Mapping and modeling the impact of climate change on recreational ecosystem services using machine learning and big data

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Introduction

•Recreational ecosystem services (RES) contributed ~$460 billion/yr to the US economy (pre-COVID)

•RES demand is determined by environmental factors, causing high vulnerability to climate change

•Cultural ES (e.g. RES) and climate change impacts to them are understudied, mainly due to data availability issues

•Major lack of connecting social and ecological systems

Methods

Social Media Data

•Recreation data is sparce and low-resolution, gathering such data is difficult/impossible on large scales

•Geolocated social media data offers a novel, globally available, high-res proxy from a beneficiary perspective

•Photo sharing social media data can be used to calculate photos per user per day as a proxy for demand of RES

•We test Flickr data as a proxy for demand of RES in CA

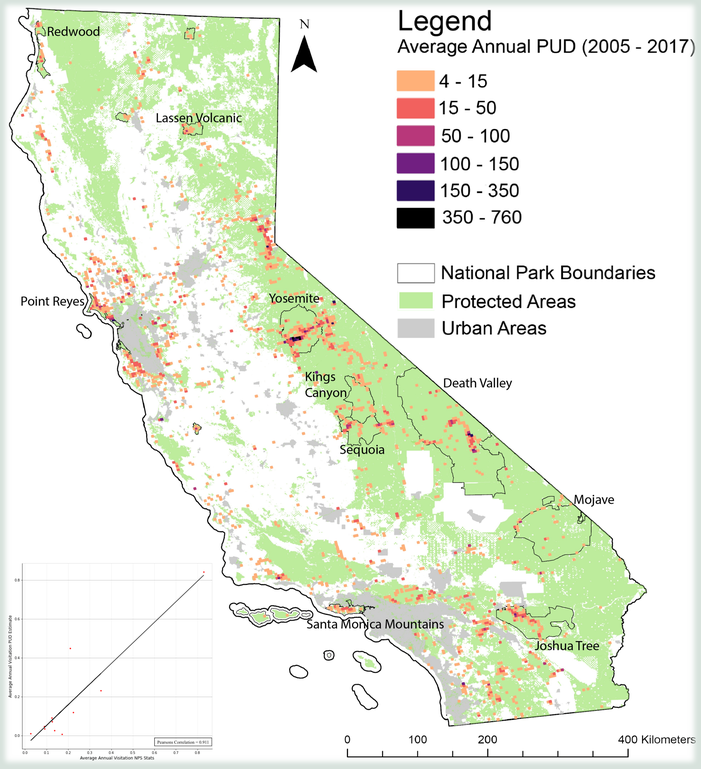

Figure 1. Map showing average annual photo-user-day per pixel in CA (2005 – 2017) as estimated from Flickr data. **(Bottom left)** Photo-user-day validation.

Random Forest Model

•Data driven machine learning model used to connect peak season (July – Sep) RES demand to environmental conditions/features

•These relationships can then be extrapolated into the future

•RF allows us to estimate variable importance and can better handle nonlinear interactions within social-ecological systems

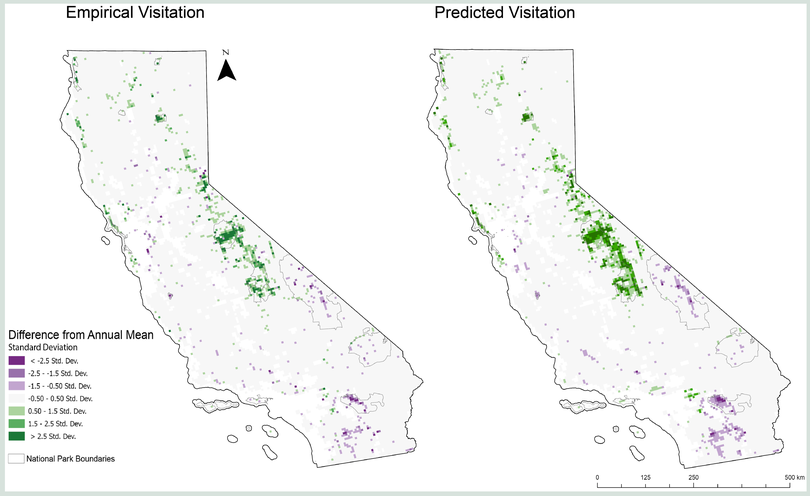

Figure 2. (left) Peak season (July – Sep) PUD difference from annual mean as estimated from Flickr data. **(right)** Model predictions for peak season PUD difference from annual mean.

