SMUD

Nature-Based Carbon Solutions and Biodiversity Program Feasibility Study Update

November 10, 2026





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Study Progress and Next Steps

Completed

Defined the study area and three ecoregions

Compiled GIS data on landcover and soils

Estimated current carbon stocks and 2045 scenarios

Underway

Evaluating potential priority practices by region and landcover

Assessing opportunities for carbon preservation and sequestration

Next

Identify and assess SMUD-specific opportunities

Prepare a project development framework

From Carbon Inventory to Project Opportunities

The feasibility study is moving from understanding existing carbon stocks to identifying actionable opportunities.

CARBON INVENTORY

Where is carbon currently stored?

↓

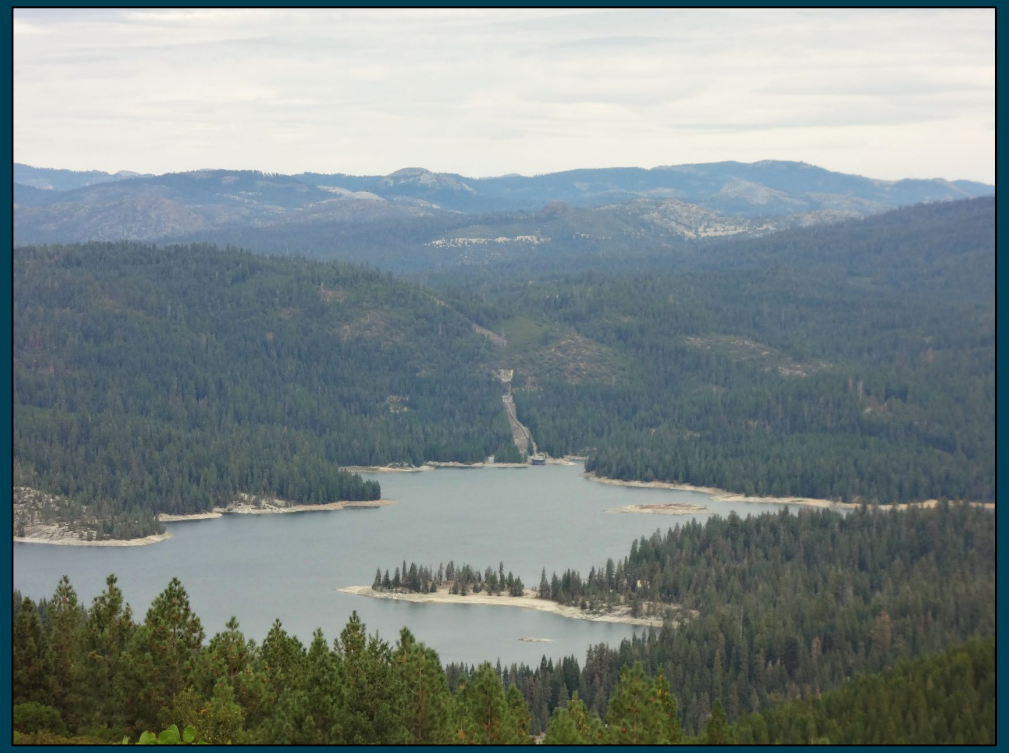
PRACTICE SCREENING

What actions could protect or increase carbon and biodiversity?

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OPPORTUNITY ASSESSMENT

Where could SMUD help implement them?



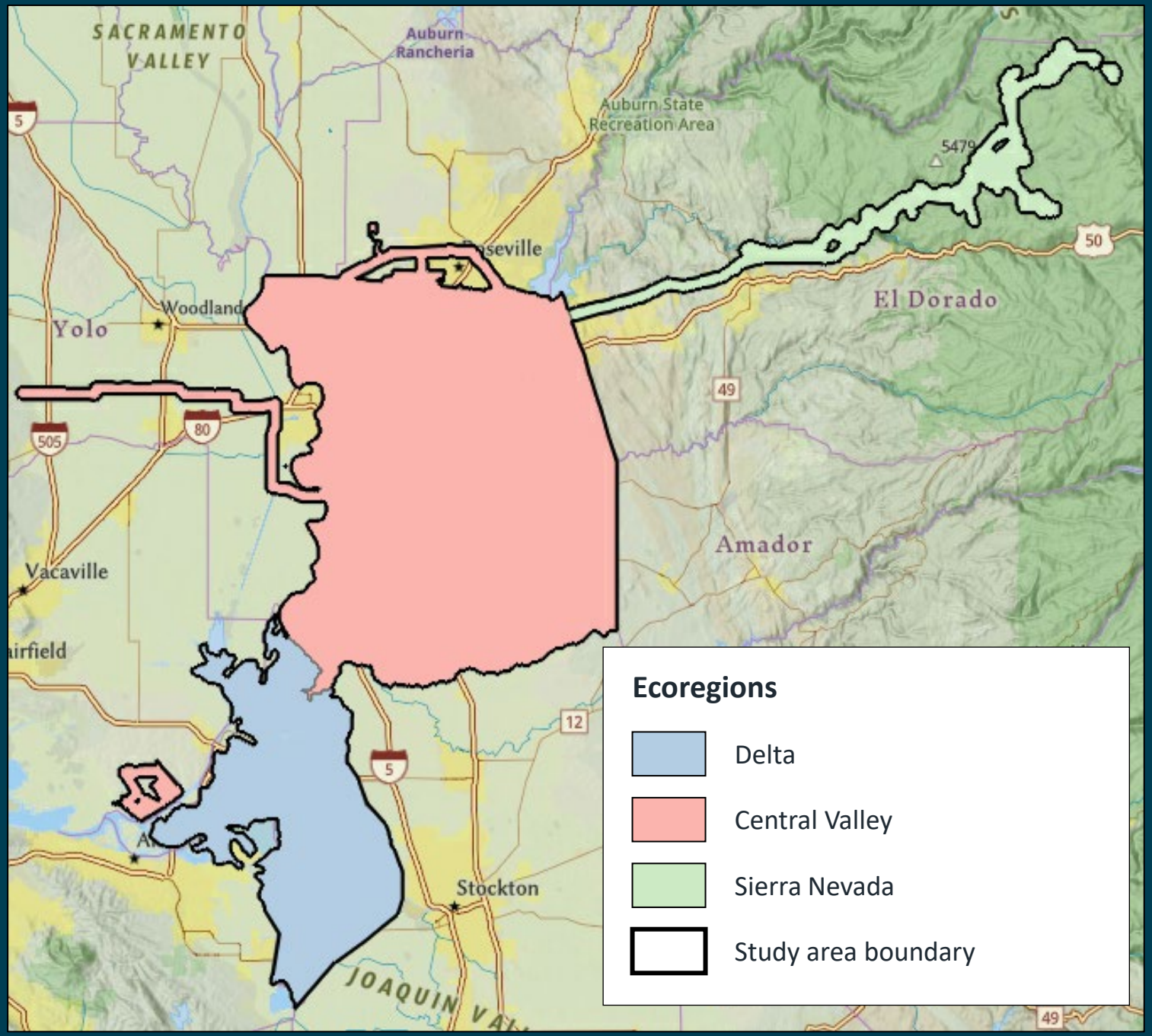
Biodiversity, cost, feasibility, and other co-benefits inform practice and opportunity prioritization.

