Land Use & Environmental Analysis for Busbar Mapping

- Presenters: CEC Land Use Planning Unit
- Date: November 12, 2025

Agenda

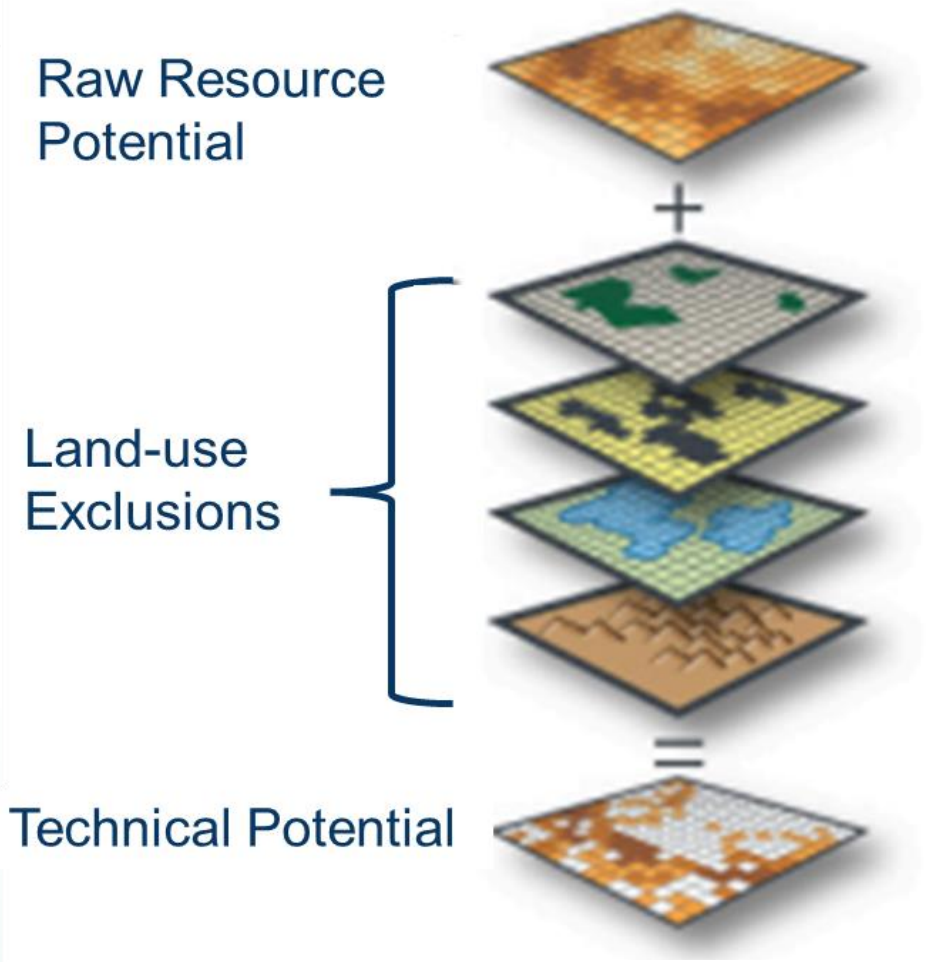
1) **Overview:** Land use and environmental analysis methods for busbar mapping
    a) Purpose
    b) Description of methods
    c) Example

2) **Results for this cycle (26-27 TPP) and comparison with last cycle (25-26 TPP)**
    a) Recent Updates (data and methods)
    b) Solar
    c) Wind
    d) Geothermal
    e) Pumped Storage Hydroelectric (PSH)

Land Use & Environmental Analysis Methods Overview

Purpose of Land Use and Environmental Analysis

- Understand environmental, biological and land use conditions around substations
- Land use and environmental analysis comprises Criteria 3 and 4 of the seven criteria* used to determine "criteria alignment" for mapping capacity to substations
  - Criteria 3: Land-use implications and feasibility factors
  - Criteria 4: Environmental (conservation and biological) impact factors
- Landscape-level analysis that is not meant to be site-specific



Modified from Maclaurin et al. 2019*

*Maclaurin, Galen, Nick Grue, Anthony Lopez, Donna Heimiller, Michael Rossol, Grant Buster, and Travis Williams. 2019. The Renewable Energy Potential (reV) Model: A Geospatial Platform for Technical Potential and Supply Curve Modeling. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-73067. https://www.nrel.gov/docs/fy19osti/73067.pdf.

* For more detailed information on these criteria, see slide 18 of *Proposed Updates to the Busbar Mapping Methodology (August 2025).*

Land Use & Environmental Factors Analyzed

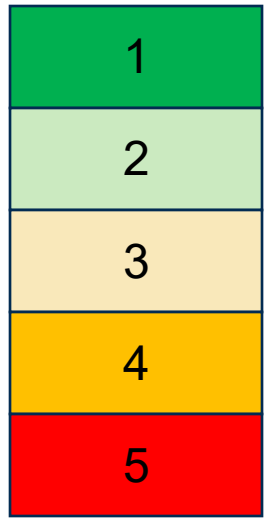
- When allocating MW to substations, the land use and environmental factors listed below are analyzed.
- Calculated as the percentage of the total resource potential that contains a given environmental factor
- Lower percentages are relatively more favorable and result in lower criteria scores – higher percentages result in higher scores (less favorable).

Land Use and Environmental Factors

Criteria 3
- Lower-implication land (as determined by Core screen)
- High Fire Threat Areas
- High Parcelization Areas (solar only)
- Critically Overdrafted Groundwater Basins
- High and Low Value Cropland Areas

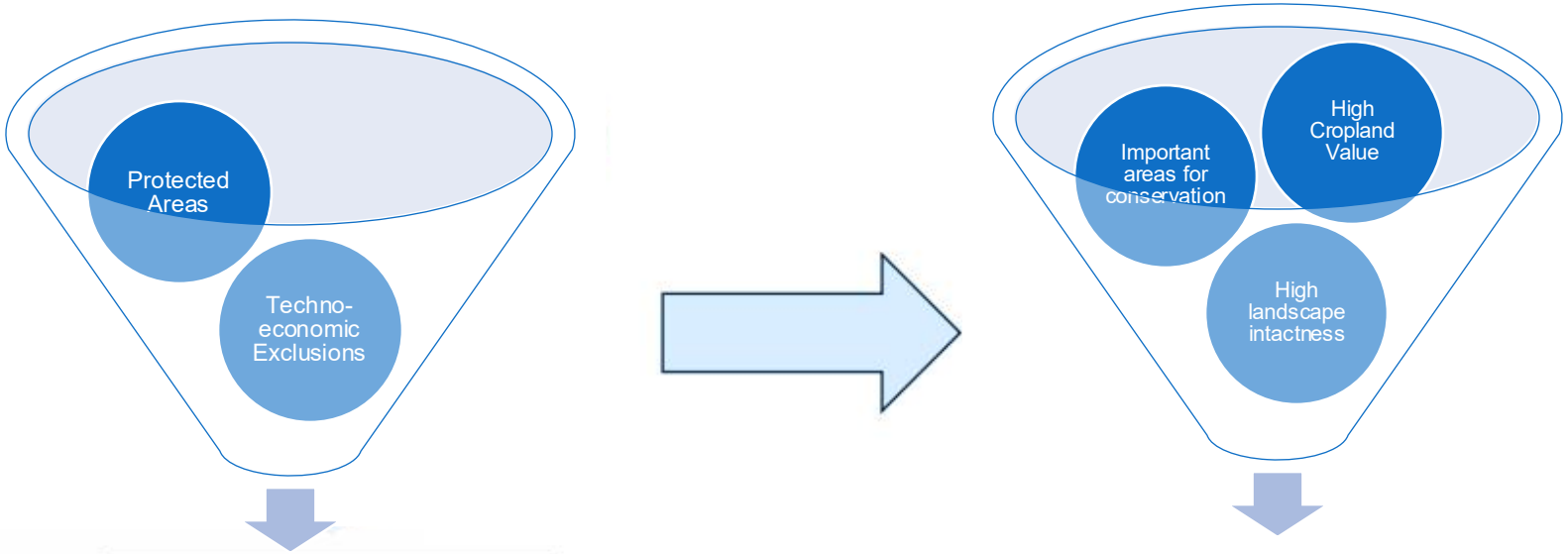
Criteria 4
- High Terrestrial Connectivity
- High Terrestrial Biodiversity Areas
- High Terrestrial Irreplaceability
- Terrestrial Landscape Intactness
- Combined Areas of Conservation Emphasis (ACE) layers (High Terrestrial Connectivity, Biodiversity and Irreplaceability)
- Wetlands

