Tracking Channel Changes and Sediment in the Pescadero-Butano Watershed

San Francisco Bay Water Board

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February 12, 2015

Water Boards

Acknowledgements

- *Martin Trso* for his work as the lead investigator for the studies we are presenting tonight

- *Professor Bill Dietrich, UC Berkeley,* for acting as a technical advisor for the studies

How Do We Track Sediment? Analysis and Methods

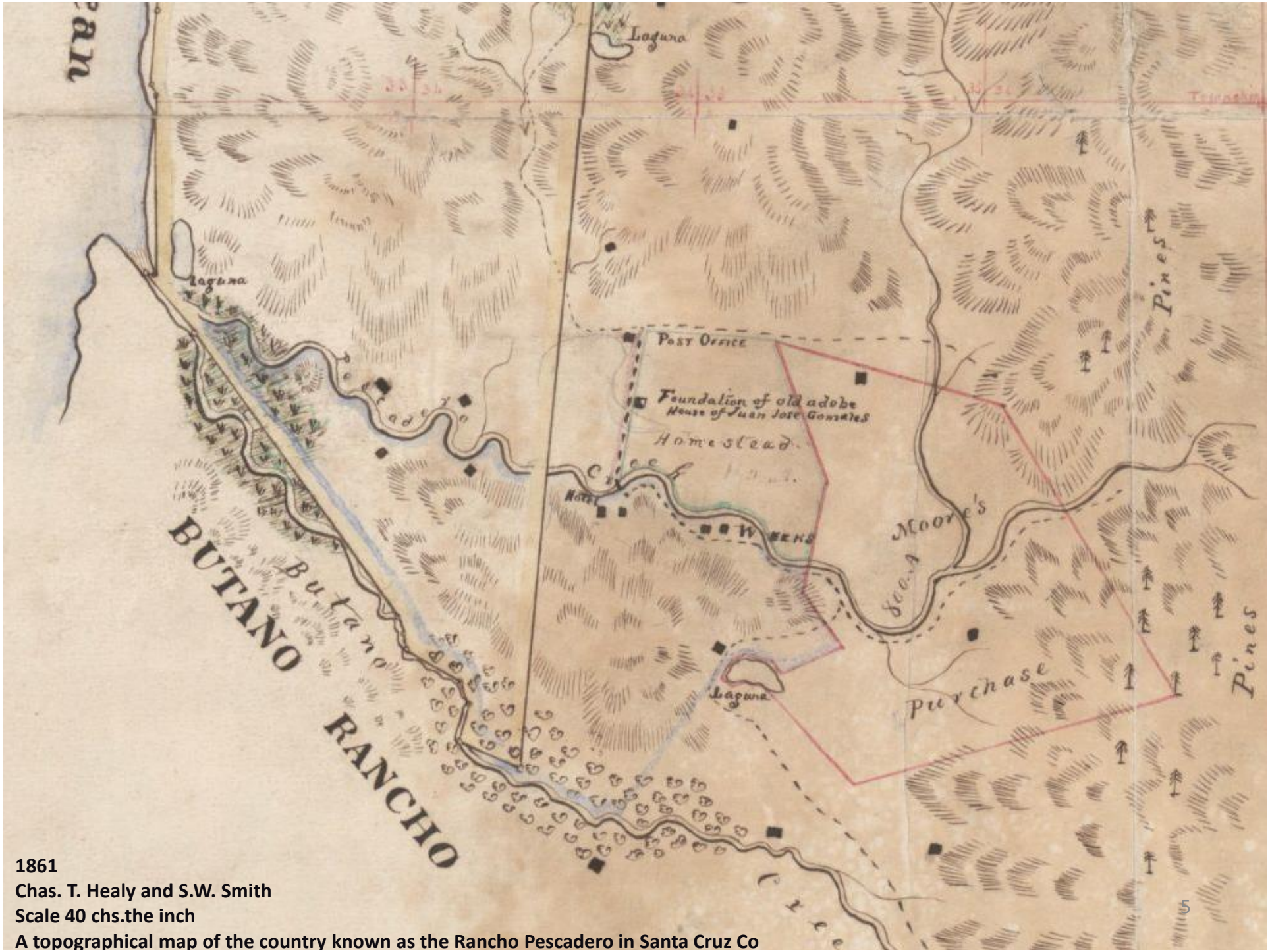
- Channel changes
  - Extensive channel surveys
  - Interview of long-time residents
  - Interpretation of historical photographs, maps, paintings, and documents
- Sediment budget
  - Extensive field work in the watershed and in the channels
  - Interpretation of time-sequential aerial photographs
  - Field surveys
  - Analysis of high-resolution topography (2005 LiDAR)
  - Review of existing studies

Fishery

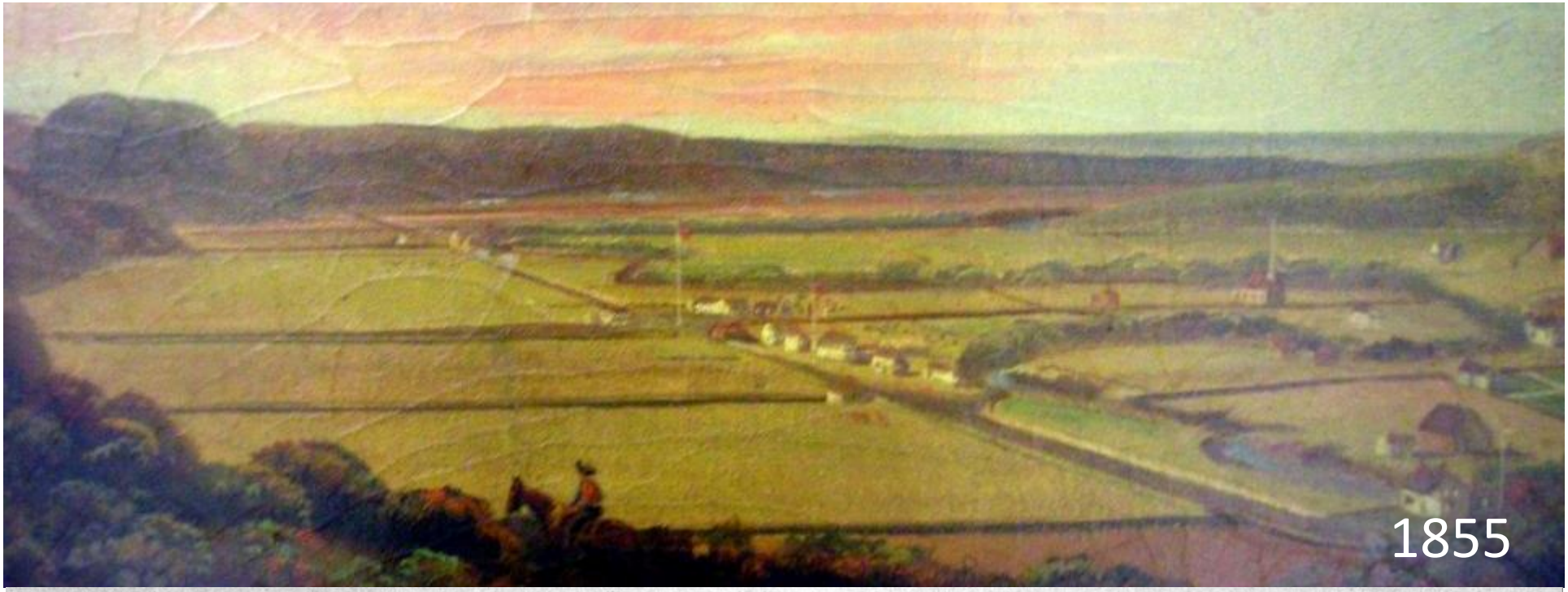
"Pescadero" is the Spanish for "fishery," and the name is indicative. The creeks which come down from the mountains all along this coast swarm with the spotted trout of California, and afford fine sport in the early part of the season. In places along their banks, the honeysuckle bushes and other shrubs and vines form a chapparal so dense that you must wade for miles to whip the stream; but one hundred, two hundred, or even three hundred trout are often basketed in a single day's fishing by one individual. It does not rain here from April until the last of November or December; but as the days become shorter, and the sun's rays less powerful, the evaporation which caused the streams to dwindle to mere strings of detached ponds decreases, and all over the State, especially in the Coast Range, the rivers commence to rise. Thompson, a hospitable landlord, took me down to the mouth of the Pescadero for a little sport. We sent a Mexican after worms for bait. The Mexican sent a negro, and we sent a Chinaman after the negro, and got them all at last. The row down the creek was short. We saw hundreds of mallards and teal,

handsomest fish I ever caught. Eight- and ten-pounders are common, and they are the most delicious fish for frying or broiling which ever swam the sea. Great crabs came in also with the tide, and we dipped several of them out with our net. In two hours we corralled fourteen salmon-trout, losing several more by hooks breaking, and then, the slack-water coming on and the fish ceasing to bite with avidity, hoisted sail and went swiftly gliding back up the stream to the hotel. It was, all in all, the best morning's sport I have ever enjoyed in my life, and I have shot and fished from the Red River of the North to the Rio Grande, and from the Atlantic to the Pacific.

"The California angler can find on no spot above ground a fairer field for the display of his piscatory skill than the brooks flowing into Half Moon Bay, on the coast, some fifty miles below San Francisco. Parties of gentlemen from this city have recently met with extraordinary luck, and have brought back **wagon loads of beautiful speckled trout**. A week or two ago, four expert fishermen, **after two days' sport**, counted the number caught by the party, and found that they had **captured two thousand of the finny inhabitants** of these waters." – Daily Alta, May 13, 1857



1861
Chas. T. Healy and S.W. Smith
Scale 40 chs.the inch
A topographical map of the country known as the Rancho Pescadero in Santa Cruz Co