ASCENT: Study Area Carbon Stock Inventory and Forecast

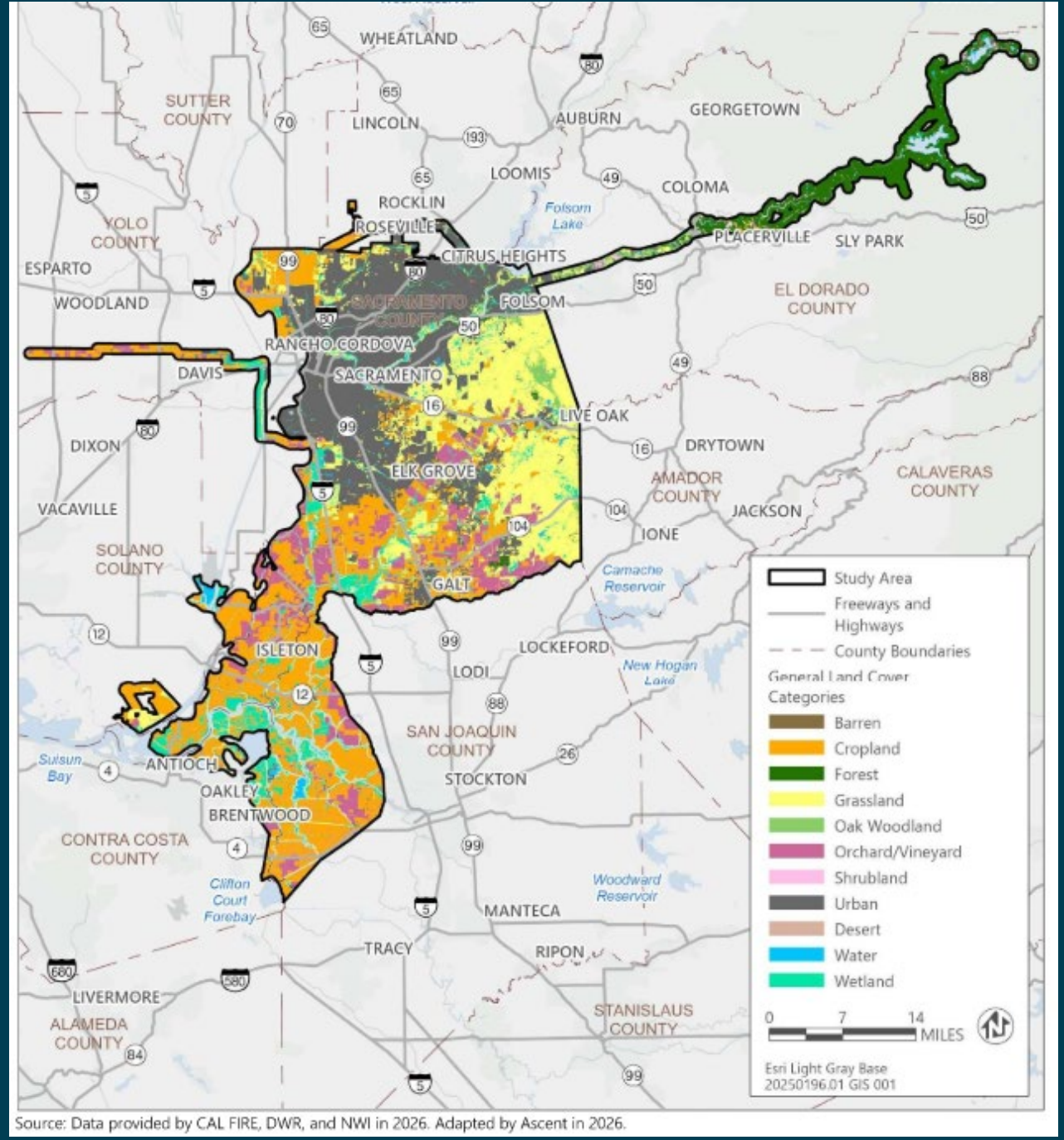
- [Ascent slides here]
- Hannah will be reviewing the carbon inventory methodology (brief) and the key findings of the carbon inventory analysis, including an estimated 2045 carbon stock forecast for the study area under a business-as-usual scenario compared to the CARB scoping plan scenario. She will also discuss the current work Ascent is doing to support creating a GIS tool hosted on SMUD's server to support opportunities analyses and a potential future public facing storyboard.

