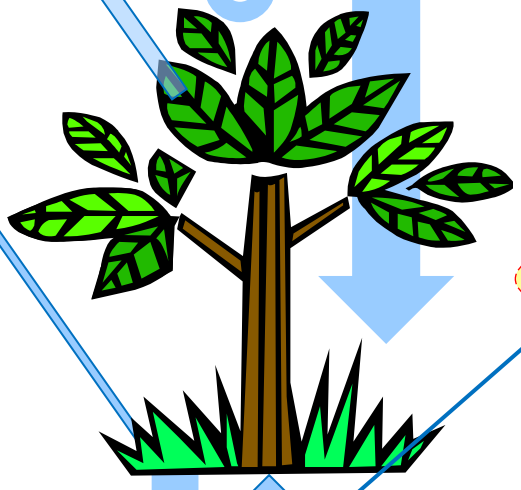
Precipitation
100

Canopy evaporation
20

Throughfall **80**

Transpiration **17**

Evaporation
7



$6H_2O + 6CO_2 + light \rightarrow C_6H_{12}O_6 + 6O_2$

photosynthesis

The relative volume of water locked to wood through photosynthesis during the same time would be roughly **0,01**

Runoff **57**

Infiltration

Root uptake

Forest Water Flows

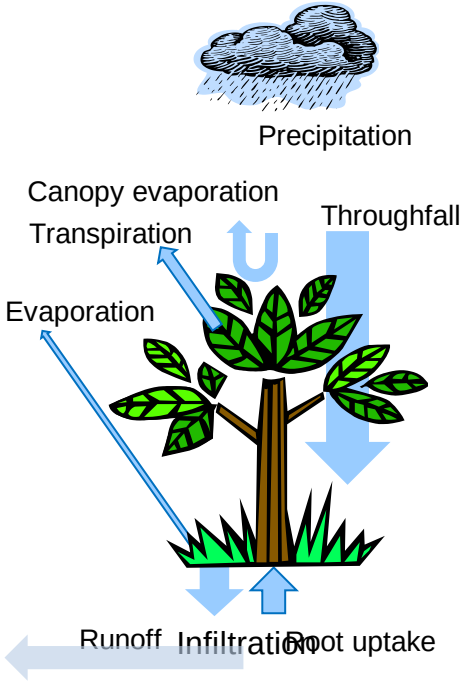
Effect of logging

Logging stops transpiration and canopy evaporation but soil/understory evaporation increases and compensates all or a share of those two

The result depends on soil properties and water availability.

In very dry conditions the trees take water deep from the soil and can keep up transpiration even if soil surface is dry and there is hardly no soil evaporation. Logging stops transpiration. With no water consumption for transpiraton the water table may rise and give possibilities for increased soil/understory evaporation.

In wet conditions growing trees decrease soil evaporation with their shadow and by slowing down the winds near soil surface. Logging reveals the soil surface to sun and winds increasing evaporation, which compensates ceased transpiration. Part of the surplus water ends to increased runoff.



Forest biomass and drainage

Secondary effects of ditching

Drainage lowers the water level exposing new organic material (peat) to oxygen.

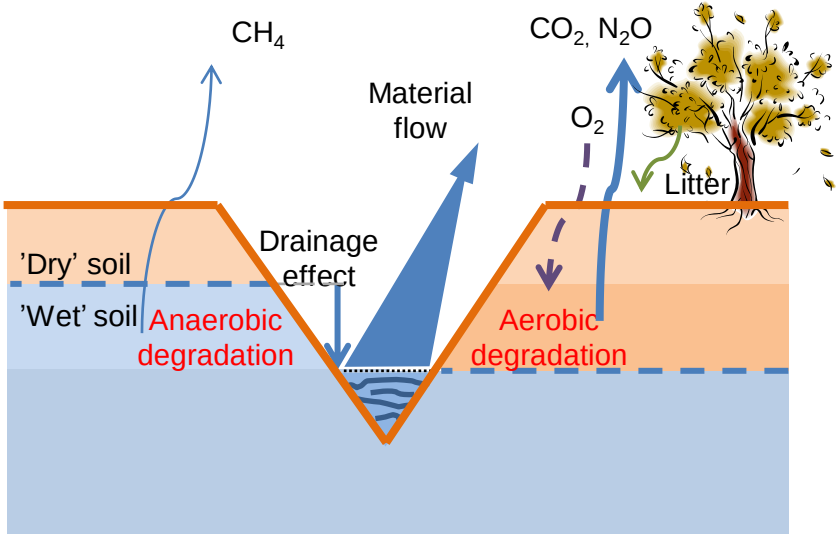
This starts **aerobic degradation** and slows down **anaerobic** methane production

