

# Impacts of Historic Drought on Water Yield and Ecosystem Productivity across the United States National Forests and Grasslands

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## INTRODUCTION

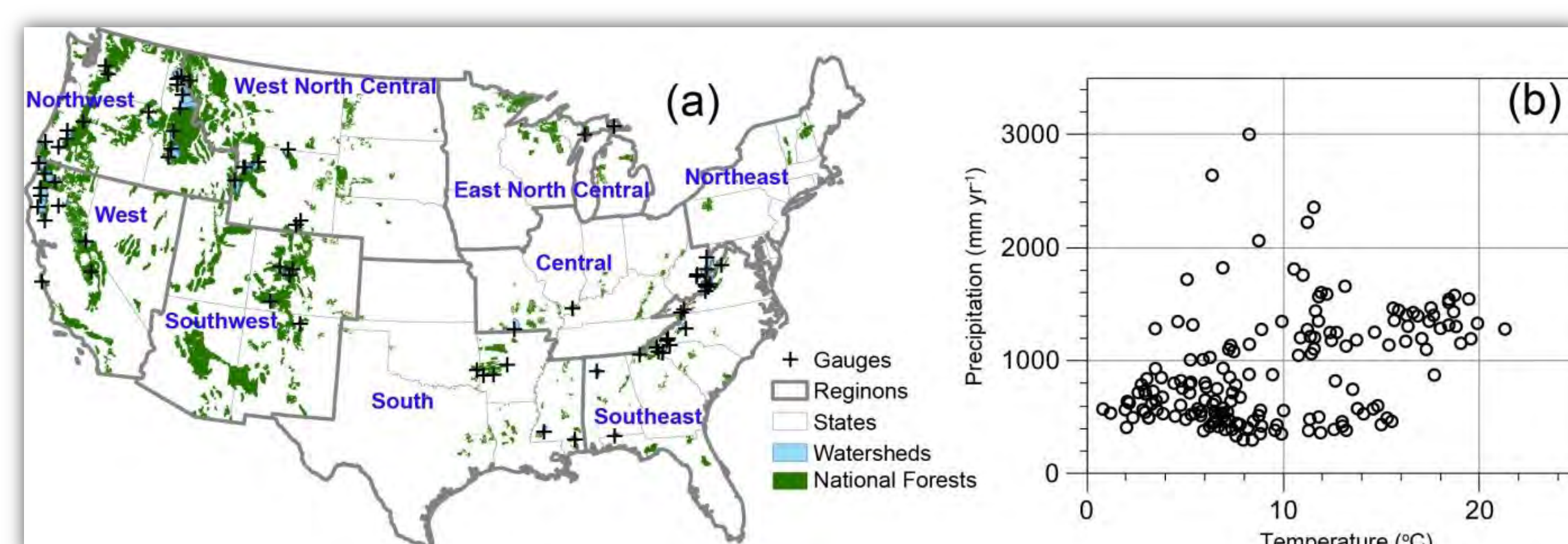
- ✓ Drought is one of the most common and costly disasters, and poses a serious threat to the National Forests and Grasslands system (NFs).
- ✓ Due to the dynamic nature of droughts and the complex mechanisms of ecohydrologic response to droughts in forest ecosystems, a comprehensive quantitative assessment of drought impacts on the large scale NF ecosystem services is needed.

## OBJECTIVES

- To evaluate performance of the Water Supply and Stress Index (WaSSI) model using observed watershed water yield (Q) and other estimates of evapotranspiration (ET) and gross primary productivity (GPP) for 170 NFs
- To explore the impacts of historic droughts on Q and GPP in the 170 NFs during 1961-2012
- To provide some useful information for USDA-FS managers to mitigate the negative drought impacts on the NFs ecosystem services

