Appendix G
Socio-economic Vulnerability Analysis

American River Watershed Resilience Pilot Study Equity Assessment

Public Release Draft

February 6, 2026

1. Introduction

The American River Watershed Resilience Pilot (ARWRP) Study developed a data-driven approach to map and evaluate where and how communities within the American River (RWA) watersheds are exposed and sensitive to extreme heat, drought, wildfire, and flooding. The analysis quantifies social vulnerability to these climate hazards to support informed, risk-based decision-making. This approach builds on datasets from the State's Vulnerable Communities Platform (VCP) and is adapted for subregional, watershed-scale application.

1.1 Vulnerable Communities Platform

The VCP is a web-based geospatial tool intended to provide a starting point for identifying communities that face the greatest combined climate risks and social vulnerability, and for guiding equitable adaptation. Launched by the Governor's Office of Land Use and Climate Innovation (LCI) in October 2025, the VCP is California's first statewide tool that integrates climate-hazard data with community-vulnerability information.

VCP combines climate-hazard indicators with social vulnerability indicators to generate hazard-specific social scores and visualize the intersection of hazard exposure and social vulnerability for five hazards: extreme heat, wildfire, flooding, sea level rise, and drought. Social vulnerability is assessed using a consistent set of demographic, socioeconomic, housing, health, environmental, and access-related indicators that apply across hazards. The platform uses a standardized percentile-based scoring system, making results comparable and easy to interpret for planning and equity-focused decision-making.

2. Methodology

The ARWRP study extends the VCP methodology with targeted refinements to support watershed-scale analysis, enabling a more accurate representation of social vulnerability and community-level climate impacts. By maintaining the VCP's underlying concepts, indicator definitions, and population-based approach, the ARWRP assessment delivers results that are tailored for local decision-making yet remain fully consistent with California's statewide climate vulnerability framework.

2.1 Refinements for Watershed-Scale Analysis

1. Local Percentile Rescaling: The public VCP classifies vulnerability at the statewide scale using Low, Medium, and High categories. While useful for broad comparison, this statewide framing can obscure meaningful differences within a watershed. To improve local relevance, VCP social and hazard scores (e.g., flood sensitivity and heat sensitivity) were recalculated as *watershed-relative percentiles*, enabling communities to be evaluated in relation to others within the same watershed rather than statewide. Additional statistical renormalization was applied to more accurately characterize how vulnerability is distributed internally across the watershed and to increase the sensitivity of the analysis for local planning. This refinement accomplishes the following:

- Reveal within-watershed variation in sensitivity.
- Identify localized "hot spots" that statewide ranking would flatten.
- Retain VCP's original 0/1/2 scoring thresholds (less than or equal to 50^{th}; 51^{st} to 75^{th}; and greater than 75^{th} percentiles).

2. More Precise Population Representation using Federal Emergency Management Agency (FEMA) Counts: Although the VCP relies on high resolution FEMA/ORNL LandScan population data (approximately 90 meters), its downloadable social vulnerability data are aggregated at the census blockgroup scale. The ARWRP analysis merges social characteristics directly with FEMA's high resolution population counts in their specific locations, resulting in a clearer understanding of who is actually affected in their precise locations.-resolution FEMA/ORNL LandScan population data -vulnerability data are aggregated at the census block-group scale.-resolution population counts

3. Integration of Planning-Grade Hazard Layers: Project-specific modeling outputs were developed to map extreme heat exposure, wildfire probability, flooding, and drought at a resolution appropriate for local planning. These planning-grade layers provide a more accurate representation of localized climate risk than statewide hazard datasets.

To maintain consistency with VCP methodological standards, the following quality assurance and quality control steps were applied:

- Verify that cumulative percentiles approximate a complete 0 to 100% distribution.
- Confirm that the highest discrete social score aligns with the highest percentile bin.
- Document the total evaluated population for each hazard layer.
- Label all outputs as relative within the hazard-relevant population.
- Exclude null values (i.e., areas where the hazard is not applicable or not evaluated) from percentile calculations.
- Retain zero values (i.e., valid low scores) to preserve the true distribution and avoid bias.

As a result of these refinements, small and expected differences may appear in the population counts underlying each hazard-specific social vulnerability score. These variations occur because each score is calculated only for population units with complete (i.e., non-null) data for all indicators associated with that hazard.

3. Results

Table 1 shows selected climate hazards, metrics, and supporting reference periods for modeling these.

Table 1. Overview of Climate Hazard Metrics, Definitions, and Reference Periods

Metric	Definition	Reference Periods
Extreme Heat Days	Projected change in number of Extreme Heat Days per year when daily maximum temperature is greater than 95° F historical temperature (days/yr)	• Annual_p50_Hist: Absolute values (days/year) for Historical Period (1981 to 2010)
		• Annual_p50_Mid: Absolute values (days/year) for Mid Future Period (2041 to 2070)
Extreme Precipitation	Projected change in 1% annual exceedance probability precipitation (%) of a 3-day storm	• Annual_p50_Mid_Change: Change (%) for Mid Future Period (2041 to 2070)
		• Annual_p50_Late_Change: Change (%) for Late Future Period (2071 to 2100)
Wildfire Burn Probability	Projected changes for estimated decadal wildfire probabilities (%)	• Decadal_Prob_Hist_Median: Absolute values (%) for Historical Period (1981 to 2010)
		• Decadal_Prob_Mid_Median: Absolute values (%) for Mid Future Period (2041 to 2070)

3.1 Precipitation-based Flooding

Flood sensitivity was evaluated using two complementary methods:

- The first method analyzed changes in 3-day extreme precipitation totals—a duration characteristic of atmospheric river events that have historically driven major flooding in the American River watershed. This metric captures how climate change may increase the magnitude and frequency of short-duration, high-intensity rainfall that contributes to both fluvial and pluvial flooding. By comparing historical (1961 to 2010) conditions with mid-century projections (2016 to 2065), the analysis identifies communities that may face heightened flood risk as the most intense multi-day storms grow more severe over time.
  - **3-day extreme precipitation event**, which represents the projected change in the intensity of the heaviest 3-day rainfall totals under historical and future climate conditions. **Reference periods:** 'Historical': 1961 to 2010; 'Mid-Future': 2016 to 2065.

  Maps illustrating present and mid-future social vulnerability to precipitation-based flooding are included in Attachment 1.

- The second method examined localized levee-breach scenarios using California Department of Water Resources' modeled inundation maps for downtown Sacramento, providing an additional perspective on flood vulnerability associated with levee performance and failure pathways.
  - Levee-breach flood-inundation scenario, which was modeled using an enhanced version of the 1986 flood event, adjusted to reflect a 125-year return interval. This representative event provides a realistic basis for mapping and for evaluating current and future flood exposure

  The map illustrating social vulnerability to inundation-based flooding, based on the 125-year event, is provided in Attachment 2. Table 2 details the distribution of population sensitive to flooding caused by extreme precipitation.