Strong compliance with criteria, alignment with criteria's prioritized or favorable conditions



Significant non-compliance with criteria, no alignment with stated criteria, fully meets conditions criteria seek to limit or avoid

Identifying Total Resource Potential and Lower-Implication Land (Solar Example)

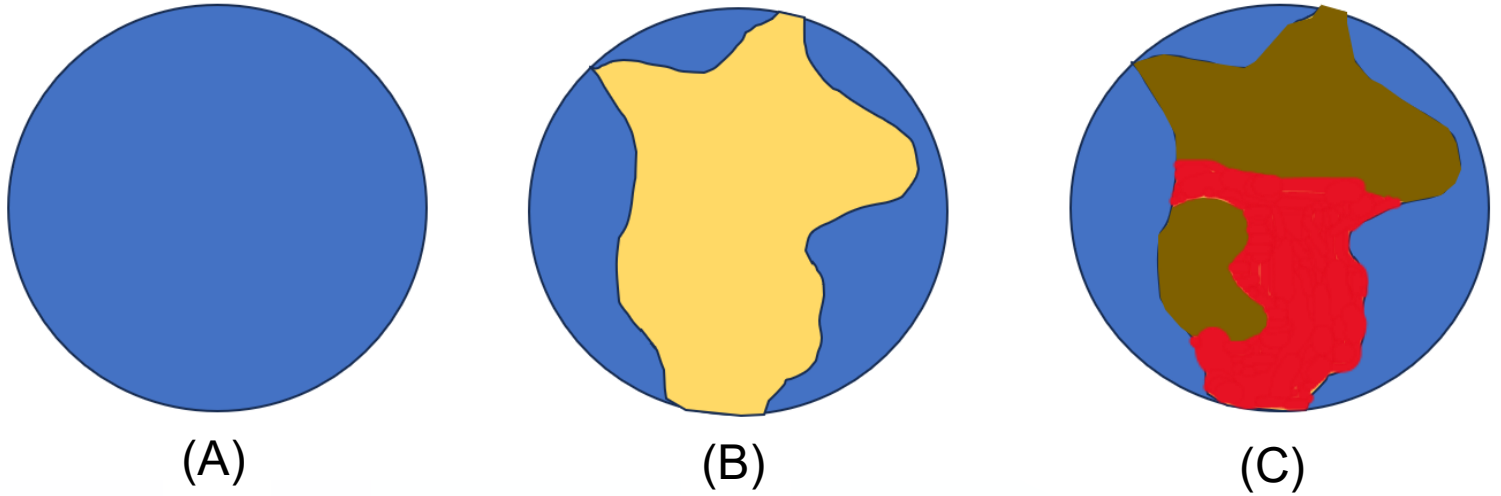


Solar "total resource potential" after applying base exclusions

Solar "lower-implication land" after applying environmental constraints

This serves as a starting point for the substation analysis.

Method for Land Use And Environmental Analysis for Substations (Solar/Wind)



Buffer Area Around Substation

Total Resource Potential

Higher-Implication Area

Lower-Implication Area

A) Create a circular buffer (radii between 5 and 30 miles) around each substation

B) Bring in environmental factor datasets; limit all to total resource potential area (areas outside of the protected area layer and the techno-economic exclusion area)

C) Using these datasets, calculate acreage and percent of total resource potential for:

1. Higher and lower implication acreages, defined by Core Land Use Screen
2. Intersection of high environmental, biological, cropland, fire threat and parcelization factors
3. Lower (and higher) implication area utilization by MW mapped to substations

Example Land Use and Environmental Analysis for a Substation

	Solar (10-mile radius around substation)	Wind (20-mile radius around substation)
Example capacity (MW) allocation	**300**	**300**
Acres of Lower-Implication land	3,500	10,000
Acres of Higher-Implication land	4,000	5,000
Solar Capacity Density (Acres /MW)	10	
Wind Capacity Density (Acres /MW)	40	
Lower-Implication MW - based on capacity density	350	250
Higher-Implication MW - based on capacity density	400	125
Percent of Lower-Implication area used for MW allocation	86%	100%
Percent of Higher-Implication area used for MW allocation	0%	40%

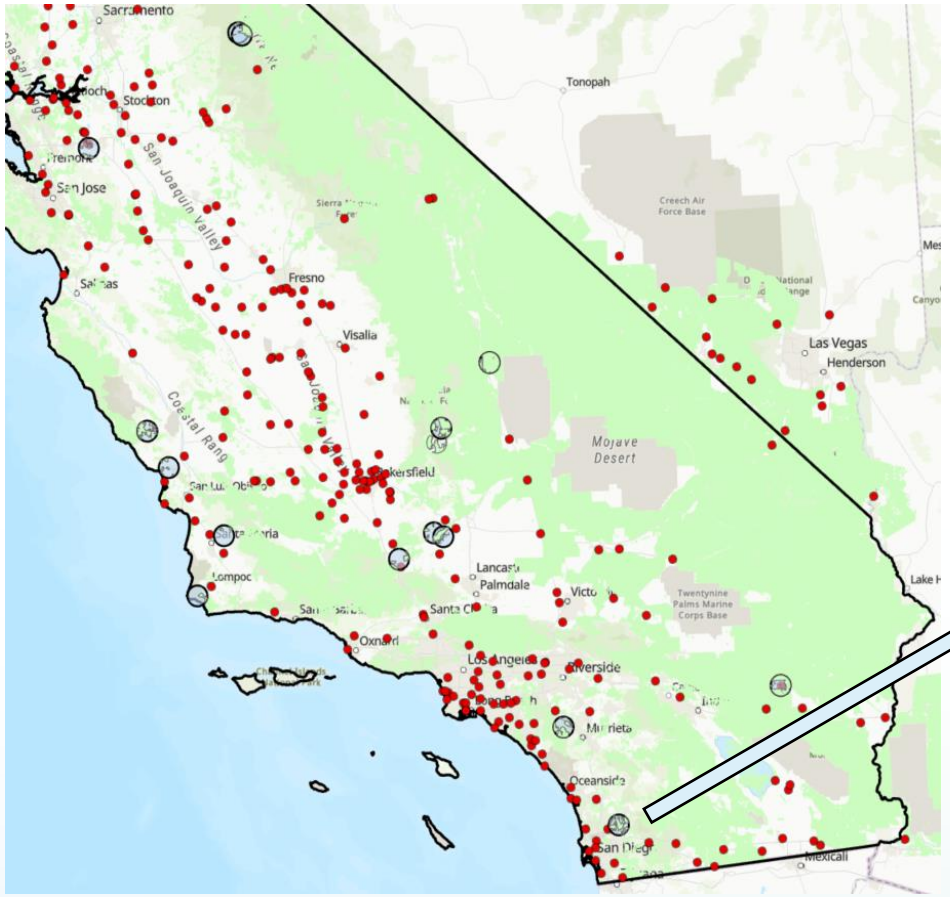
- Hypothetical example: 300 MW of solar and 300 MW of wind are allocated to a substation
  - Solar uses 300 MW of 350 MW (or 86%) of lower-implication MW (and no higher-implication MW)
  - Wind uses all lower-implication MW (250 MW of 250 MW) plus 40% of higher implication MW (50 MW of the 125 MW)
- **Wind would receive a higher (less favorable) score than solar.**

