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From Wetland Ecosystem Services to Nature-based Solutions

ADB HQ on 27–30 June 2023

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Nature Based Solutions: An Introduction and Case Studies

Conor Shea, Ph.D., P.E.
Civil Engineer – Hydraulics and Geomorphology

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Professional Background:

- **Civil Engineer**
- **Fluvial Geomorphologist**

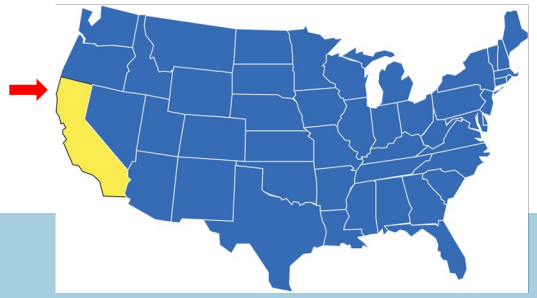
Role:

- U.S. Fish and Wildlife Service

- Design and implement restoration projects to improve wetland and stream habitats for fish and wildlife

Office Location:

- Northern California Coast, USA



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LEARNING OBJECTIVES

- Define Nature Based Solutions
- Wetland Processes
- Design Approach for Nature Based Solutions
- Nature Based Techniques
- Set Up for Breakout Session on Identifying Solutions

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NATURE BASED SOLUTIONS

Nature based solutions:
- are inspired and supported by nature
- are cost-effective
- build resilience
- provide environmental, social and economic benefits.

Nature based solutions benefit biodiversity and support the delivery of a range of ecosystem services.

Example: Armored shoreline replaced by living shoreline that dissipates wave energy, allows sediment transfer to marsh, enhances habitat.

Adapted from: European Research Executive Agency, 2020; Photos: Maryland Department of Natural Resources

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SPECTRUM OF NATURE BASED SOLUTIONS

Restoration	Rehabilitation/ Remediation	Enhancement	Stabilization
Return processes, functions, and form to historic conditions.	Removal of impairments and improvement of degraded conditions, but not to historic conditions.	Create new habitat where it did not exist previously.	Stabilize degraded state against further impairment.

Decreasing physical and ecological resilience.
Decreasing freedom to adjust boundaries and for biota to adapt to disturbances.

Increasing factor of safety.
Increasing biological and physical diversity.

Adapted from Gillian et al. 2005

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NATURE BASED DESIGN PRINCIPLES

Design Philosophy for Nature Based Solutions:

Principles:

1. Target root causes of habitat and ecosystem impairment.
2. Restore physical, chemical, and biological ***processes*** that ***create*** and ***maintain*** natural environments.
3. Tailor restoration actions to local potential or historical condition.
4. Match scale of restoration to scale of problem.
5. Define expected outcomes.

Adapted from: Beechie et al., BioScience, 2010.

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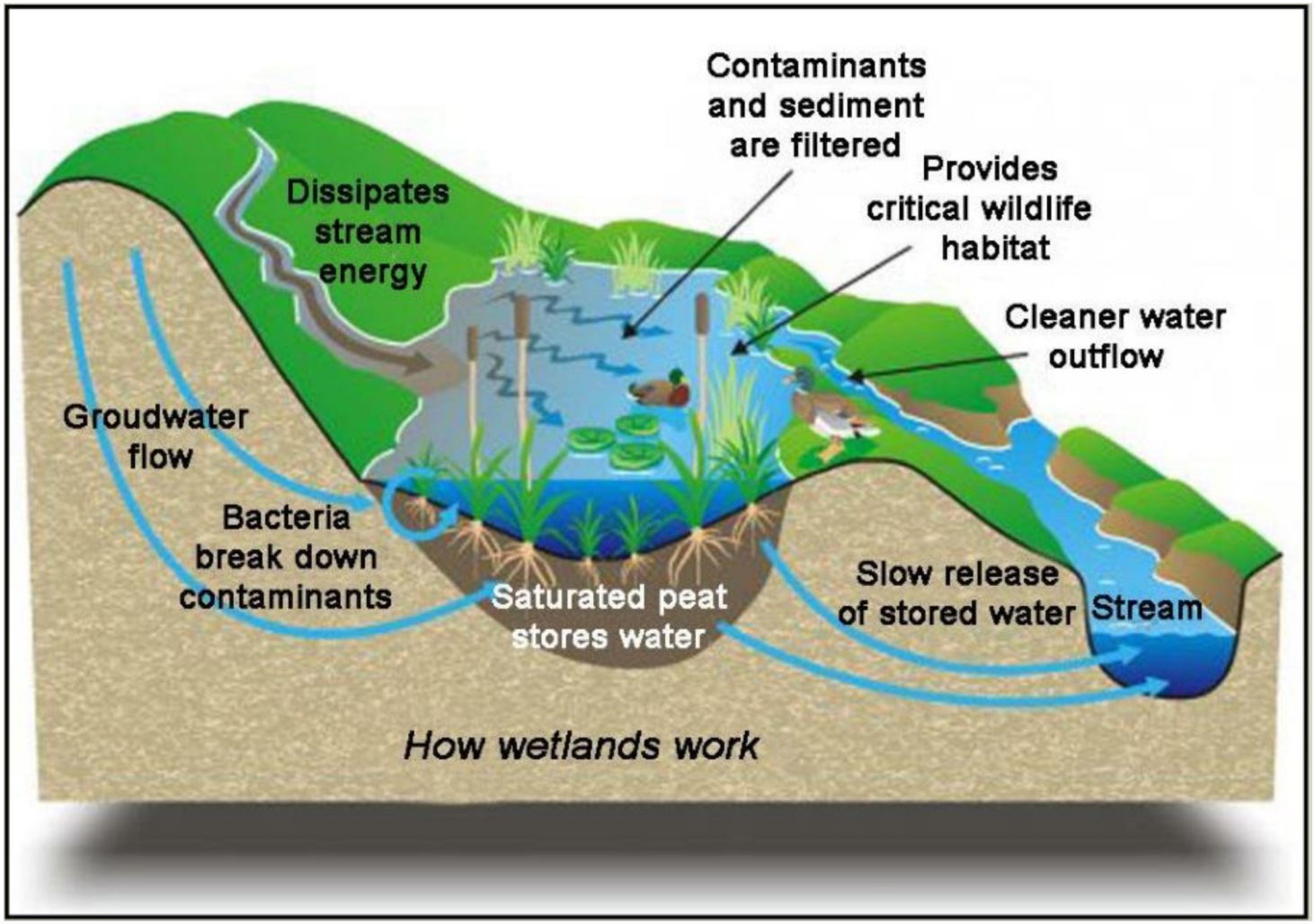
FRESHWATER WETLAND PROCESSES



Source: Wynn Cudmore, NSF Grant #0757239

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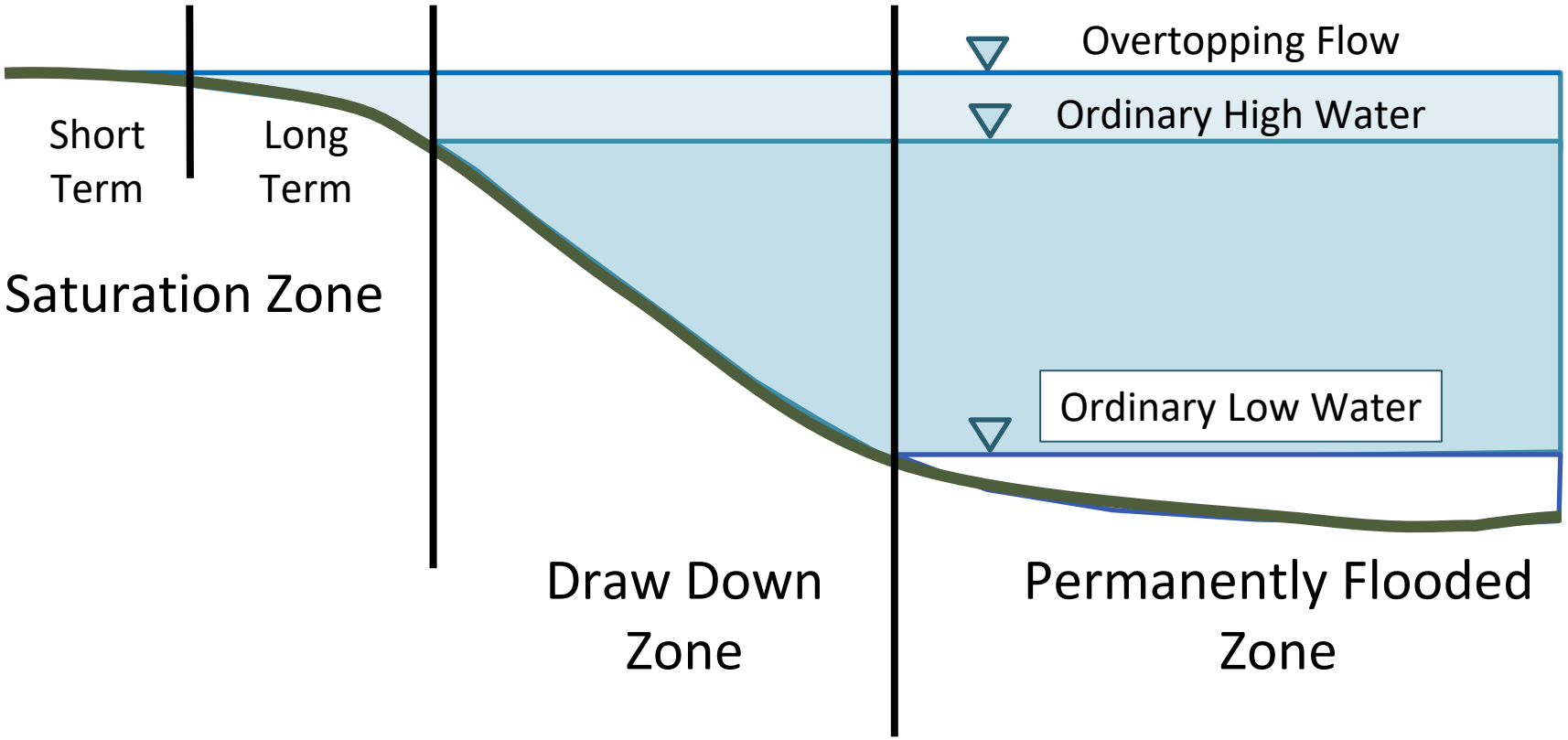
FRESHWATER WETLAND HYDROLOGIC ZONES



