

Coupling distributed stormwater collection and managed aquifer recharge: Field application, modeling, and implications

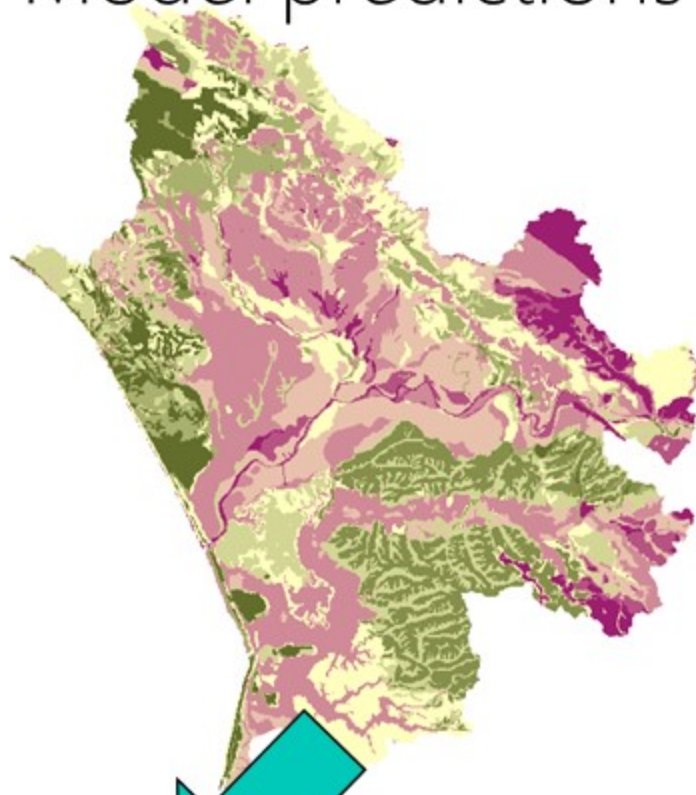
**S. Beganskas, A. Fisher, K. Young**



High-resolution data



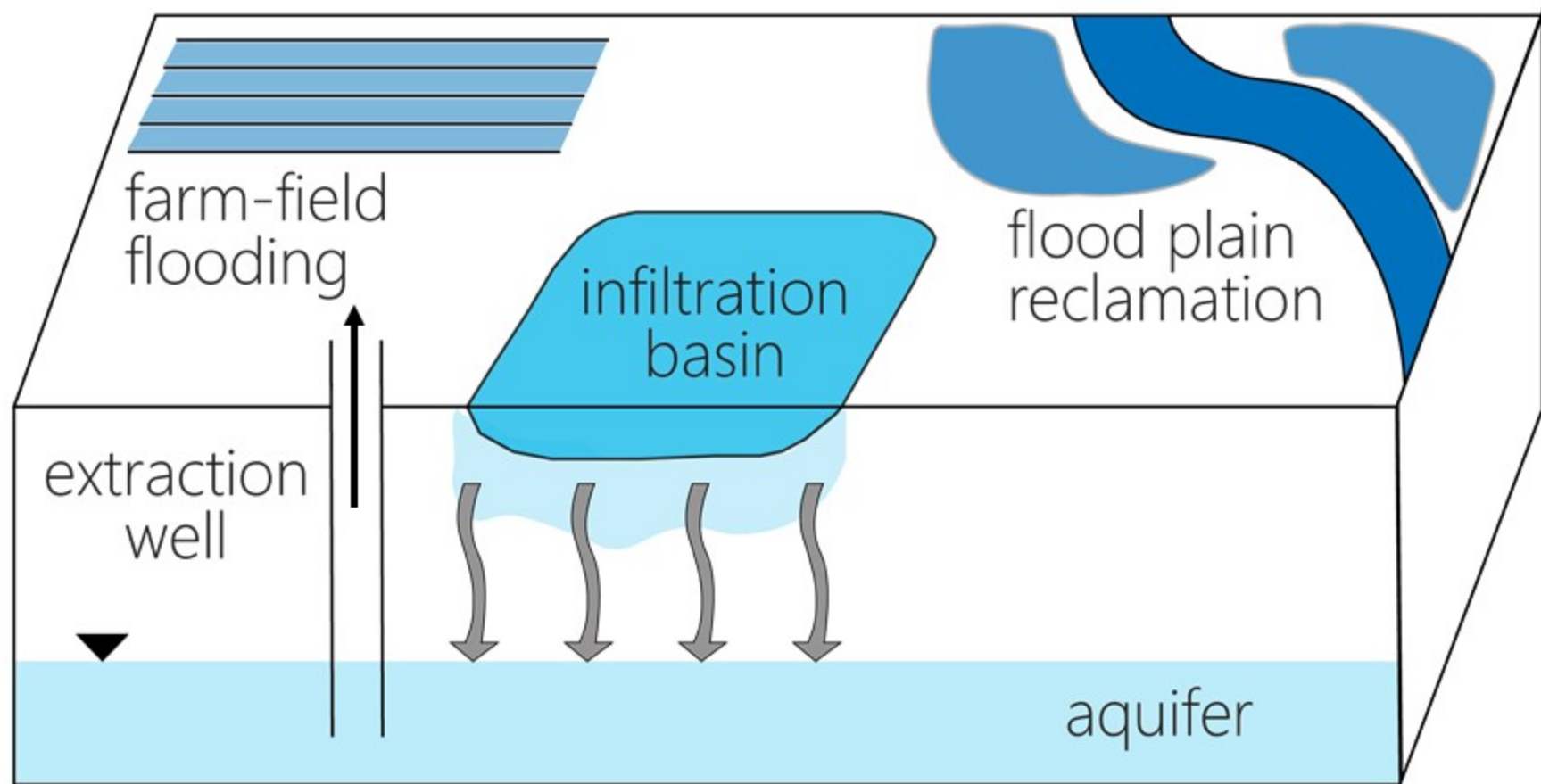
Model predictions



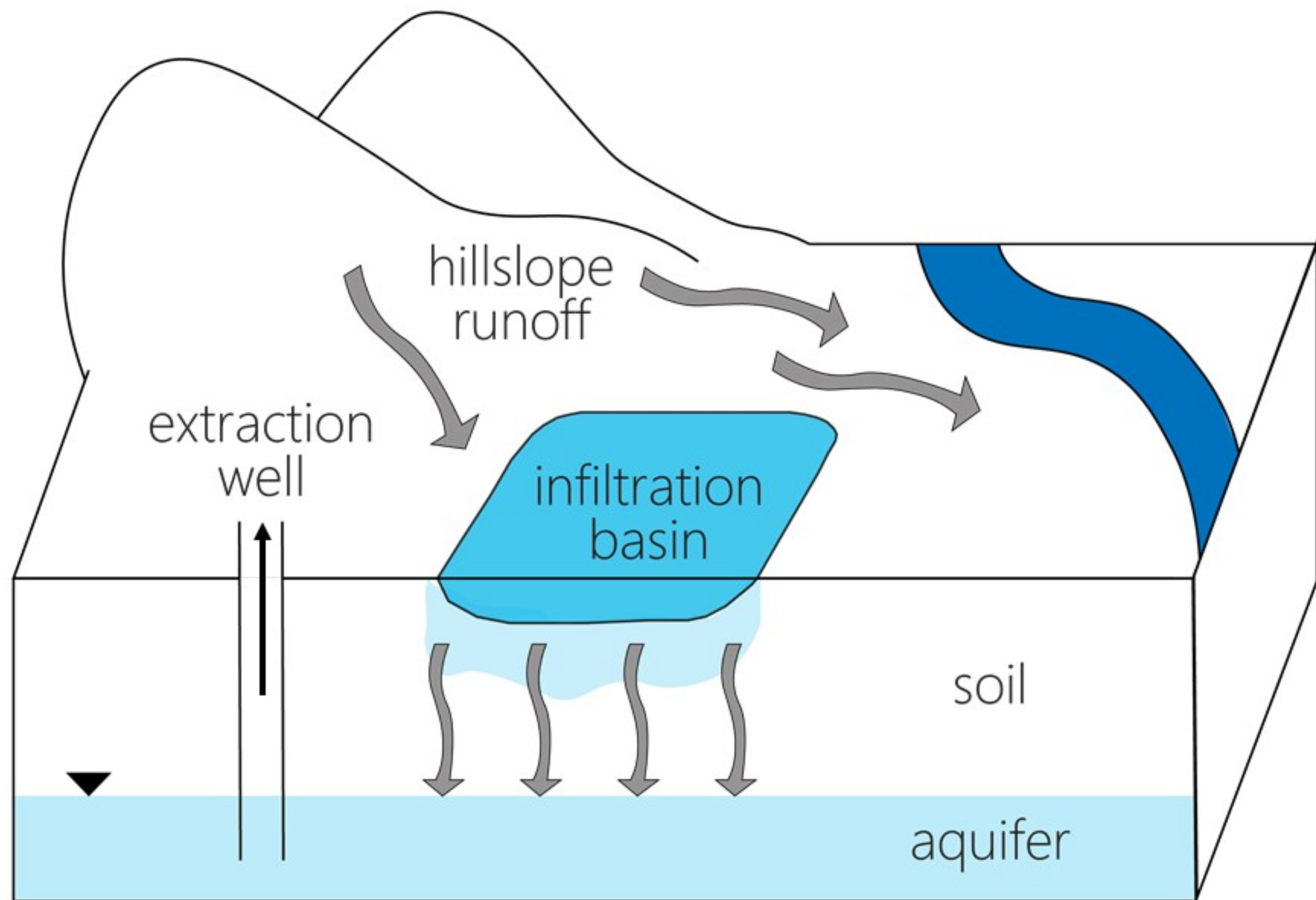
**Distributed stormwater collection for groundwater recharge can be effective over a range of climate scenarios**



Managed aquifer recharge (MAR)  
introduces surface water underground  
to increase groundwater supply



# Hillslope runoff as a source for MAR



# Runoff as a source for MAR

Low-impact  
development  
(LID)



Regional  
spreading  
grounds





# Runoff as a source for MAR

Low-impact  
development  
(LID)

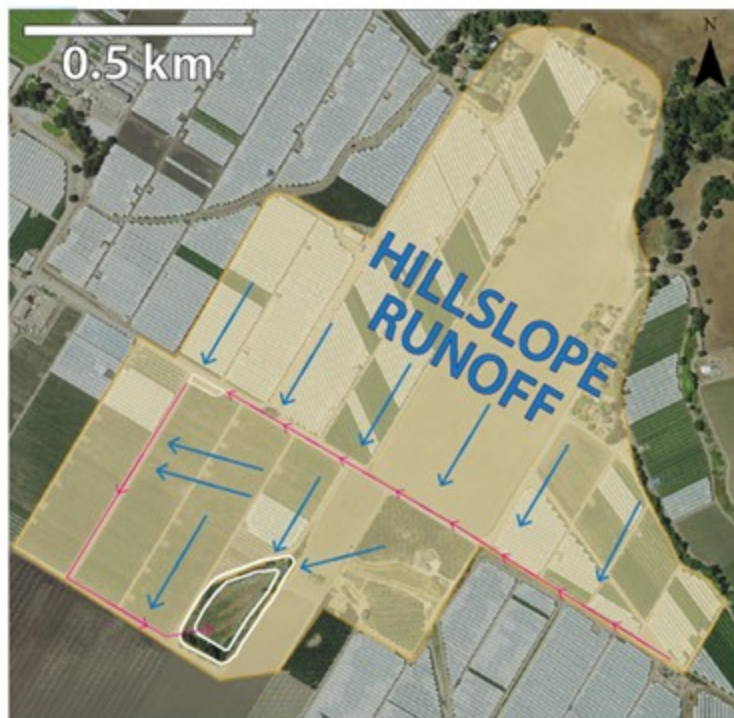
**~ 1 af/yr  
at each site**

(e.g., Newcomer et al.  
2014)



Distributed stormwater  
collection (DSC–MAR)

**100 – 1,000 af/yr**



Regional  
spreading  
grounds

**10,000+ af/yr  
at each site**

(e.g., Orange County  
Water District)

