What are dry season dewfall patterns in old growth Douglas-fir canopies and how well do meteorological measurements predict them?

Canopy wetting patterns and the determinants of dry season dewfall in an old growth Douglas-fir canopy

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How does the weather, including frost and wetting from rain and dew influence the microclimates in forest canopies? The researchers used direct measurements over the vertical range of a 65-m Douglas fir tree over 4 years and a meteorological station over 15 years to determine how water inputs, drying cycles, and tree complexity influence canopy microclimates over years and across seasons. They also used their data to test two models, the Penman equation and a logistic model trained on in-tree data, which are intended to predict seasonal dewfall.

What are annual patterns of forest canopy wetting?

Each height in the canopy was wet for approximately half the year, and dry for half. This included dewfall wetting, which resulted in 16.4% more wet days than rainfall alone.

How do wetting patterns differ among seasons?

During the wet season the upper canopy experienced more wetting events of shorter duration with intervening dry periods. The lower canopy levels and forest floor experienced more wet time and frosted time and surface drying was an order of magnitude longer.

Wet and dry period frequency and duration during the spring and fall shoulder seasons followed the same pattern as the wet season, but to a lesser degree. Both seasons had dry spells during which the lower canopy dried completely. During spring there was less dew-wetted time in the upper canopy.

During the dry season the upper canopy had more frequent wetting events than the lower canopy. Dewfall was the main source of wetting and the events were shorter with greater separation than in other seasons.

How well did the two models predict dewfall?

When using data from the PRIMET weather station, the Penman equation correctly predicted dewfall on 87% of the days with measured dewfall and had a 40% false positive rate. The PRIMET equation did not perform as well when using in-tree measurements.

Logistic modeling performed much better when using in-tree data. The single variable model using dewpoint depression explained 87% of the variance. It correctly predicted dewfall on 75% of days with measured dewfall and had 12 false positives.

What should managers focus on when predicting or estimating dewfall?

- When interested in predicting dewfall in a forest, especially across a landscape, such as valley floor, slope, and ridge areas, in-tree canopy measurements of air temperature and humidity will provide the best dewfall predictions with the least amount of instrumentation.
- The specific conditions on nights with dewfall seem to indicate that air temperature cooling toward the dewpoint has a greater influence on dewfall than does increases in specific humidity. Specific humidity does not appear to differ between dew and non-dew nights.

What research will improve our understanding of canopy wetting, microclimates, and community composition?

- Further research into the cost of transition between dry period dormancy and wet period resurrection for bryophytes and lichens will help understand the patterns of epiphyte growth in forests and shed light on when wetting is beneficial.
- The factors influencing air cooling should be further evaluated to understand how changing climate, which is predicted to increase dry season temperature and duration, will impact canopy wetting and, therefore, plant health.

Research Approach/Methods

- The researchers measured air temperature, relative humidity, wind speed and direction, and leaf wetness at six heights in a single old growth Douglas-fir tree at five-minute intervals 2017-2020.
- They collected net radiation, air temperature, downwelling solar radiation, precipitation, and volumetric water content at 100cm depth in an open meadow approximately 700 m southwest of the tree.
- From the measured values and subsequent calculations, the researchers determined the wet, dry, and shoulder spring and fall periods over a 16 year period.
- They then tested two approaches to predicting dewfall during the dry season with meteorological data, the Penman approach, and a logistic model approach.

Keywords canopy microclimate, surface wetting, rainfall interception, dew, dewfall prediction, frost

Images (see below)