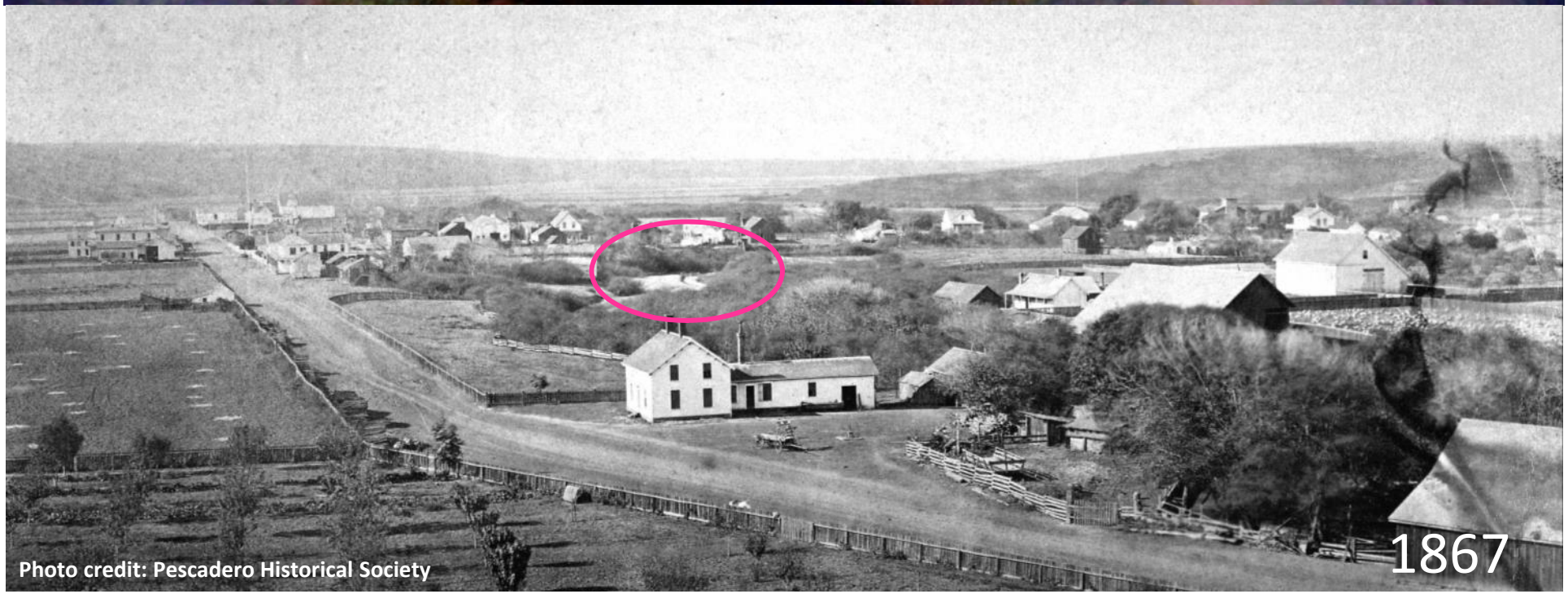
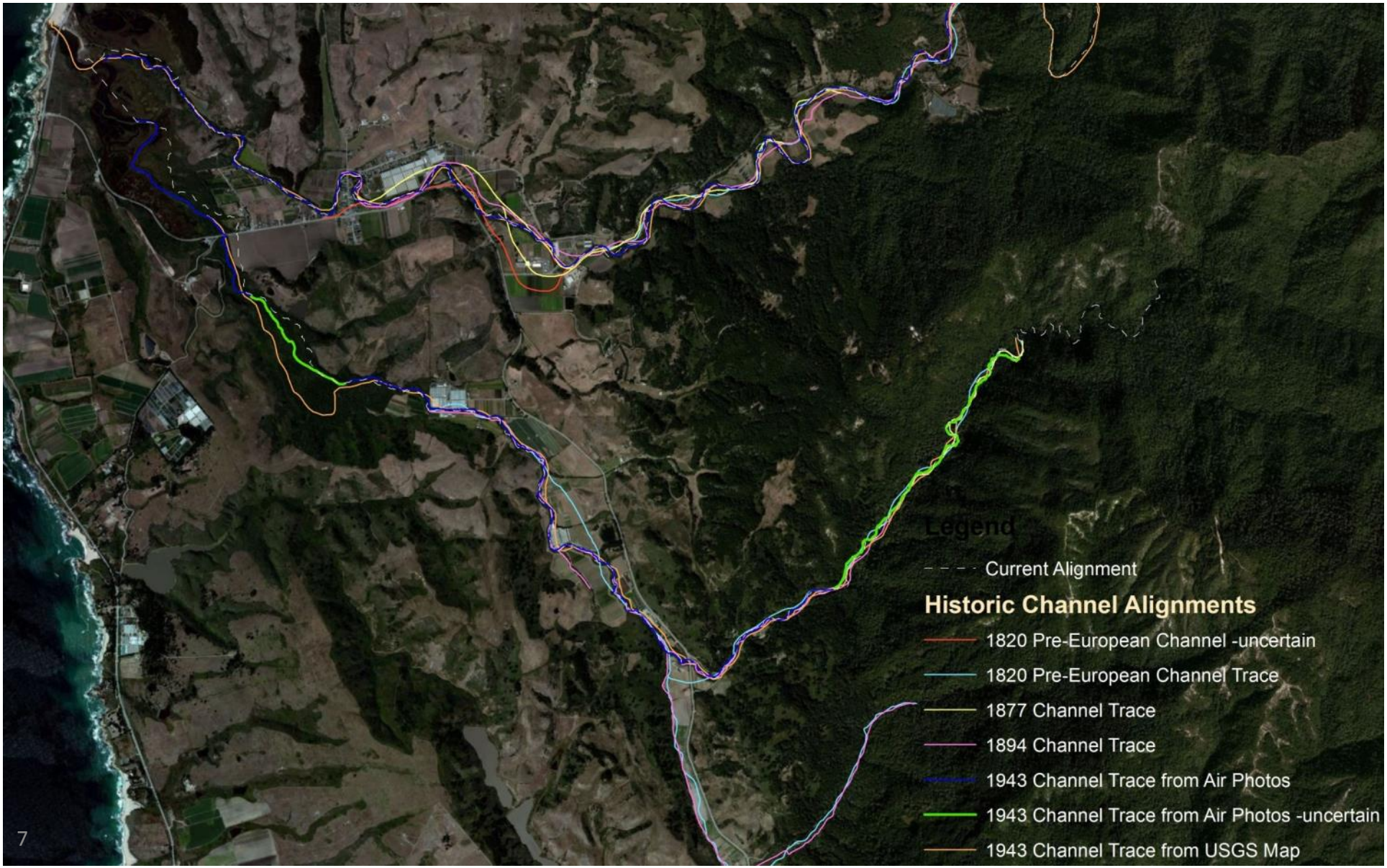
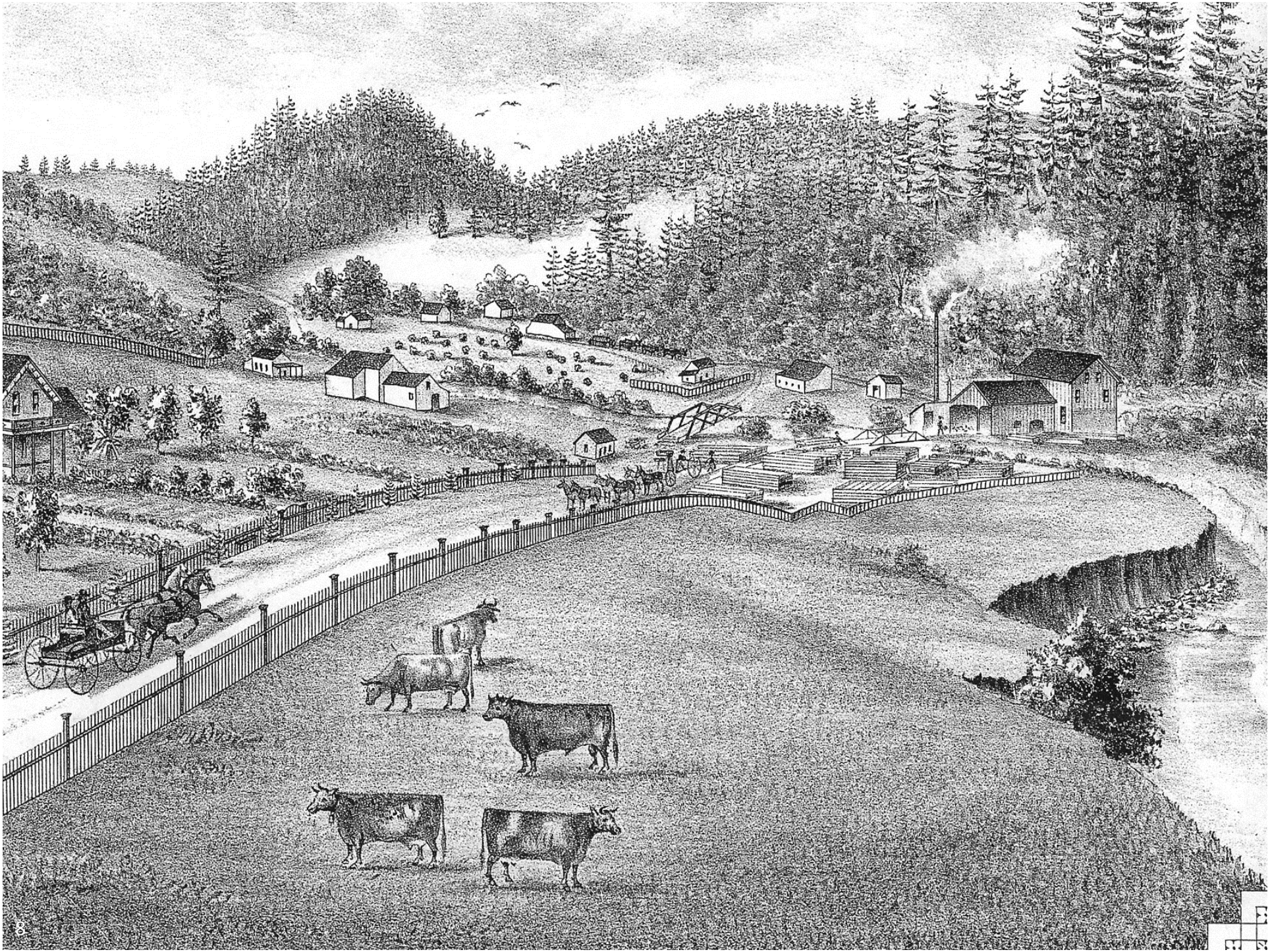


Photo credit: Pescadero Historical Society

Wide Channel-Floodplain Corridor





Pescadero Early 1900s

1915

1920

ca 1915

Photo credit: Pescadero Historical Society

Butano Early 1900s

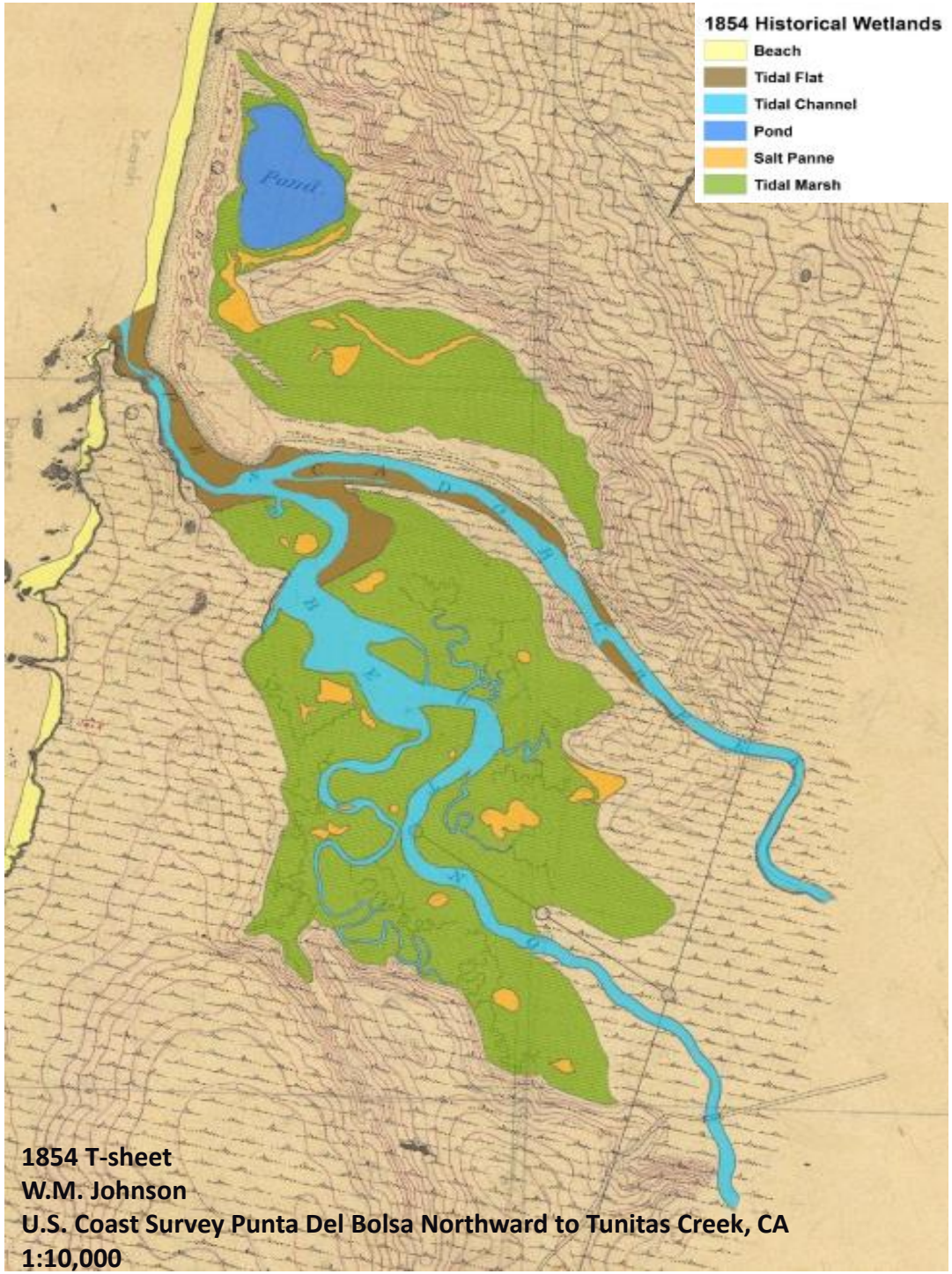
Early 1900s

1915

Photo Credit: Al Sollars

Pre-European Lagoon and Marsh

- Extensive wetlands with well developed drainage channels
- Larger marsh
- Deep and 100 ft wide channels