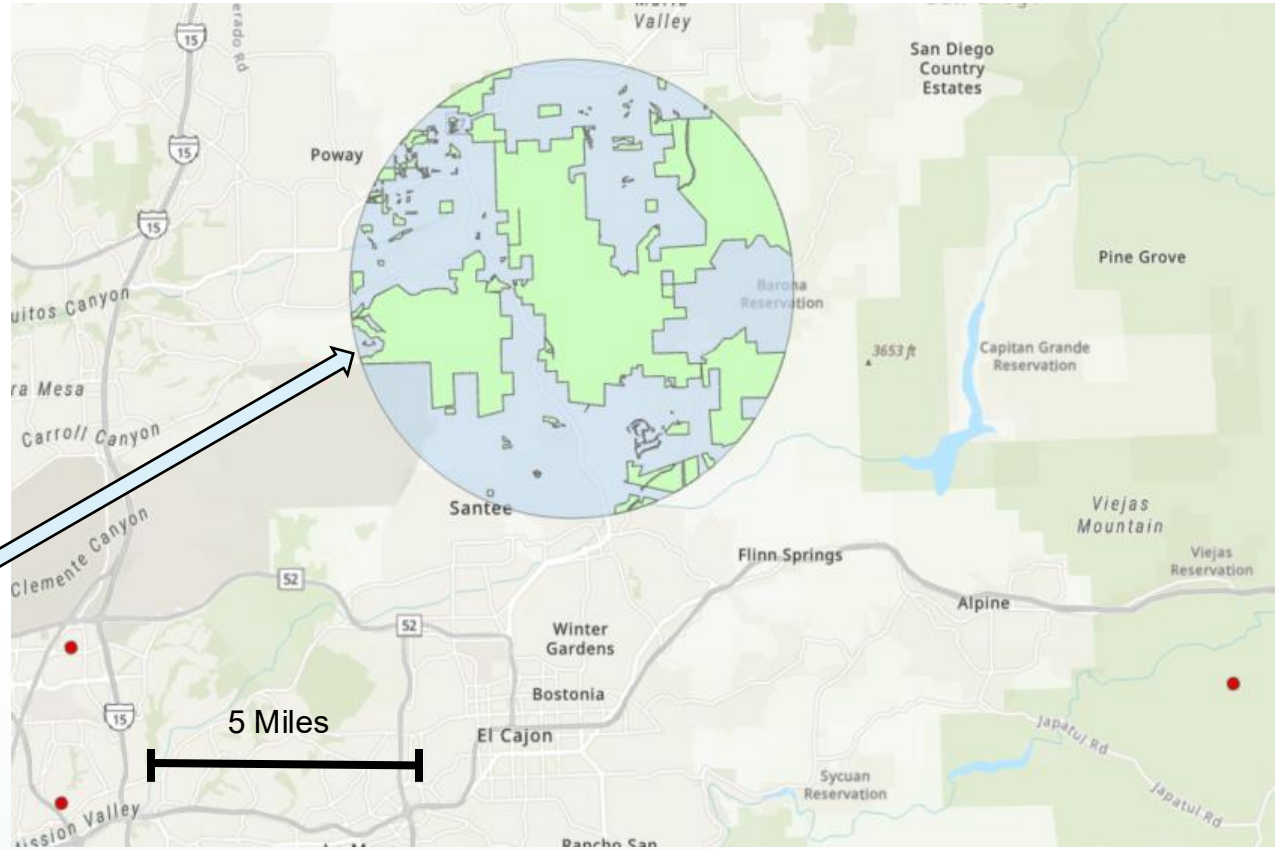
Pumped Storage Hydroelectric (PSH) Method Overview

Landscape-level metrics	Site-specific metrics
ACE Aquatic Irreplaceaility	Probable lower reservoir (new, existing, off-stream, on-stream)
ACE Aquatic Rare Species Richness	Probable upper reservoir (new, existing, off-stream, on-stream)
Protected Area Layer	License status (Active, preliminary permits, pending preliminary permits)
High Terrestrial Biodiversity	Probable water source
High Terrestrial Connectivity	Interconnection nearby substation
High Terrestrial Irreplaceability	
High Terrestrial Intactness	

- PSH environmental criteria alignment levels reflect landscape level and site-specific metrics
- Today's presentation focuses on landscape-level GIS metrics

PSH Method, Continued





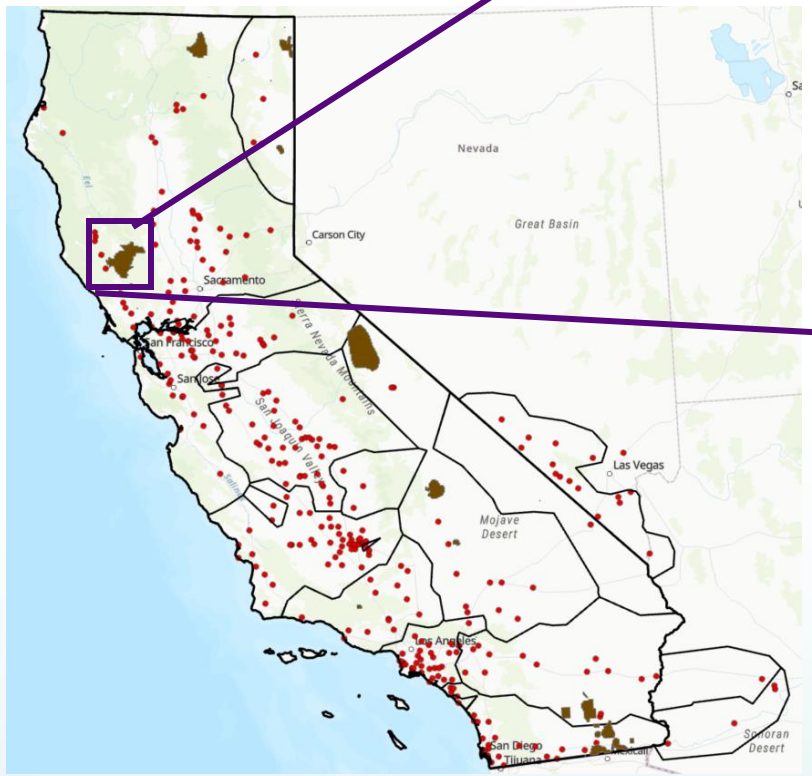
	5-mile radius around PSH site
	Substations
	Protected Area Layer

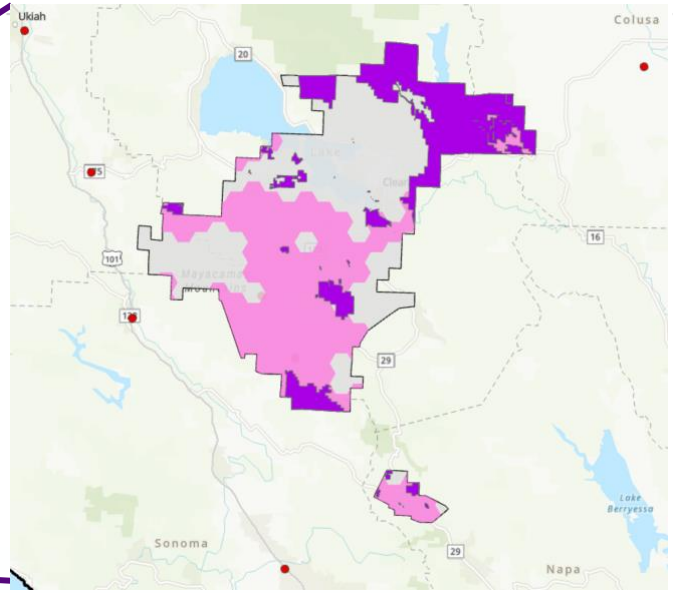
- Analysis examines area with resource potential in 5-mile radius around PSH site

Geothermal Method Overview

- Consider environmental metrics in areas within geothermal fields that are not excluded by the Protected Area Layer (PAL)
  - For these areas, calculate environmental metrics to determine criteria alignment
- Geothermal capacity is then allocated to nearby substations

Geothermal Example





Geothermal Field Within Protected Area Layer

Geothermal Field Remaining

High Biodiversity within non-Protected Area of Geoethermal Field

Substations

Geothermal Field

- The “high biodiversity” acreage not excluded by the Protected Area Layer is divided by the total area with resource potential
  - Pink / (gray + pink): this percentage is used to determine criteria alignment

Results Overview

Refresher – Data Updates Driving New Results

- Protected Area Layer (PAL): Using updated components of the Protected Area Layer. PAL also now includes out-of-state (OOS) areas
- New wind resource data (now using Global Wind Atlas Data instead of NREL capacity factor data)
- Terrestrial Intactness Layer: 2025 Conservation Biology Institute (CBI) version (previously 2018)
- Critical Habitat: Now using 2025 version from US Fish and Wildlife Service (previously used 2022)
- Fire threat maps: Now using U.S. Forest Service data (previously used CPUC Fire Threat Maps)
- Parcelization Data: Now using 2023 or later publicly available county data (previously: proprietary data from Lightbox)
- 2024 BLM PEIS (aka Western Solar Plan for solar)
    - Opened additional acreage in Southern Nevada and Western Arizona for potential solar capacity