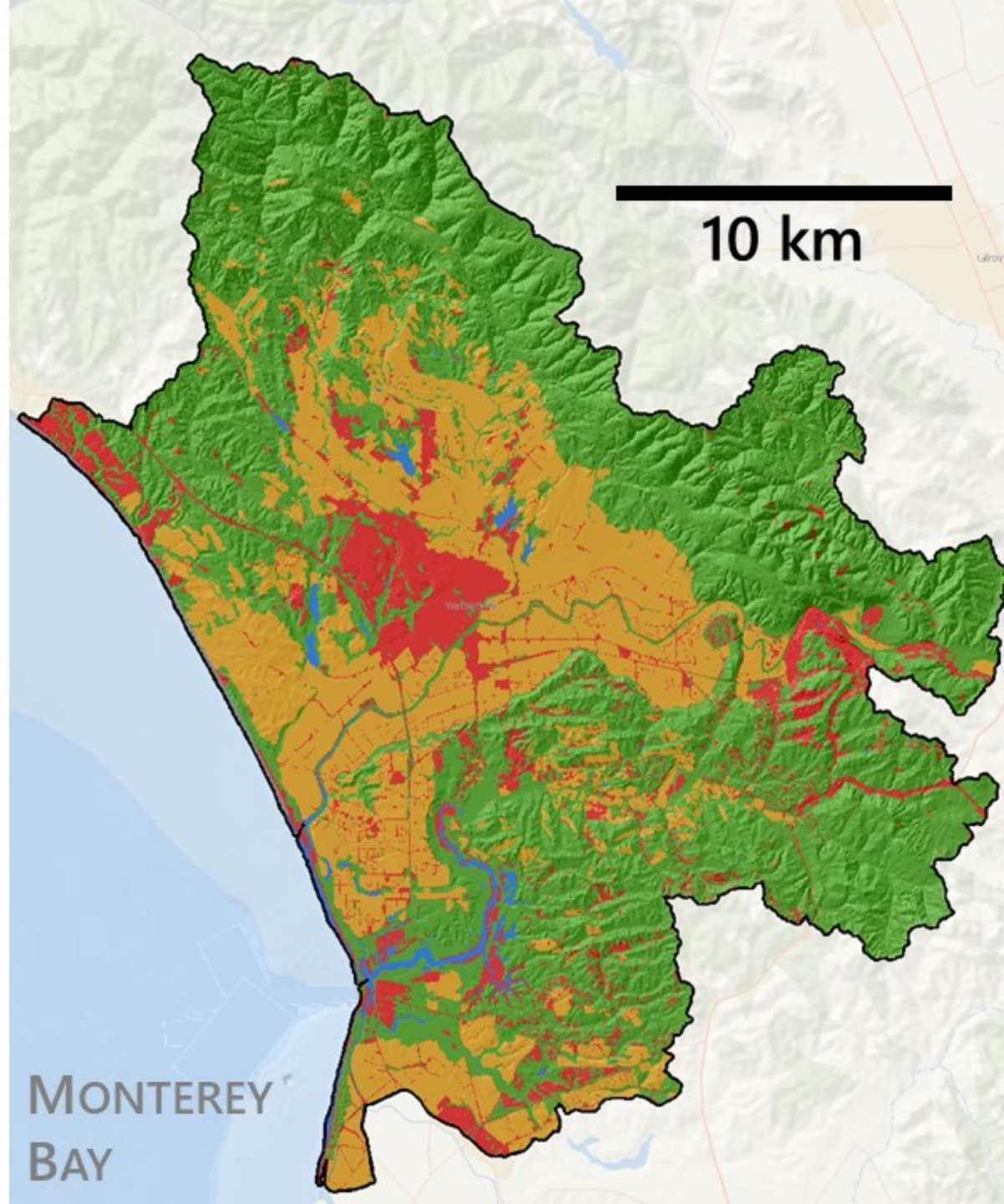


# Pajaro Valley Groundwater Basin (PVGB)

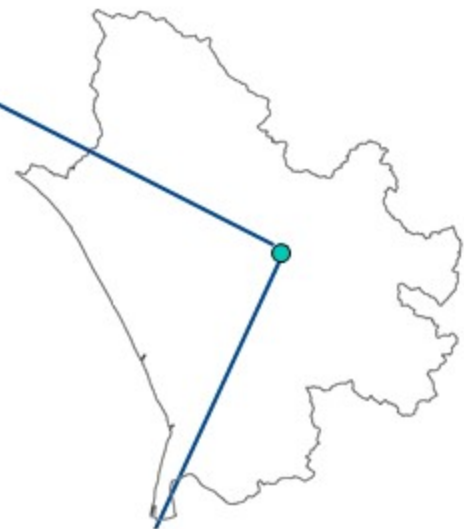
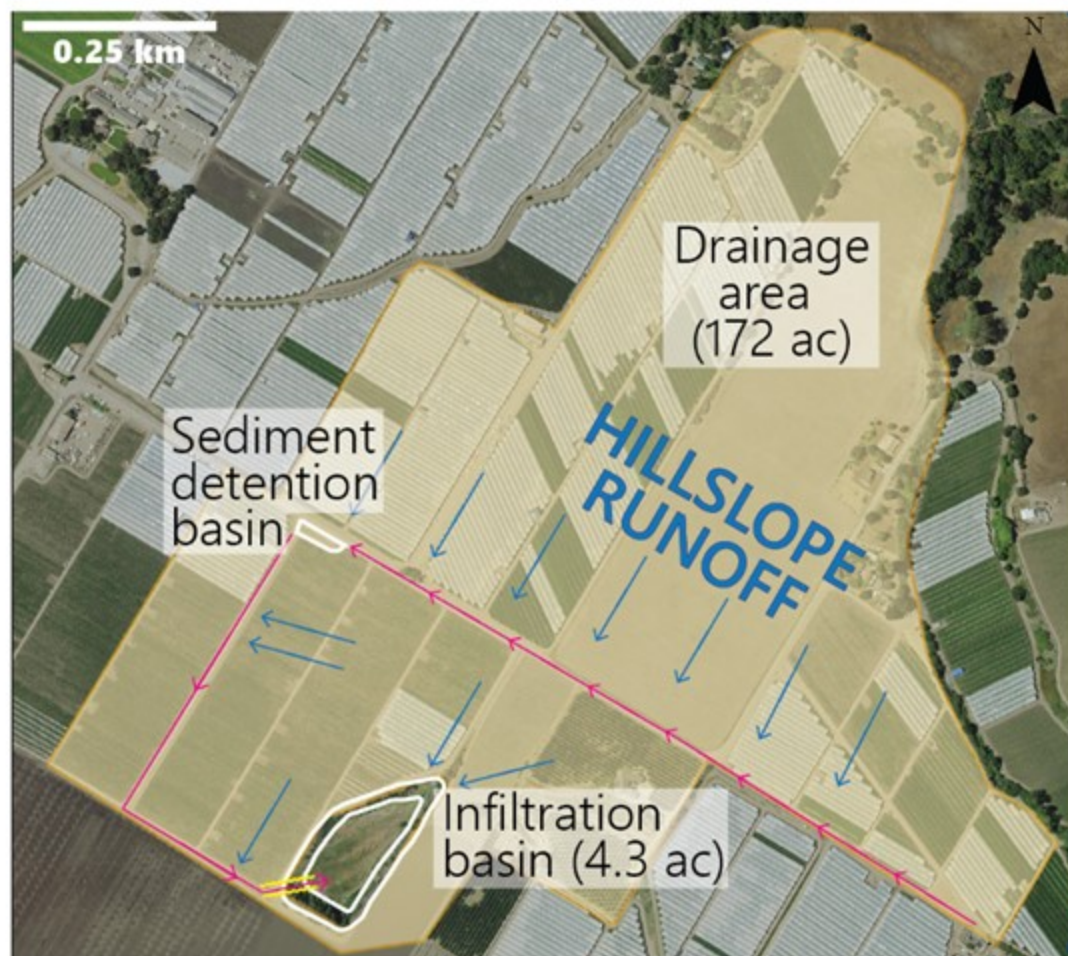
**Overdraft:**  
**10,000–15,000**  
**af/yr**

## Land use

- Urban
- Agriculture
- Vegetation





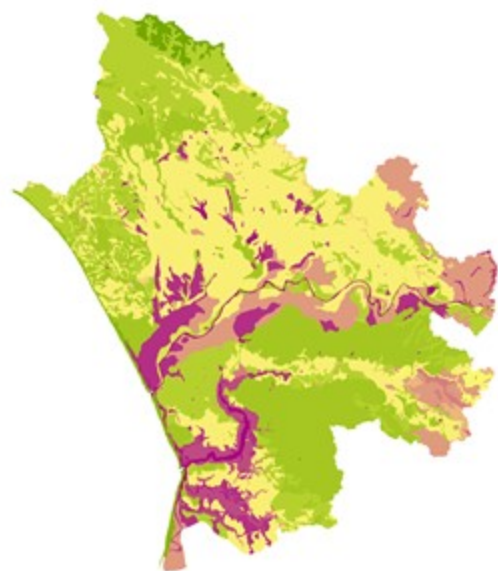
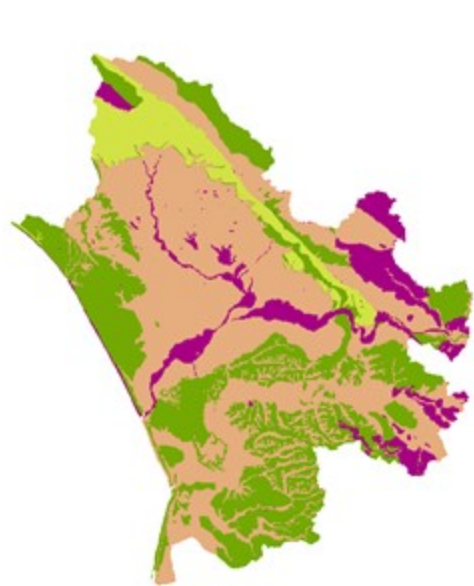


**Program goal:**  
**1,000 af/yr**  
**(10% overdraft)**

**Project goal:**  
**>100 af/yr**

DSC-MAR field site: Measured precipitation,  
runoff, sediment transport for 6 years





