HÁSKÓLINN Á AKUREYRI

WETWOOD – CARBON AND WATER BALANCE OF AN AFFORESTED DRAINED PETALAND IN S-ICELAND

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Carbon and water balance of an afforested shallow drained peatland in Iceland

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PEATLANDS IN ICELAND

- Peatlands are a prominent landscape features in Iceland – cover approx 8% of the total land area
- Huge areas were drained between 1950s to 1990s (4200 km^2 of ditches were excavated or 4% of the total land area)
- Purpose of draining was mostly for agricultural purpose (hayfields, croplands and live-stock grazing)
- Today, substantial areas of these drained wetlands have fallen out of use and do not serve as agricultural areas

=> this land-use category is currently estimated to be the single greatest source of greenhouse gases (GHG) to the atmosphere, amounting up to 70% of all greenhouse gas emissions in Iceland

MITIGATION OPTIONS ON DRAINED PEATLANDS

- Mitigation options
  - Rewetting – restoring the peatlands
  - Plant trees (afforestation)
- To date - neither land-use change option has been much practiced in Iceland.
- Rewetting: Restored wetlands cover 10 ha (0,1 km^2
- Afforestation: afforested drained wetlands only cover 3800 ha (38 km2)

=> Lack of published data on the real effect of these two mitigating methods have prevented Icelandic authorities to act so far.

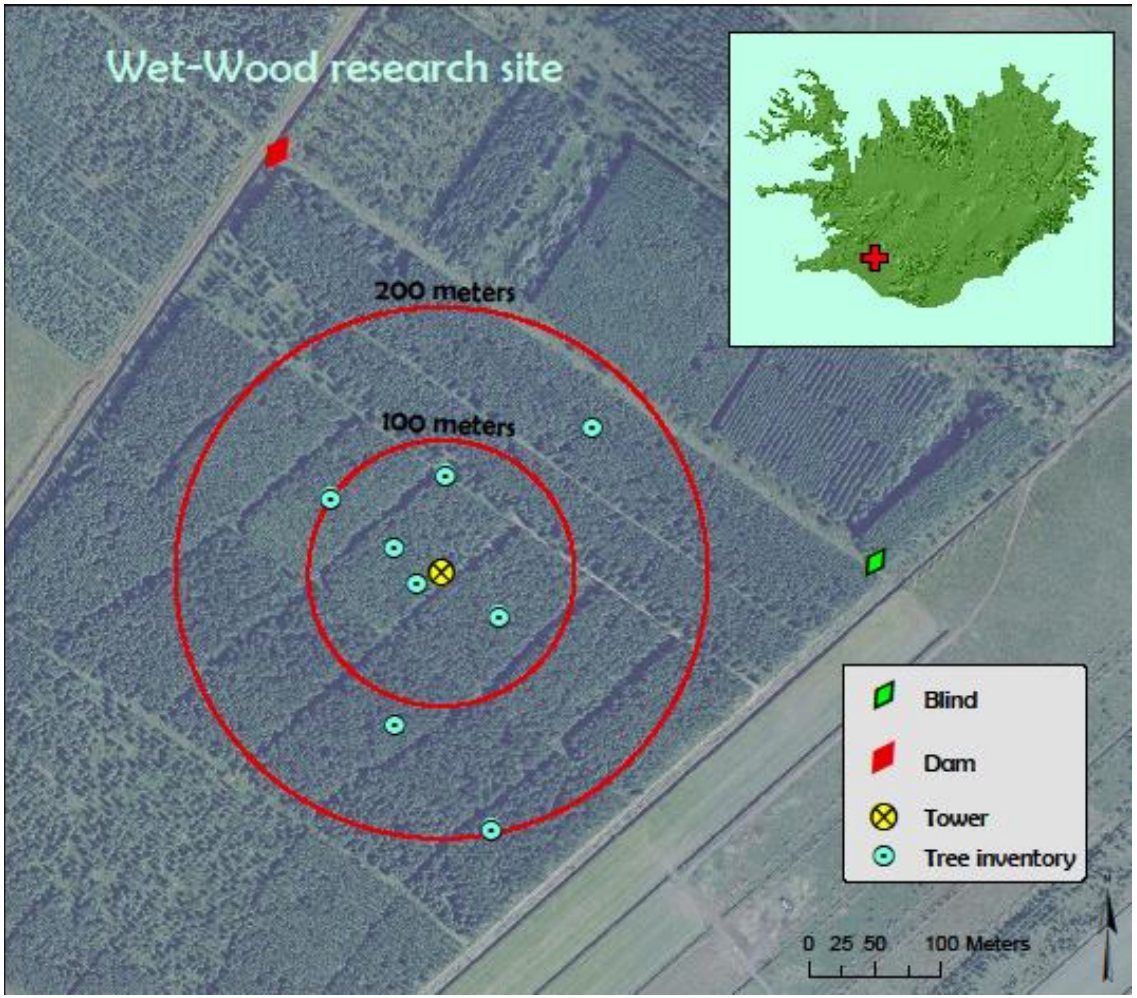
THE WETWOOD PROJECT

- Aim:
  - to estimate the annual C and water balances of a 23–25 year old deciduous forest plantation on a drained peatland in S-Iceland, using the eddy-covariance technique and hydrological, meteorological and inventory measurements.
  - We hypothesised that the drained forest would be a net CO_2 source, due to relatively high decomposition fluxes from the drained peatland soils and because of the expected high amounts of C that would leave the ecosystem as DOC and POC through drainage ditches in the relatively wet climate.

