Surface Water Management Benefits of Ground PV: *The PV-SMaRT Project*

Minnesota Habitat Friendly Solar Program
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PV-SMaRT
Project
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The Objective

Photovoltaic
Stormwater Management
Research and Testing

(PV-SMaRT)

- ✓ Reduce balance of system soft costs associated with stormwater infrastructure requirements
- ✓ Improve water quality outcomes
- ✓ Develop and disseminate:
    - Research-based, solar-specific resources for estimating stormwater runoff
    - Best practices for stormwater management and water quality at ground-mounted PV facilities.

Factors Considered

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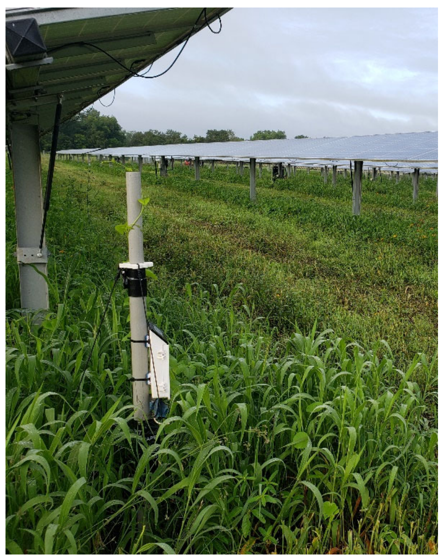
- A runoff calculator is being developed to overcome barriers to permitting stormwater runoff at ground solar photovoltaic (PV) sites by accounting for:
  - Solar panel design (fixed or tracking modules, ratio of impervious to pervious area)
  - Climatic factors (precipitation, wind speed, wind direction)
  - Soil and topographic characteristics (soil hydrology, slope)
  - Surface cover (turf, pollinator habitat, etc)

Study Sites in PV-SMaRT Project

Minnesota

Oregon

New York



Georgia

New York: 18 MW fixed, 2-in-portrait PV array, 108 acres. Silty clay loam soil (D soil) with tall grass and clover mix, ungrazed or grazed by sheep with 49” annual rainfall.

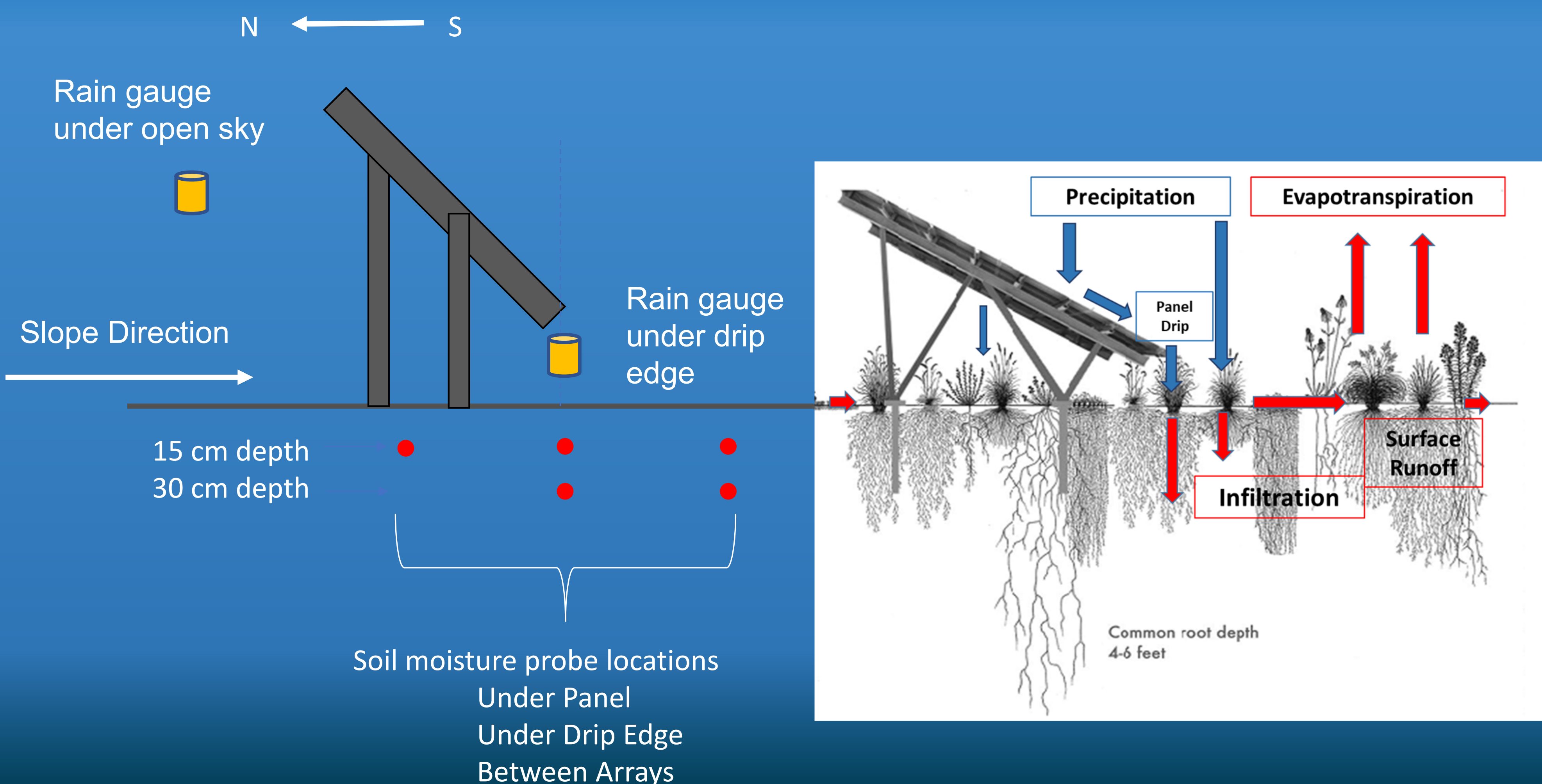
Georgia: 1.3 MW tracking 1-in-portrait PV array, 8 acres. Flat site with sandy clay soil (B soil), mowed cover crops, high diversity pollinator mix, and 49” annual rainfall.