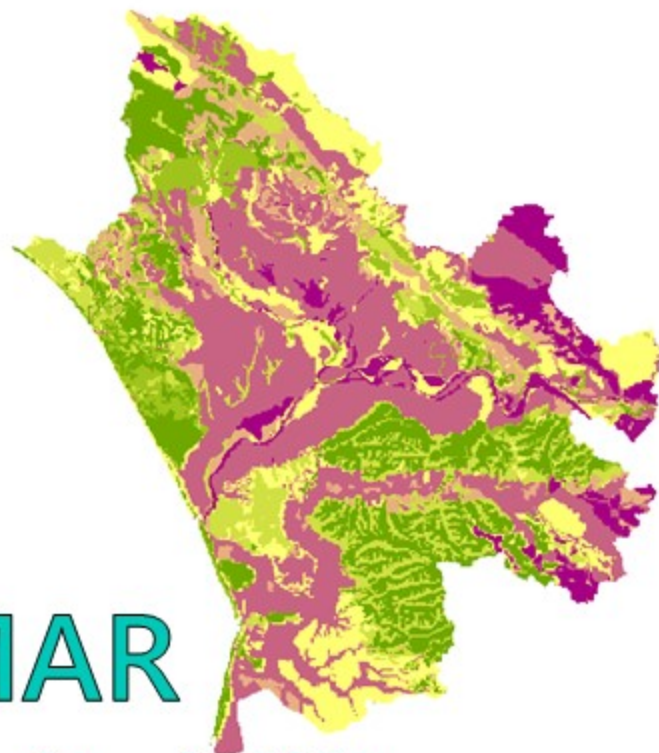
Bedrock  
geology

+

Infiltration  
capacity

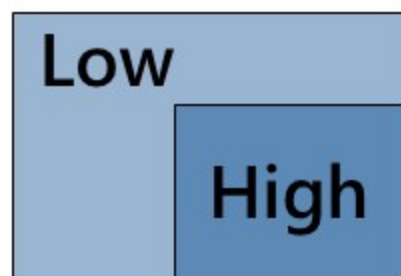
=

**MAR**  
**suitability**  
(surface data)



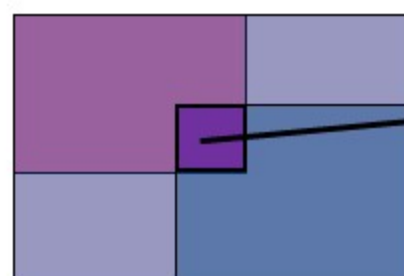
Property 1

+



Property 2

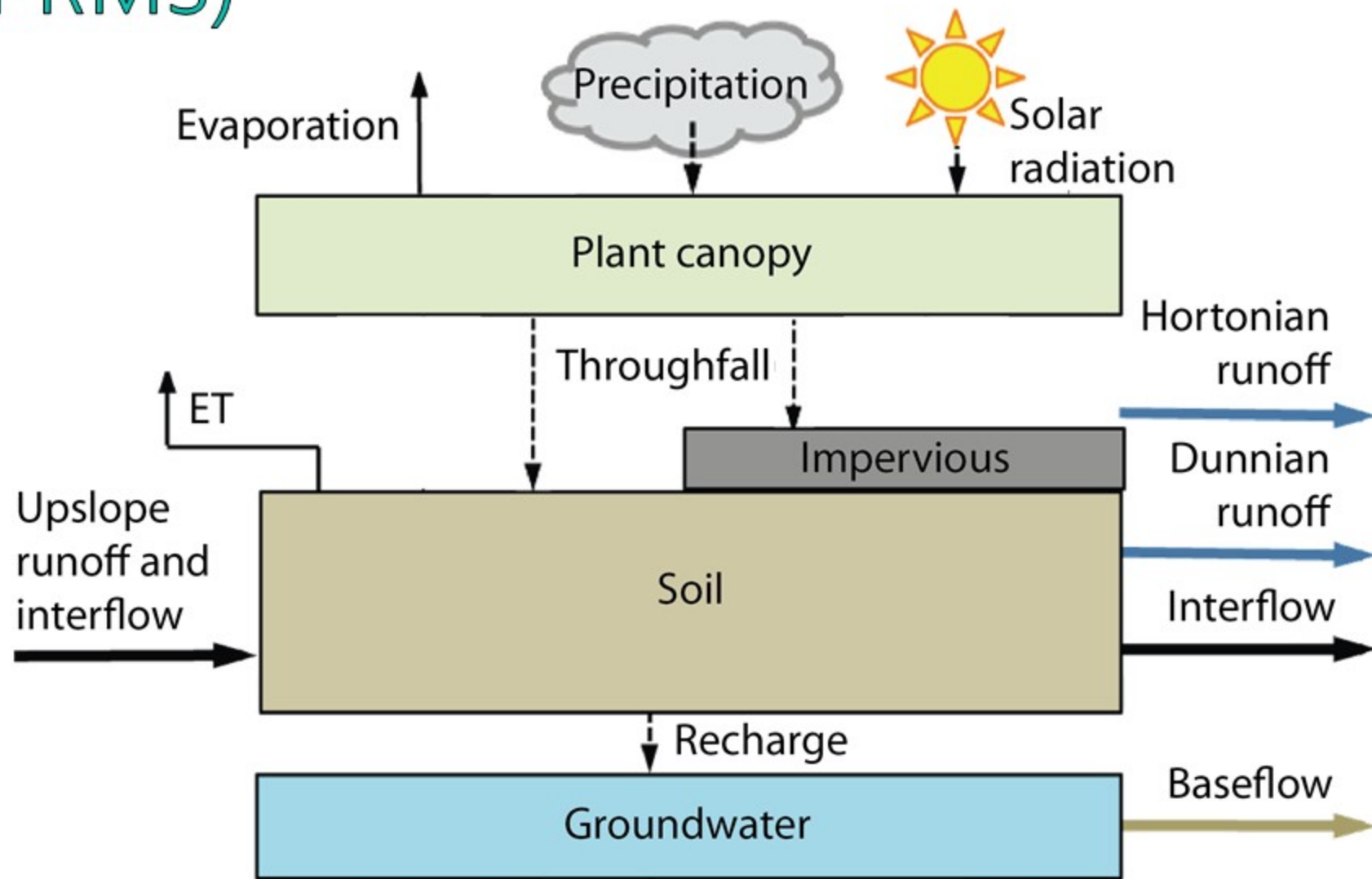
=



Combined

Higher  
suitability  
area

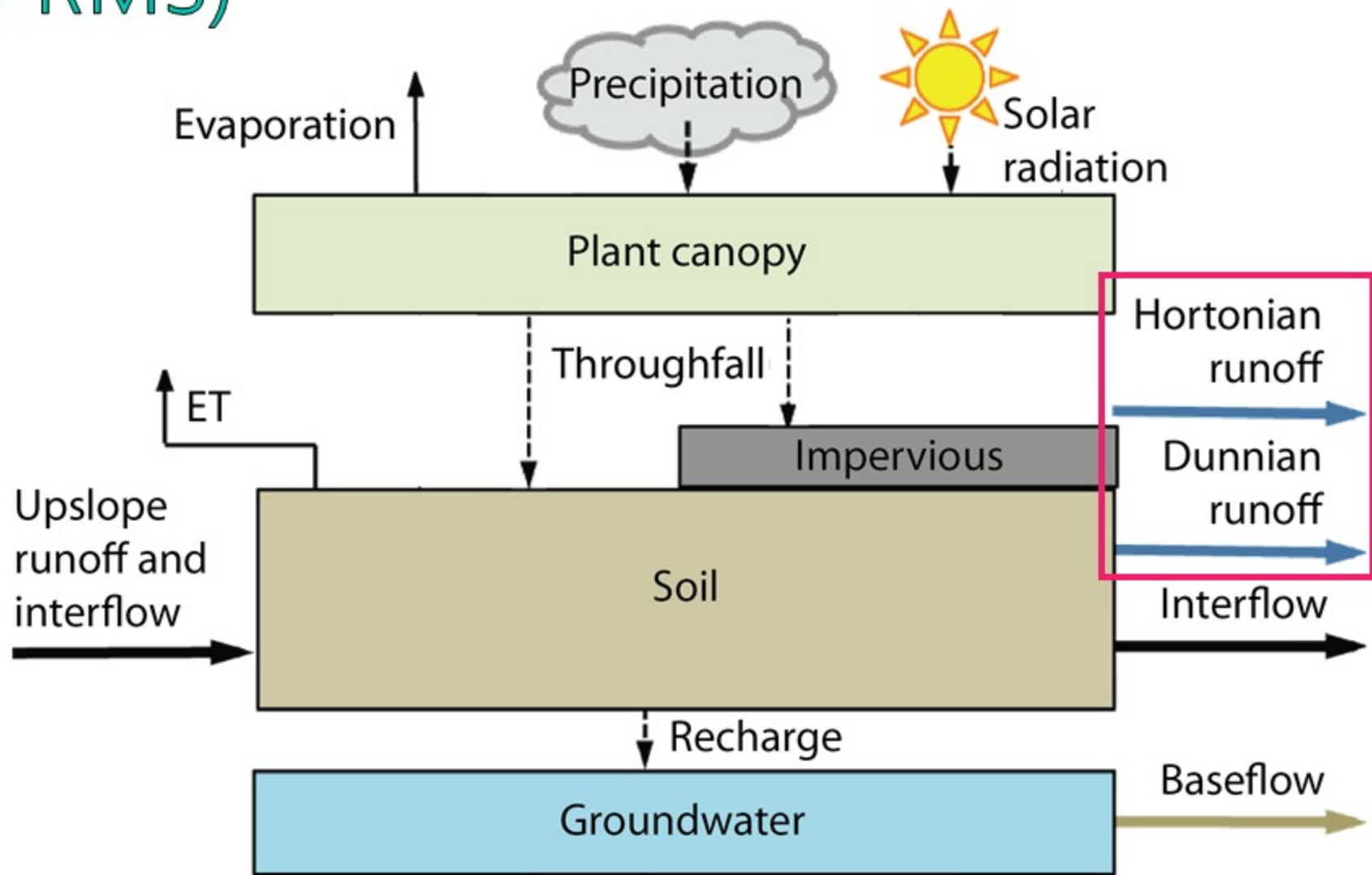
# Precipitation–Runoff Modeling System (PRMS)



modified from Markstrom et al. (2015)



# Precipitation–Runoff Modeling System (PRMS)



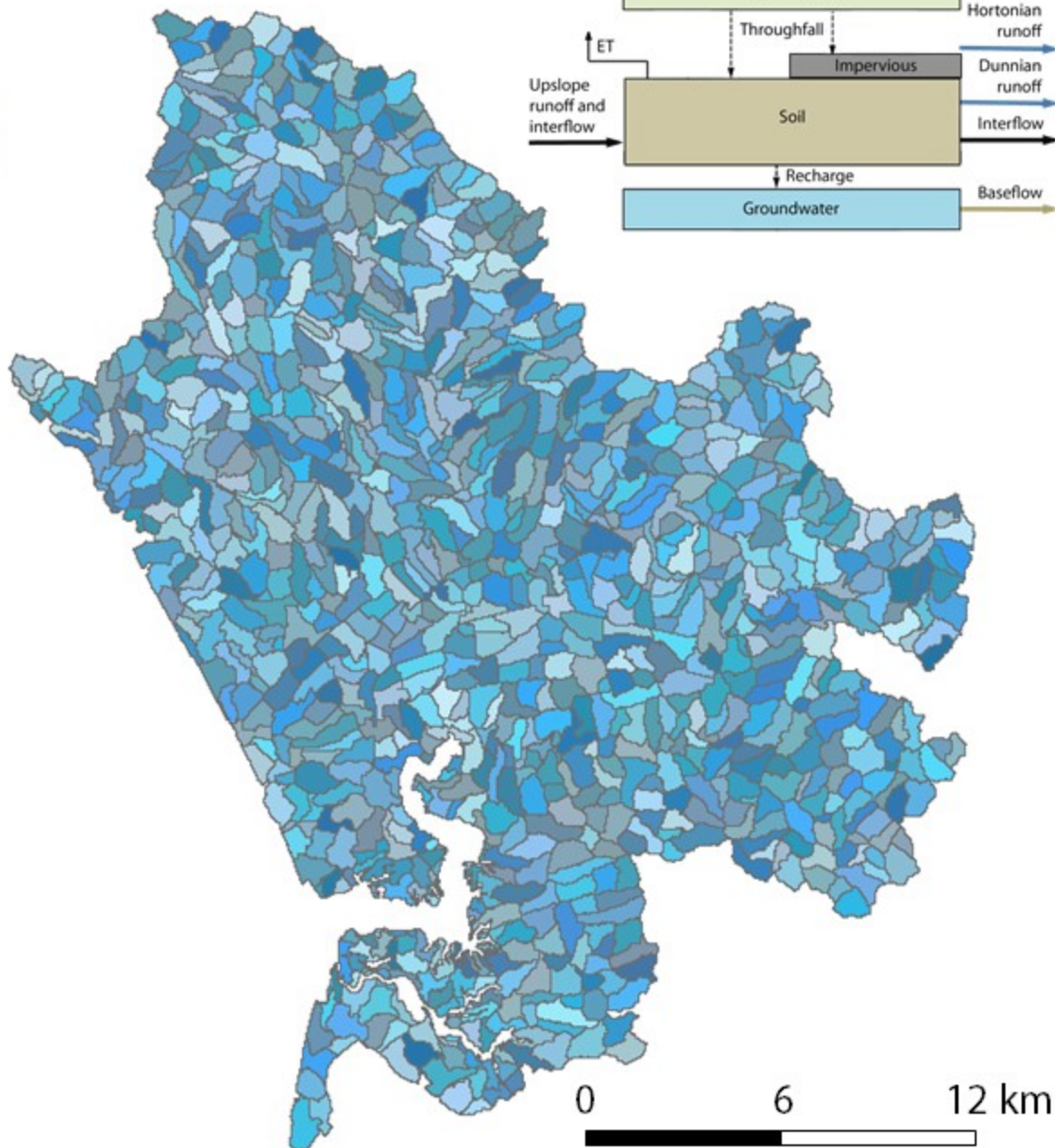
modified from Markstrom et al. (2015)

# PVGB model discretization

Model cells delineated topographically

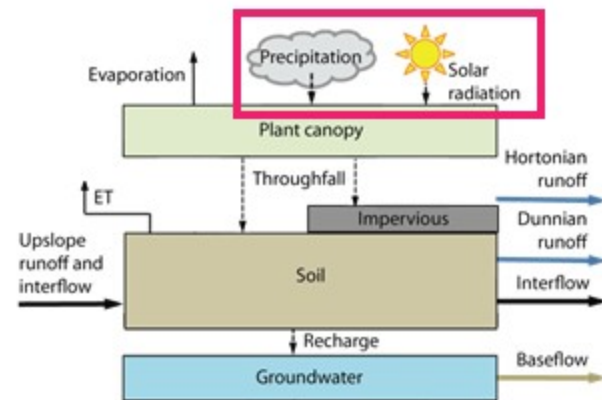
25–250 acres  
(0.1–1 km<sup>2</sup>)

Flow routed from one cell to the next

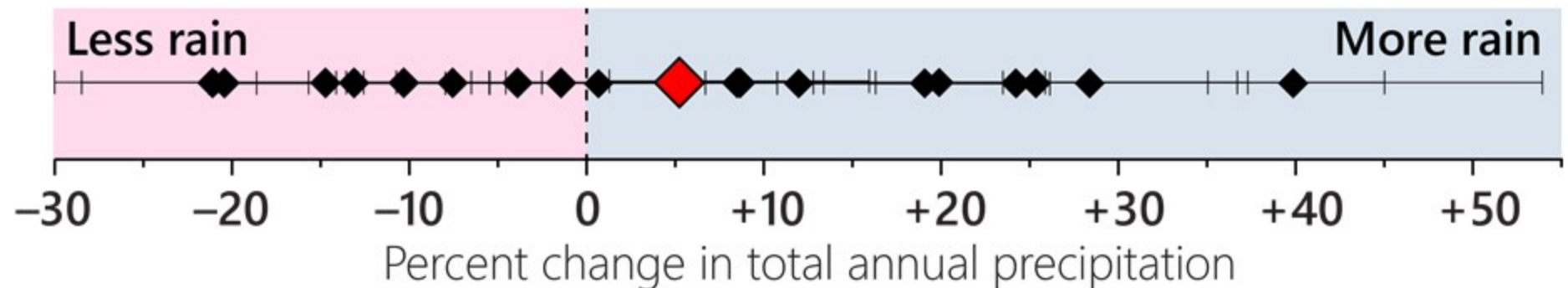




# Input climate data to drive model?



Precipitation projections for California  
2070–2099 relative to 1951–1980

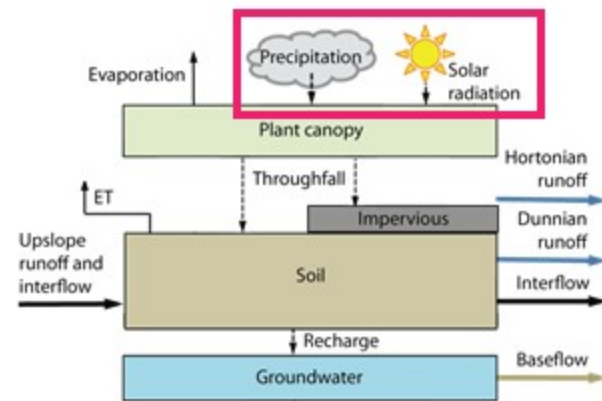


*modified from Flint and Flint 2014*

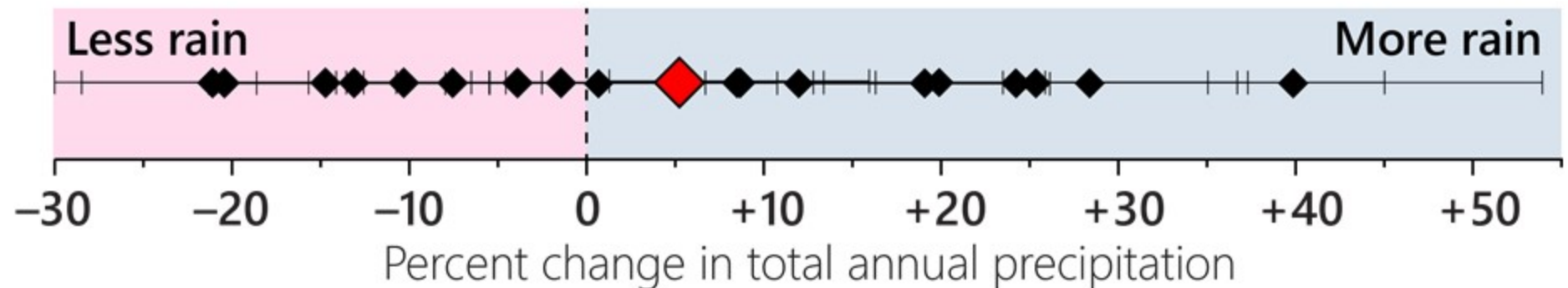
Future uncertainty:

- Increase or decrease total rainfall?