Three ecoregions defined

to organize the feasibility study and opportunities assessment



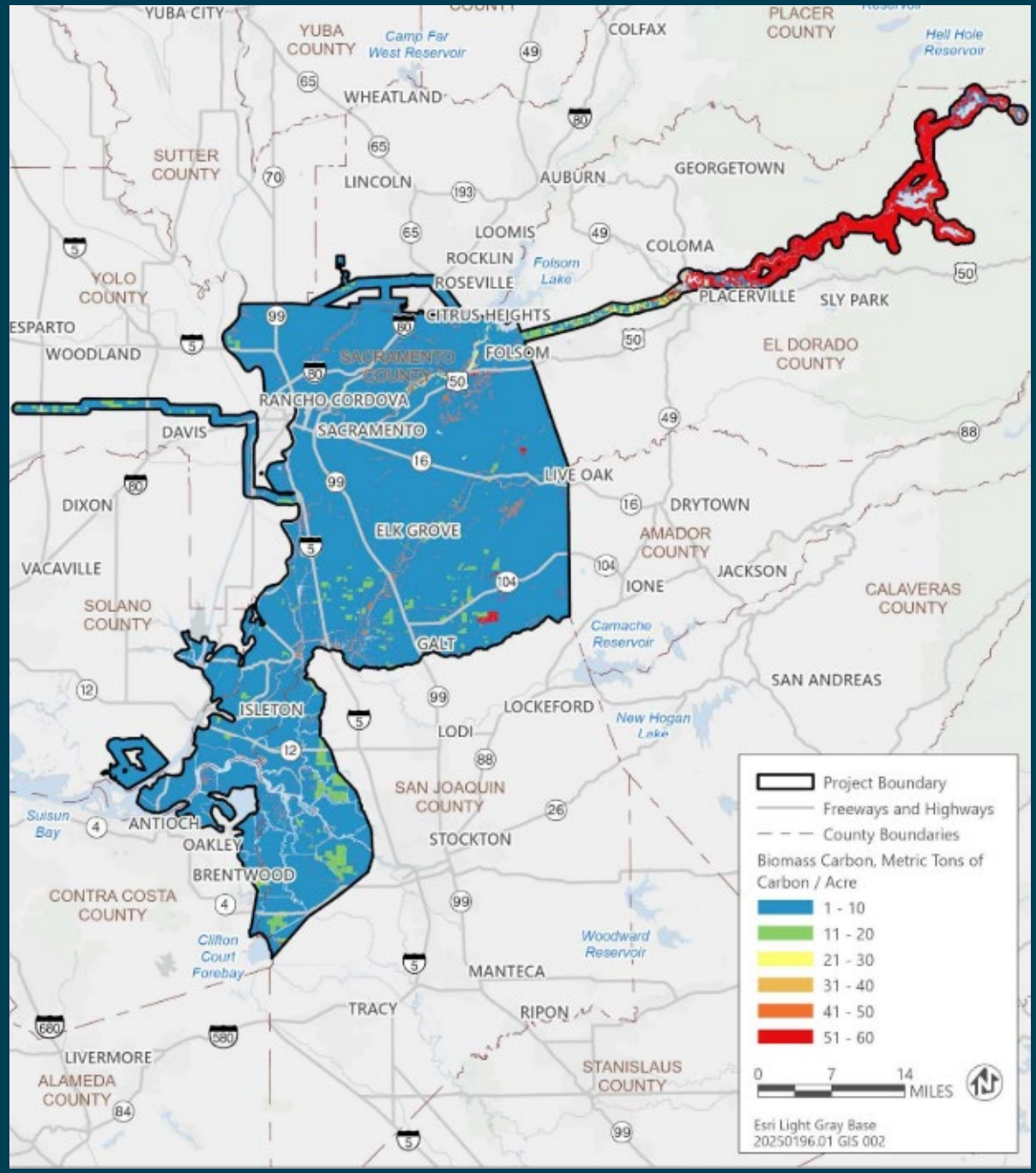
Landcover patterns distinguish the three regions



Source: Data provided by CAL FIRE, DWR, and NWI in 2026. Adapted by Ascent in 2026.