STUDIES ON THE CARBON PART - IN ICELAND:

- Forestry:
  - Good estimates on C-sequestration of different tree species
  - Not mandy studies on the total C-balance of an ecosystem:
    - 11 year old larch forest in E-Iceland: -7,2 t CO_2 ha/yr (Bjarnadottir et al, 2009)
    - 7 year old Populus forest in S-Iceland: -3,7 tonn CO_2 ha/yr (Sigurdsson et al, 2000)
- Draining:
  - Lack of research:
    - Drained peatlands in V-Iceland: 14,1 t CO_2 ha/yr (Ólafsdóttir, R., 2015)
    - Drained peatlands in S-Iceland: 2,6-11,4 tonn CO_2 ha/yr (Gunnarsdóttir, G.E.G., 2017)
    - Drained peatlands in N-Europe: 20,9 t CO_2 ha/yr (IPCC, 2014)

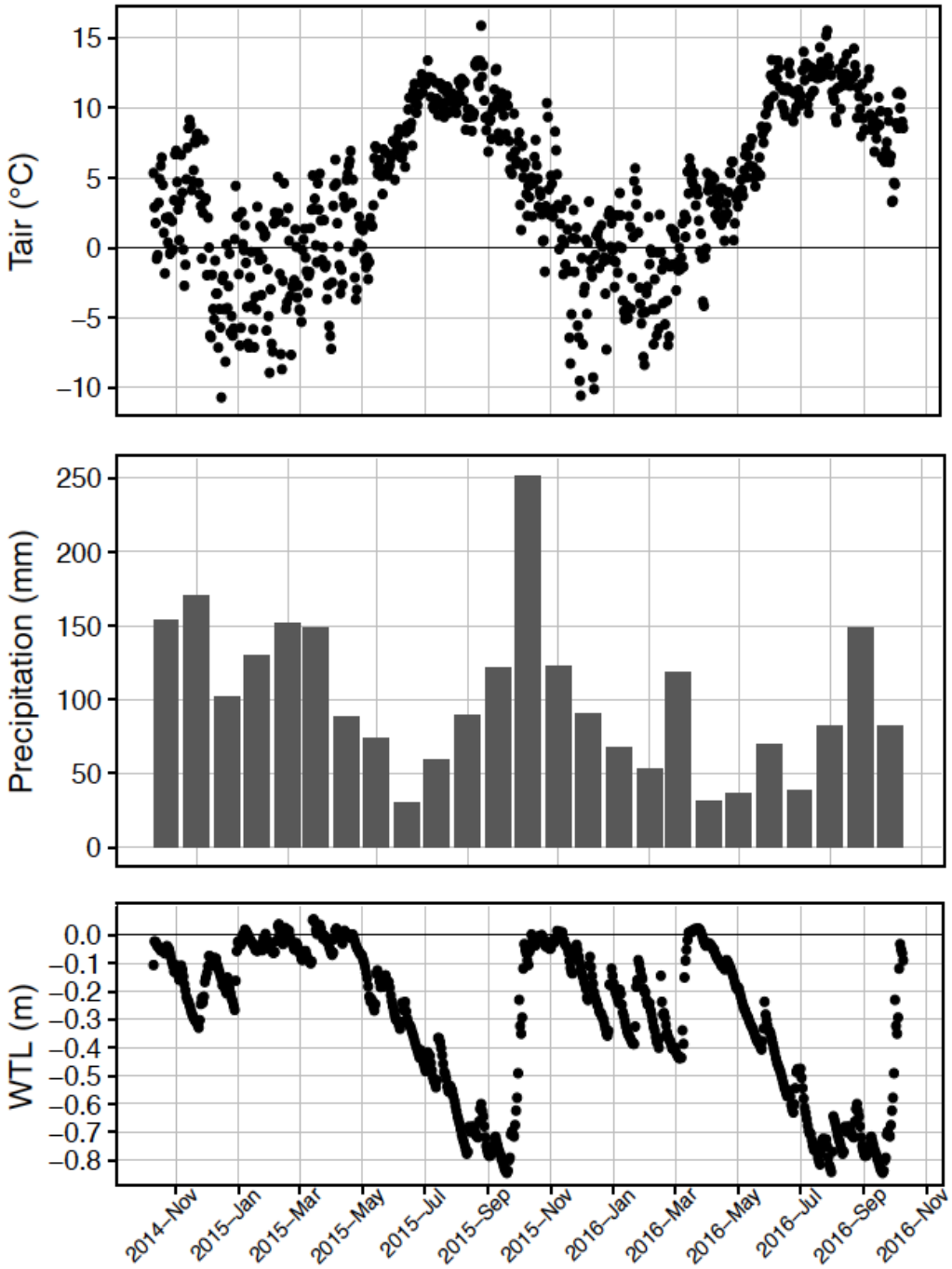
Research area – 25 yr old Aspen forest (*Populus trichocarpa*) in S-Iceland, planted on a drained peatland (85 ha). Draining was done in 1959 and planting was done in 1992.