## METHODOLOGY

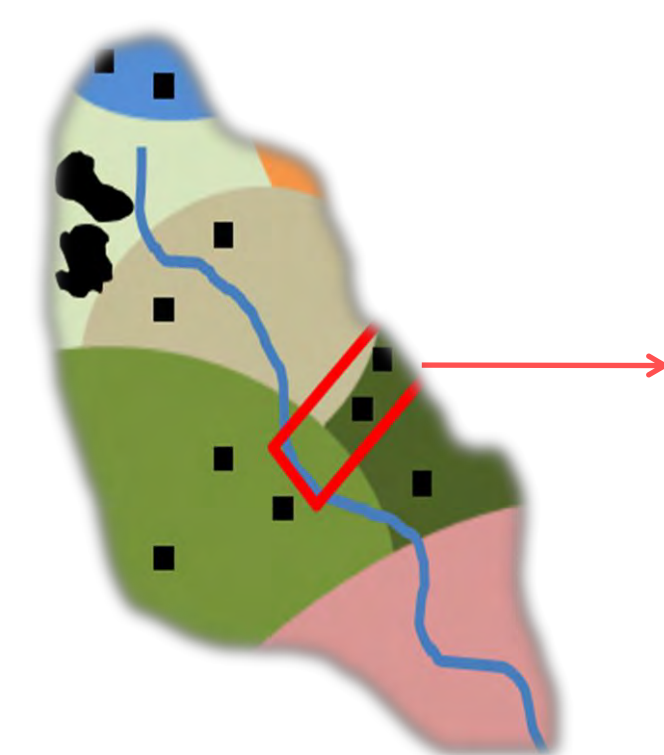
**Study area:** 170 NFs over the conterminous U.S. (CONUS)



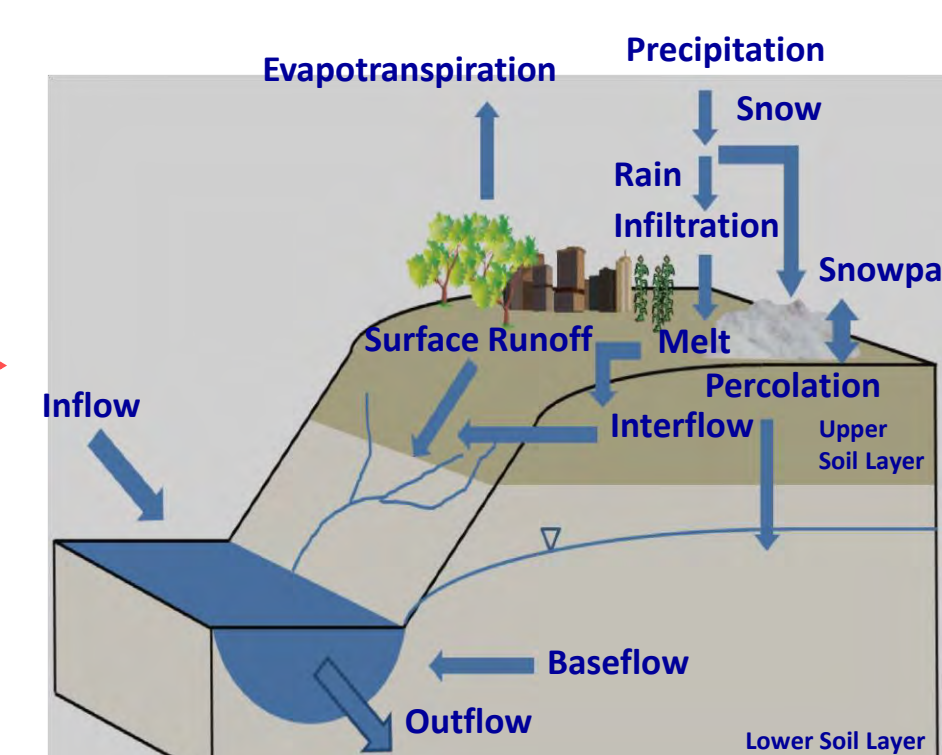
**Model:** WaSSI Monthly Water Balance Model (Sun et al. 2008, 2011; Caldwell et al. 2012)

### Watershed-Specific Land Cover and Evapotranspiration

- Crop
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Grassland
- Shrubland
- Wetland
- Water
- Urban
- Barren
- Impervious



### Hydrologic Processes



Evaluated Top-five drought years that received the 5 lowest annual precipitation at each NF during 1961-2012.