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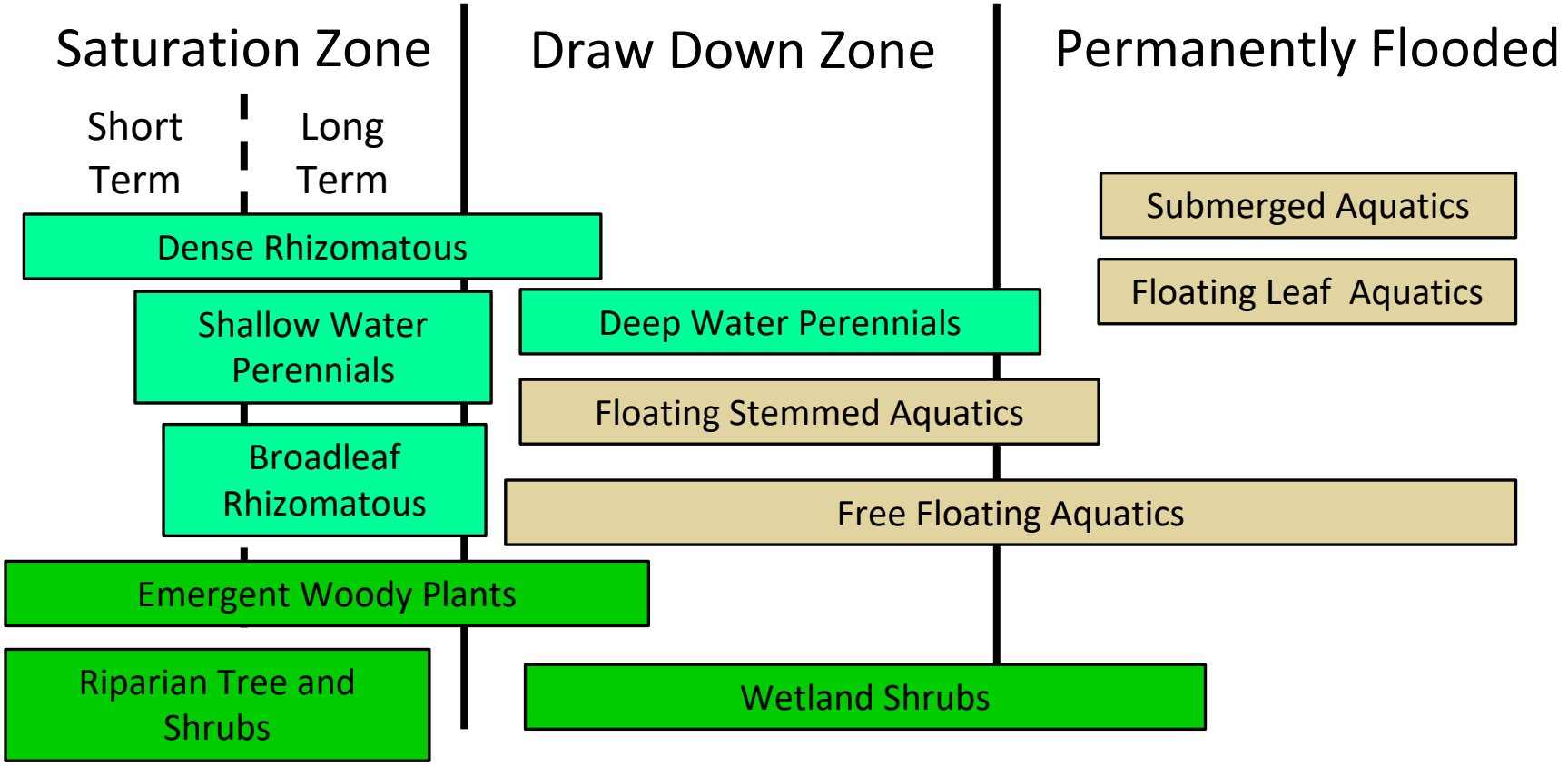
FRESHWATER WETLAND VEGETATION ZONES



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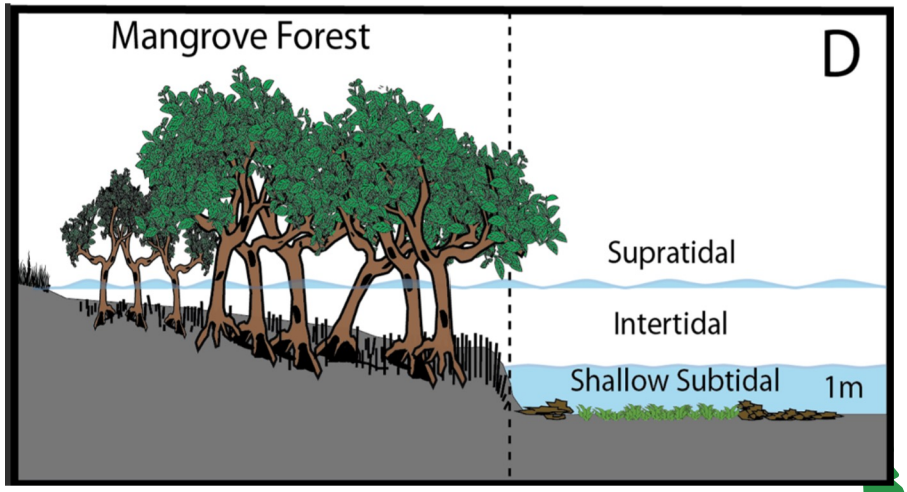
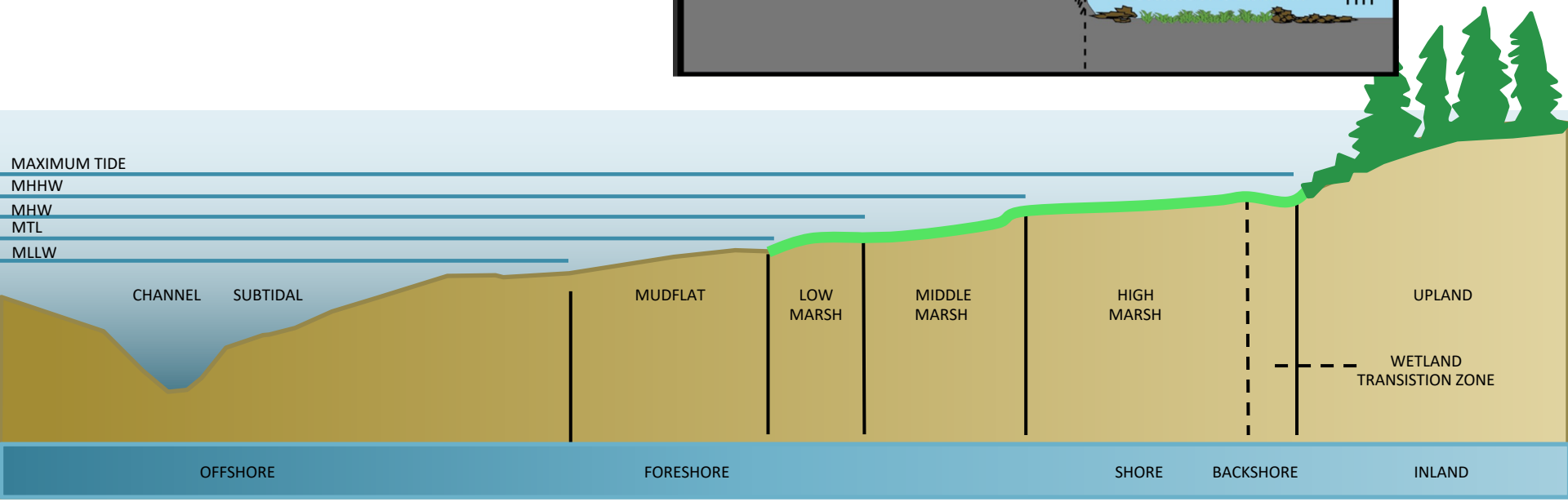
TIDAL WETLAND VEGETATION ZONES

