# vTAC

## East Branch of Soquel Creek

## Illustration of the Pilot Projects Interim Guidelines Preliminary Draft Proposal

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**California Department of Forestry and Fire Protection**

**March 29, 2011**

# Talk Outline

I. Background Information on the Soquel Creek watershed.

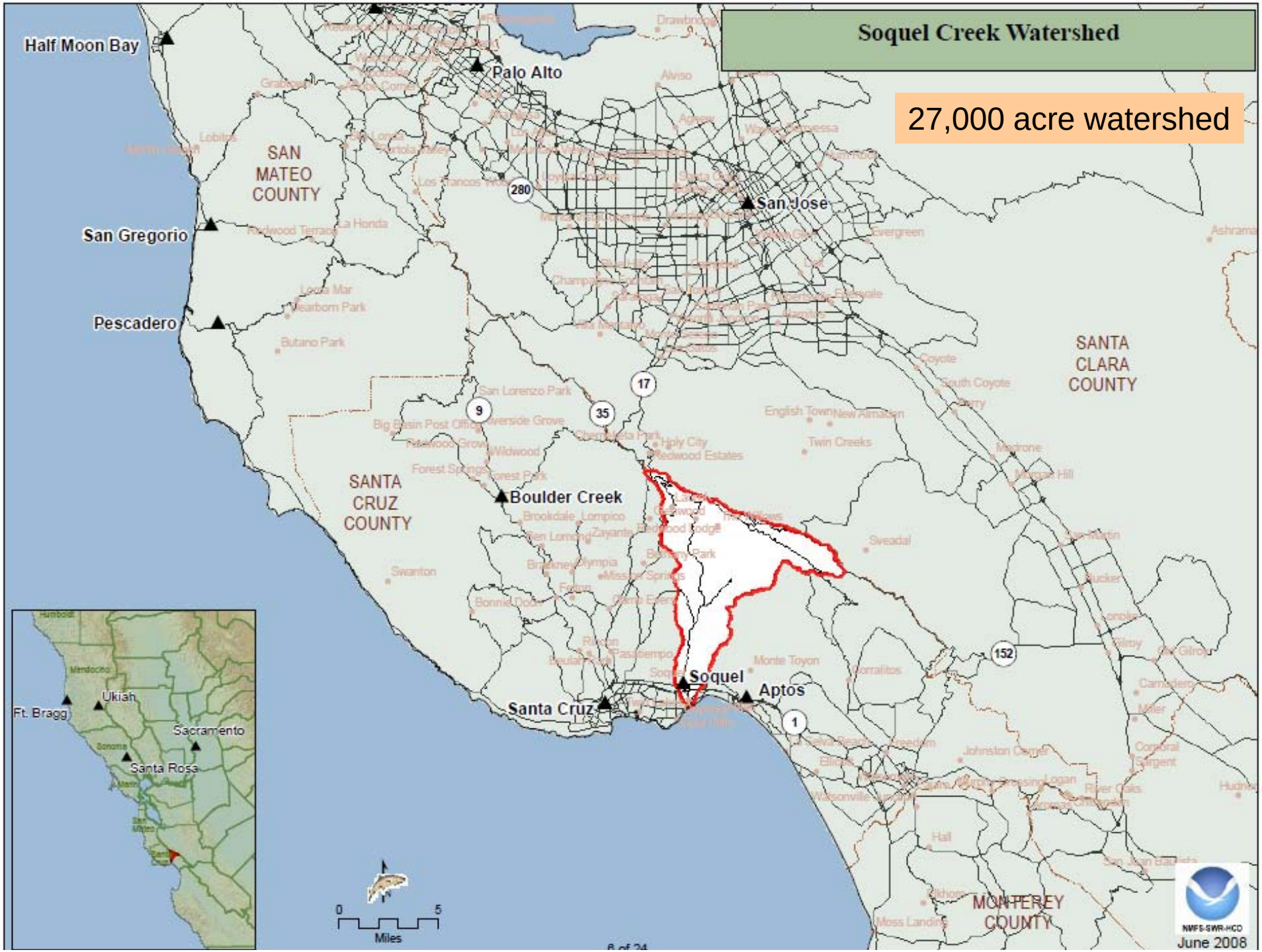
II. Evaluation of existing site conditions (i.e., riparian stand and geomorphic classification).

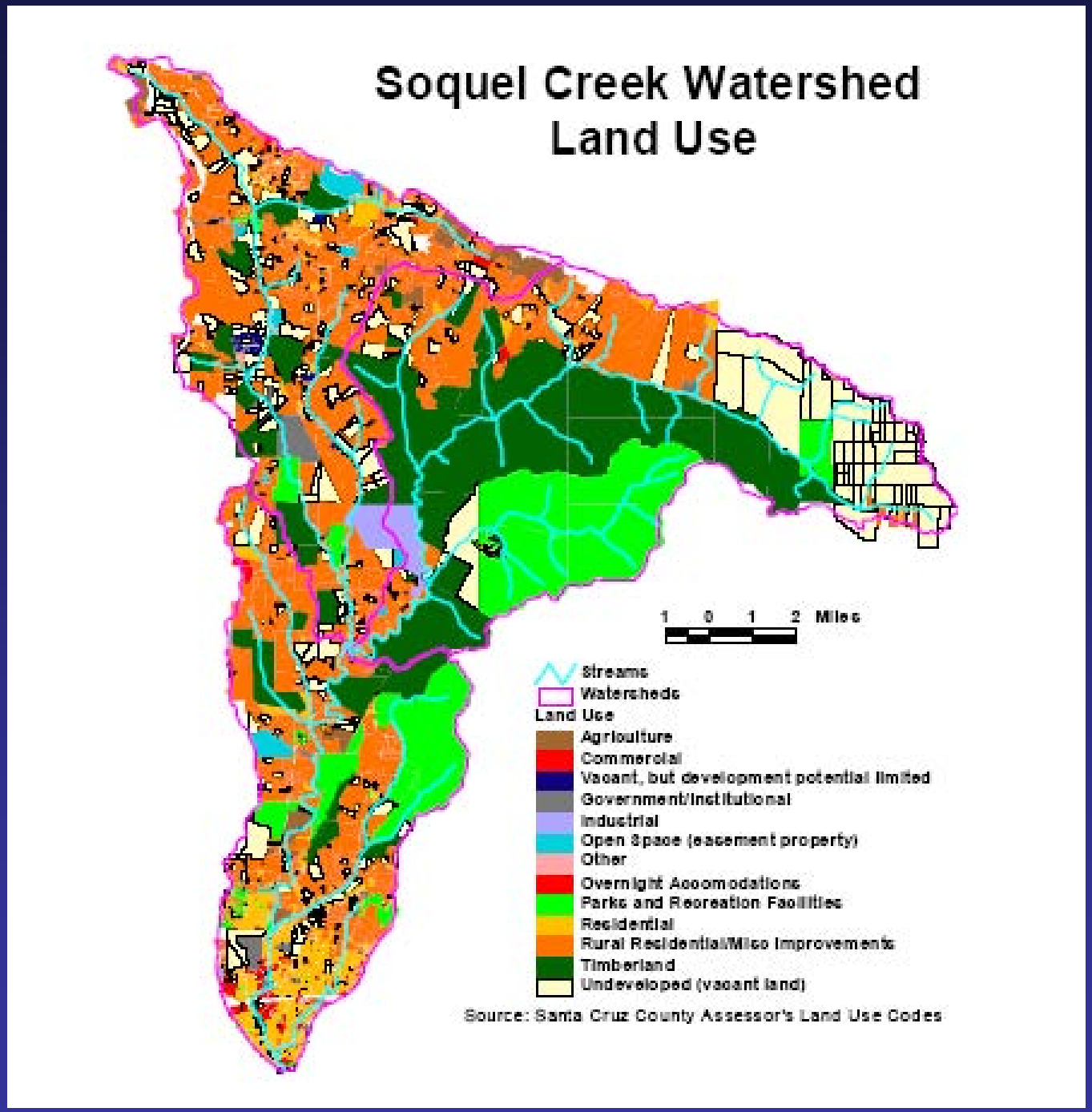
III. Identification of Functional Priorities and Site Objectives with Rule Matrices.

IV. Development of site prescriptions.

V. Other Section 916.9 Section V requirements.

# I. Background Information on the Soquel Creek Watershed

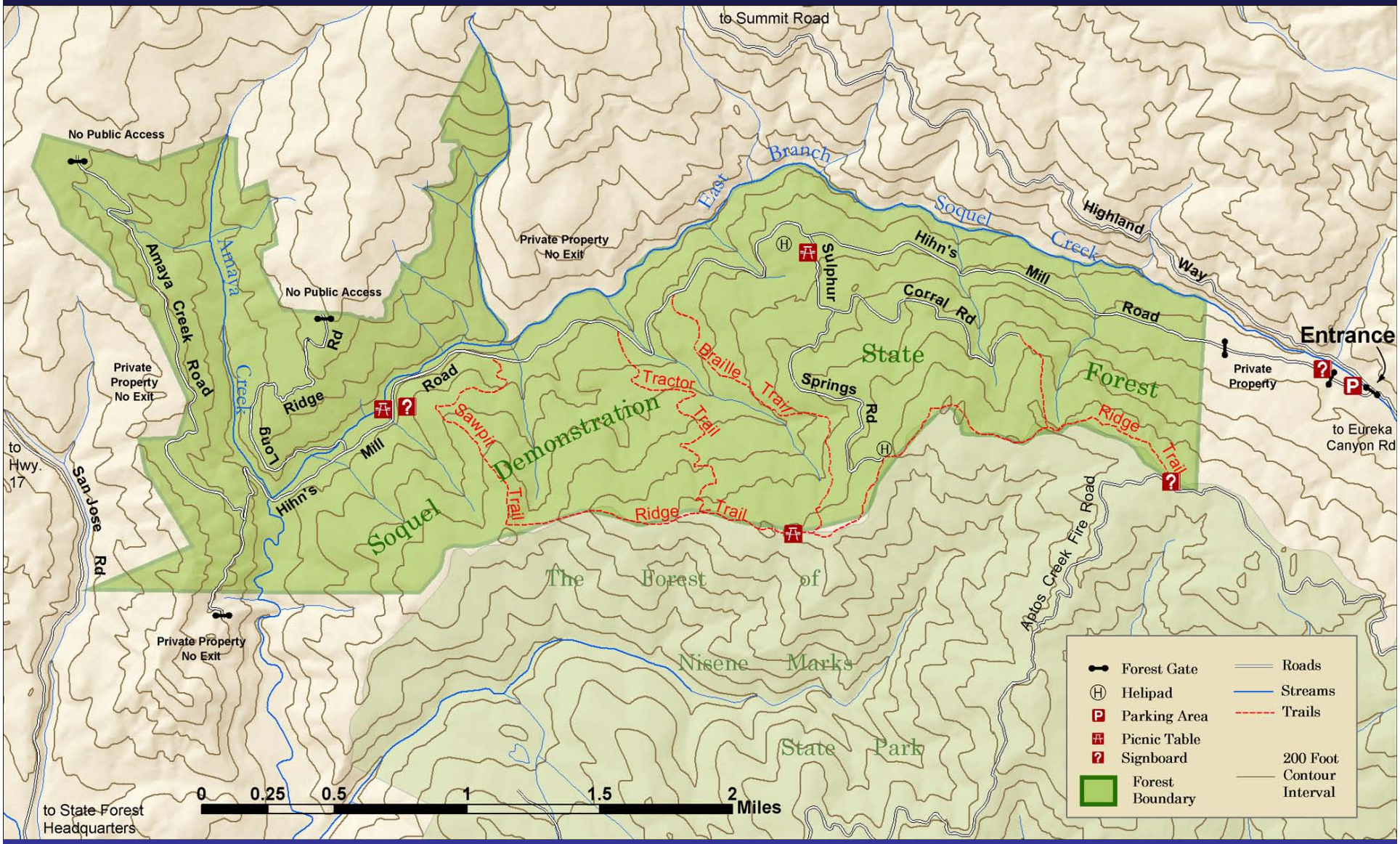

Soquel Creek Watershed
27,000 acre watershed
Half Moon Bay
Palo Alto
San Jose
San Gregorio
Pescadero
SAN MATEO COUNTY
SANTA CLARA COUNTY
SANTA CRUZ COUNTY
MONTEREY COUNTY
Boulder Creek
Soquel
Aptos
Santa Cruz
280
17
9
35
152
1
Ft. Bragg
Ukiah
Sacramento
Santa Rosa
0
5
Miles
NMFS-SWR-HCD
June 2008