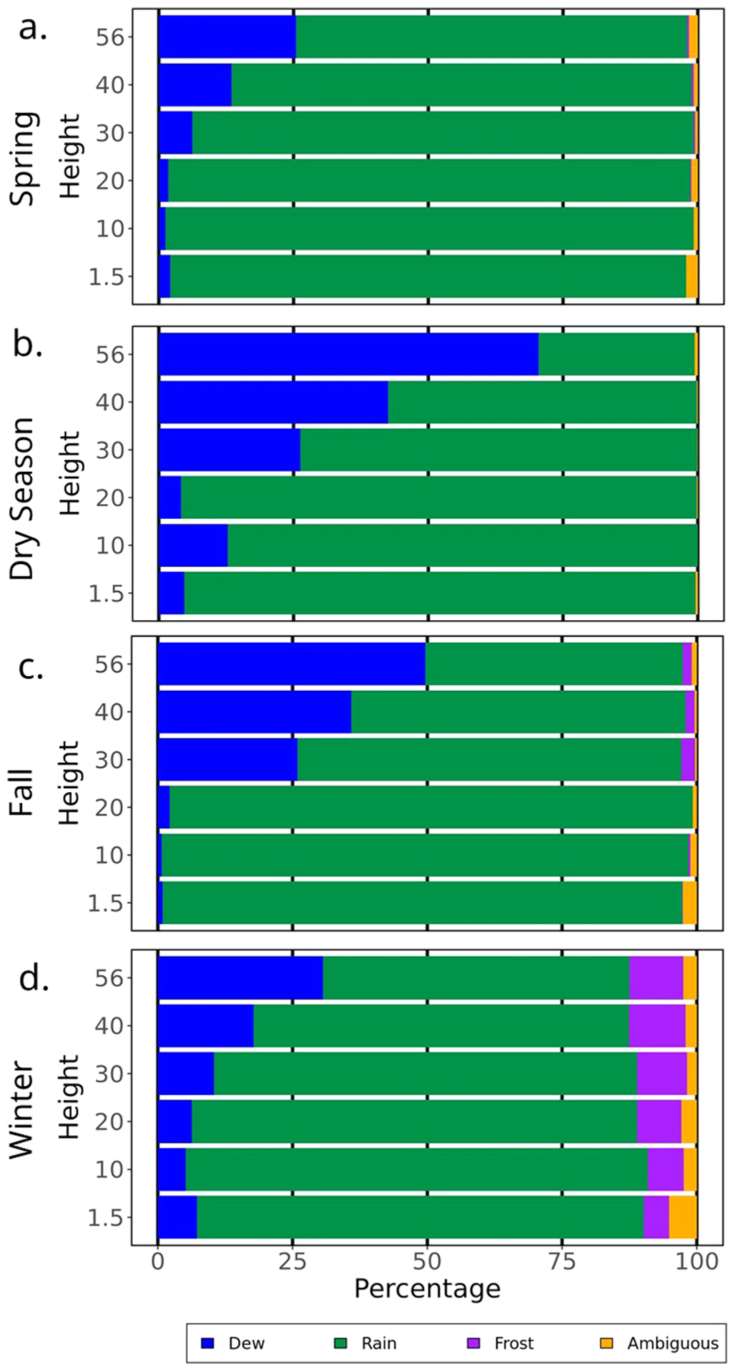

Fig. 5 in Sibley et al. 2022. Contributions to canopy wetness by type for each season across the years 2017–2020. Percentages are based on time spent wet (i.e., not the percent of time that sensors were wetted by each phenomenon, as that varied dramatically across seasons).