For more detail and background information, see the presentations from the August 19 MAG, and the Nov 5, 2024 busbar workshop

Refresher – Methods Updates Driving New Results

- Geothermal: Land use analysis on area outside of the protected area (previously, used entire geothermal field)
- Pumped Storage Hydro: Presented a regional approach in August MAG, but reverting to 25/26 TPP method based on stakeholder input

For more detail and background information, see the presentations from the August 19 MAG, and the Nov 5, 2024 busbar workshop

Data also posted on CEC GIS portal: https://caenergy.maps.arcgis.com/home/item.html?id=22315eedfe394ca0931c703426c225ec

Solar Results

Solar: Lower-Implication land by RESOLVE Zone (All Substations Within CA)

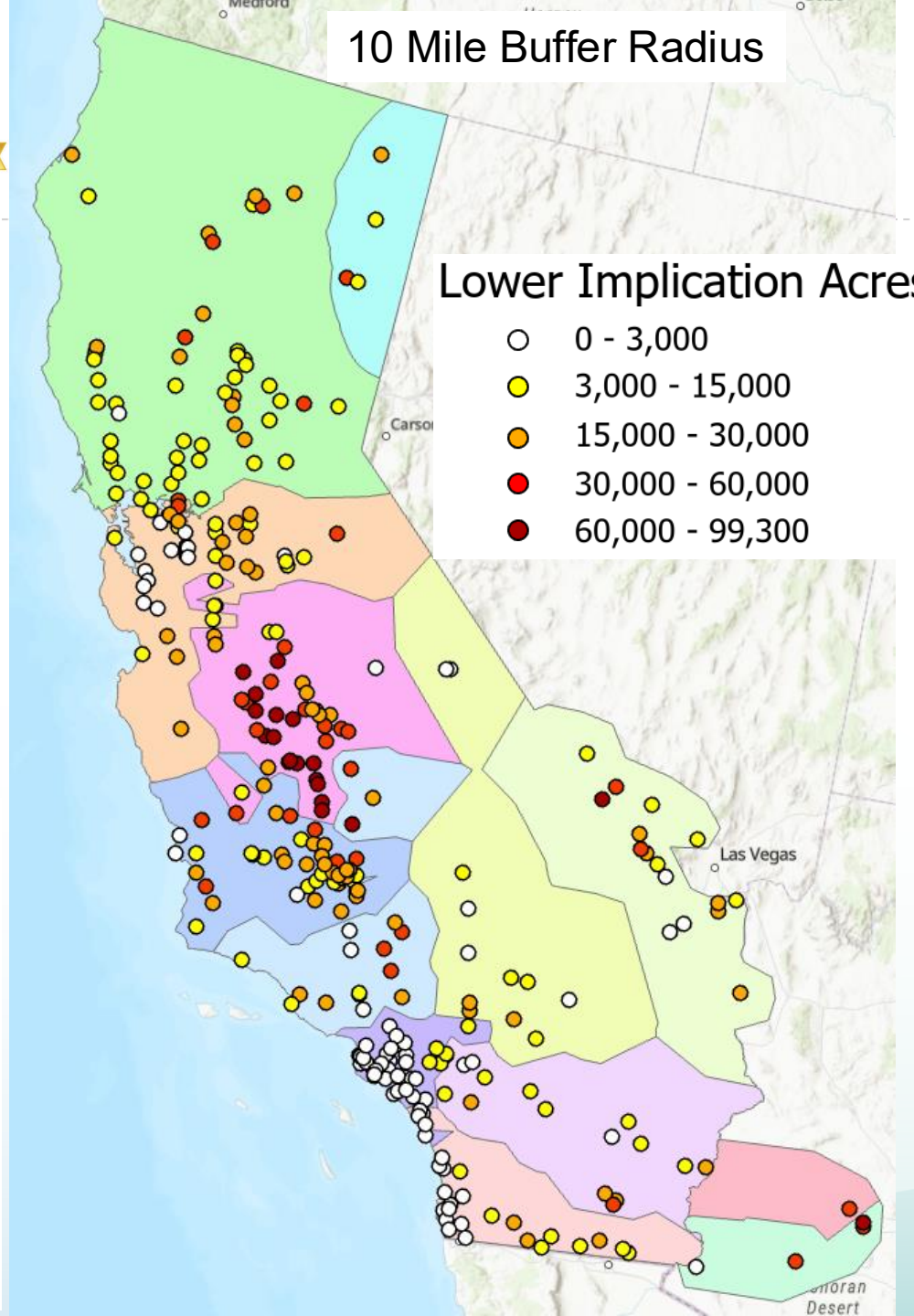
RESOLVE Region	Number of Substations in Region	Lower-Implication Acres (26-27 TPP)*	Lower-Implication Acres (25-26 TPP)*	Percent Change
Northeast CA	4	66,377	60,859	9%
PGE Fresno	43	841,133	832,534	1%
PGE GBA	43	267,303	256,356	4%
PGE Kern	46	395,084	404,647	-2%
PGE NGBA	50	461,725	413,517	12%
SCE Eastern	16	106,115	137,762	-23%
SCE Metro	36	10,714	11,629	-8%
SCE NOL	12	88,391	86,736	2%
SCE Northern	18	376,419	381,371	-1%
SDGE Imperial	26	117,091	103,146	14%
Total	**294**	**2,730,352**	**2,688,558**	**2%**

Within a 10-mile buffer around substations:

- Overall, about 2% more lower-implication land in this TPP cycle compared to last

*Within a 10-mile buffer around substations only, NOT all acres in the region.
Note: In-state results only shown here. Out-of-state results not shown in this comparison because CEC did not calculate out-of-state results last cycle.

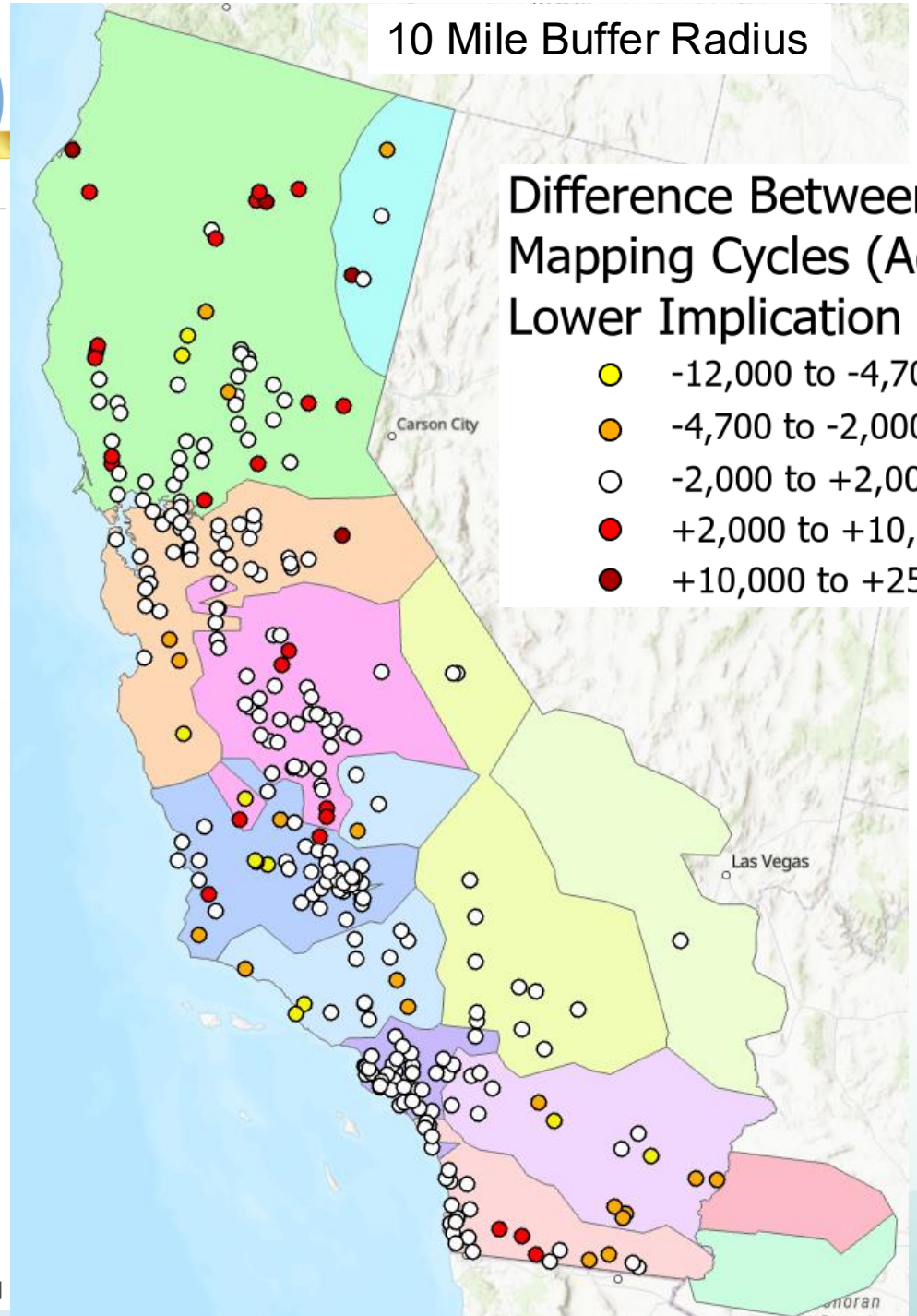
Lower Implication Land Acres (Solar)