Source: Ascent 2026

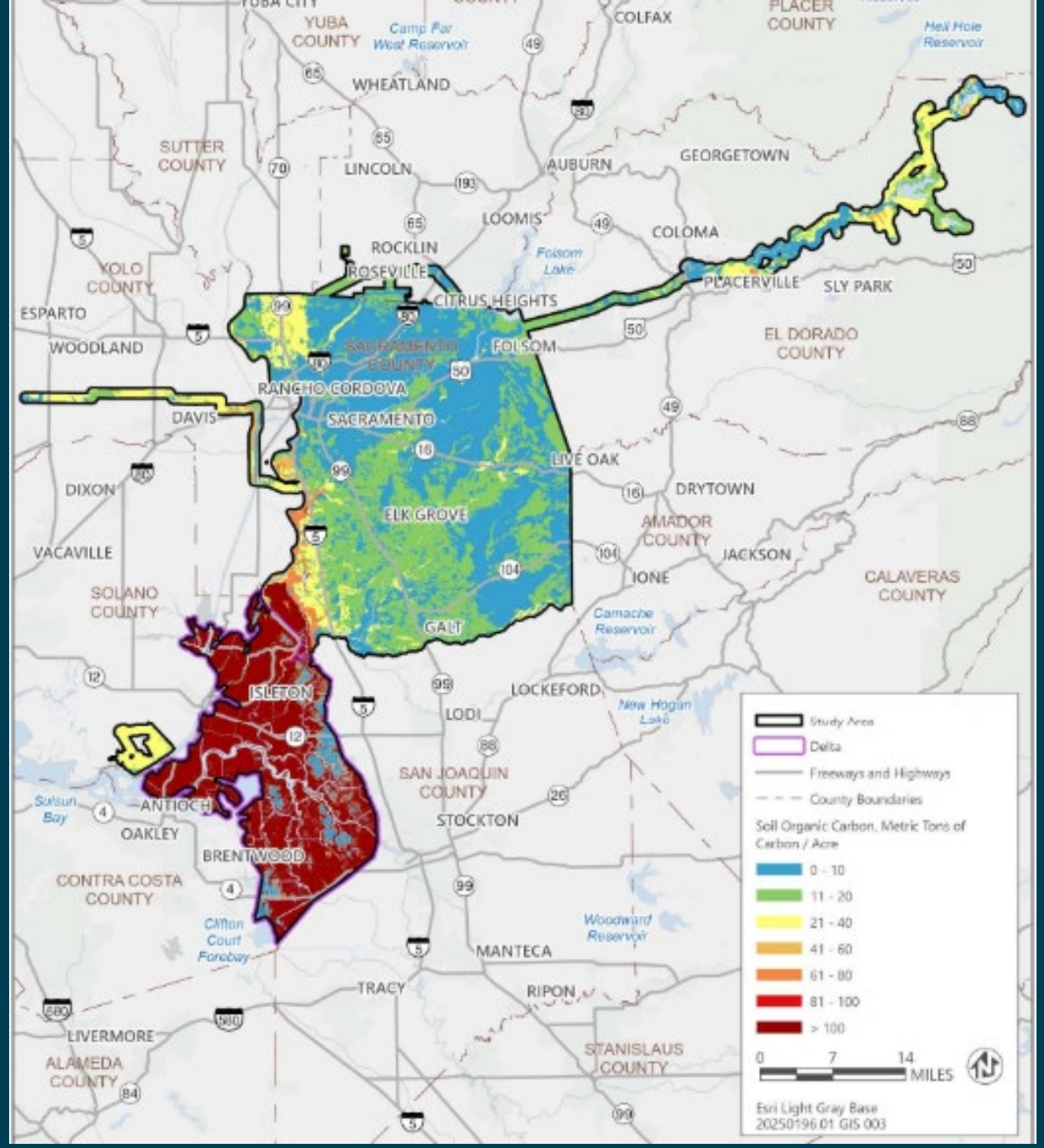
Biomass (aboveground) carbon density is highest in the Sierra portion of the study area



Source: Ascent 2026

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Soil carbon density is highest in Delta peatlands

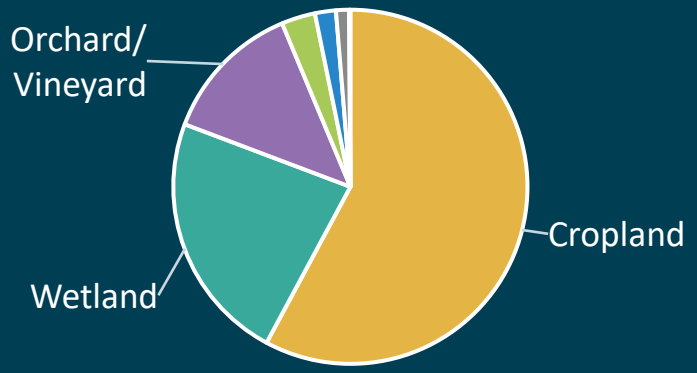


Source: Ascent 2026

Landcover composition guides practice assessment by region

Delta

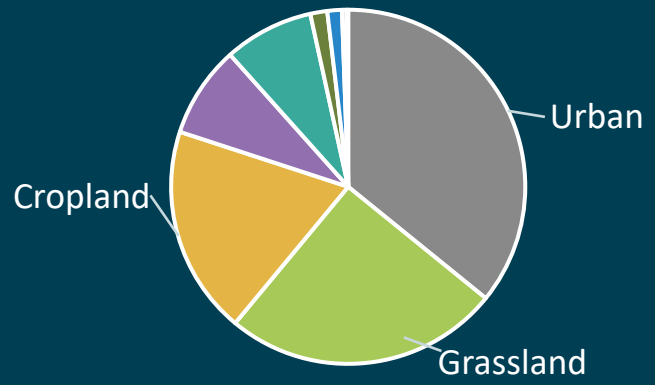
Cropland and wetlands predominate



Landcover	Acres	%
Cropland	**121,297**	**58**
Wetland	**48,003**	**23**
Orchard/Vineyard	**27,162**	**13**
Grassland	6,464	3
Water	4,006	2
Urban	2,493	1
Other	244	<1

