Water use in a riparian cottonwood ecosystem:

Eddy covariance measurements and scaling along a river corridor

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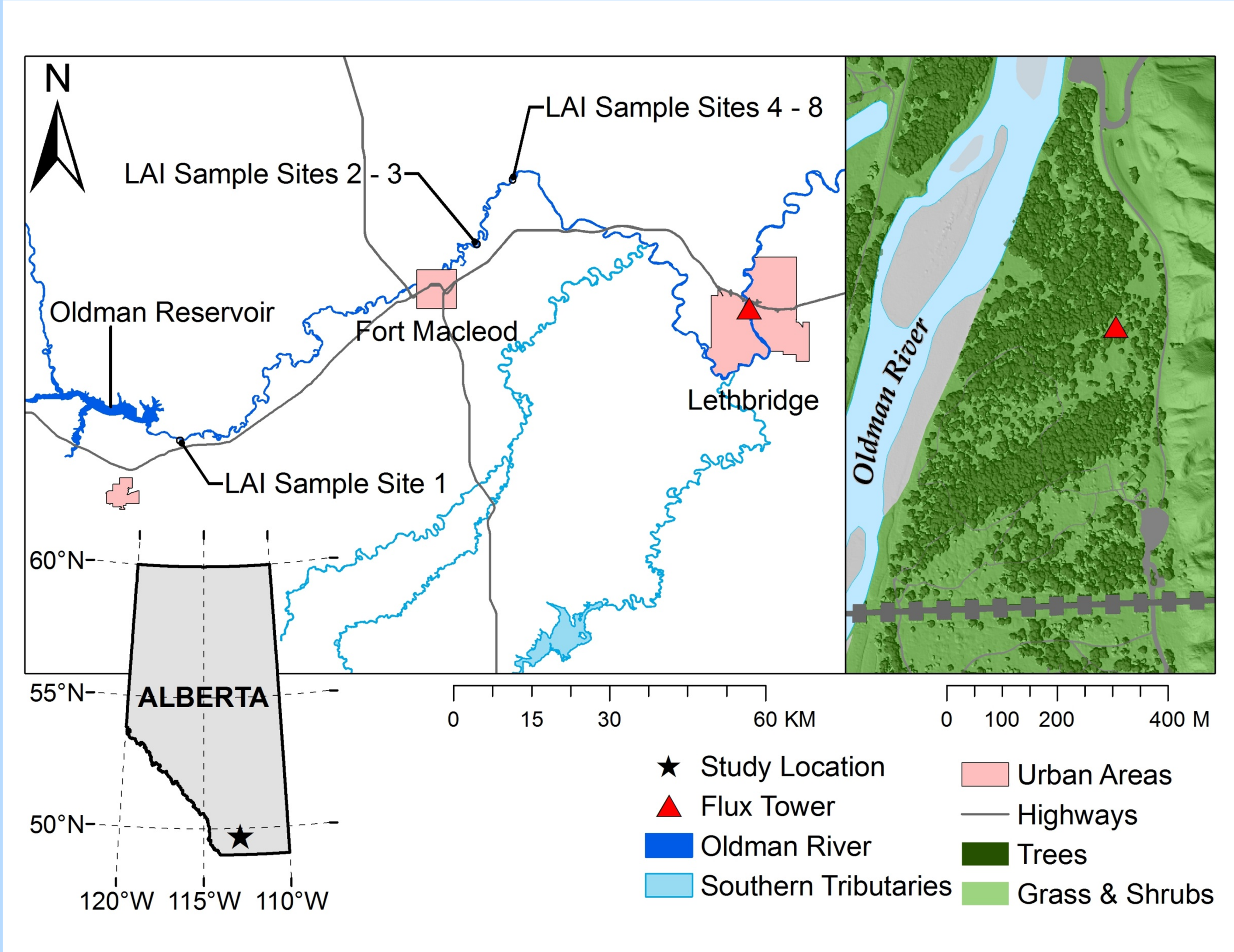
Objectives