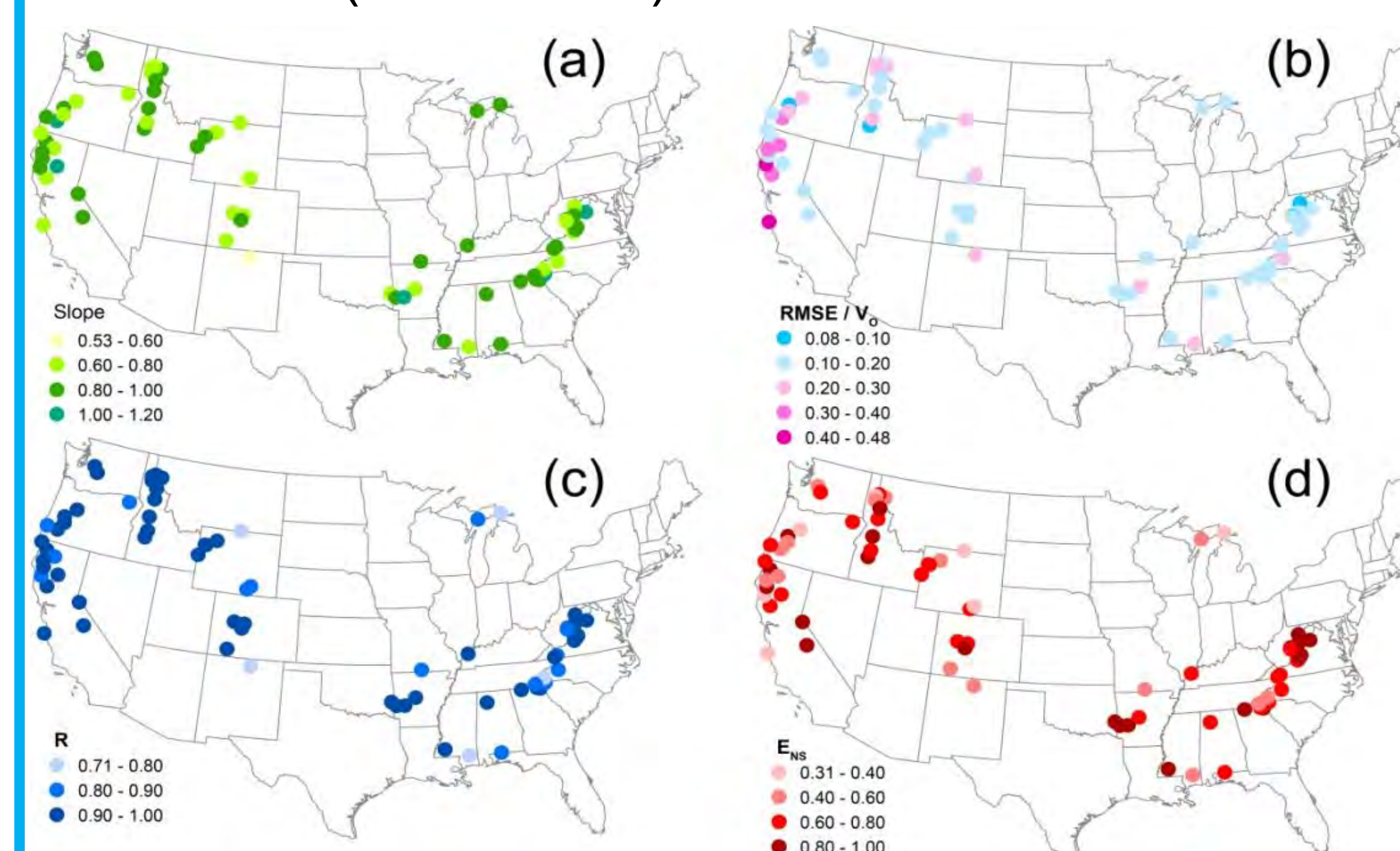
**Datasets:** PRISM precipitation and air temperature (1961-2012); 72 USGS gauges streamflow (1990-2009) MODIS ET (2000-2006; Mu et al., 2010) EC-MOD GPP (2001-2006; Xiao et al., 2010)