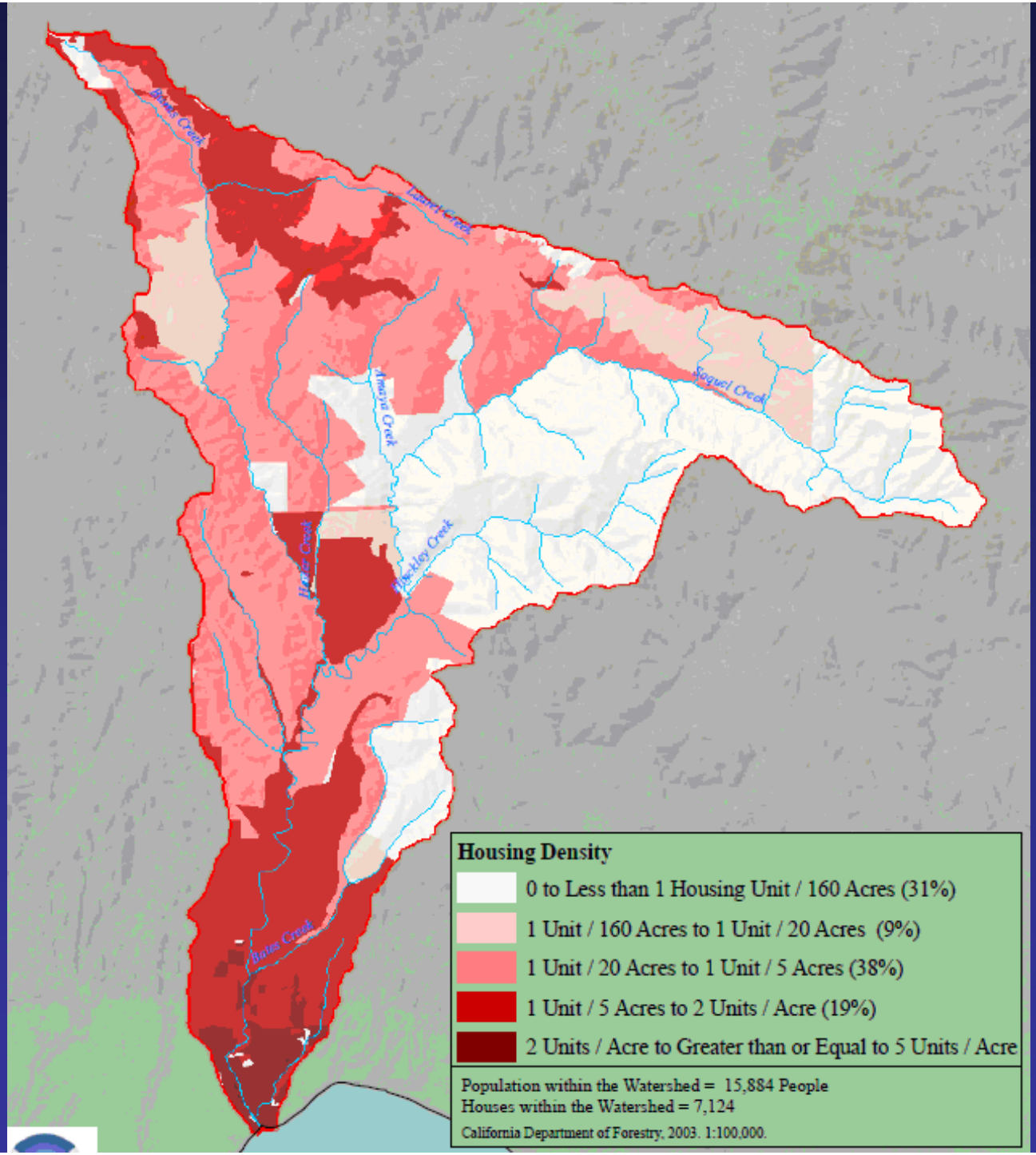

**Soquel Creek—one of 28 Focus Watersheds in NMFS's CCC Coho Salmon Recovery Plan**

Image: NMFS 2010

# Soquel Demonstration State Forest

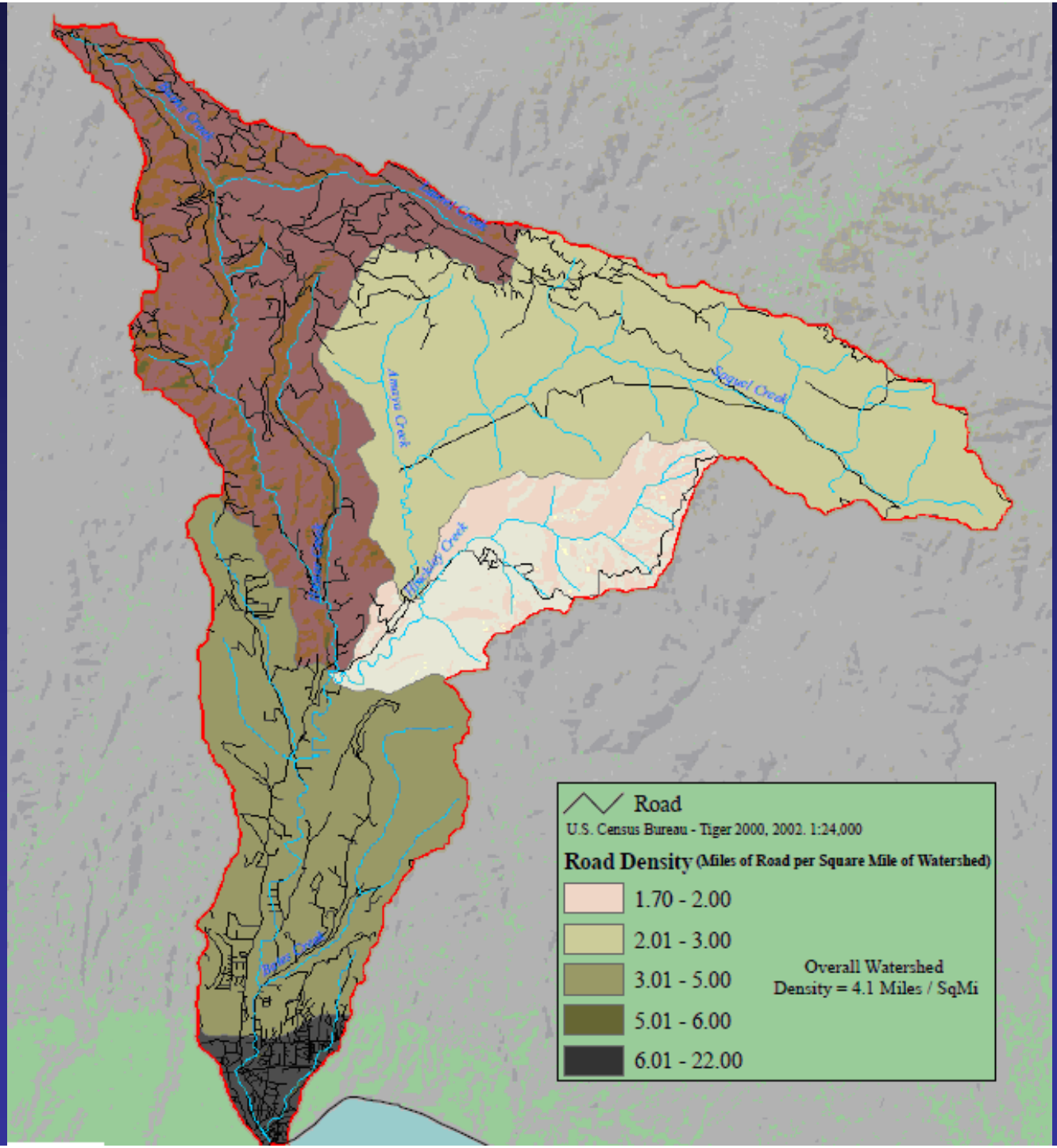



**SDSF = ~2700 acres**



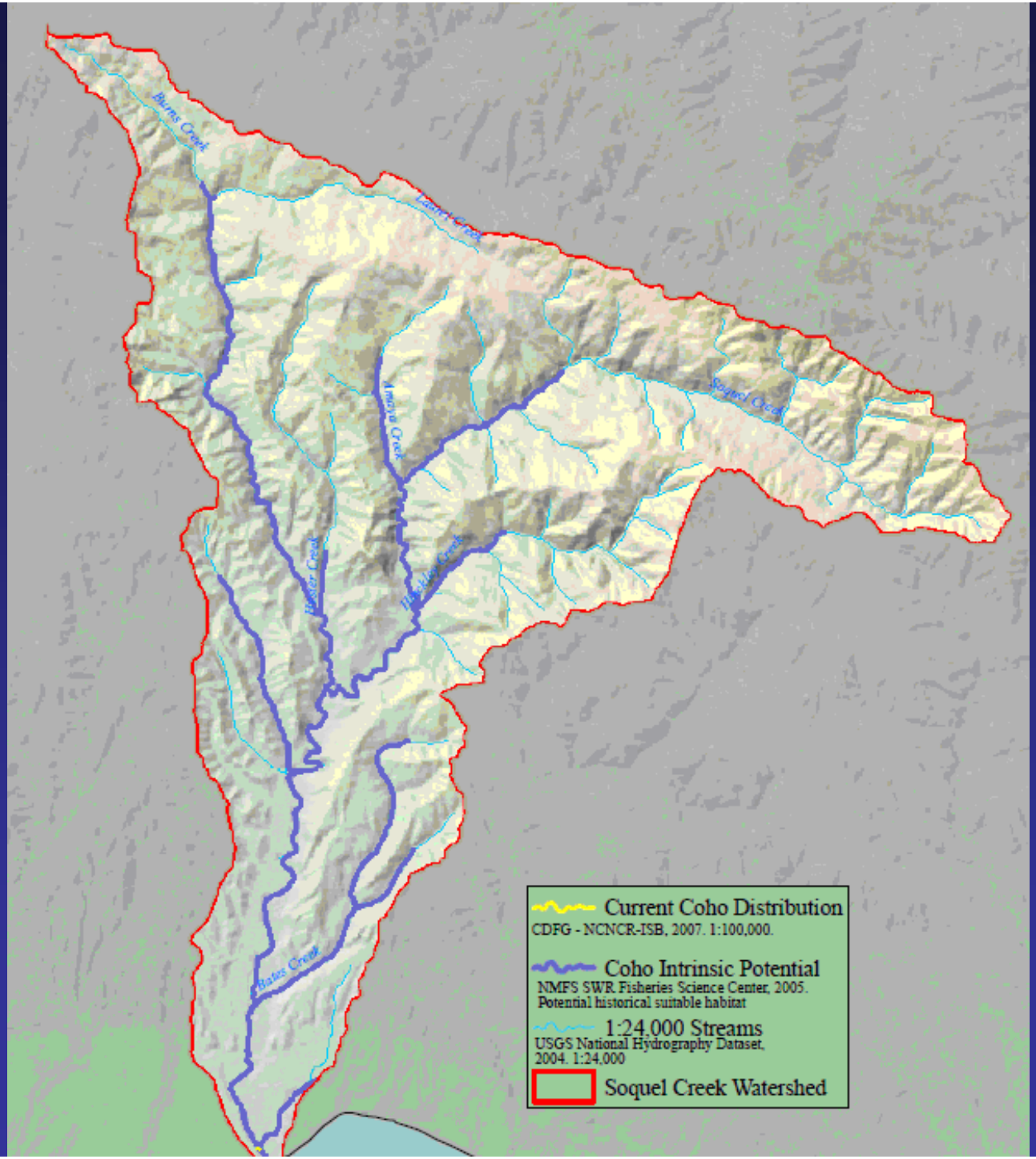

# Housing Density in the Soquel Creek Watershed

Image: NMFS 2010




# Road Density in the Soquel Creek Watershed

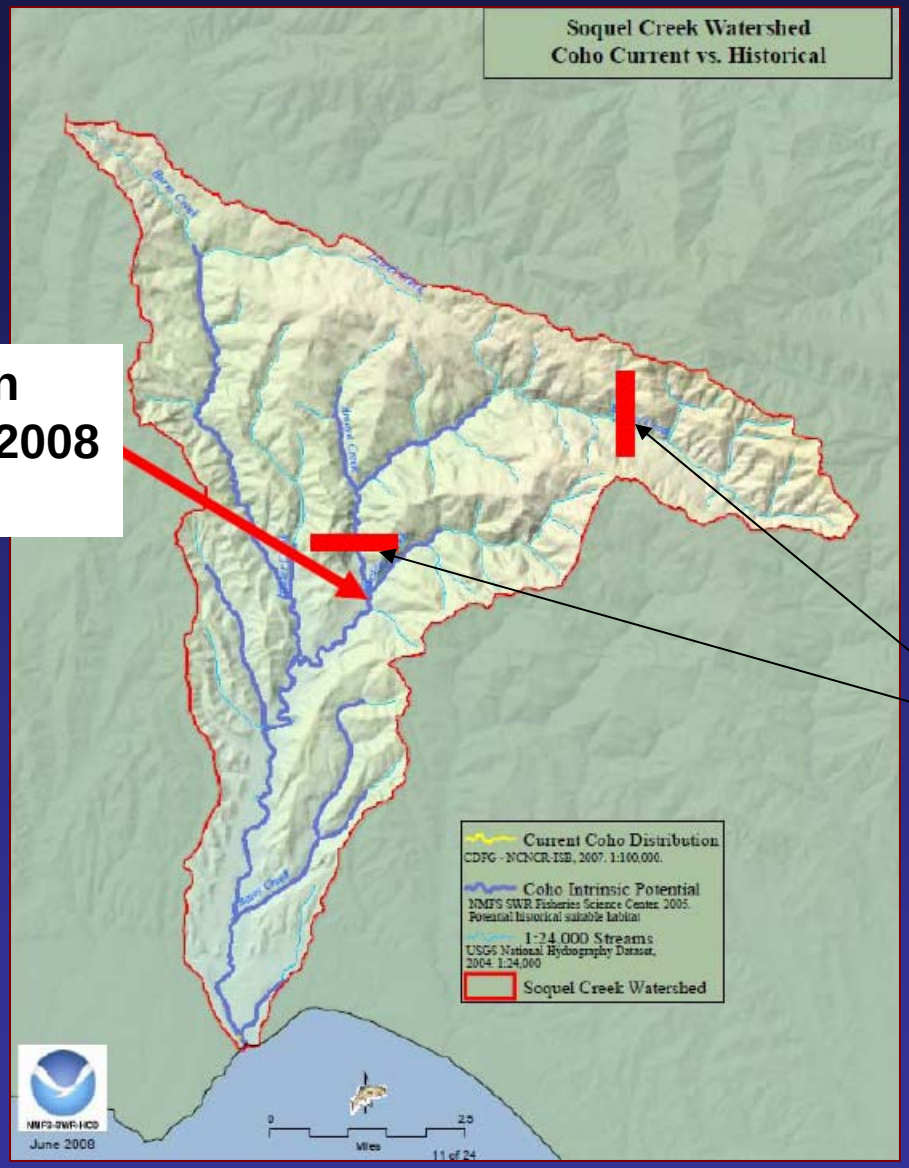
Image: NMFS 2010




# Coho Salmon Intrinsic Potential in the Soquel Creek Watershed

Image: NMFS 2010

# Soquel Creek Watershed




**Coho Salmon observed in 2008 by NMFS**

**Soquel Demonstration State Forest Boundaries**

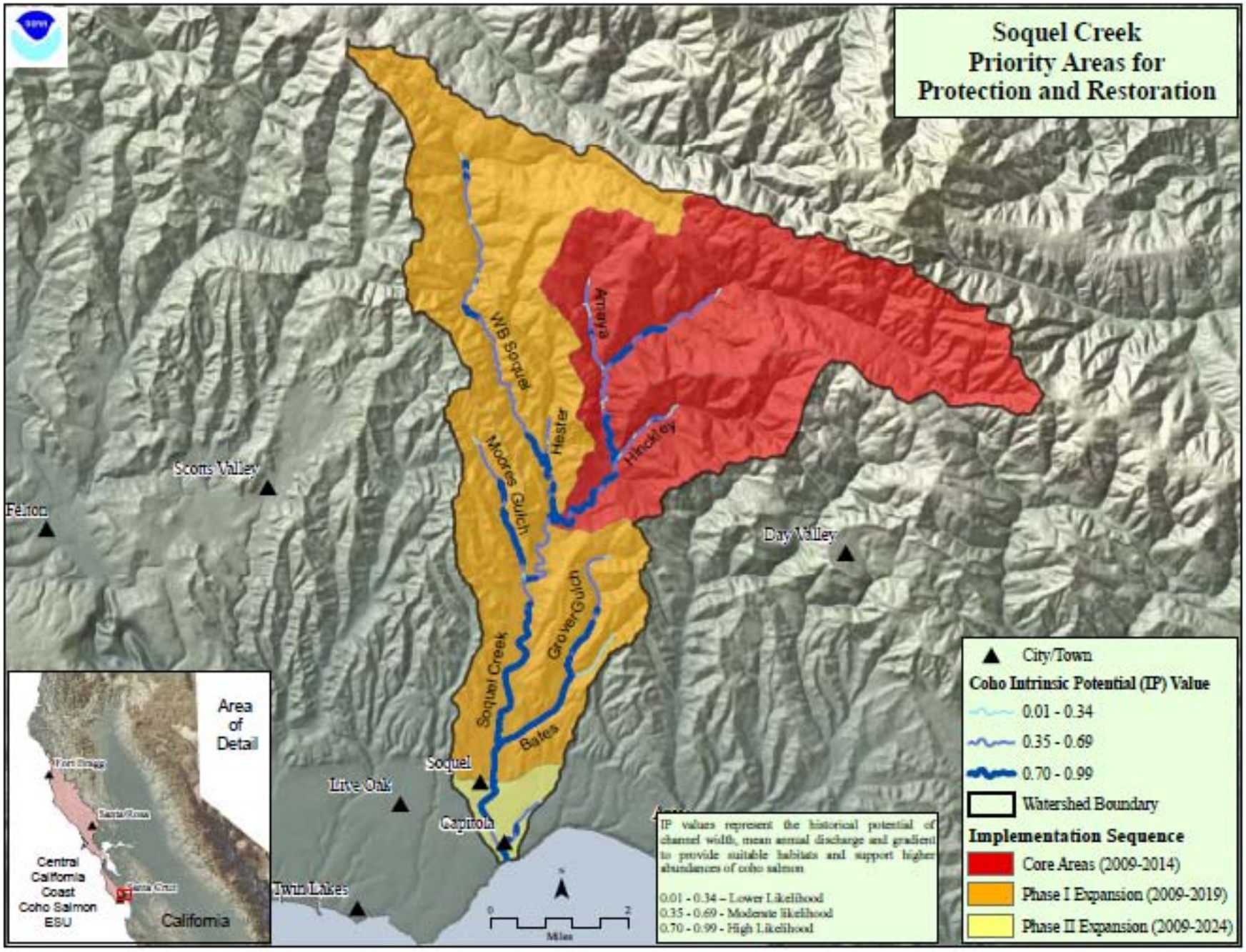



Image: NMFS 2010

# Soquel Demonstration State Forest-Large Wood Placement Project

- **Large wood loading is very low in Soquel Creek due to extensive log removal efforts from the 1950s to the 1990s.**

Photo: Don Alley, D.W. Alley and Associates

# Soquel Demonstration State Forest-Large Wood Placement Project

- Long history of <u>wood removal</u> due to problems with wood jams during large floods at watercourse crossing structures.

# Wood Jam at Soquel Drive Bridge following the January 1982 Flood Event

Photo: Mitch Swanson, Swanson Hydrology & Geomorphology

| | Soquel Creek Threats Across Targets | Spawning Adults | Eggs | Summer Rearing Juveniles | Winter Rearing Juveniles | Smolts | Multiple Life Stages | Overall Threat Rank |
|---|---|---|---|---|---|---|---|---|
| | Project-specific threats | 1 | 2 | 3 | 4 | 5 | 6 | |
| 1 | Residential and Commercial Development | Medium | High | Very High | High | High | High | Very High |
| 2 | Storms and Flooding | Low | High | High | High | High | High | High |
| 3 | Droughts | High | Medium | Very High | Medium | Medium | Medium | High |
| 4 | Fire and Fuel Management | Medium | High | Very High | Medium | Medium | Medium | High |
| 5 | Roads and Railroads | Medium | High | High | High | Medium | High | High |
| 6 | Water Diversion and Impoundment | Medium | Medium | Very High | Medium | Medium | Medium | High |
| 7 | Climate Change | Medium | Medium | High | Medium | Medium | Medium | High |
| 8 | Logging and Wood Harvesting | Medium | Medium | High | Medium | Medium | Medium | High |
| 9 | Mining | Low | Medium | High | Low | Low | Medium | Medium |
| 10 | Fishing and Collecting | High | - | Medium | Low | Medium | - | Medium |
| 11 | Disease, Predation, and Competition | Medium | - | Medium | - | High | - | Medium |
| 12 | Livestock Farming and Ranching | Medium | Medium | Medium | Medium | Medium | Medium | Medium |
| 13 | Agricultural Practices | Medium | Low | Medium | Medium | Medium | Medium | Medium |
| 14 | Channel Modification | Medium | Low | Medium | Medium | Low | Medium | Medium |
| 15 | Recreational Areas and Activities | Medium | Low | Low | Medium | Low | Medium | Medium |
| 16 | Hatcheries and Aquaculture | - | - | - | Low | Low | - | Low |
| | Threat Status for Targets and Project | High | High | Very High | High | High | High | Very High |

Image: NMFS 2010

# CCC Coho Recovery Plan
# Soquel Creek Watershed
## NMFS 2010

### The Watershed at a Glance

| | |
|---|---|
| Spawning Quantity & Quality: | GOOD |
| Summer Water Temperatures: | FAIR |
| Depth & Shelter of Pools | FAIR |
| Large Wood Frequency: | POOR |
| Riparian Canopy: | GOOD |
