Alterations in ‘ecosystem water yield’ associated with land use changes under different precipitation regimes

Shani Rohatyn (1,2,3), Efrat Ramati (1), Fyodor Tatarinov (1), Eyal Rotenberg (1), Eran Tas (2), and Dan Yakir (1)

(1) Earth and Planetary Sciences, Weizmann Institute of Science, Rehovot, Israel, (2) Faculty of Agriculture, Food and Environment, the Hebrew University of Jerusalem, Rehovot, Israel, (3) The advanced school for environmental science. The Hebrew University of Jerusalem. Israel.

Introduction

Changes in rainfall regimes and land cover results in complex alterations in plant water use and in ecosystem water balance, which are not well quantified, especially in dry regions. This results in poor estimates of **‘ecosystem water yield’** (WYe; the difference between precipitation, P, input and evapotranspiration, ET, losses), which provides the water available for runoff and re-charge, and ultimately also for human consumption at larger scales.

Objectives & Hypothesis

The aim was to examine the interactions between the effects of land use change (from sparse shrubland to pine forest) and changes in the precipitation regime (from Humid Mediterranean to semi-arid conditions) on WYe.

We hypothesized that **afforestation increases ET and reduced WYe**, but the impact of forestation diminishes with decreasing precipitation.

Afforestation 1944 vs. 2006

Methods

We used a custom-built mobile laboratory (Fig. 1) for eddy co-variance measurements, deployed on a campaign basis (10-15 days each). Measurements were carried out during 2012-2015 in three paired sites of *Pinus halepensis* forests (F) and adjacent non-forest (NF) ecosystems along the rainfall gradient in Israel, from 290 (Semi Arid, SA) to 755 mm (Humid Mediterranean, HM) in annual precipitation.

For the estimation of annual WYe we developed a meteorological based statistical algorithm, described here in 3 steps (fig. 2-4):

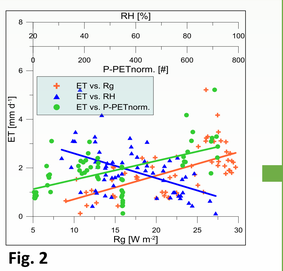


Fig. 2 Multiple stepwise regression of ET over met. parameters (Rg, T, RH, cumulated normalized P-PET)

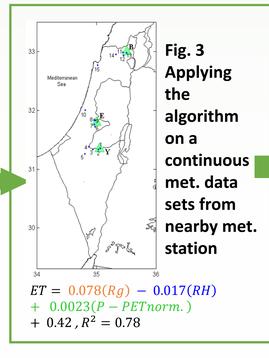


Fig. 3 Applying the algorithm on a continuous met. data sets from nearby met. station

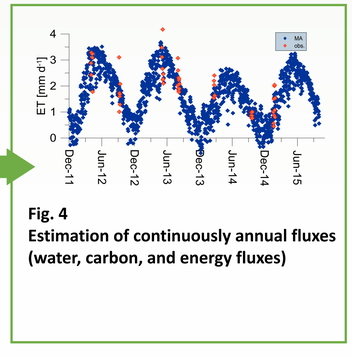
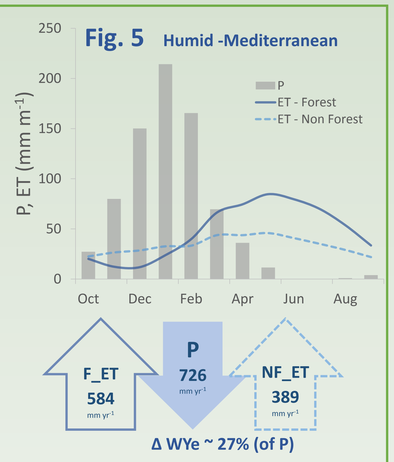
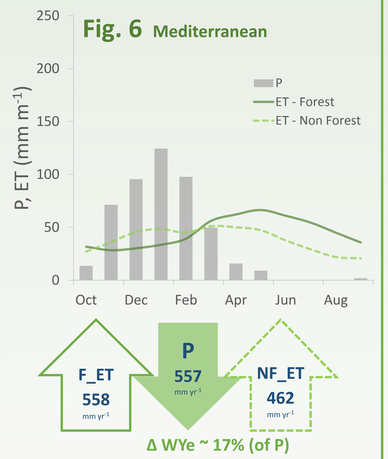


