Sesion: H1 - (Environmental Applications)
Transdisciplinary Integrated Assessment Modeling
[Socio-eco-env. Scenarios and Model Applications]

University of Victoria

Assessing the Impact of Land Use Changes on Groundwater Recharge and Summer Low Flows in a Drying Watershed

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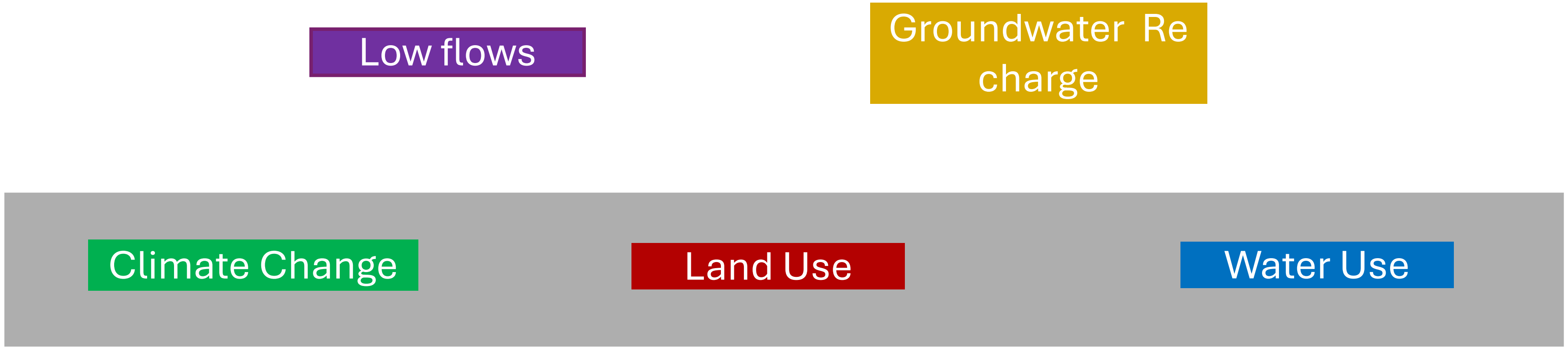
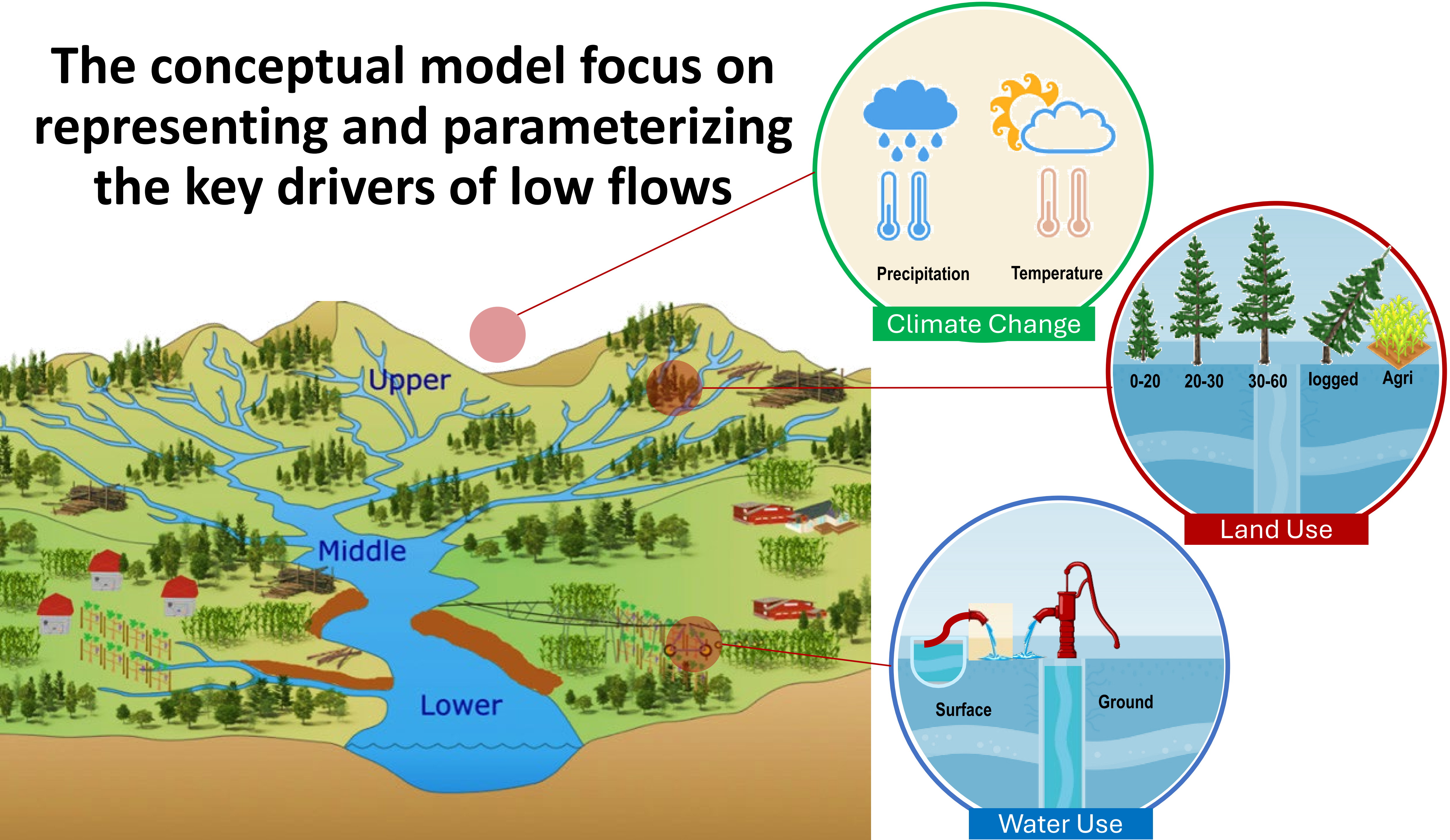
The research is focused on low flows, forest harvesting, and SWAT-MODFLOW

- What are the drivers of low flows?
- How is forest harvesting affecting low flows?
- How the model in SWAT-MODFLOW can contribute to understand the connections between low flows, land use, and groundwater?

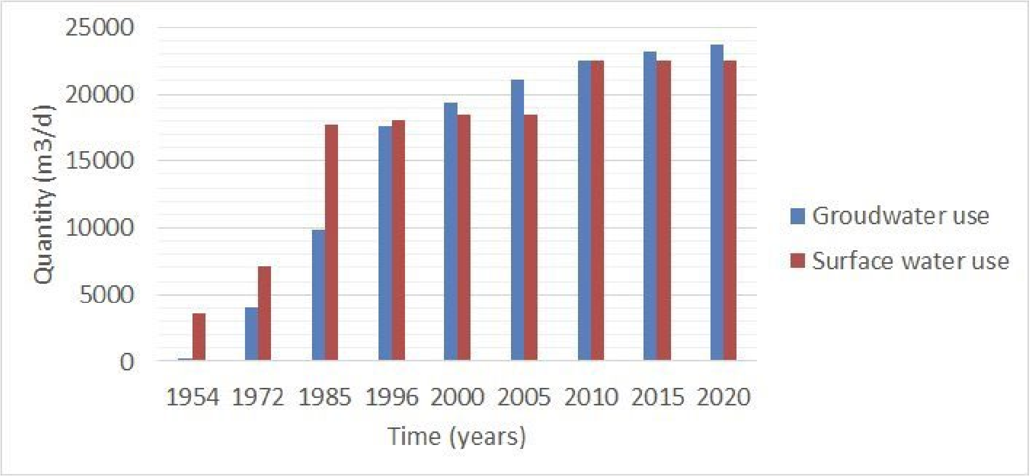


The conceptual model focus on representing and parameterizing the key drivers of low flows

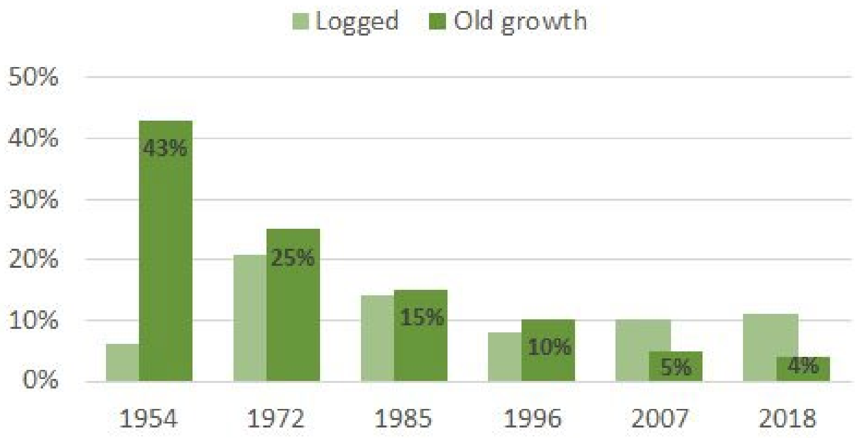


Land use, water use, and climate drivers have changed through time, potentially impacting low flows