| Off channel/Floodplain Quality: | POOR |
| Estuary Function: | POOR |

# Highest Priorities for Restoration to Prevent Coho Salmon Extinction in the Soquel Creek Watershed NMFS 2010

- Increase the quantity of off channel habitat.
- Increase the amount of large wood in the channel.
- Limit the number of new roads and decrease the amount of existing near stream roads.
- Diminish the amount of sediment input.
- Improve and expand the estuary.
- Enhance and increase shelter provided within pools.
- Improve floodplain connectivity to provide rearing habitat.

# SOQUEL CREEK WATERSHED ASSESSMENT AND ENHANCEMENT PROJECT PLAN (SCCRCD 2003)

- The East Branch flowing through the Soquel Demonstration State Forest (SDSF) is the primary spawning grounds for steelhead in the Soquel Creek watershed.
- The highest densities of young-of-the-year steelhead occur in the SDSF.
- Juvenile growth rate is slow with low summer baseflow, requiring two years for fish to reach smolt size.

# II. Evaluation of Existing Site Conditions

- Riparian Stand Classification
- Geomorphic Classification

# Fern Gulch Timber Sale

- 300 ft. Late Succession Management Areas (each side of bankfull channel width).
- **Dominant WHR class** in LSMA = **4D** (11-24 in QMD and canopy cover > 60%).
- Coast redwood mainly in outer 150 ft zone or on floodplain/terrace. Floodplain/terraces also have considerable component of red alder, other hardwoods.
- Steep inner gorge/unstable areas near the floodplain, dominant vegetation is tanoak and limited conifer.

Outer 150-300 ft portion of the Late Succession Management Area in the Fern Gulch Timber Sale Area

Steep Inner Gorge
Area along the East
Branch of Soquel
Creek

# Soquel Creek—
# Flood Prone Area

East Branch of Soquel Creek—Coast Redwood in the Flood Prone Area

# SOQUEL CREEK WATERSHED ASSESSMENT AND ENHANCEMENT PROJECT PLAN

## (SCCRCD 2003)

| RIPARIAN VEGETATION | |
|---|---|
| Dominant Vegetation Type | Conifers with large deciduous component below Fern Gulch. |
| Canopy Cover | No data available. |
| Non-Native Presence | Low. |
| Other | Shortage of large conifers within 100 year floodplain for both recruitment zone and canopy. Good deciduous contribution to riparian channel |

Large woody material is scarce in the East Branch and recruitment is low on the East Branch, but higher in tributaries.

# Riparian Classification

**Table D-1: Dominant Vegetation Types**

| | |
|---|---|
| >= 70% Coniferous Species | Conifer Dominated |
| >= 70% Hardwood Species | Hardwood Dominated |
| All Other Cases | Mixed |

**Table D-2: Average Tree Size Classes[1]**

| | |
|---|---|
| Small | <12 inches DBH |
| Medium | >=12 and < 20 inches DBH |
| Large | >=20 inches DBH |

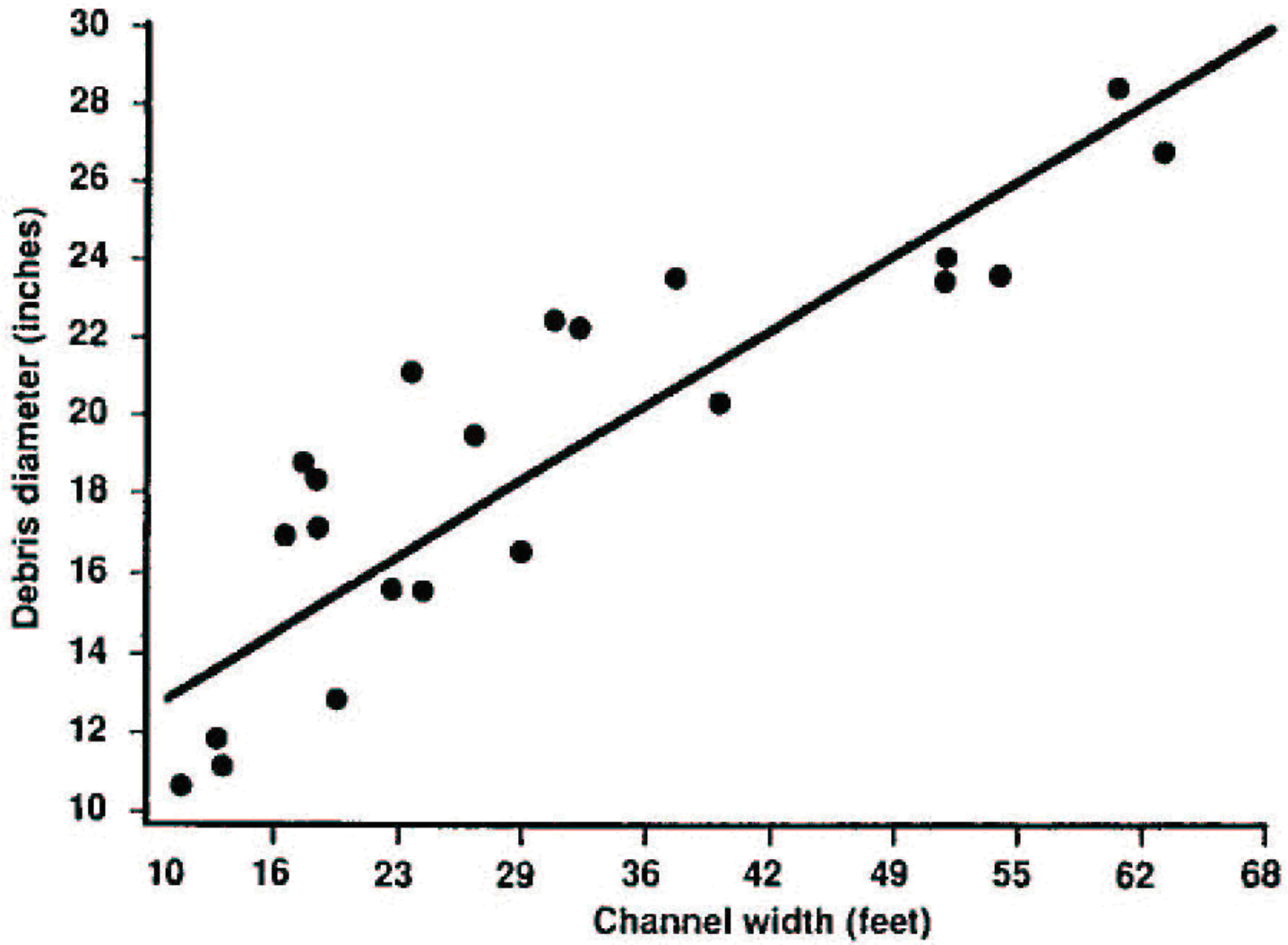
Based on Bilby and Ward (1989) diagram for diameter and a bankfull channel width of 80 ft, average tree size is **smaller than functional** (would need a diameter of greater than 30 inches).

**Type of Vegetation = Mixed (M)**

**Relative Tree Size = Smaller than functional (S)**

# Bilby and Ward 1989 Debris Diameter-Channel Width Figure

34




80

# Riparian Classification

## Stocking Level

- D--Active mortality for hardwood species (large percent of red alder resulted from the 1955 flood).
- U--Low mortality for coast redwood.
- U--Low mortality for limited number of Douglas-fir.