Litter production increases as trees grow

Ditches increase **material flow** from the forest mainly during the first years after ditching

Quantitative carbon flow and climate effect data of the process still is very inaccurate, large variations depending on soil properties and its CH_4 emission

On long term, carbon in the dried peat layer is lost to atmosphere but it is at least partly restored to trees growing on that area plus methane emission has ended. Material lost through ditches has partly sedimented to local watercourse



Emissions of forest management

Final felling

For 1 % of forest area annually, 200 000 ha/a

Fertilization

For 0,1 % of forest area annually, 25 000 ha/a

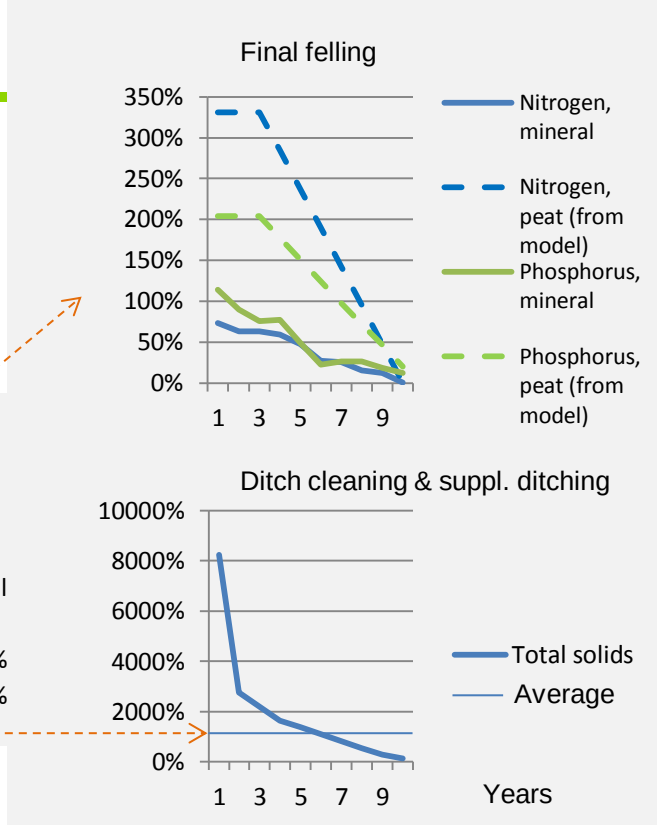
Ditch cleaning and supplementary ditching

For 1-2 % of peat land forest area annually, 70 000 ha/a

Additional emission from forest management during 10 years after operation compared to natural emission level

calculated from Finer et. al

	Final felling		Ditch	Fertilization	
	Mineral soil	Peat soil	cleaning	Mineral soil	Peat soil
Nitrogen	40 %	200 %	0 %	120 %	0 %
Phosphorus	50 %	130 %	200 %	0 %	300 %
Solids			1500 %		



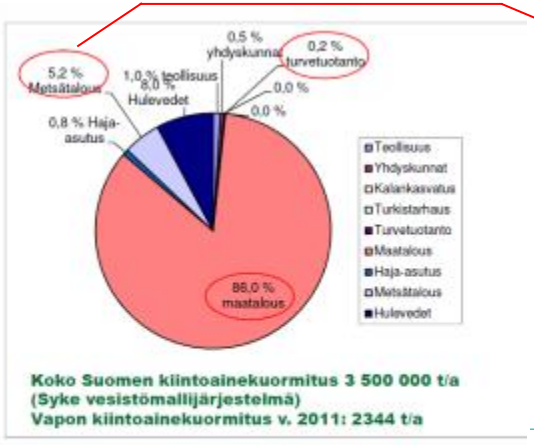
⇒ Emissions from management operations

- are local
- main effect during the first years
- large relative and potentially visible effect as solid material from ditch cleaning