Central Valley

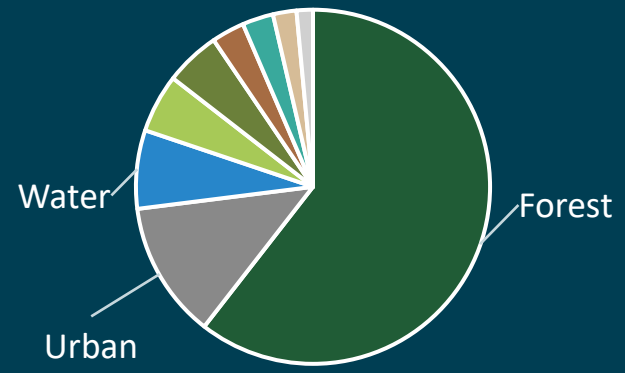
Urban land, grassland, and cropland form a mixed landscape



Landcover	Acres	%
Urban	216,637	**36**
Grassland	152,189	**25**
Cropland	114,893	**19**
Orchard/Vineyard	50,551	8
Wetland	49,418	8
Oak Woodland	9,332	2
Water	8,052	1
Forest	2,380	<1
Barren	1,011	<1

Sierra Nevada

Forest is the dominant landcover



Landcover	Acres	%
Forest	**51,715**	**61**
Urban	**10,667**	**12**
Water	6,120	7
Grassland	4,553	5
Oak Woodland	4,298	5
Shrubland	2,565	3
Wetland	2,424	3
Barren	1,832	2
Other	1,275	1

How Biodiversity Informs the Feasibility Study

1. Practice Selection

Carbon + biodiversity

Prioritize practices with strong carbon and habitat benefits.

Retain selected practices having uncertain carbon benefits when biodiversity benefits are strong.

2. Site Opportunity Screening

Right practice + right place

Protect or enhance areas with high existing biodiversity value.

Restore or connect habitats where appropriate.

Identify and avoid significant ecological tradeoffs.

Matching Candidate Practices to Regional Landcover for Further Evaluation

Ecoregion	Landcover Type	Study Area Acreage	Candidate Practice Types													
			P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	P13	P14
Delta	Cropland	148,459	●	●	●			●	●			●				
	Wetland	48,003	●					●	●							
	Grassland	6,464	●		●			●	●	●						
	Urban	2,493			●		●									
Central Valley (Non-Delta)	Urban	216,637			●		●									
	Cropland	165,444	●	●	●						●					
	Grassland	152,189	●		●					●	●					●
	Wetland	49,418	●					●								
	Oak Woodland	9,332	●			●										●
	Forest	2,380	●			●								●	●	
Sierra Nevada (UARP)	Forest	51,715	●			●								●	●	
	Urban	10,667			●		●								●	
	Grassland	4,553	●		●					●			●			●
	Oak Woodland	4,298	●			●										●
	Shrubland	2,565	●			●									●	
	Wetland	2,424	●					●					●			
	Cropland	1,275	●	●	●											

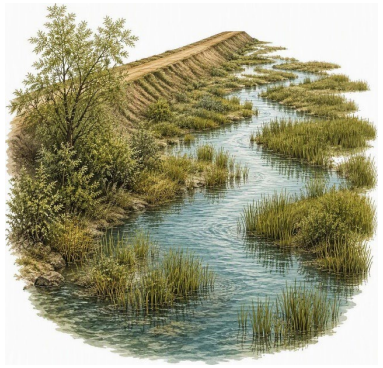
Practice Type Key

P01. Avoid Land Conversion
P02. Climate Smart Agriculture
P03. Hedgerow Establishment
P04. Fuels Reduction Treatments
P05. Urban Tree Plantings
P06. Non-Tidal Wetland Restoration
P07. Tidal Wetland Restoration
P08. Grassland Management Practices
P09. Riparian and/or Floodplain Restoration
P10. Conversion to Rice or Paludiculture
P11. Meadow Restoration
P12. Reforestation/Forest Restoration
P13. Wildland Urban Interface Defensible Space
P14. Oak Woodland Restoration

Notes: Only landcover types with at least 1,000 acres within each ecoregion's portion of the Study Area are presented. Acreages represent mapped landcover extent, not acreage suitable or available for practice implementation. Several practice types in this table encompass multiple individual practices.

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Delta Region: Protecting Peat Soil Carbon



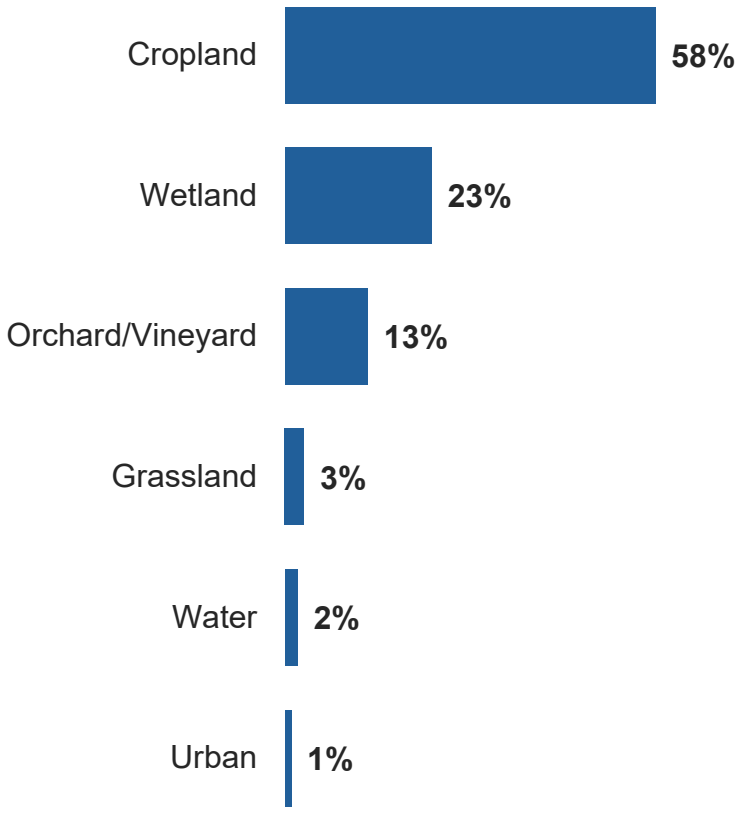
LANDSCAPE CHARACTERISTICS

Predominately peat soil agriculture and managed wetlands. Deep organic soil carbon stores accumulated when area supported tidal marsh for ~7,000 years prior to land reclamation for agriculture.