Stocking Level = Under stocked (U)

# Geomorphic Classification

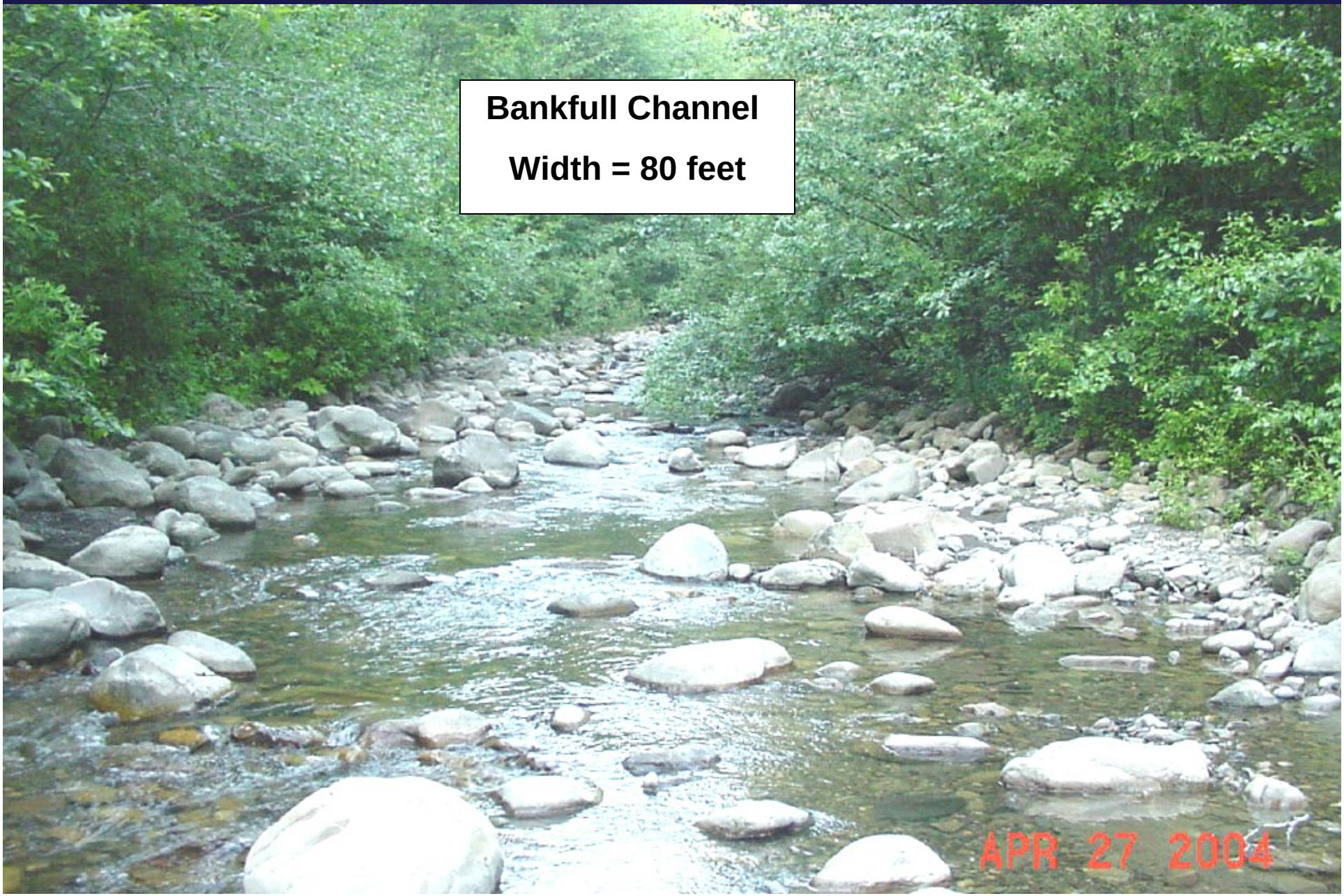
- **Confinement:**
  - Confined (VW < 2CW), moderately confined (2CW < VW < 4CW), or unconfined (VW > 4CW).

- **Channel gradient and typical channel bed morphology:**
  - <1% (pool riffle), 1-2% (pool riffle, plane bed), 2-4% (plane bed, forced pool riffle), 4-8% (step pool), 8-20% (cascade), and >20% (colluvial).

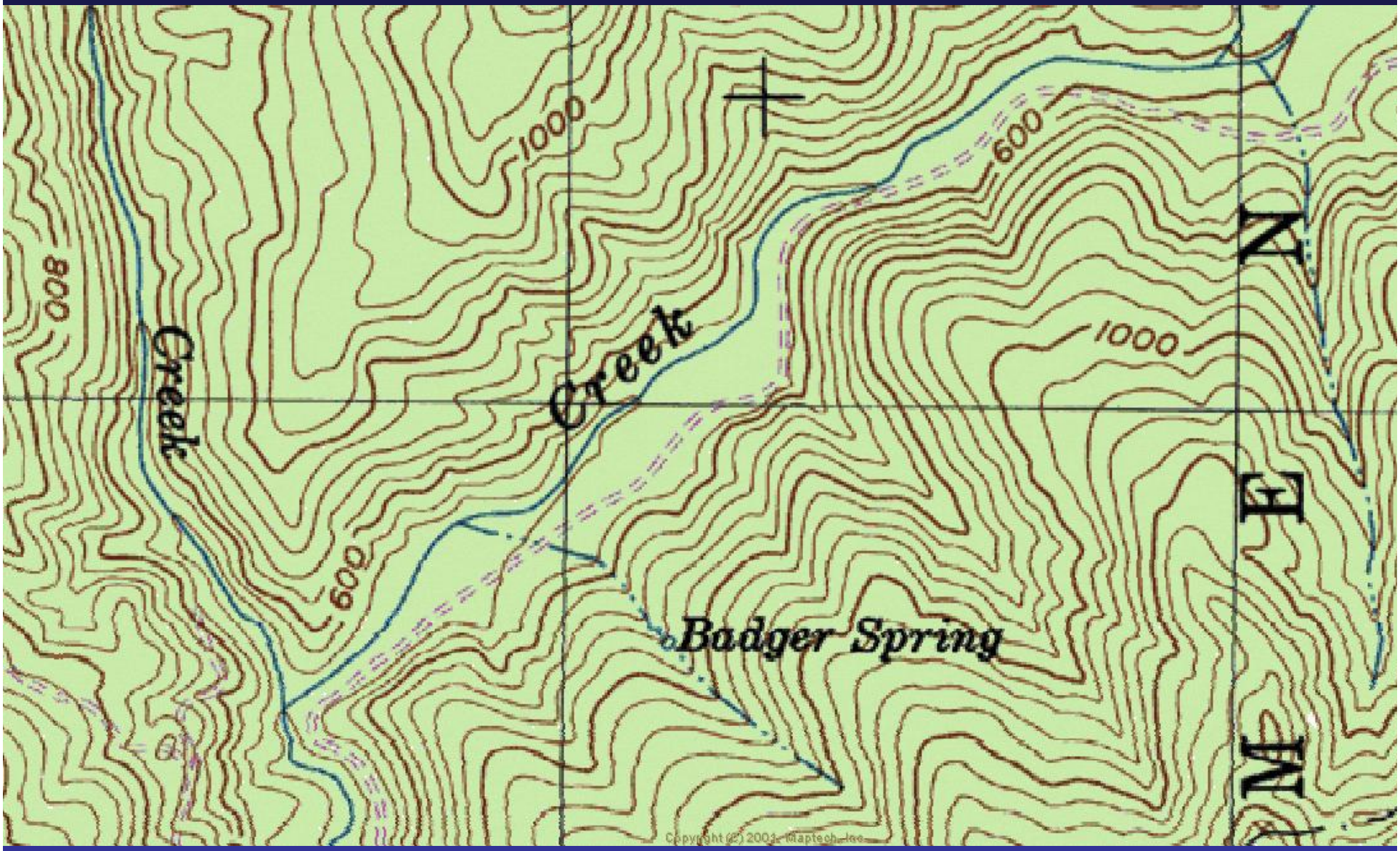
Typical East Branch of Soquel Creek Channel Conditions—Above the Bridge
3% Channel Gradient

Typical East Branch of Soquel Creek Channel Conditions— Below the Bridge
2% Channel Gradient

# East Branch of Soquel Creek--
# Unconfined Channel with a Flood Prone Area



# East Branch of Soquel Creek




**Measured Valley Floor Widths from Map: 374 ft; 581 ft; 445 ft; 535 ft; 483 ft.**

**Mean = 485 ft**

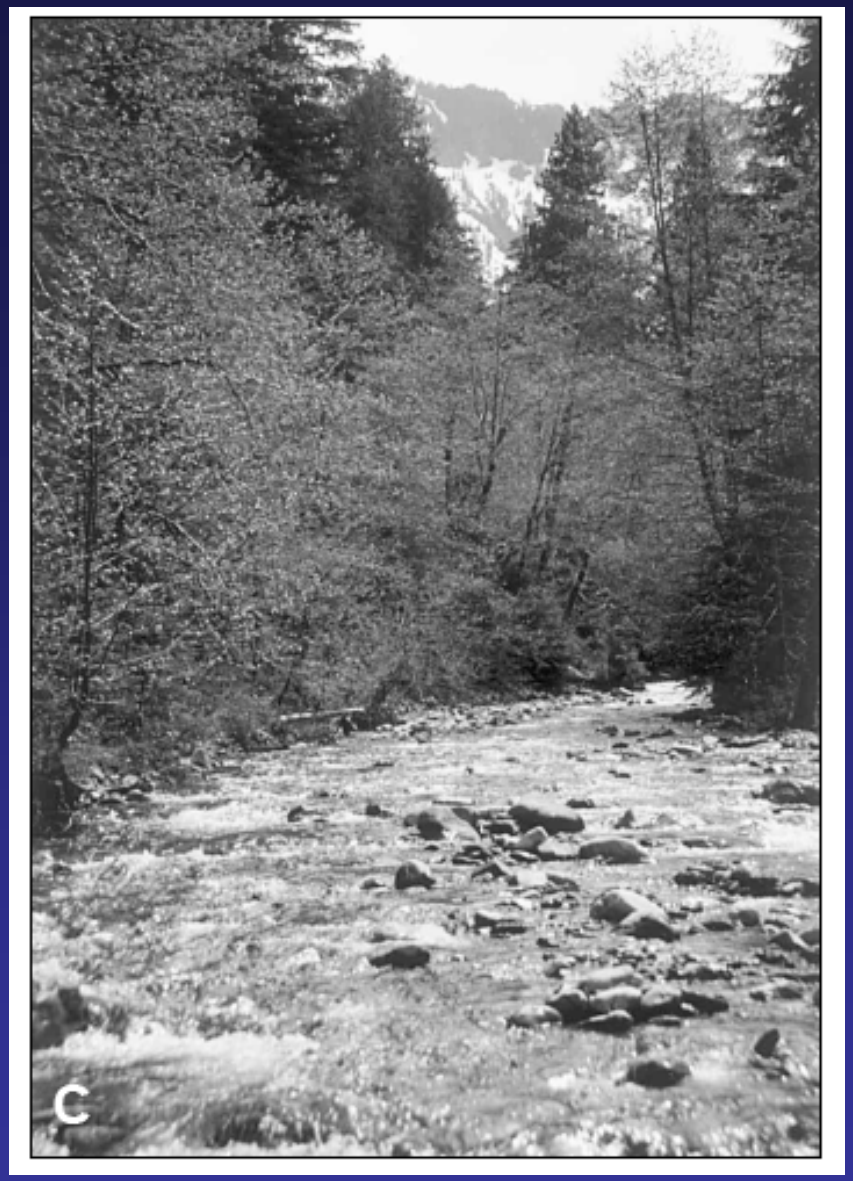
# East Branch of Soquel Creek near Fern Gulch: Unconfined Channel

- **Valley Floor Width = 485 feet**
- **Bankfull Channel Width = 80 feet**
- **Ratio of Valley Floor Width to Bankfull Channel Width: 485/80 = 6.1**
- **Unconfined Channel with a Flood Prone Area**

# Geomorphic Classification

- Channel gradient: 2-3%.
- Unconfined (VW > 4CW).
- Channel Reach Morphology:
  - Plane bed
  - Forced pool riffle*

*Boulder/Bedrock and Limited Large Wood




Plane Bed Example

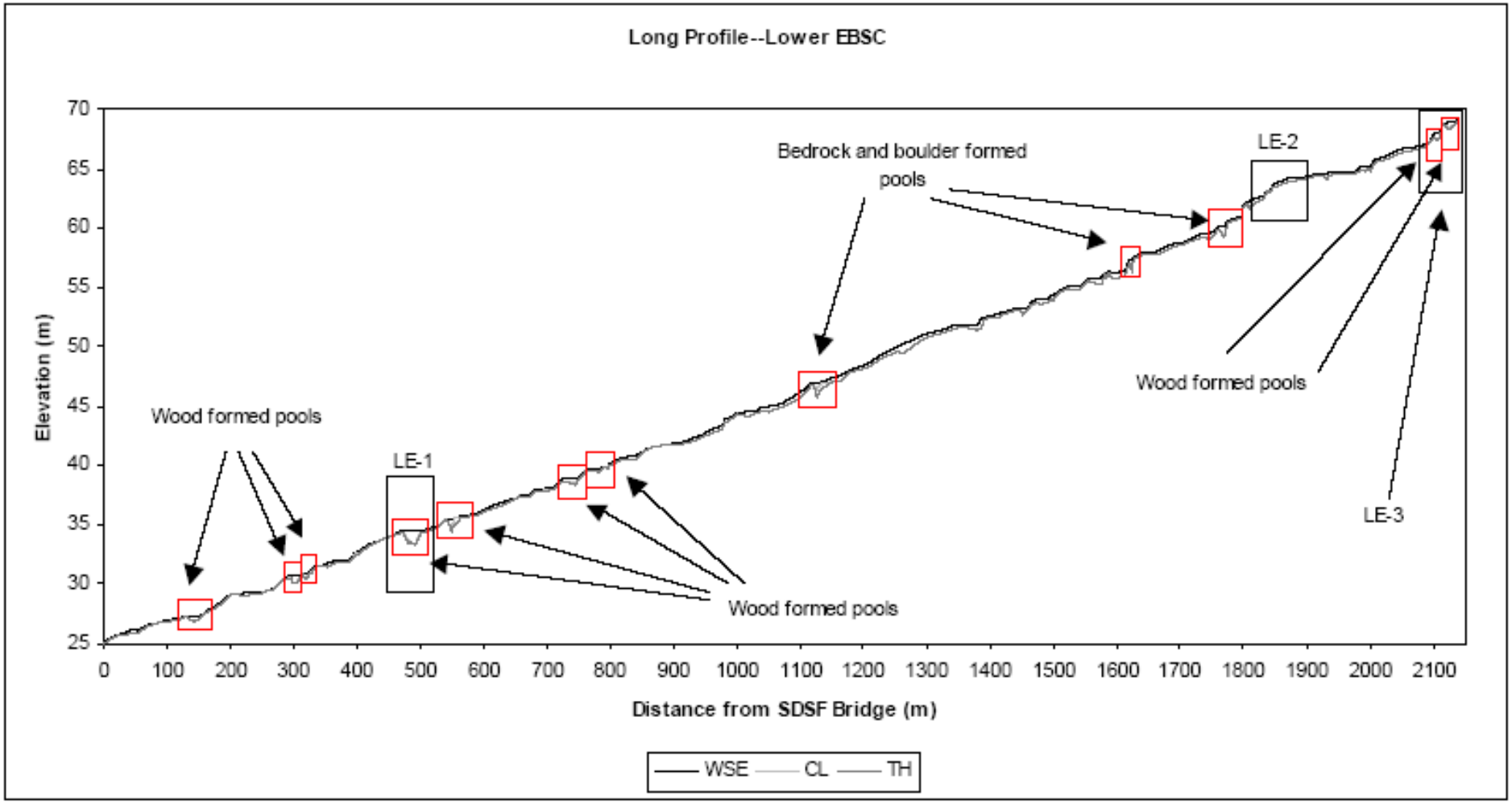
Forced Pool Riffle

Photos: Montgomery and Buffington 1997

# Plane Bed Channel Characteristics
## (Montgomery and Buffington 1997)

- Typical bed material = gravel to cobble.
- Typical channel slope = 1.5 to 3%.
- Typical confinement = variable.
- Sediment storage = overbank on floodplain.
- Dominant sediment sources = debris flows, bank failure, and fluvial.
- Introduction of flow obstructions forces local pool and bar formation.

