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Predicting forested catchment evapotranspiration and streamflow from stand sapwood area and Aridity Index

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Estimating the water balance of ungauged catchments has been the subject of decades of research. An extension of the fundamental problem of estimating the hydrology is then understanding how do changes in catchment attributes affect the water balance component? This is a particular issue in forest hydrology where vegetation exerts such a strong influence on evapotranspiration (ET), and consequent streamflow (Q). Given the primacy of trees in the water balance, and the potential for change to species and density through logging, fire, pests and diseases and drought, methods that directly relate ET/Q to vegetation structure, species, and stand density are very powerful. Plot studies on tree water use routinely use sapwood area (SA) to calculate transpiration and upscale to the stand/catchment scale. Recent work in south eastern Australian forests have found stand-wide SA to be linearly correlated ($R2 = 0.89$) with long term mean annual loss (P-Q), and hence, long term mean annual catchment streamflow. Robust relationships can be built between basal area (BA), tree density and stand SA. BA and density are common forest inventory measurements. Until now, no research has related the fundamental stand attribute of SA to streamflow. The data sets include catchments that have been thinned and with varying age classes. Thus far these analyses have been for energy limited systems in wetter forest types. SA has proven to be a more robust biometric than leaf area index which varies seasonally.
That long term ET/Q is correlated with vegetation conforms to the Budyko framework. Use of a downscaled (20 m) Aridity Index (AI) has shown distinct correlations with stand SA, and therefore T. Structural patterns at a the hillslope scale not only correlate with SA and T, but also with interception (I) and forest floor evaporation (Es). These correlations between AI and I and Es have given $R2 > 0.8$. The result of these studies suggest an ability to estimate mean annual ET fluxes at sub hillslope scale using mappable attributes (AI, forest inventory data). Advances in forest inventory techniques, including LiDAR, mean stand attributes can increasingly be mapped over large areas.
If combined with process measurements, these mapped attributes provide a powerful platform for simple but robust modelling at the sub-hillslope scale, including exploring hinge points of stand vulnerability to the drier, hotter climate predicted for SE Australia where energy limited systems may face water limitation.