Table 2. Distribution of Population Sensitivity to Flooding Caused by Extreme Precipitation

Score	Flood Bin	Flood Sensitive Population Count	Flood Sensitivity Distribution
0 to 2	1	309,824	14%
3 to 4	2	382,829	17%
5 to 6	3	427,529	19%
7 to 8	4	326,652	14%
9 to 19	5	823,549	36%
Total		2,270,383	100%

Based on basin-specific studies of historical rainfall and flood response, a threshold of **greater than or equal to 6 inches of precipitation over 3 days** was selected to represent flood potential associated with atmospheric river events. Higher thresholds (greater than or equal to 9 to 12 inches) are more strongly linked to major historical flooding, but these extreme totals occur predominantly in sparsely populated upper-watershed areas. Under both present and mid-future climate conditions, 3-day precipitation events exceeding 6 inches remain largely confined to these headwater zones. As a result, direct population exposure is relatively limited: affecting roughly **2% of residents today**, increasing to approximately **4% by mid-century** as storm intensity increases.

Despite limited population exposure in the upper watershed, the downstream hydrologic consequences are substantial. As 3-day extreme precipitation events intensify, resulting runoff pulses move rapidly through the American and Sacramento rivers, raising downstream water levels and increasing pressure on levees that protect densely populated urban areas. Communities such as downtown Sacramento, North Sacramento, Natomas, and the Pocket/Meadowview corridor—all situated behind levees in low-lying basins—are particularly vulnerable to rapid inundation if levees overtop or breach.

Future hydrologic projections reinforce this heightened risk. A flow that is currently associated with a **124-year recurrence interval** is expected to occur every **65 to 103 years by 2072**, nearly doubling the likelihood of a large breach-driven flood. More frequent events show even greater change: **10-year floods** are projected to produce **2.1 to 4.2 feet higher water levels**, placing additional strain on already stressed levee segments and increasing the probability of seepage, overtopping, and structural failure. This pattern mirrors historical experience: during the **1986 flood**, intense upper-watershed rainfall produced high downstream flows that contributed to levee failures and the inundation of thousands of homes.

Together, these conditions indicate that while the most extreme rainfall remains concentrated upstream, the **downstream impacts—higher flows, elevated water levels, and increased levee stress—pose significant risks for densely populated and socially vulnerable communities**. Neighborhoods in and around downtown Sacramento, North Sacramento, Natomas, and the Pocket/Meadowview corridor face elevated exposure because they occupy low-lying basins where floodwaters can accumulate quickly if levees fail or overtop. Many of the neighborhoods with the greatest exposure include higher proportions of lower-income households, renters, seniors living alone, outdoor workers, and residents with limited transportation access or flood insurance: these factors reduce a community's capacity to prepare for, respond to, and recover from flooding.

Under modeled **125-year levee-breach scenarios**, approximately **12.5% of the watershed population** would be affected, and **59% of those affected fall within the highest flood-sensitivity category**, underscoring the disproportionate burden on vulnerable communities.

3.2 Wildfire

The wildfire metric captures how climate change may increase the frequency or likelihood of wildfire occurrence across the landscape. The metric highlights which communities and locations could face heightened wildfire risk over time. The following metric was selected to measure exposure to wildfire:

- **Wildfire Burn Probability**, which represents the estimated percent likelihood that a given area will burn in a typical year under historical and future climate conditions. **Reference periods:** 'Historical': 1981 to 2010; 'Mid-Future': 2041 to 2070

Maps illustrating present and mid-future social vulnerability to extreme heat are included in Attachment 3. Table 3 provides the distribution of population sensitivity to wildfire.

Table 3. Distribution of Population Sensitivity to Wildfire

Score	Wildfire Bin	Wildfire Sensitive Population Count	Wildfire Sensitivity Distribution
0 to 3	1	428,075	19%
4 to 5	2	359,706	16%
6 to 8	3	524,097	23%
9 to 12	4	412,402	18%
13 to 22	5	546,103	24%
Total		2,270,383	100%

Under current conditions, roughly 14% of the population is exposed to a greater than 15% increase in decadal wildfire burn probability. Of those exposed, about 4% fall into the highest wildfire sensitivity category. Under mid-future conditions, the exposed population increases to 34%—more than double today's share. Within this group, an estimated 176,654 people (23%) are classified as highly sensitive to wildfire, representing a fivefold increase in the number of people in the highest risk category and indicating significantly elevated susceptibility to wildfire impacts. Figure 1 illustrates the population exposure to wildfire.

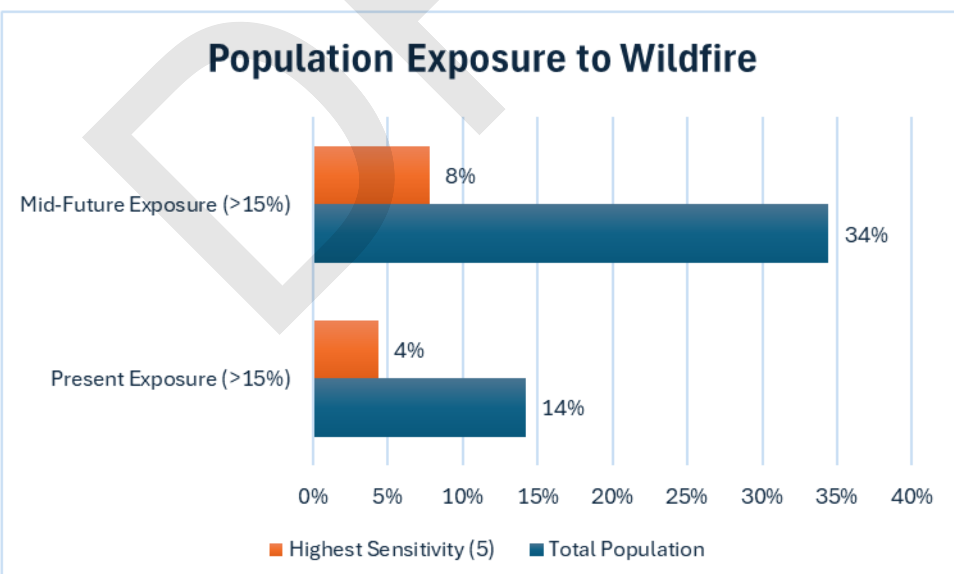


Figure 1. Population Exposed to Wildfire (greater than 15% decadal probability)

3.3 Extreme Heat

The extreme heat metric shows how much more frequently communities are expected to experience dangerous heat conditions. By comparing historical conditions with modeled future changes, the metric provides a clear picture of how heat exposure is expected to intensify and which parts of the watershed may experience the greatest increases. The following metric was selected to measure exposure to extreme heat:

- Projected change in the **number of Extreme Heat Days per year,** defined as days when the daily maximum temperature exceeds 95 degrees Fahrenheit (°F)

Maps illustrating present and mid-future social vulnerability to extreme heat are included in Attachment 4. Table 4 provides the distribution of population sensitivity to extreme heat.

Table 4. Distribution of Population Sensitivity to Extreme Heat

Score	Heat Bin	Heat Sensitive Population Count	Heat Sensitivity Distribution
1 to 5	1	409,429	18%
6 to 7	2	267,469	12%
8 to 9	3	363,217	16%
10 to 12	4	466,680	21%
13 to 25	5	763,588	34%
Total		2,270,383	100%

More than 99% of the population in the American River Watershed is projected to experience an increase of 30 or more Extreme Heat Days (defined as days exceeding 95°F) per year. This reflects the concentration of settlement and urban development in the lower watershed, while the higher elevation Sierra Nevada areas remain largely rural and sparsely populated. Nearly one third of the watershed's residents fall within the highest sensitivity category to extreme heat. Figure 2 illustrates the population exposure to extreme heat.