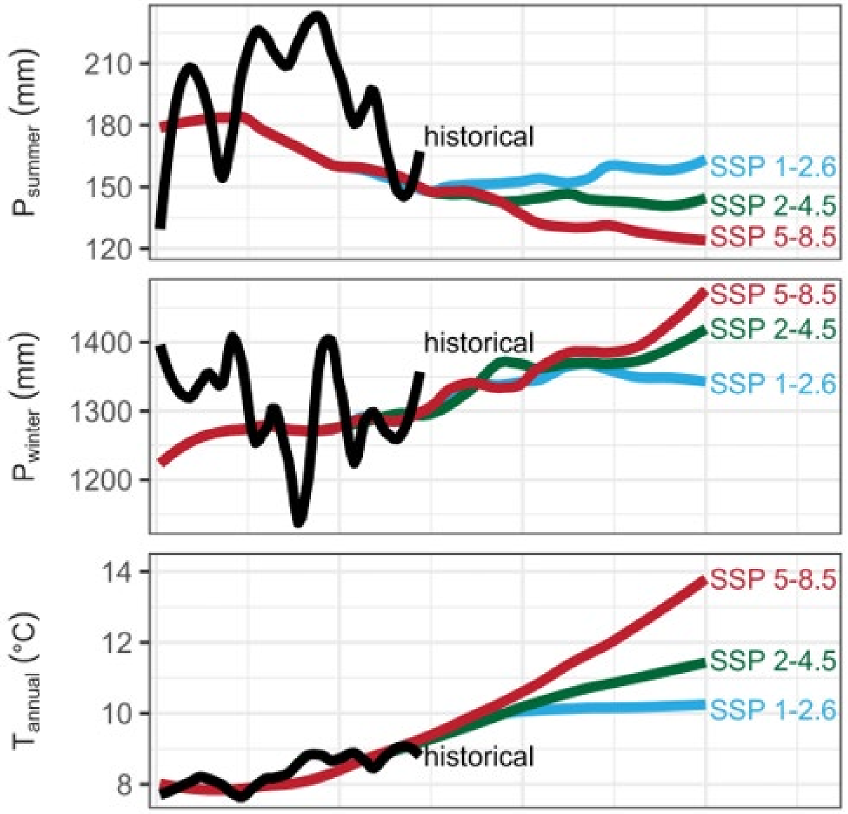
Water use



Vegetation changes



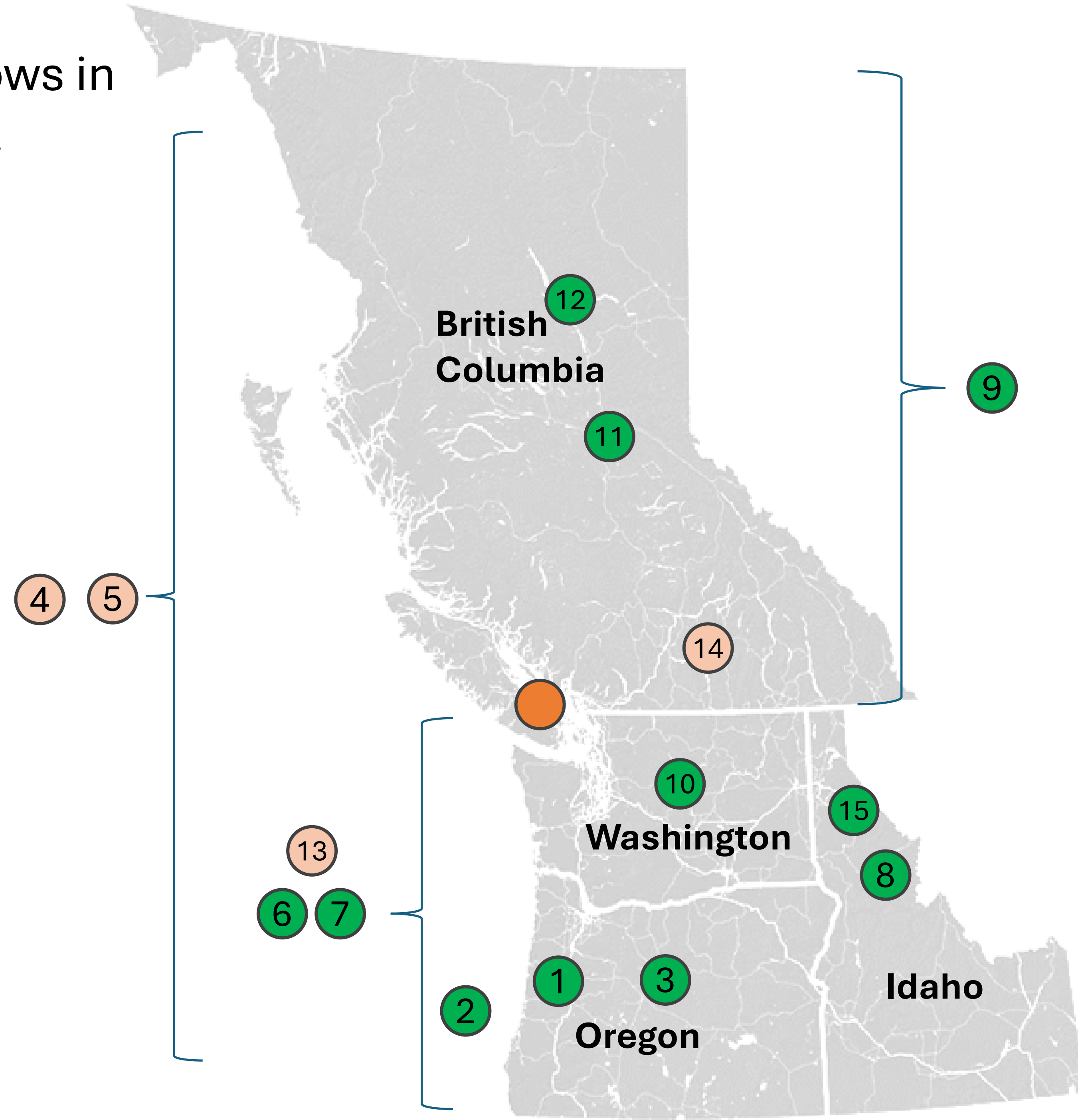
Climate change



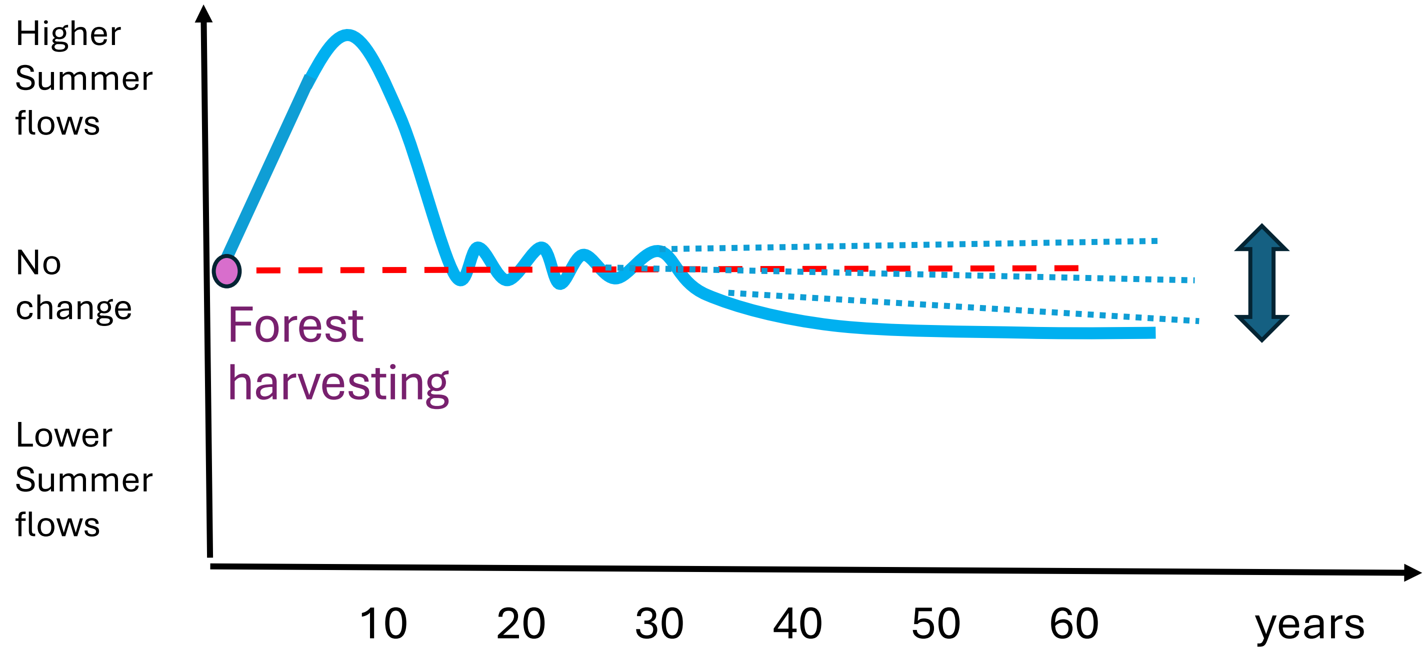
The impacts of forest harvesting on low flows in the Pacific Northwest is well studied but…

#	Authors, year	Topic
1	Segura, et al., 2020	**Long-term effects of forest harvesting.**
2	Perry & Jones, 2017	**Summer streamflow Douglas-fir forest**
3	Crampe, et al., 2021	**Runoff response old-growth forest to planted forest**
4	Moore et al., 2020	**Effects of forest harvesting on warm-season low flows**
5	Coble et al., 2020	**Long-term hydrological response to forest harvest**
6	Luce & Holden, 2009	**Declining annual streamflow distributions**
7	Grant, 2008	**Effects of forest practices on peak**
8	King, 1989	**Streamflow responses to road building and harvesting**
9	Pike et al., 2010	**Compendium of forest hydrology**
10	Li et al., 2018	**Cumulative effects of forest disturbance**
11	Wei & Zhang, 2010	**Streamflow change caused by forest disturbance**
12	Hou et al., 2022	**Cumulative forest disturbances decrease runoff**
13	Stednick, 1996	**Effects of timber harvest on annual water yield.**
14	Moore & Scott, 2005	**Streamflow changes following salvage harvesting**
15	Gravelle & Link, 2007	**Timber Harvesting and Stream Temperatures**