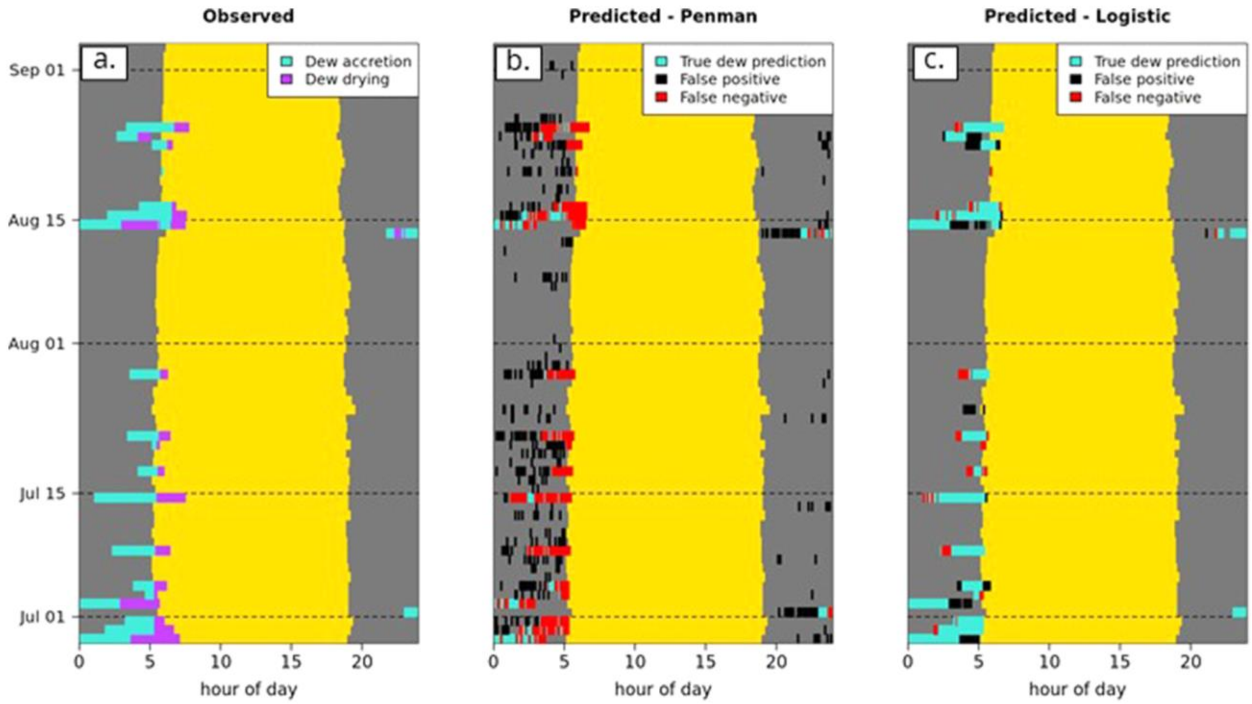

Fig. 6 in Sibley et al. 2022. Observed and predicted dew accretion and drying during the dry season of 2017. Transition between night and day denoted in all panels using gray and yellow background colors (day defined as > 10 W m⍰ 2 incident solar radiation). Panel a shows observed intervals of dew accretion and dew drying through the season. Panel b shows dew accretion as predicted by the Penman equation supplied with data from the PRIMET station, where LE < 0 mm is classified as a dew forming period. Panel c shows dew accretion as predicted using a logistic function with dewpoint depression as a predictor and a probability threshold of 0.5. False positives indicate where dewfall was predicted but not observed. False negatives indicate where dewfall was not predicted, but it was observed.

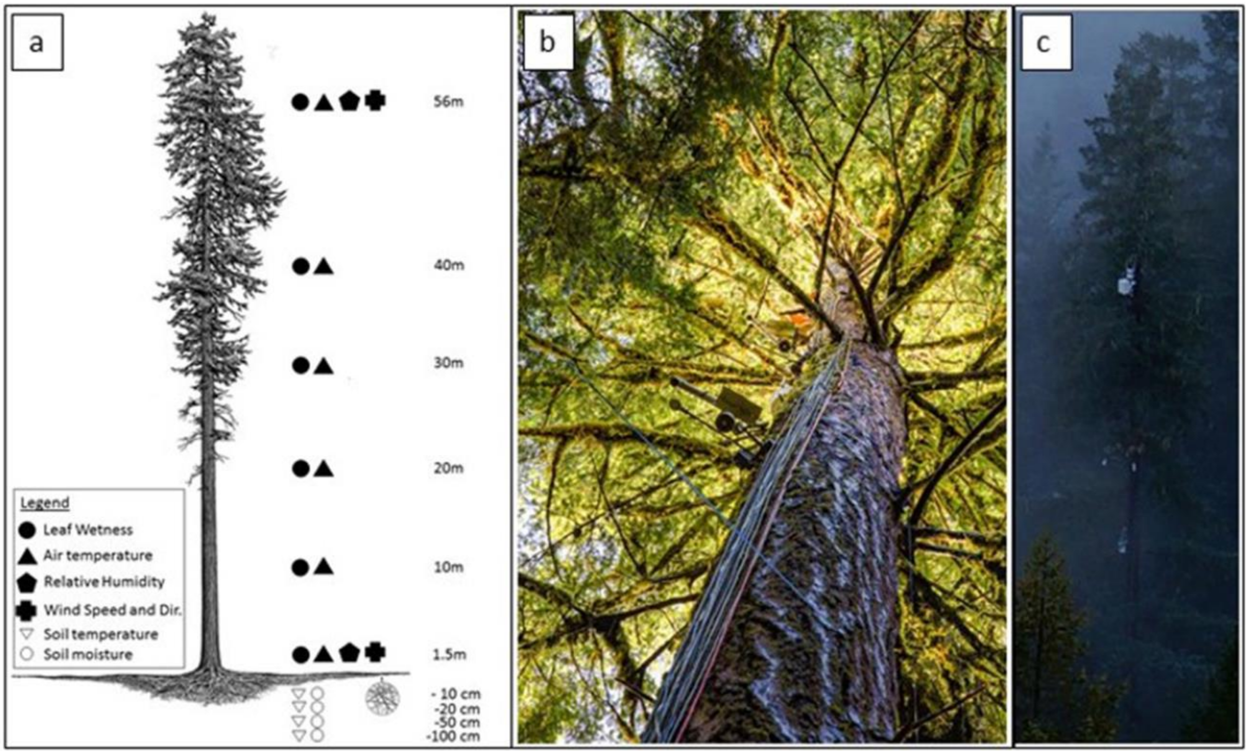

Fig. 2 in Sibley et al. 2022. (a) Illustration of the measurement tree, measurement heights within the tree, and the variables recorded at each height (illustration by Van Pelt and North (1996)). (b) View of the instrument clusters at 20 and 30 m above ground (photo credit Leah Wilson). (c) View of the upper 30 m of the tree. The white instrument enclosure in the photograph is at 56 m a.g.l. (photo credit Adam Sibley).