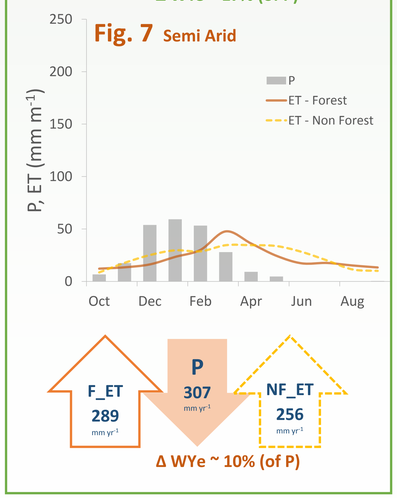
Fig. 4 Estimation of continuously annual fluxes (water, carbon, and energy fluxes)

Results

- **Annual cycles of ET** and P in 3 paired sites (F & NF), in Semi arid (SA, Fig. 5), Mediterranean (M, Fig. 6) and Humid Mediterranean (HM, Fig. 7): The peak season is short and early in the SA site, and longer and later in the M and MM sites.
- Long-term mean **annual water budgets**: Arrows below the figures, shows increase in annual ET when changing the land cover from NF (dashed line) to F (solid line), this increase results in loss of water and reduction of WYe, from ~27% to ~10% of P in the HM and SA, respectively.







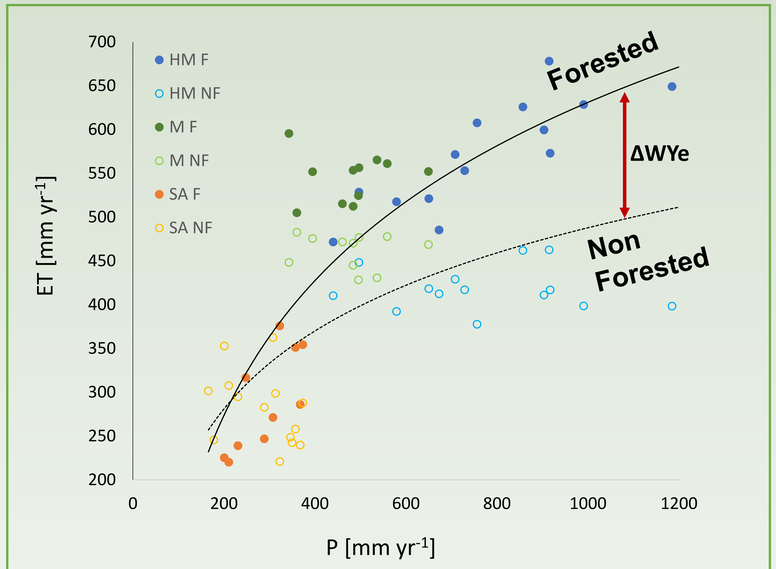


Fig. 8: Changes in annual sum of ET in forests (F) and adjacent non-forested (NF) ecosystems along the rainfall gradient. Differences between F and NF ecosystems are presented here as ΔWYe and diminish with decreasing precipitation.

Conclusions

- The experimental approach based on the Mobile-Lab provides a useful alternative to many permanent flux sites, or complex manipulation experiments, and allow quantification of the effects of land use changes during environmental changes, such as associated with global warming.
- **Afforestation is associated with loss in WYe** due to increase in ET, but this impact is non-linear and diminishes with decreasing precipitation.
- The results provide an incentive to maintain and even **increase forestry in dry, or drying, conditions** to benefit from ecosystem services other than WYe (e.g. carbon sequestration, wood production, recreation).

Contact: shani.roahtyn@weizmann.ac.il