Marsh and Lagoon Sedimentation

- 50% reduction in open water area between 1900 and 1960

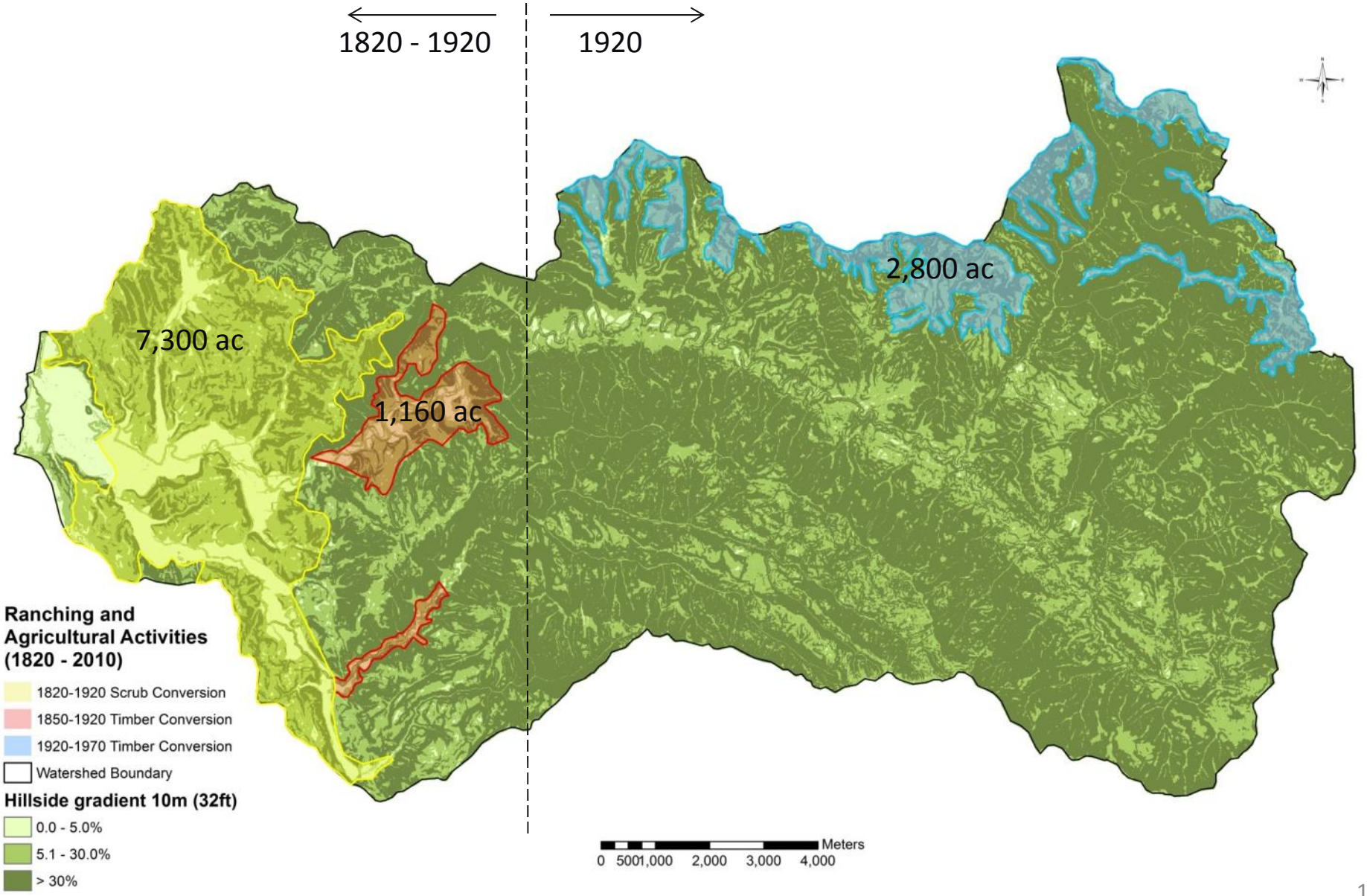
- Volume of water coming in and out of the estuary is reduced by 75%

Year	Tidal Prism
1854	225 ac-ft
2011	60 ac-ft

Land Use Changes

Date	Event
Pre-1820	"Natural" conditions
October 1769	Portola Expedition – first Spanish contact
1770 - 1820	Spanish period Grazing, introduction of non-native plants
1820 - 1850	Mexican period Land grants, livestock importation
1850 - 1920	Early American period Early logging, start of ranching and dairy farming
1856	Pescadero established
1860s-1890s	First wave of heavy logging of redwoods in Pescadero and lower Butano Agriculture including wheat, oat, barley, and flax farming
1920 - 1970	Post WWII industrial boom
1920s-1930s	Construction of levees, channelization of Butano and Pescadero channels in marsh Farming in floodplains
1930s-1960s	Highest rates of marsh reclamation and agricultural expansion
1940	Construction of Highway 1 Bridge Temporary haul road built downstream of bridge
1950s-1970s	Post-WWII logging boom: road building and extensive bulldozer logging in old growth of North and South Forks Butano Creek
1960s	State of California begins to acquire property in Pescadero Marsh
	Pescadero Road Bridge constructed in 1961
	Second wave of logging in upper Pescadero (e.g. Slate, Oil Creeks)
1970 - 2010	Second wave of logging in North and South Butano Creeks Pescadero Marsh restoration projects