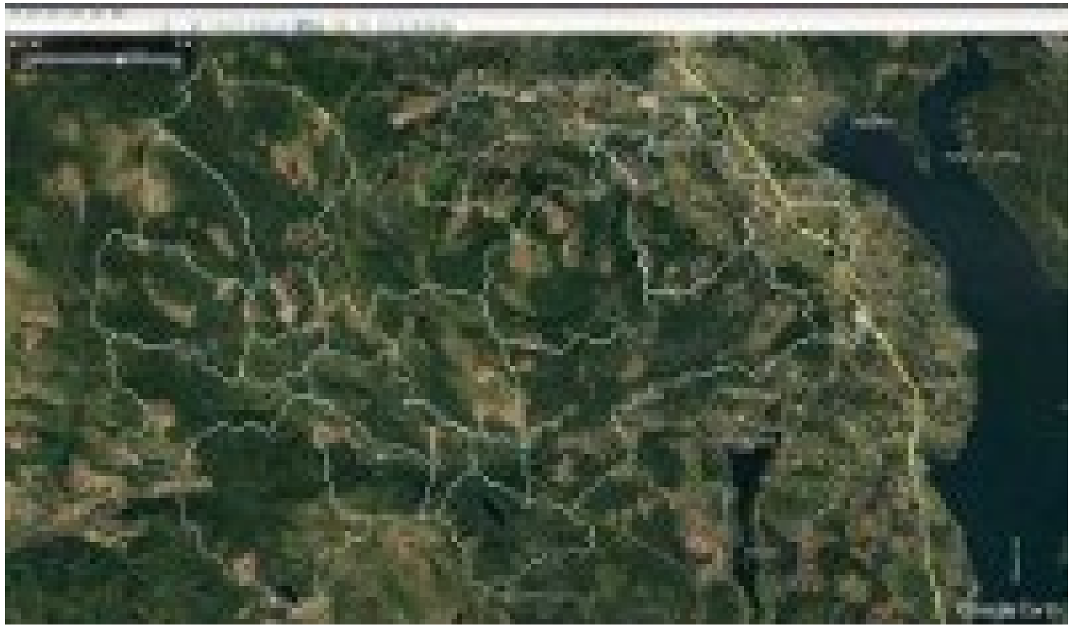
(orange)	**Study area**
(light orange)	**Review paper**
(green)	**Research paper**



But the with uncertain, contradictory or location-specific results



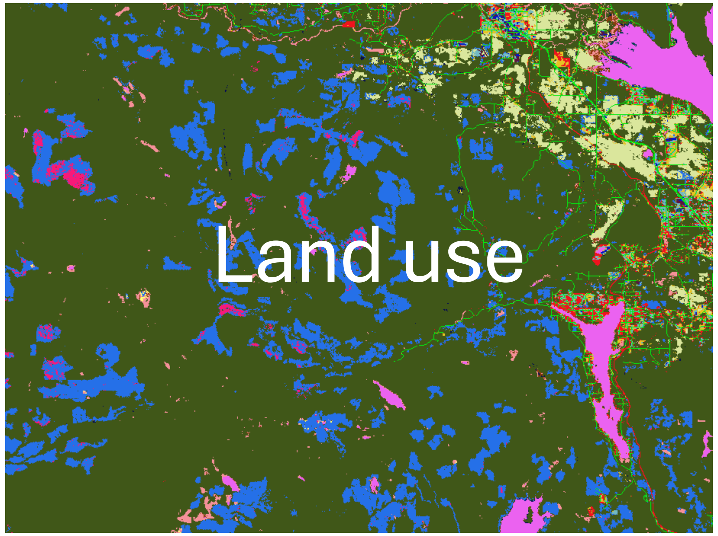
Main tree: Douglas Fir
Time: (1984-2020), Google Earth

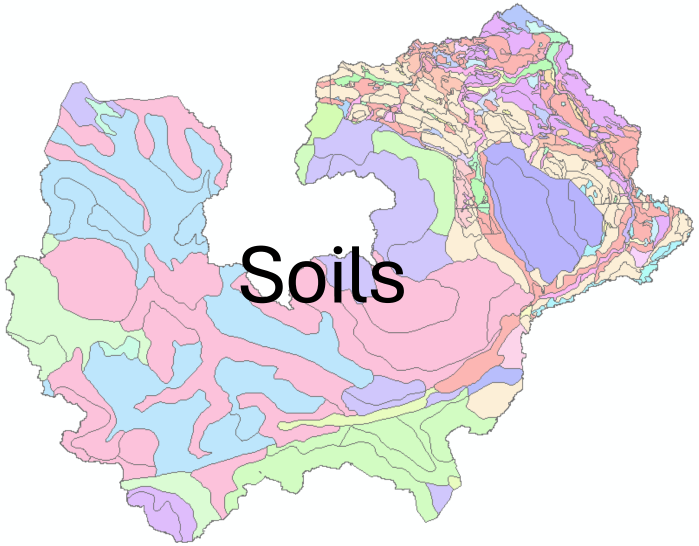


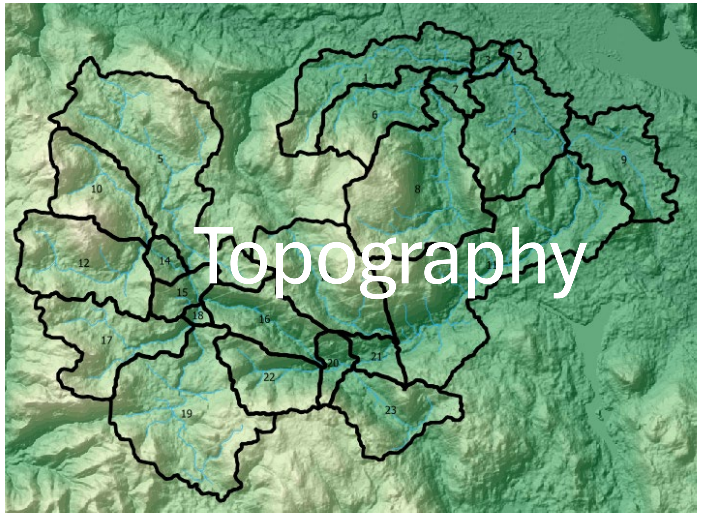
Crampe et al., 2020

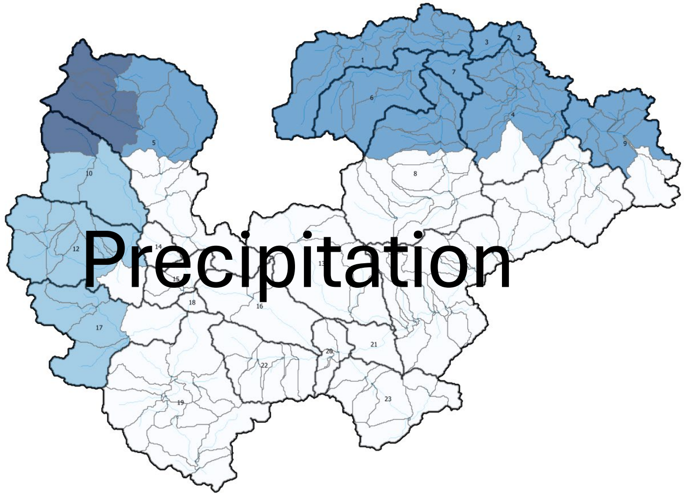
SWAT-MODFLOW needs climate, surface and subsurface data to...

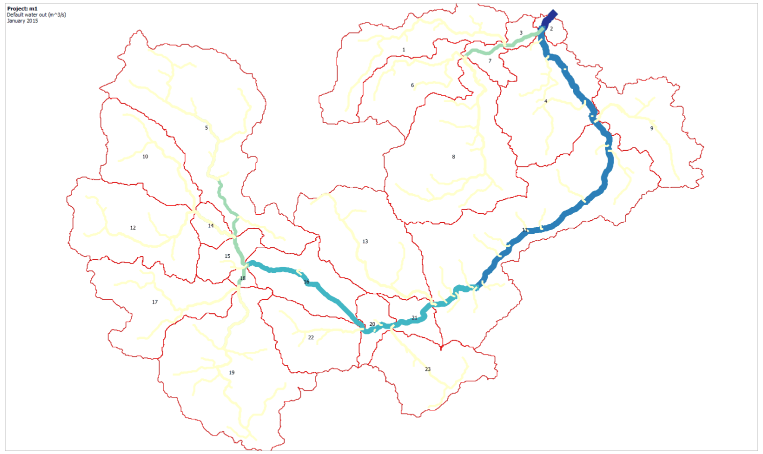
...predict streamflow, evapotranspiration etc.