Vegetation in Tidal Zones Controlled by Tidal Inundation





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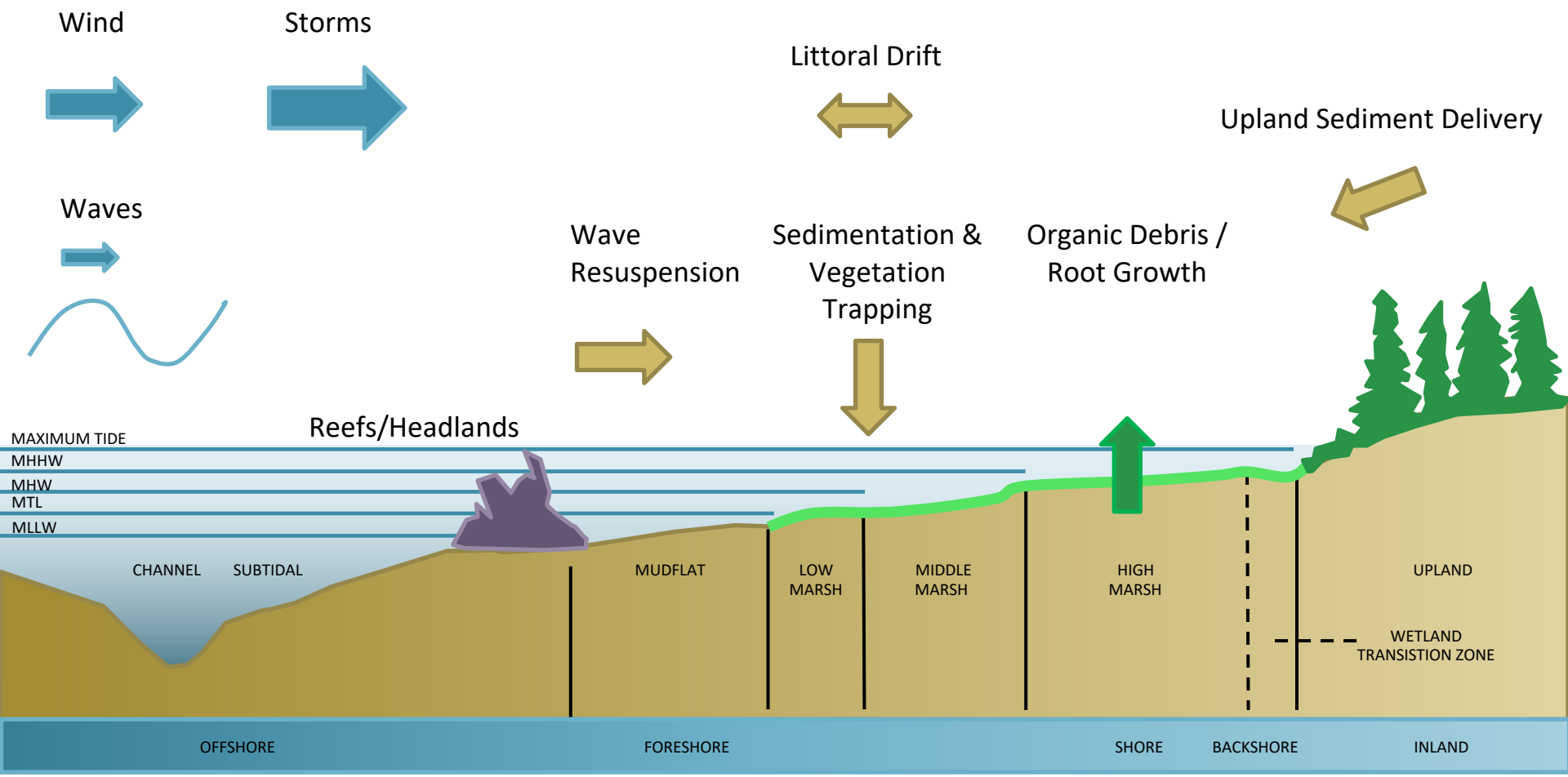
TIDAL WETLAND PROCESSES



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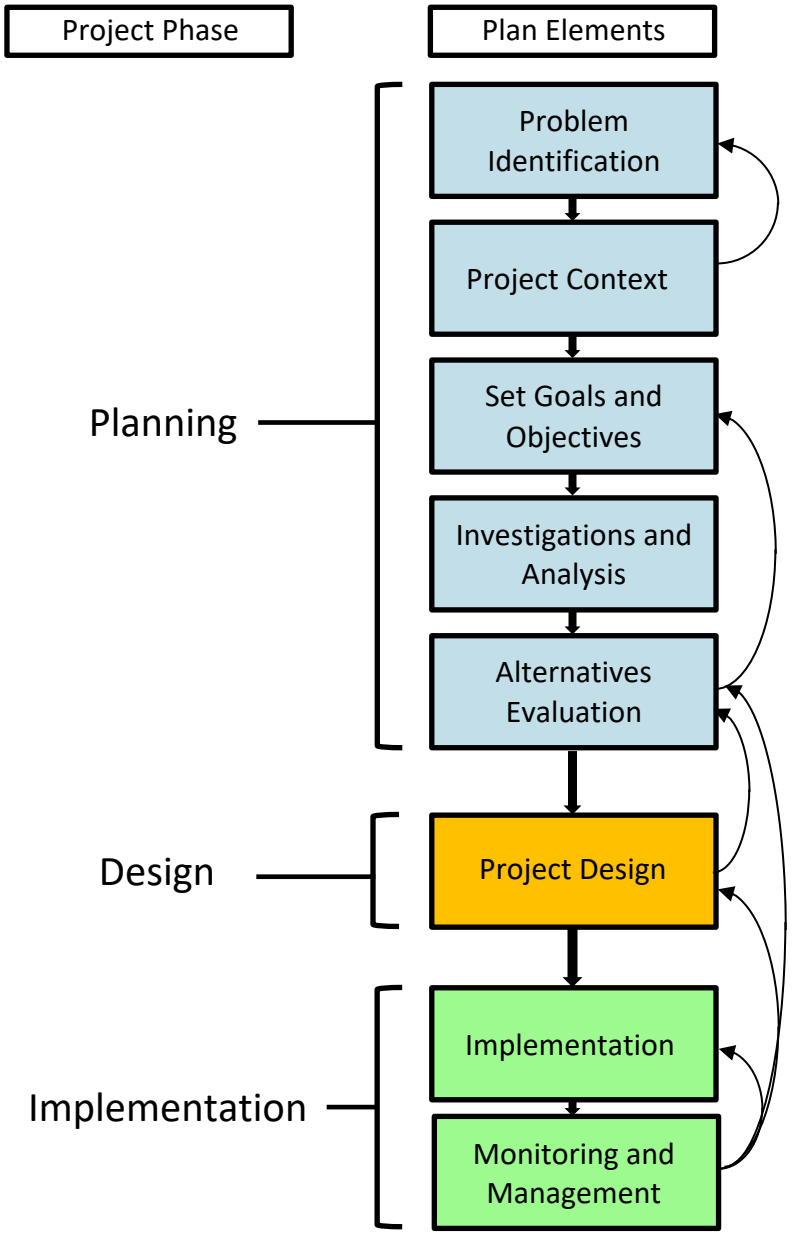
NATURE BASED SOLUTIONS PLAN DEVELOPMENT



Adapted from: Skidmore et al. 2011

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PROBLEM IDENTIFICATION: CAUSES OF WETLAND IMPAIRMENTS

Wetland Functions and Ecosystem Services are Impaired when Processes are Disturbed by:

- Agricultural Reclamation
- Flood / Shore Protection
- Urbanization
- Subsidence
- Dredging/Navigation
- Water Pollution
- Roadways/Utilities
- Sea Level Rise
- Invasives
- Lack of Protection

Restore Processes by Addressing Causes

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PROBLEM IDENTIFICATION: PROBLEM SCALE

Identify Scope of Impairment and Causes:

Local:
- Land Use Disturbances
- Infrastructure

Regional:
- Urbanization
- Diversion of Water/Sediment

Temporal:
- Climate Change
- Subsidence/Sea Level Rise
- Typhoon/Flooding

Ecological:
- Disease
- Invasives

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PROJECT CONTEXT

- Geomorphic and Ecological Setting:
  - Hydrologic and Sediment Regime
  - Climate and Geology
  - What is Feasible?
  - What is Appropriate?
- Physical Constraints:
  - Infrastructure
  - Legacy Impacts
  - Existing Land Use
- Social and Economic Issues
- Management Goals
- Regulatory Issues

SETTING GOALS AND OBJECTIVES

Goals (What):

- Defines desired project outcome
- Efficiently express project intent
- Set framework for evaluating project actions
- Avoid prescriptive statements
- Do not specify methods

Objectives (How):

- Define specific actions for achieving goals
- Specify measurable actions
- Realistic/Achievable

EXAMPLE GOAL STATEMENTS

- Restore the natural character and function of freshwater wetland complex and improve fish habitat
- Rehabilitate ecological functions of degraded salt marsh and improve habitat availability for migratory shorebirds
- Prevent further loss of mudflat habitat
- Promote salt marsh resilience to rising sea levels

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SMART OBJECTIVES

SMART – Criteria for Defining Project Objectives:

- **Specific**: objectives are clear, concise statements that specify what you want to achieve.
- **Measurable**: objectives use parameters that can be measured before and after project implementation.
- **Achievable**: objectives are geomorphically and ecologically possible.
- **Relevant**: objectives are clearly related to and support the project goal.
- **Time bound**: objectives are bound by a specified time frame.