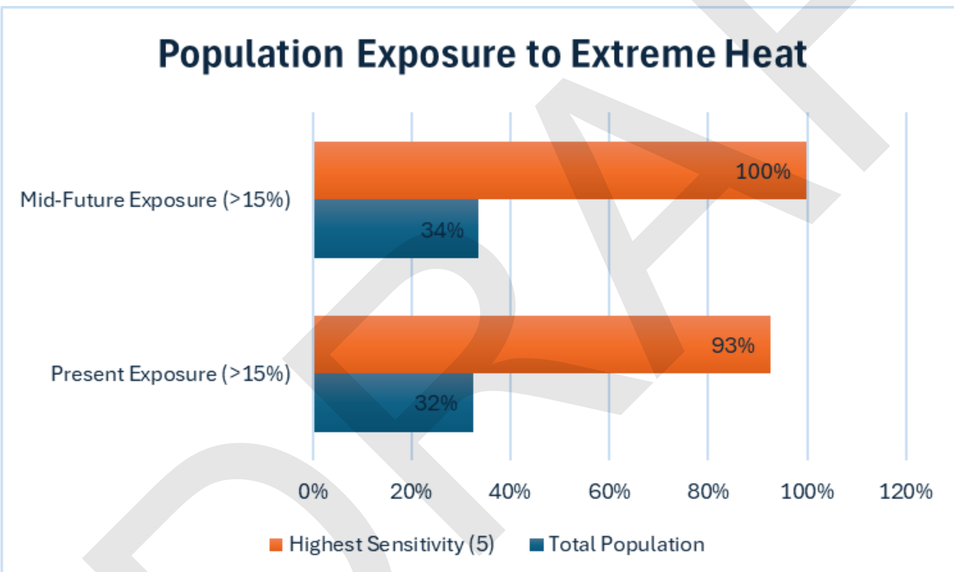


Figure 2. Population Exposed to Extreme (greater than or equal to 30 days increase in Extreme Heat Days over 95°F)

3.4 Drought

The drought metric illustrates how much more severe and prolonged drought deficits are expected to become as the climate warms. By comparing historical flow deficits with modeled future changes, the metric communicates how drought severity is projected to intensify, and which parts of the watershed may see the greatest increases in water supply vulnerability. Values were calculated for the historical baseline (1961–2010) and compared to midcentury conditions (2016–2065). The change is expressed as a percentage, highlighting where drought deficits are expected to worsen most significantly over time. The following metric was selected to measure exposure to drought conditions:

- Projected change in maximum cumulative annual flow deficit (%), based on the total annual flow volume

Maps illustrating present and mid-future social vulnerability to drought are included in Attachment 4. Table 5 provides the distribution of population sensitivity to drought.

Table 5. Distribution of Population Sensitivity to Drought

Score	Drought Bin	Drought Sensitive Population Count	Drought Sensitivity Distribution
0 to 3	1	37,849	19.7%
4	2	17,659	9.2%
5 to 7	3	56,074	29.2%
8 to 9	4	36,180	18.8%
10 to 19	5	44,466	23.1%
Total		192,228	100.0%

Under present-day conditions, reductions in streamflow across the RWA watersheds are already evident, with the most pronounced decreases concentrated in the upper watershed as seen in Attachment 1A. These headwater areas are highly dependent on snowpack accumulation and gradual seasonal melt, making them particularly sensitive to drought-driven shifts in precipitation and temperature. Reduced flows in these regions signal diminished snowpack storage and altered runoff timing, which cascade downstream to affect reservoir inflows, water supply reliability, cold-water habitat, and ecosystem function throughout the watershed.

Mid-future projects indicate that drought conditions will worsen, with anticipated flow reductions reaching up to 25% in the same upper watershed areas as seen in Attachment 1B. This incidicates a structural shift in watershed hydrology, where significant declines increase the likelihood of more frequent and prolonged low-flow conditions. This results in reduced carryover storage in reservoirs, and heightened competition among water supply, environmental, and hydropower demands—particularly during late summer and dry years. These hydrologic changes have direct and uneven impacts on downstream populations that rely on the system for municipal water supply and energy generation. As water utilities face reduced surface water availability, communities may experience the following:

- Increased reliance on alternative supplies
- Higher treatment and conveyance costs
- Upward pressure on water rates.

These cost burdens disproportionately affect low-income households, fixed-income residents, and communities already experiencing affordability stress. Over time, sustained drought conditions can compound inequities by increasing exposure to water use restrictions, service disruptions, and deferred infrastructure investments.

Attachments

Attachment 1 – Precipitation-based Flooding Social Vulnerability Maps

Attachment 1A – Precipitation-based Flooding Social Vulnerability Map – Present Conditions

Attachment 1B - Precipitation-based Flooding Social Vulnerability Map – Mid Future Conditions