CARBON OBJECTIVE

Halt ongoing peat oxidation emissions and protect significant stored soil carbon through rewetting.

LANDCOVER, % OF REGION'S STUDY AREA



POTENTIALLY RELEVANT PRACTICES

Described in this presentation

- Non-Tidal Wetland Restoration
- Conversion to Rice or Paludiculture

Additional candidate practices

- Tidal Wetland Restoration
- Avoid Land Conversion
- Climate Smart Agriculture
- Grassland Management Practices
- Hedgerow Establishment
- Urban Tree Plantings

Delta Peatlands: Nontidal Wetland Restoration

NONTIDAL WETLAND RESTORATION



CARBON BENEFIT

~8.25 MT CO_2e/acre/year*

MECHANISM

Restore shallowly flooded emergent wetland on drained peat soils. Halts peat oxidation and supports biomass and soil carbon accumulation.

SCREENING COST

~$3,000–$7,000/acre* implementation cost

PRACTICE COBENEFITS

Strong co-benefits for biodiversity and habitat. Subsidence reversal co-benefits increase ecological resilience and can support levee stability and state water supply reliability.

* Carbon and cost estimates are preliminary screening values and subject to refinement in the final feasibility study. GHG benefits represent average screening values; GHG net benefits depend strongly on baseline peat-soil emissions.

Sources: CARB 2022, Appendix I; Hemes et al. 2019; Vaughn et al. 2024.

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Delta Peatlands: Rice Farming

RICE FARMING



CARBON BENEFIT

~2.58 MT CO_2e/acre/year*

MECHANISM

Convert drained-rootzone agriculture to rice farming on suitable peat soils. Reduce ongoing peat-soil emissions. Benefit depends on baseline conditions.

SCREENING COST

~$1,000/acre* initial conversion cost

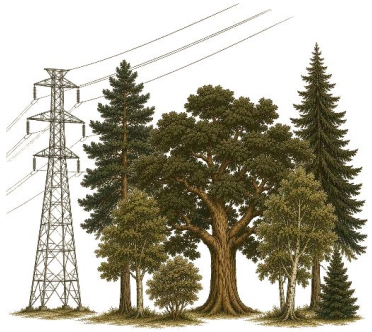
PRACTICE COBENEFITS

Can provide waterbird habitat and halt peat-soil subsidence while retaining agricultural production. Habitat benefits depend on field and water management.

* Carbon and cost estimates are preliminary screening values and subject to refinement in the final feasibility study. GHG benefits represent average screening values, GHG net benefits depend strongly on baseline peat-soil emissions.

Sources: CARB 2022, Appendix I; CDFA Healthy Soils (Bingham 2026); Vaughn et al. 2024.

Sierra Nevada Region: Reducing Wildfire Carbon Loss



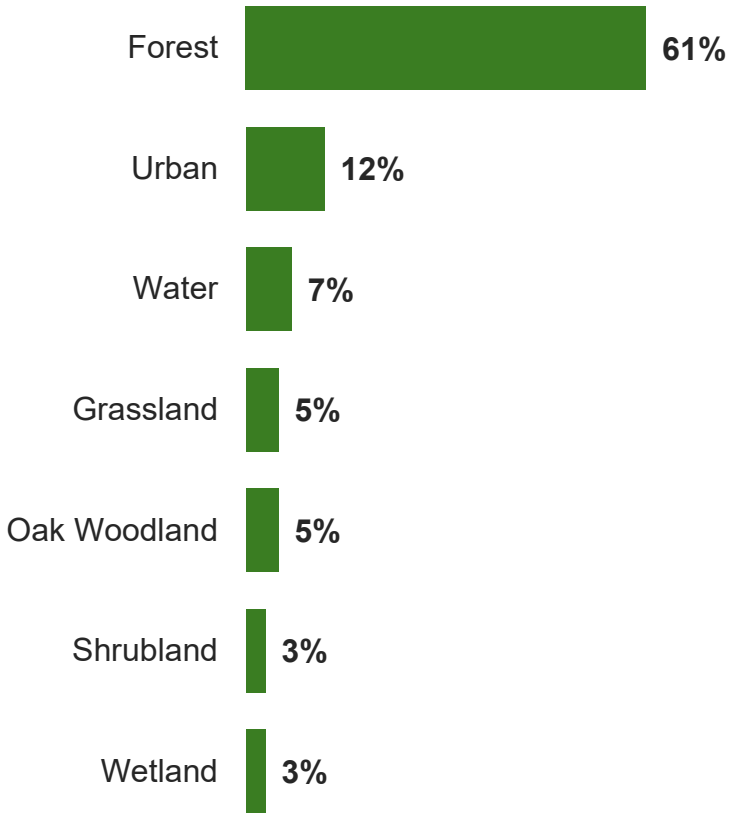
LANDSCAPE CHARACTERISTICS

Forests, shrublands and oak woodlands. Steep terrain, dense forest, and increasing wildfire risk shape carbon outcomes.