### Acknowledgements

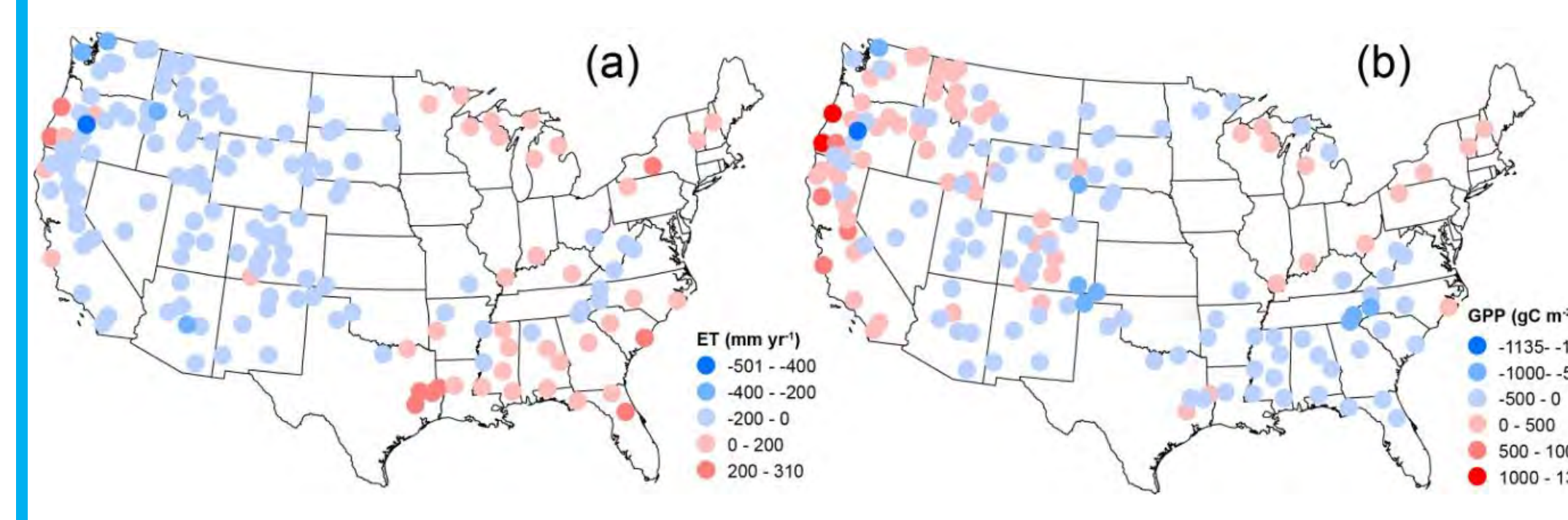
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## MODEL EVALUATION

Annual Q (1990-2009) over 72 USGS watersheds



Multi-year mean differences (MODIS estimate – WaSSI simulation) in annual ET (2000-2006) and GPP (2001-2006) across the 170 NFs



## CONCLUSIONS

- The WaSSI model is effective for modeling ET, Q and GPP across the 170 NFs;
- Extent of extreme droughts across the NFs increased during the last decade;
- Extreme droughts can exert adverse impacts on the NFs hydrology and productivity;
- This study provides a comprehensive benchmark assessment of likely drought impacts on hydrology and productivity using a consistent method and datasets across the CONUS.