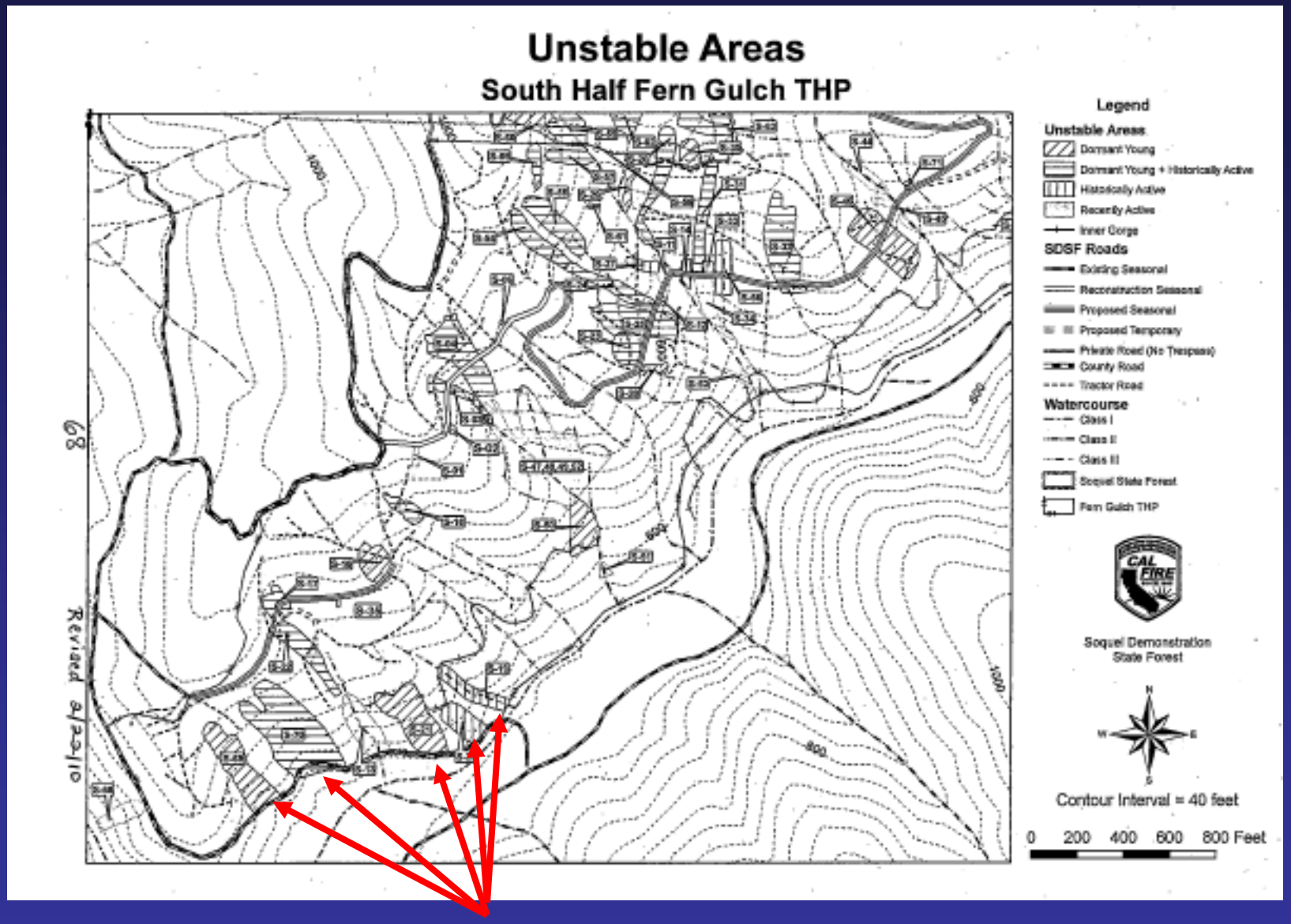
# Long Profile of Lower East Branch Soquel Creek Showing the Location of Wood and Bedrock/Boulder Formed Pools




**Only 9 Wood Formed Pools in 1.3 Miles of Stream Channel**

Image: Lassettre and Kondolf 2003

# Geomorphic Classification




**Eco-Geomorphic Hotspot: Debris Flow Source Areas**

# III. Identification of Functional Priorities and Site Objectives with Rule Matrices

# Riparian Site Conditions

| Riparian Class | | | Inherent Functional Levels | | |
|---|---|---|---|---|---|
| | | | Wood Supply | Nutrient Supply | Thermal Loading |
| C | S | D | Moderate | Poor | Good |
| C | S | F | Poor | Poor | Good |
| C | S | U | Poor | Moderate | Moderate |
| C | L | D | Good | Moderate | Good |
| C | L | F | Good | Moderate | Good |
| C | L | U | Moderate | Moderate | Moderate |
| C | M | D | Good | Moderate | Good |
| C | M | F | Good | Moderate | Good |
| C | M | U | Moderate | Moderate | Moderate |
| H | S | D | Moderate | Good | Good |
| H | S | F | Poor | Good | Good |
| H | S | U | Poor | Good | Moderate |
| H | L | D | Moderate | Good | Good |
| H | L | F | Poor | Good | Good |
| H | L | U | Poor | Good | Moderate |
| H | M | D | Moderate | Good | Good |
| H | M | F | Poor | Good | Good |
| H | M | U | Poor | Good | Moderate |
| M | S | D | Moderate | Moderate | Good |
| M | S | F | Moderate | Moderate | Good |
| M | S | U | Poor | Good | Moderate |
| M | L | D | Good | Moderate | Good |
| M | L | F | Good | Good | Good |
| M | L | U | Moderate | Good | Moderate |
| M | M | D | Good | Good | Good |
| M | M | F | Good | Good | Good |
| M | M | U | Moderate | Good | Moderate |

M = mixed vegetation;
S = smaller than functional;
U = Under stocked for coast redwood/DF

**Use riparian site condition classification to identify existing functional response potential for wood supply, thermal loading, and nutrient supply**

# Riparian Site Conditions

Could Argue that the Riparian Stand is **Hardwood Dominated**—Results in the Same Functional Level calls

| Riparian Class | | | Inherent Functional Levels | | |
|---|---|---|---|---|---|
| | | | Wood Supply | Nutrient Supply | Thermal Loading |
| C | S | D | Moderate | Poor | Good |
| C | S | F | Poor | Poor | Good |
| C | S | U | Poor | Moderate | Moderate |
| C | L | D | Good | Moderate | Good |
| C | L | F | Good | Moderate | Good |
| C | L | U | Moderate | Moderate | Moderate |
| C | M | D | Good | Moderate | Good |
| C | M | F | Good | Moderate | Good |
| C | M | U | Moderate | Moderate | Moderate |
| H | S | D | Moderate | Good | Good |
| H | S | F | Poor | Good | Good |
| H | S | U | Poor | Good | Moderate |
| H | L | D | Moderate | Good | Good |
| H | L | F | Poor | Good | Good |
| H | L | U | Poor | Good | Moderate |
| H | M | D | Moderate | Good | Good |
| H | M | F | Poor | Good | Good |
| H | M | U | Poor | Good | Moderate |
| M | S | D | Moderate | Moderate | Good |
| M | S | F | Moderate | Moderate | Good |
| M | S | U | Poor | Good | Moderate |
| M | L | D | Good | Moderate | Good |
| M | L | F | Good | Good | Good |
| M | L | U | Moderate | Good | Moderate |
| M | M | D | Good | Good | Good |
| M | M | F | Good | Good | Good |
| M | M | U | Moderate | Good | Moderate |

**Use riparian site condition classification to identify existing functional response potential for wood supply, thermal loading, and nutrient supply**

# Functional Priorities

| | | | Functional Priority Rating | | | |
|---|---|---|---|---|---|---|
| **Class** | **Size** | **Type*** | **Wood** | **Temperature** | **Nutrients** | **Erosion** |
| I | Large | Regime | Moderate | Low | Low | High |
| | | Braided | Moderate | Low | Low | High |
| | | Pool Riffle | High | Low | Low | High |
| | Medium | Regime | Moderate | Moderate | High | High |
| | | Braided | Moderate | Moderate | High | High |
| | | Pool Riffle | Moderate | Moderate | High | High |
| | | Forced Pool Riffle | High | Moderate | High | High |
| | | Plane Bed | High | High | High | Moderate |
| | | Step-Pool | Moderate | High | Moderate | Low |
| | | Cascade | Low | High | Moderate | Low |
| | Small | Pool Riffle | High | High | High | High |
| | | Forced Pool Riffle | High | High | High | High |
| | | Plane Bed | High | High | High | Moderate |
| | | Step-Pool | Moderate | High | Moderate | Low |
| | | Cascade | Low | High | Moderate | Low |
| II | All | Pool Riffle | Moderate | Moderate | Moderate | High |
| | | Forced Pool Riffle | High | Moderate | Moderate | High |
| | | Plane Bed | Low | Moderate | Low | Moderate |
| | | Step-Pool | Low | Moderate | Low | Low |
| | | Cascade | Low | Moderate | Low | Low |
| III | All | Colluvial | Varied | Moderate | Low | Varied |
| Hotspots | All | Debris Flow Sources | High | Moderate | Low | High |
| | | Debris/alluvial Fans | High | Moderate | Low | High |
| | | Tributary Junctions | Moderate | Moderate | High | Moderate |
| | | Class II Transition | Low | High | High | Moderate |
| | | **Sensitivity Zone** | **75% SPTH** | **33 feet** | **66 feet** | **Variable** *(min 33 feet)* |

# Segment Rule Matrix

| Channel Classification | Functional Priority | Riparian Classification: Site Condition – Good | Fair | Poor |
|---|---|---|---|---|
| | High | Protect | Maintain | Improve |
| | Mod. | Maintain | Improve | Improve |
| | Low | Generally Available | Generally Available | Maintain |

| Wood | Temperature | Nutrients | Erosion |
|---|---|---|---|

# Rule Matrix Defines Generalized Site Objectives for Each Riparian Exchange Function

| Segment Objectives | | | | |
|---|---|---|---|---|
| | **Wood** | **Temperature** | **Nutrients** | **Erosion** |
| **Protect** | Maximize retention of recruitable wood | Maximize retention of vegetation that blocks incoming solar radiation | Maximize retention of existing high nutrient vegetation | Prevent and avoid ground disturbances that may disturb banks and/or concentrate runoff |
| **Maintain** | Minimize removal of recruitable wood | Minimize reduction in shade | Minimize reduction in nutrient supply | Minimize ground disturbances that may disturb banks and/or concentrate runoff |
| **Improve** | Carefully identify individual tree selection that encourage desired silvicultural responses | Carefully identify individual tree selection that minimizes reduction in shade | Encourage treatments that promote balanced primary production and establishment of high nutrient species | Consider treatments that support recovery of eroding lands (e.g. planting, biotechnical stabilization, etc) |
| **Generally Available** | Treatment constraints for this function are minimized | Treatment constraints for this function are minimized | Treatment constraints for this function are minimized | Treatment constraints for this function are minimized |

# IV. Development of Site Prescriptions

- Large Wood Placement Project

- Late Succession Management Area Use

# Soquel Demonstration State Forest-Large Wood Placement Project*

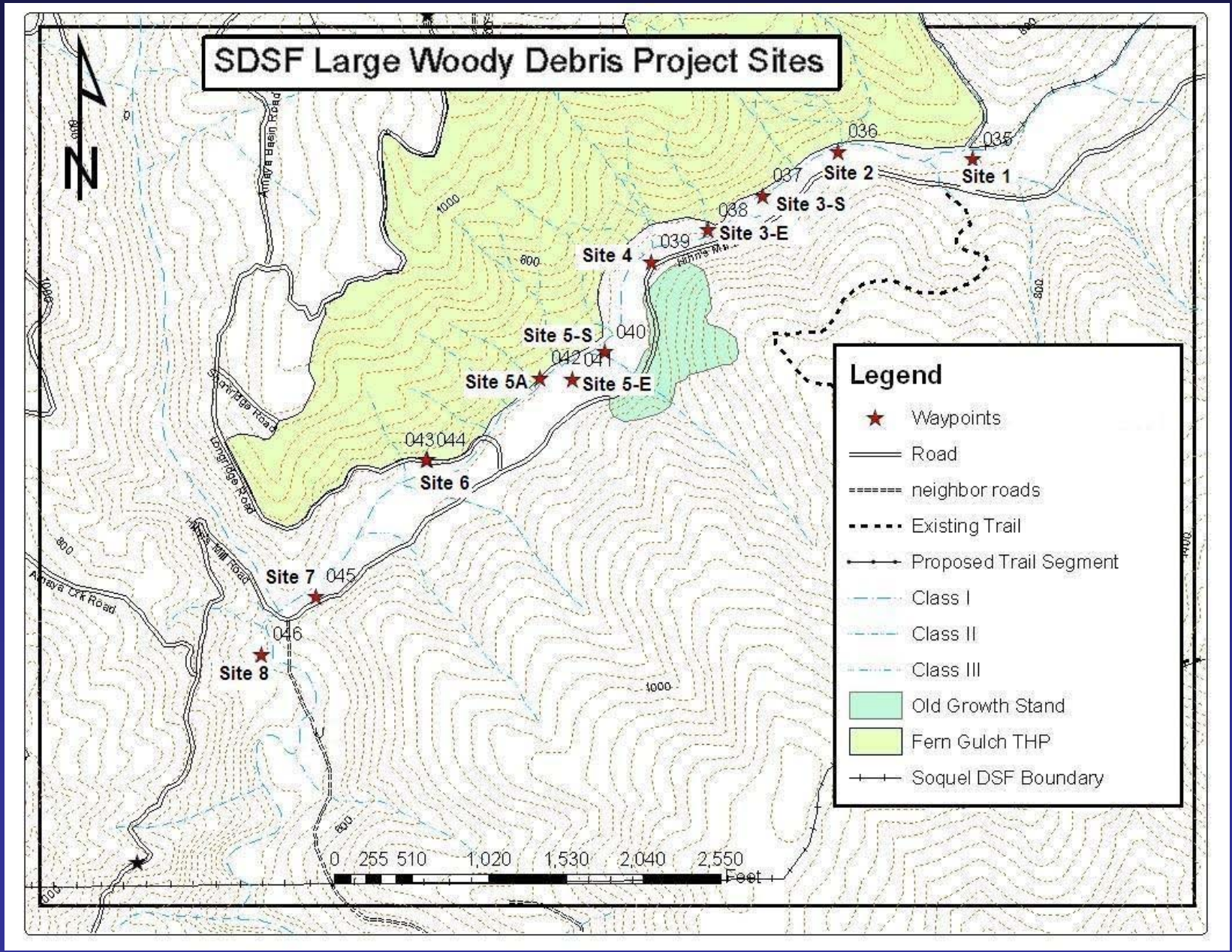
- **<u>Goals of the Project</u>:**
  - **Accomplish placement of large wood that will contribute to survival of coho salmon and steelhead in the Soquel Creek watershed.**
  - **Demonstrate feasibility of a large wood placement project outside of a THP or DFG grant.**
  - **Conduct an experiment to determine success of different types of wood placement projects.**