Adapted from Skidmore et al. 2011

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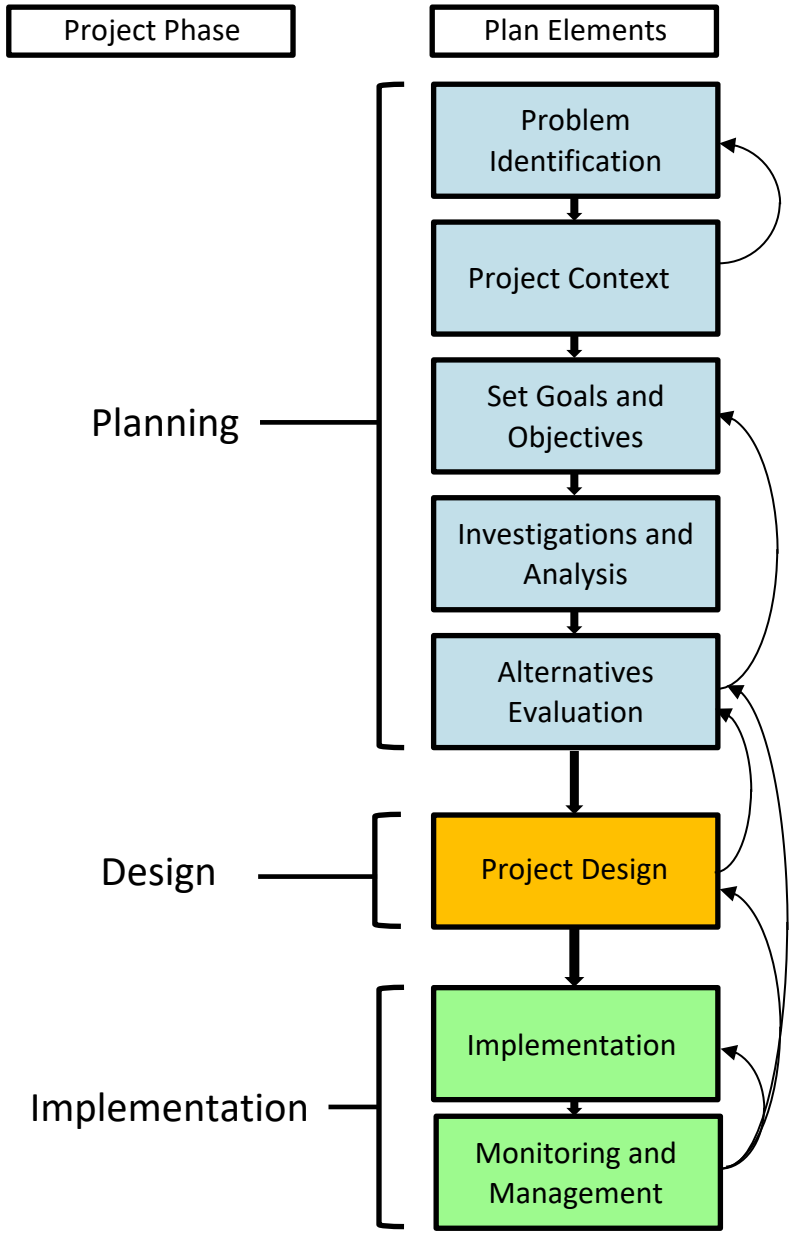
EXAMPLE GOAL AND OBJECTIVES

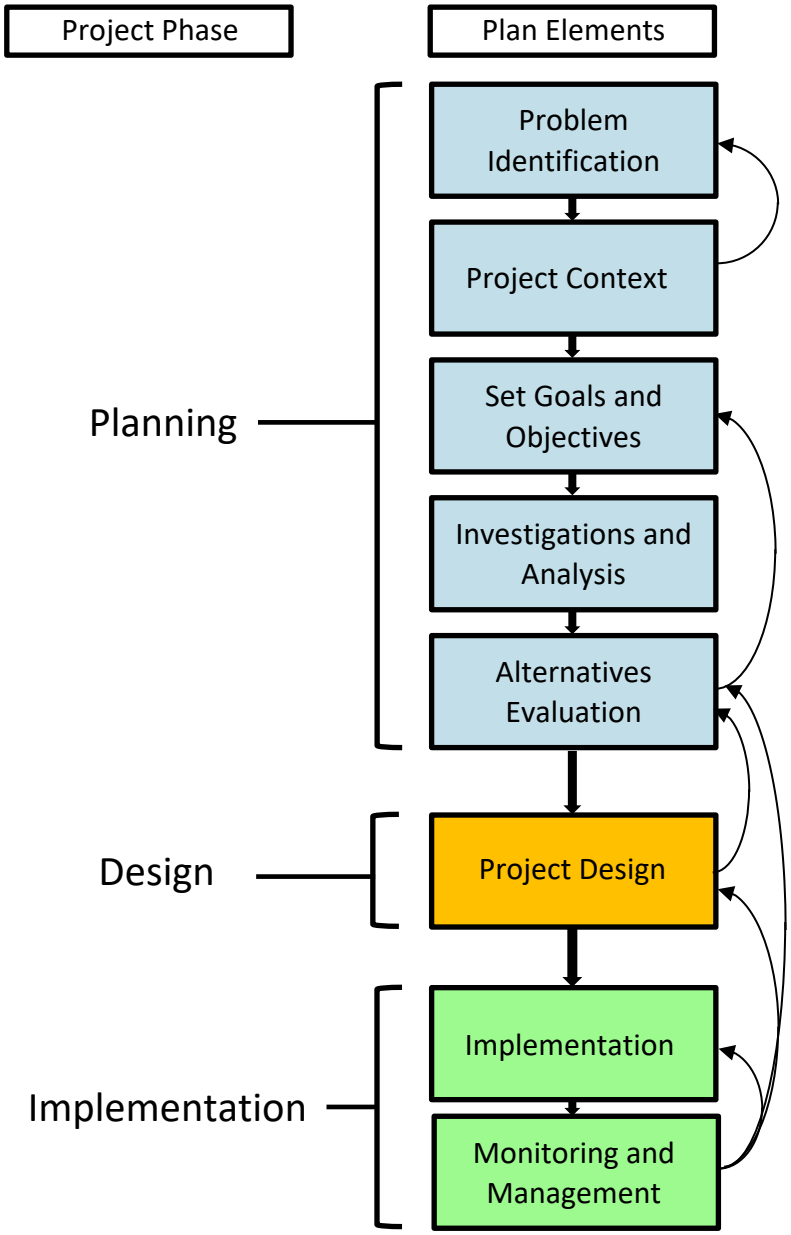
GOAL	OBJECTIVE	PARAMETER	TARGET	TIMEFRAME	RELEVANCE	ACHIEVABLE
Rehabilitate ecological functions of degraded salt marsh to improve habitat availability for migratory shorebirds.	Restore unmuted tidal hydrology	Tidal range: MHHW and MLLW	Salt marsh MHHW and MLLW within 0.1m of open bay/ocean.	At completion of project construction	Salt marshes rely on tidal flows to deliver sediment, nutrients, and water supply to a marsh.	Yes. Requires site analysis and appropriate hydraulic design.
	Establish native salt marsh vegetation	Percent cover of native species	Greater than 70% native species	Within 5 years	Native wildlife species adapted to native vegetation.	Yes. Requires analysis of ability of local vegetation to colonize site, necessity for planting plan, and planning for control of invasives
	Increase habitat for migratory shorebirds	Area of healthy salt marsh	250 Hectares of Marsh with greater than 70% native species	Within 5 years	Salt marsh habitat provides cover and forage for migratory birds.	Yes.
	Increase overwintering population	Population of target species	Increase winter population by 25%	Within 5 years	Salt marsh habitat provides cover and forage for migratory birds.	Maybe -- assumption is that improved habitat will increase population, but can not control other factors that impact population size (diseases, drought, etc.).



DEVELOP AND EVALUATE ALTERNATIVES

- Identify project elements that accomplish objectives
- Consider alternative actions including:
  - "no-action" alternative
  - passive management actions
- Question Constraints
- Evaluate effectiveness of alternatives:
  - Do project elements work together?
  - Does alternative restore processes?
- Compare and Rank Alternatives:
  - Evaluate effectiveness and costs
  - Consider costs of short-term impacts and long-term maintenance
- Select preferred alternative and document

Adapted from: Skidmore et al. 2011



DEVELOPING NATURE BASED DESIGNS

- Multi-disciplinary team: Engineers, Biologists, Geomorphologists, Environmental Scientists
- Establish that project elements accomplish objectives
- Plan for how project will be implemented