Attachment 2 – Inundation-based Flooding Social Vulnerability Maps

Attachment 2A – Inundation-based Flooding Social Vulnerability Map

Attachment 3 – Wildfire Social Vulnerability Maps

Attachment 3A – Wildfire Social Vulnerability Map – Present Conditions

Attachment 3B - Wildfire Social Vulnerability Map – Mid Future Conditions

Attachment 4 – Extreme Heat Social Vulnerability Maps

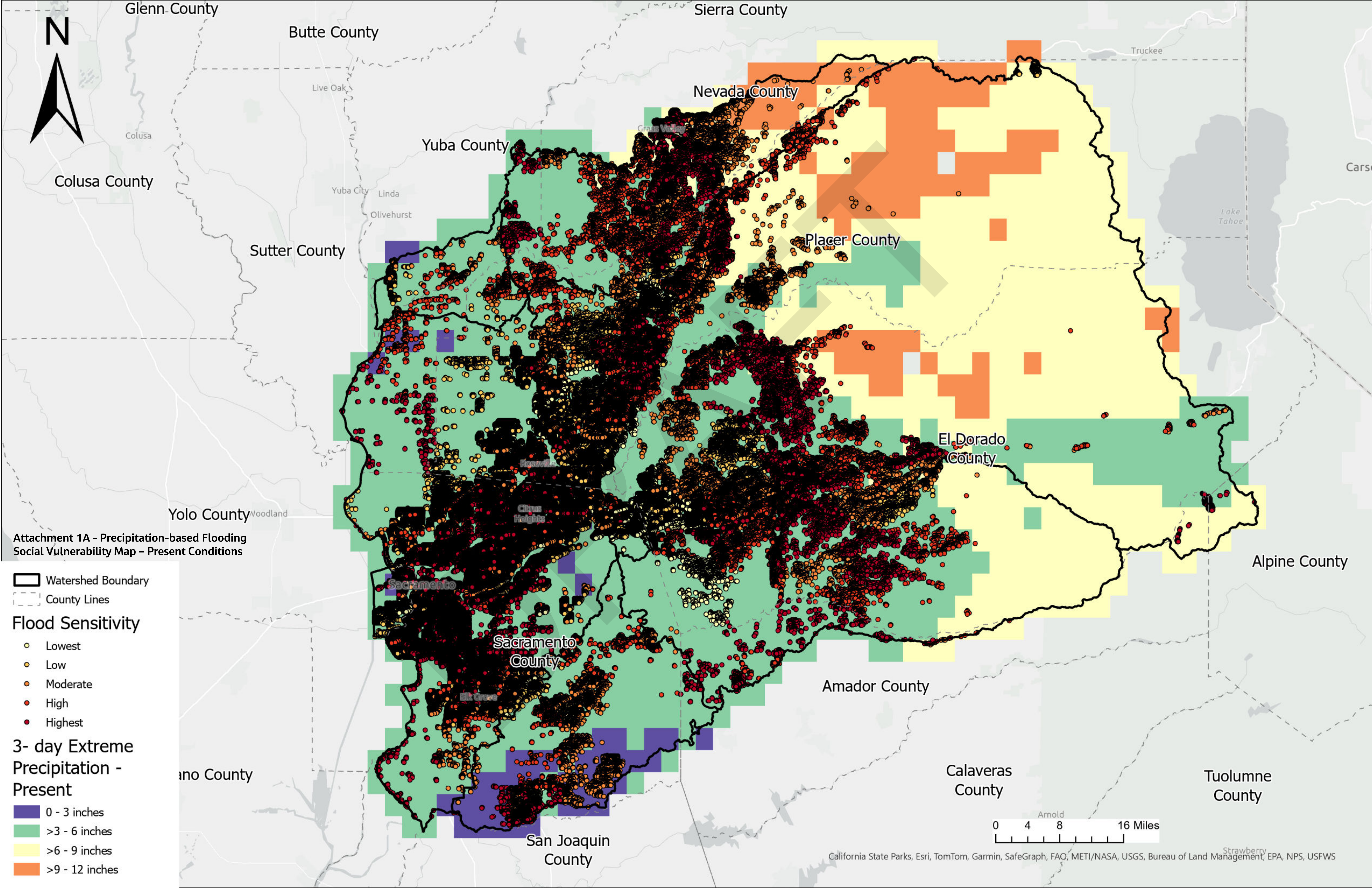
Attachment 4A – Extreme Heat Social Vulnerability Map – Present Conditions

Attachment 4B - Extreme Heat Social Vulnerability Map – Mid Future Conditions

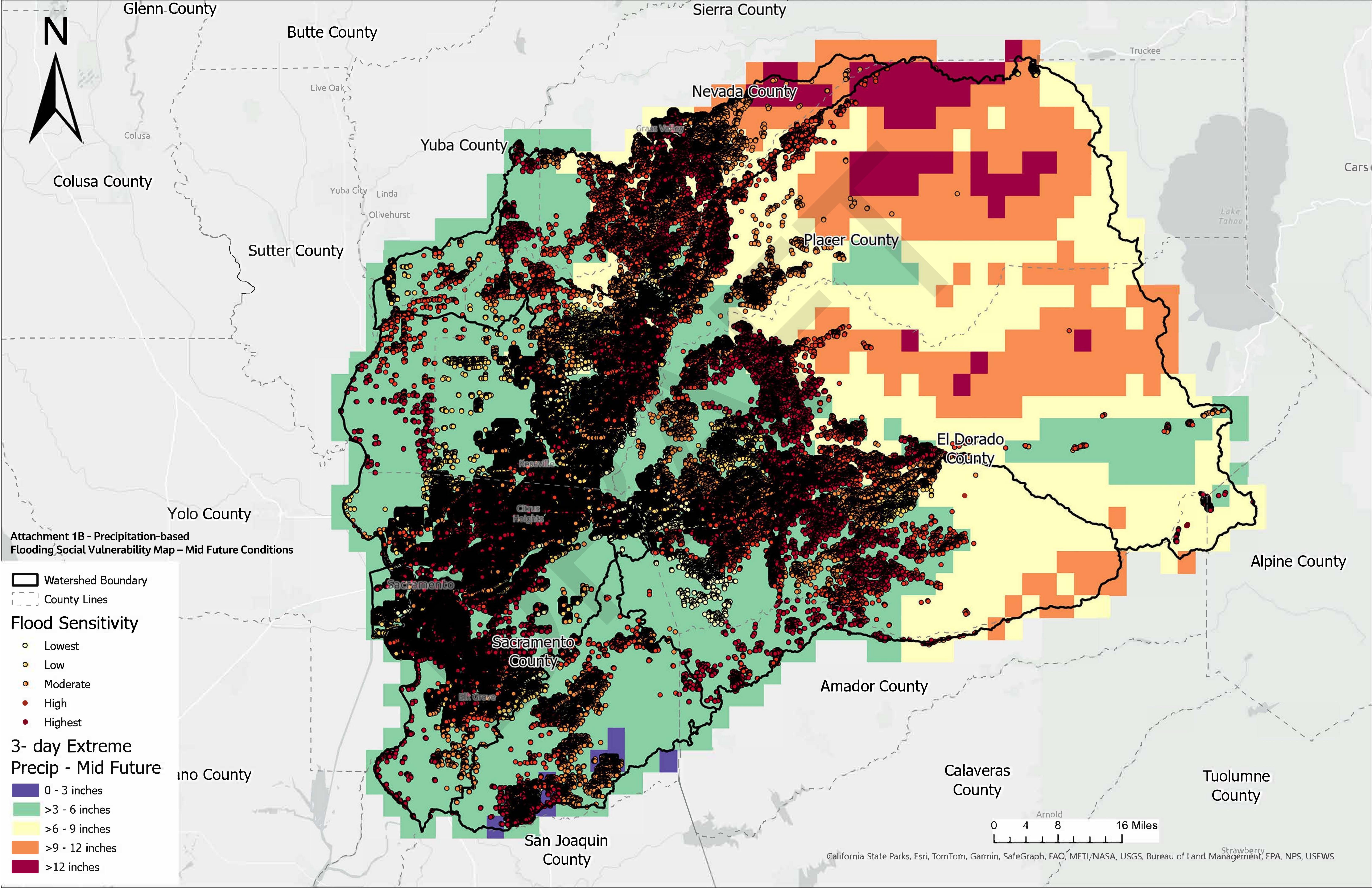
Attachment 5 – Drought Social Vulnerability Maps