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Precipitation projections for California  
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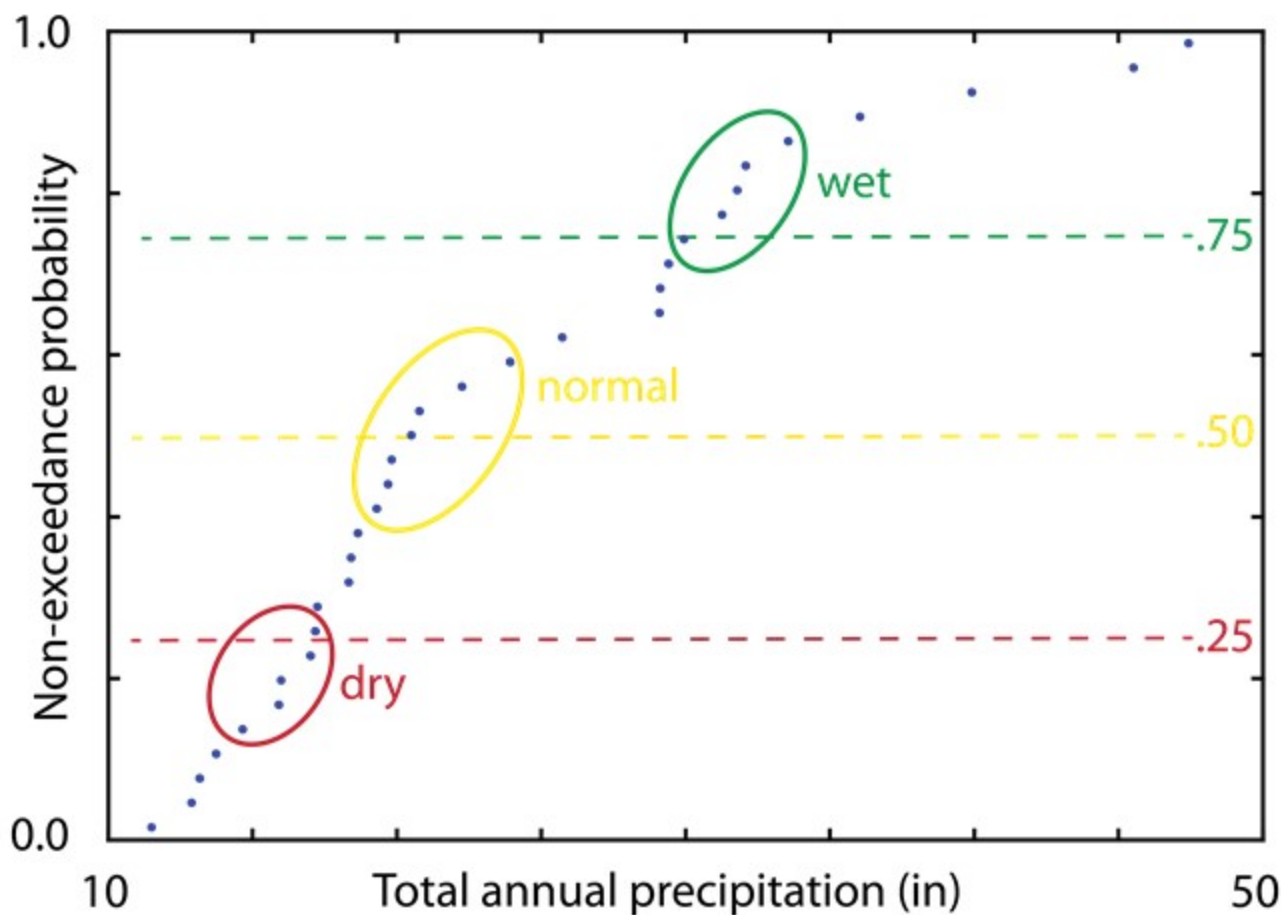
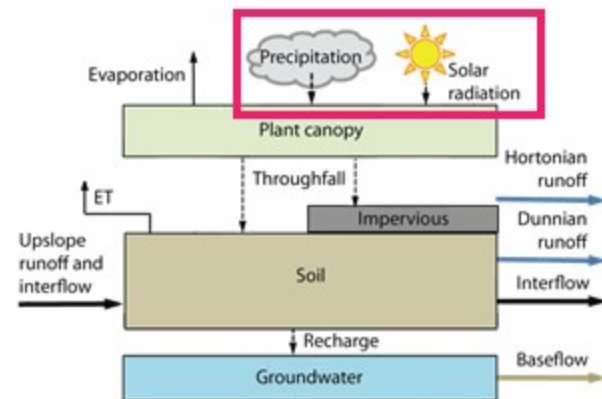
*modified from Flint and Flint 2014*

## Future uncertainty:

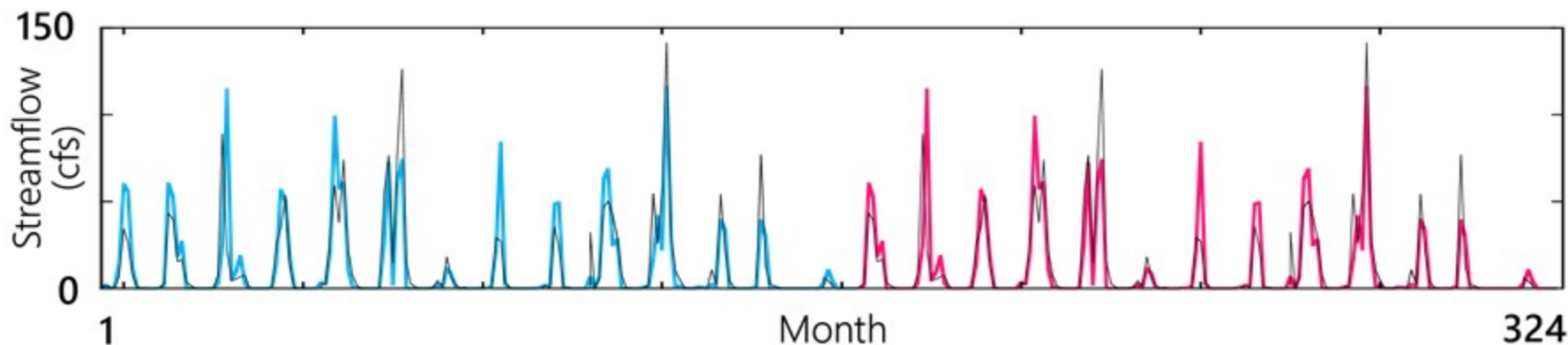
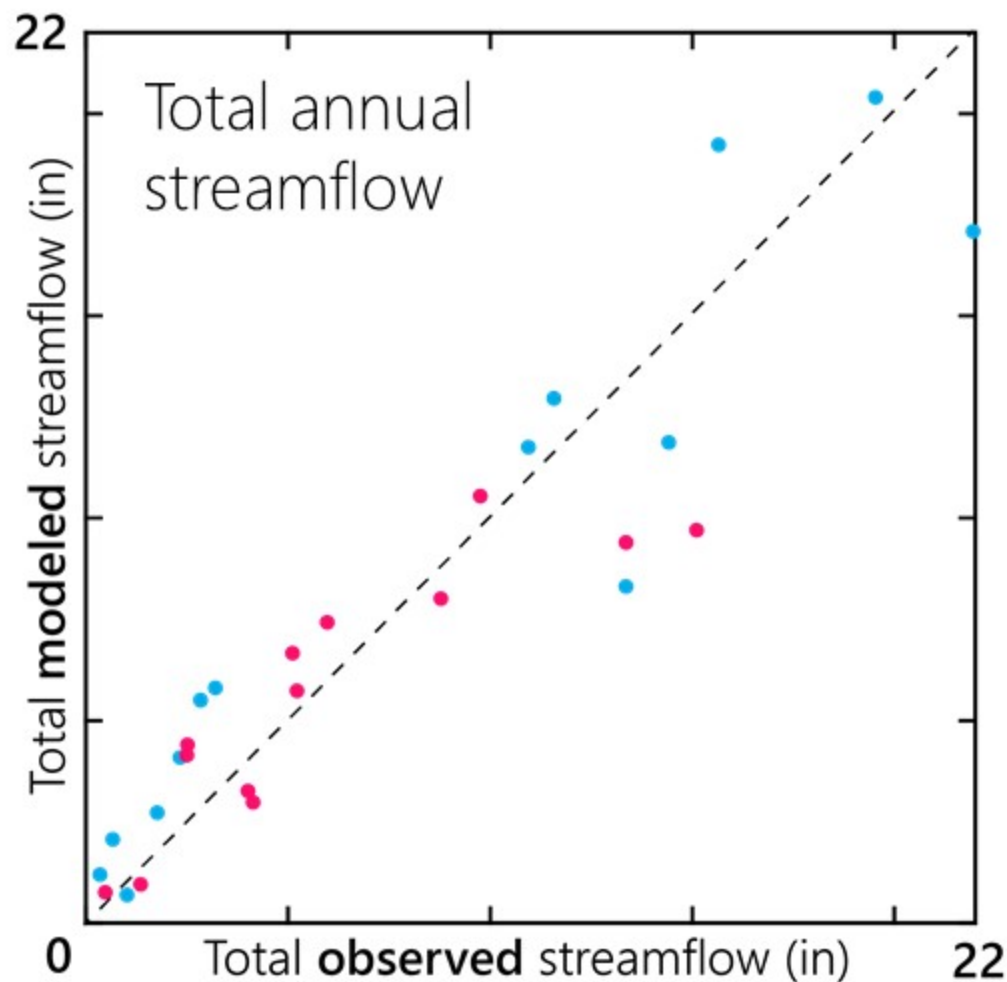
- Increase or decrease total rainfall?
- Distribution of rainfall in space/time?



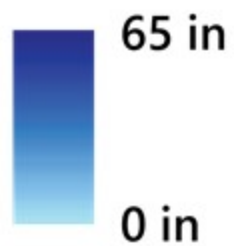
We created  
model climate scenarios  
using historical data



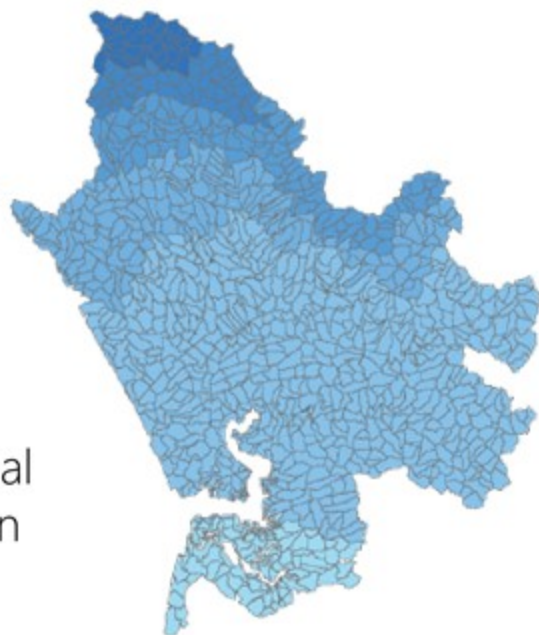
# Streamflow calibration and validation







Mean annual  
precipitation



**DRY**



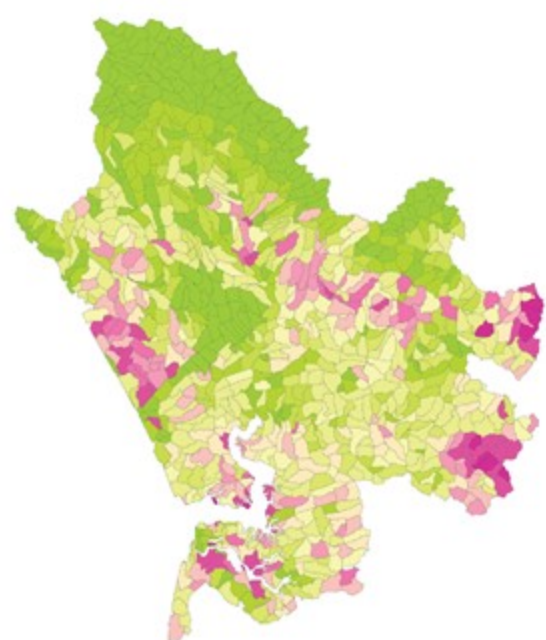
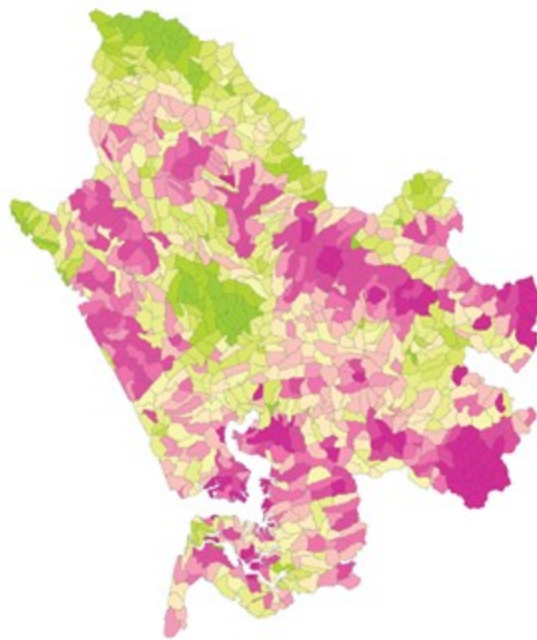
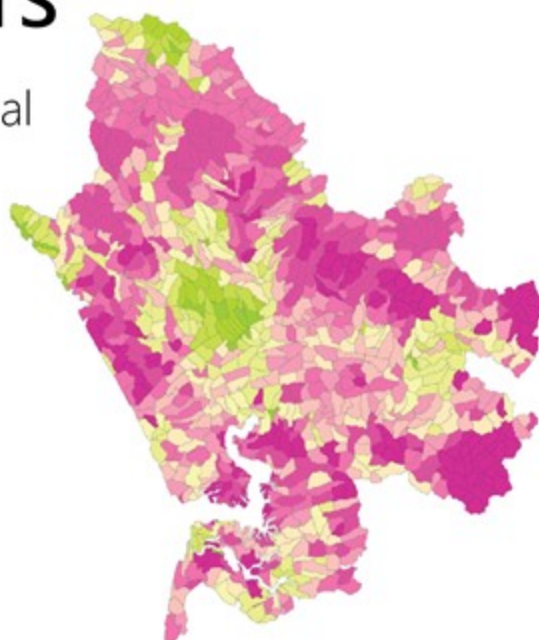
**NORMAL**