*Project to be done in conjunction with the Fern Gulch THP (but not part of THP)

# Soquel Demonstration State Forest-
# Large Wood Placement Project Partners

- NOAA National Marine Fisheries Service
- NOAA Southwest Fisheries Science Center
- CAL FIRE
- CGS
- DFG
- Resource Conservation District of Santa Cruz County
- Santa Cruz County
- *Alnus* Ecological

# Potential Large Wood Placement Sites Located on Reconnaissance Survey in Nov 2010



# Soquel Demonstration State Forest-Large Wood Placement Project

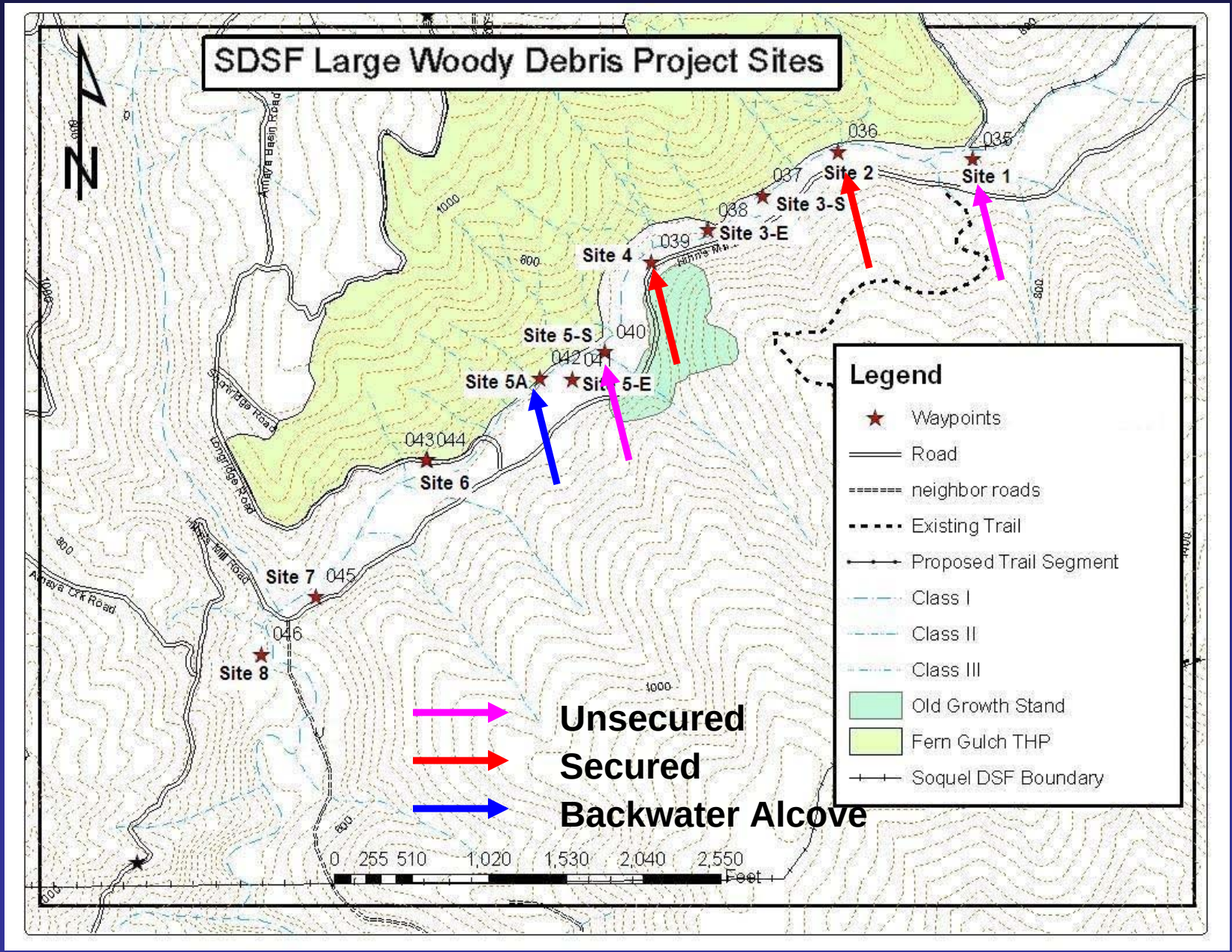
Study Design for Summer 2011

- **Sites 1 and 5: "Unsecured sites"**
  - Place unanchored wood in the channel--hopefully with root wads, along with one or more other logs (total of 2-4 trees with one large keystone piece).
  - Meet NMFS loading recommendation: 1.3-4 pieces/100 m for a large channel.
  - Install 3-4 "clumps" at both sites 1 and 5 along a 300-500 ft reach.

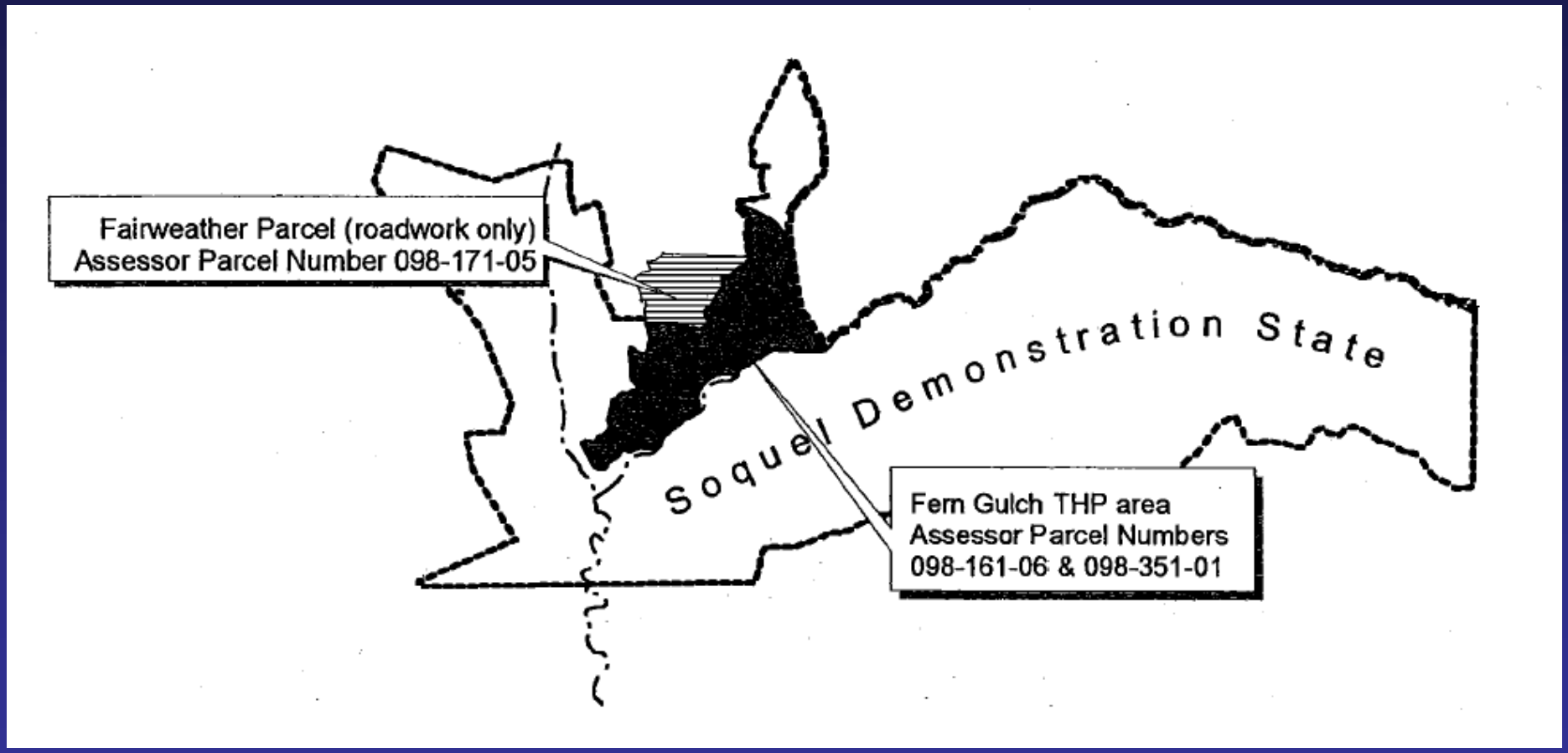
- **Sites 2 and 4: "Secured sites"**
  - Engineered structures = log-vanes.
  - Install 2-3 structures within a 250 ft reach at both sites 2 and 4.
  - At each site, at least one structure will include additional wood and/or rootwads for cover.
  - Develop a "complex" of pools and gravel bars at each site.

- **Site 5A: Build backwater alcove** in an existing side channel area.

# Potential Large Wood Placement Sites Located on Reconnaissance Survey in Nov 2010



# Fern Gulch Timber Sale Area




**Many of the Trees for the Large Wood Placement Project are Expected to come from Road Construction Work Associated with the Fern Gulch Timber Sale**

Site 1: Tree Excavating, Tree Felling
Anchoring Pieces Between Boulders
Goal: 3-4 clumps with 2-4 pieces, with at least one with root wad attached