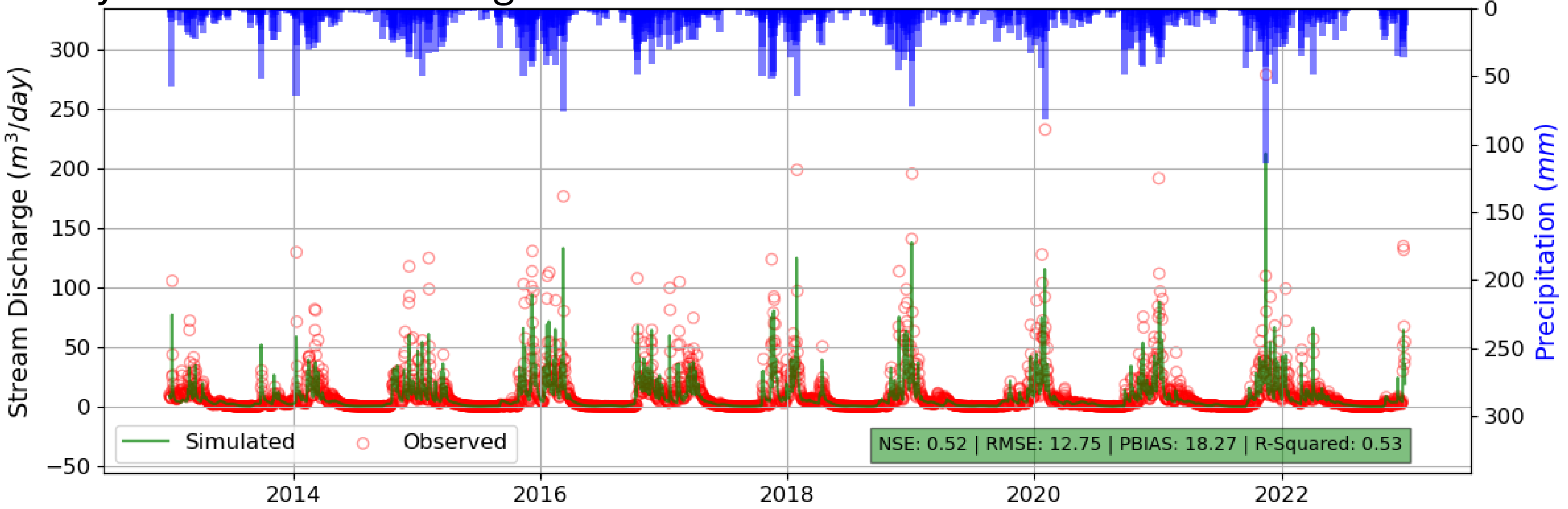




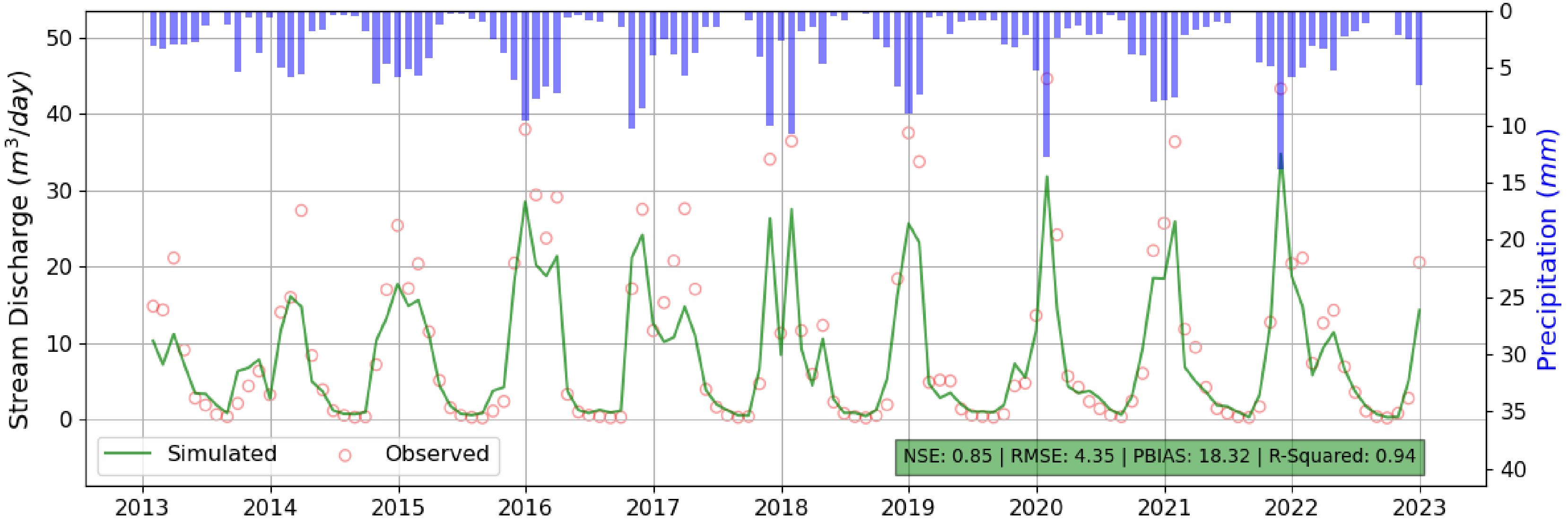
That can be compared against government and community observations

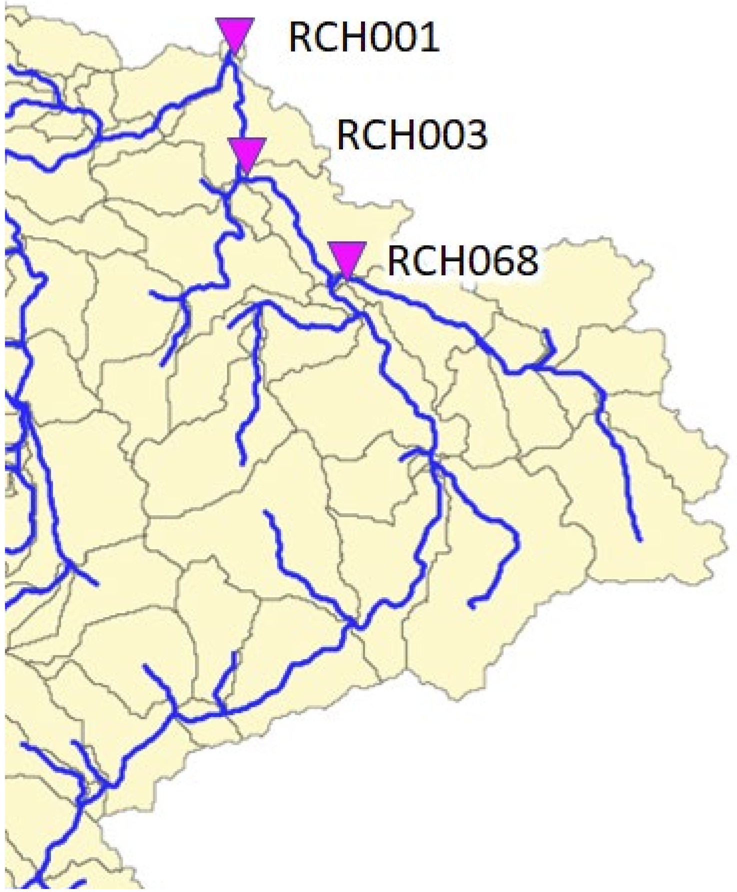
Model exhibits moderate performance on a daily scale but performs significantly better on a monthly scale