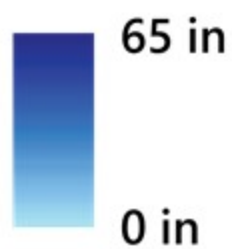


**WET**

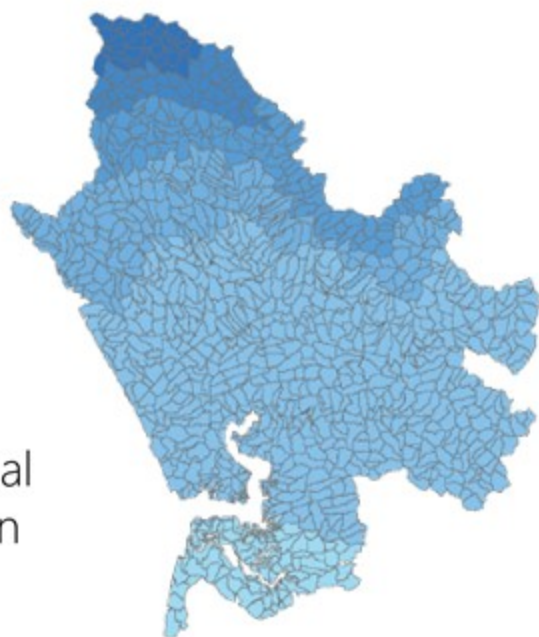
# MODEL RESULTS

Mean annual  
hillslope  
runoff



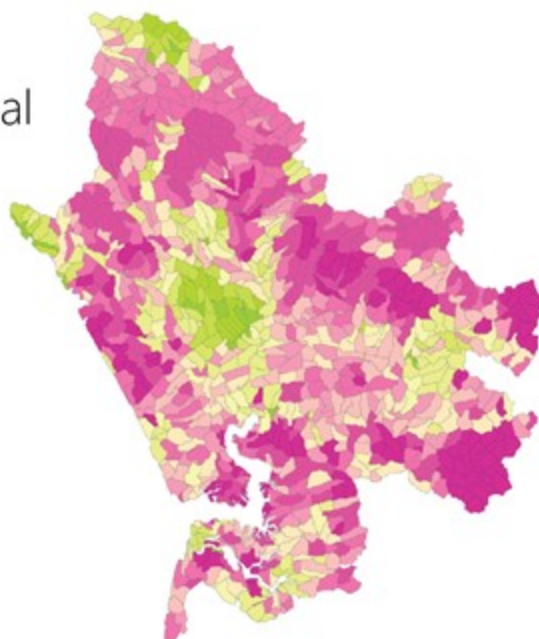


Mean annual  
precipitation



**DRY**

Mean annual  
hillslope  
runoff

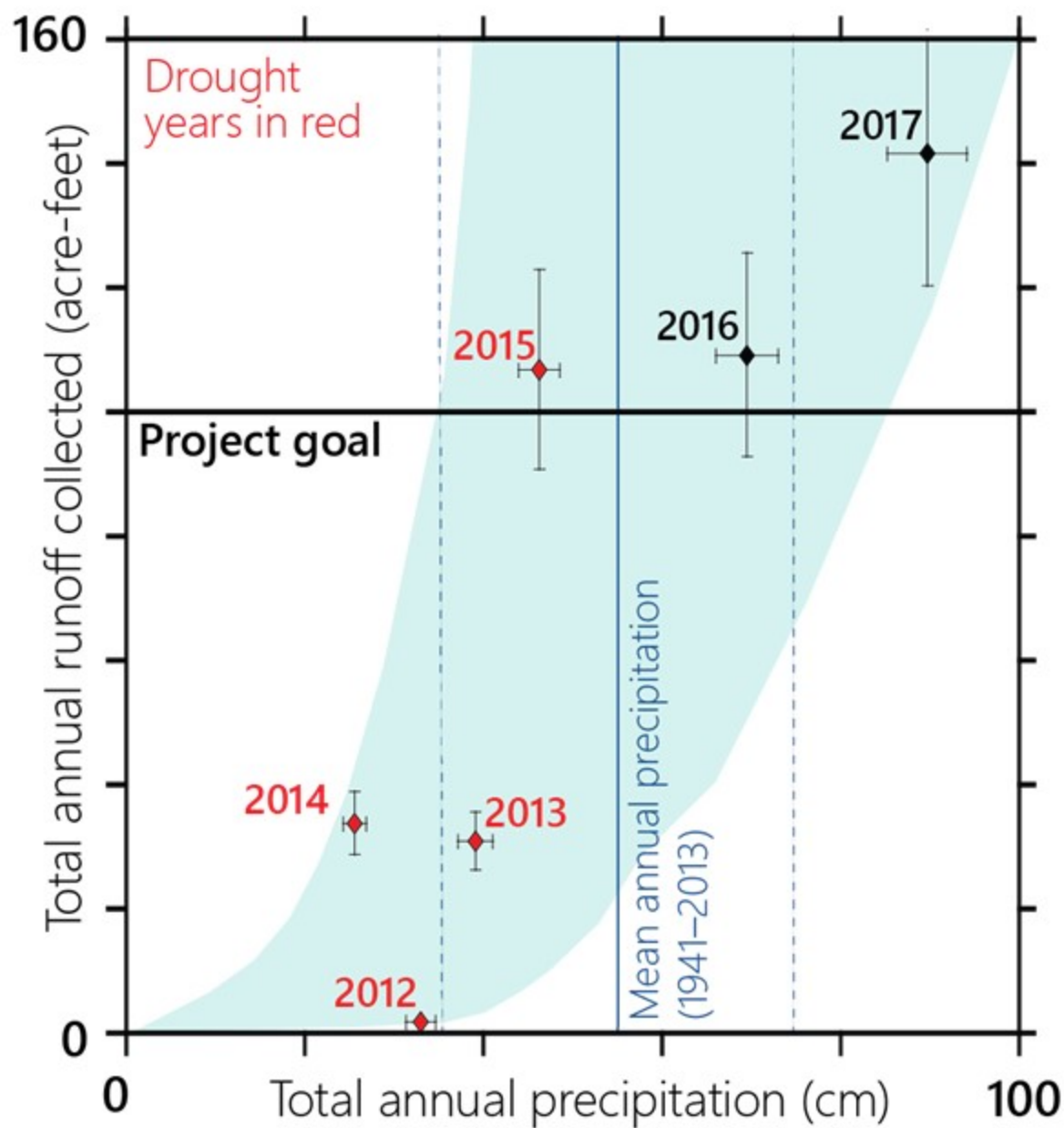


Model results:

In the dry scenario,  
**>20,000 ac-ft/yr**  
of hillslope runoff is  
generated in the  
PVGB (much more  
in wetter years).

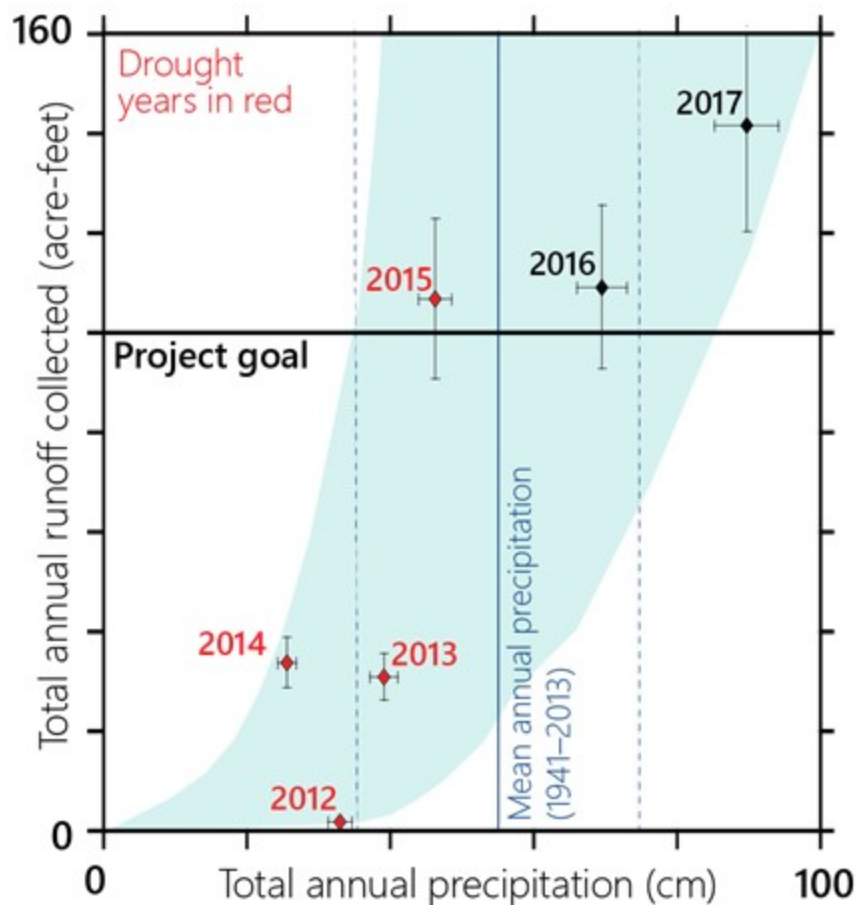


Field results:  
The project  
exceeded its  
goal in one of  
four drought  
years

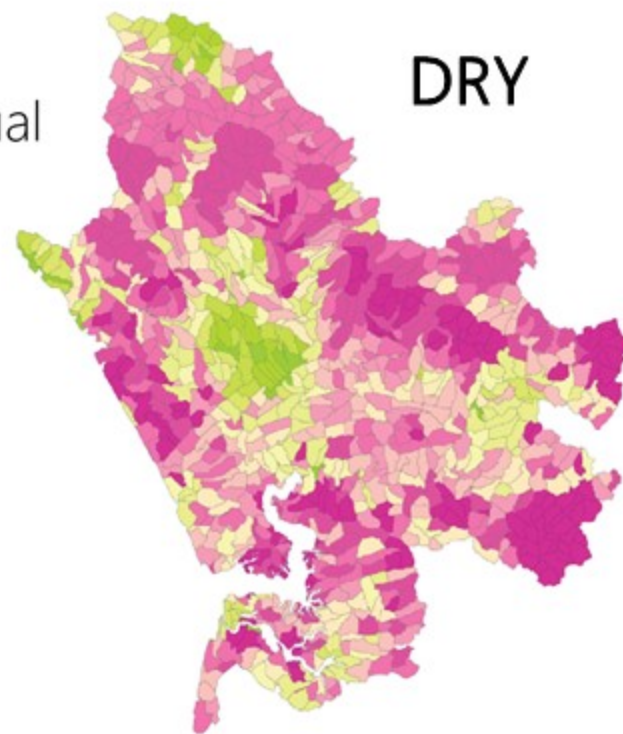
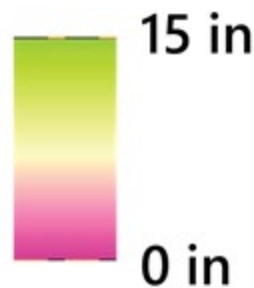


# Field + model results:

Enough runoff is generated to support DSC–MAR even during dry times



Mean annual hillslope runoff

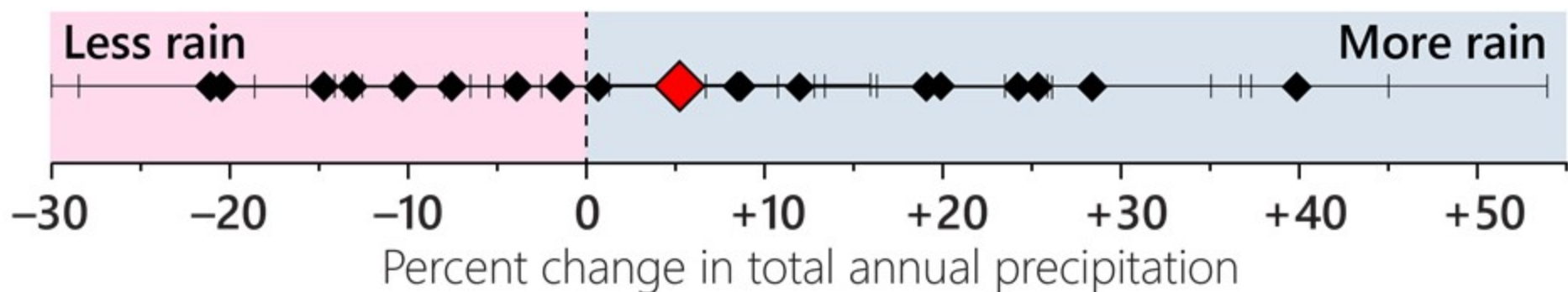




Field + model results:

DSC–MAR can be an effective water management strategy over a wide range of precipitation regimes