CARBON OBJECTIVE

Reduce severe wildfire-driven biomass loss and support resilient recovery.

LANDCOVER, % OF REGION'S STUDY AREA



POTENTIALLY RELEVANT PRACTICES

Described in this presentation

- Fuels Reduction Treatments

Additional candidate practices

- Avoid Land Conversion
- Reforestation/Forest Restoration
- Wildland Urban Interface Defensible Space
- Oak Woodland Restoration
- Meadow Restoration
- Grassland Management Practices
- Climate Smart Agriculture
- Hedgerow Establishment
- Urban Tree Plantings

Sierra Nevada Forests: Fuels Reduction

THINNING + PRESCRIBED FIRE



CARBON BENEFIT

Avoided carbon loss
+ forest carbon resilience

No defensible generic CO_2e/acre/year value determined

MECHANISM

Strategic thinning and prescribed fire reduce ladder and surface fuels, reducing catastrophic wildfire risk. Helps protect long-term forest carbon stocks by reducing the risk of carbon loss from high-severity wildfire.

SCREENING COST

~$800–$2,500/acre* treatment

PRACTICE COBENEFITS

Significant co-benefits include forest resilience, biodiversity and habitat values, and protection of SMUD infrastructure. Additionally reducing forest density may increase base streamflows for hydropower generation.

* Carbon and cost estimates are preliminary screening values and subject to refinement in the final feasibility study.
Sources: CARB 2022 Appendix I; Wear et al. 2025; Guo et al. 2023; Saksa et al. 2017

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Central Valley Region: Building Soil and Biomass Carbon



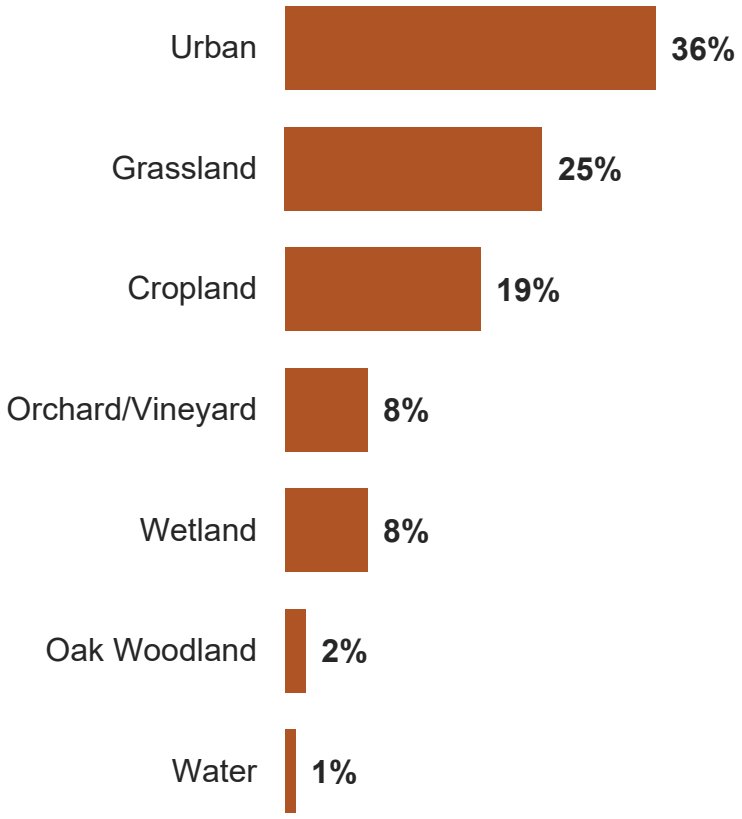
LANDSCAPE CHARACTERISTICS

Urban areas, grasslands, and mineral soil agricultural landcovers predominant in a mosaic.

CARBON OBJECTIVE

Maintain stable land uses (preserve high value landcover types from urban development) and build or retain soil and biomass carbon.

LANDCOVER, % OF REGION'S STUDY AREA



POTENTIALLY RELEVANT PRACTICES

Described in this presentation

- Grassland Management Practices
- Avoid Land Conversion
- Hedgerow Establishment

Additional candidate practices

- Urban Tree Plantings
- Riparian and/or Floodplain Restoration
- Non-Tidal Wetland Restoration
- Fuels Reduction Treatments
- Reforestation/Forest Restoration
- Wildland Urban Interface Defensible Space
- Oak Woodland Restoration
- Climate Smart Agriculture

Central Valley: Grassland Compost Addition

GRASSLAND COMPOST ADDITION



CARBON BENEFIT

~0.2–4.5 MT CO_2e/ac/yr*

MECHANISM

Compost application increases soil carbon, supports plant growth. Best fit: low-diversity rangelands.

SCREENING COST

~$320–$510/acre/application*

PRACTICE COBENEFITS AND TRADEOFFS

Co-benefits/tradeoffs: potential soil health, water retention, grassland/forage productivity, erosion reduction, and waste-management benefits; potential nutrient runoff and native biodiversity impacts (increased fertility may favor nonnative plant species).

* Carbon and cost estimates are preliminary screening values and subject to refinement in the final feasibility study.

Sources: Comet-Planner 2025; CARB 2017; Gravuer 2016.