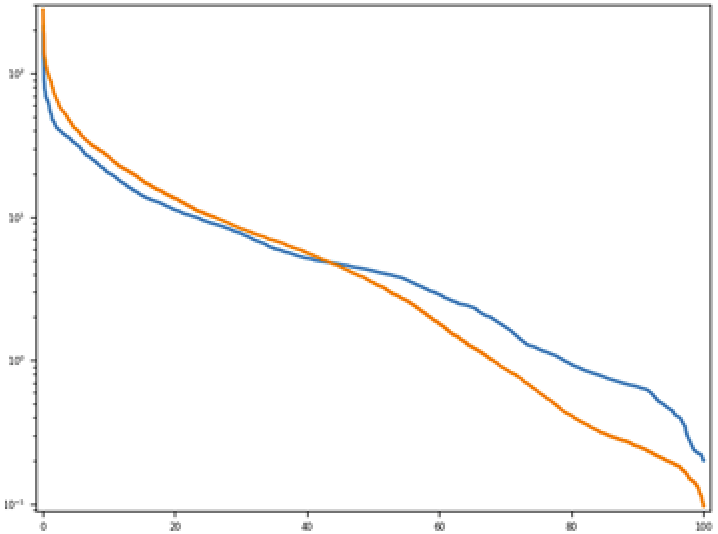
Daily streamflow discharge at RCH003



Monthly average streamflow discharge at RCH003

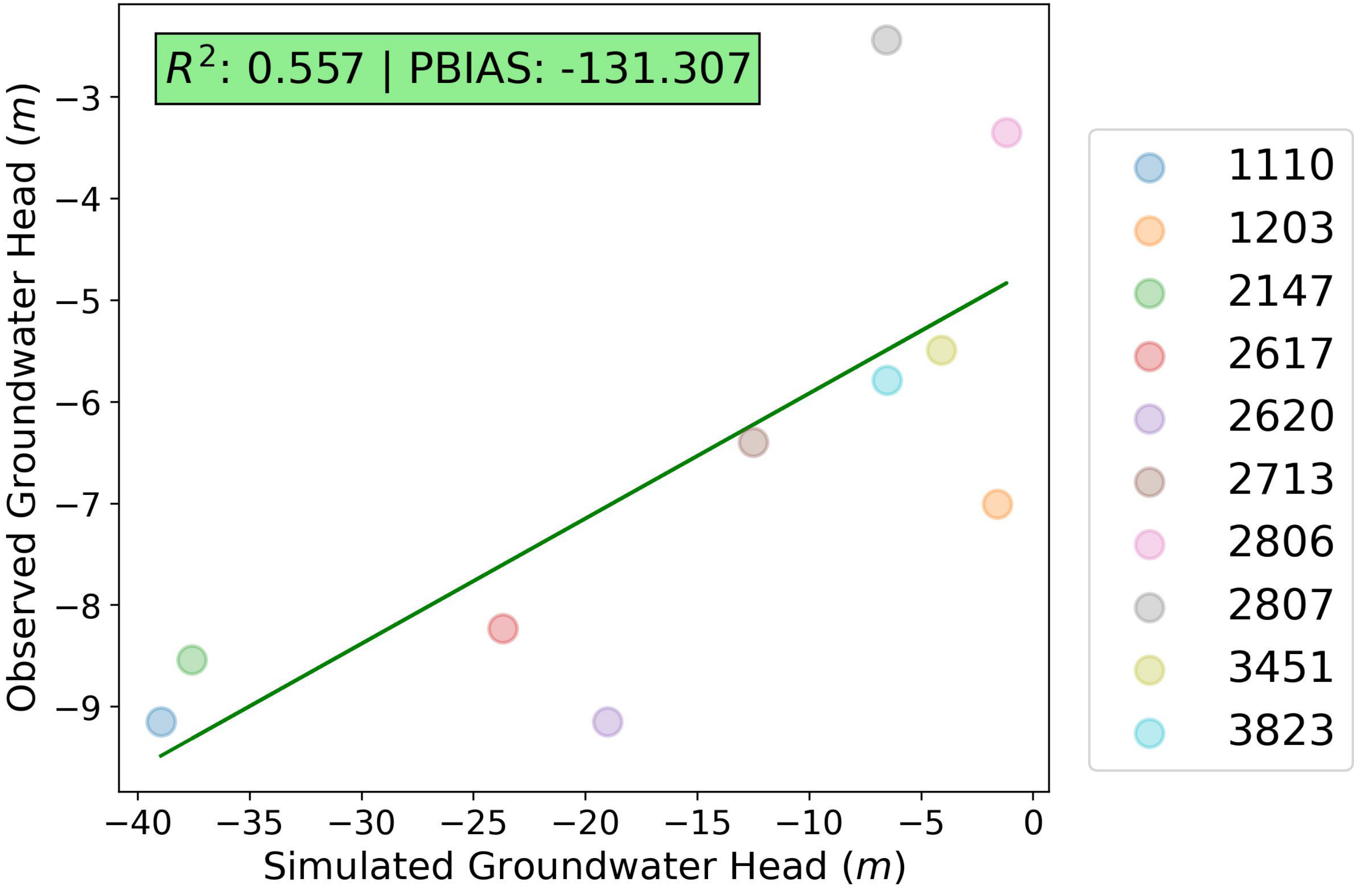


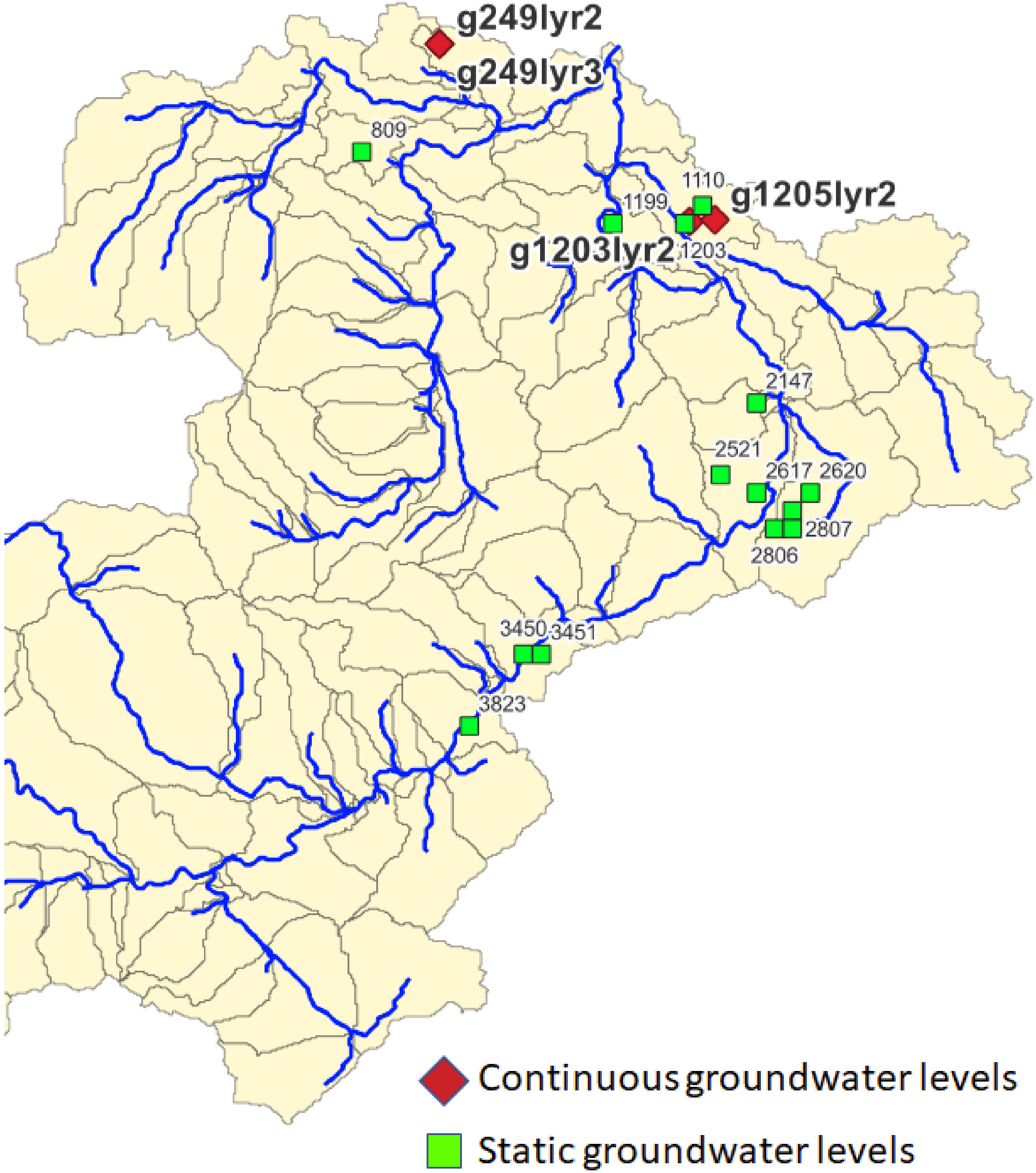




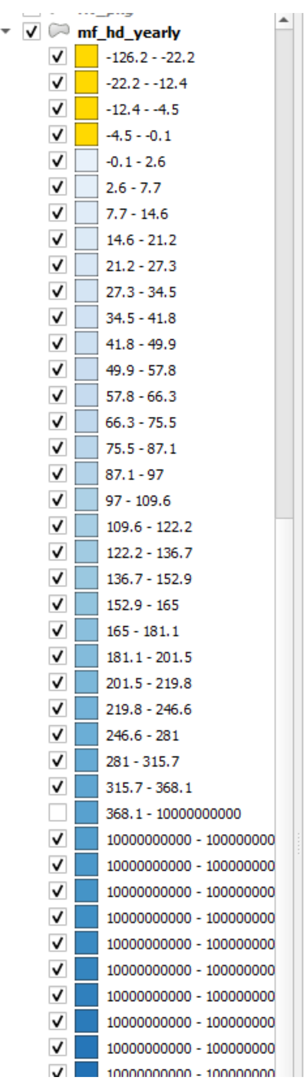
Calibrated model represents sparse, available groundwater level observations

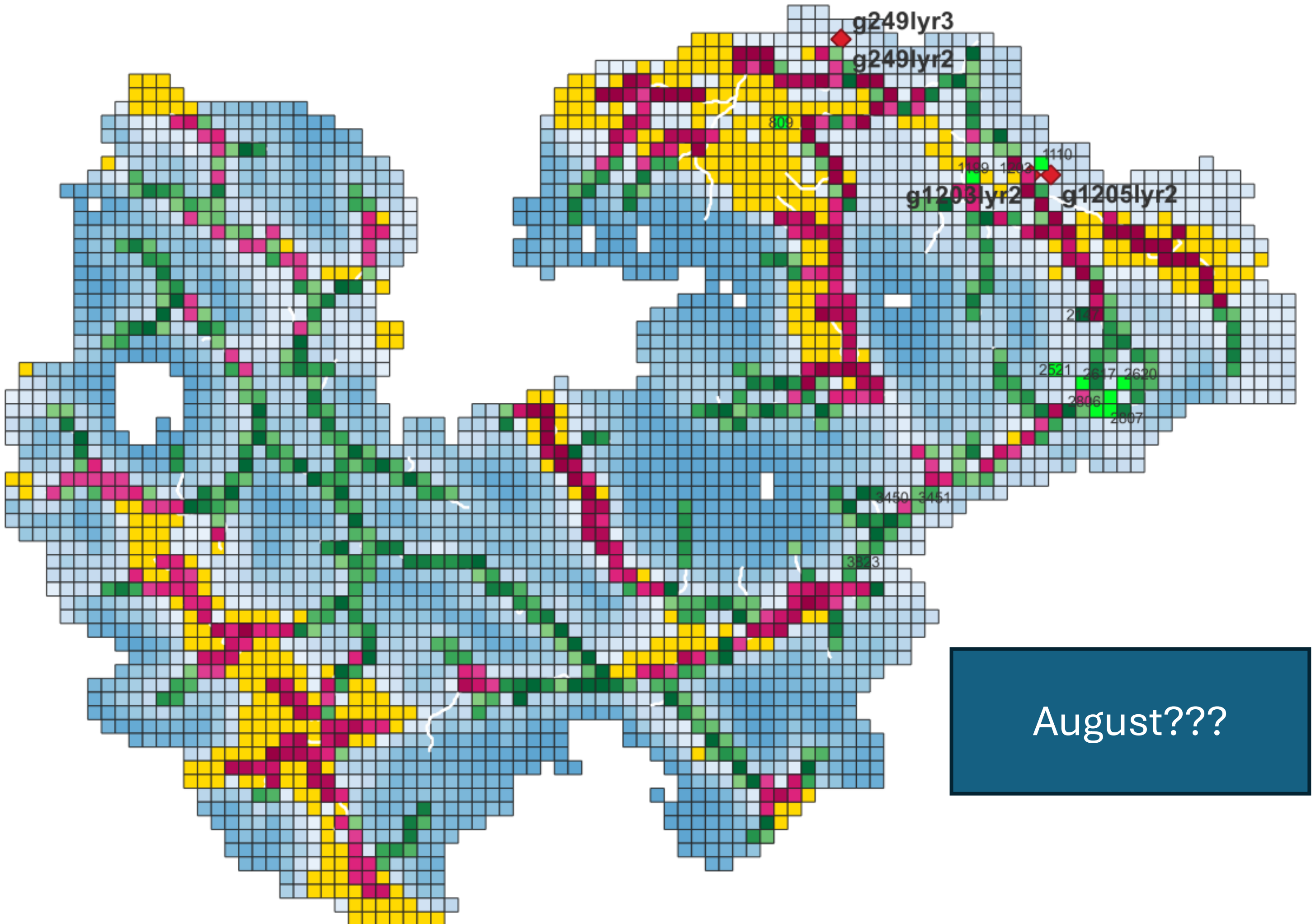
Static groundwater levels





Model predictions align with field observations of gaining and losing groundwater-surface water interactions