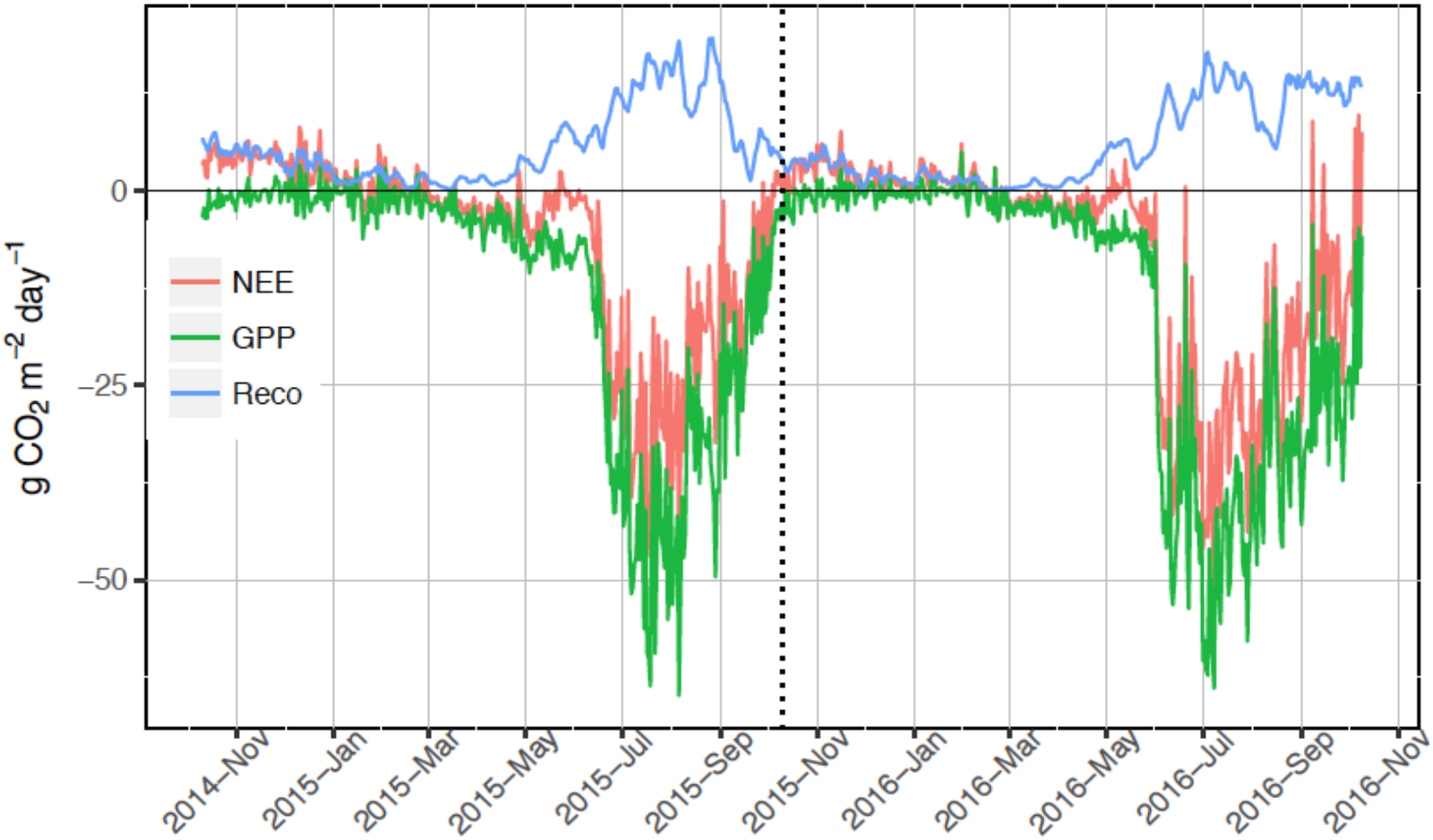
Eddy covariance measurements started in 2014 and continued for 2 years

Building dams in 2014

Measurements on C through water run-off

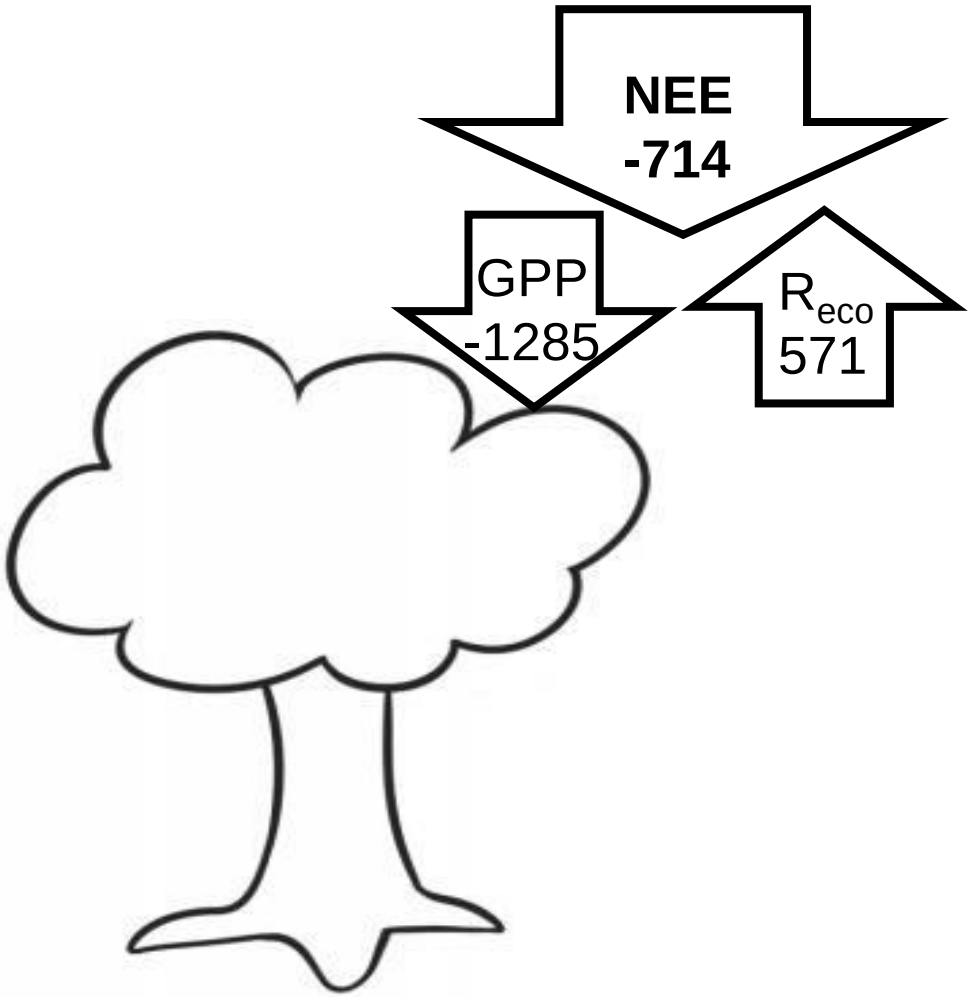

Tair (°C)
15
10
5
0
−5
−10
Precipitation (mm)
250
200
150
100
50
0
WTL (m)
0.0
−0.1
−0.2
−0.3
−0.4
−0.5
−0.6
−0.7
−0.8
2014−Nov
2015−Jan
2015−Mar
2015−May
2015−Jul
2015−Sep
2015−Nov
2016−Jan
2016−Mar
2016−May
2016−Jul
2016−Sep
2016−Nov