Attachment 5A – Drought Social Vulnerability Map – Present Conditions

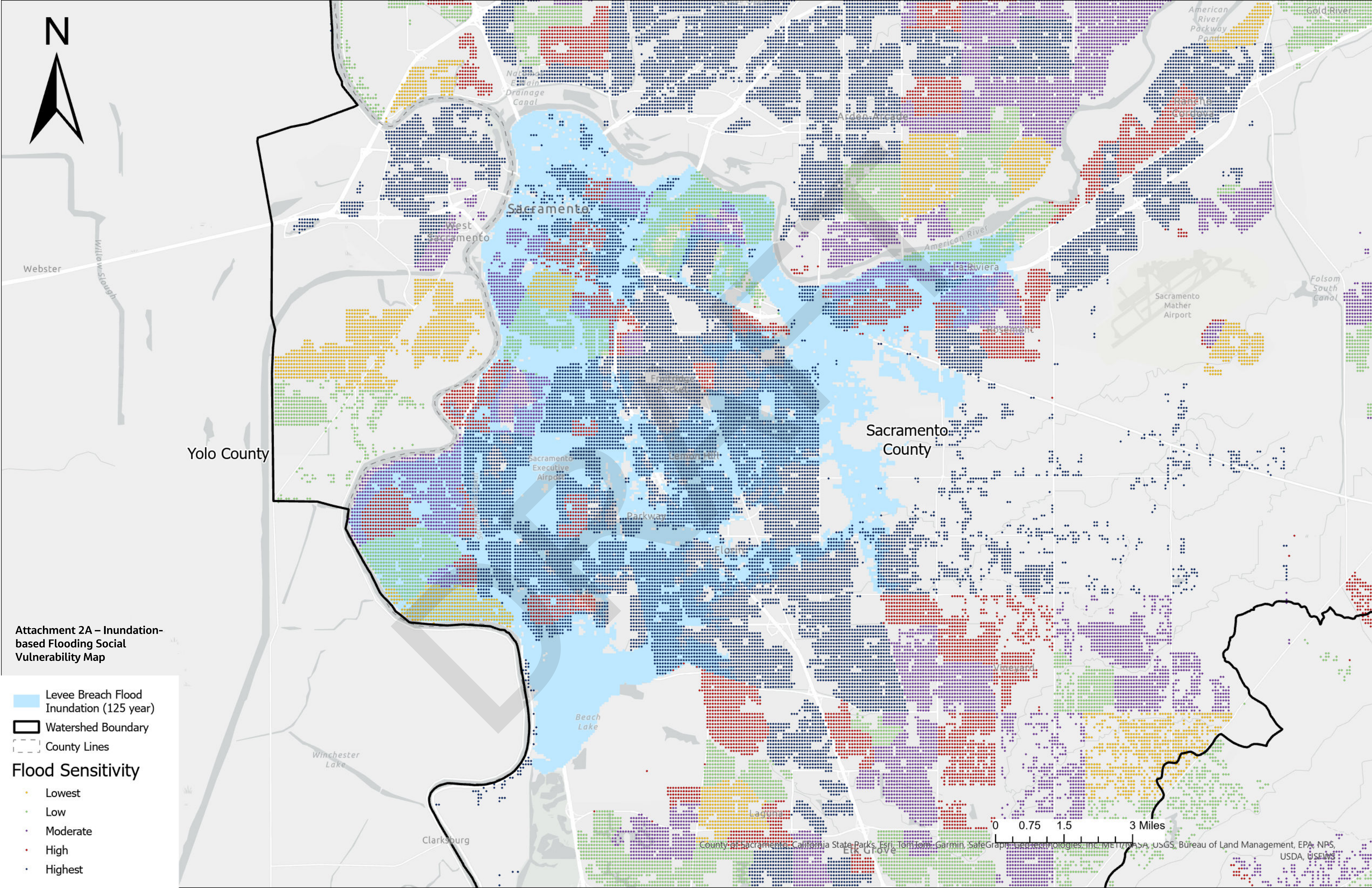
Attachment 5B - Drought Social Vulnerability Map – Mid Future Conditions



Attachment 1A - Precipitation-based Flooding Social Vulnerability Map – Present Conditions