Minnesota: 3.4 MW fixed, 2-in-portrait PV array, 29 acres. Sandy loam soil (A soil) with 5% slope, pollinator mix with black eye Susan daisies, and 37” annual rainfall.

Oregon: 9.9 MW tracking 2-in-portrait PV array, 45.8 acres. Flat site with clay soil (D soil), diverse pollinator seed mix and 16” annual rainfall.

Colorado: 1 MW tracking 1-in-portrait PV array, 6 acres. Clay soil (C soil) with pollinator vegetation, grazed by goats, with 16” annual rainfall.

Sensor Monitoring at E-W Oriented Fixed Angle Solar Arrays (MN)

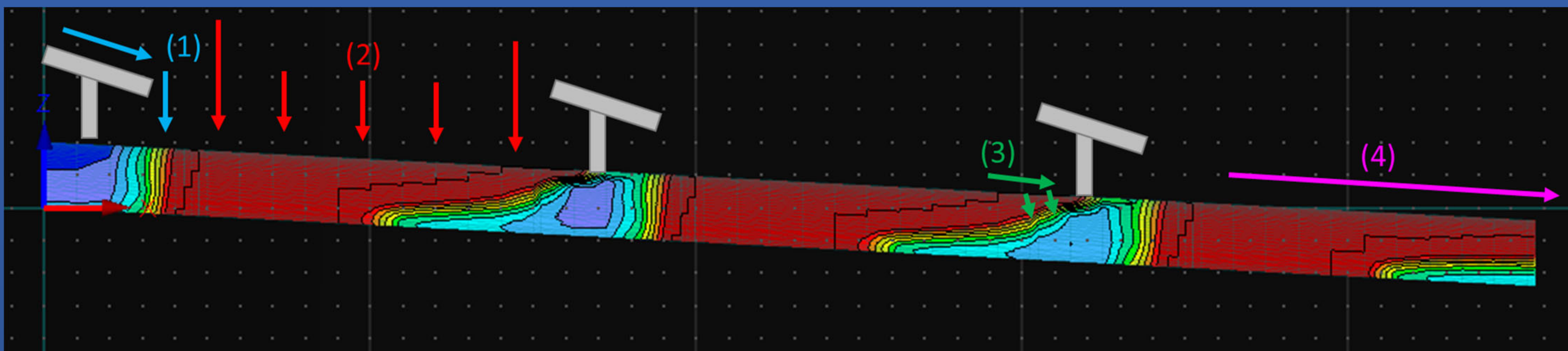


Site characterization

- Digital Elevation Model (DEM) analysis for elevation and slope
- Soil series mapping
- Soil texture and bulk density
- Soil moisture measurements
- Soil infiltration and runoff measurements
- Site vegetation density, speciation and rooting depth measurements
- Precipitation, wind speed and direction measurements