C-balance during 2 years



Year 1: **22,5 t CO_2 ha/yr**
Year 2: **29,8 t CO_2 ha/yr**

g C m^{-2} yr^{-1}



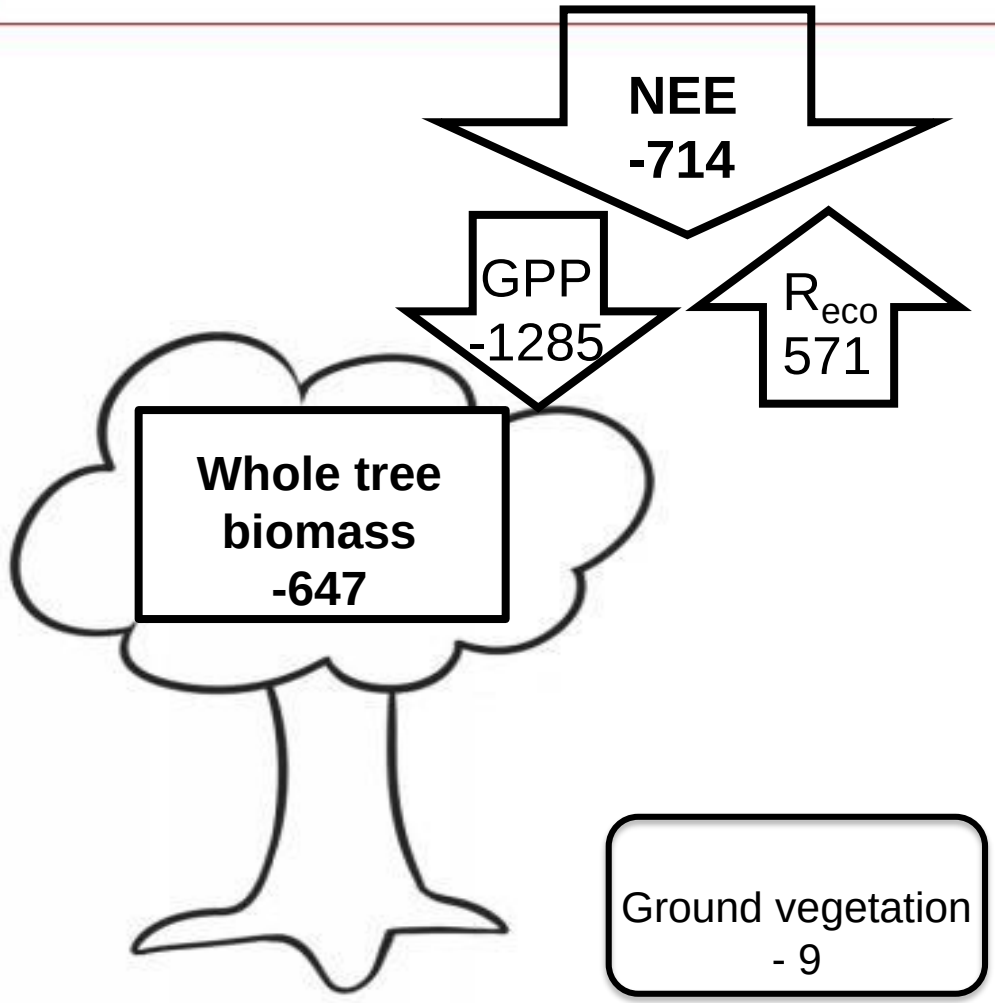
CARBON STOCK OF TREES

Year	Standing Biomass (kgC/m2)	Incriment (kgC/m2)	Average OH (m)	BA	Stem volume (m3/ha)	Average dbh (cm)
2015	6,87	0,557	11,54	26,64	126,99	152,83
2016	7,43	0,801	11,82	28,41	137,50	158,38
2017	8,23		12,55	31,60	152,65	166,22