Attachment 1B - Precipitation-based Flooding Social Vulnerability Map – Mid Future Conditions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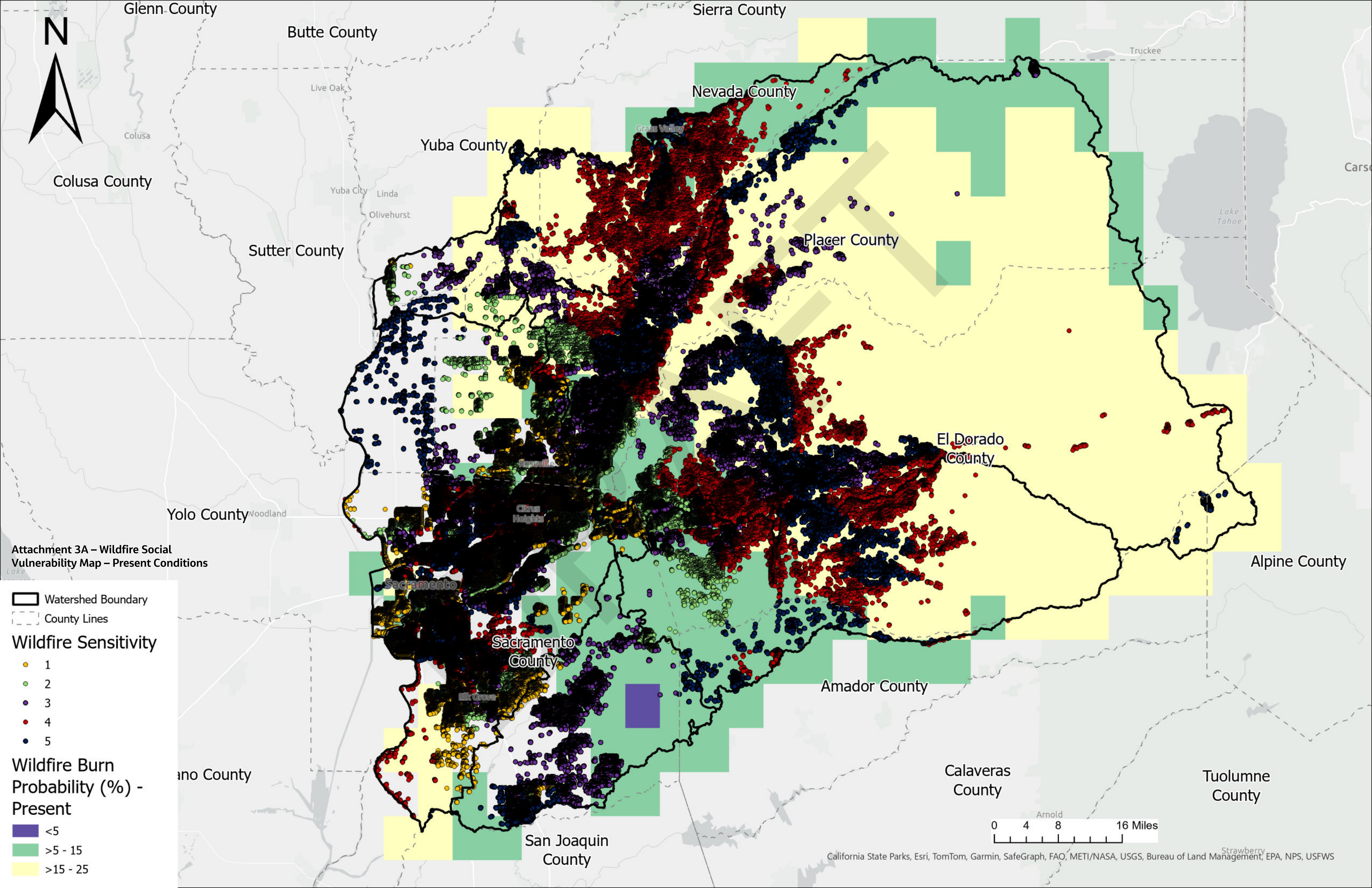
Attachment 2A – Inundation-based Flooding Social Vulnerability Map
Levee Breach Flood Inundation (125 year)
Watershed Boundary
County Lines
Flood Sensitivity
Lowest
Low
Moderate
High
Highest
Yolo County
Sacramento County
Sacramento
West Sacramento
Arden-Arcade
Rancho Cordova
La Riviera
Rosemont
Sacramento Mather Airport
Sacramento Executive Airport
Lemon Hill
Parkway
Florin
Vineyard
Laguna
Elk Grove
Clarksburg
Beach Lake
Winchester Lake
Webster
Willow Slough
Natomas East Main Drainage Canal
American River
American River Parkway Pond
Gold River
Folsom South Canal
0 0.75 1.5 3 Miles
County of Sacramento, California State Parks, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USDA, USFWS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Attachment 3A – Wildfire Social Vulnerability Map – Present Conditions
