WATER FLUXES FROM LEAF TO ECOSYSTEM SCALES IN A SEASONAL MEXICAN CLOUD FOREST:
GLOBAL CONTEXT AND IMPLICATIONS FOR FUTURE RESEARCH PRIORITIES

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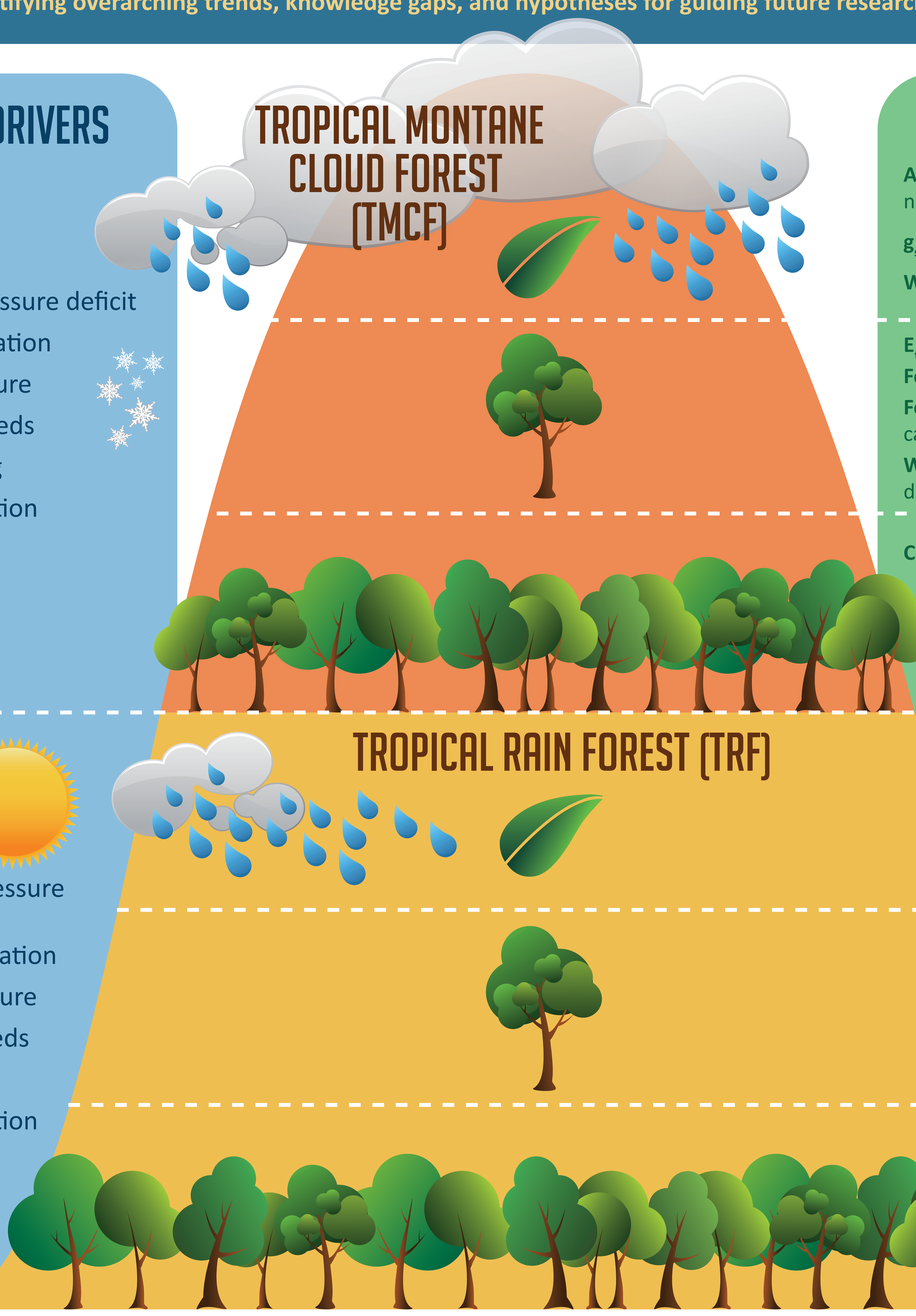
RATIONALE AND OBJECTIVES