Hydrus-3D Runoff Modeling

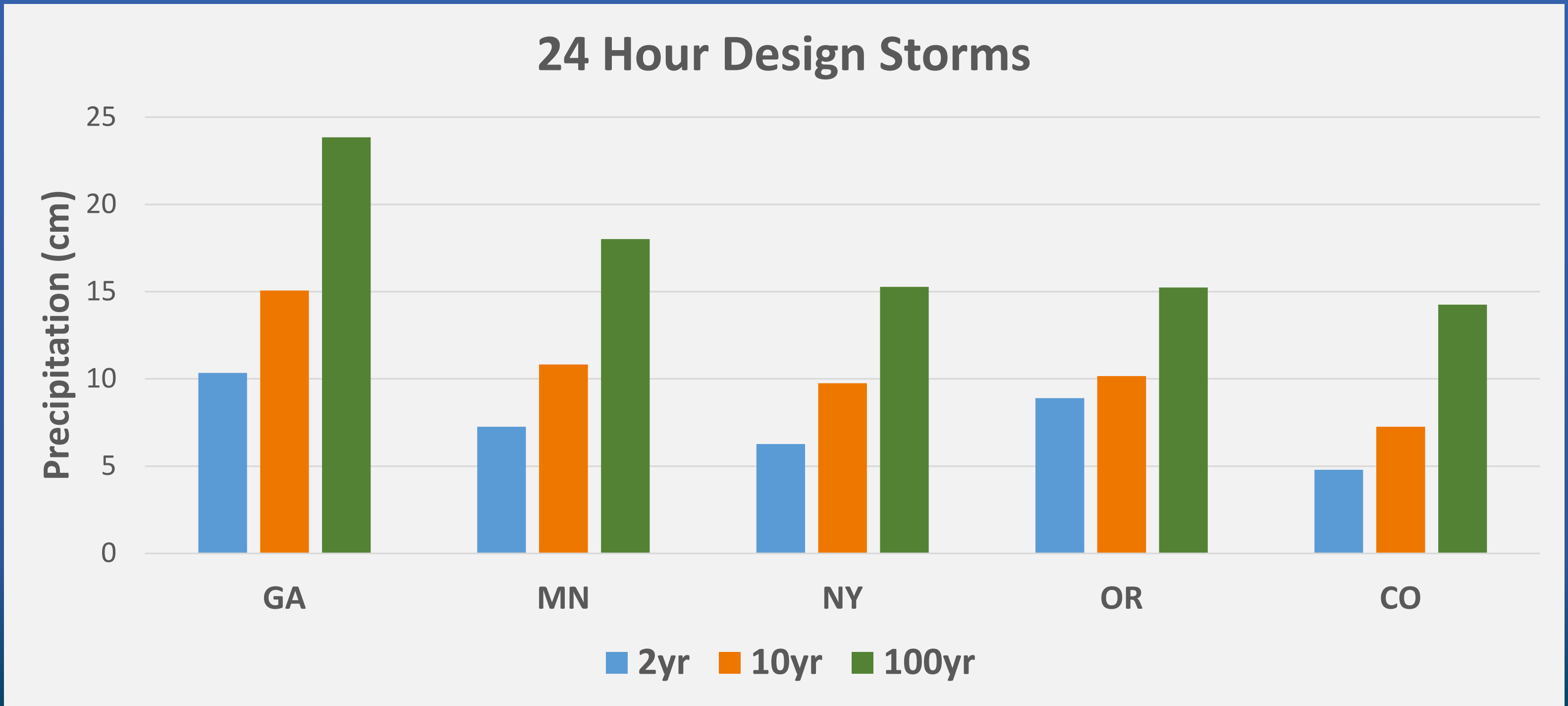
- Model accommodates:
  1) concentrated panel runoff
  2) incident precipitation
  3) routing of surface runoff and infiltration under next panel
  4) total accumulated surface runoff of the system