Watershed Boundary
County Lines
Wildfire Sensitivity
1
2
3
4
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Wildfire Burn Probability (%) - Present
<5
>5 - 15
>15 - 25
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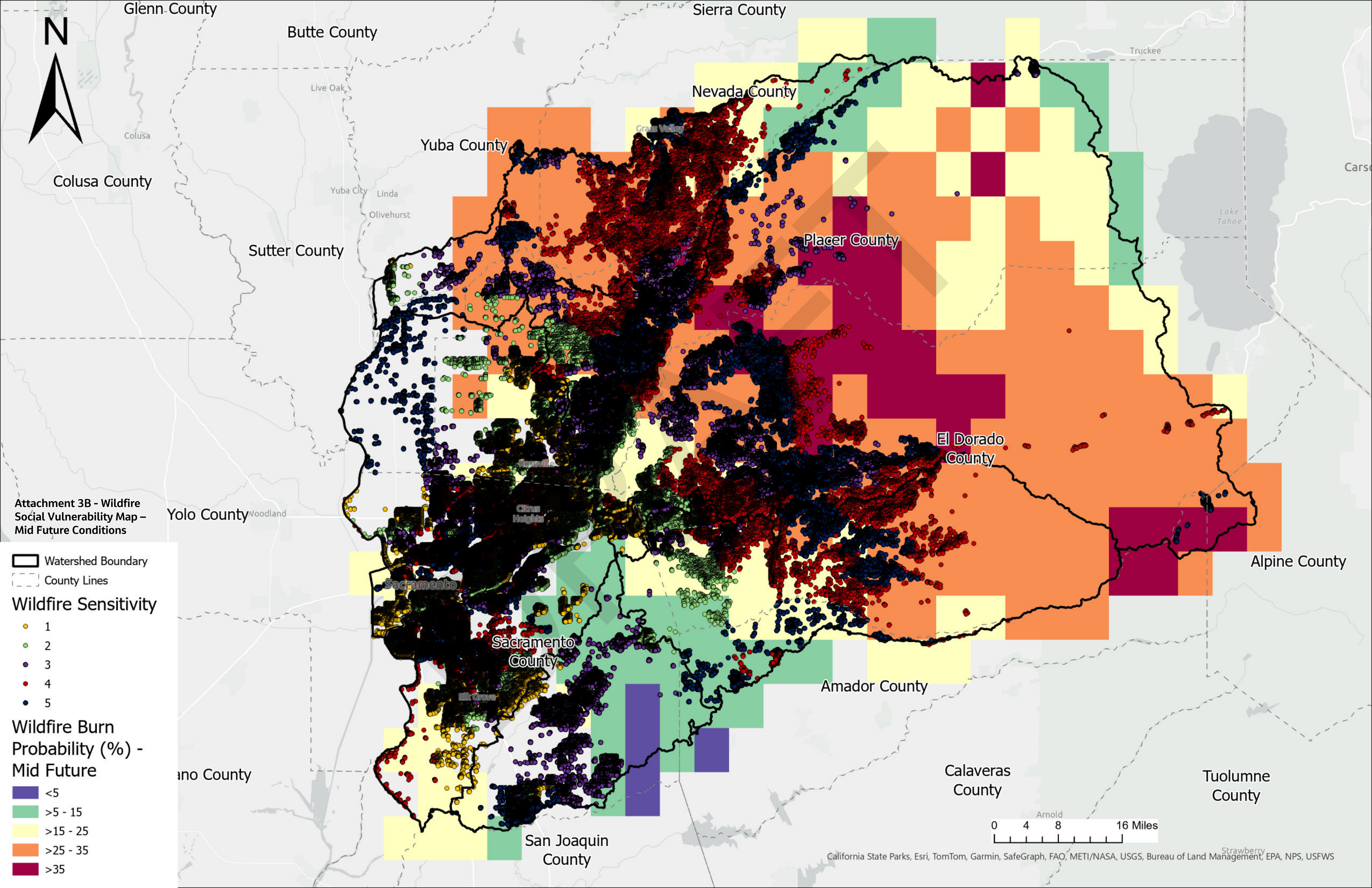
California State Parks, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USFWS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Lake Tahoe
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Roseville
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El Dorado County
Attachment 3B - Wildfire Social Vulnerability Map – Mid Future Conditions
Yolo County
Woodland
Alpine County
Watershed Boundary
County Lines
Wildfire Sensitivity
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Wildfire Burn Probability (%) - Mid Future
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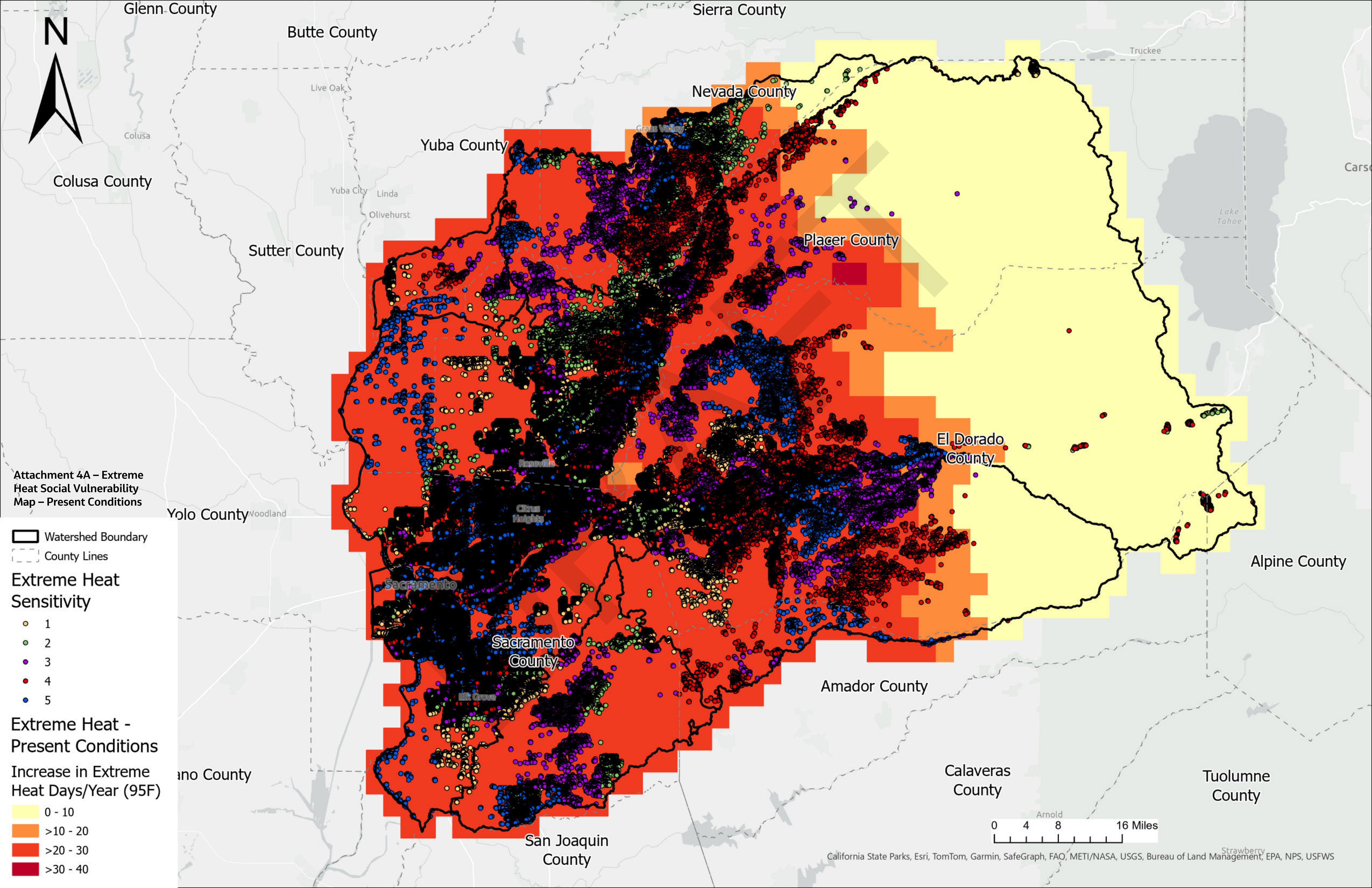