Precipitation projections for California  
2070–2099 relative to 1951–1980

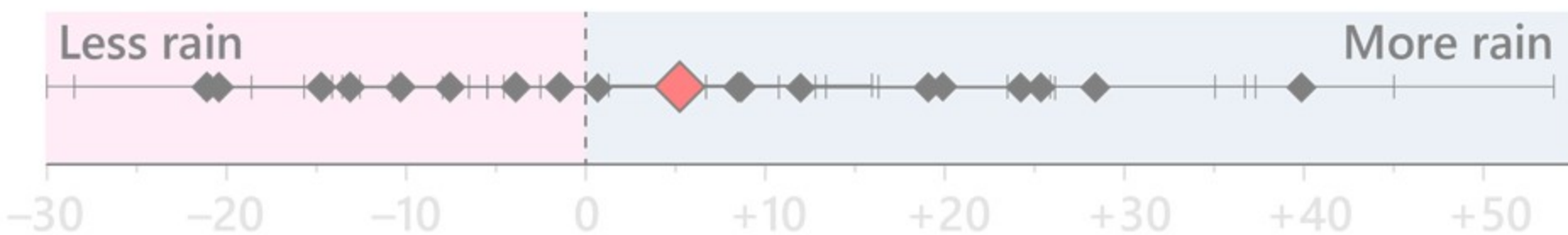


*modified from Flint and Flint 2014*

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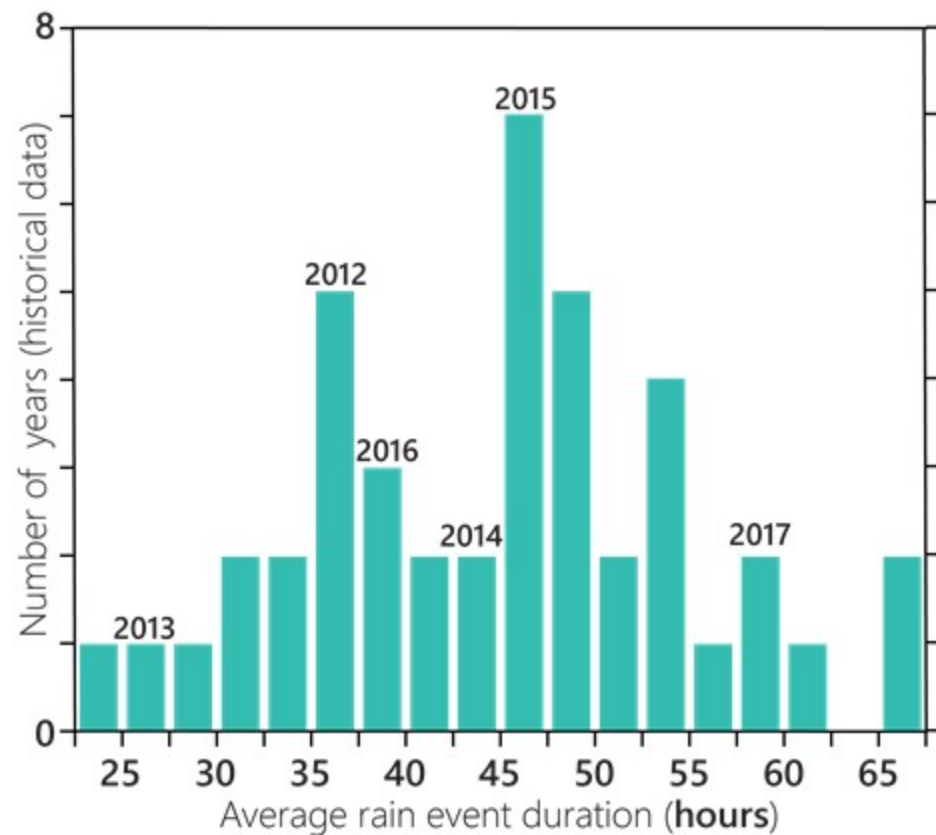
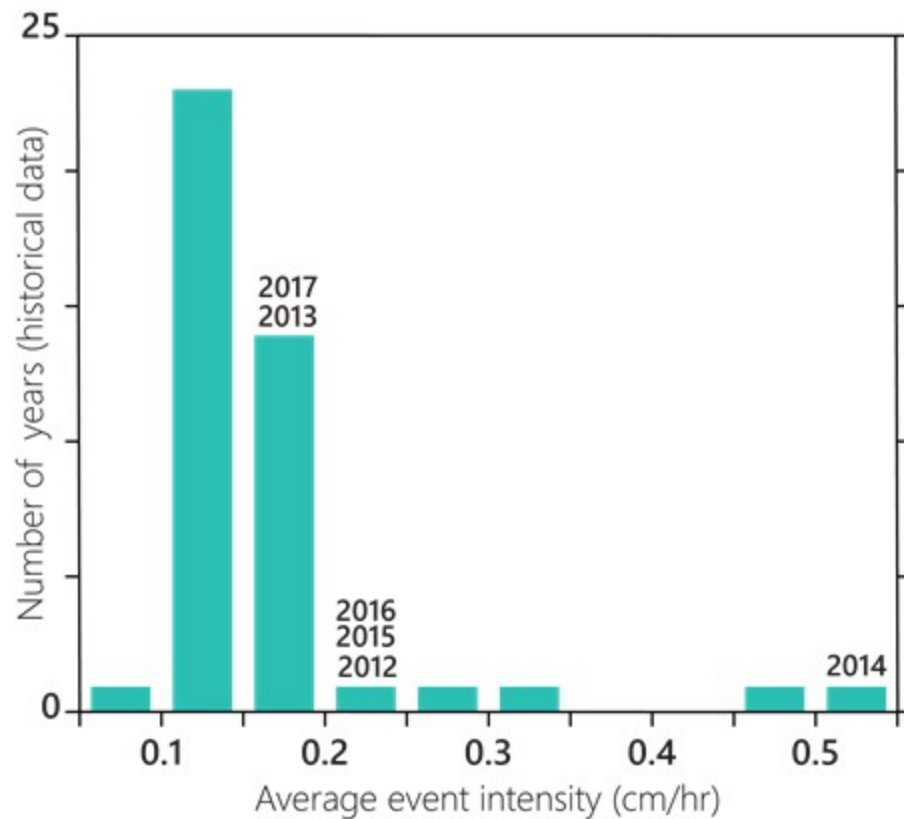
Precipitation projections for California  
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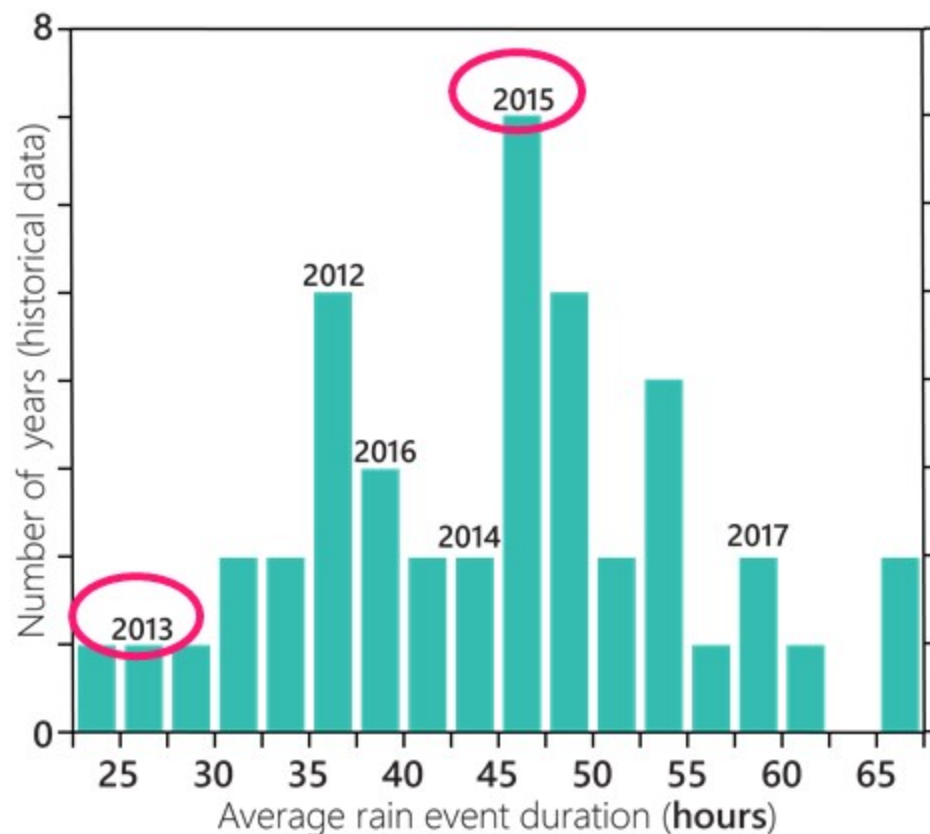
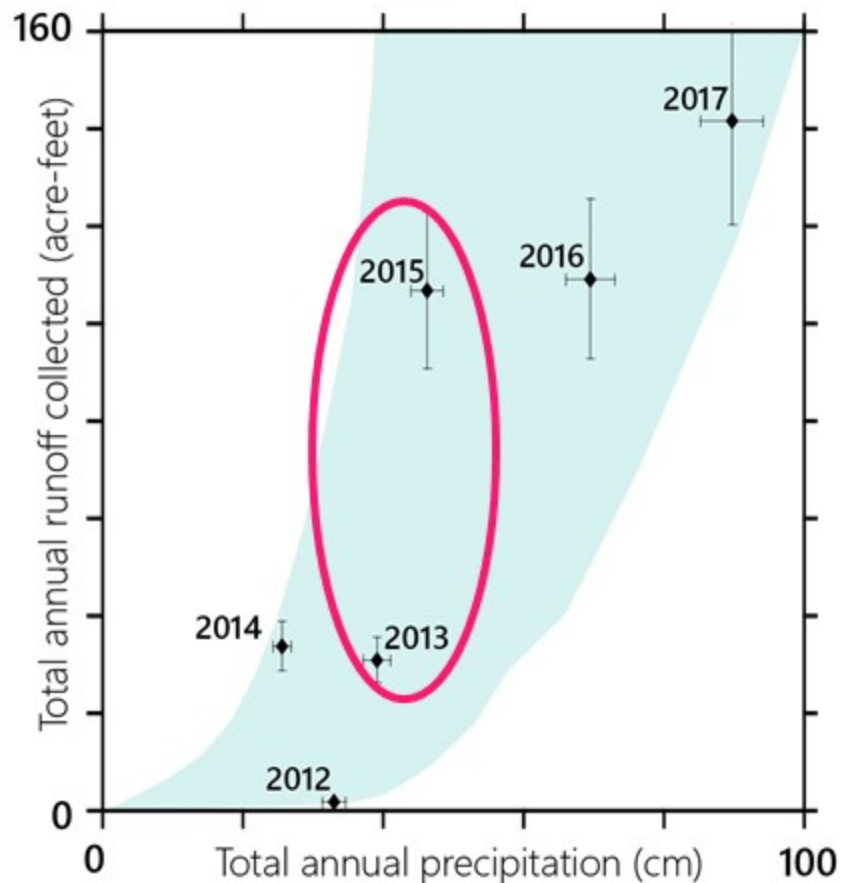
**What about the distribution of rainfall in time?**

*modified from Flint and Flint 2014*

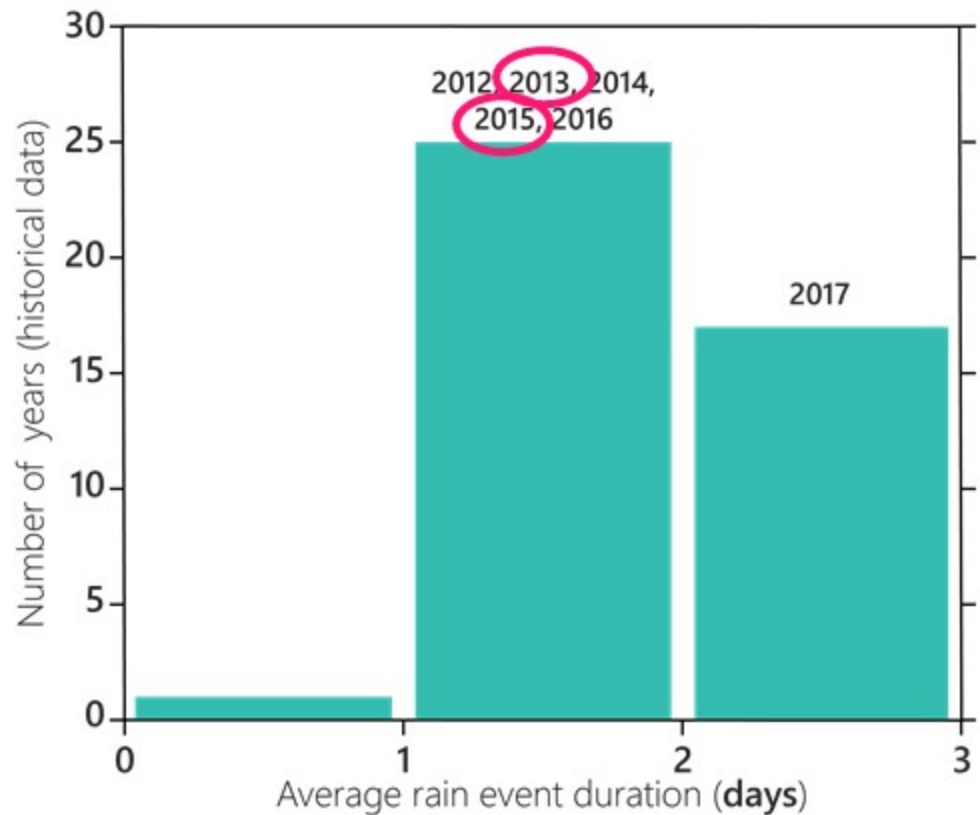
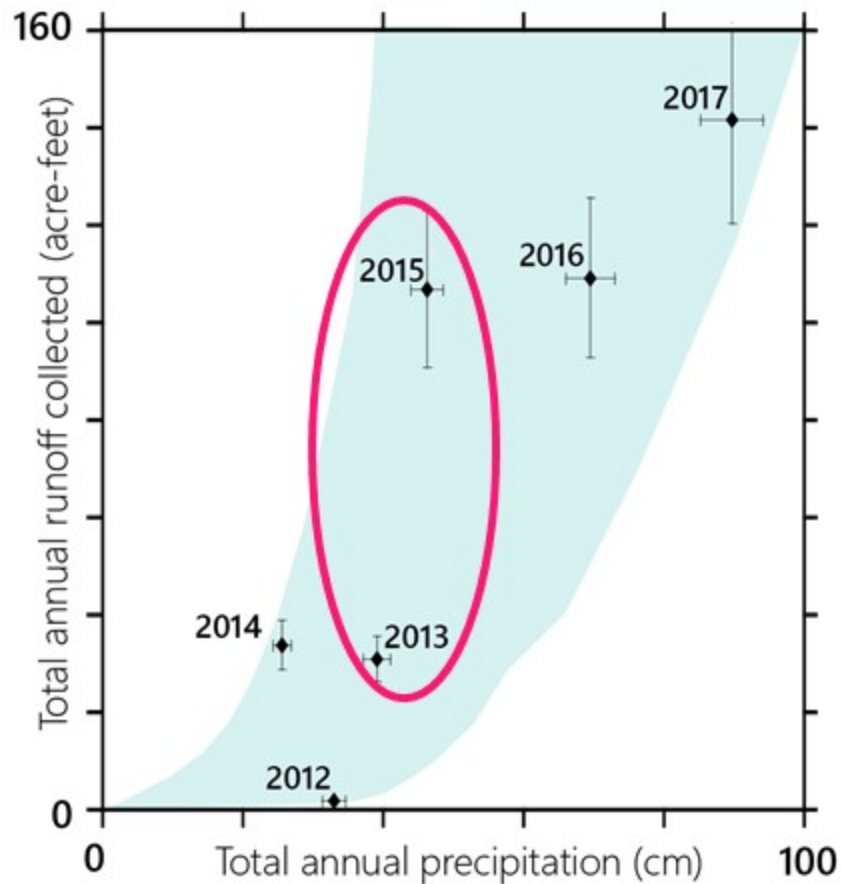