- Substations with the most lower implication acres located in PG&E Fresno, PG&E Kern, and PG&E GBA
- Relatively fewer acres of lower-implication land near substations in southern coast of California and Bay Area

►Lower-implication acres within 10-mile radius of substations available for mapping solar resources

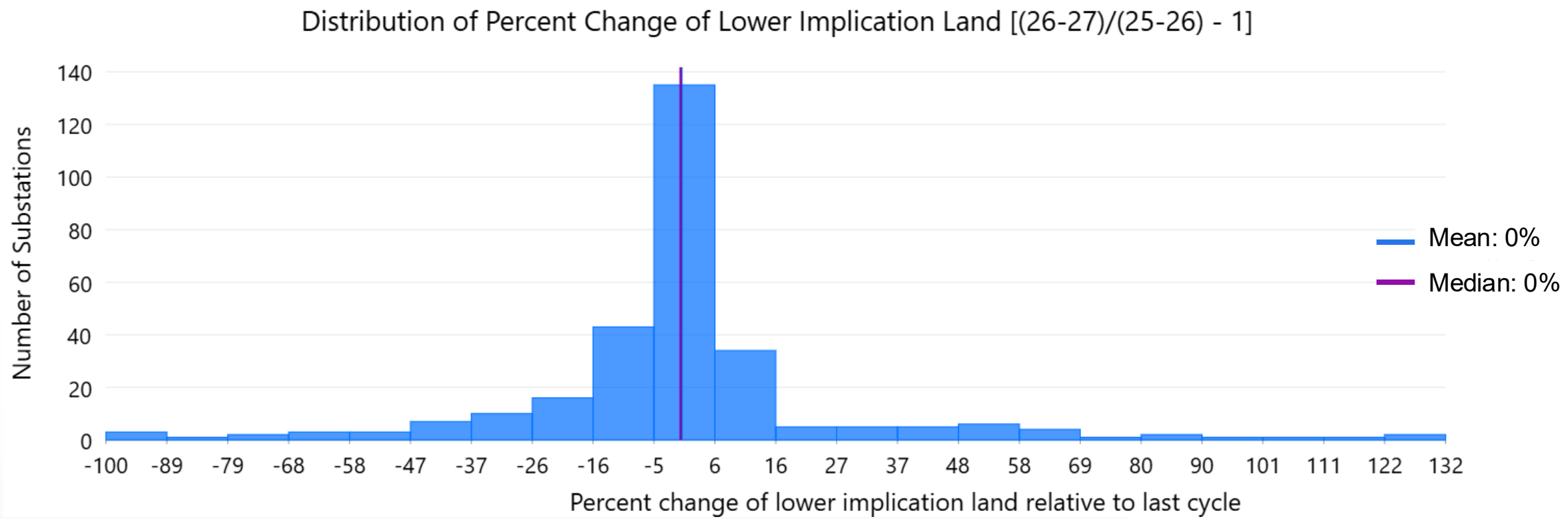
Solar Comparison



- For most substations, the amount of lower implication acres has not changed significantly from 25-26 to 26-27 busbar cycles due to land use data updates

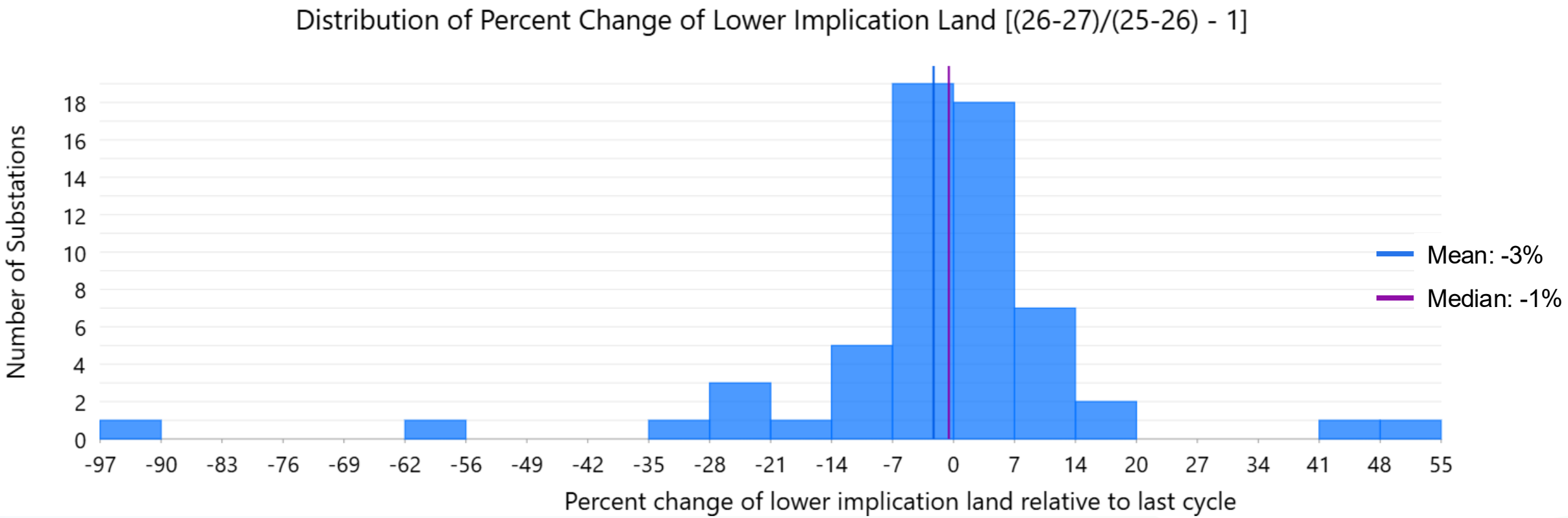
Negative values represent a decrease in lower-implication acres from the 25-26 busbar cycle, less available in 26-27 Busbar Cycle.
Positive values represent an increase in lower-implication acres from the 25-26 busbar cycle, more available in 26-27 Busbar Cycle.