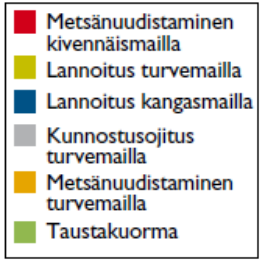
Solid material emissions of ditching

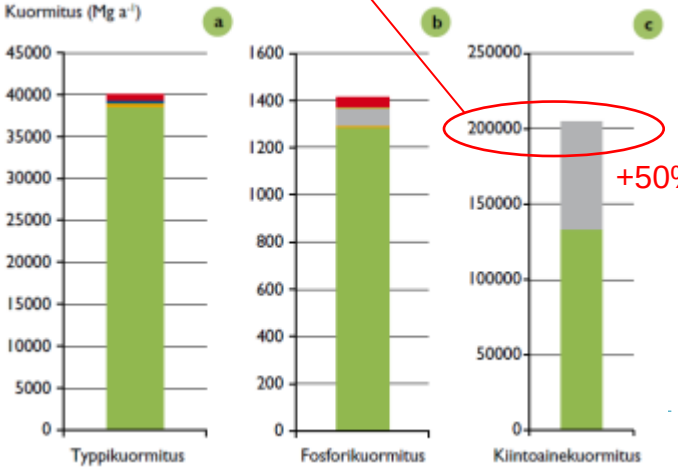
- Emissions from forests to lakes is causing increasing discussion (mainly in local newspapers).
- Peat production has been the main target for accusations
- There seems to a large disagreement of the size of the damage between citizens around the lakes and peat production companies
- Forest management (ditch cleaning) is a good target for a large part of the accusations

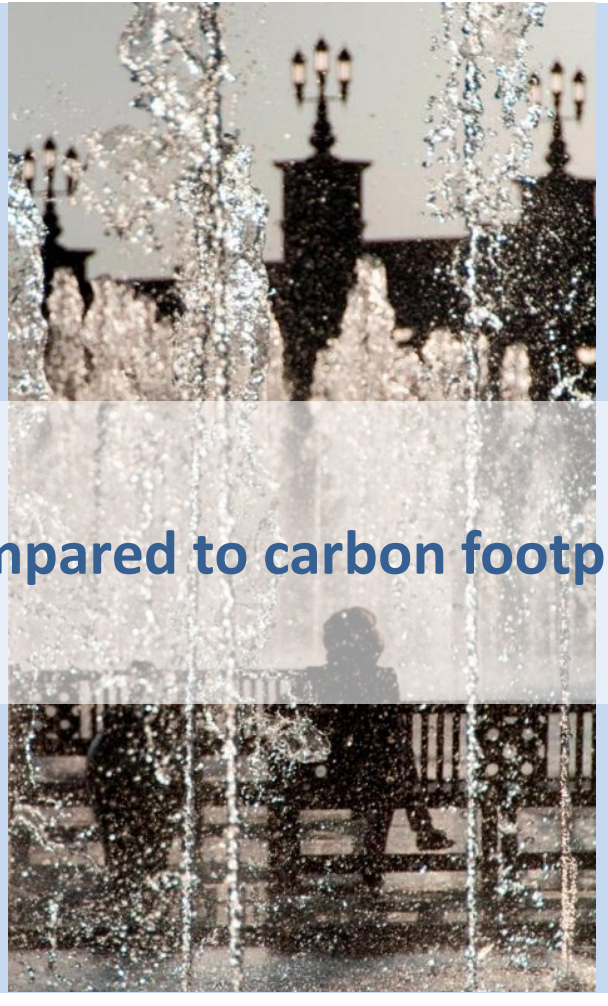
Koska keskustelussa turvetuotanto on vallannut pääosan, haluan tuoda esille ojituksen ongelmat. Metsäojituksia tehdään kivennäismailla ja metsää kasvavilla turvemailla vesihaittojen estämiseksi ja tämä tuottaa hyviä tuloksia.
Mutta ojituksia on tehty paljon myös selvillä suoalueilla ja suurin osa näistä on ollut turhia, toivottua metsänkasvua ei ole tapahtunut. Haitat, eli suoluonnon ja alapuolisen vesistön pilaantuminen, ovat kyllä toteutuneet.