Watershed Changes – Agriculture and Ranching

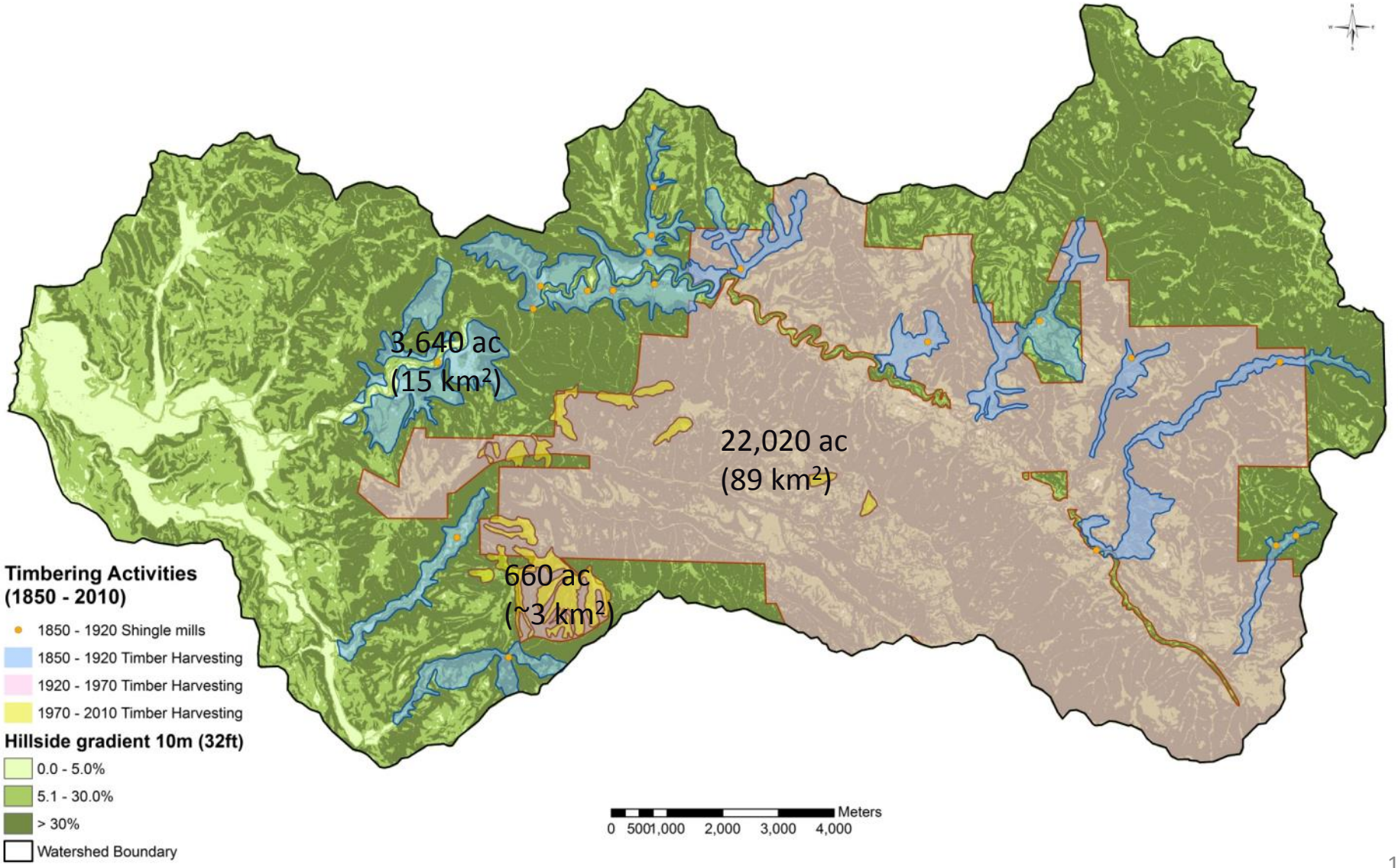


1890

1884

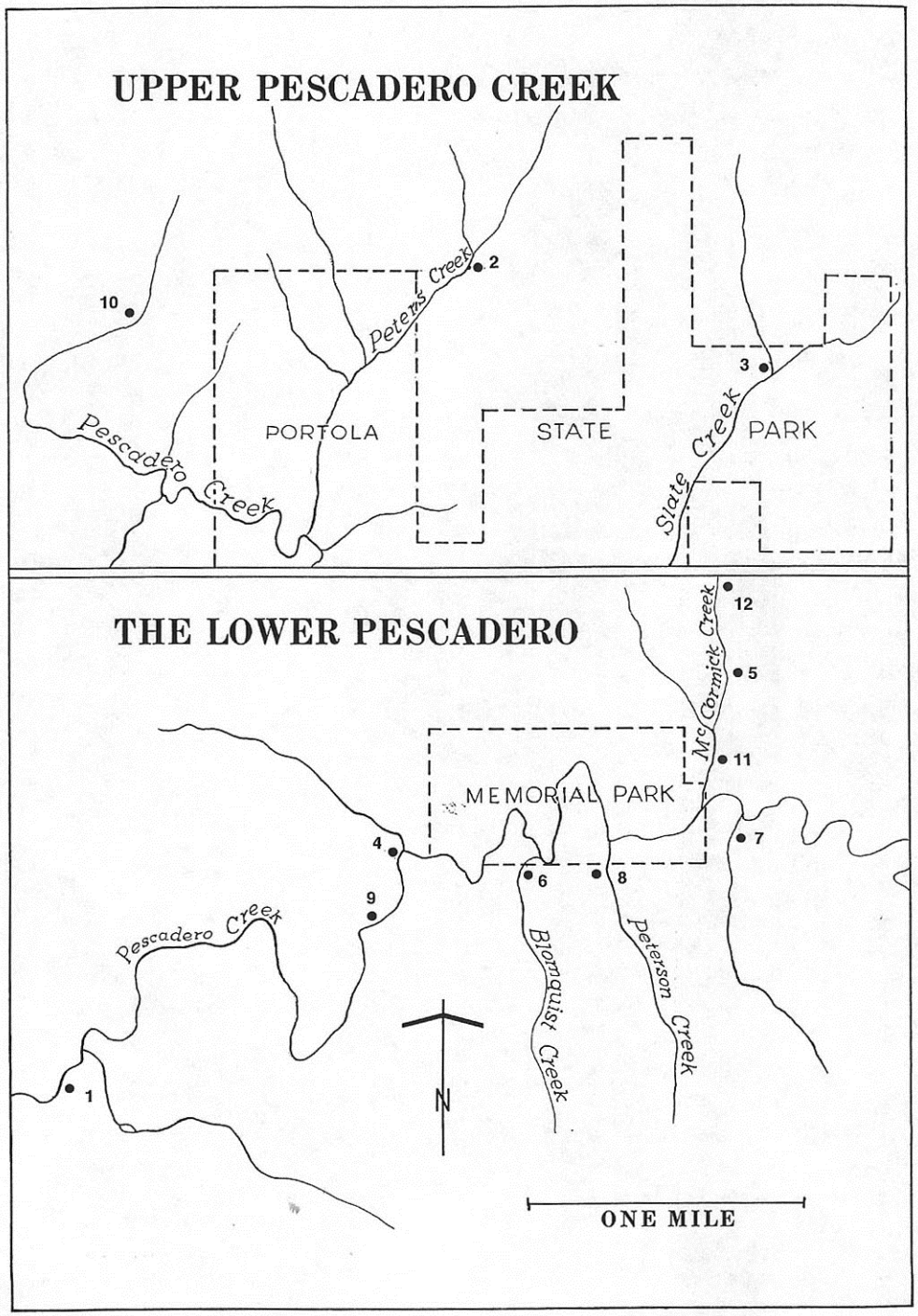
Watershed Changes – Timber Harvesting

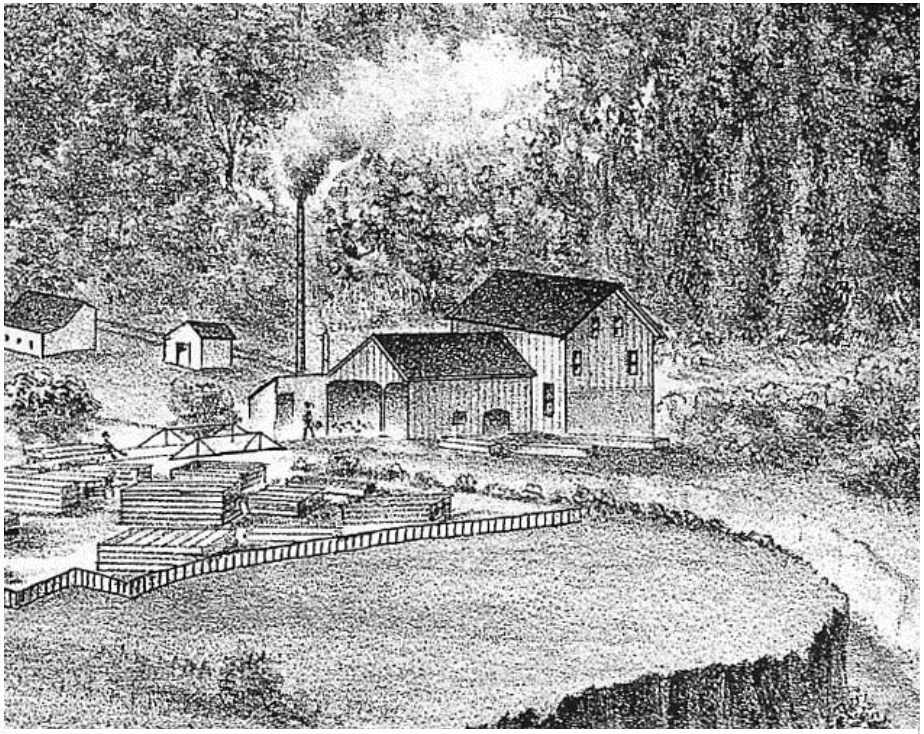
1850 - 2010

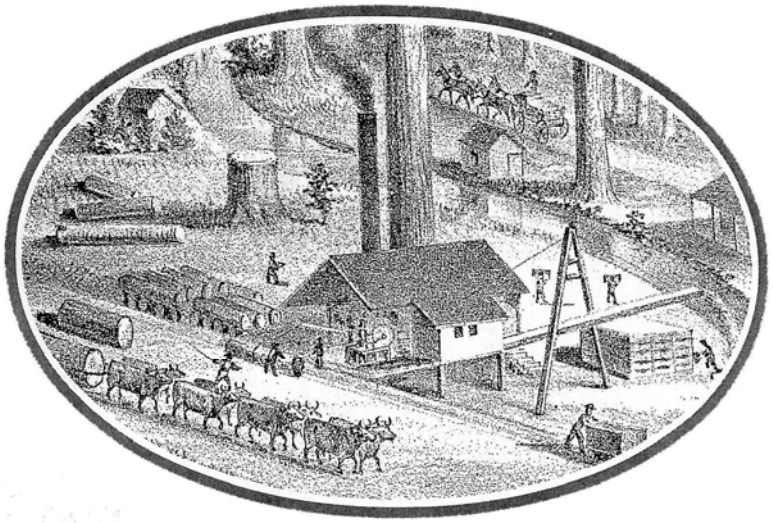


S.C. LBR.CO.

THE PON U.
GAZOS.







A drawing of the Purdy Pharis shingle mill in Purissima Canyon, 1870's.

SEPTEMBER 19, 1903. 3

REDWOODS OF THE PESCADERO VALLEY TO FALL UNDER THE WOODMAN'S AX

California Timber Company Purchases Holdings in San Mateo County, Installs a Large Plant on Waterman Creek and Begins to Clear the Forest

YOUTHFUL BRIDE KILLS HERSELF

Recent Death of Father and Mother Causes Insanity.

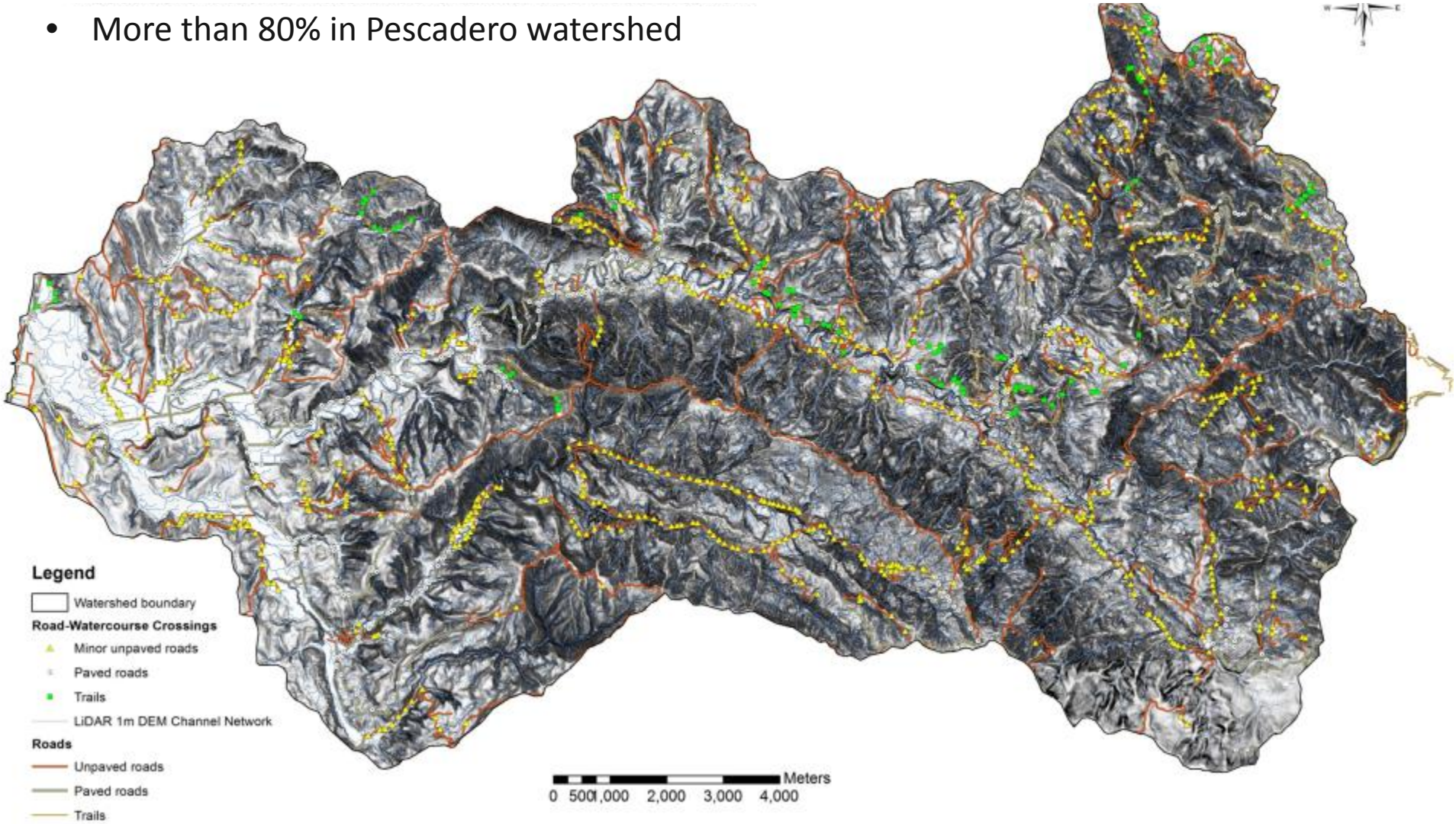
Hopkins Mill

"The days of the redwood trees which have made famous the valley through which Pescadero Creek runs are numbered […] It is evident that within a few years the redwoods in this section will be nearly all destroyed."