Attachment 4A – Extreme Heat Social Vulnerability Map – Present Conditions
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Woodland
Arnold
Strawberry
Carso
Watershed Boundary
County Lines
Extreme Heat Sensitivity
1
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Extreme Heat - Present Conditions
Increase in Extreme Heat Days/Year (95F)
0 - 10
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>30 - 40
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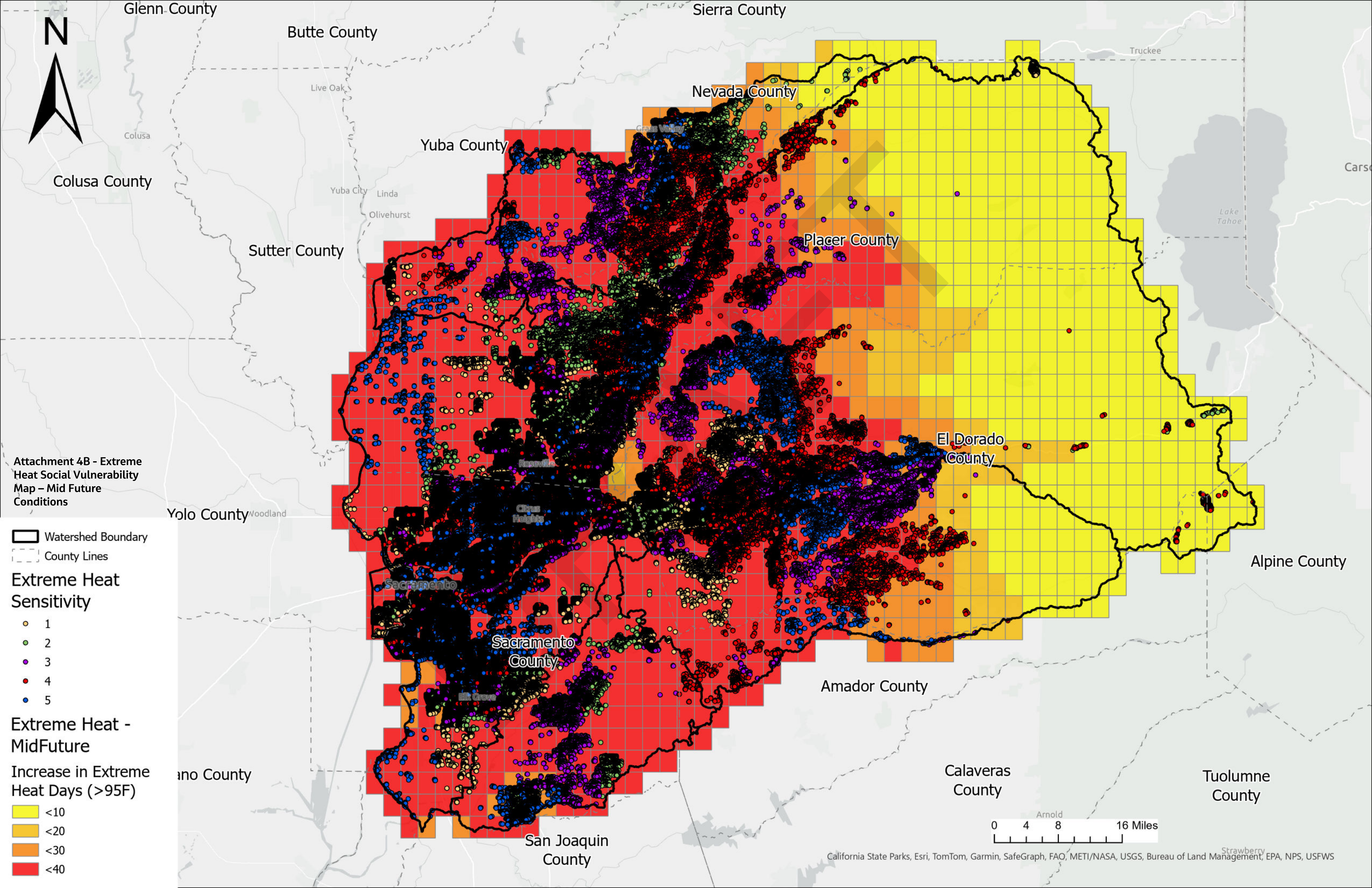
California State Parks, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USFWS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Attachment 4B - Extreme Heat Social Vulnerability Map – Mid Future Conditions
Watershed Boundary
County Lines
Extreme Heat Sensitivity
1
2
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Extreme Heat - MidFuture
Increase in Extreme Heat Days (>95F)
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<20
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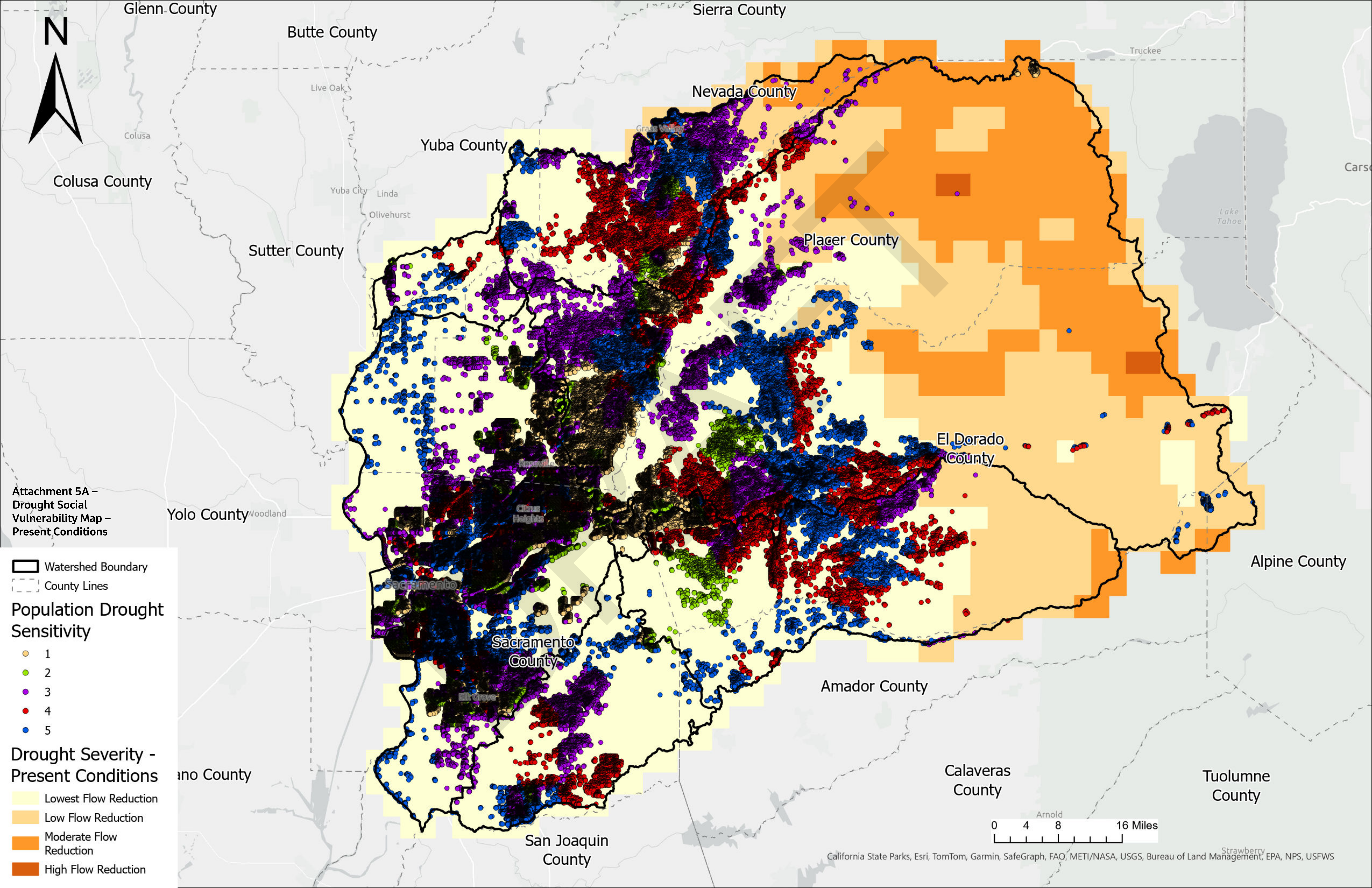
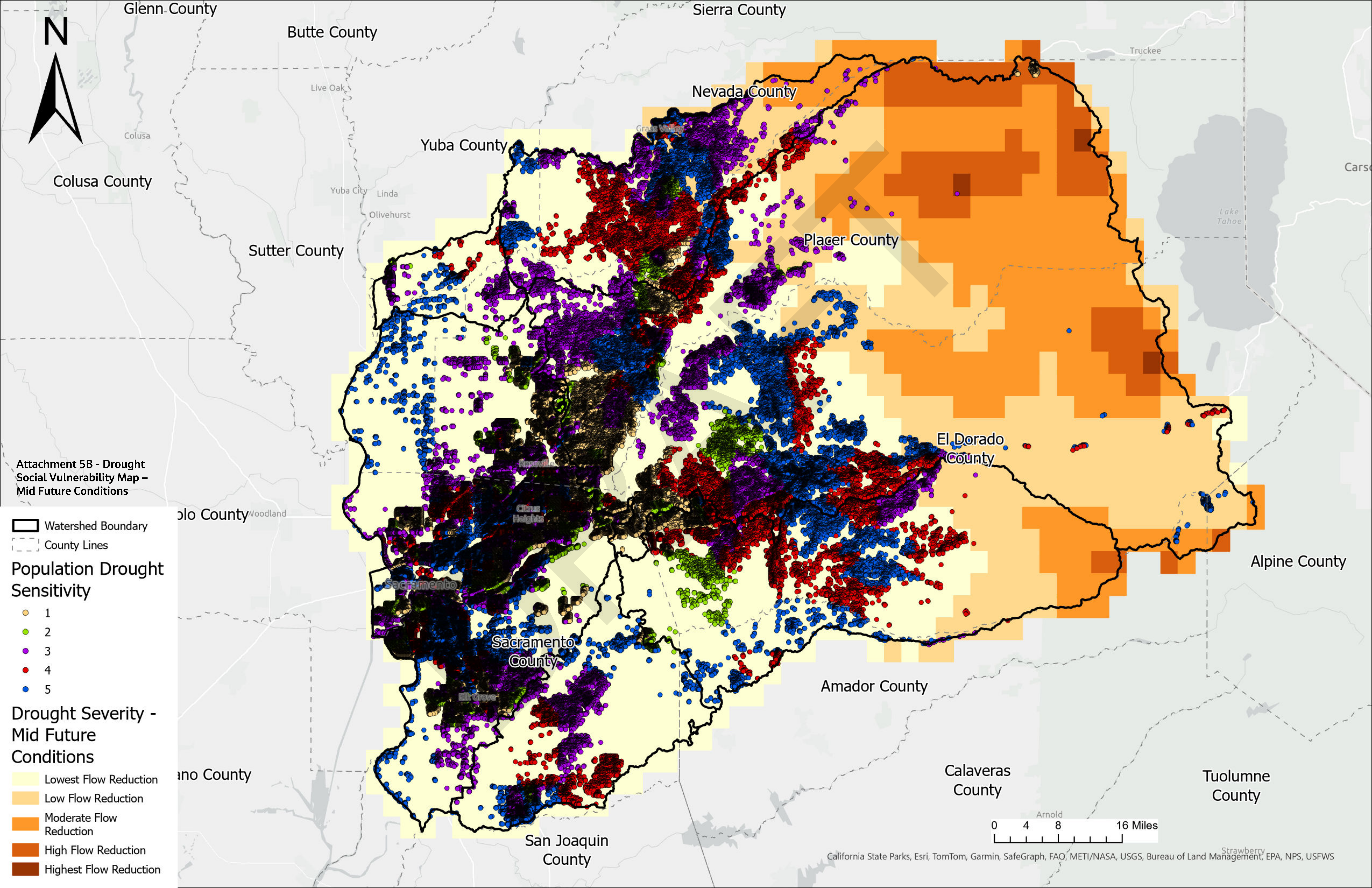
0 4 8 16 Miles
California State Parks, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USFWS



Attachment 5A – Drought Social Vulnerability Map – Present Conditions



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Lake Tahoe
Roseville
Citrus Heights
Sacramento
Elk Grove
Woodland
Arnold
Strawberry
Carso
Attachment 5B - Drought Social Vulnerability Map – Mid Future Conditions
Watershed Boundary
County Lines
Population Drought Sensitivity
1
2
3
4
5
Drought Severity - Mid Future Conditions
Lowest Flow Reduction
Low Flow Reduction
Moderate Flow Reduction
High Flow Reduction
Highest Flow Reduction
0 4 8 16 Miles
California State Parks, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USFWS