Distribution of Lower-Implication Land Percent Change (Solar - All Substations Statewide)



- Overall, average percent change is close to zero
- Most substations' changes are within ±6%

Distribution of Percent Change (Only Substations Allocated MW for Solar in 25-26 TPP)



- Overall, average percent change is close to zero (-3% on average)
- Most substations' changes are within ±7%

Wind Results

Results: Wind by RESOLVE Zone (All Substations within CA)

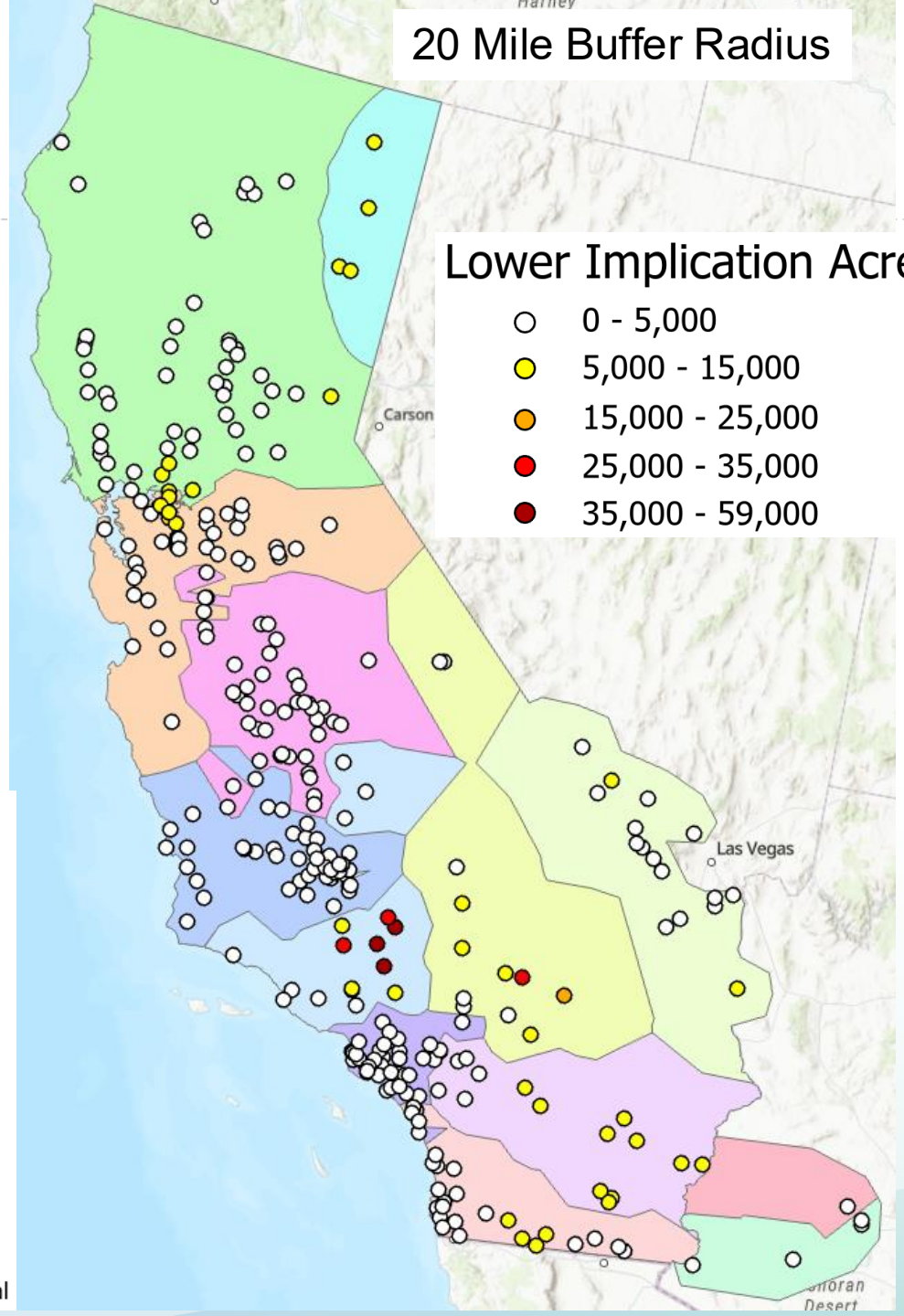
RESOLVE Region	Number of Substations in Region	Lower-Implication Acres (26-27 TPP)*	Lower-Implication Acres (25-26 TPP)*	Percent Change
Northeast CA	4	33,103	83,017	-60%
PGE Fresno	43	186	935,579	-100%
PGE GBA	43	8,033	227,702	-96%
PGE Kern	46	4,036	79,190	-95%
PGE NGBA	50	29,848	726,280	-96%
SCE Eastern	16	51,604	117,617	-56%
SCE Metro	36	808	3,666	-78%
SCE NOL	12	49,409	161,463	-69%
SCE Northern	18	72,810	133,909	-46%
SDGE Imperial	26	15,958	210,994	-92%
Total	**294**	**265,795**	**2,679,417**	**-90%**

Within a 20-mile buffer around substations:

- About 90% less lower-implication land in this TPP cycle compared to last.

*Within a 20-mile buffer around substations only, NOT all acres in the region.
Note: In-state results only shown here. Out-of-state results not shown in this comparison because CEC did not calculate out-of-state results last cycle.

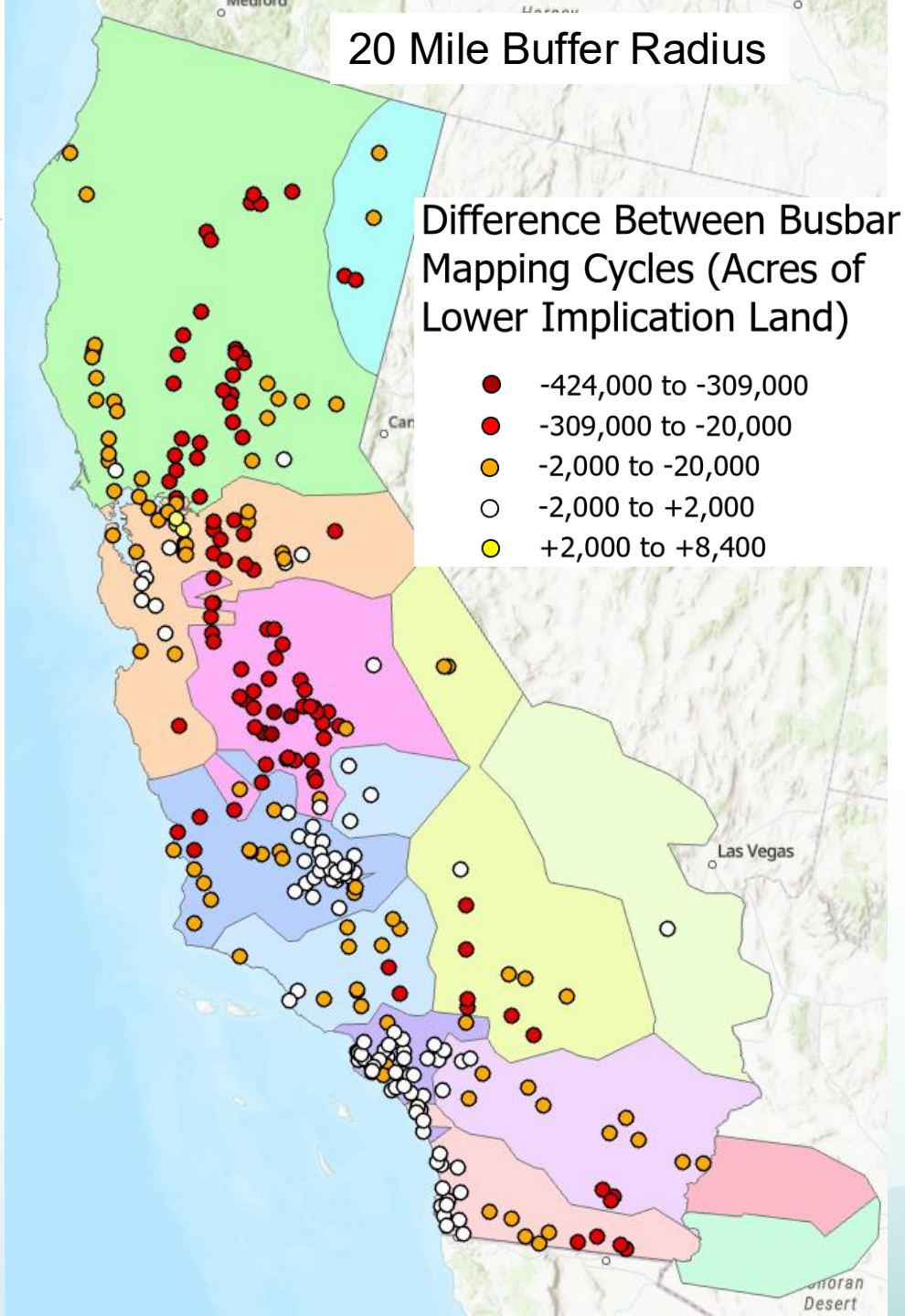
Lower Implication Land Acres (Wind)



- Most substations have < 5,000 acres of lower implication land
  - Limited high wind resource potential areas
- SCE Metro, PG&E NGBA, and Northeast CA have the greatest wind resource potential
- SCE Eastern and Northeast have moderate wind resource potential
  - Due to BLM resource management plans

►*Lower-implication acres within 20-mile radius of substations available for mapping wind resources*