An important emerging area in ecohydrology is linking information about ecophysiological processes at the leaf and plant scales to patterns observed on the ecosystem to landscape scales. Tropical montane cloud forests (TMCFs) are unique ecosystems that experience frequent and persistent emersion in low-lying cloud—or fog, which leads to but have been understudied by physiological ecologists due to their remote location and difficult terrain. Critical to advancing fundamental knowledge about the ecohydrological functioning of TMCFs is to elucidate how unique plant ecophysiological traits and processes of TMCF plants influence water and carbon fluxes from the leaf to ecosystem scales.

Additionally, understanding how water-carbon fluxes in cloud forests differ from non-cloud affected tropical rainforests (TRFs) that often occur below the cloud forest belt can provide additional insight into how physical and biological drivers interact to control water and carbon cycling in diverse ecosystems and improve projections of future climate change impacts.

The objective of this poster is to synthesize, compare, and contrast the current state of knowledge about leaf-to-ecosystem ecophysiological processes controlling water and carbon fluxes in TMCFs and TRFs, focusing on our research from Mexico while also providing a larger global context, as a basis for identifying overarching trends, knowledge gaps, and hypotheses for guiding future research.

PHYSICAL DRIVERS



TMCF:

- Low Vapor pressure deficit
- Low solar radiation
- Low temperature
- High wind speeds
- High cloud/fog
- High precipitation

TRF:

- High Vapor pressure deficit
- High solar radiation
- High temperature
- Low wind speeds
- Low cloud/fog
- High precipitation

GLOBAL CONTEXT

TMCF

A_{sat}: 5.5-9.1 µmol m^{-2} sec^{-1} ($\bar{x}$ = 7.2 µmol m^{-2} sec^{-1}); not correlated with elevation [1]

g_s: 60-400 mmol m^{-2} sec^{-1} ($\bar{x}$ = 222 µmol m^{-2} sec^{-1}) [1]

WUE trend: increasing WUE with elevation [2,3]

$E_{t\text{-}tree}$: 5.5-63 L day^{-1}; $\bar{x}$ = 24.7 L day^{-1} [4]

Foliar uptake: 37-100% of Et [5]

Foliar uptake: TMCF species 12% higher foliar uptake capacity vs. premontane species [6]

WUE: 2.4 - 6.6 µmol CO_2 / mmol H_2O m^{-2} sec^{-1} [13]; decreases with increasing precipitation and elevation [3]

Cloud water interception: 22-1990 mm $year^{-1}$; 5-75% % of MAP [7]

E_t: 65-646 mm yr^{-1}; $\bar{x}$ = 395 [1]

E_t suppression by fog: 10-95% [8,9,10]

Nighttime E_t: 7-33% of E_t [5]

TRF

A_{sat}: 13-19 [8]; 3.7-20.3 µmol m^{-2} sec^{-1} ($\bar{x}$ = 10 $µmol^{-2}$ sec^{-1}); increases with elevation [3]

g_s: $\bar{x}$ = 370 mmol m^{-2} sec^{-1} [12,13]

WUE: 1.4 - 3.8µmol CO_2 / mmol H_2O m^{-2} sec^{-1} [14]

iWUE: increases with increasing precipitation and elevation [15]

$E_{t\text{-}tree}$: 47-379 L day^{-1} [11]

E_t: 694-1131 mm yr^{-1} ($\bar{x}$ = 957 mm yr^{-1}) [17]

MEXICO STUDY

Study site: 2000-3000 m a.s.l.; seasonally dry TMCF (3000-3500 mm $year^{-1}$; 80% in wet season)