- Model has been successfully calibrated using measured soil moisture data

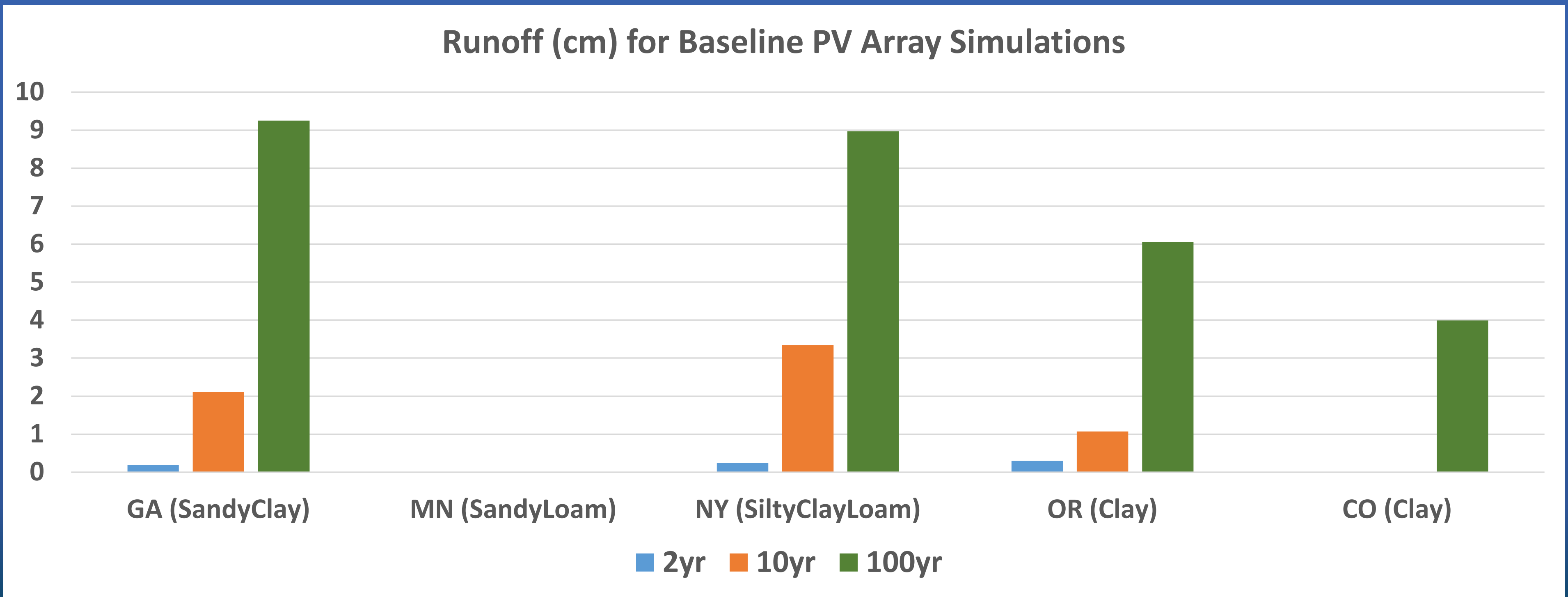
Design Storms for Hydrus Modeling

- Three 24-hour baseline design storm events (cm of rain) were based on NOAA Atlas 14 precipitation frequency estimates
- Note that design storm depths differ considerably across sites and return frequencies, with GA having the largest and CO the smallest storm depths