180 000 t/a 200 000 t/a







Compared to carbon footprint

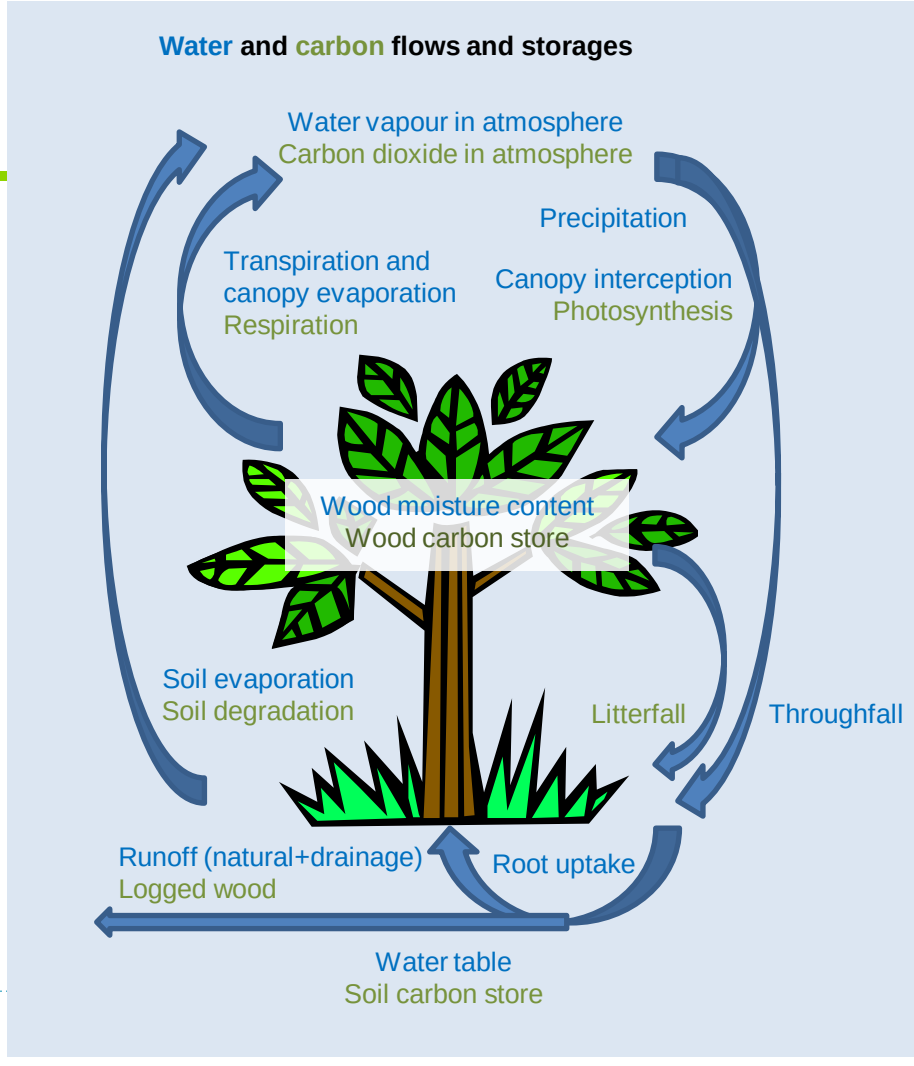
Water footprint compared to carbon footprint

Critical for forest water balance and water availability

- water table and runoff

Critical for forest carbon balance

- storage in trees and soil



Water footprint compared to carbon footprint

	Water	Carbon
Viewpoint	Resource/raw material	Emission/waste
Key problem	Scarcity of local water storage Pollution of any water source	Excess carbon in atmosphere ⇒ Reduced global carbon storage
Activity measured	Use and polluting of water	Reducing carbon storage
	⇒ Taking water from a reservoir is analog to releasing carbon from carbon storage ⇒ The problem includes also water pollutation ⇒ Local scarcity estimation needed for water, carbon problem is a global phenomenom	
Lobbying approaches (forest sector)	Measuring the impacts to water of Using wood ⇒ Compare regional water availability when wood is used and not used (natural flows only)	Avoid comparing *wood is used and not used*, define the effect of using wood by measuring the actual carbon storage development of large forest areas

Water management

Water management

In Finland water management principles for biomass procurement can be found from legislation, certification rules and quidelines for sustainable forest management

Water legislation
- gives guidelines of preventing the damage to water systems including the effects of ditch cleaning

Forest legislation
- protects the surroundings of small water systems in the forest

Environmental legislation
- prohibits the damage of groundwater

Forest certification
- no new ditcing areas allowed
- requires exclusion areas near water systems
- special attention to groundwater areas

Water management

Water management methods in forest management have two main targets:

1. To protect the biodiversity of such special water related areas as waterfronts, ponds, brooks, fountains, wetlands and ground water areas by limiting operations near them
2. To minimise the potential increase of water related emissions such as solid (including erosion), humus and nutrients as a result of forest management activities

Examples of water management methods

- catchment area planning
- identifying erosion sensitive areas and planning flow structures (flow channel erosion) and soil preparation (surface erosion) according to that
- using sludge holes, bottom barriers and excavation breaks to decrease solid emissions of ditch cleaning
- surface draining areas to prevent solid material and nutrient emissions
- exclusion areas by water fronts, brooks and ponds


Conclusions

Forest management impacts

Forest management operations (thinning, final felling)
- does not consume water
- decreases evapotranspiration (total water evaporation of the area)
- increases water infiltration to soil and water runoff
- => increases water availability

Forest management causes water emissions (solid material, nutrients)
- most notable effect as solid material from ditch cleaning and supplementary ditching

Most important water related impact is the area's hydrologic change caused by ditching affecting
- the area's flora and fauna
- as well as to the carbon storage of the area, first increasing it above the surface through wood growth, later decreasing is as the peat layer slowly degrades with the help oxygen reaching it

Water management practices are motivated by legislation and certification. This has led to practices and quidelines to preserve water dependent biodiversity and to minimise water related emissions of solids, humus and nutrients resulting from forest operations.

Kiitos!