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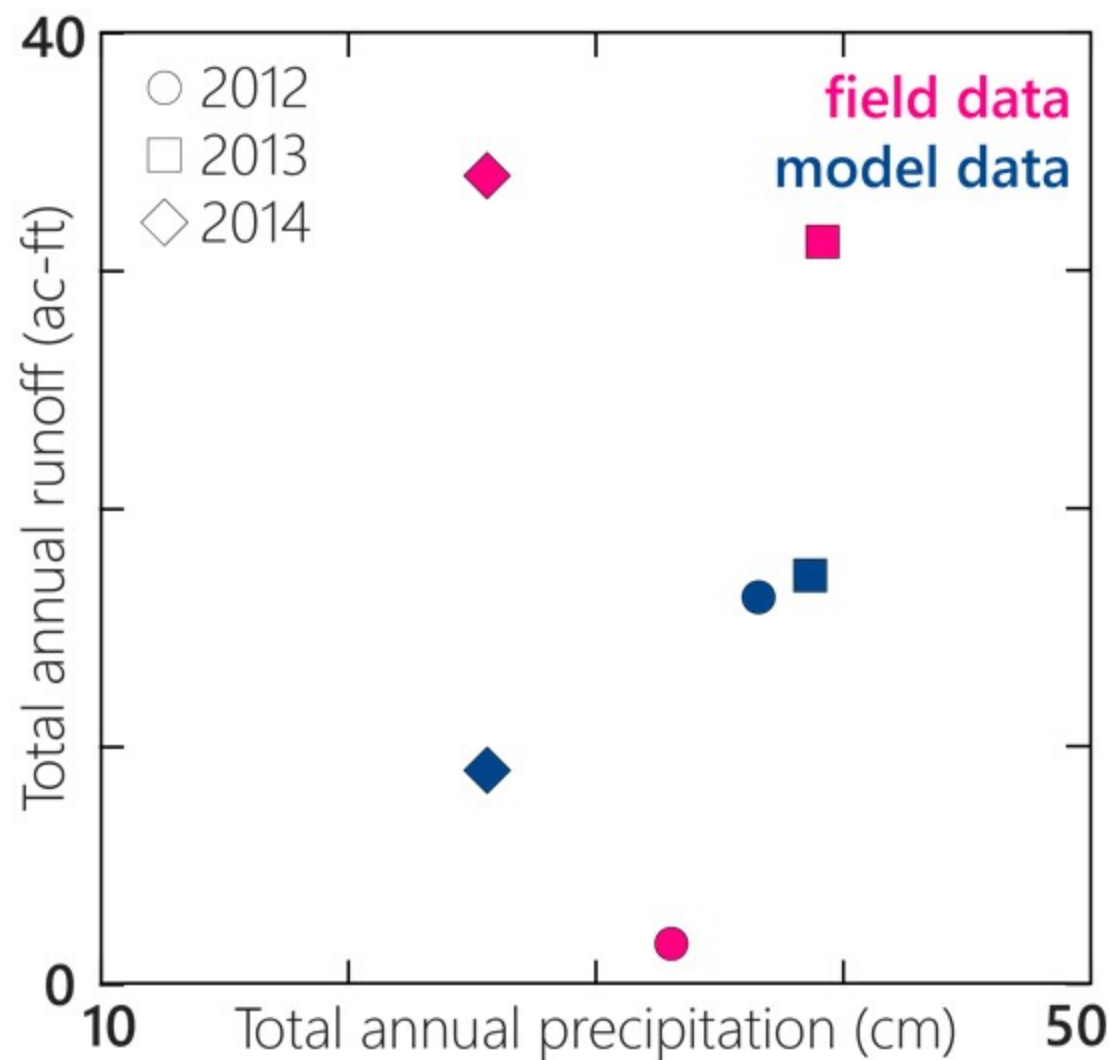


Field results: Hourly precipitation characteristics matter



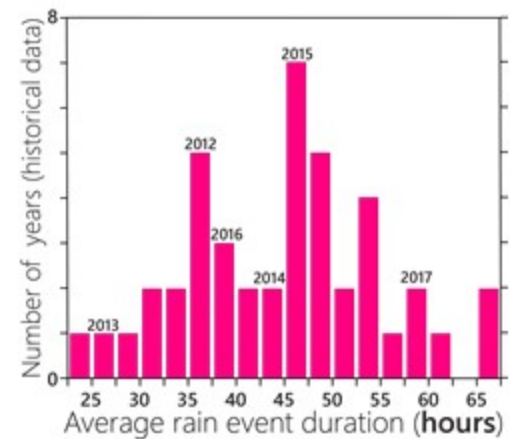
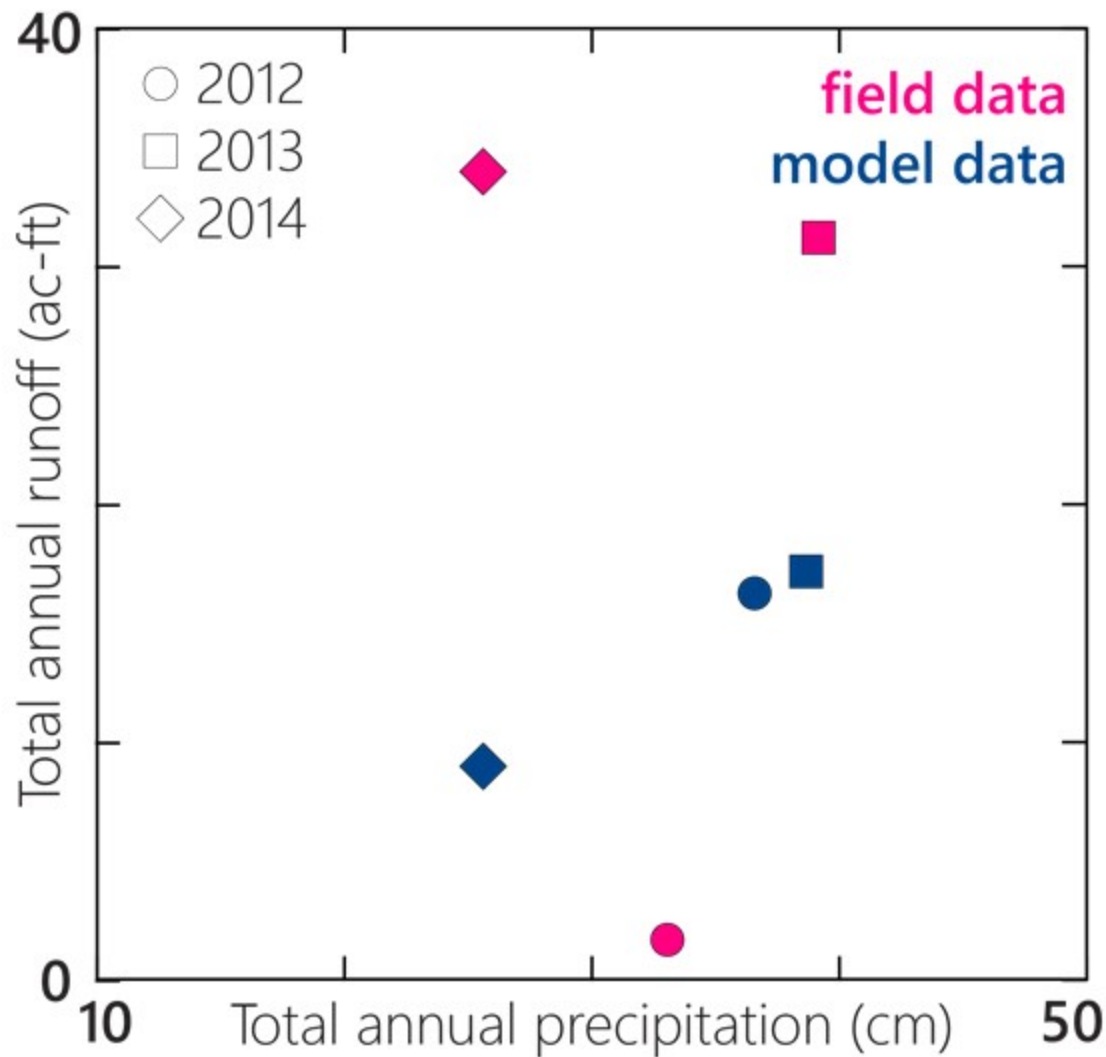
Field results: Significant results from hourly data are obscured in daily data



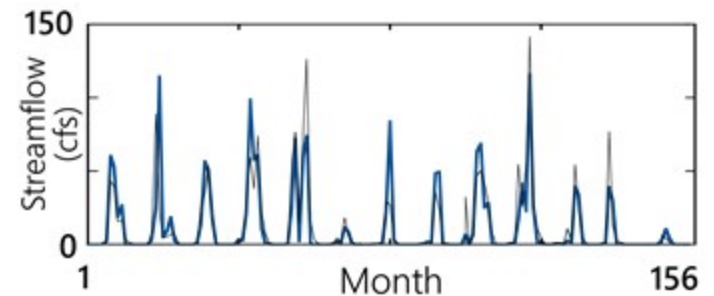


Reconciling  
model and  
field results:

Model results  
accurately  
represent  
general  
range, but not  
year-to-year  
specifics

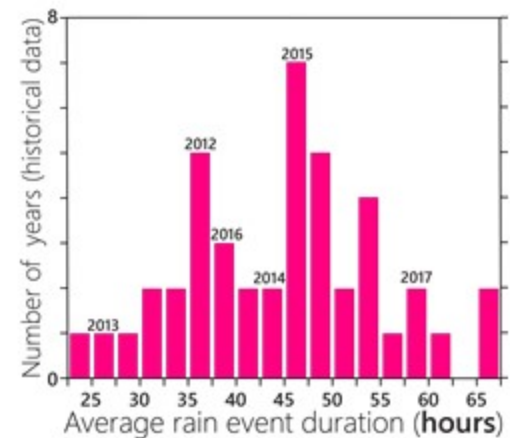
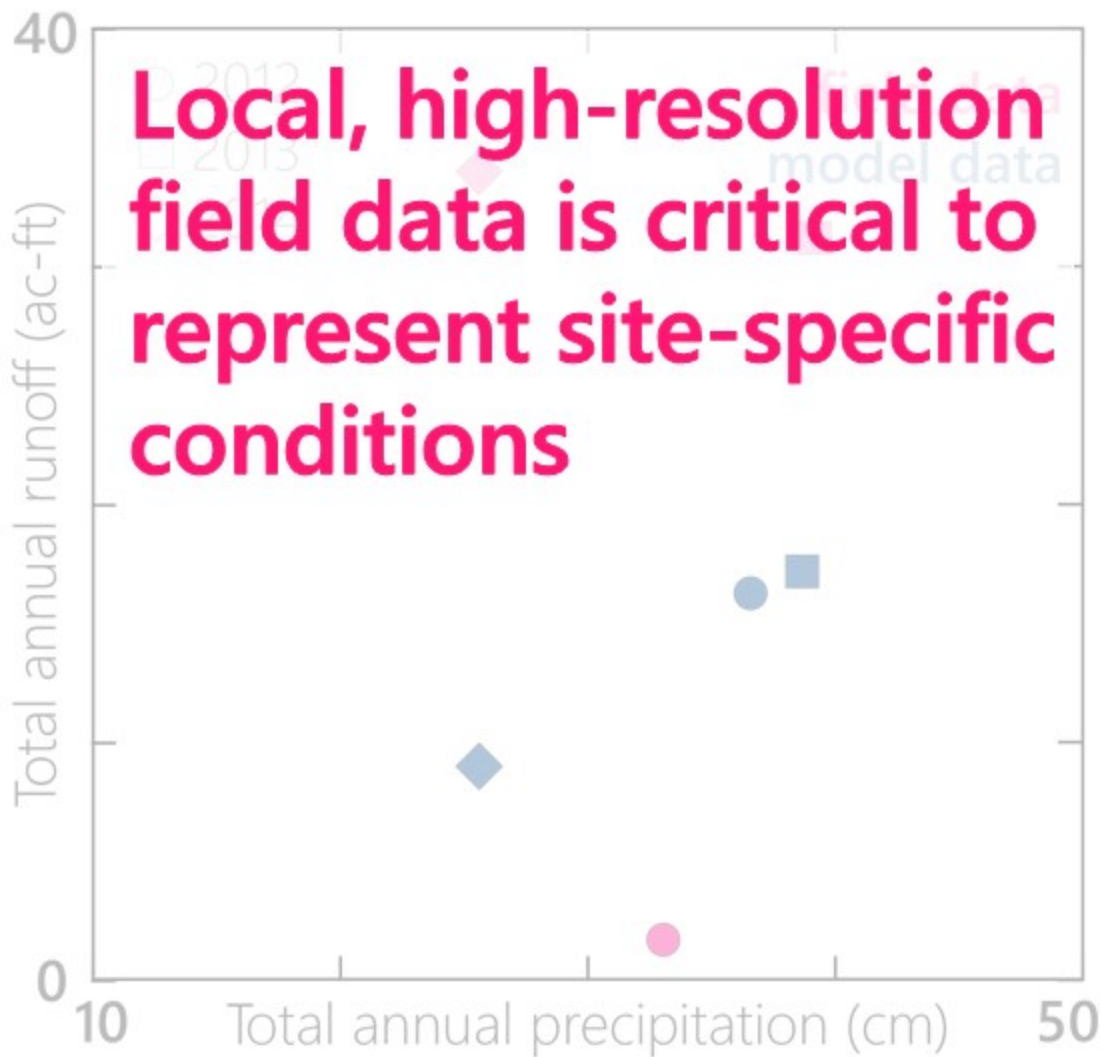


**field: sub-hourly scale processes dominate**

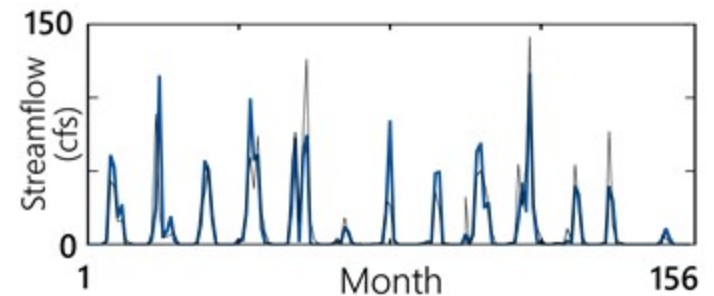


**model: daily time step, annual predictions**

There is limited data available to drive models with time steps  $< 1$  day



**field: sub-hourly scale processes dominate**



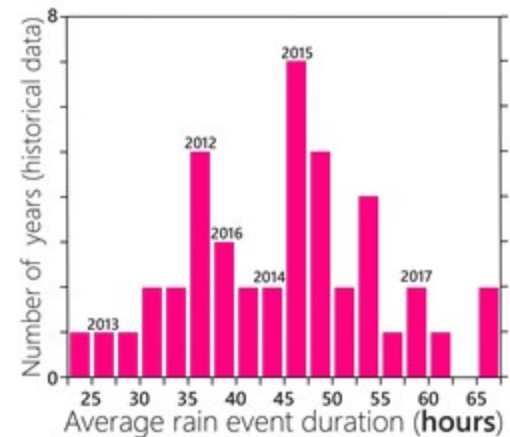
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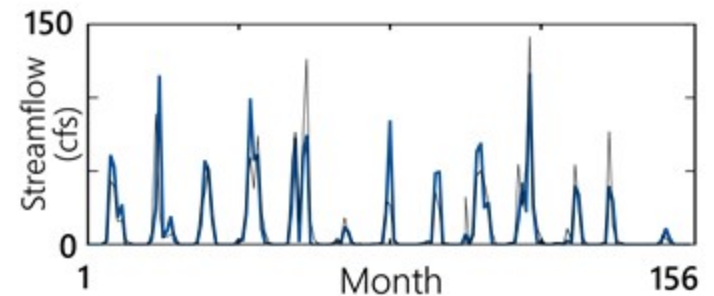