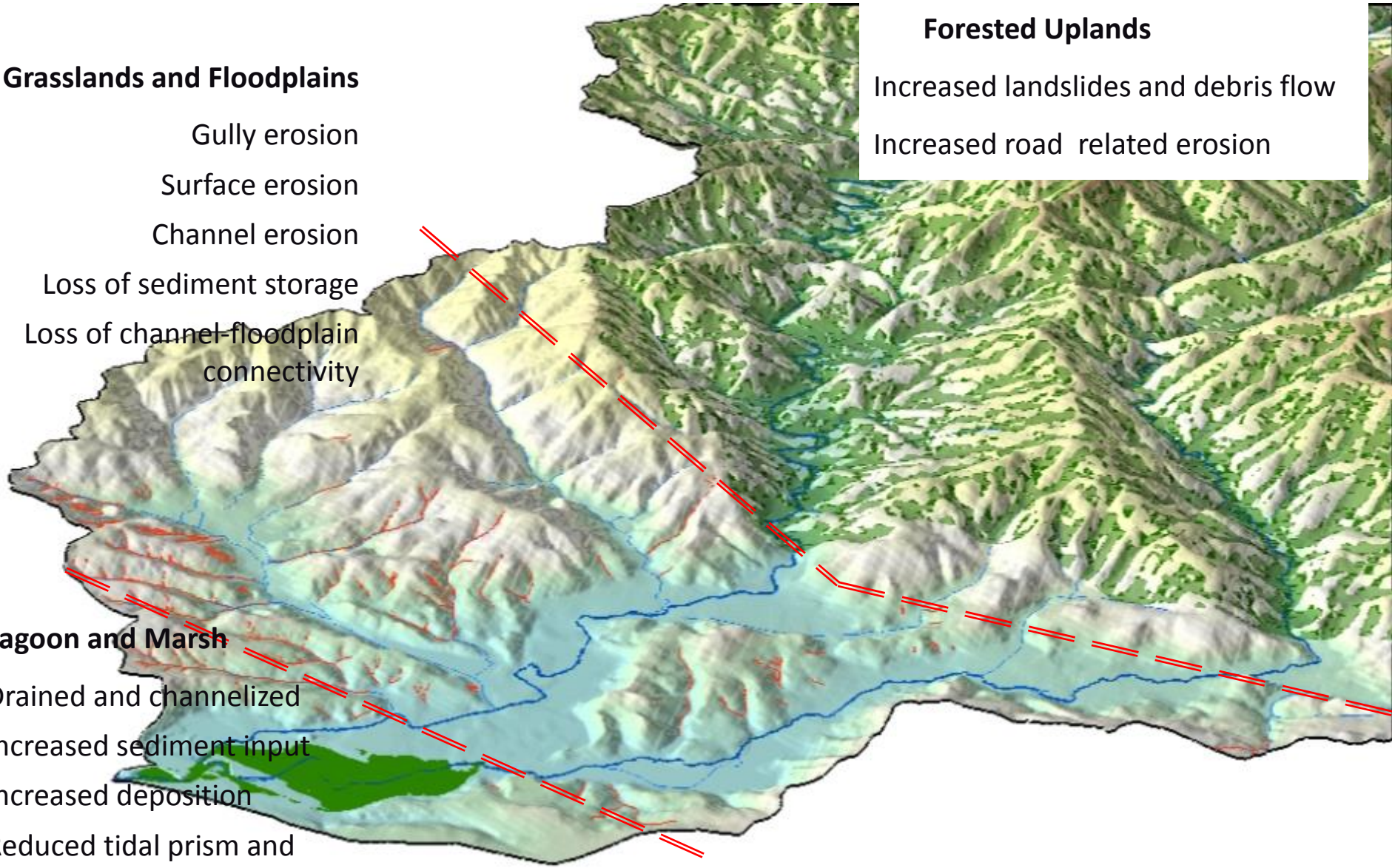
Excerpt from San Francisco Call of September 19, 1903

300 Miles of Roads

- 1,380 road-watercourse crossings
- More than 80% in Pescadero watershed



Profound Geomorphic Transformation



Forested Uplands

Increased landslides and debris flow

Increased road related erosion

Grasslands and Floodplains

Gully erosion

Surface erosion

Channel erosion

Loss of sediment storage

Loss of channel-floodplain connectivity

Lagoon and Marsh

Drained and channelized

Increased sediment input

Increased deposition

Reduced tidal prism and flushing

Reduced summer flows

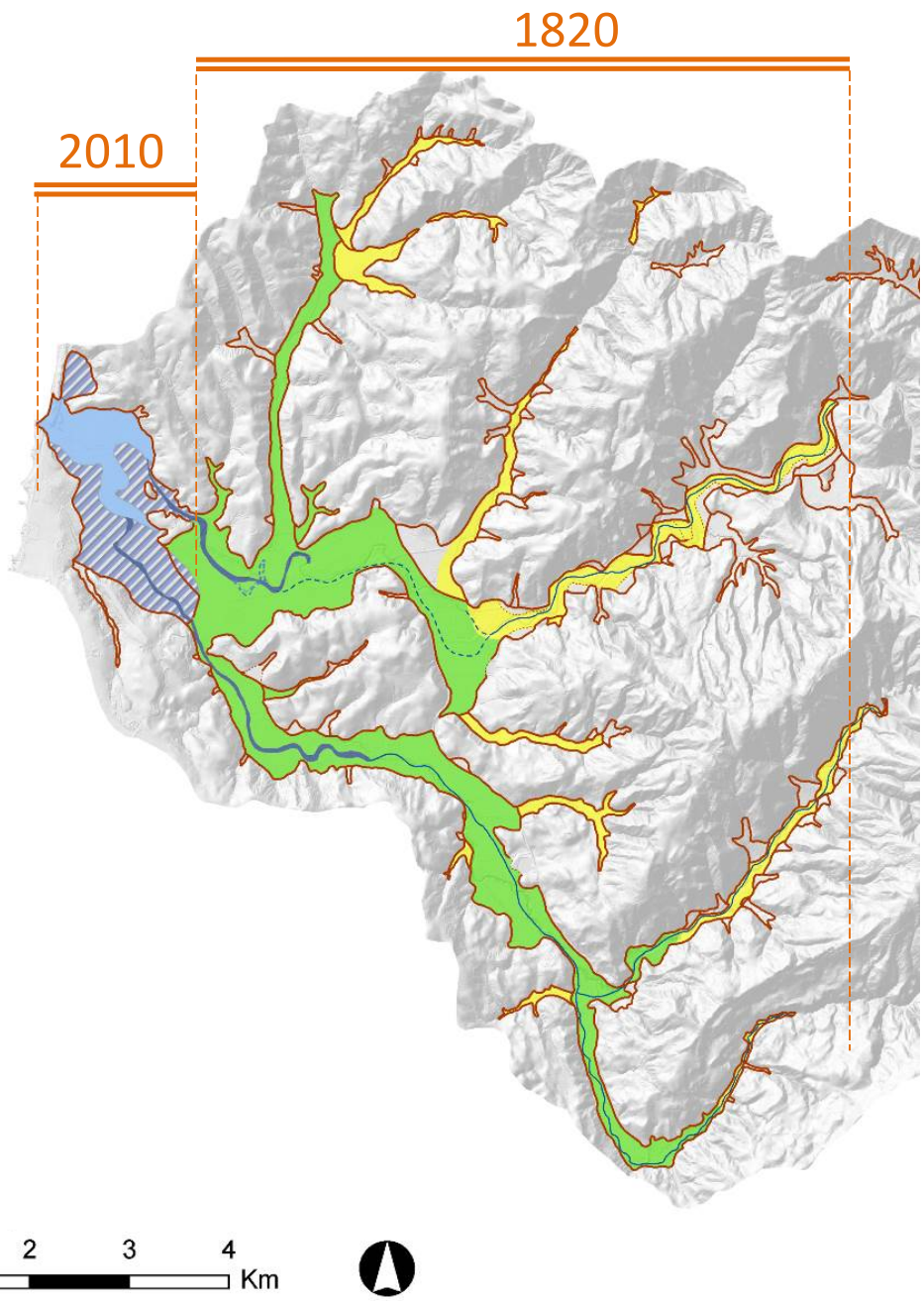
Sediment Impacts for Fish

Degraded fish habitat conditions due to:

1. Channel incision and simplification
   - No connection to floodplains
   - Deep, straight, clean channels like canals
   - No wood in the channels
2. Increase in sediment supply
   - Too much erosion on the hillslopes
   - Too much fine sediment in pools and riffles
3. Shrinking Lagoon
   - Lagoon habitat, which is critical, is getting smaller
   - Lagoon mouth closing for longer durations and opening later
4. Barriers to upstream habitat

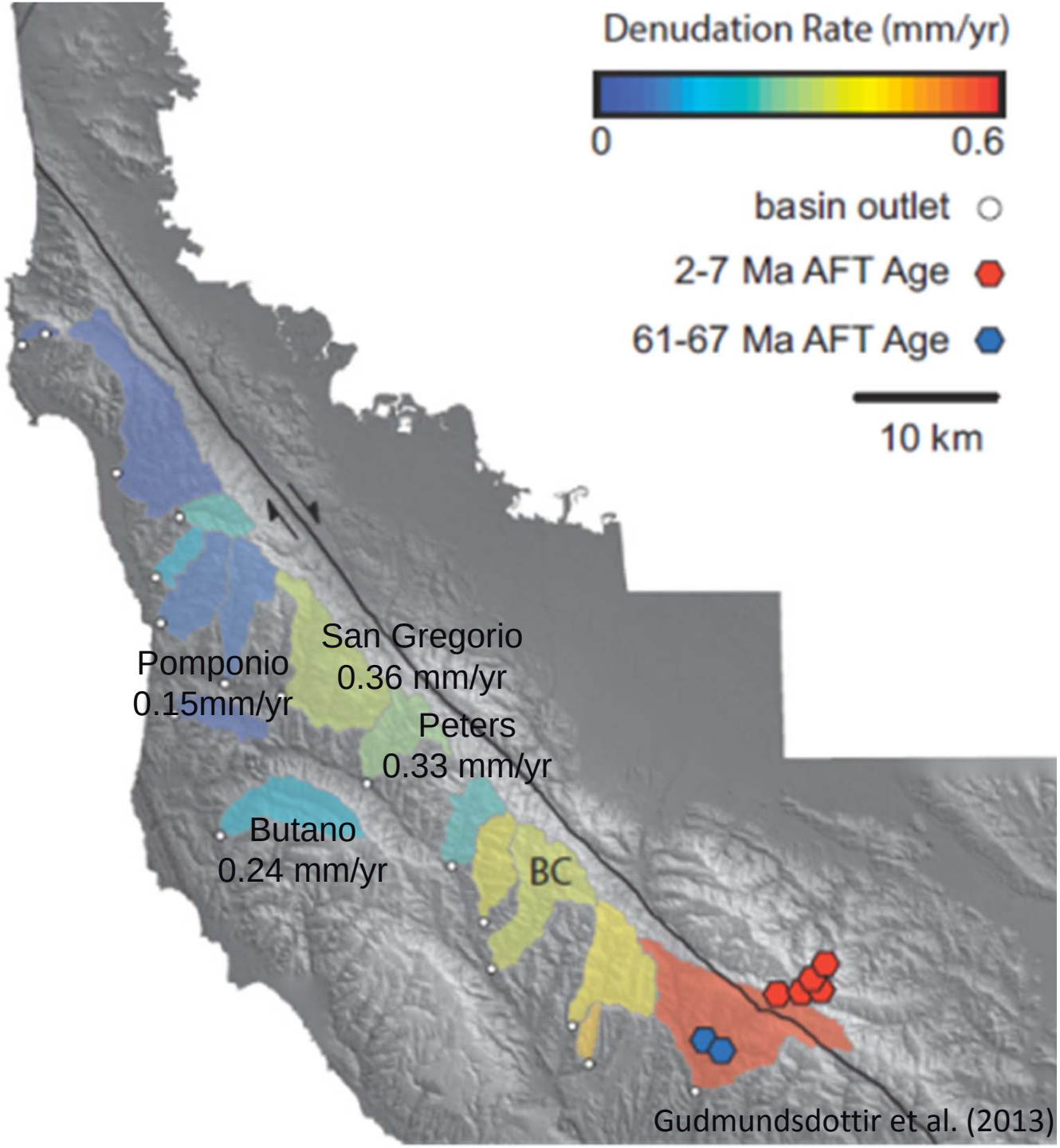
- Loss of swampy meadows
- Incised and widening channels
- Increased sediment delivery
- Shrinking lagoon