Adapted from: Skidmore et al. 2011

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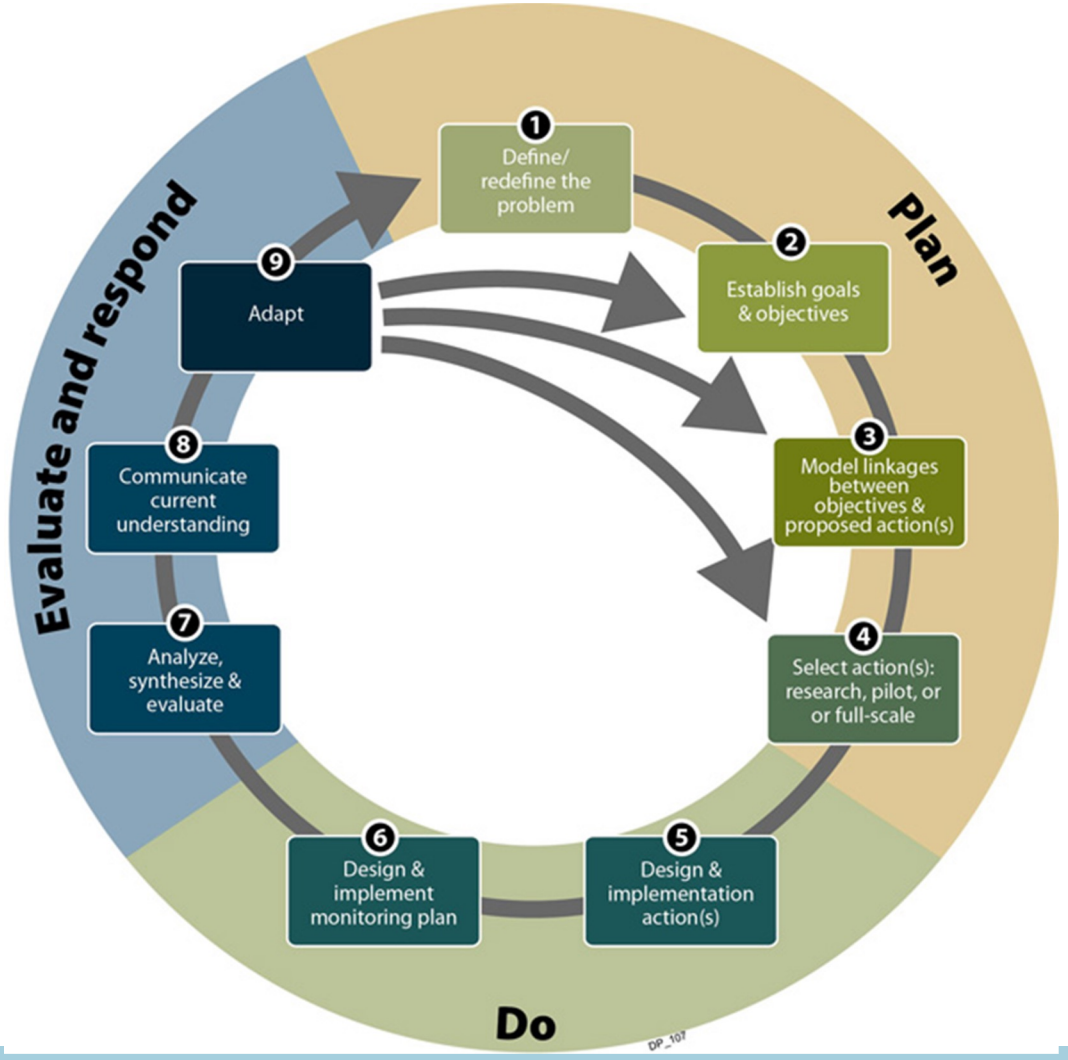
ADAPTIVE MANAGEMENT

- Implement
- Monitor
- Evaluate
- Question your Assumptions
- Adjust/Adapt Action



Graphic: California Department of Fish and Wildlife

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NATURE BASED RESTORATION TECHNIQUES

Employ natural materials (plants, sediment, wood, rock etc.) to restore or replicate natural processes

- **Living Shorelines**
- **Tidal Marsh Restoration**
  - **Horizontal Levees**
  - **Managed Retreat**
  - **Managed Tides**
- **Wetland Drainage Remediation**
- **Bioengineering**

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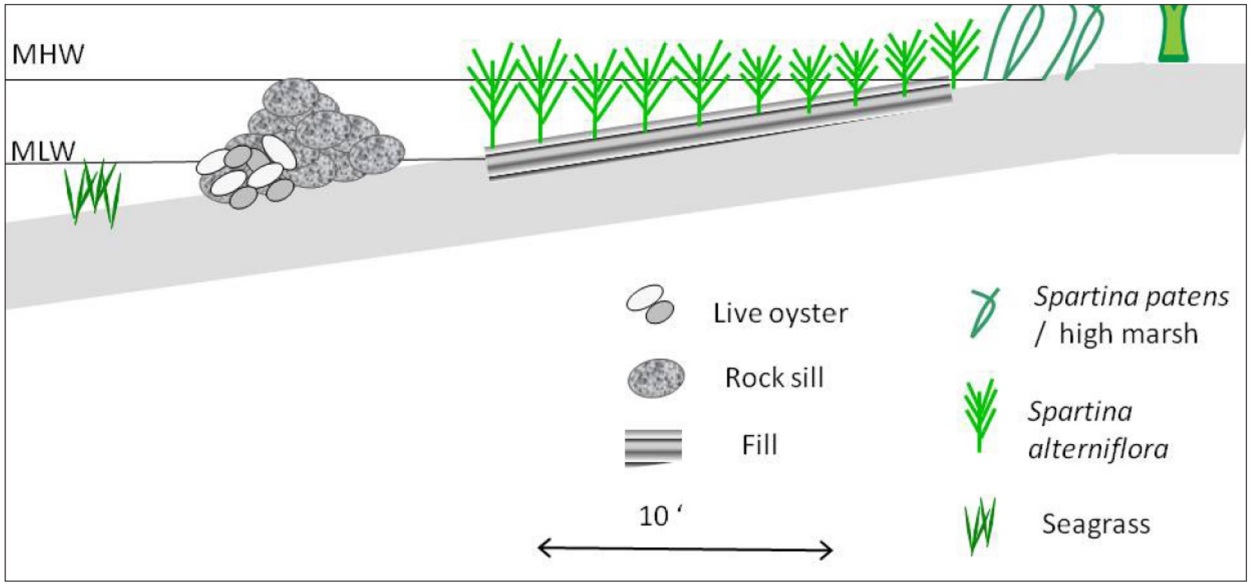
LIVING SHORELINES

Variety of techniques that restore natural shorelines using natural materials such as plants, oysters, or rock.

Typical Components:

- **Marsh planting**
- **Beach fill**
- **Toe protection**
- **Off-shore Sills/Breakwaters**
- **Bioengineering stabilization**



Images: USGS SIR Report 2010-5254

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LIVING SHORELINES

Design Objectives:

- **Remove hard shorelines**
- **Dissipate wave energy**
- **Trap sediment**
- **Restore biological connection between open water and upland**
- **Promote biological response**

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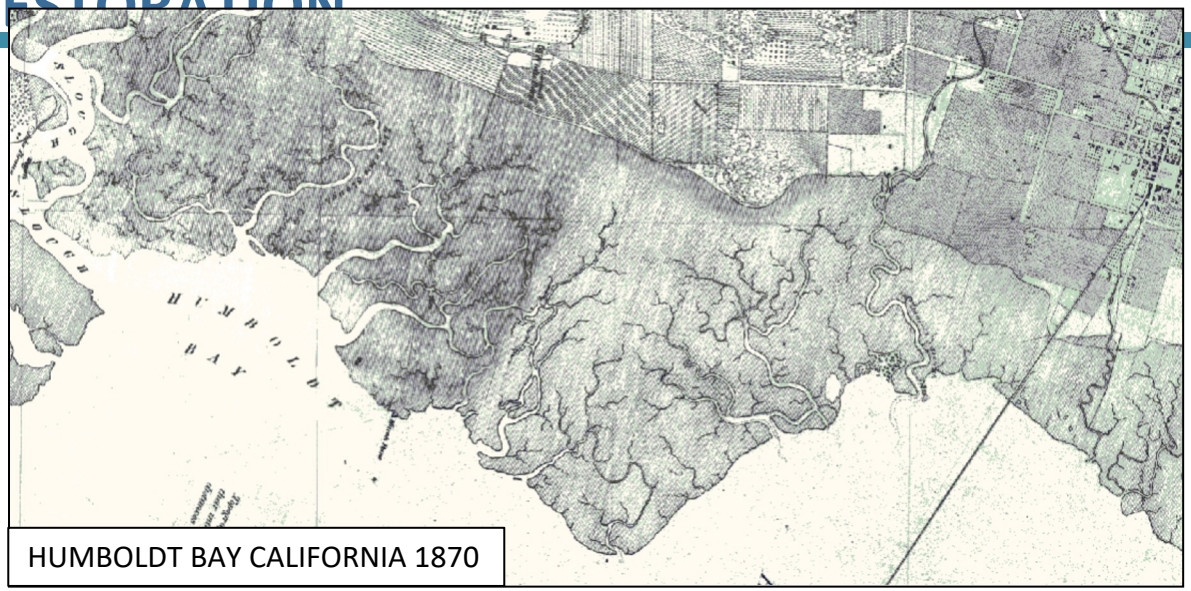
TIDAL MARSH RESTORATION

Goals:

- Retore reclaimed tidal marshes to original condition

Issues:

- Subsidence
- Sediment Supply
- Infrastructure conflicts
- Loss of Agricultural Land
- Flood protection
- Sea level rise