### References

Mu, Q., et al., 2010. Remote Sensing of Environment 115, 1781-1800.  
 Sun, G., et al., 2008. Journal of the American Water Resources Association 44(6),1441-1457.  
 Sun, G., et al., 2011. Journal of Geophysical Research 116 (G00J05), doi:10.1029/2010JG001573.  
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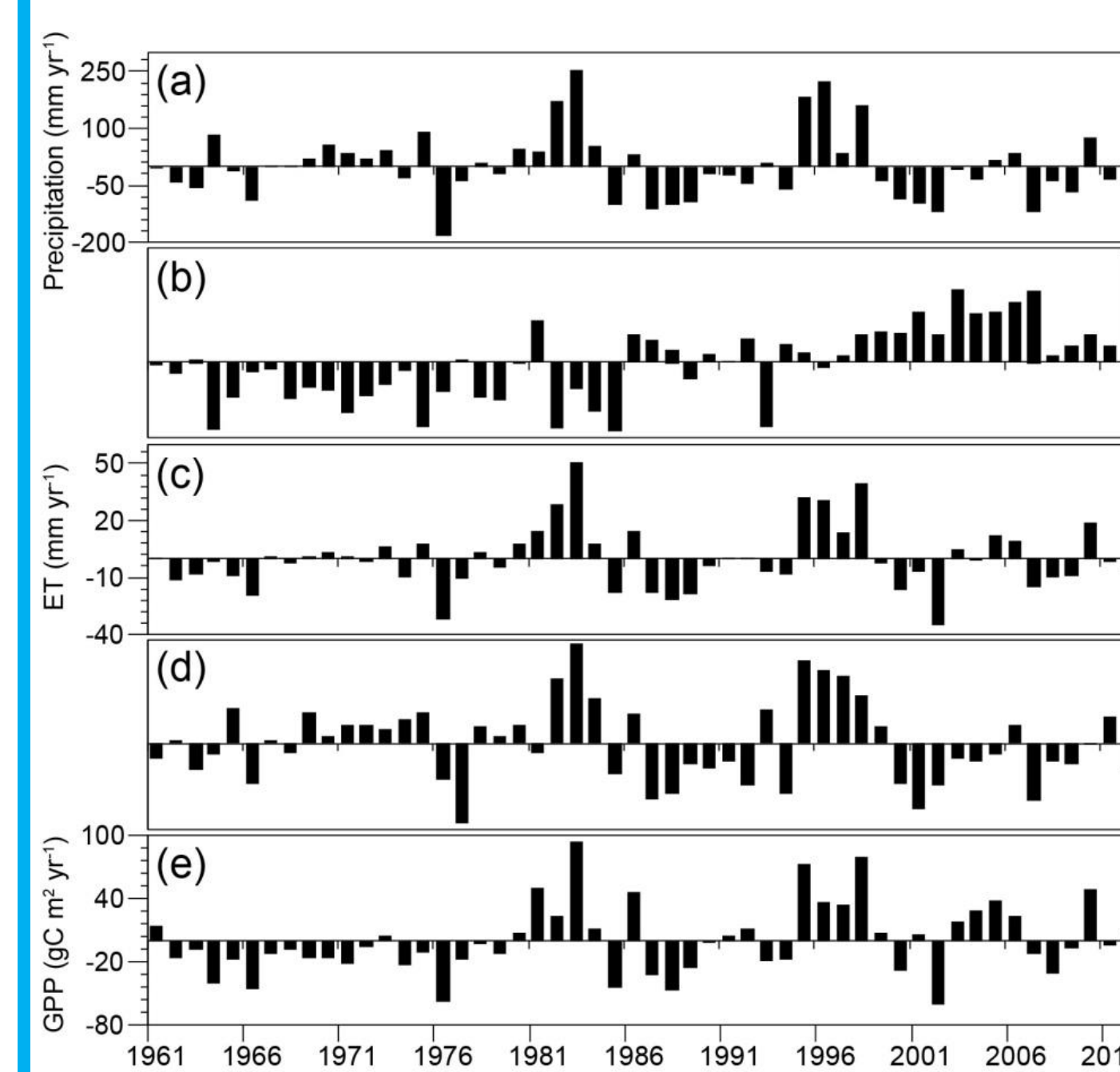
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[www.forestthreats.org/research/tools/WaSSI](http://www.forestthreats.org/research/tools/WaSSI)