**Flagged Access Route for Excavator to Reach Site No. 1.**

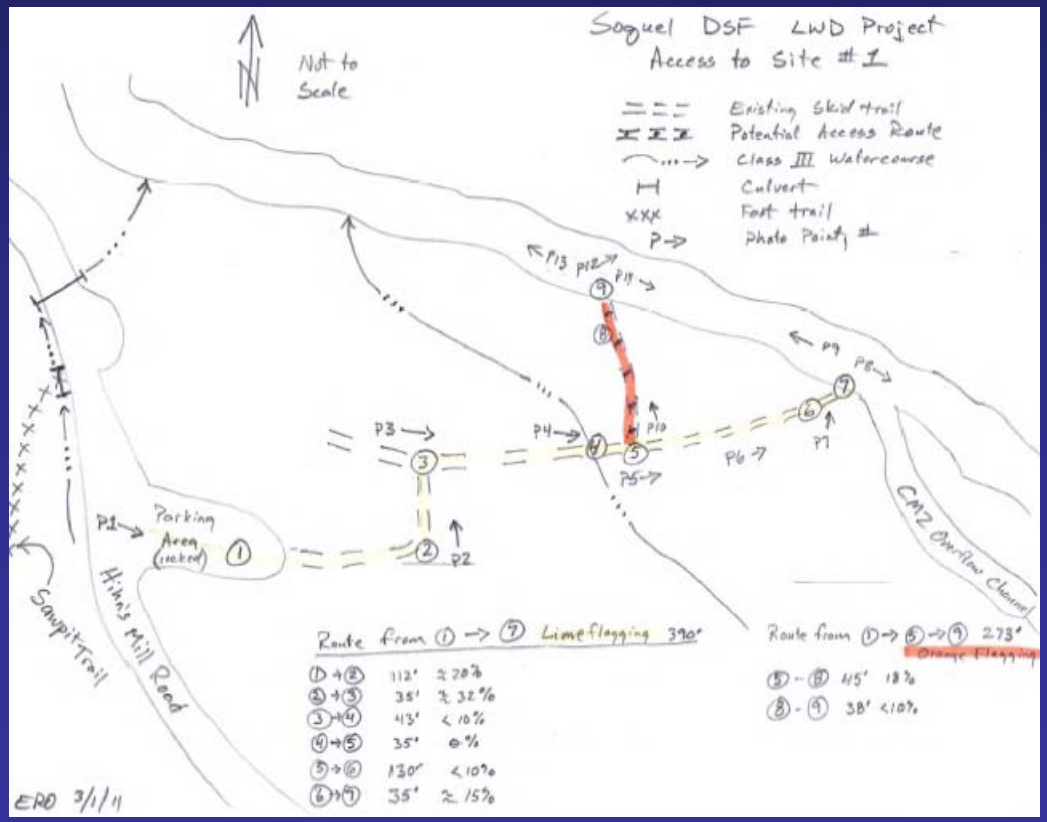



Image: Ed Orre, SDSF

# Example of Unanchored Wood: Clark Fork of the Ten Mile River Watershed, Mendocino County

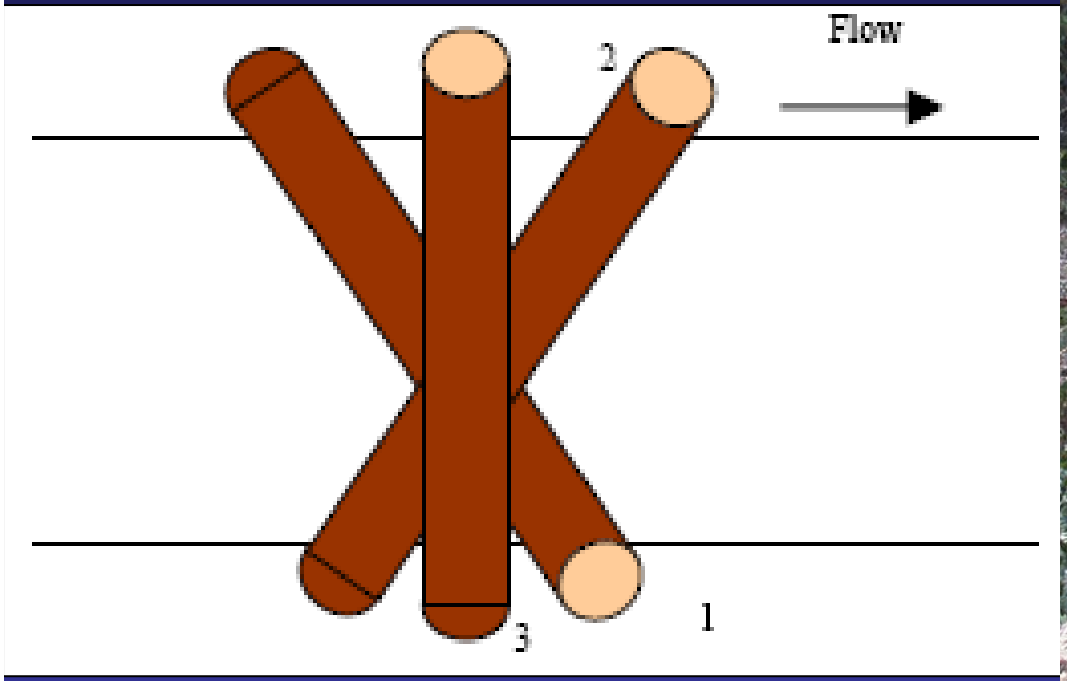


Photo and Diagram: Dave Wright, Campbell Timberland Management

# Example of Unanchored Wood: Clark Fork of the Ten Mile River Watershed, Mendocino County

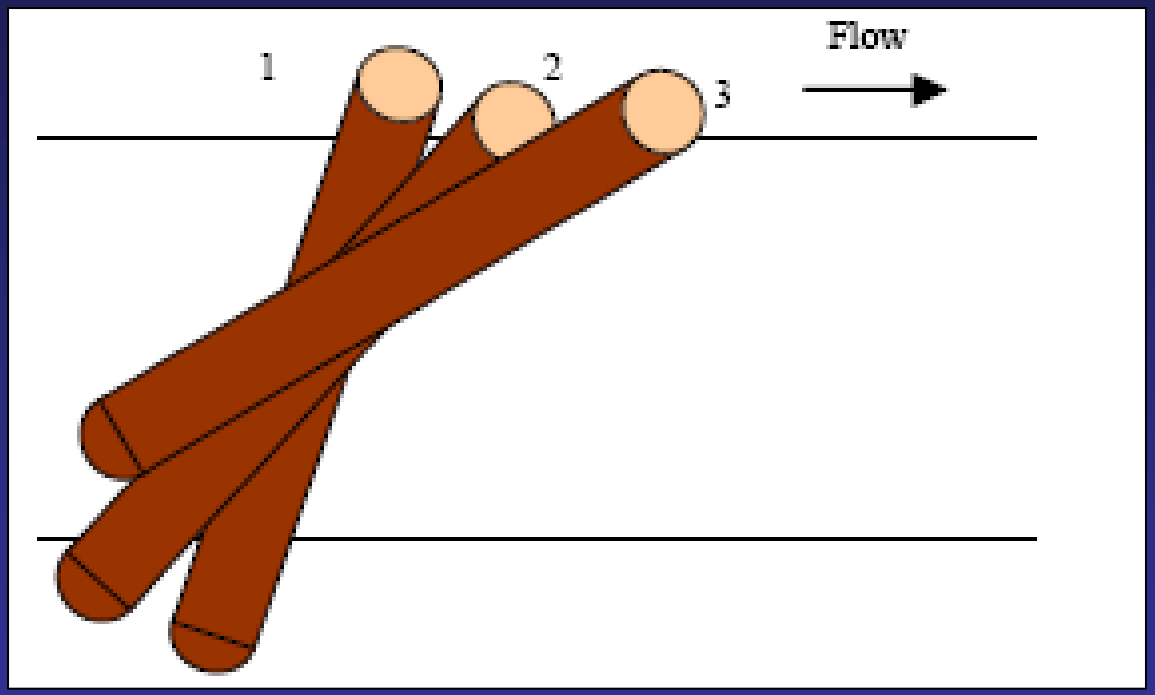
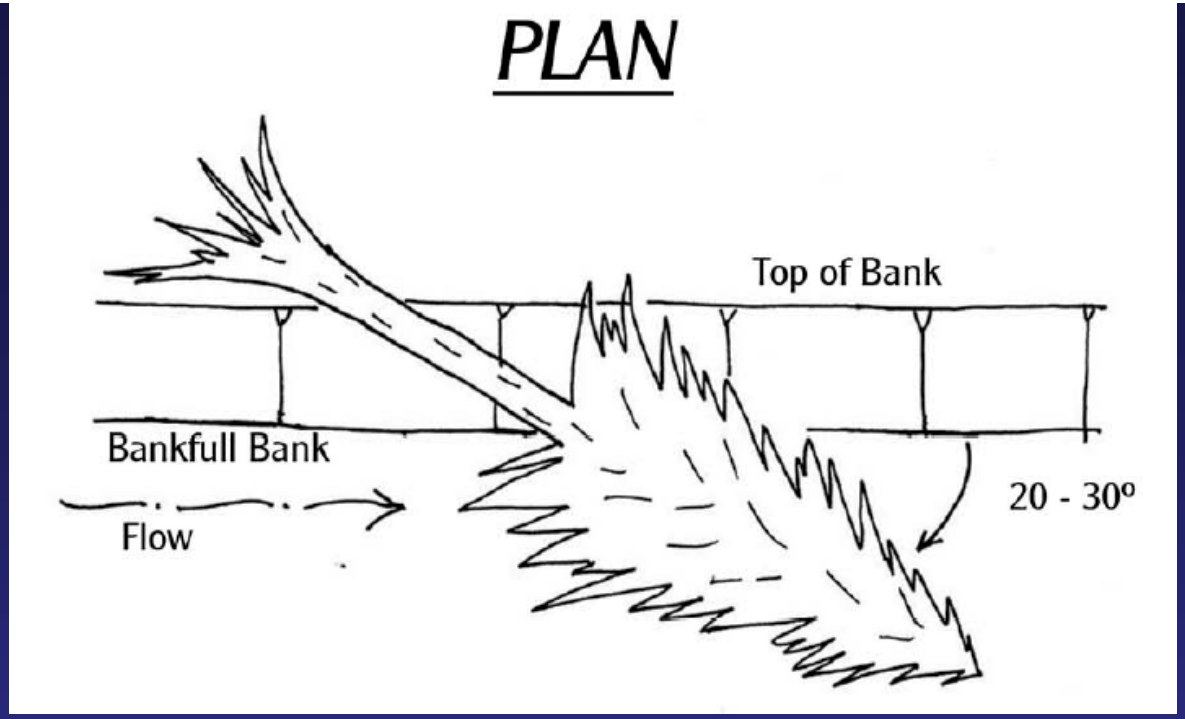



Diagram: Dave Wright, Campbell Timberland Management

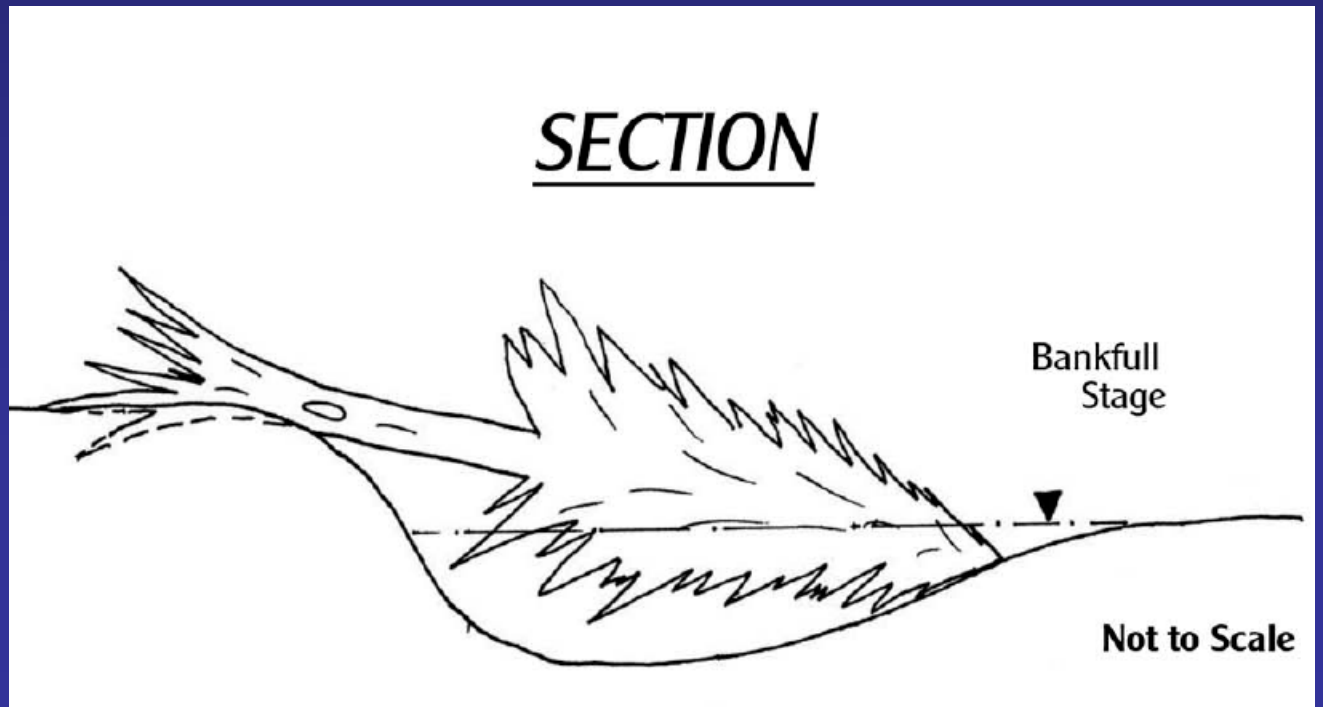
Photo: Dave Wright,
Campbell Timberland
Management

Site 5: Site for Tree Felling, Tree Excavating, Trucking in Trees with Root wads Attached
Goal: 3-4 clumps with 2-4 pieces, with at least one with root wad attached

Example of a
Douglas-fir tree that
can be toppled into
the East Branch of
Soquel Creek channel