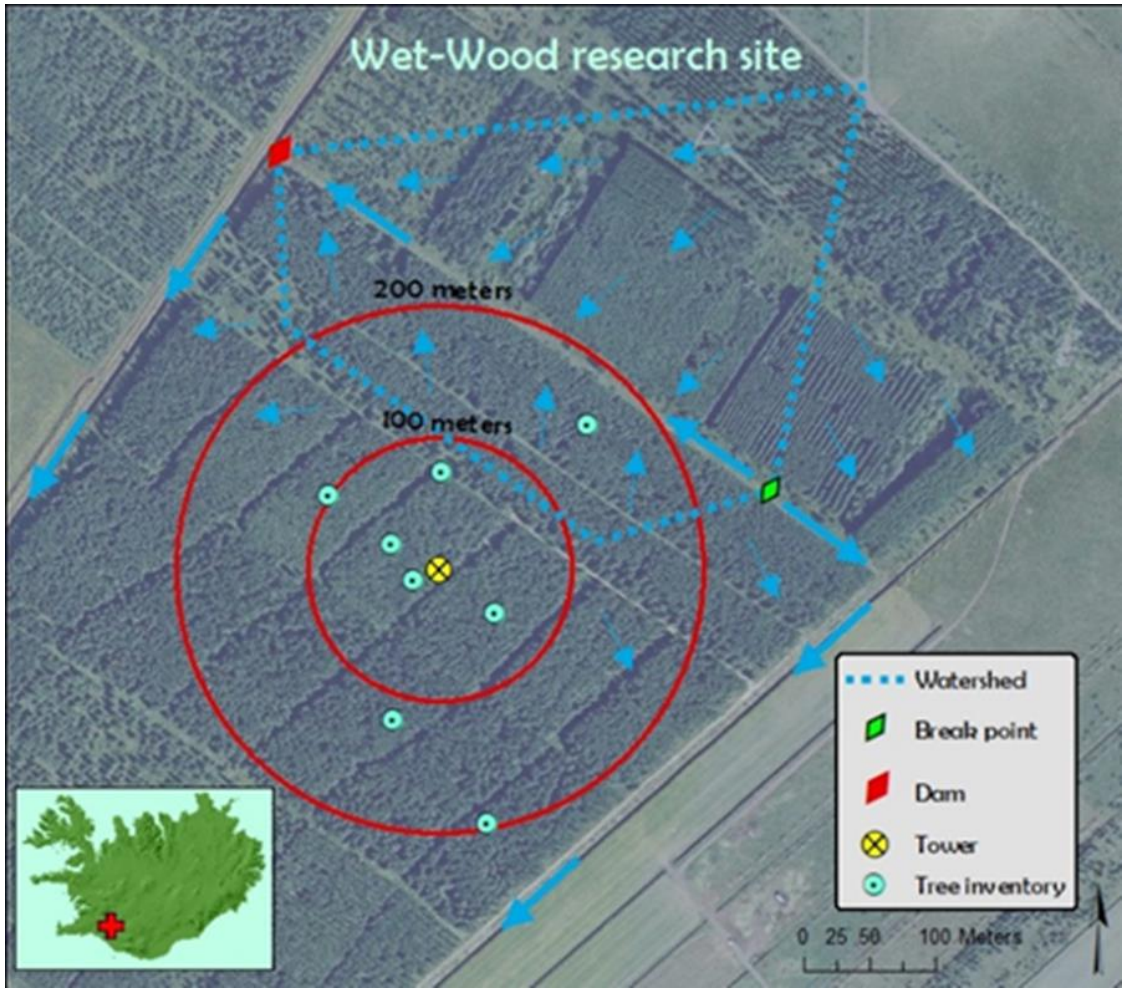
Annual C increment (in CO_2) – trees aboveground and coarse roots:

Year 1: **14,9 t CO_2 ha/yr**
Year 2: **21,9 t CO_2 ha/yr**

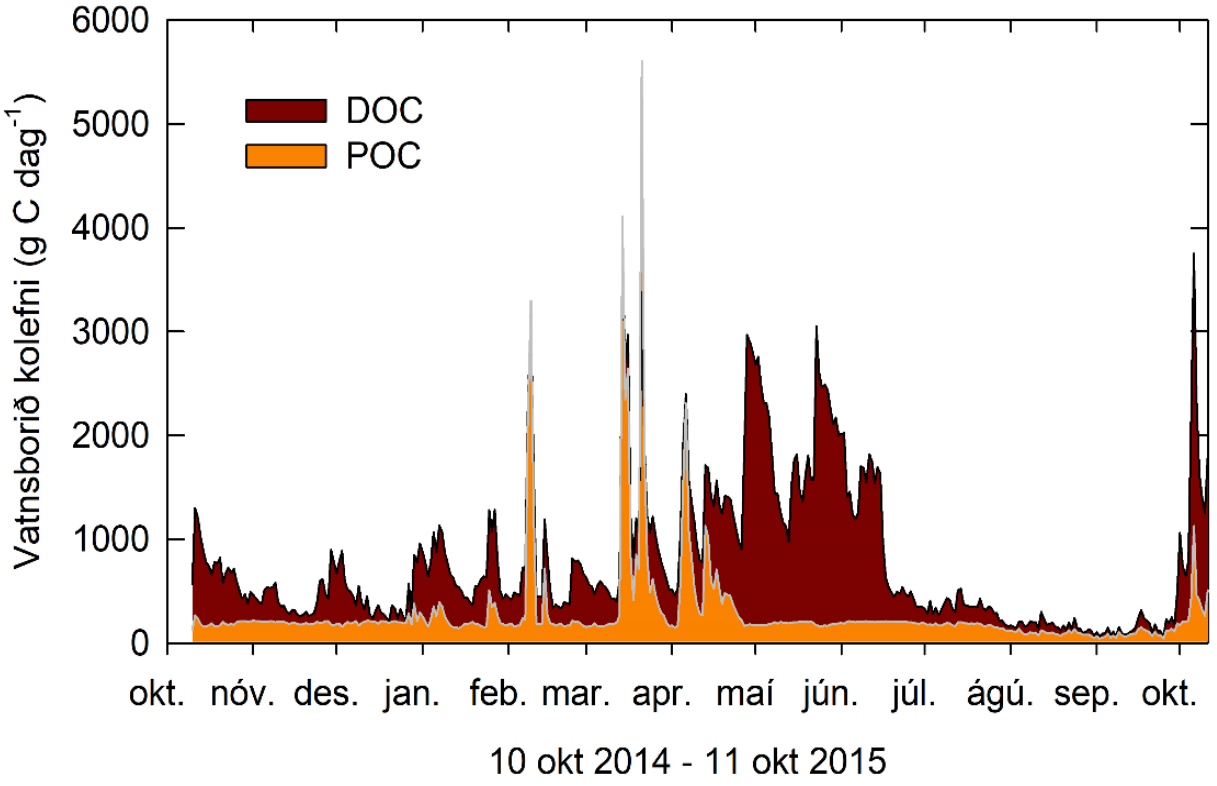
g C m^{-2} yr^{-1}


NEE
-714
GPP
-1285
R_{eco}
571
Whole tree
biomass
-647
Ground vegetation
- 9

C-RUNOFF WITH WATER THROUGH DITCHES



Estimation of the run-off area: 10,6 ha

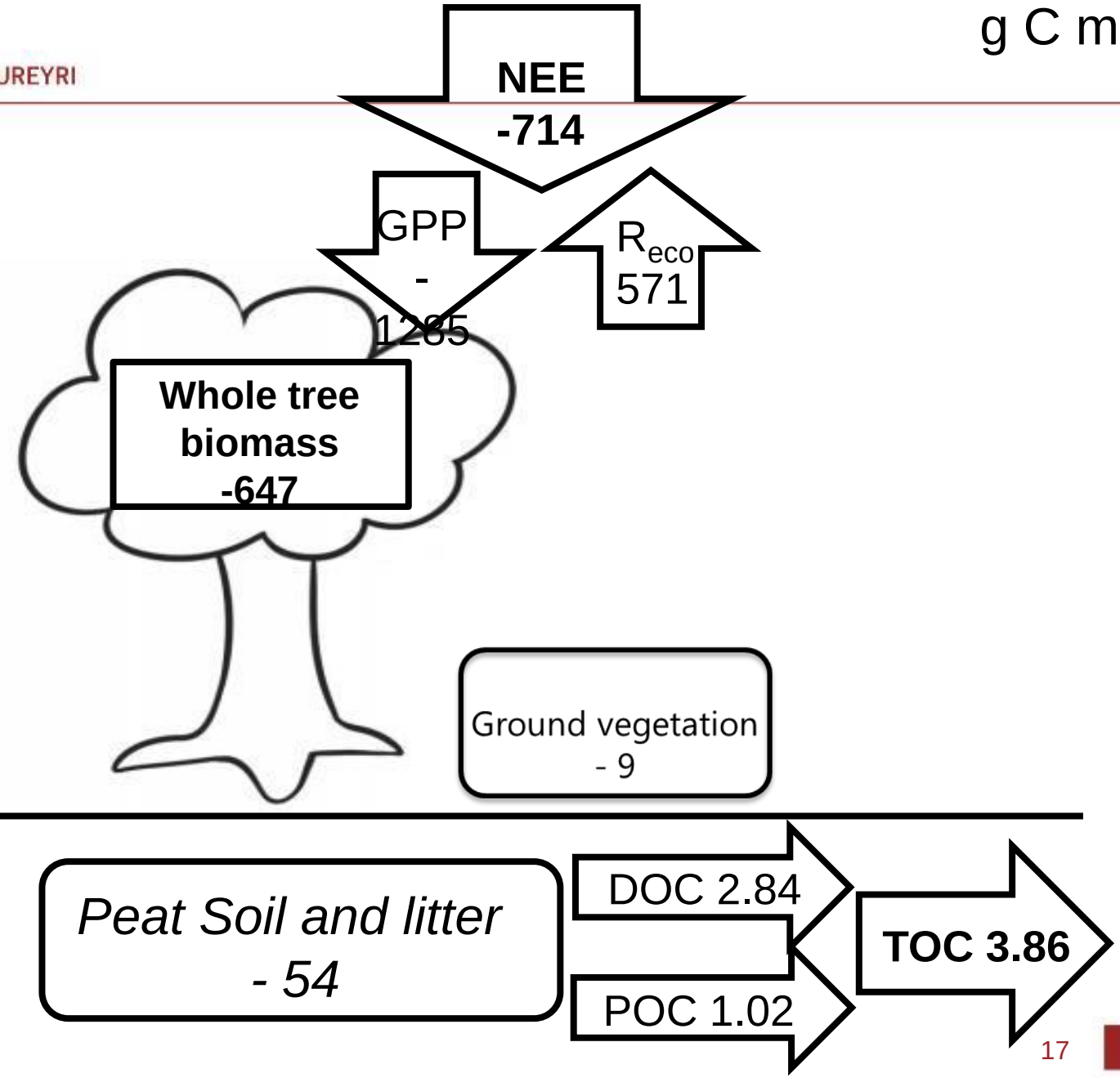