Baseline Runoff Modeling Arrays with Pollinators

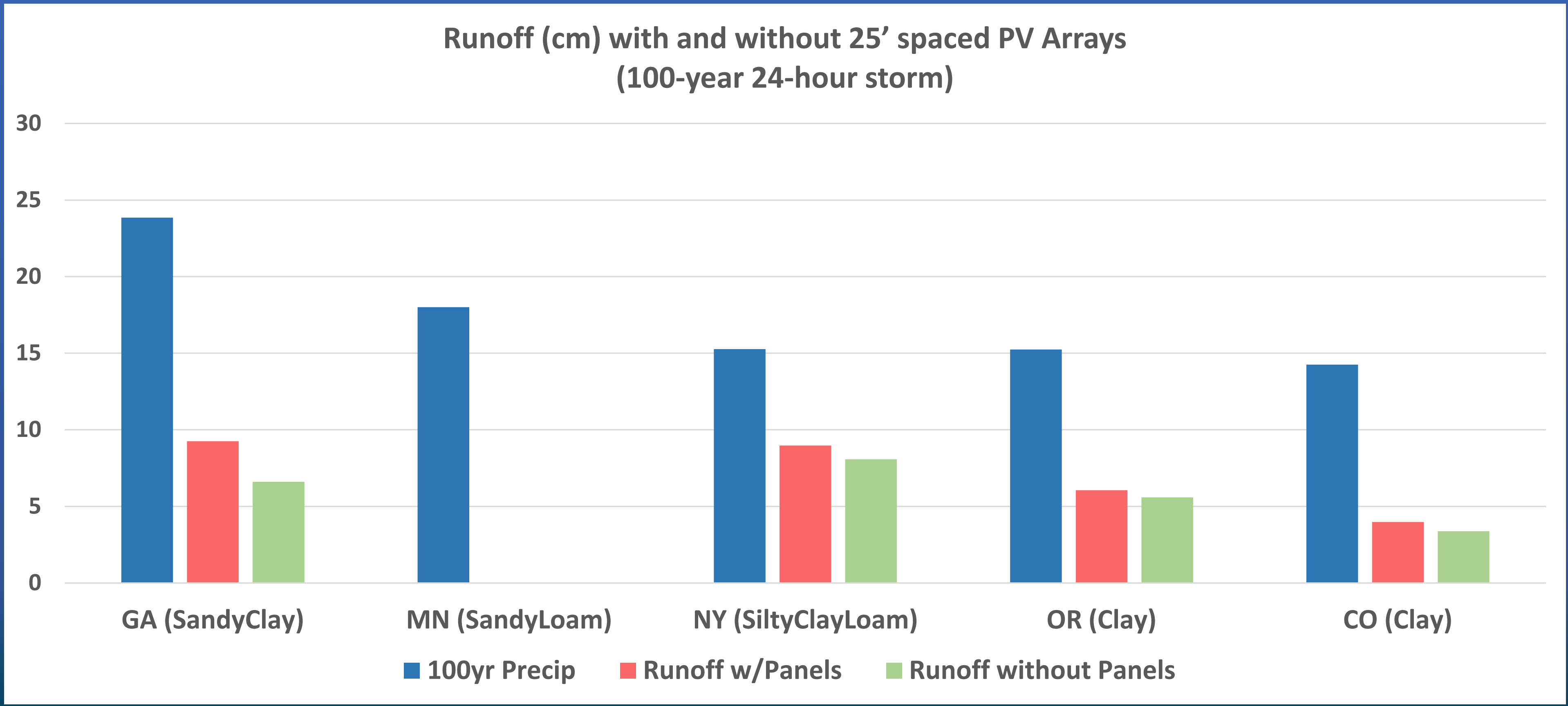
- Runoff depends on design storm depth, soil type, saturated and field capacity water contents and calibrated soil hydraulic properties
- No runoff was generated from the sandy loam at the MN site



Note: All soils were assumed to be 1m deep for these simulations

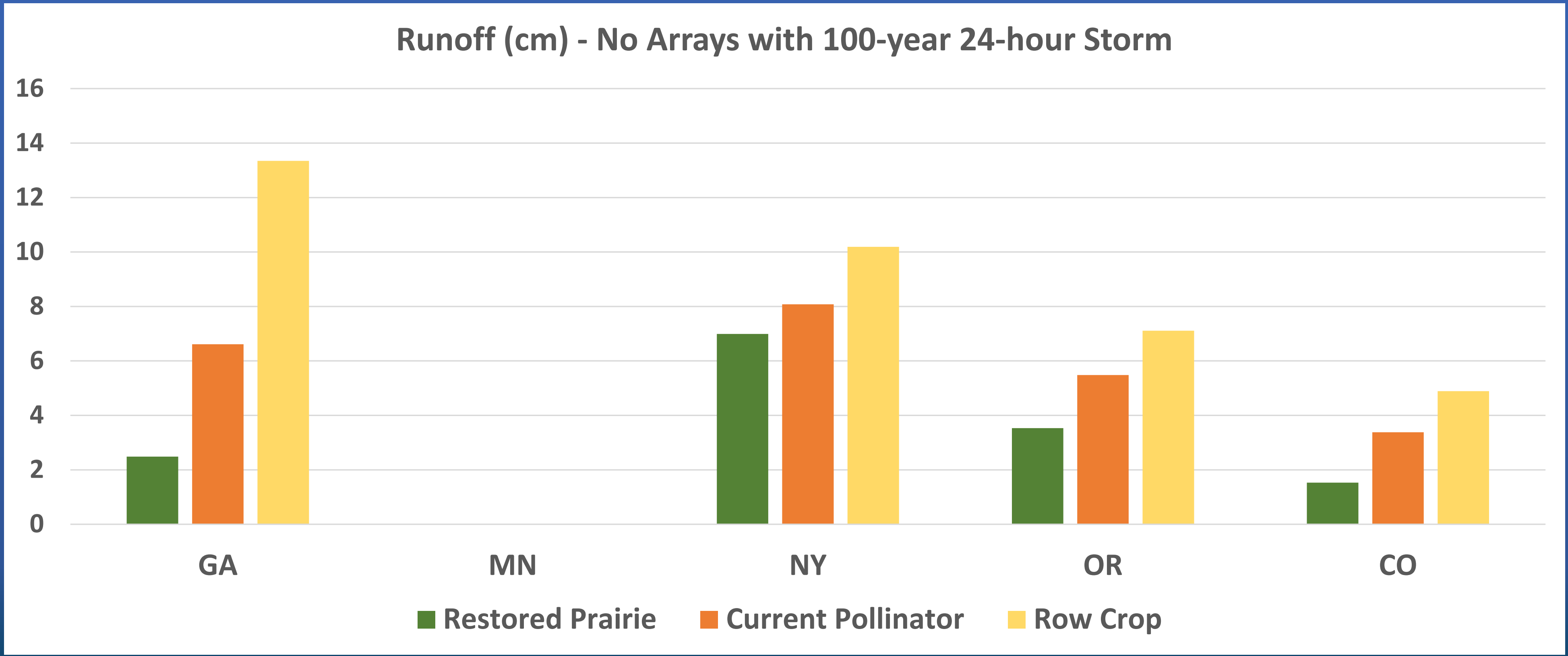
Hydrus Runoff: Pollinator Vegetation with and w/o Arrays