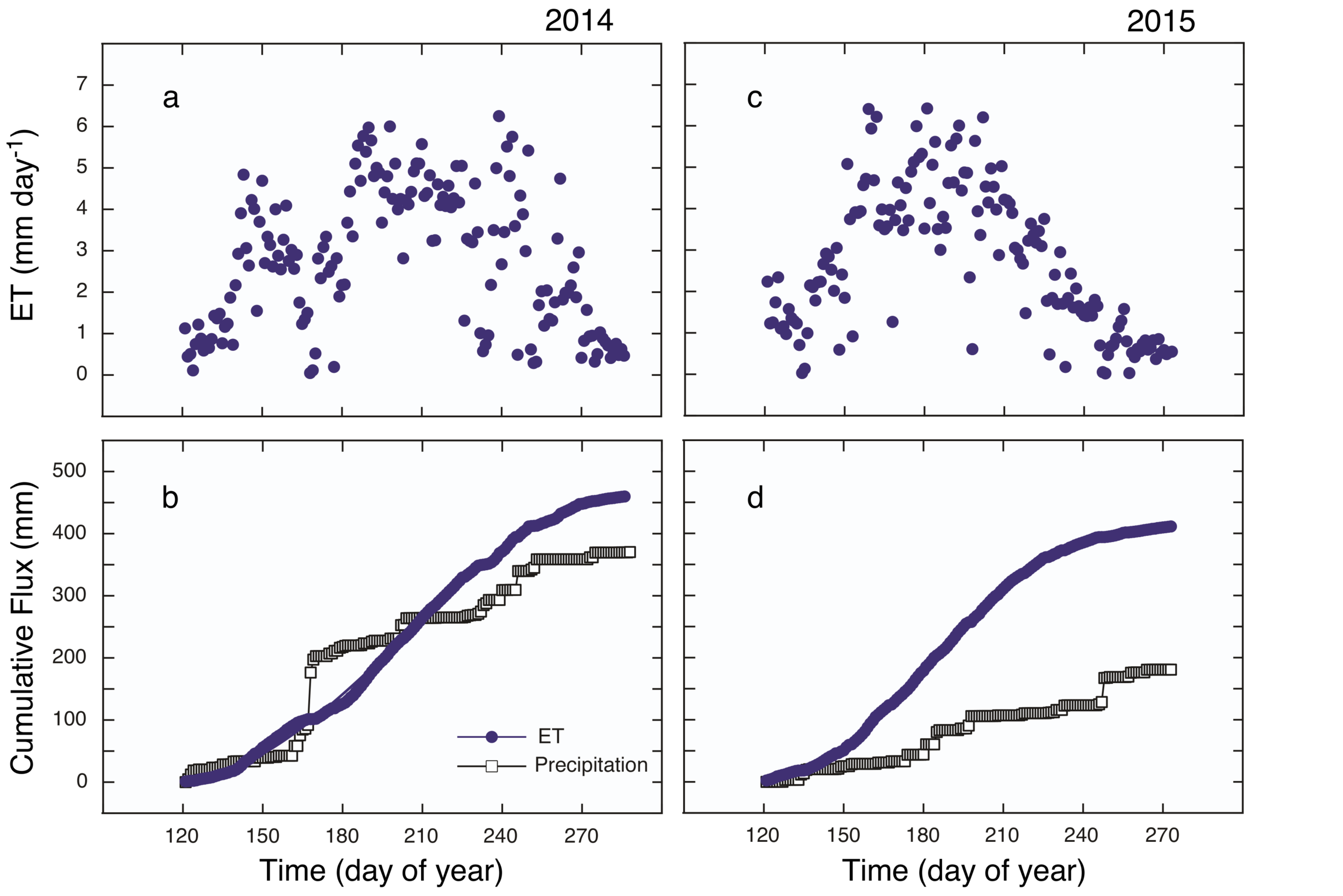
The survival of riparian forests depends on water input from their adjacent rivers. There are multiple, additional demands on river water, prompting the question, how much water must be left flowing within a river to sustain the native riparian ecosystems?

To address this, we made eddy covariance measurements of riparian cottonwood forest evapotranspiration (ET) in a representative site and used remote sensing and the Penman-Monteith equation to scale-up ET along the 171 km corridor from the Oldman River reservoir to Lethbridge, AB.

Our study included two years with contrasting May-October precipitation; 2015 (192 mm) was drier than normal (268±92 mm) and 2014 was wet (374 mm) with over-bank flooding.