Sediment deposition shifted downstream



Natural Background Erosion Rates

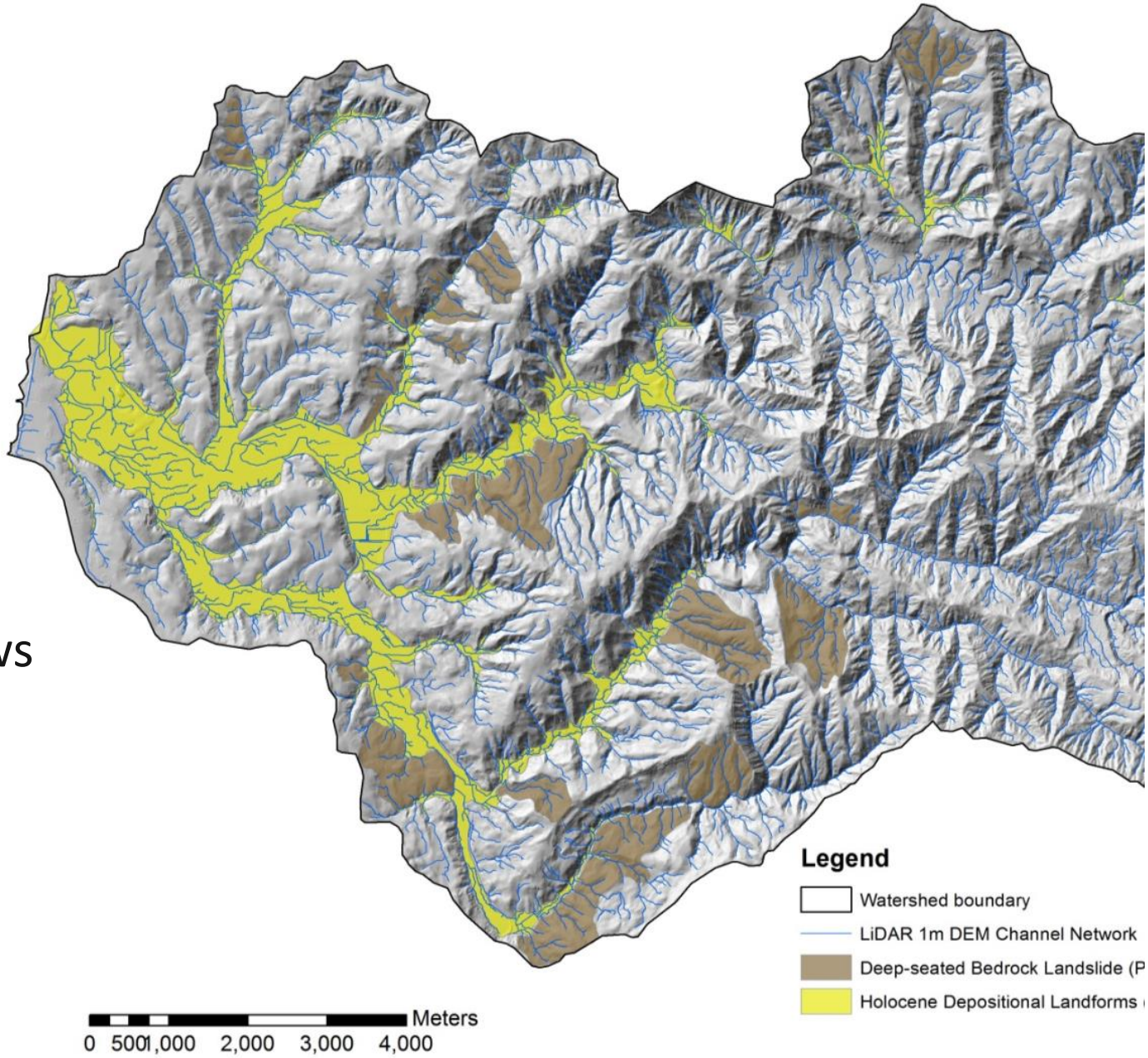
- Cosmogenic radionuclides in the area
- 0.25 mm/yr
  570 tons/km^2-yr
  110,000 tons/yr
  delivered to channels



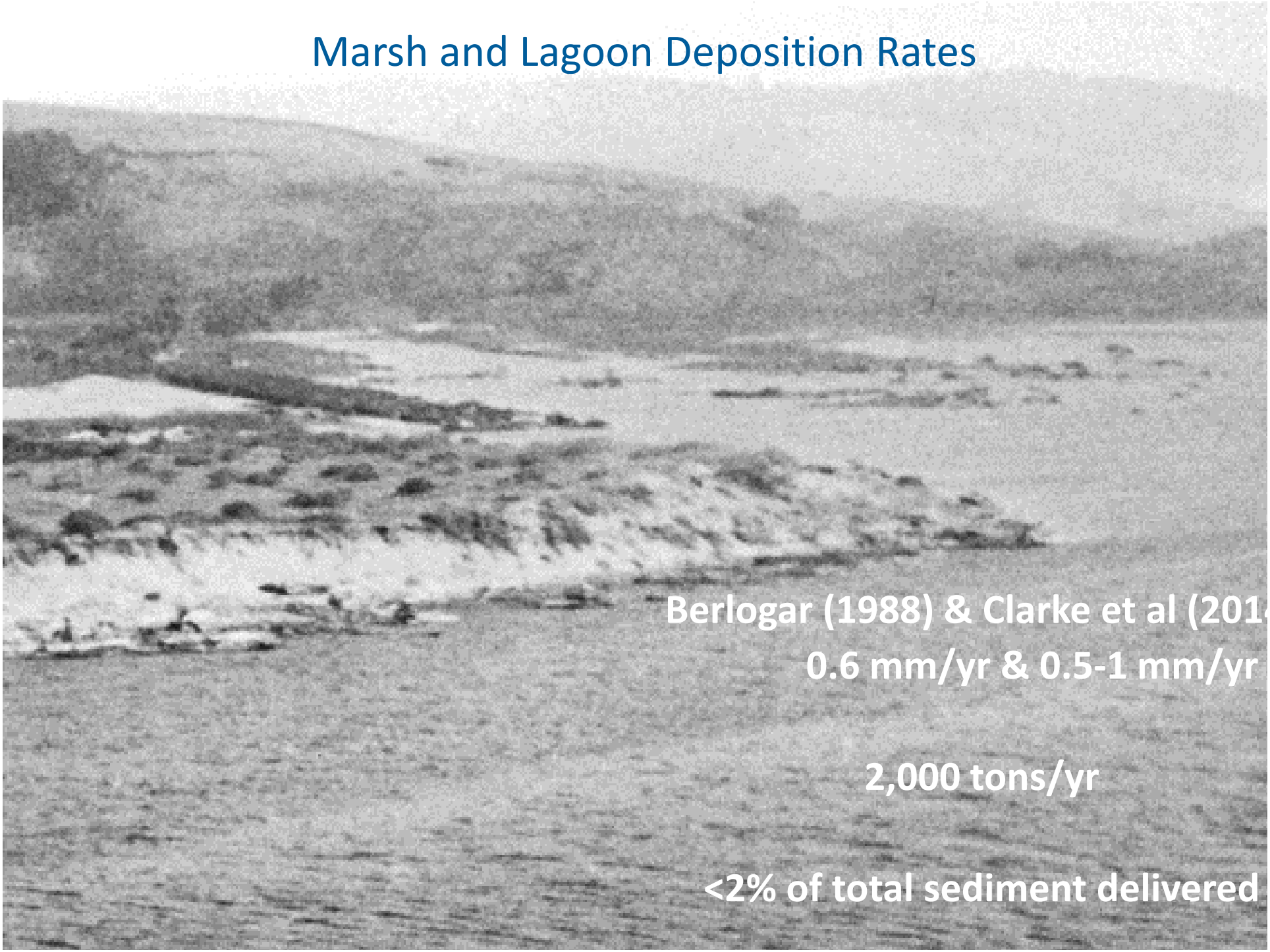
Gudmundsdottir et al. (2013)

Natural Sediment Storage Rates

- 175 million tons accumulated during last 6,000 years
- 30,000 tons/yr stored in the valleys and swampy meadows
- ~30% of total deposited



Marsh and Lagoon Deposition Rates



Berlogar (1988) & Clarke et al (201

0.6 mm/yr & 0.5-1 mm/yr

2,000 tons/yr

<2% of total sediment delivered

Main Sediment Sources

Sediment Source	Management Association
Landslides natural land use-related	roads and logging
Gullies land use-related	roads, grazing, agriculture
Chanel incision land use-related	channelization, flood management, logging, agriculture,
Surface erosion land use-related	roads, grazing, agriculture
Road surface erosion land use-related	roads
Soil creep natural land use-related	roads

Channel incision
since 1860s on Pescadero and
1920s on Butano

Pescadero incised 5 to 15 ft
along 11 mi

Butano incised 15 to 25 ft
along 6 mi

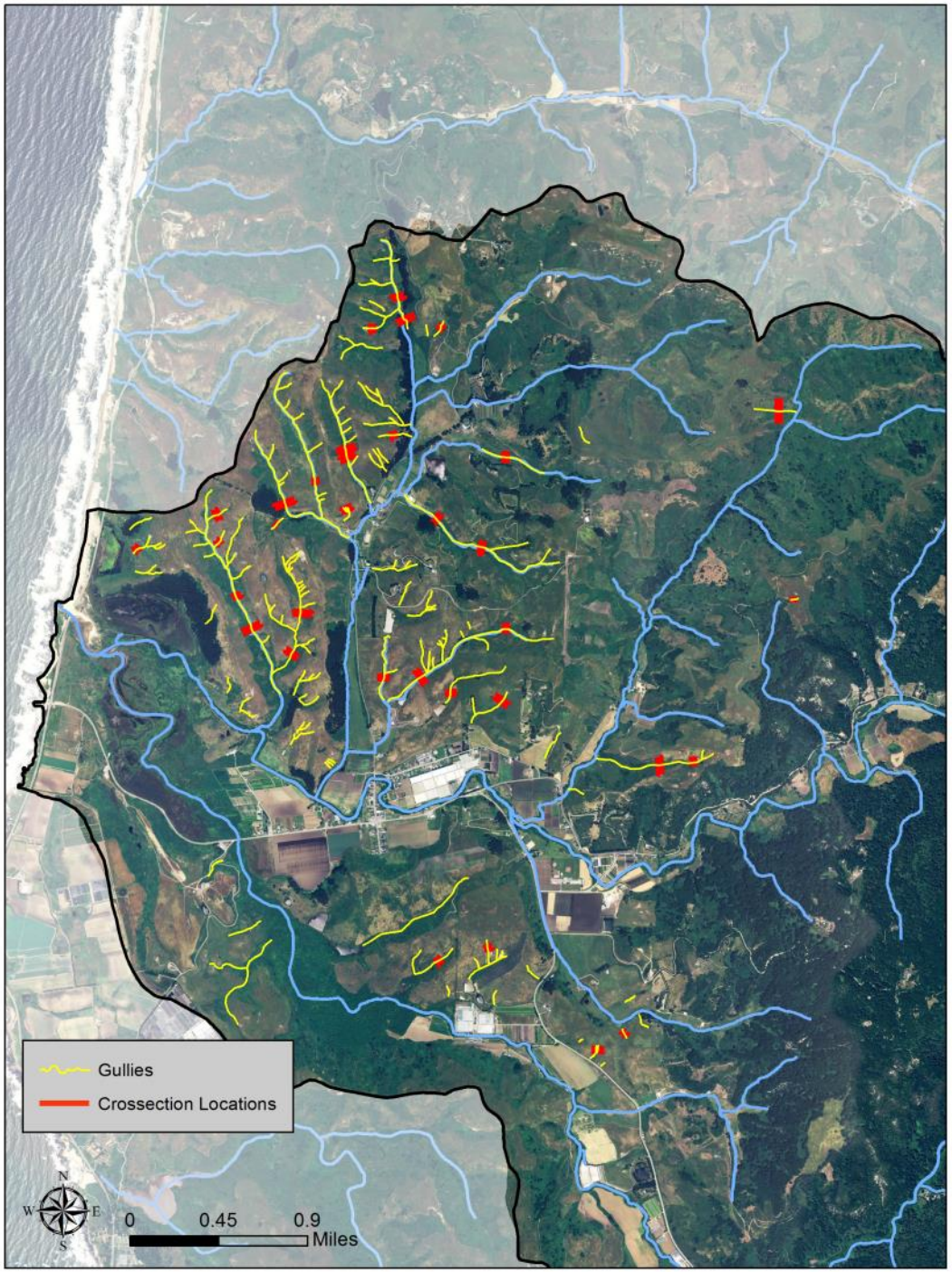
3.5 million tons or 30,000 tons/yr
of sediment generated since