**Local, high-resolution  
field data is critical to  
represent site-specific  
conditions...**

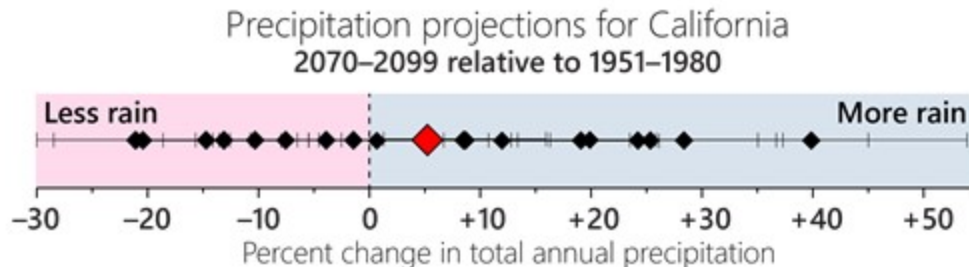
**because we may not  
be able to predict  
changes in rainfall  
distribution**



**field: sub-hourly scale  
processes dominate**



**model: daily time step,  
annual predictions**



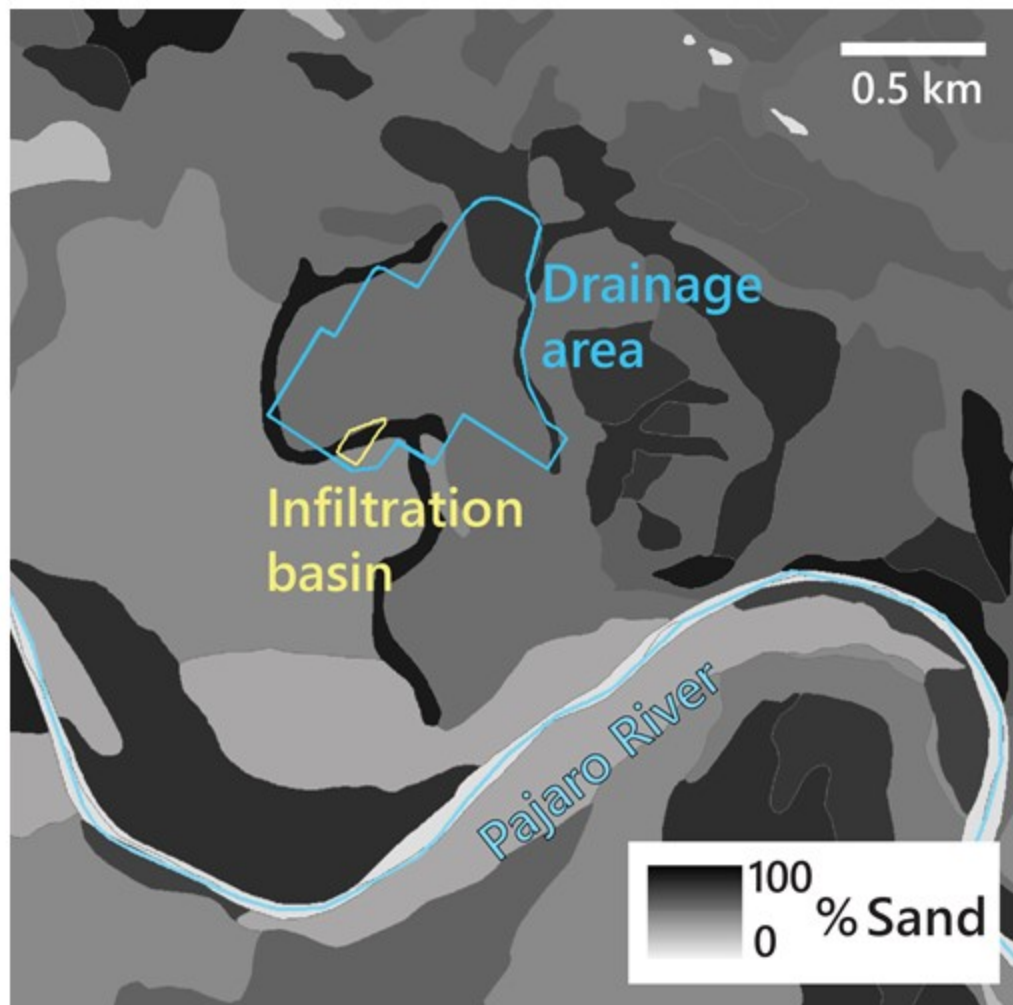


Field challenges:

Hillslope runoff  
transports and  
deposits  
fine-grained  
sediment

**>900 tons in 3 yr!**

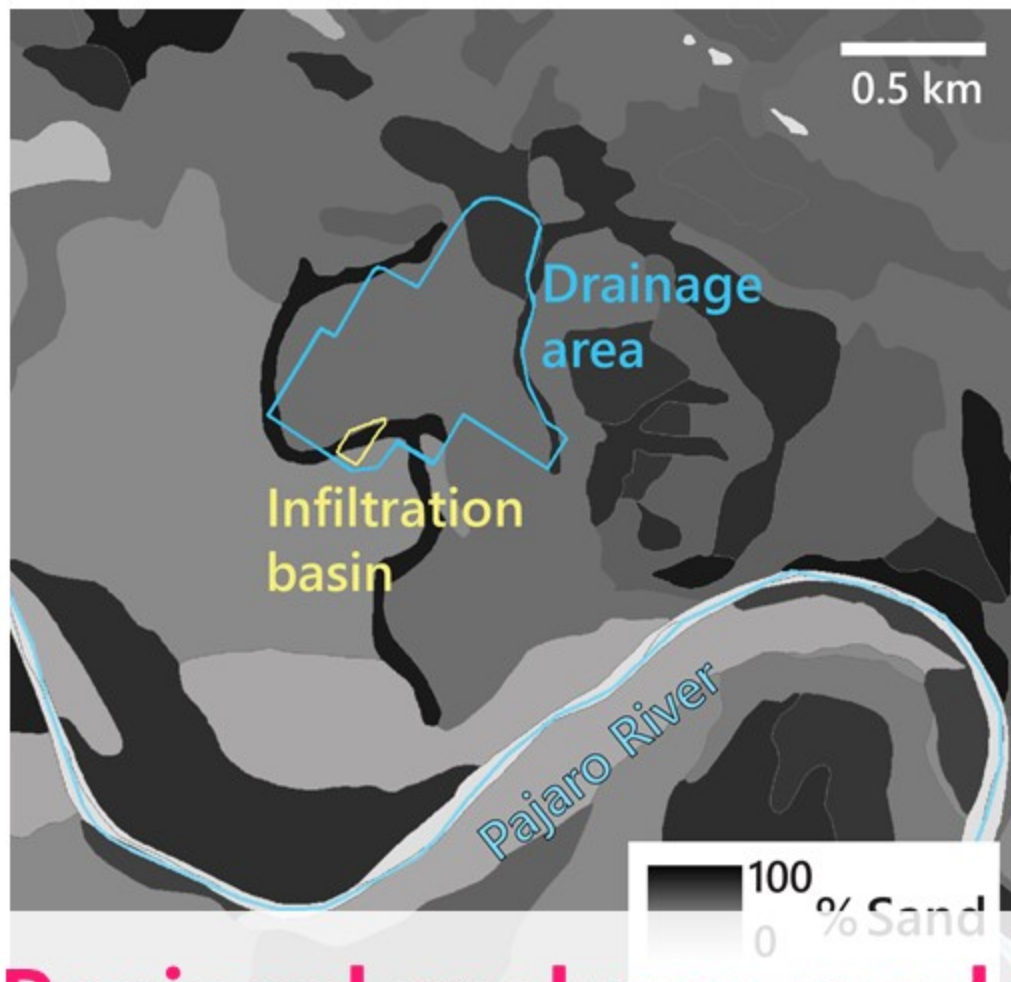




Insights from regional data:

- Infiltration basin especially coarse
- Drainage area comparatively finer-grained





Insights from regional data:

- Infiltration basin especially coarse
- Drainage area comparatively finer-grained

**Regional analyses, models, and field validation play a crucial role in field project development and maintenance**

**Modeling and field results demonstrate effectiveness of DSC-MAR**

Even during times of low total rainfall

**Great value in validating site design with field measurements and regional models**

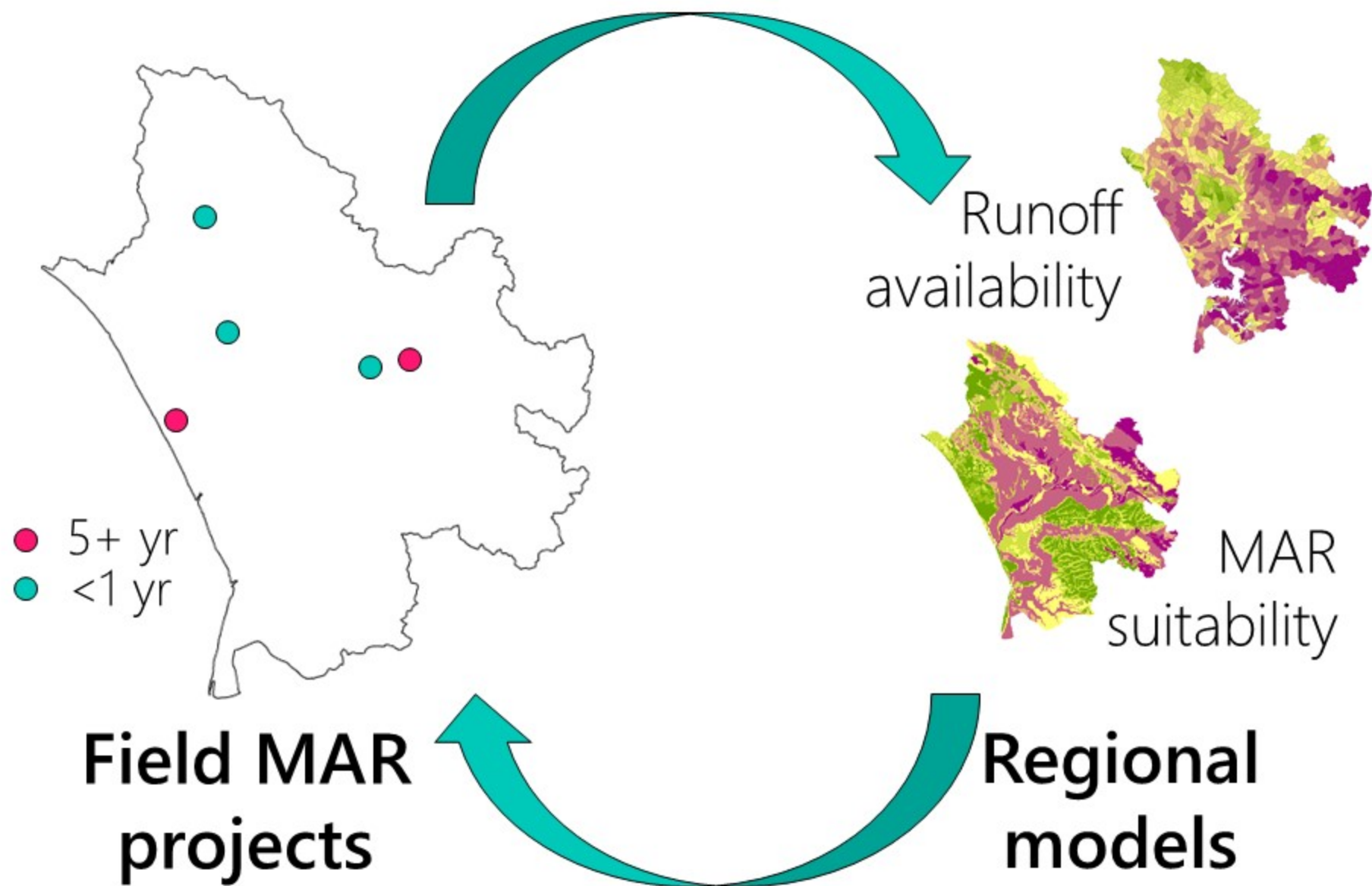
Not just what is working well, but why, and insights into future project design

**Field data and models each have limitations, using both can give a more complete picture**

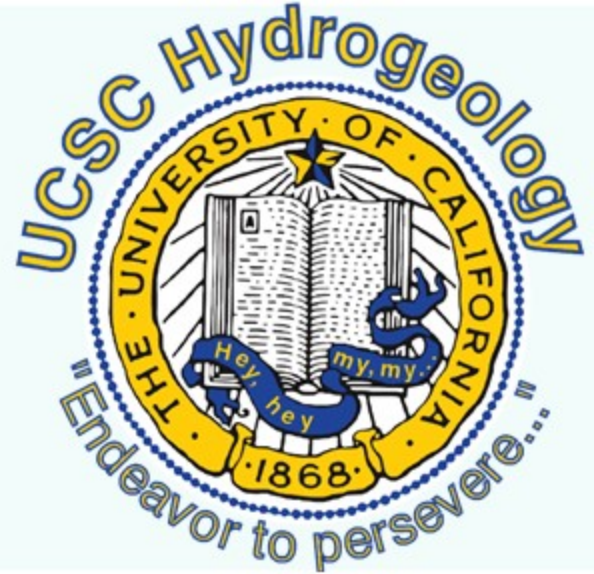
Field data: high resolution (space and time)

Regional models: put field results into context

# Ongoing work in the PVGB







**Thank you!**  
*[sbegansk@ucsc.edu](mailto:sbegansk@ucsc.edu)*



**RESOURCE**  
CONSERVATION DISTRICT  
OF SANTA CRUZ COUNTY



State of California  
**Coastal Conservancy**



**The Recharge Initiative**  
Replenish • Recover • Restore