DOC: 316 kg C yr^{-1}

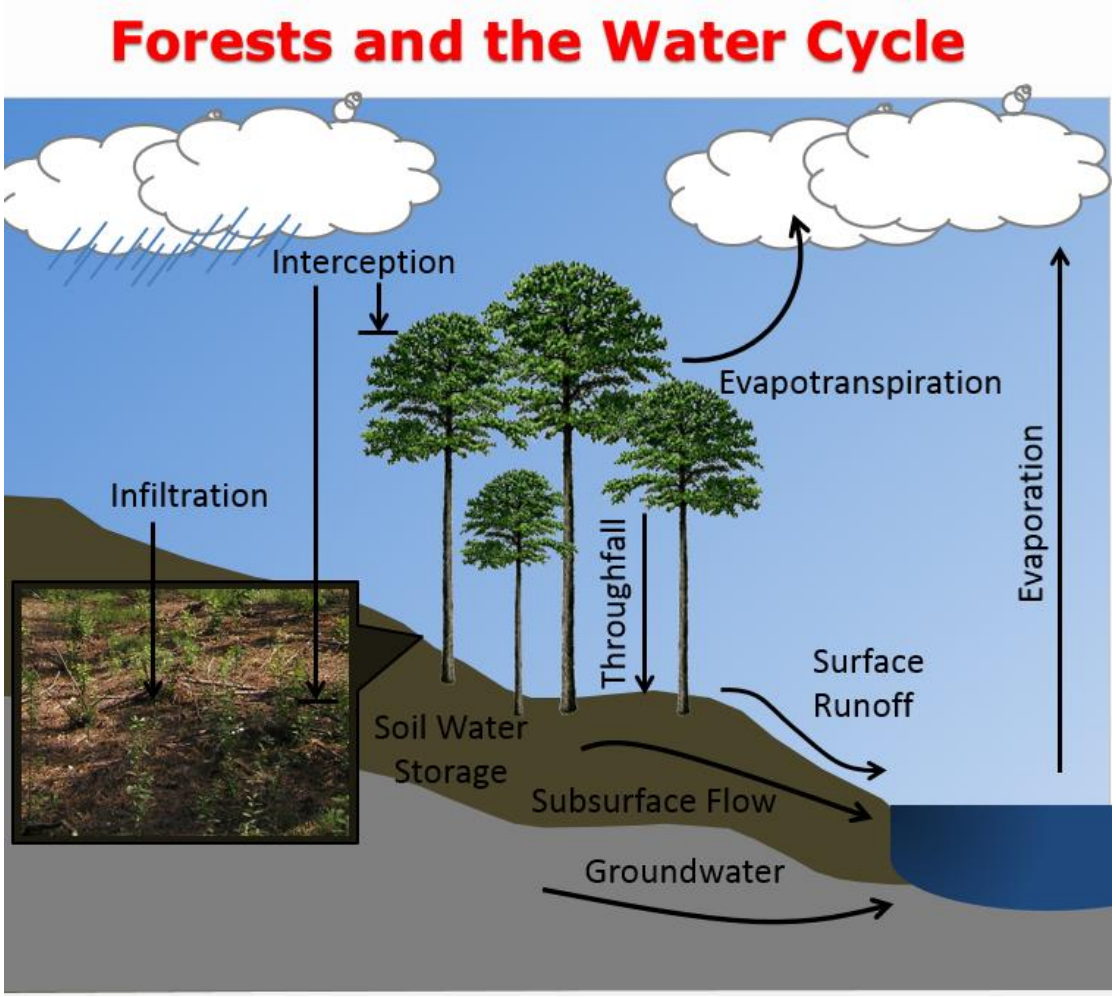
POC: 94 kg C yr^{-1}

In total **410** kg C yr^{-1} for the total run-off area

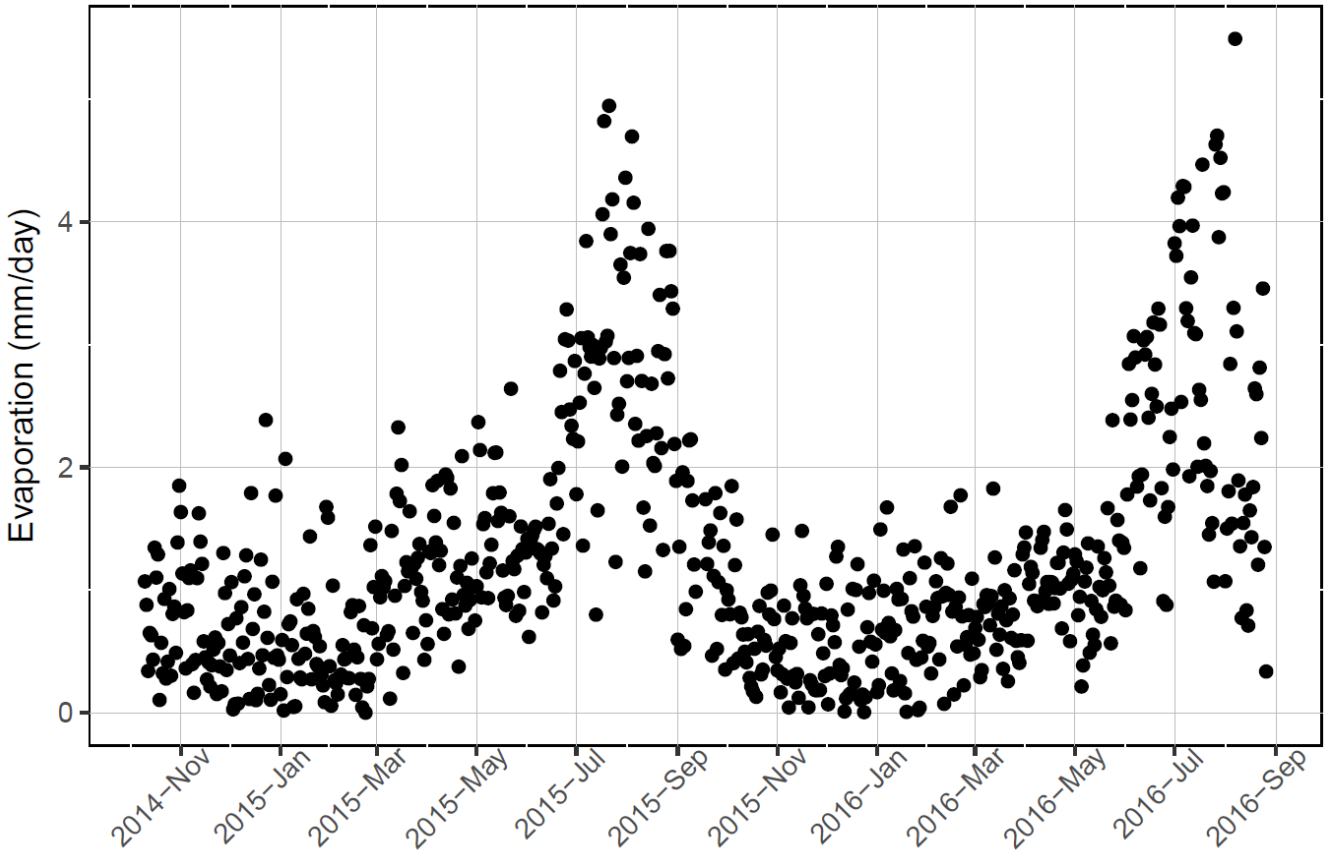
g C m^{-2} yr^{-1}


NEE
-714
GPP
-
1285
R_{eco}
571
Whole tree
biomass
-647
Ground vegetation
- 9
Peat Soil and litter
- 54
DOC 2.84
POC 1.02
TOC 3.86