20,000 tons/yr along Butano

10,000 tons/yr along Pescadero

Surface Erosion

- 17.5 mi^2 of rangelands and agricultural areas
- 36,000 tons/yr
- Close proximity to the lagoon and marsh -> significant fine sediment delivered directly to the lagoon



Gully Erosion

- Triggered in 1860
- Active on 11 mi^2 in rangelands and agricultural areas
- ~23 mi of gully channels
- 2.3 million tons of sediment delivered to channels

5/1953
1953
2012
10/1991
1953
2012
5/2012
1953
2012
1,000 ft

Gully Erosion

- 26,000 tons/yr delivered
- 8,000 tons/yr is deposited on gully fans

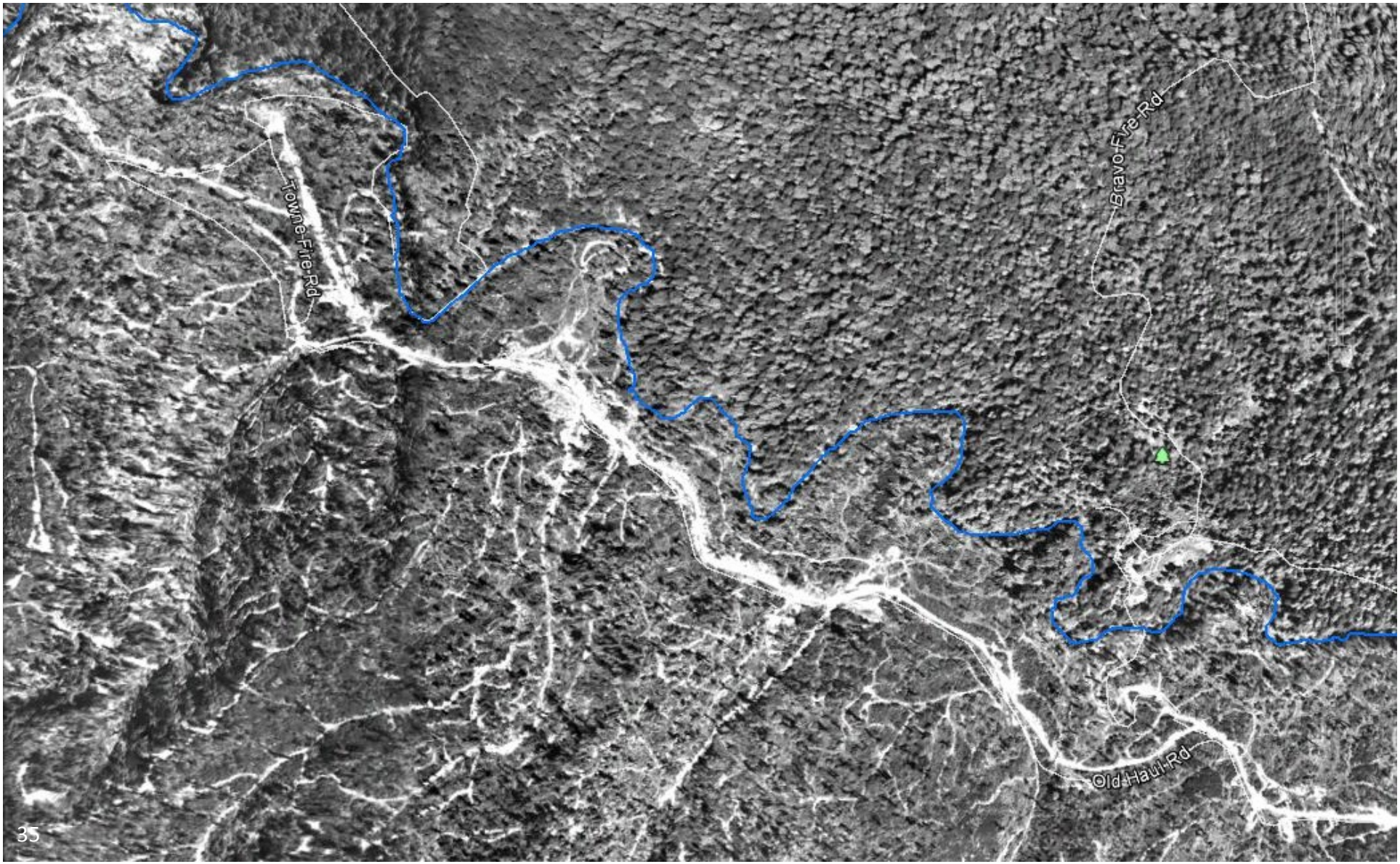
Landslides & Debris Flows

- PWA 2004 study
- Legacy sediment sources primarily due to timber harvest activities
- For 1920-1970 period, intense clear-cutting over an area of approximately 34 mi^2; legacy impacts continuing

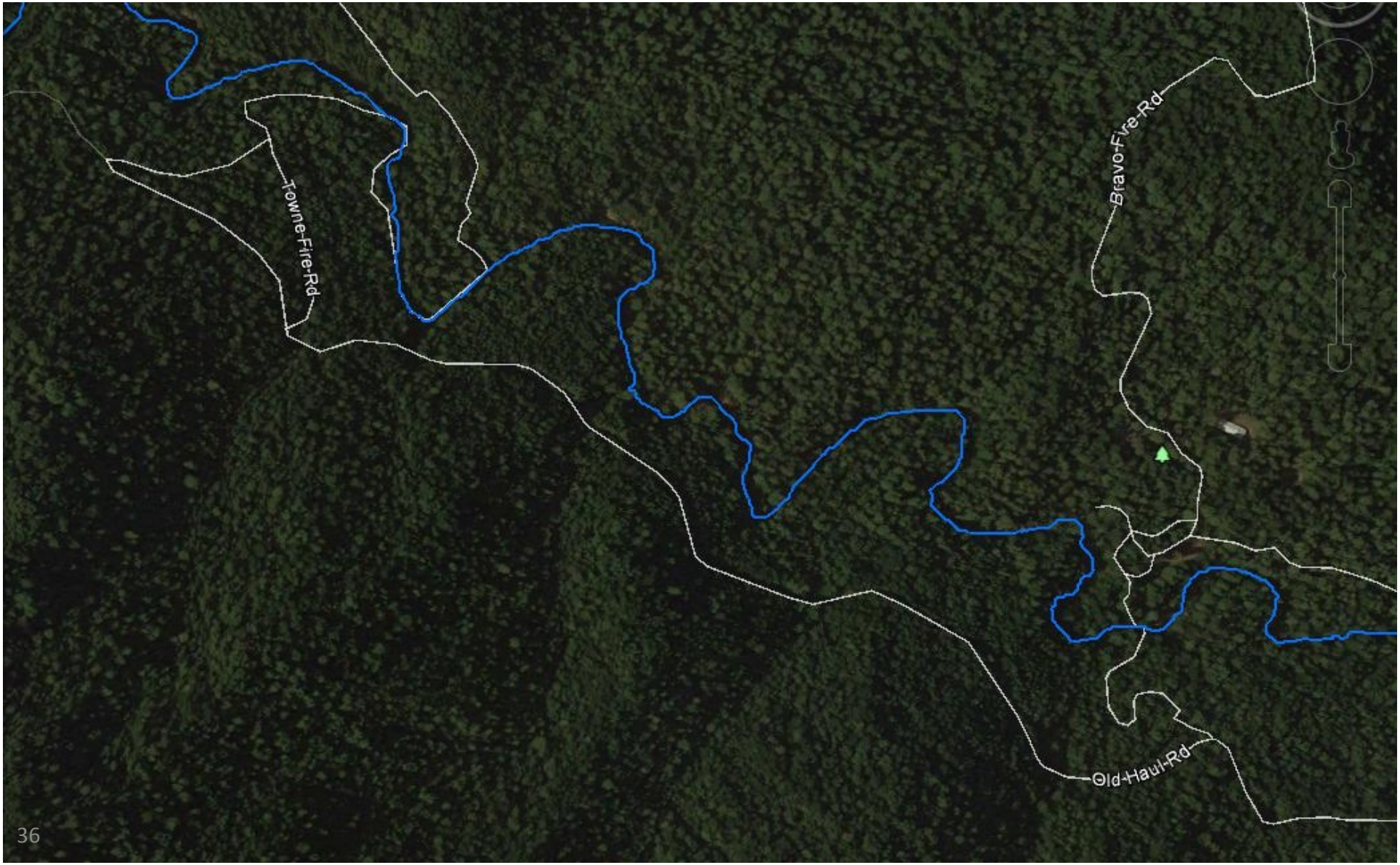
  For 1970-2010 period, over 350 ac clear-cut in Butano sub-watershed

  ~8,500 ac selectively cut today
- 26,000 tons/yr of sediment delivered to channels