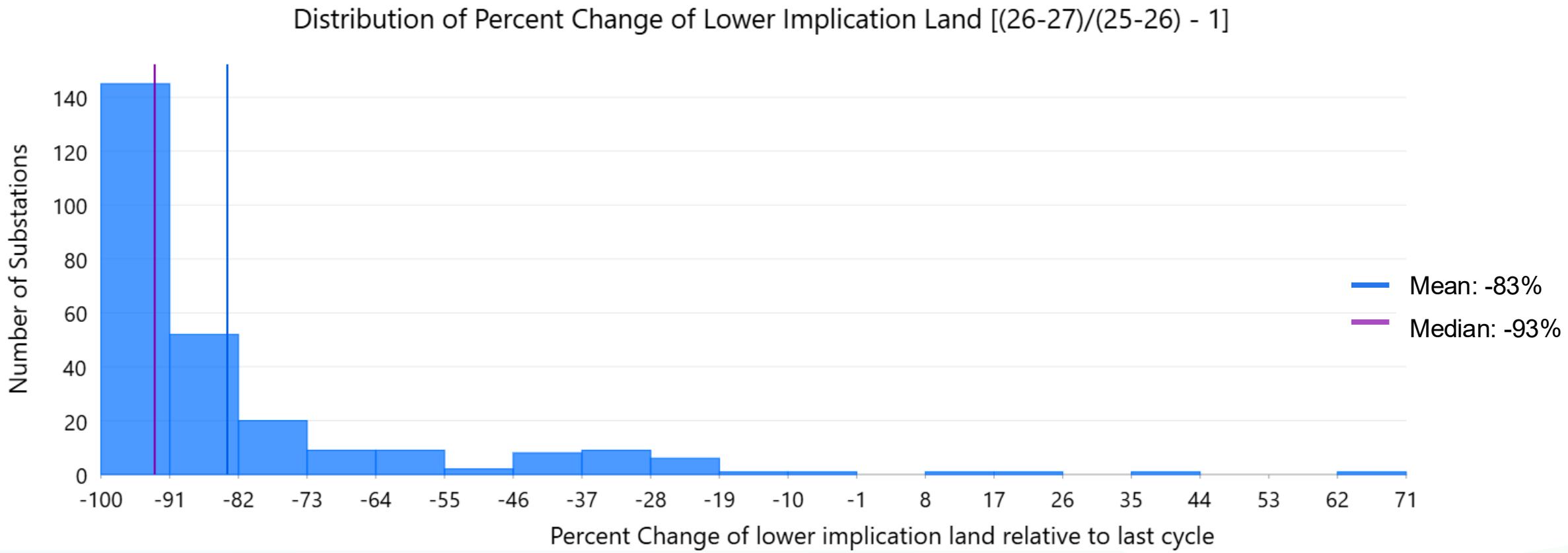
Wind Comparison



- Overall, lower-implication land decreases relative to last TPP cycle due to GWA data
- PGE Greater Bay Area and SCE Northern show substations with large growth in lower implication land
- Capacity density used to determine MW allocations could vary per substation.
  - Staff is exploring varying capacity densities to capture turbine optimization in complex environments from Lopez et al. 2023

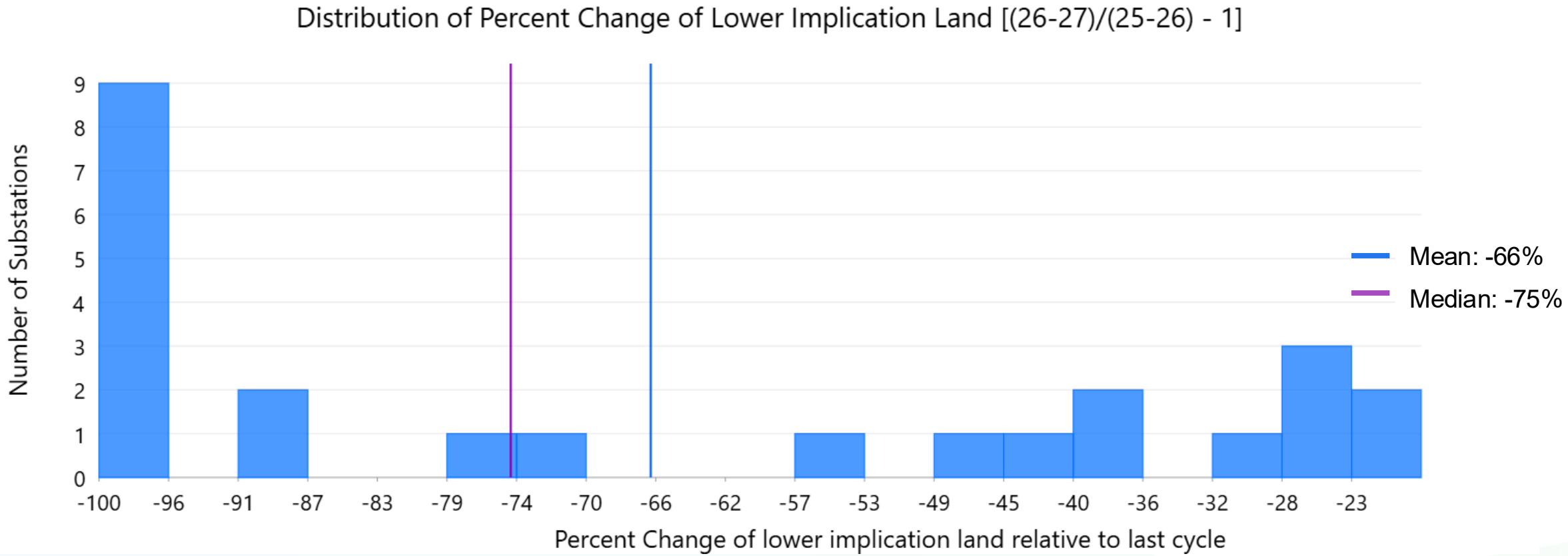
Negative values represent a decrease in low implication acres from the 25-26 busbar cycle, less available in 26-27 Busbar Cycle.
Positive values represent an increase in low implication acres from the 25-26 busbar cycle, more available in 26-27 Busbar Cycle.

Distribution of Percent Change of Lower Implication Land (Wind - All Substations Statewide)



- Median value shows half of substations experienced a decrease of 93 percent or more

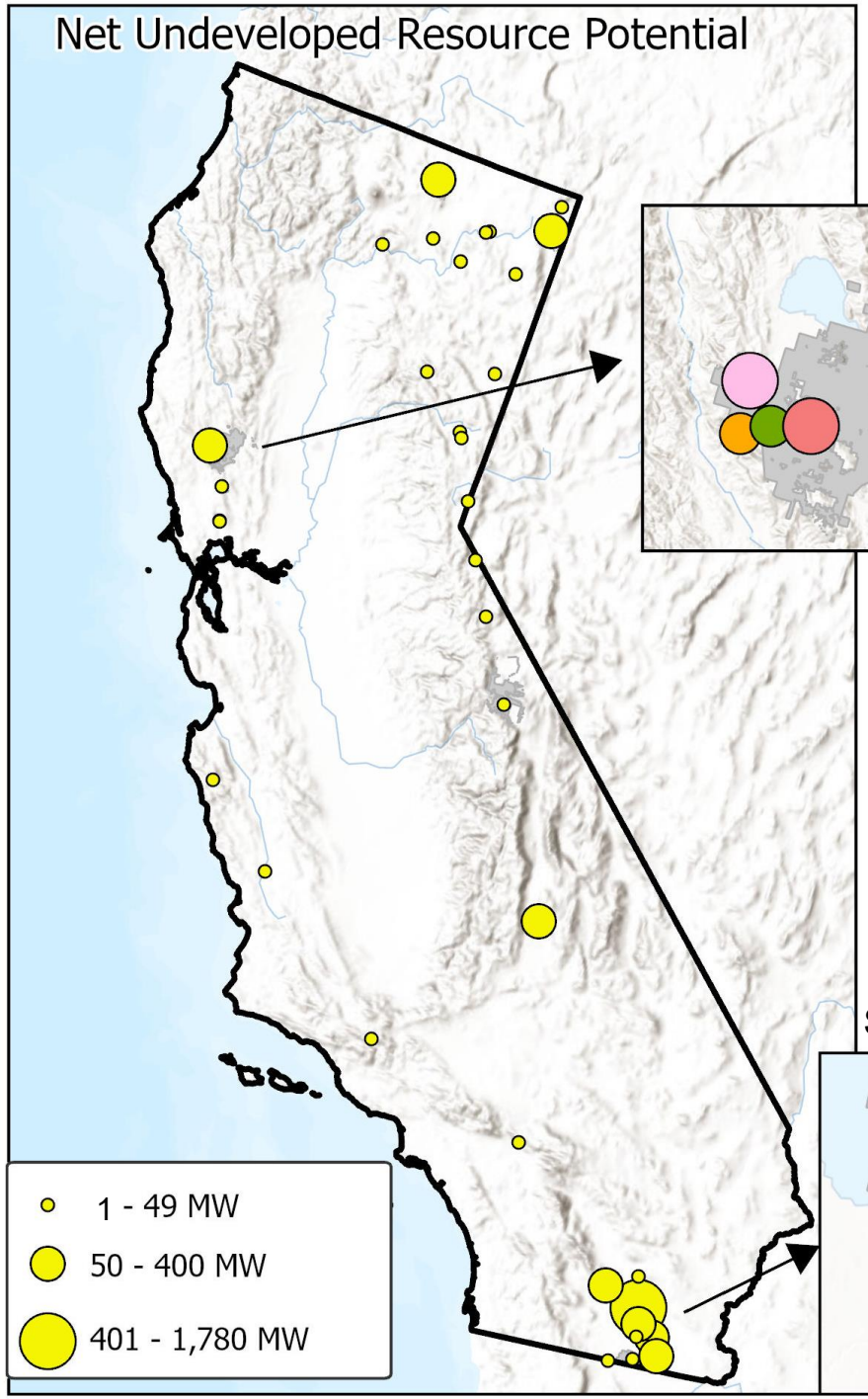
Distribution of Percent Change of Lower Implication Land (Only Substations Allocated MW for Wind in 25-26 TPP)