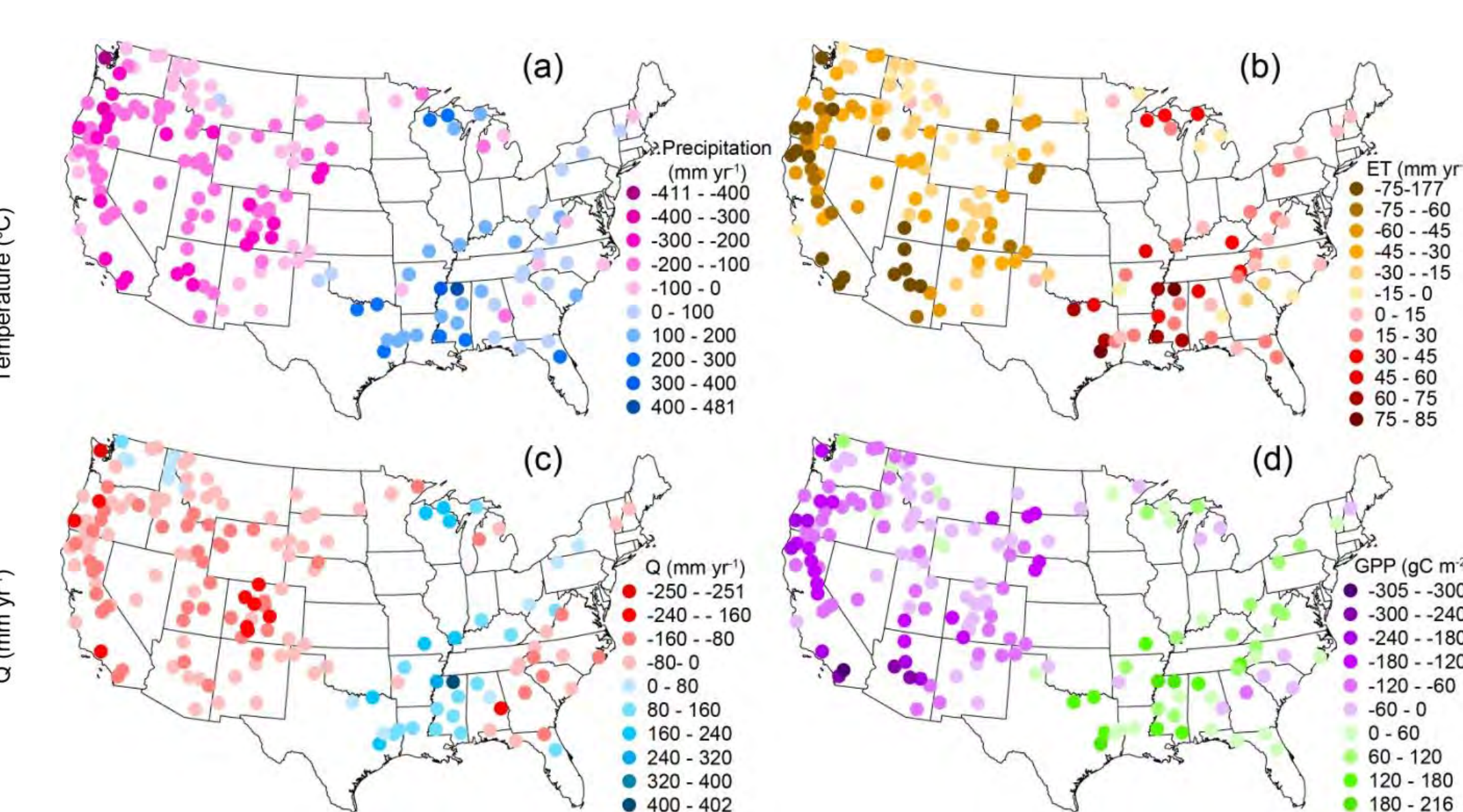
## IMPACTS

Variability of annual climate, Q, and GPP during 1961-2012

Anomalies of annual mean climate across 170 NFs

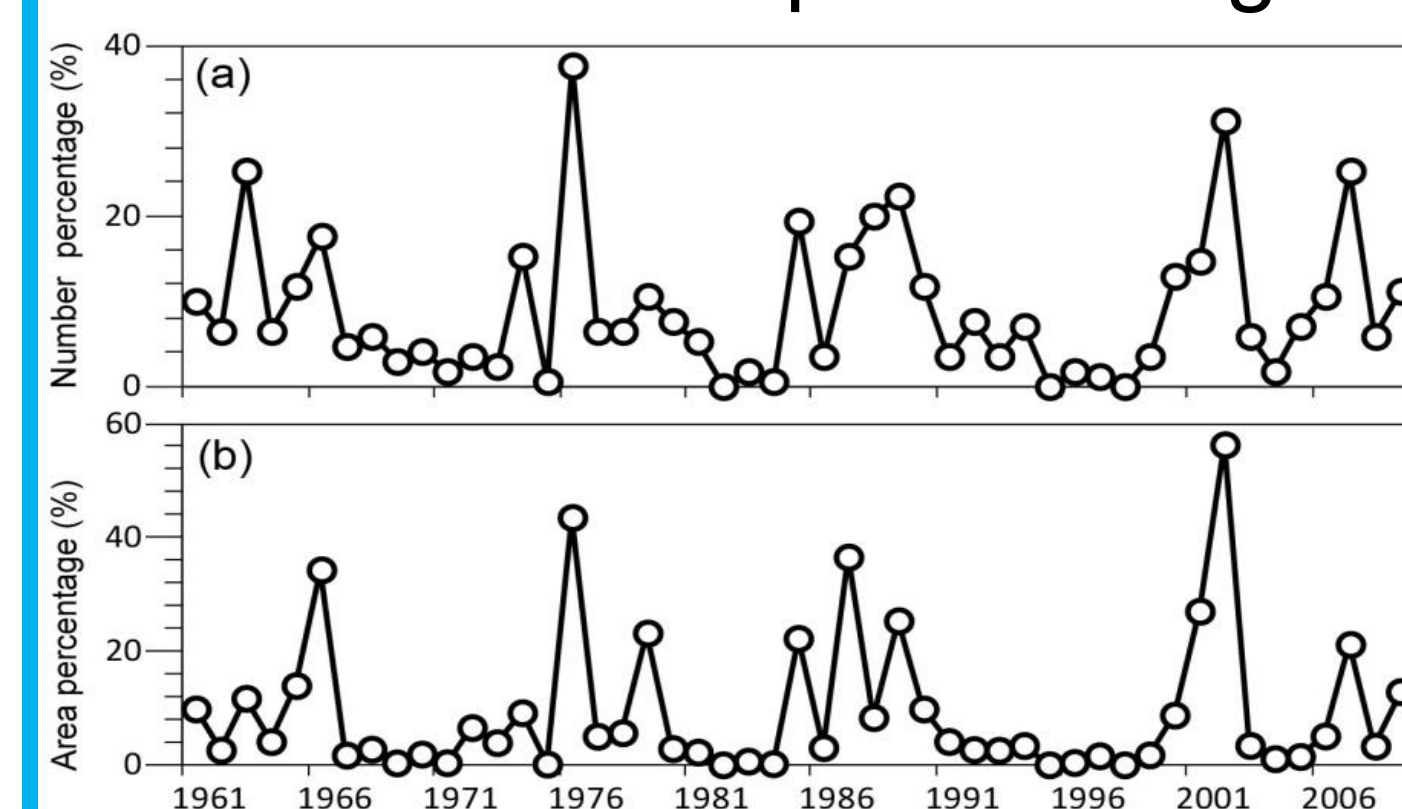


Anomalies of annual mean climate in 2002