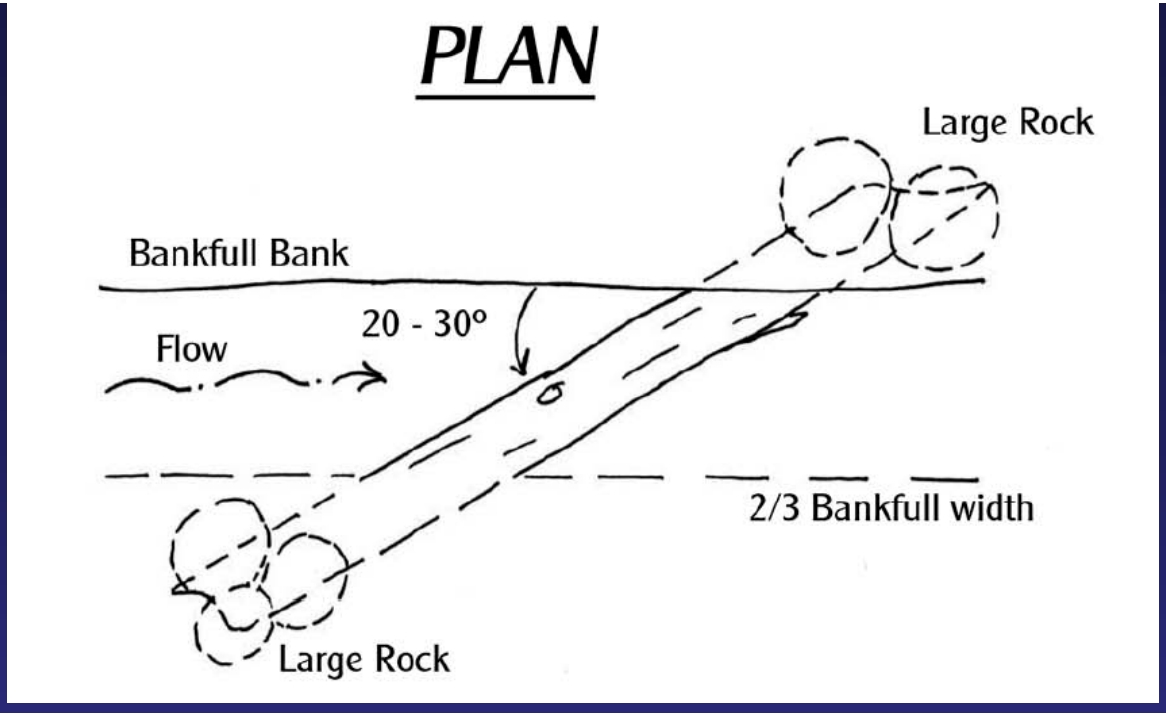

# Diagrams of Typical LWD Introduction via Tree Fall—Downstream Fall

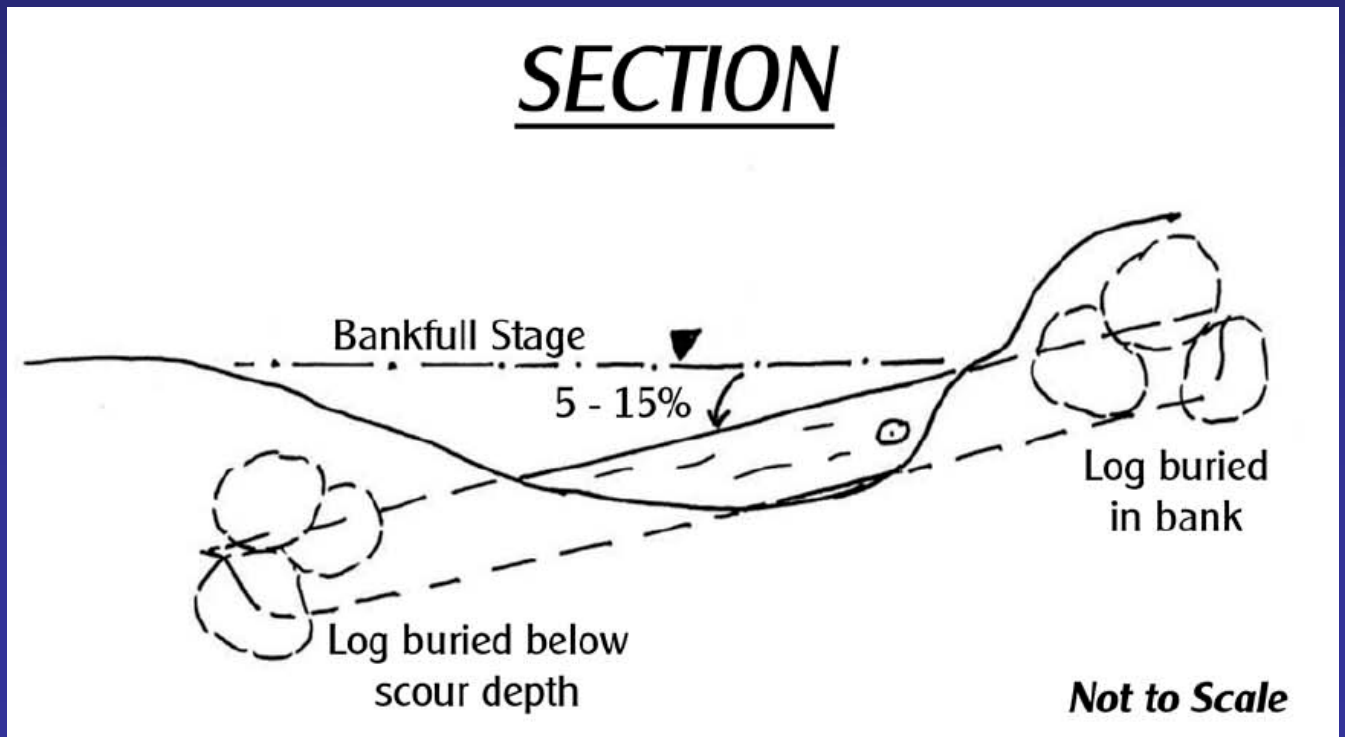



**Images:**
**S. Reynolds, CGS**

Existing Large Wood in
the East Branch of Soquel
Creek Channel

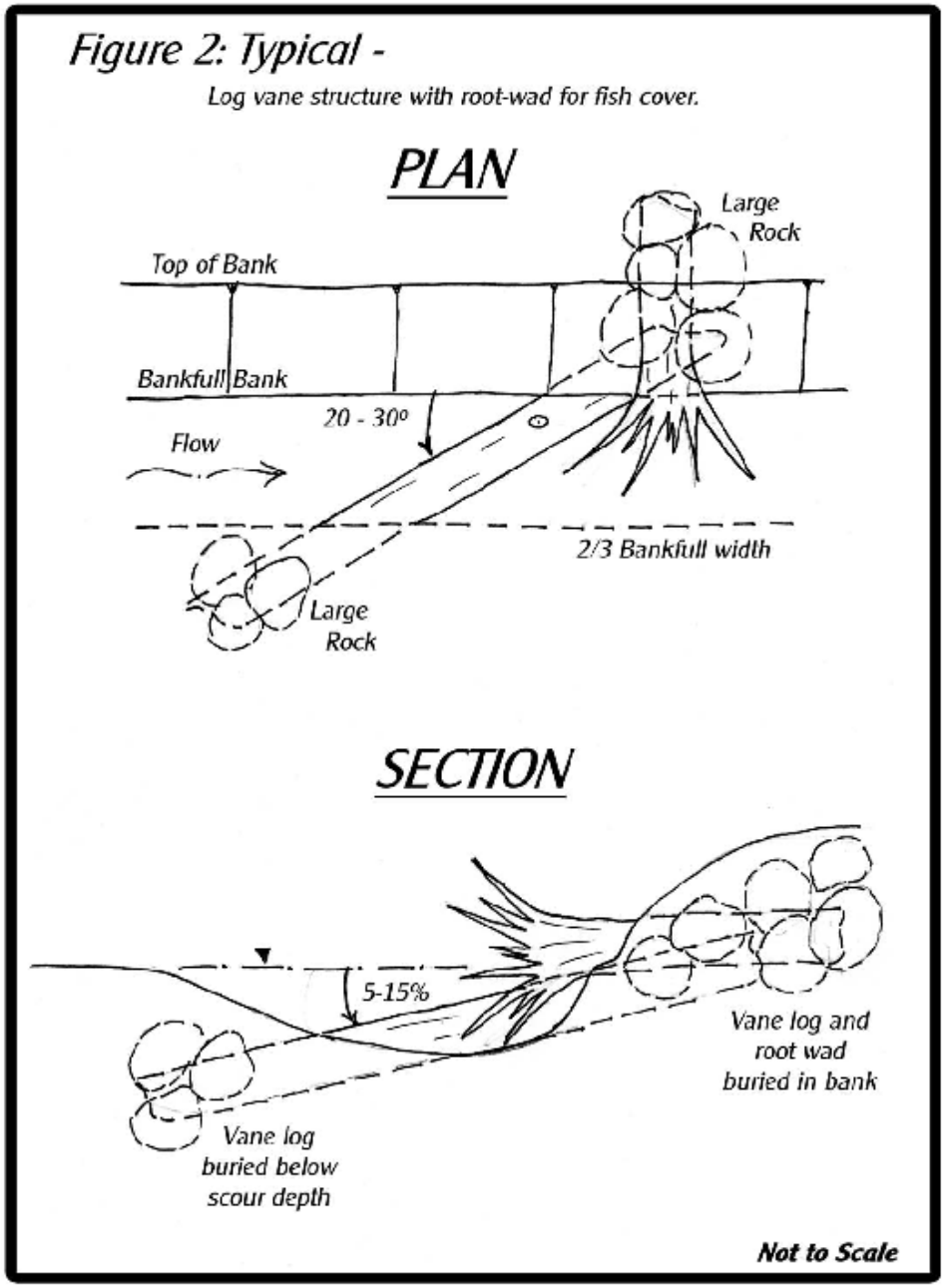
Site 2: Site for Log Vane Structure
2-3 Structures installed in a 250 ft Reach




# Diagrams of a Typical Log Vane Structure

Images:
S. Reynolds, CGS




**Log Vane Structure with Additional Tree and Rootwad for Enhanced Fish Habitat**

**Image: S. Reynolds, CGS**

Site 4: Site for Log Vane Structure
2-3 Structures installed in a 250 ft Reach

Site 4: Site for Log Vane Structure
Hihn's Mill Road

Field Reconnaissance Team
Examining Existing Wood in
East Branch Soquel Creek

Site 5A: Build Backwater Alcove in Overflow Channel Area

# Next Steps for SDSF Wood Project

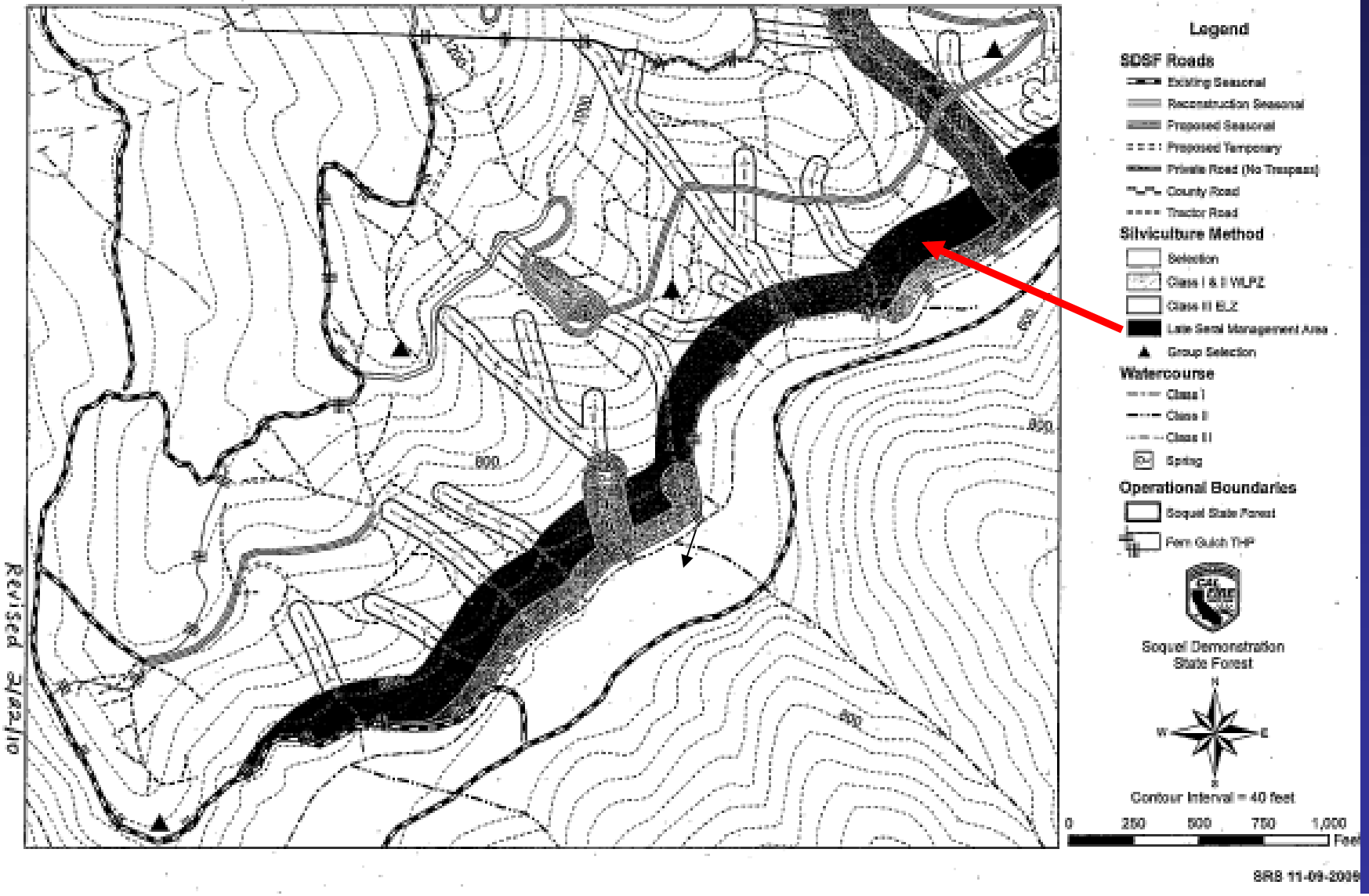
- **Steve Reynolds, CGS, is finishing the preliminary project design documents for the field sites.**
- **Jim Robins, *Alnus* Ecological, will be obtaining the necessary permits for the project when he has the plans from Mr. Reynolds (funding from a Coastal Conservancy grant).**
- **Dr. Sue Sogard, NOAA SWFSC, is developing a BACI experimental design. A "mini-MOU" has been developed and signed by the SWFSC; awaiting signature by CAL FIRE Acting Director.**
- **Jennifer Nelson, DFG, is completing the biological assessment.**
- **Field installation is to occur in the summer of 2011 under a separate CAL FIRE contract from the Fern Gulch Timber Sale contract.**

# Late Succession Management Area Use for the Fern Gulch THP

**(Soquel Demonstration State Forest General Forest Management Plan)**

- **Used to promote the development and maintenance of functional old-growth habitat characteristics.**
- **Width of 300 feet on each side of the bankfull channel.**
- **At selected locations where conifers are lacking, Douglas-fir and coast redwood trees are to be planted to promote long-term recruitment of large wood in streams.**
- **All woody riparian (i.e., hydrophytic) vegetation to be retained except where riparian function would be enhanced by removing such vegetation.**

# Late Succession Management Area Use for the Fern Gulch THP



# V. Other Section 916.9 Section V Requirements

| | Positive Effect | Negative Effect |
|---|---|---|
| Beneficial Functions of Riparian Zones | (L/M/H) | (L/M/H) |
| | | |
| *Channel Zone, Channel Bed* | | |
| Streambed and flow modification by LWD | H | NA |
| Channel bed stabilization | H | NA |
| Spawning and rearing habitats | H | NA |
| Sediment filtration in CMZ, FPA | NA | L |
| Flood flow attenuation in CMZ, FPA | NA | L |
| Overflow channels for fish refugia | H | NA |
| Hyporheic zone function | NA | NA |
| *Core Zone* | | |
| Bank stability | H | NA |
| Large wood recruitment potential | NA | L |
| Water temperature control (shade reduction) | NA | L |
| Nutrient production and input | L | NA |
| Sediment filtration | NA | L |
| *Inner Zone* | | |
| Large wood recruitment potential | NA | L |
| Water temperature control (shade reduction) | NA | L |
| Nutrient production and input | L | NA |
| Microclimate control | NA | L |
| Structural diversity for terrestrial wildlife habitat | NA | L |
| Sediment filtration | NA | L |
| *Outer Zone* | | |
| Wind resistance for riparian zone stability | NA | NA |
| Microclimate control | NA | NA |
| Large wood recruitment (esp. landslide processes) | NA | NA |
| Structural diversity for terrestrial wildlife habitat | NA | NA |
| Sediment filtration | NA | NA |

**916.9 (v) (3)(A)4.**

**Identify potential effects to beneficial functions, both positive and negative**

# Need to Consider Downstream Impacts (Positive and Negative)*

- Will large wood introduction into the East Branch of Soquel Creek cause a adverse or positive downstream impact?

- Project designed so that large wood will not adversely impact downstream infrastructure (bridges, culverts, etc.).

*Dr. Doug Martin's Comment on Interim Guidance Document

# Summary Points

- **The Soquel Creek watershed has poor large wood loading and poor off-channel/ floodplain quality, resulting in poor habitat conditions for state and federally listed anadromous salmonids.**
- **Riparian zones have mixed composition, under sized conifers, and low mortality potential for coast redwood and Douglas-fir.**
- **The channel is low gradient (2-3%), unconfined, and can be classified as plane bed or forced pool riffle.**
- **Segment objectives include improving wood loading, maintaining shade for temperature control, and protecting existing nutrient input.**
- **Site prescriptions include use of Late Succession Management Areas (300 ft each side) as part of the Fern Gulch THP and a large wood placement project, testing both unanchored and anchored wood installations (outside the THP process).**

# References


- D.W. Alley and Associates. 2009. Soquel Creek watershed habitat typing. Brookdale, CA.
- Lassettre, N. and M. Kondolf. 2003. Process based management of large woody debris at the basin scale, Soquel Creek, California. Final Report prepared for CAL FIRE.
- Montgomery, M. and J. Buffington. 1997. Channel reach morphology in mountain drainage basins. GSA Bulletin 109: 596-611.
- National Marine Fisheries Service. 2010. Public review draft recovery plan for CCC coho salmon ESU. NMFS Santa Rosa.
- Santa Cruz County Resource Conservation District. 2003. Soquel Creek watershed assessment and enhancement plan. Capitola, CA