THE WATER BALANCE WITHIN THE FOREST

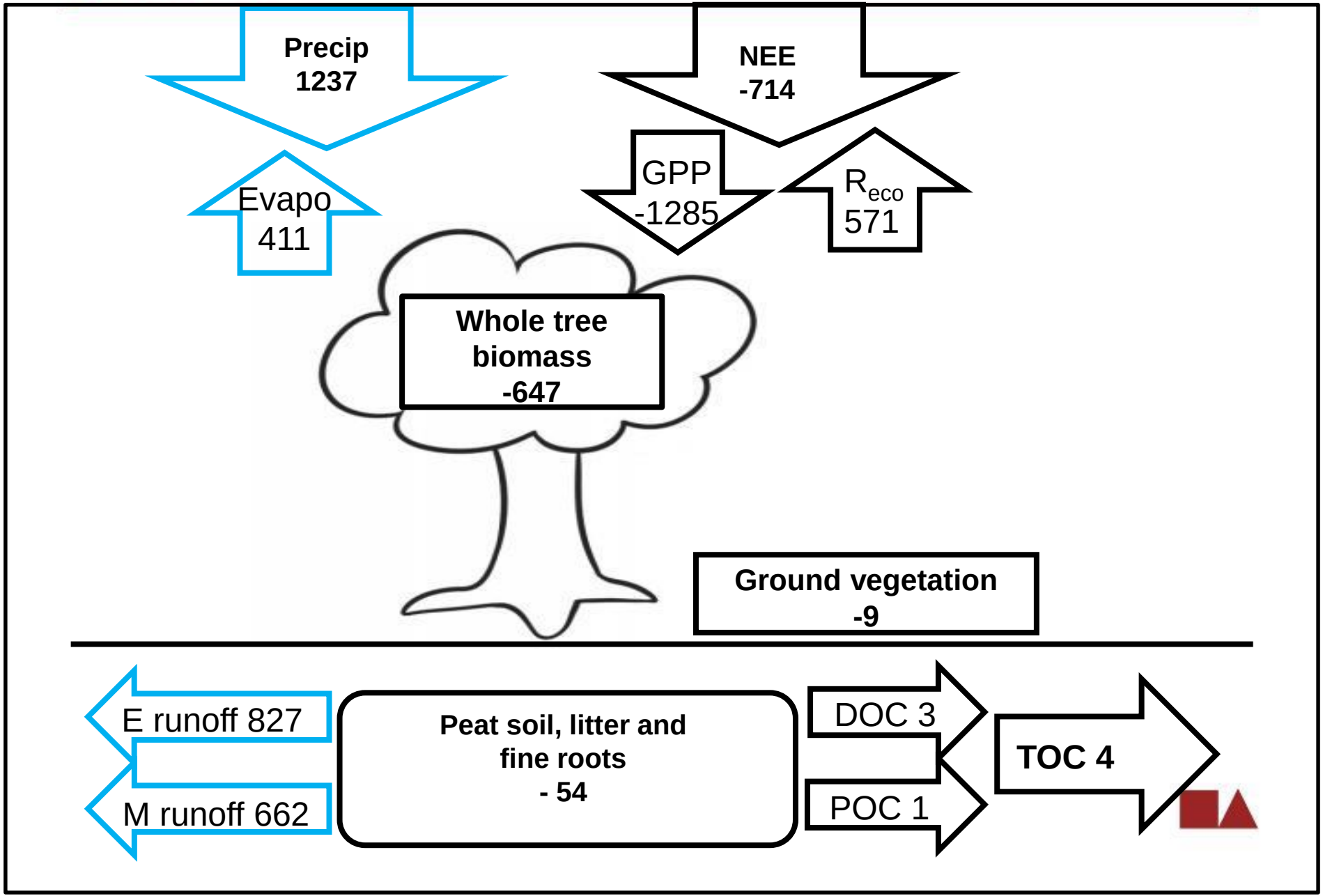


EVAPOTRANSPIRATION



Total precipitation for one year: 1237 mm
Total evapotranspiration for one year: 411 mm

g C m^{-2} yr^{-1}


Precip
1237
NEE
-714
GPP
-1285
R_{eco}
571
Evapo
411
Whole tree
biomass
-647
Ground vegetation
-9
E runoff 827
M runoff 662
Peat soil, litter and
fine roots
- 54
DOC 3
POC 1
TOC 4

THE WATER BALANCE

- First whole year measurements of evapotranspiration in Iceland
  - One older study in Gunnarholt: 30% evapotranspiration (Sigurðsson ofl. 2004)
- This study: total evapotranspiration was 33%
- Studies for other countries show as much as 90% evapotranspiration in very dence forests (Sun et al., 2008)

CONCLUSIONS

- A strong sink, an average NEE value of -714 g C m^{-2} yr^{-1}
- Only 0.5% of the total NEE was lost through lateral TOC transport, leaving 710 g C m^{-2} yr^{-1} as the total NEP
- 91% of the observed NEP could be explained by the annual biomass increment of the trees and 1.3% by the ground vegetation, leaving 7,5% that most likely accumulated in leaf, fine-root litter and soil C stocks.
- A limitation to the ecosystem C balance (NEP) is that it only covers CO_2 and TOC but not CH_4.
- On average, 33% of the annual measured precipitation was estimated to have evaporated back to the atmosphere.
- This left 416 mm for potential runoff, which was somewhat lower value than the measured runoff (827 mm).

WHAT EXPLAINES HIGH NEE NUMBERS??

- Possible explanations for a strong sink:
  - High GPP – unusually productive forest type, growing very fast at this age span
  - Low Reco – low winter CO_2 emissions due to high off-season ground water levels
  - The soil is a key component!!
- Final conclusion:
  - at a certain age span, afforestation seems to be a valid method to reverse the expected negative C-balance of poorly drained pastures in Iceland that have been abandoned