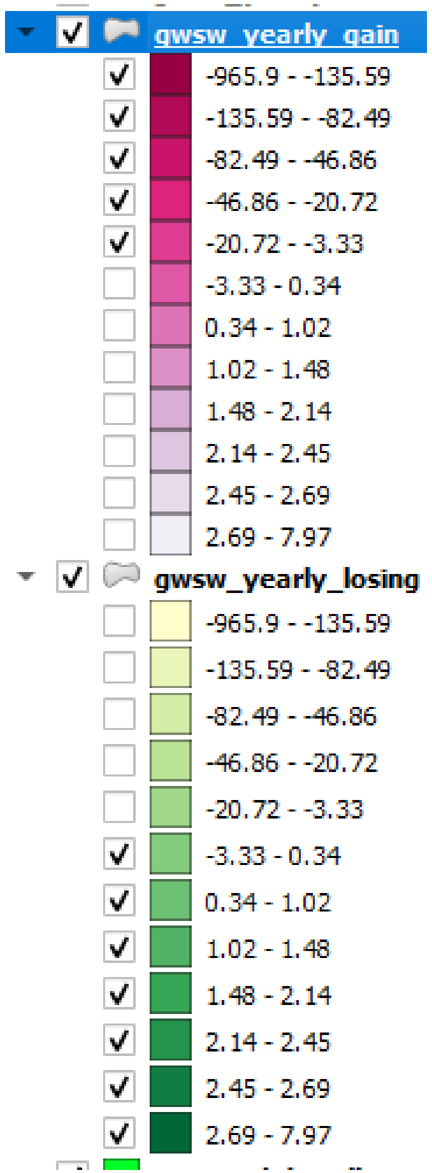




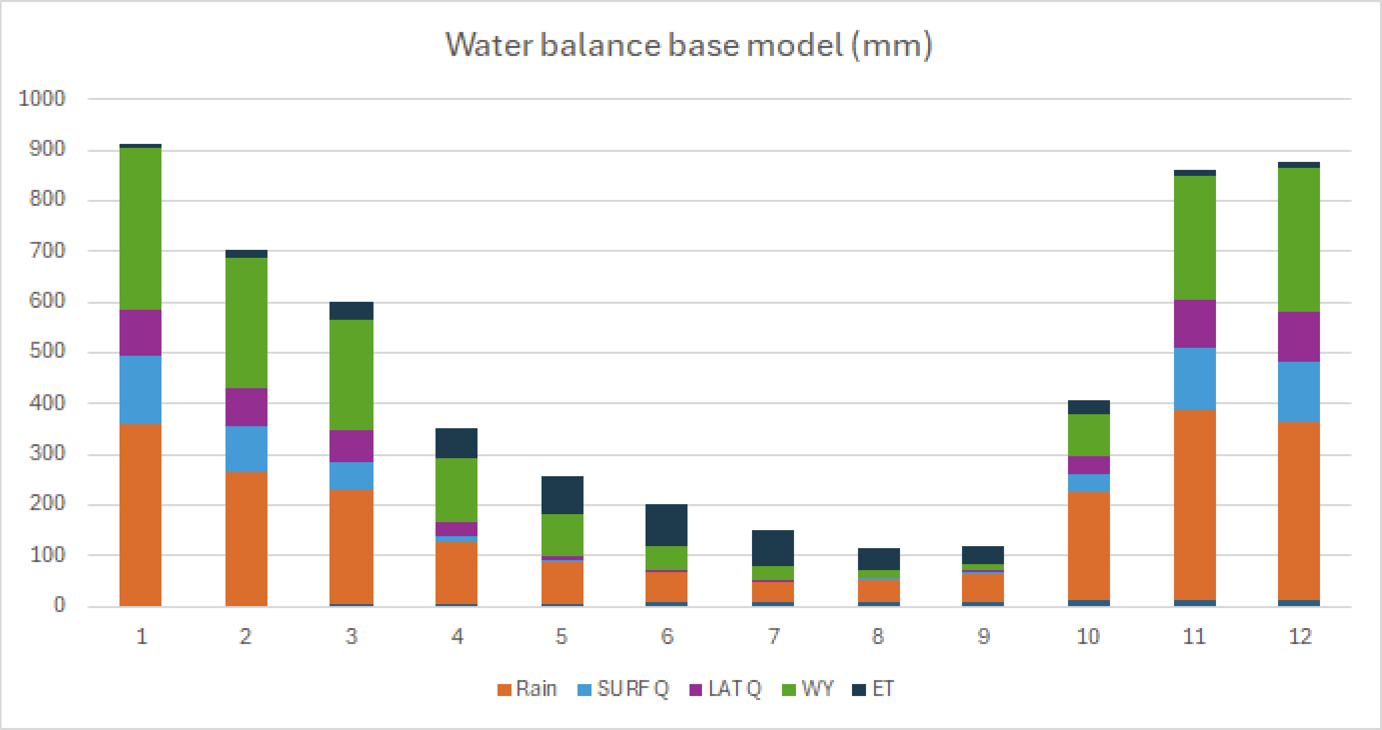
August???

Depth to water (m) in 2022
(Yellow color can be considered shallow water tables)

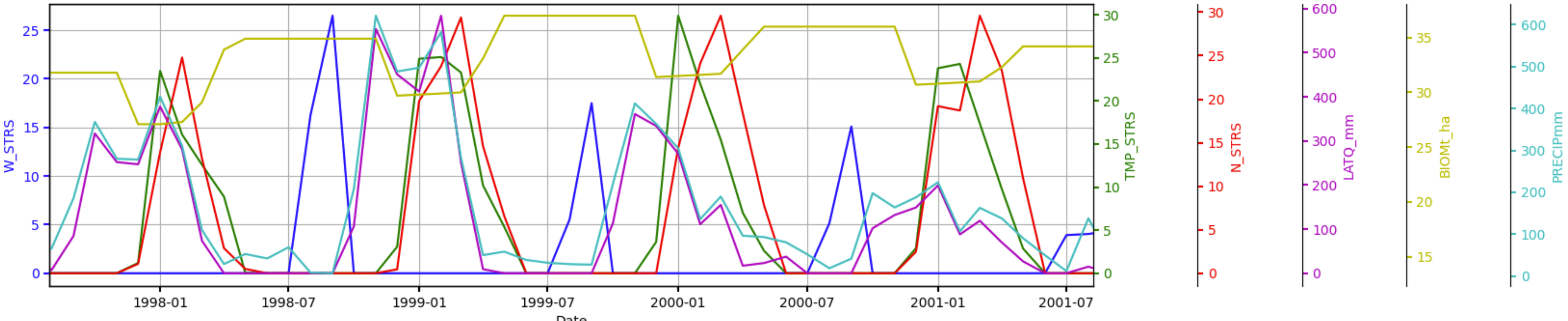
Yearly averaged m^3/day (2022)



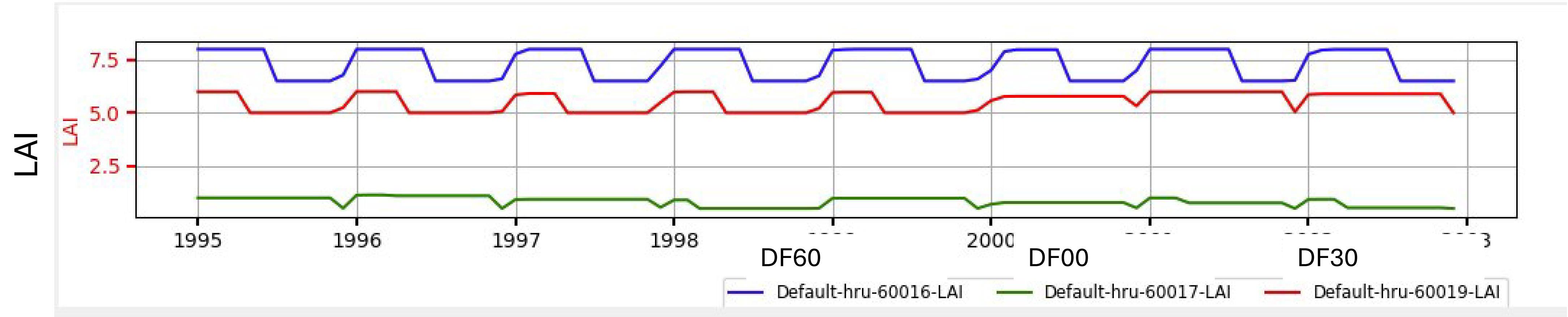
Water yield and evapotranspiration decreases during low flow while plant stress reduces forest growth