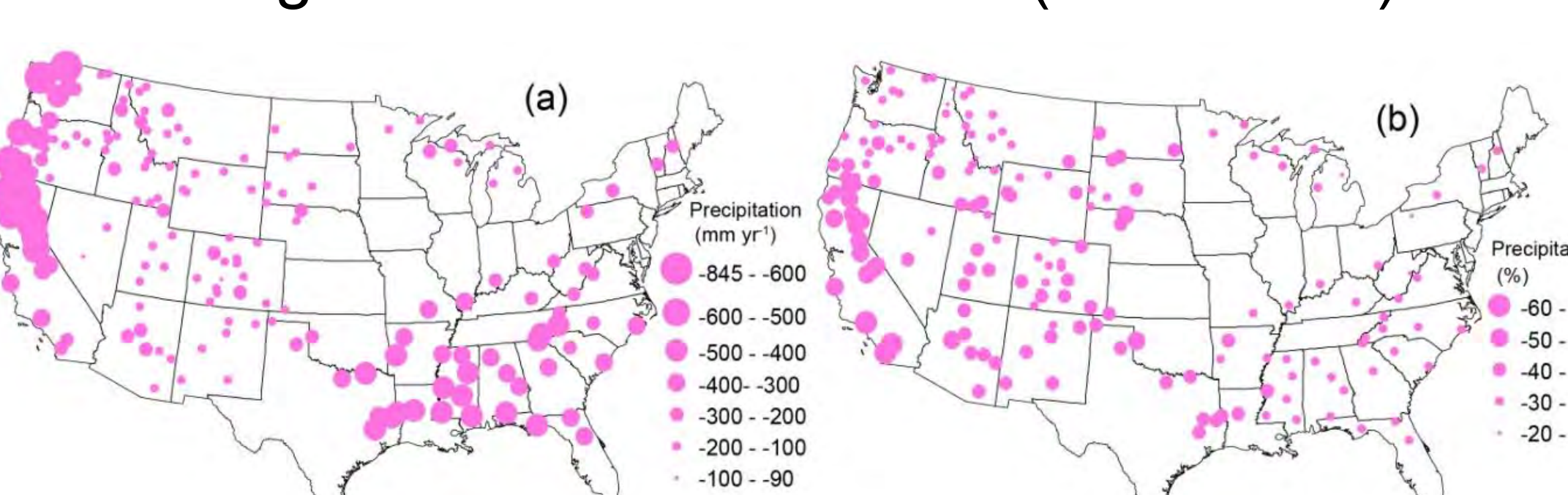


### Top-five droughts

Number and area percentage of NFs with the top-five droughts



Deviations of mean annual precipitation for the top-five droughts from annual means (1961-2012)



### Impacts of extreme droughts