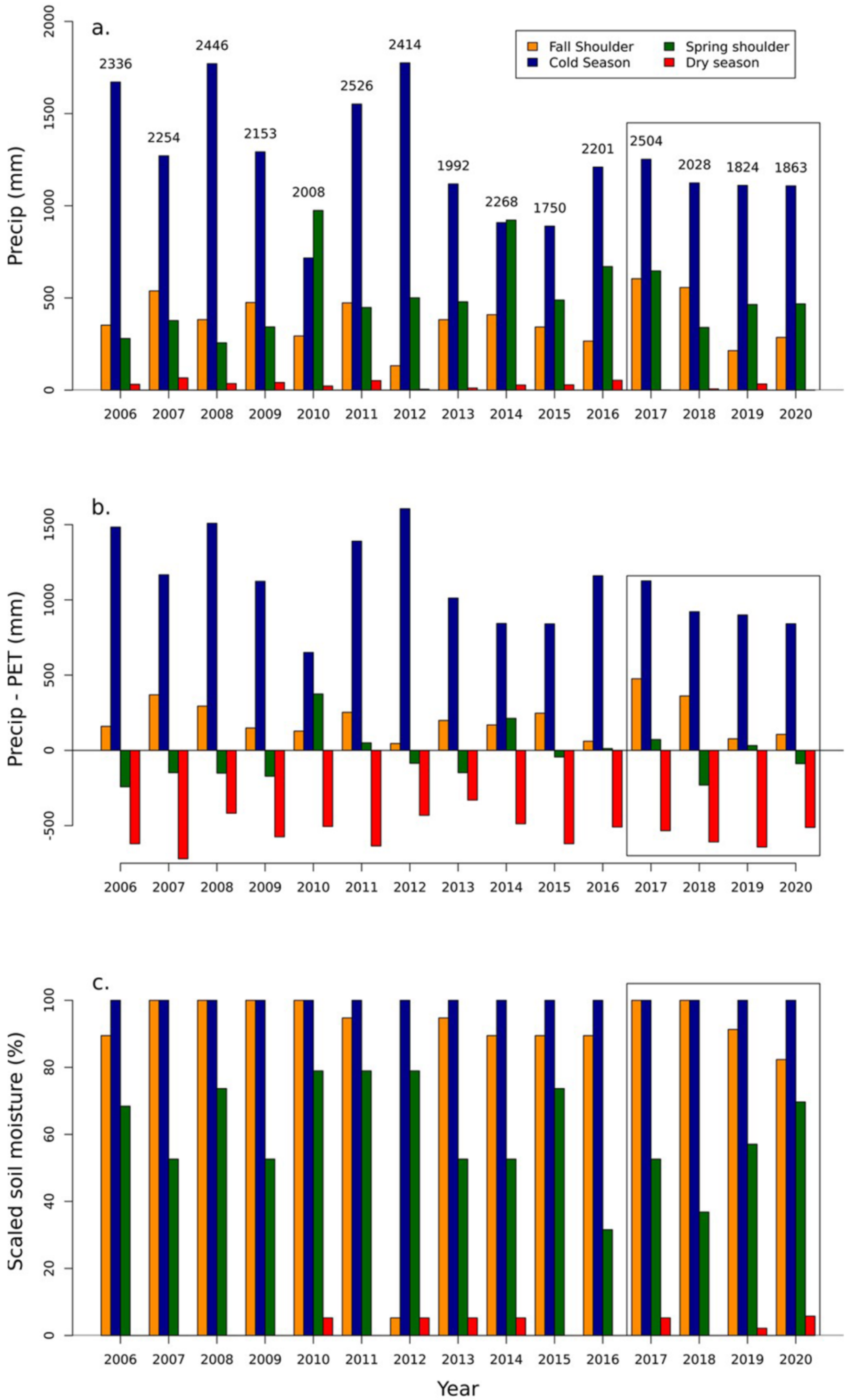

Fig. 3 in Sibley et al. 2022. Water availability in the water years 2006 to 2020, which have been divided into seasons using the methods described in Section 2.4. (a). Total rainfall values within season. Numbers above each group of bars indicate total annual rainfall in mm. (b). Total precipitation minus PET within each season. (c). remaining soil moisture at the end of each season, scaled between field capacity (0.25) and the observed minimum over the extant record (0.06).