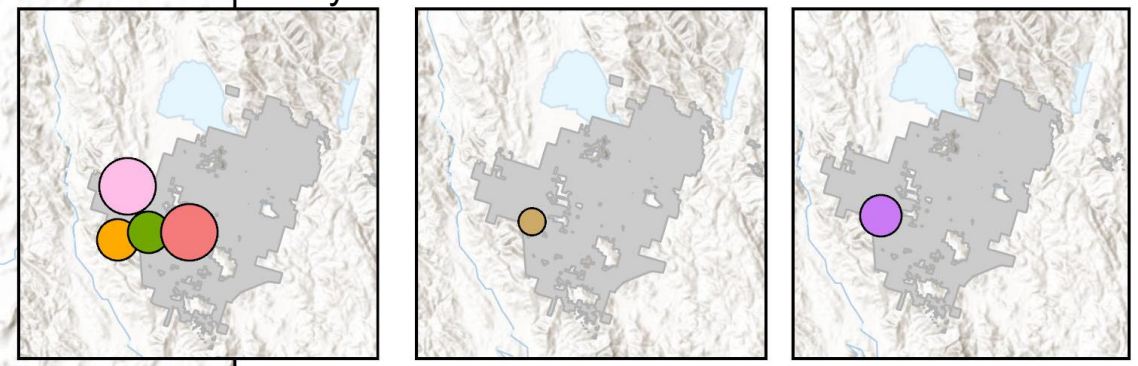
- Median value shows half of these substations experienced a decrease of 75 percent or more

Geothermal Results

Geothermal Results



Geysers



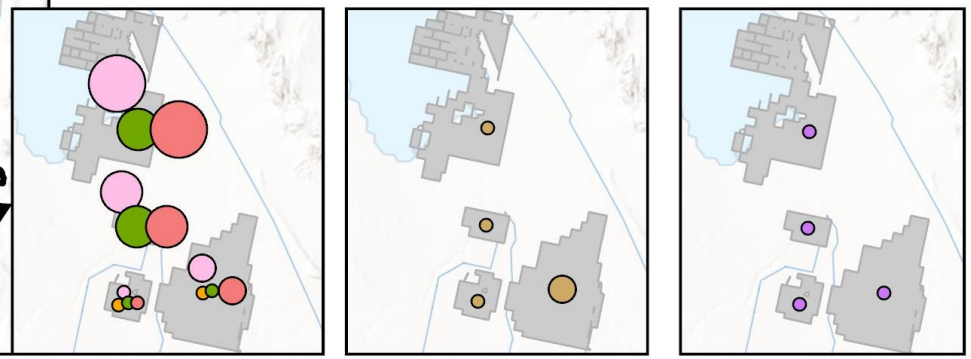
Legend for Metrics

- High Biodiversity
- High Connectivity
- High Irreplaceability
- Combined High ACE
- High Intactness
- Tier 2 Fire Threat
- Geothermal Field, Lower-Implication

Scale for Metrics

- 0 - 10%
- 10 - 30%
- 30 - 60%
- 60 - 100%

Salton Sea, Brawley, East Brawley and South Brawley



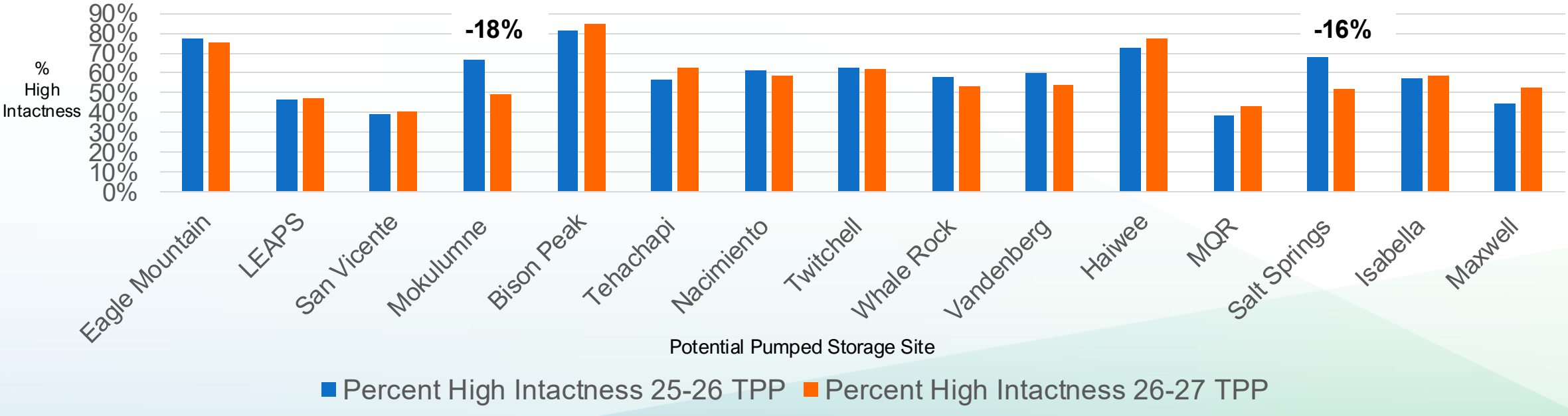
- Large variability in biological & conservation metrics, but most values for large geothermal fields are below 60% of non-PAL land in geothermal field
  - Elevated presence of Combined High ACE metric because it is the union of all three ACE factors
- Most large geothermal fields exist in low-risk areas for wildfires. Geysers is the exception (percent overlap of both fire threat tiers less than 50%)
- **Most geothermal fields show strong levels of compliance with Criteria 3 and 4***

*3 is Land use implications and feasibility factors; 4 is environmental (conservation and biological) impact factors

PSH Results

PSH Results: Differences in Presence of High Intactness

- Most PSH sites show slight change within ±6% in percent high intactness of the 5-mile buffer area
- Mokulumne and Salt Springs show the most substantial changes



Conclusions

- **Solar Results**
  - The amount of lower implication land saw small increase (2%) from last cycle, for most RESOLVE regions
- **Wind Results**
  - Most substations saw a large decrease (90%) in lower implication acreage, largely due to the Global Wind Atlas resource quality screen
- **Geothermal Results**
  - Most geothermal fields show strong levels of compliance with land use and environmental criteria
- **PSH Results**
  - Most PSH sites show slight change within ±6% in percent high intactness cover for the 5-mile buffer area
  - Mokulumne and Salt Springs show the most substantial changes

- Data updates will be posted to the CEC ArcGIS Online Portal here

Thank You!