- Pollinator vegetation simulated in both scenarios
- Runoff increases on average by 15% with arrays relative to without arrays



Hydrus Runoff: Effect of Vegetation w/o Arrays

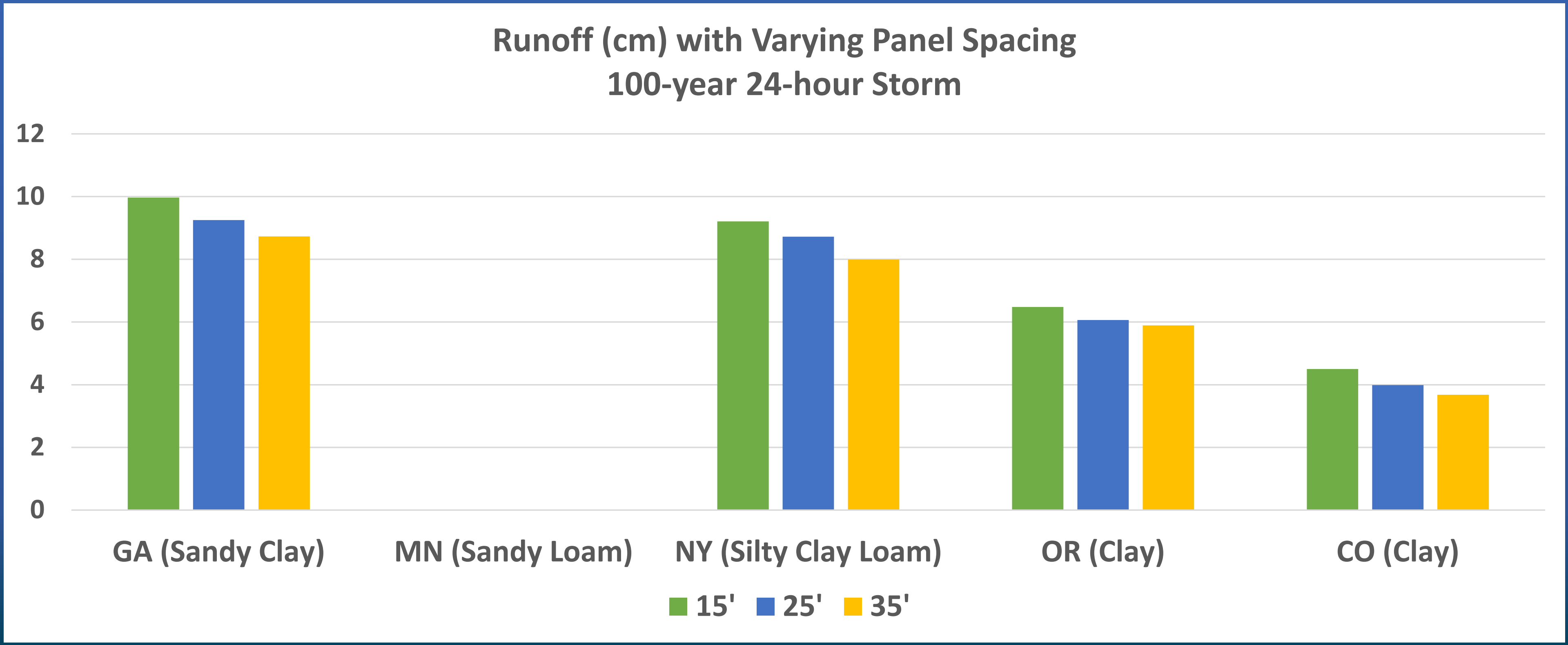
- Soil parameters altered based on Chandrasoma et al., 2016
- Row crop has higher runoff than mature prairie or pollinator habitat