Results

•Variable importance calculations show climate, especially temperature, influence RES demand, but accessibility is also a major factor

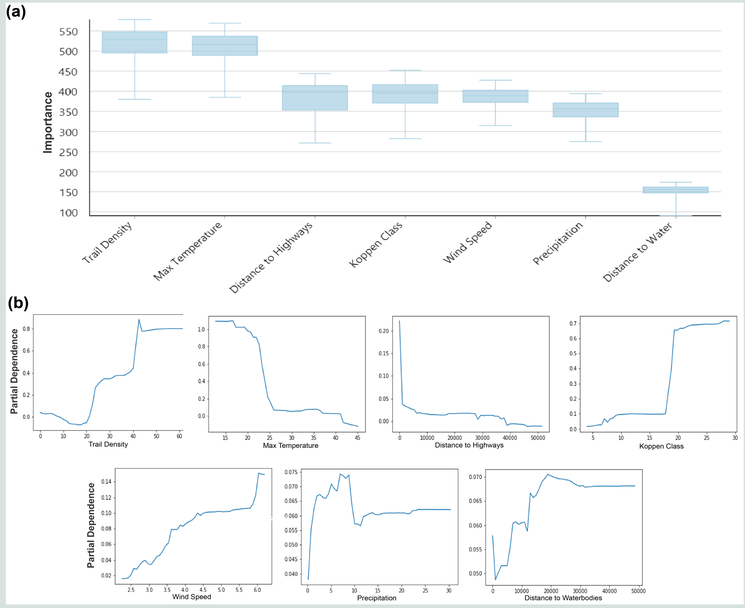

Figure 3. (a) Box plot showing the importance of different variables for recreation. **(b)** Partial dependence plots for variables.

•Patterns that currently exist are exacerbated in the future, with higher end scenarios increasing the effect

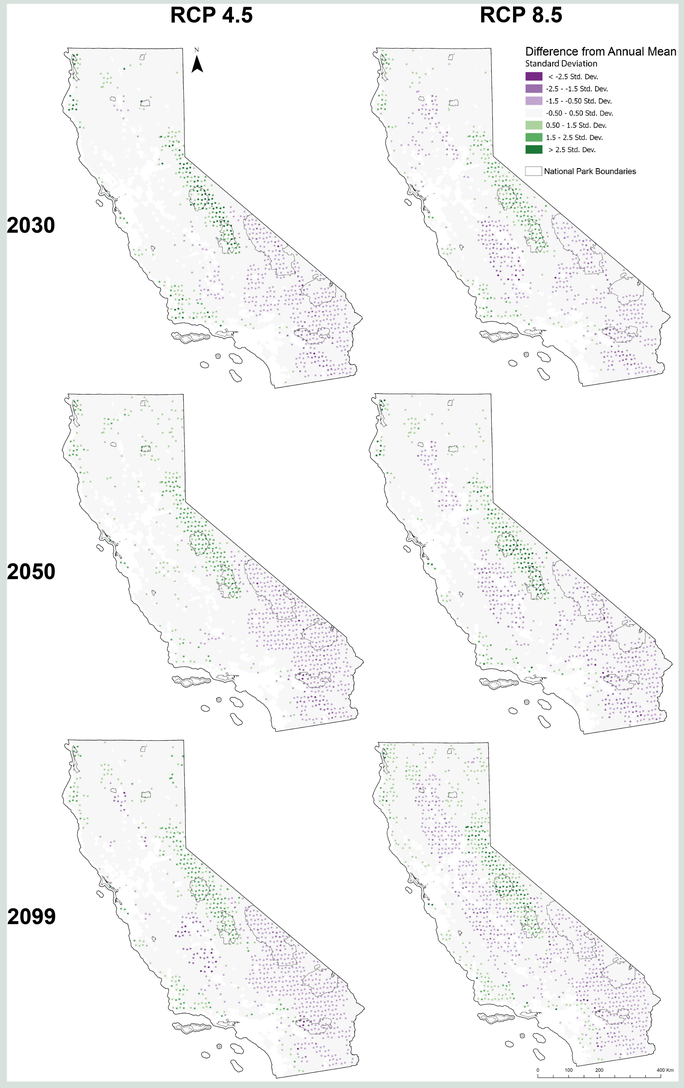

Figure 4. Maps showing model results for 2030, 2050, and 2099 under RCP 4.5 (left) and RCP 8.5 (right).

Conclusion

•Big data and machine learning offer opportunity to integrate social-ecological systems into climate impacts research and better understand implications for human well-being

•These resources also give us an opportunity to assess understudied data-poor regions

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