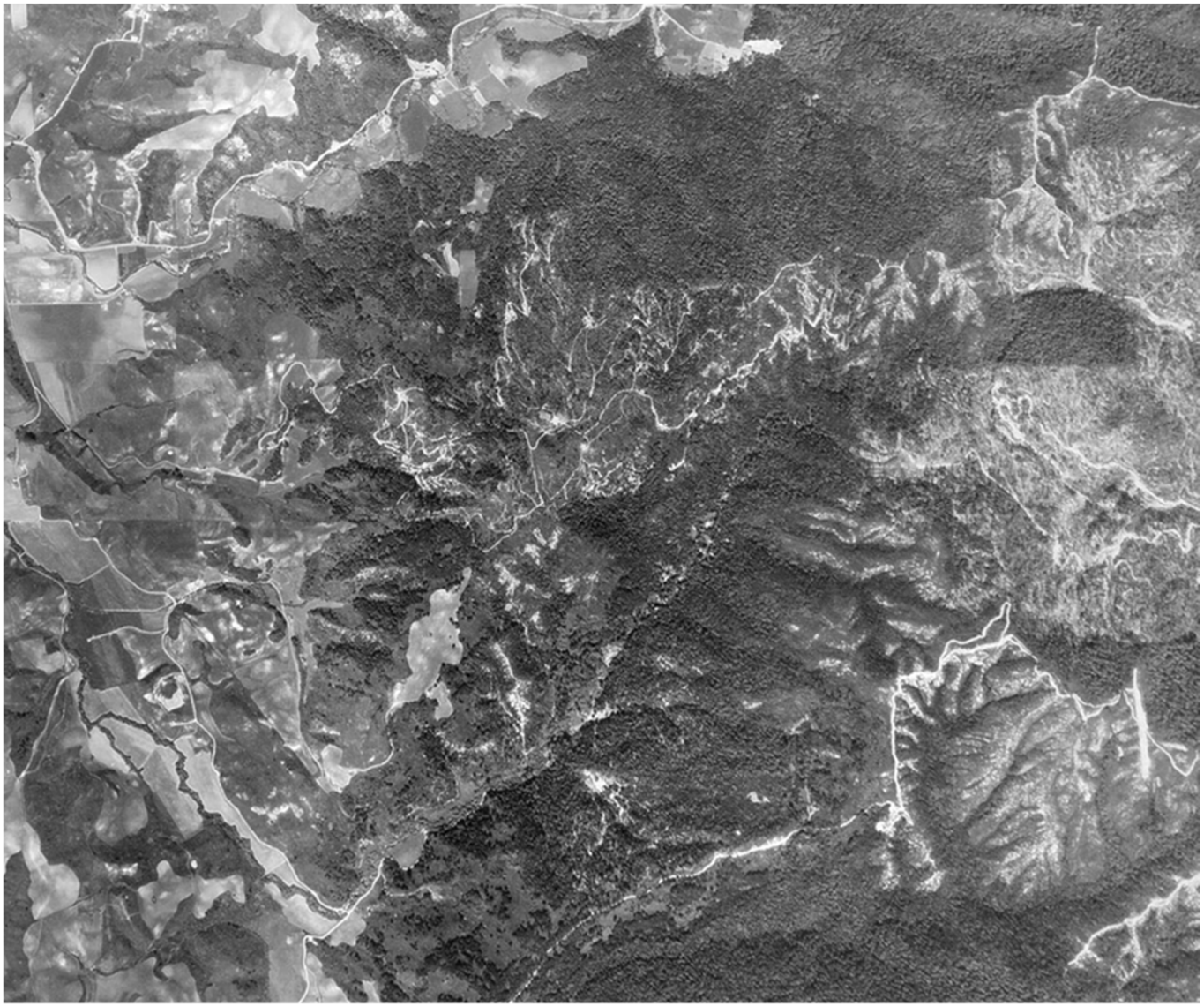
Pescadero Creek at County Park in 1953



Pescadero Creek at County Park in 2012



Butano Creek in 1960



Road-Related Erosion

- 2 types of delivery:
  Surface erosion on the road and road crossing failures
- 1.9 million tons delivered since 1920
- 19,000 tons/yr for 1970-2010 due to road crossing failures
- 5,000 tons/yr due to road-surface erosion

Marsh and Lagoon Sedimentation

- 13,000 tons/yr of deposition based on cross section comparisons of ESAPWA (2011)
  - Lagoon deposition between 0.2 to 1 m (0.5 to 3.5 ft) in 24 yrs or 2,000 tons/yr
  - Marsh deposition up to 0.4 m (1.3 ft) or 11,000 tons/yr

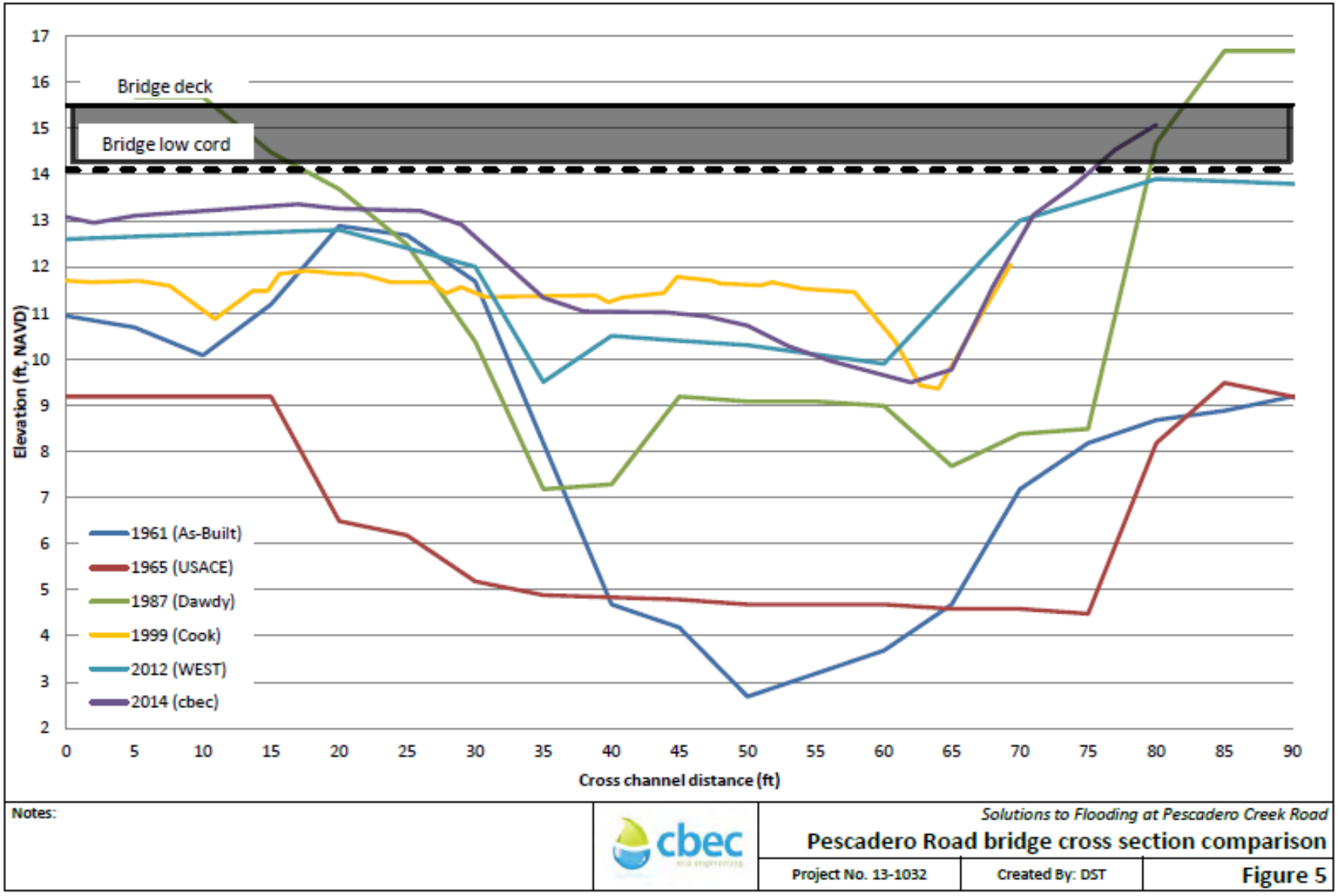
- 4.6 mm/yr or 11,000 tons/yr based on sediment core analysis by Clarke (2014)

- Anectodal information on loss of lagoon depth: 10 ft over 90 ac

  1.8 million tons since 1820 or ~10,000 tons/yr in lagoon

- Between 1.3 to 2.1 million tons between 1955 and 1985 or ~55,000 tons/yr (Curry, 1985)

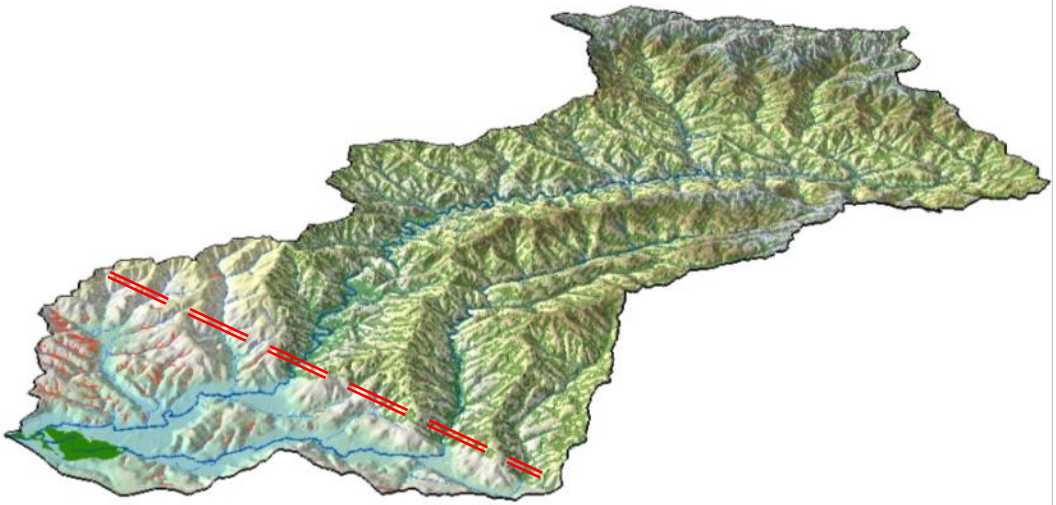
Butano Creek at PRB



	Pre-1820 (tons/yr)	1970-2010 (tons/yr)
Natural Sediment Sources	110,000	110,000
Anthropogenic Sediment Sources		
a. Surface erosion		36,000
b. Channel incision		30,000
c. Road-induced gullying/landslides		29,000
d. Landslides and debris flows in timberlands		26,000
e. Gullying on rangelands		24,000
f. Road surface erosion		5,000
Total Anthropogenic Erosion		150,000
Total Erosion	**110,000**	**260,000**
Sediment Storage		
i. Landslide/debris flow deposits		56,000
ii. Gully fans		8,000
iii. Wet meadow storage	25,000	
iv. Marsh/Lagoon sedimentation	2,000	30,000
Total Storage	**27,000**	**94,000**

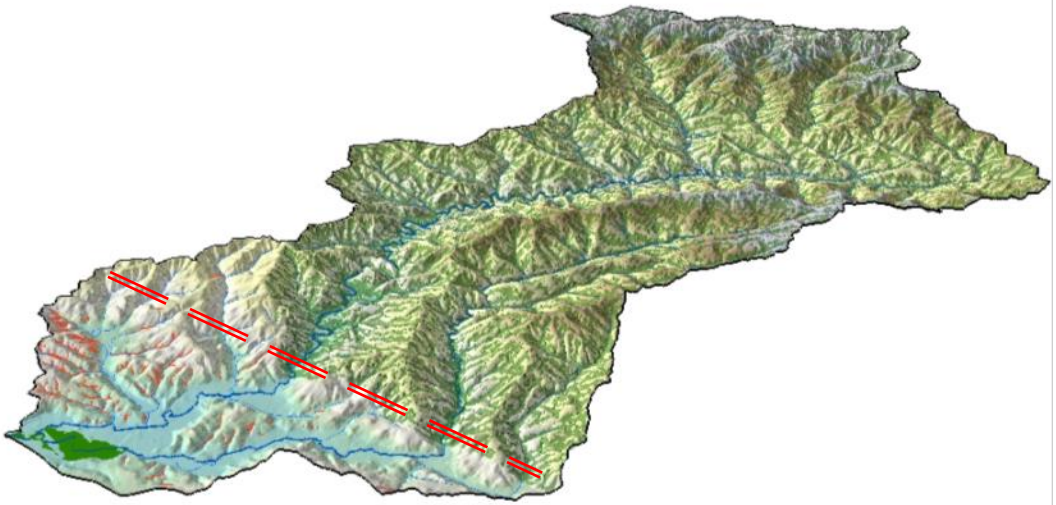
Conclusions

- Sediment delivery to channels has more than **doubled** in the last 200 years
- Surface erosion and gullies on the rangeland contribute the largest amount of sediment: 60,000 tons/yr
- 60% of human-caused sediment is generated within the western 25% of the watershed
- Channel incision is a large source of sediment and is most significant due to direct input and loss of storage



Conclusions

- Lowland contribution significant due to close proximity
- 30,000 tons that used to deposit on floodplains is now transported downstream to the marsh
- ~15 times as much sediment deposits in the marsh and the lagoon
- Elevated sediment loads are expected to continue



Next Steps

- Salmon and steelhead population model presentation

  April 2015

- Presentation of initial concepts for sediment management and channel restoration

  Fall 2015

- Public review draft of the water quality restoration plan and Water Board adoption of the plan

  Formal opportunity for review and comment

  2016

Thank You!

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Photo credit: Pescadero Historical Society circa 1927