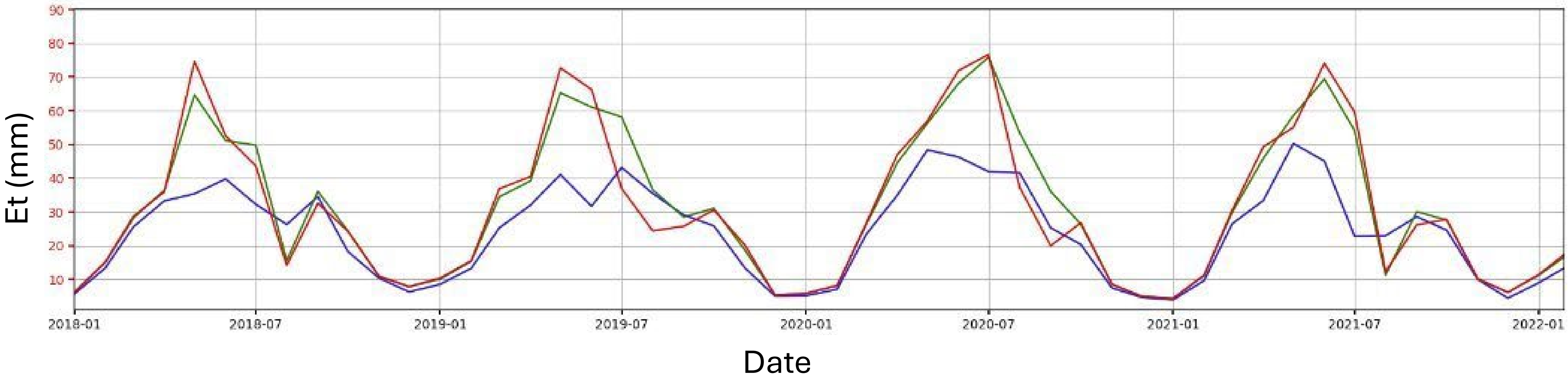


Stress variables, plant growth and flow

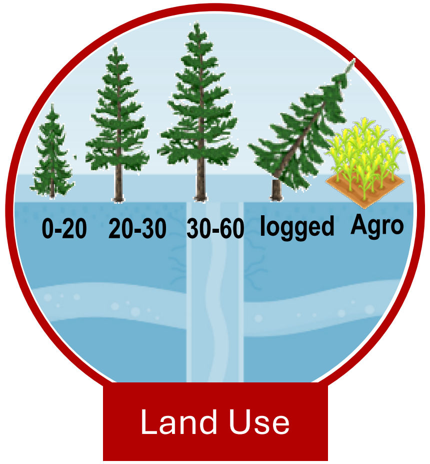


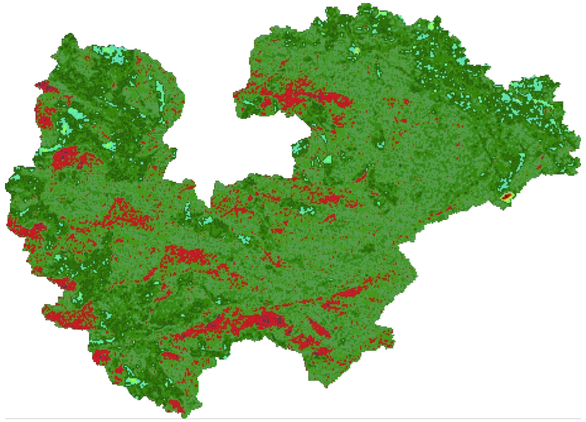
Leaf area index changes with tree age, directly affecting evapotranspiration rates