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Central Valley: Avoided Grassland Conversion

AVOIDED GRASSLAND CONVERSION



CARBON BENEFIT

~0.16–0.83 t CO_2e/ac/yr*

modeled avoided emissions from preventing grassland-to-cropland conversion

MECHANISM

Protects existing land-based carbon stocks by avoiding land type conversion. Best fit: grasslands with credible risk of land conversion.

SCREENING COST

Site-specific

Conservation easement / opportunity cost

PRACTICE COBENEFITS

Avoids habitat loss and fragmentation, with strong biodiversity and permanence benefits. A low-regrets strategy where high-value grasslands face credible conversion pressure.

* GHG benefit depends on conversion risk and baseline; value shown represents avoided conversion to croplands. Carbon estimate is a preliminary screening value and subject to refinement in the final feasibility study.

Source: Diaz et al. 2015

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Central Valley: Hedgerow Planting

HEDGEROW PLANTING



CARBON BENEFIT

~6.7 MT CO_2e/ac/year*

modeled for conversion from croplands

MECHANISM

Adds woody biomass carbon while retaining existing land use. Planting with deep mulching can also increase soil carbon stores. Best fit: agricultural edges, field margins, selected degraded grasslands, utility corridors, solar or wind facility perimeters.

SCREENING COST

~$17,000–$29,000/acre

of hedgerow established. Small footprints limit total project cost.

PRACTICE COBENEFITS

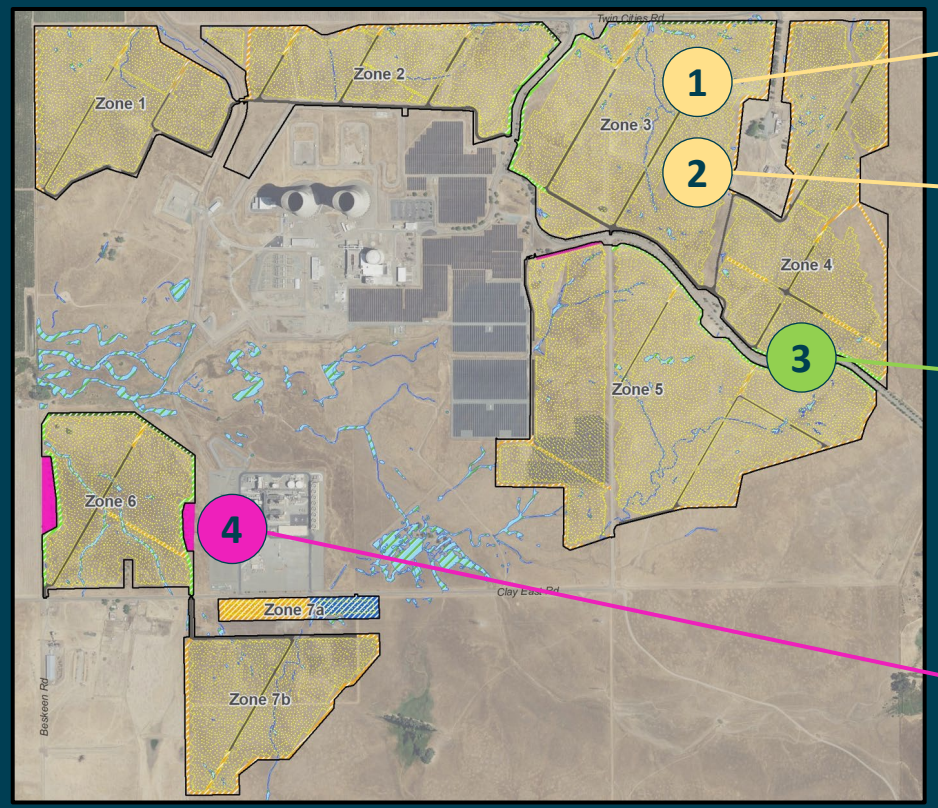
Strong biodiversity, habitat, and aesthetic benefits on working lands. Provides pollinator/beneficial-insect habitat, wildlife habitat, and habitat connectivity.

* Primarily cropland-based factor (which incorporates reduced emissions from eliminating tillage and fertilizer addition). Significantly lower confidence on grasslands.

Sources: CARB 2022 Appendix I, Chiartas et al. 2022.

Prior Project Exploration Example: Rancho Seco Solar II

This is a SMUD carbon and biodiversity opportunities project in progress, which stacks land management practices that are solar-compatible and mutually reinforcing for biodiversity, habitat, and carbon benefits on an operating large-scale solar facility.



1 Native pollinator/native grassland seeding

Native grass and forb seeding within arrays.
Biodiversity, habitat, + potential carbon benefits

2 Targeted sheep grazing

Managed grazing replaces mowing for forage + fuel control.
Biodiversity, habitat, and potential carbon benefits.

3 Native hedgerows with soil rehabilitation treatments

Rehabilitate degraded/compacted soils (carbon and habitat benefits). Plant native flowering shrubs along array edges and roads (low-stature where near panels), for aesthetic, habitat, biodiversity, and potential carbon benefits.

4 Native hedgerows without soil rehabilitation treatments

Plant flowering shrubs in healthy native soils, along array edges and roads, for aesthetic, habitat, biodiversity, and potential carbon benefits.

Source: GEI Consultants 2020

Updated Study Schedule

- **Develop Study Area** – Complete
- **Conduct Mapping and Develop Carbon Stock Inventory and Forecast** – Complete
- **Identify and Assess Practice Types and Opportunities –** Fall 2026
    1. Identify SMUD specific opportunities
    2. Conduct assessment
    3. Prepare project development framework
    4. Review with SMUD's Integrated Resource Planning Team
- **Complete Feasibility Study** – Winter 2026

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