Chandrasoma, J.M.; R.P. Udawatta; S.H. Anderson; A.L. Thompson; M.A. Abney. Soil hydraulic properties as influenced by prairie restoration. Geoderma, 283 (2016), pp. 48-56

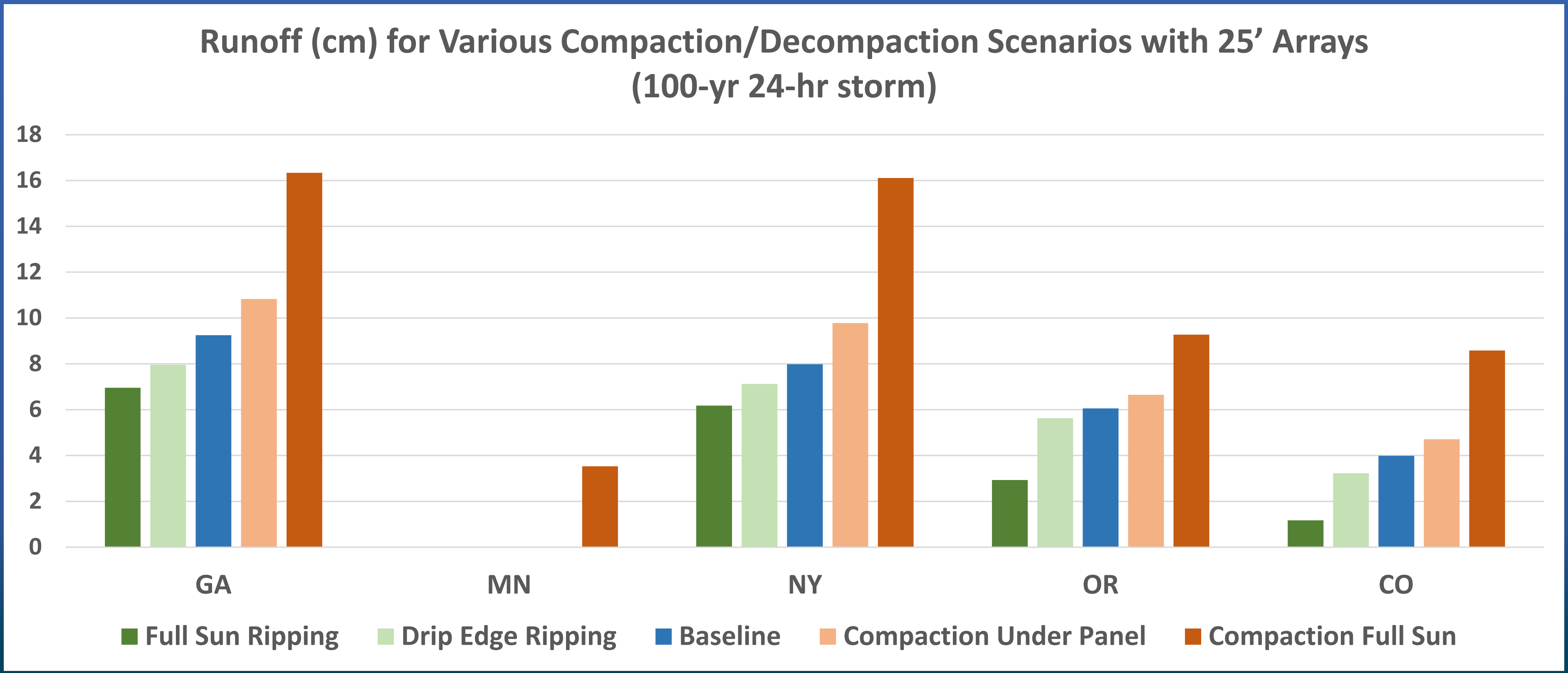
Hydrus Runoff: Effect of Array Spacing with Pollinators

- All PV-SMaRT sites have a baseline 25’ panel spacing (on-center)
- Runoff decreases as panel spacing increases