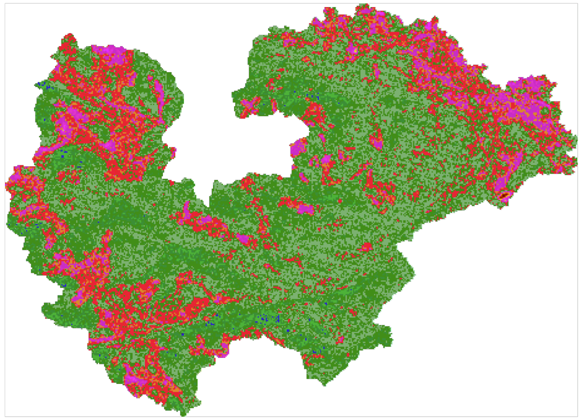


Using snapshot of the past to compare scenarios of land use



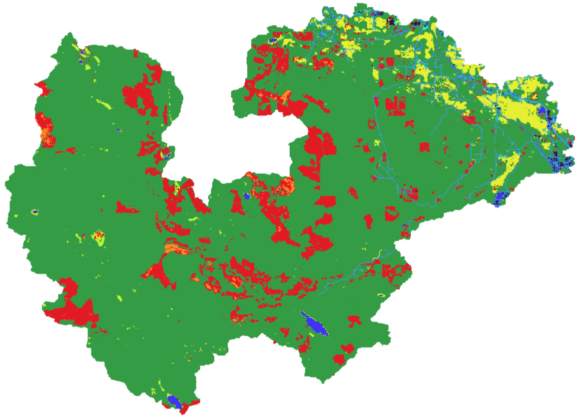


1954

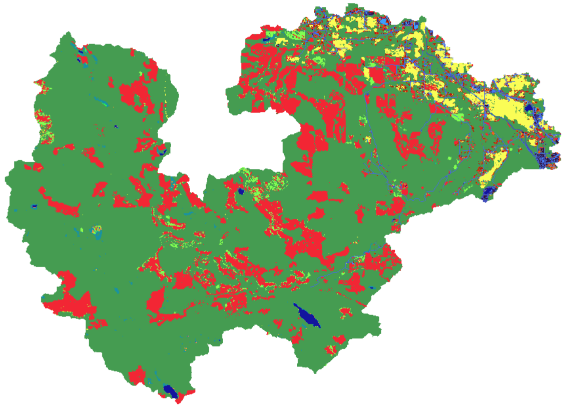


1972

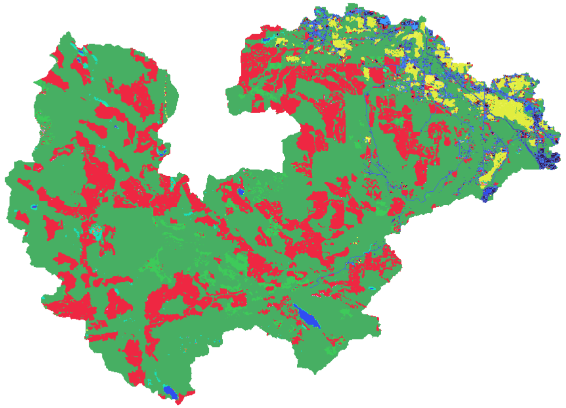
Logged areas are red



2000

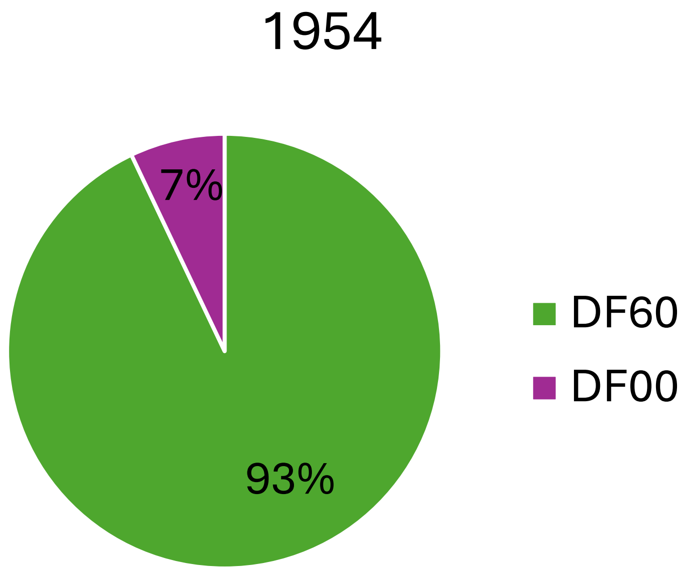


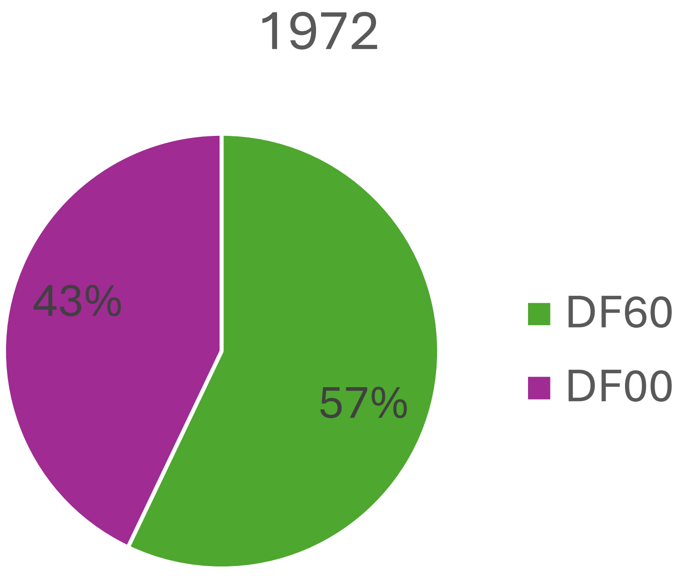
2010

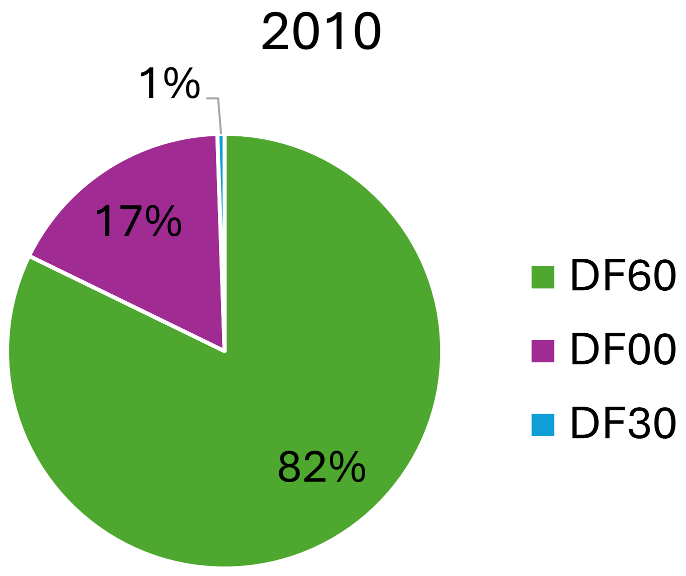


2020

Land Use Scenarios: Logging Percentages and 60-Year-Old Douglas Fir Coverage







DF: Douglas Fir tree

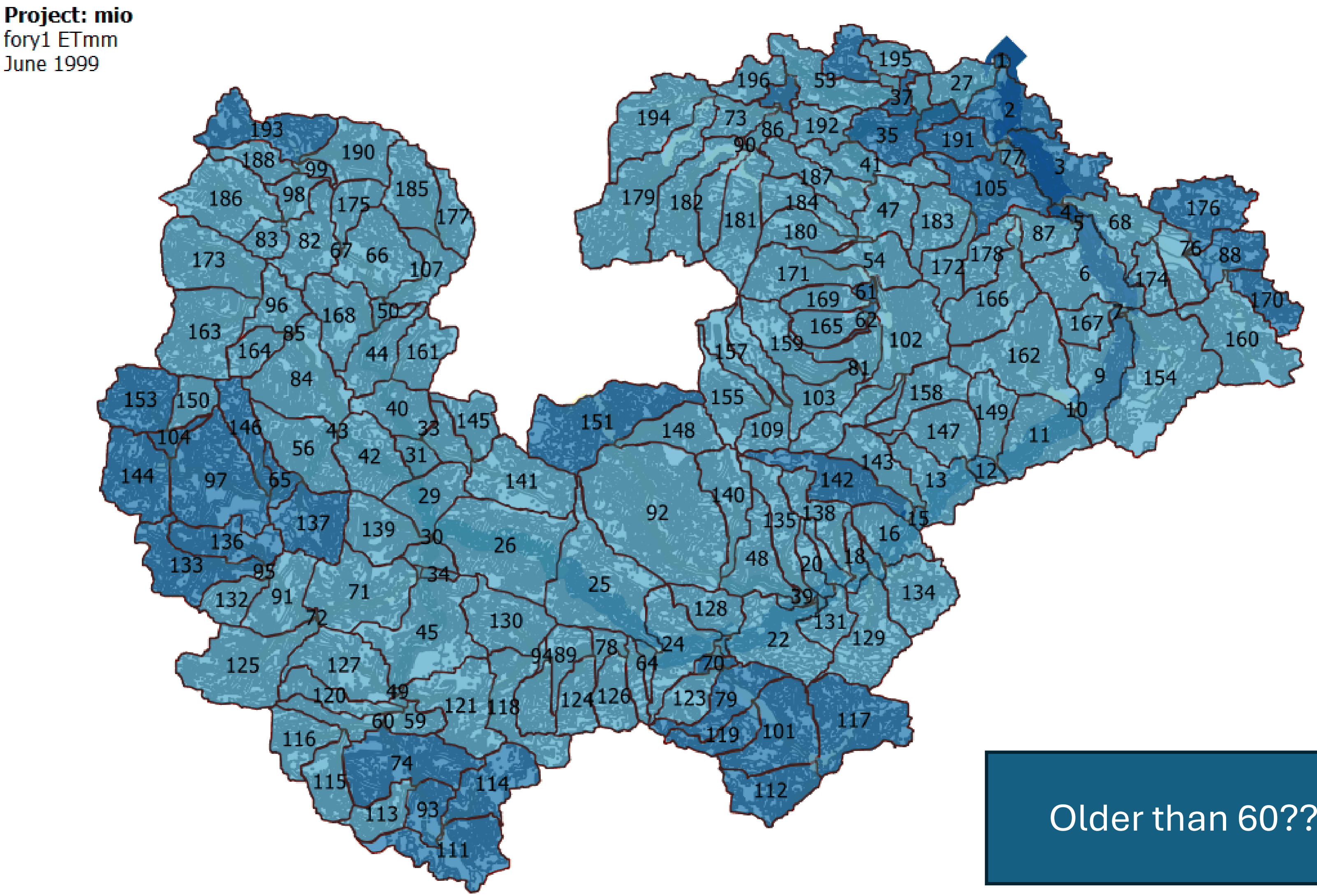
How many consecutives days were below the threshold of 2.0 m3/s in one year?

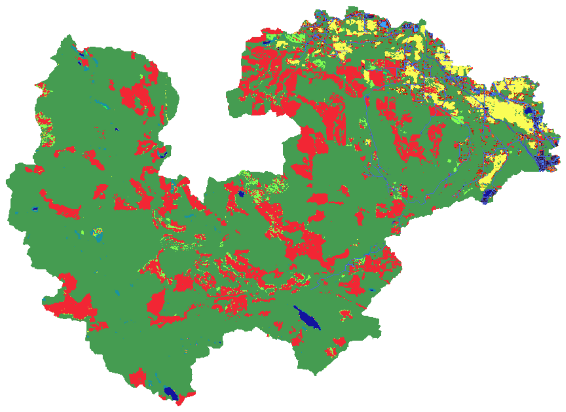
9 days

15 days

17 days

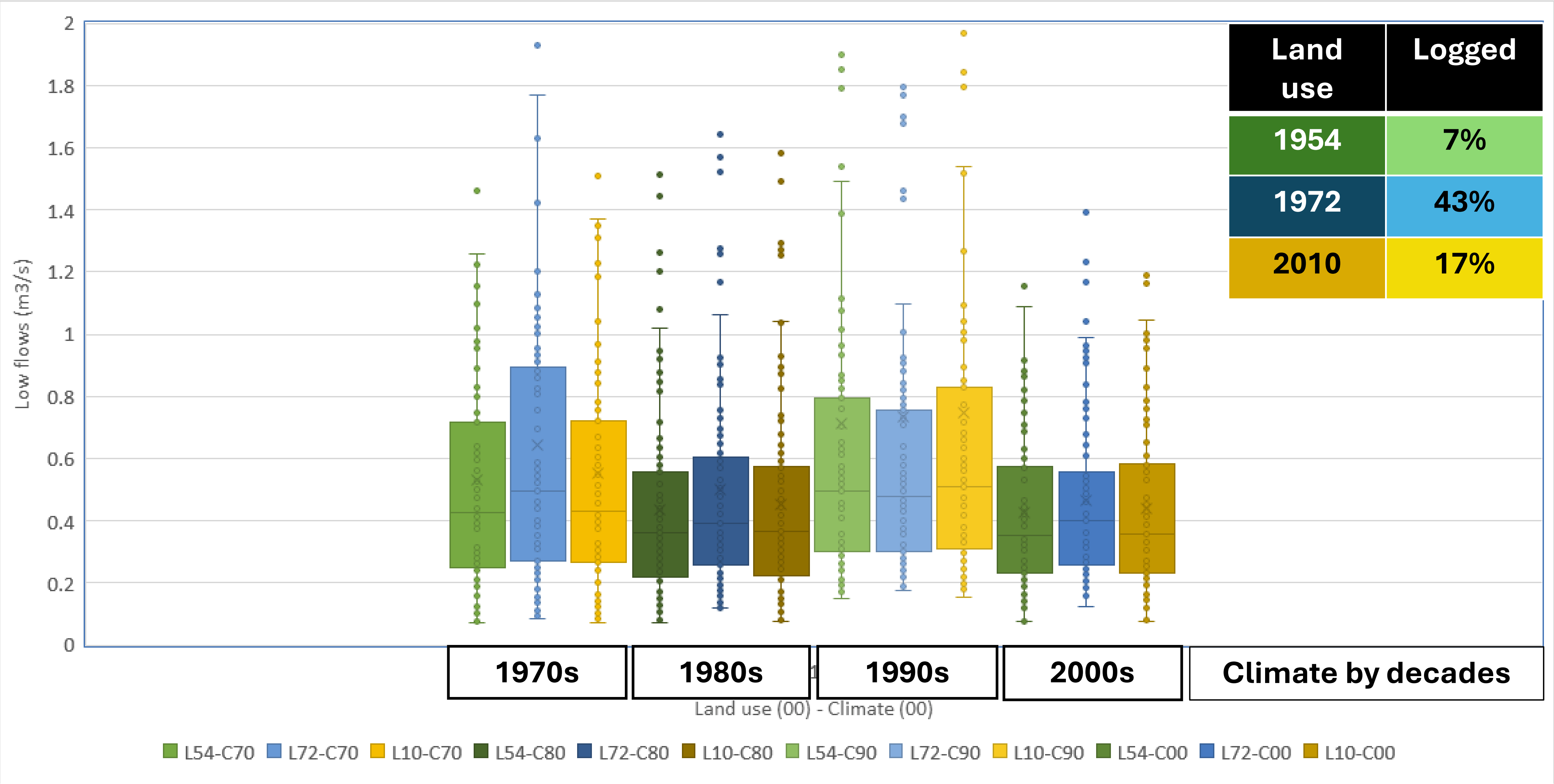
Spatially distributed evapotranspiration is higher in areas with 60 years old forest





Older than 60???

SWAT box plots showing the variability of average low flow separated by land use and climate decades, from June 10 to September 8...



Key points

- Calibration results indicate that the model exhibits moderate performance on a daily scale (NSE = 0.52) but performs significantly better on a monthly scale (NSE = 0.85).
- Land use management practices significantly affect hydrological processes, including surface runoff, evapotranspiration, and groundwater discharge. Our findings demonstrate that changes in land cover types can alter hydrological responses, corroborating results from [Crampe et al, 2020].
- Forests aged 60 years exhibit a decrease in runoff and an increase in evapotranspiration. Future research should investigate older forests to evaluate leaf area index (LAI) decay and its subsequent effects on evapotranspiration.

- Forests aged 60 years exhibit a decrease in runoff and an increase in evapotranspiration. Future research should investigate older forests to evaluate leaf area index (LAI) decay and its subsequent effects on evapotranspiration.
- SWAT forest parameters were sucessfully modified previous research data giving us a better accurate representation of the forest.
- The calibrated model results correlate strongly with fieldwork observations, accurately depicting gaining and losing streams ($R^2 = 0.94$). This concordance validates the model's capability to replicate observed hydrological phenomena in the watershed.

Limitations

- For future scenario modeling, it is recommended to utilize SWAT+ to incorporate multiple tree species within a single Hydrologic Response Unit (HRU), enhancing the model's ecological accuracy.
- The information on upper watershed aquifers is limited compared to the lower watershed. Consequently, assumptions were based on fieldwork observations and geological understanding, which may introduce some uncertainties.
- Adjusting SWAT parameters to optimize nitrate leaching and nitrogen uptake can significantly mitigate forest stress by enhancing nutrient availability, thereby promoting healthier ecosystem dynamics.

Different forest parameters for the same tree due to the period to run scenarios 10 years