HUMBOLDT BAY CALIFORNIA 1870

HUMBOLDT BAY CALIFORNIA 2005

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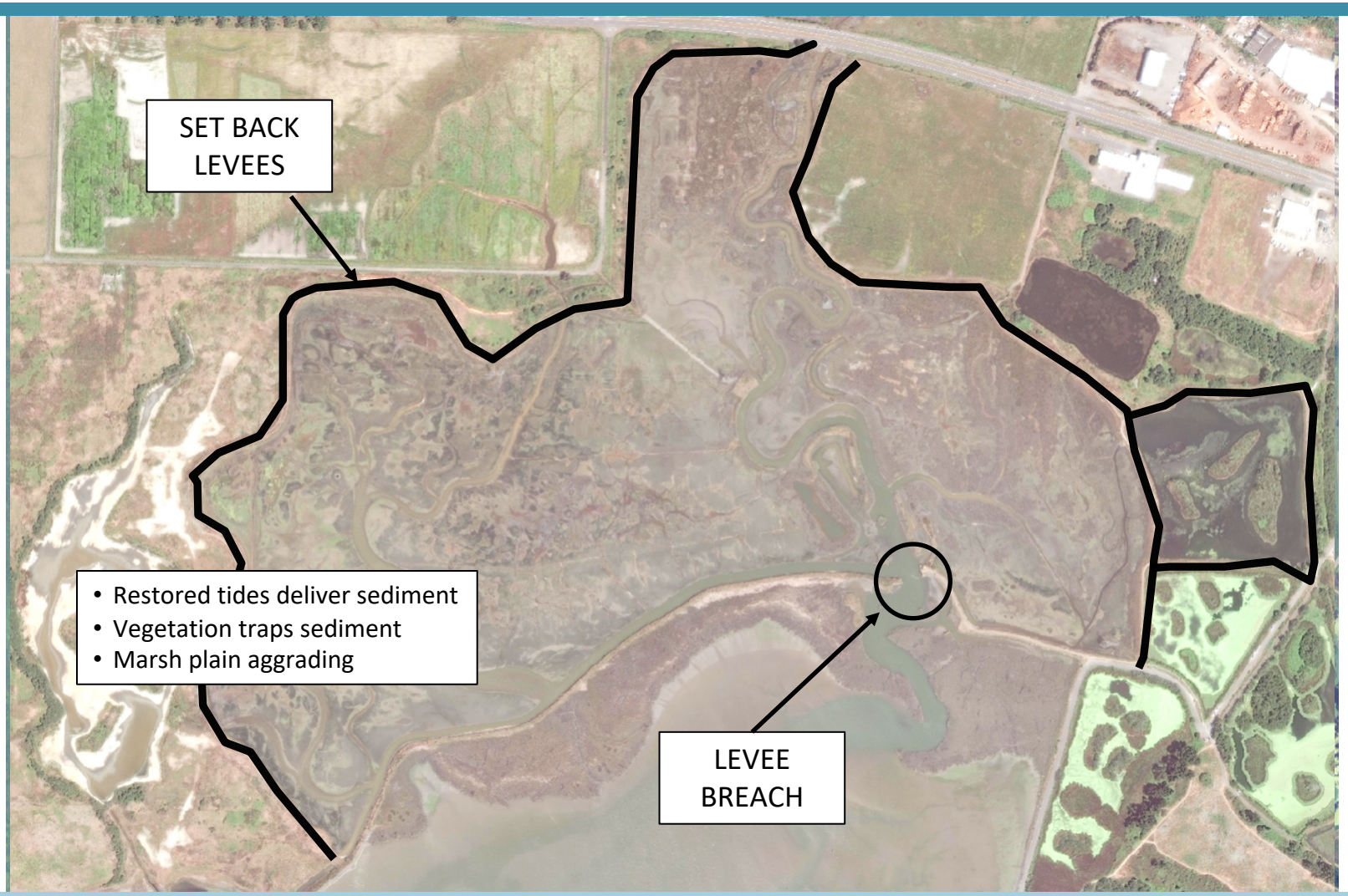
RESTORE TIDAL REGIME AND RETREAT



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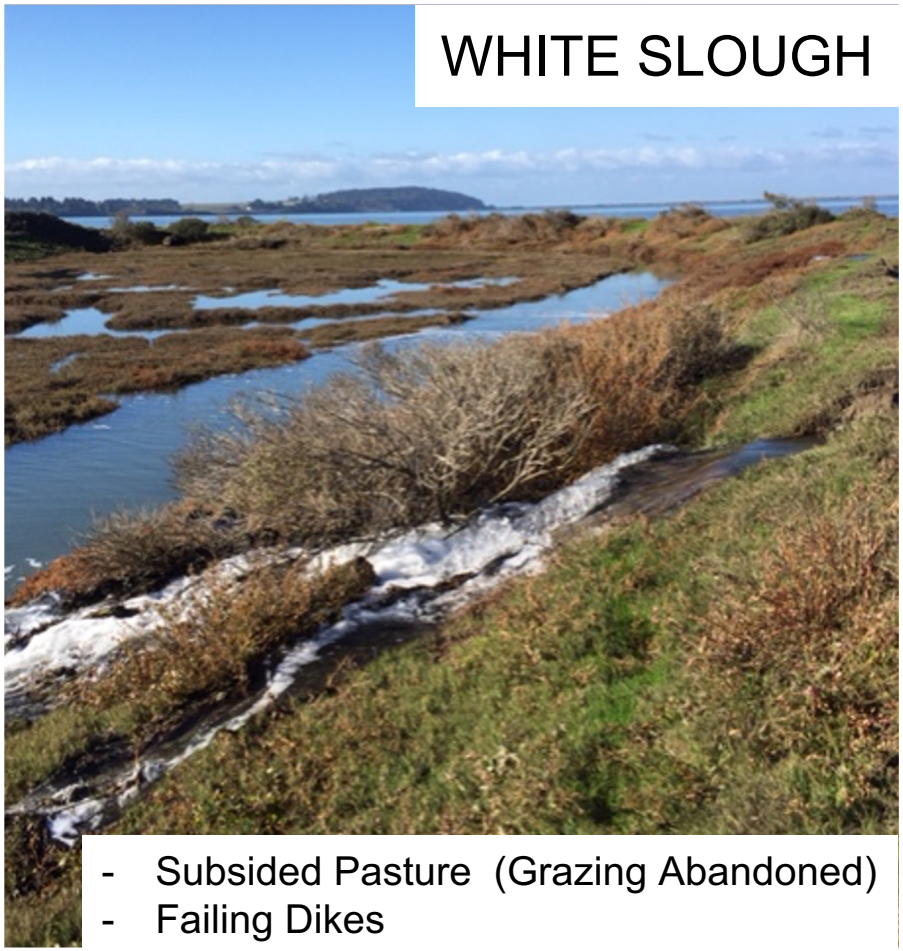
SUBSIDED MARSH RESTORATION



- Subsided Pasture (Grazing Abandoned)
- Failing Dikes

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SUBSIDED MARSH RESTORATION

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SUBSIDED MARSH RESTORATION

- 200,000 m^3 Imported Fill
- Tidal Ridges to Protect Highway
- Exterior Dikes Lowered and Breached

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HORIZONTAL LEVEE

EXISTING CONDITIONS

FUTURE CONDITIONS

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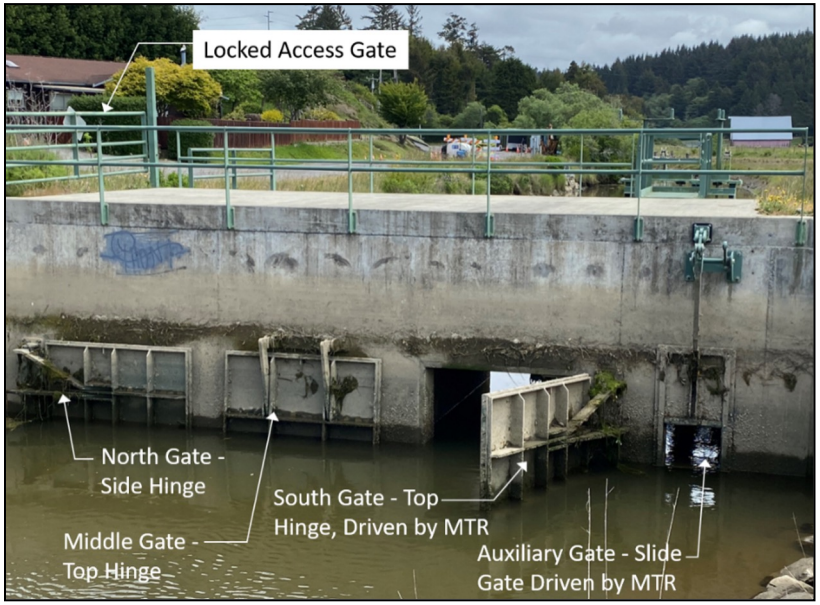
MANAGED TIDES



Create Muted Tidal Regime with Tide Gates:

- Fish Friendly Doors/Side Hinged Gates

- Gates allow controlled tide range to establish marsh while preventing flooding of adjacent low areas.

Tide Gate Photos: Michael Love and Associates

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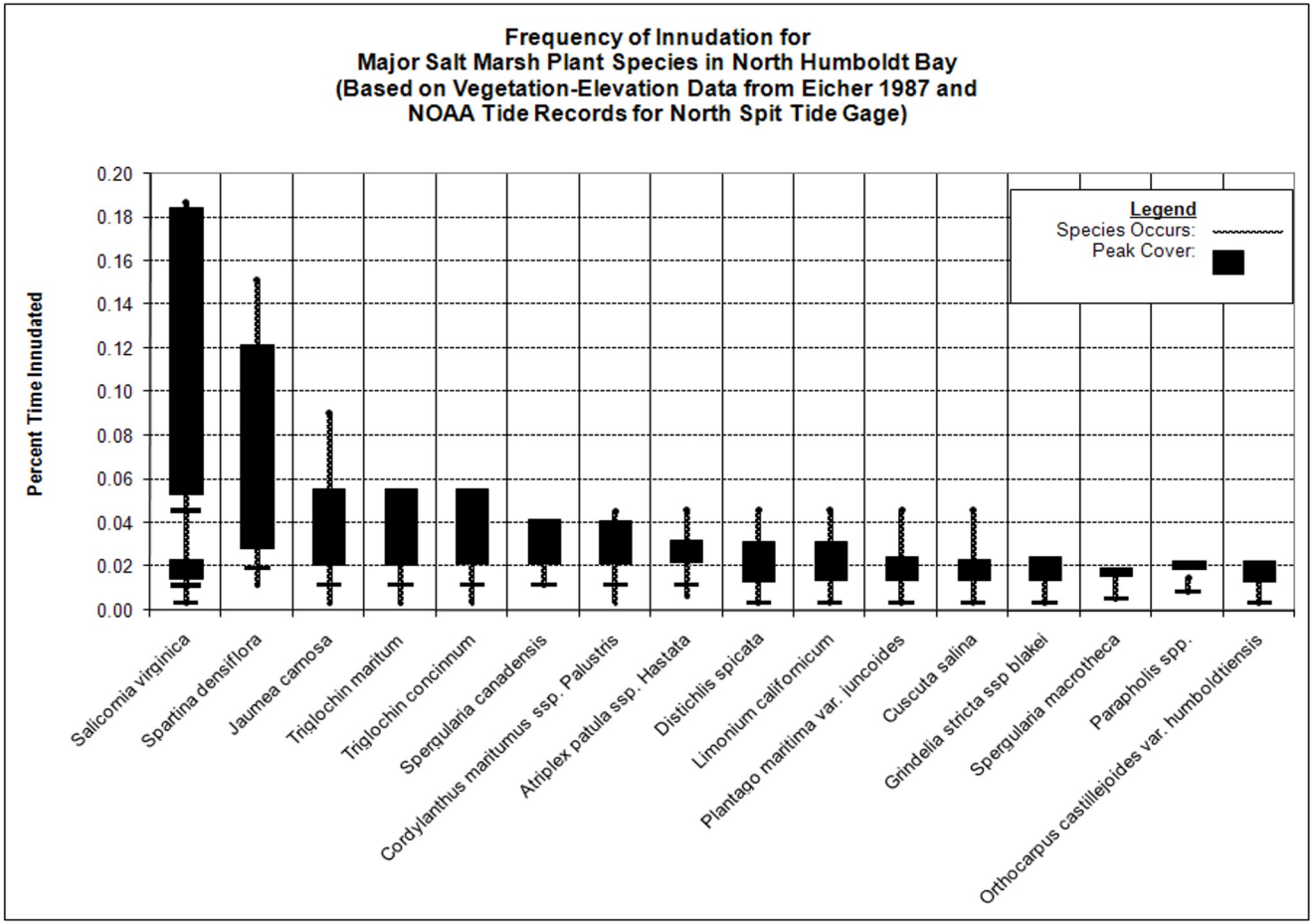
MANAGED TIDES