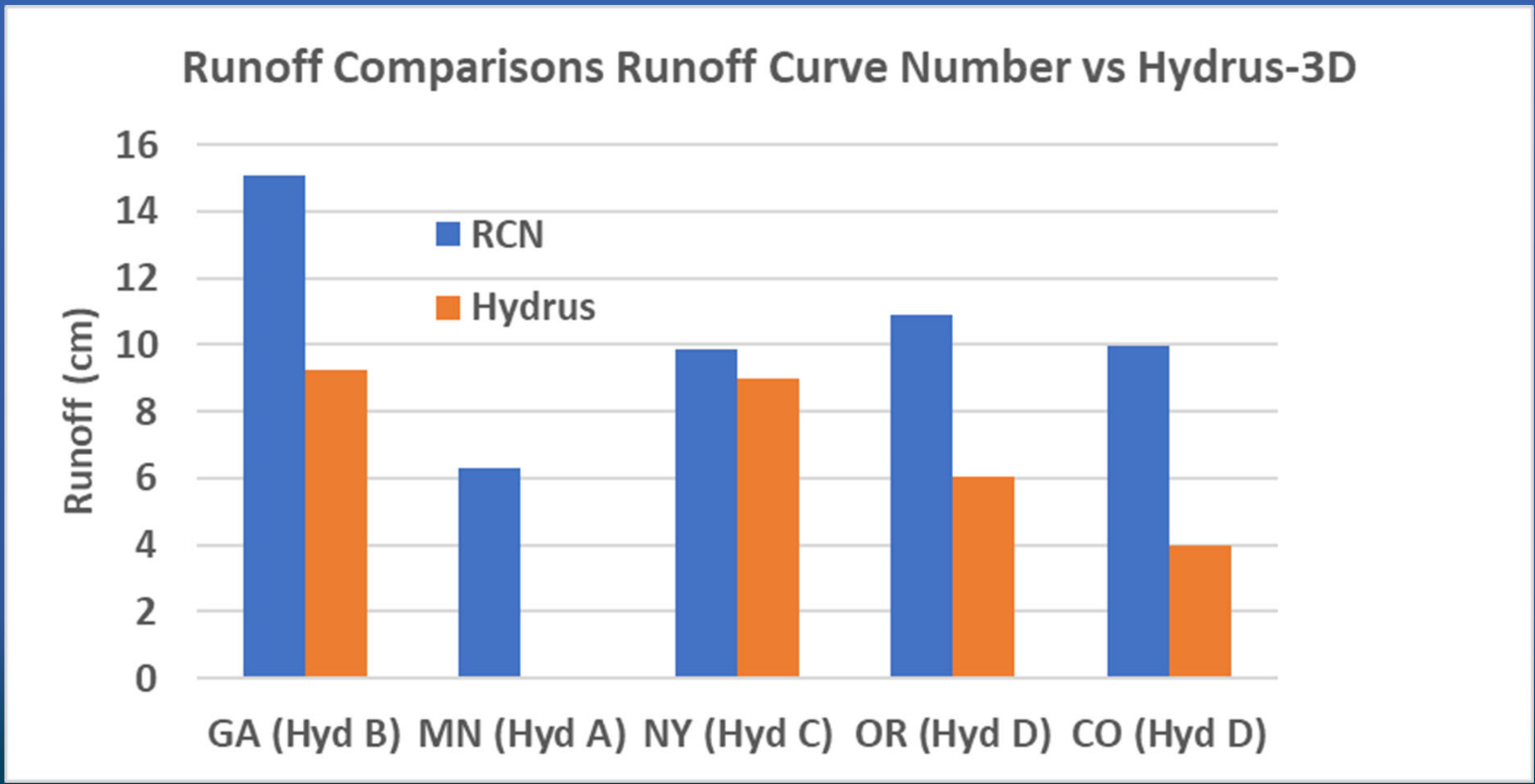
Hydrus Runoff: Effect of Bulk Density

- Bulk density change of +/- 30% simulates compaction/decompaction
- Runoff increases with bulk density (soil compaction)
- Low bulk density trench under drip edge has relatively little effect on runoff



Effect of Runoff Model

- Runoff curve number for legumes/meadow in good condition (without PV arrays) vs Hydrus (with PV arrays)
- Runoff decreases on average by 50% with Hydrus relative to NRCS RCN method



Conclusions

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- Hydrus model is able to accurately estimate runoff across a range of ground PV sites with perennial vegetation
- Row crop has higher runoff than mature prairie or pollinator habitat
- Runoff increases on average by 15% with arrays relative to without arrays
- Runoff decreases as panel spacing increases
- Runoff increases with bulk density (soil compaction)
- Runoff decreases on average by 50% with Hydrus relative to NRCS Runoff Curve Number (RCN) method

Thank You

https://www.nrel.gov/solar/pv-smart.html

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