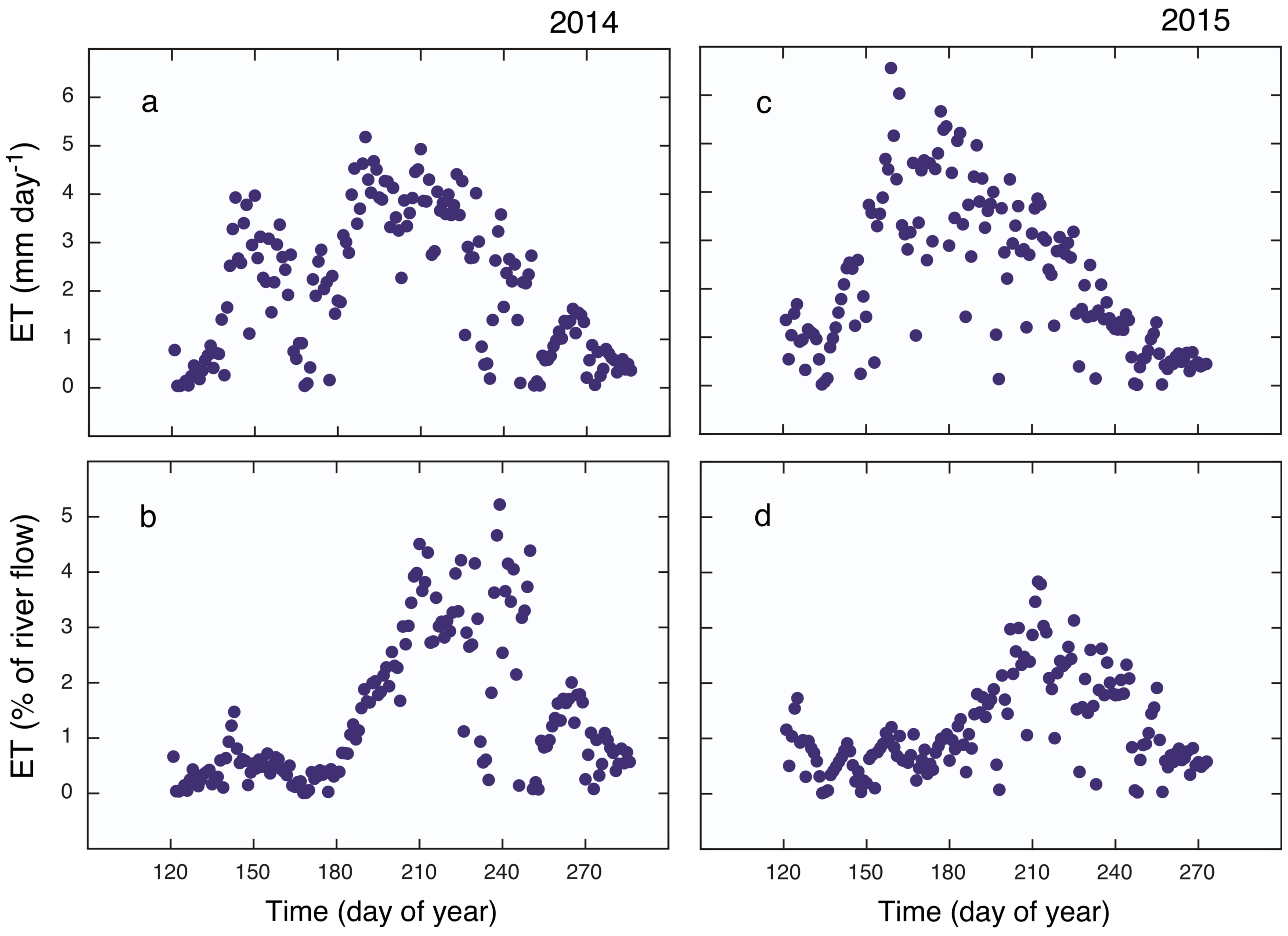


Measurements of ET and Precipitation in 2014 & 2015



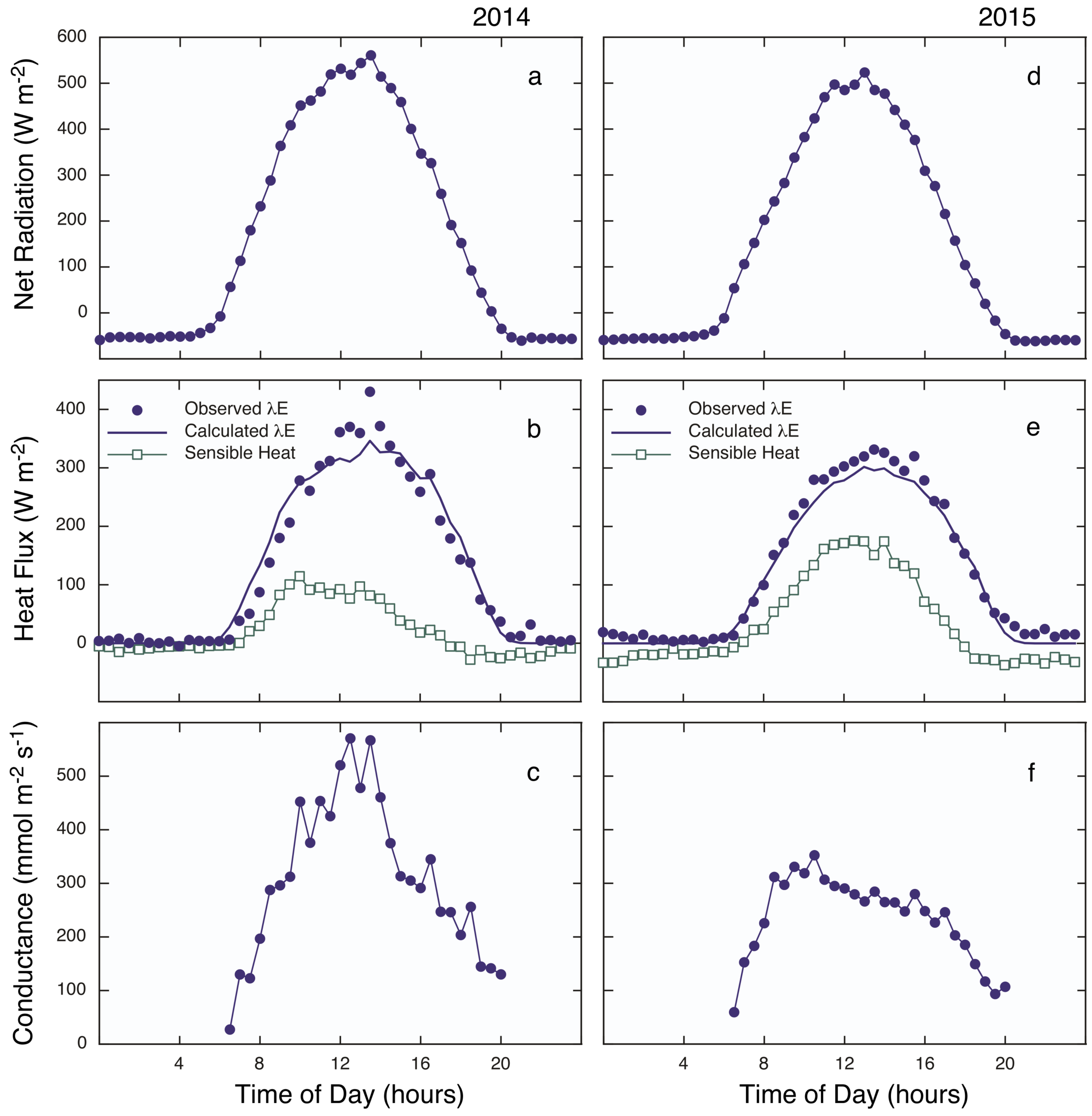
Measured cumulative forest ET was very similar in the two years despite contrasting precipitation. Cumulative ET exceeded precipitation by a much larger amount in 2015 than in 2014.

Calculations of ET for the Oldman River Corridor



We used the Penman-Monteith equation along with a parameterized model of stomatal conductance and a leaf phenology model to calculate riparian forest ET along the river corridor. Mean LAI (1.4) along the river corridor was calculated from Landsat 8 NDVI images. Forest ET during May-June was less than 1% of average river flow rates, but the ratio of ET to average river flow rate increased markedly to peak values of 4-5% in late July and early August.

Comparison of Eddy Covariance Measurements in July 2014 and 2015 (Mean Diurnal Patterns)



The mean diurnal pattern of latent heat flux in July 2014 showed higher peak values than were observed for 2015, despite similar net radiation. As a consequence, sensible heat flux during July 2015 reached slightly higher peak values than were observed in 2014. Peak canopy conductance values calculated from the inverted Penman-Monteith equation were higher in July 2014 than in 2015.

Conclusions

The water-use rates of the Oldman River cottonwood forests were high even for a broad-leaf forest, particularly given the relatively low LAI (1.4) we measured along the river corridor. The high ET rates were caused by relatively warm summer temperatures and high VPD, along with lack of significant soil moisture limitation to tree conductance and transpiration because of sufficient access to alluvial groundwater. Cottonwood forest ET increased markedly relative to river flow rates in August. This illustrates the importance of maintaining sufficient river flow rates during this time in order to supply alluvial groundwater recharge to support riparian forest ET. Model predictions indicate a high probability of low river flows in this basin in the future associated with climate change. This poses a significant threat to supporting the high water requirements of riparian forests along the Oldman River.