Critical to Re-establish Duration and Pattern of Tides



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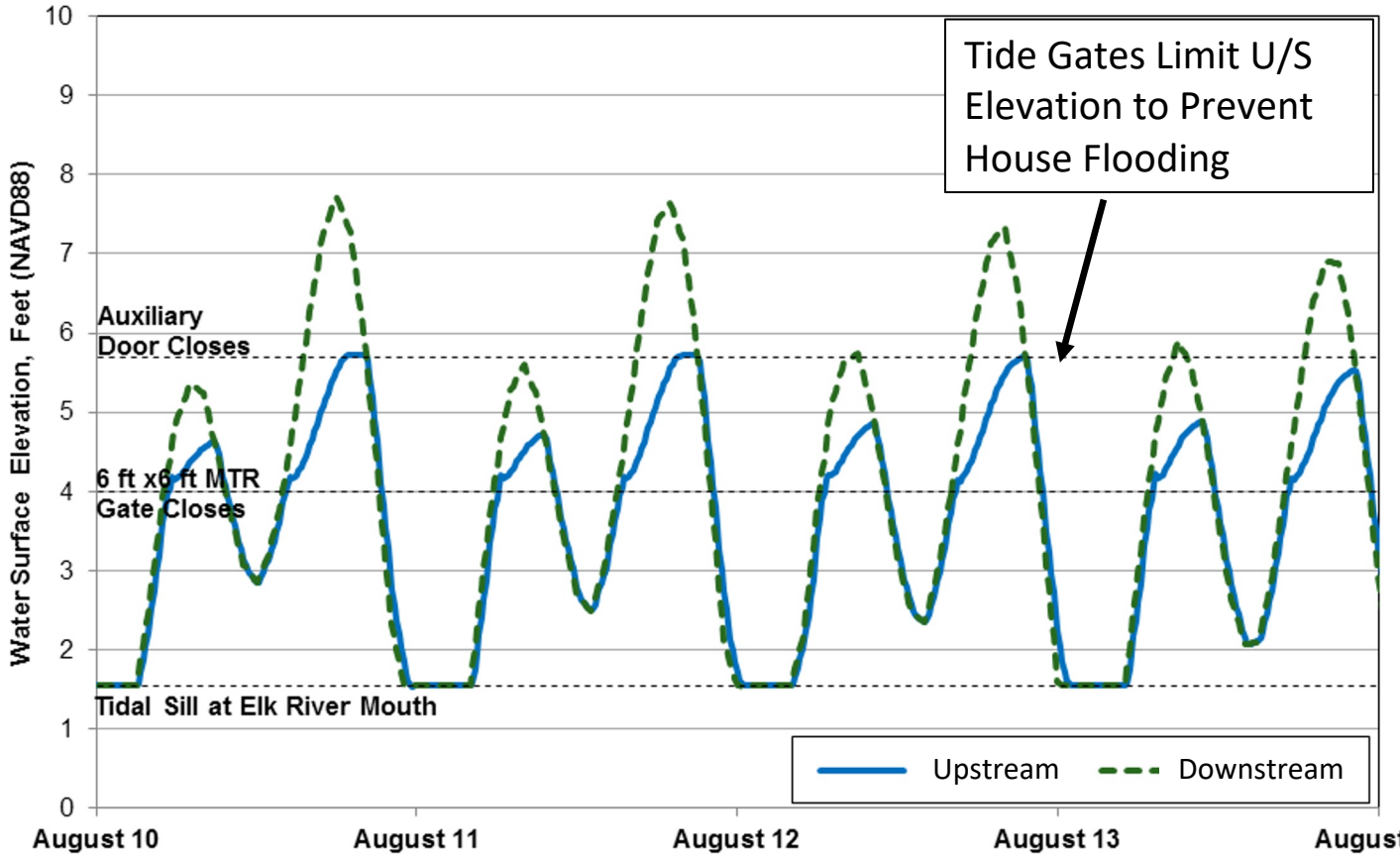
MANAGED TIDES

Critical to Re-establish Duration and Pattern of Tides:

Tide Marsh Established at Elevation 5.0 to 5.8’



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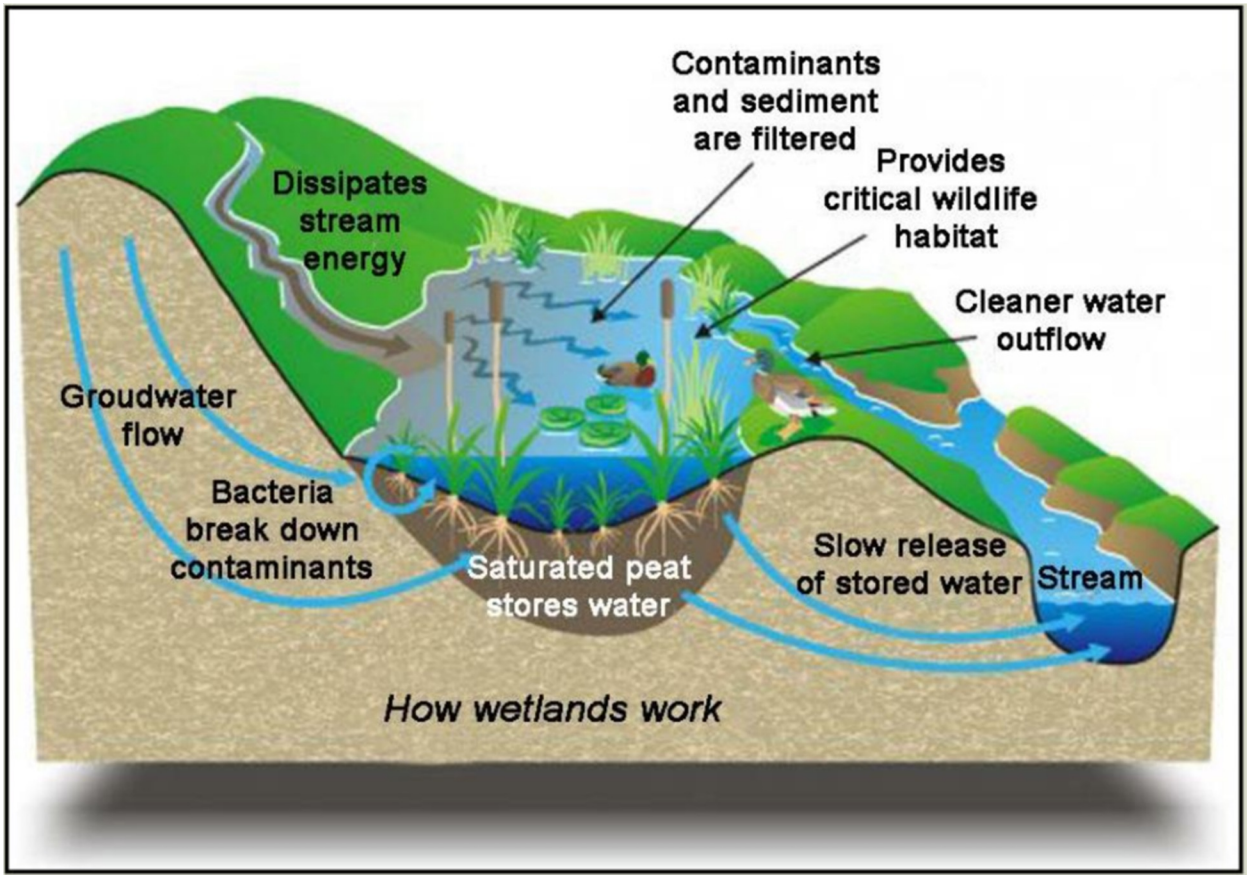
WETLAND RESTORATION

Project Goal:

- Create Wetland Hydrology

Issues:

- Wetland Drainage
- Filling
- Water diversion
- Climate Change



Source: Wynn Cudmore, NSF Grant #0757239

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REMOVE/BLOCK WETLAND DRAINS


Peat Dams


Plastic Dams

Bog Restoration

Scohaboy Bog, Tipperary, Ireland

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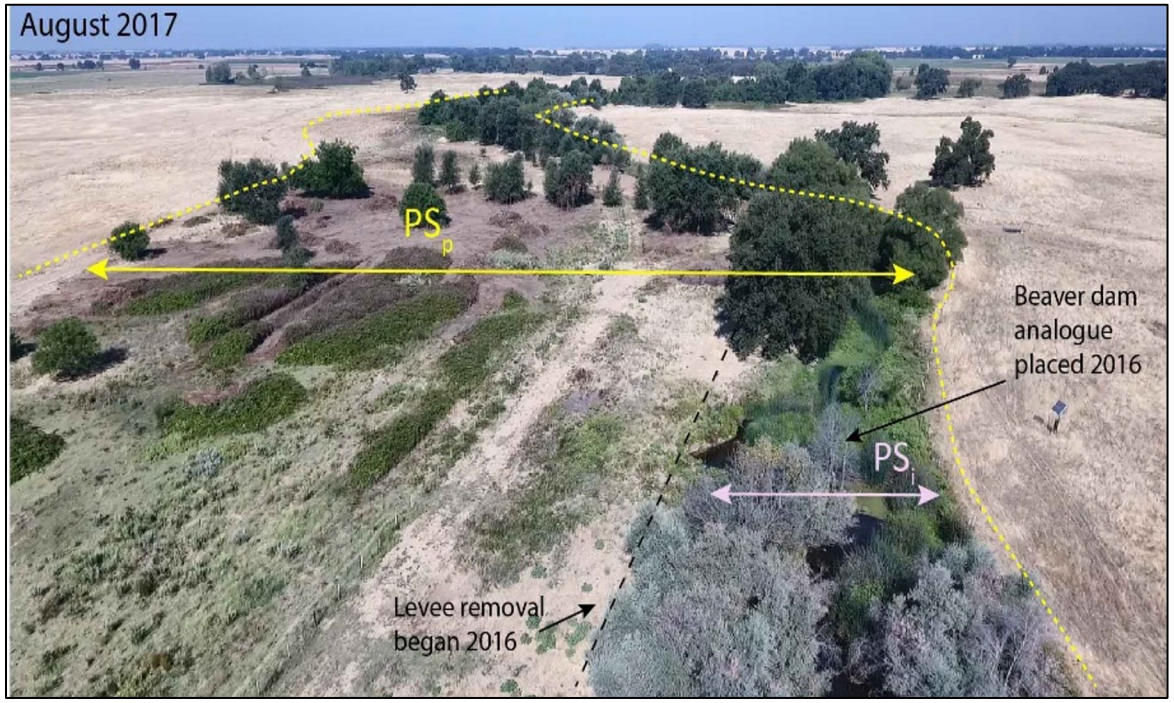
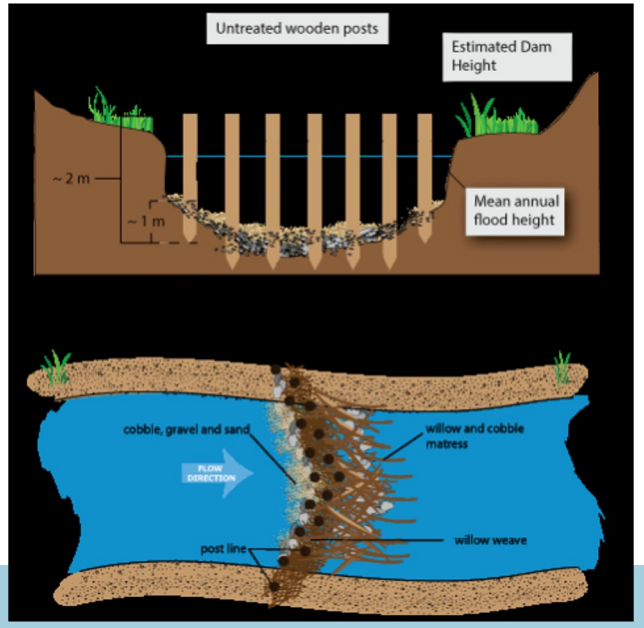
RESTORED HYDROLOGY /MANAGED RECOVERY





Wetland Meadow Restoration

Doty Ravine, California, USA

BDA Diagram: Shaverdian and Wheaton, 2017; Doty Ravine Photos: Damian Ciotti, USFWS

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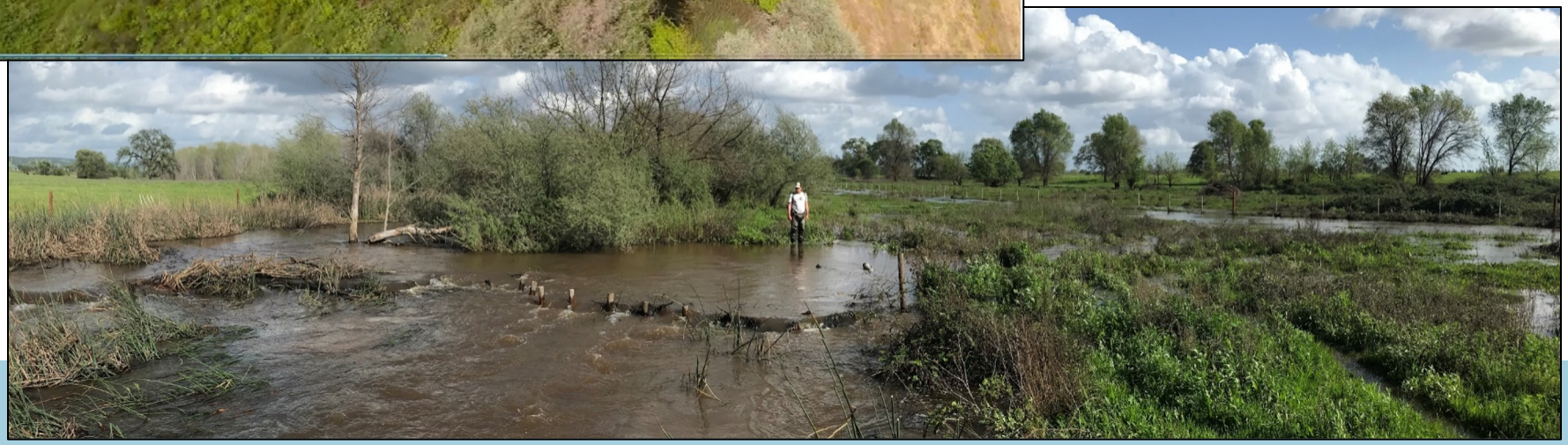
RESTORED HYDROLOGY /MANAGED RECOVERY

Wetland Meadow Restoration

Doty Ravine, California, USA

- **Wetland restored by process**

Photos: Damian Ciotti, USFWS



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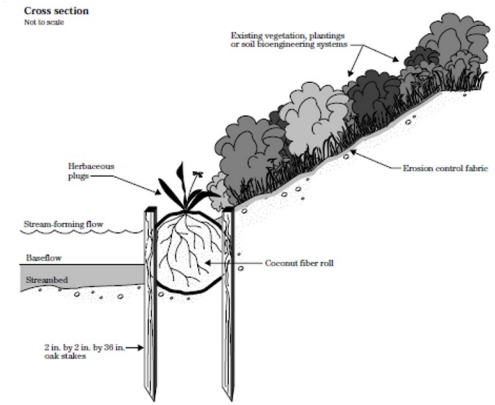
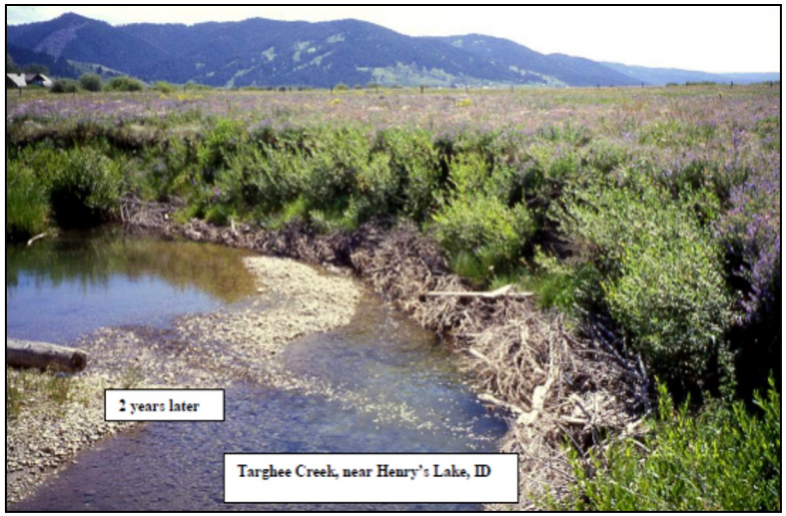
BIOENGINEERING

Employ Plants and Wood as Construction Materials for Restoration





Photos and Figures: USDA Natural Resources Conservation Service

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GETTING STARTED WITH NATURE BASE SOLUTIONS

- **Find Reference (Desired) Conditions**
- **Identify Critical Processes**
- **Develop Test Projects**
- **Monitor: Determine What Works**
- **Innovate**

South Jacoby Creek Off-Channel Wetland Enhancement

Humboldt Bay, California

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Thank you for listening!

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From Wetland Ecosystem Services to Nature-based Solutions

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