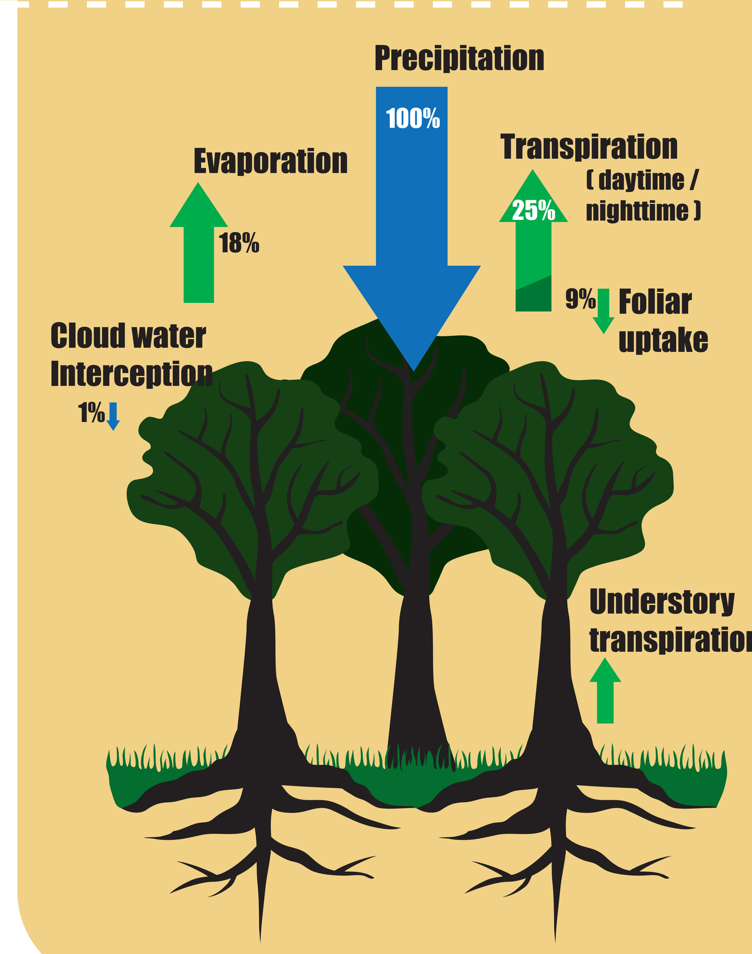
Foliar uptake: 4-16% of branch-level dry season E_t [18]

Nighttime E_t: 14-24% of dry-season water loss [5]

Cloud water interception: 54 mm $year^{-1}$; 1% of MAP [19]

E_t: 790 mm $year^{-1}$ [20]

E_t suppression by fog (relative to clear sky) : 83-90% [21]



OVERARCHING TRENDS

Despite high within- and across-site variability, a trend of lower A_{sat} and g_s, and higher WUE, in TMCFs vs. TRFs; foliar uptake and E_t suppression are important mechanisms for water balance at the leaf and ecosystem scales in TMCFs.

Nighttime E_t and foliar uptake are surprisingly high, and appear to be closely correlated with VPD and fog occurrence. Globally, this site falls in the lower range of TMCFs (e.g., low cloud water interception, high ET).

HYPOTHESES & RESEARCH RAPS

1) Physical environmental variables are stronger drivers of the trend of declining A_{sat} with elevation than differences in species' photosynthetic capacity.

2) Plant species' foliar uptake capacity, total amount, and compensation of nighttime E_t are positively correlated with fog frequency and density and degree of site seasonality.

3) Leaf-level WUE and iWUE initially decline with increasing elevation, then increase at high elevations with as fog increases and VPD and radiation decrease.

4) Declining NPP with elevation is driven by lower temperatures limiting carbon consumption.

5) High nighttime E_t, reliance on foliar uptake for plant water balance, and importance of E_T suppression by fog contribute to greater TMCF vulnerability to climate change than TRF.

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- g_s = stomatal conductance
- A_{sat} = light-saturated photosynthesis
- E_t = stand transpiration
- NPP = net primary productivity
- $E_{t\text{-}tree}$= whole tree water use
- WUE = water use efficiency
- MAP = mean annual precipitation
- iWUE = intrinsic water use efficiency derived from $\delta^{13}C$

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