A Market Driven Approach to Improve Stream Function: The Lake Tahoe Example

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Texas Stream Restoration Conference

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Purpose of Presentation

Provide a background on the approach that was used within the Lake Tahoe Basin to guide watershed and stream restoration efforts.

Provide an analysis on the effectiveness of these land use planning and restoration efforts in helping to achieve the water quality goals within the Lake Tahoe basin.

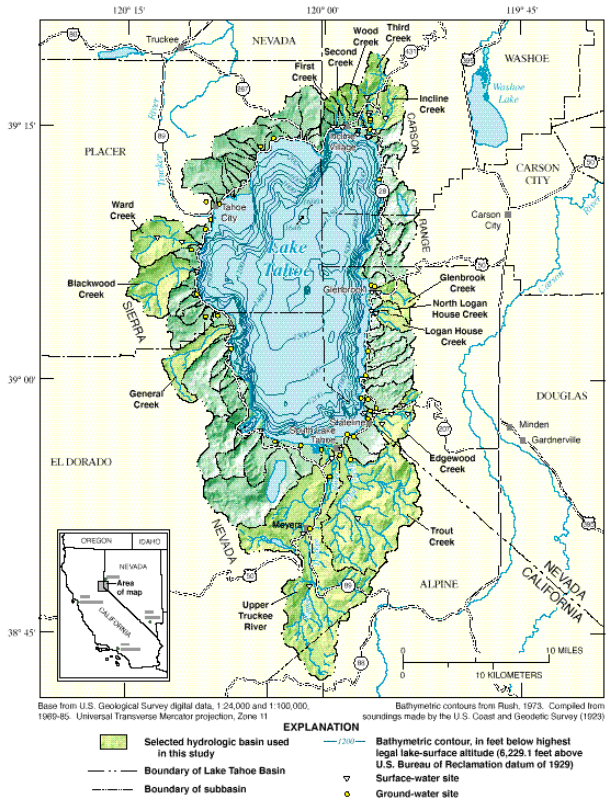

Figure 1. Geographic setting, hydrologic basins, bathymetry, and surface-water and ground-water monitoring sites in the Lake Tahoe Basin.

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Background - Hydrology

Watershed Characteristics

Area 507 Sq. Mi.

Elevation

- High 10,881 ft AMSL
- Low 6,229.1 ft AMSL

Precipitation

- High 55 inches
- Low 13 inches

Tributaries

- Largest ~50 sq. mi.
- Smallest < 1 sq. mi

Geology

- Volcanics – West Side of Lake

Lake Characteristics

Area 120,000 Acres

Type Alpine

Inflow

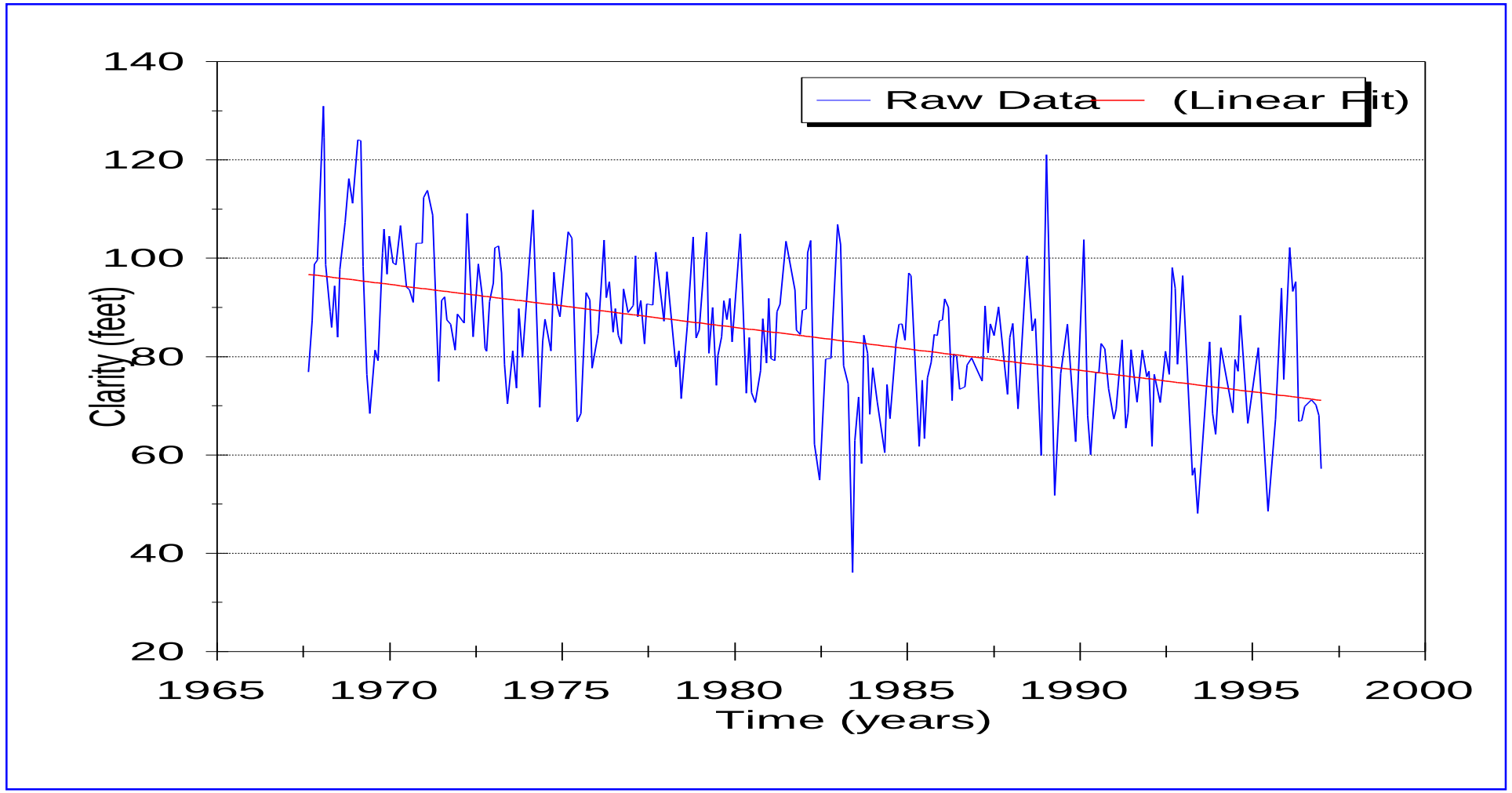
- Streams 327,000 Acre-ft/yr
- Groundwater ???
- Direct 200,000 Acre-ft/yr

Outflow

- Stream 167,000 Acre-ft/yr
- Groundwater ???
- Evaporation 360,000 Acre-ft/yr

Granitics – East Side of Lake

Background – Environmental Concern



Trends in Lake Tahoe's Clarity: 1964 - 1997

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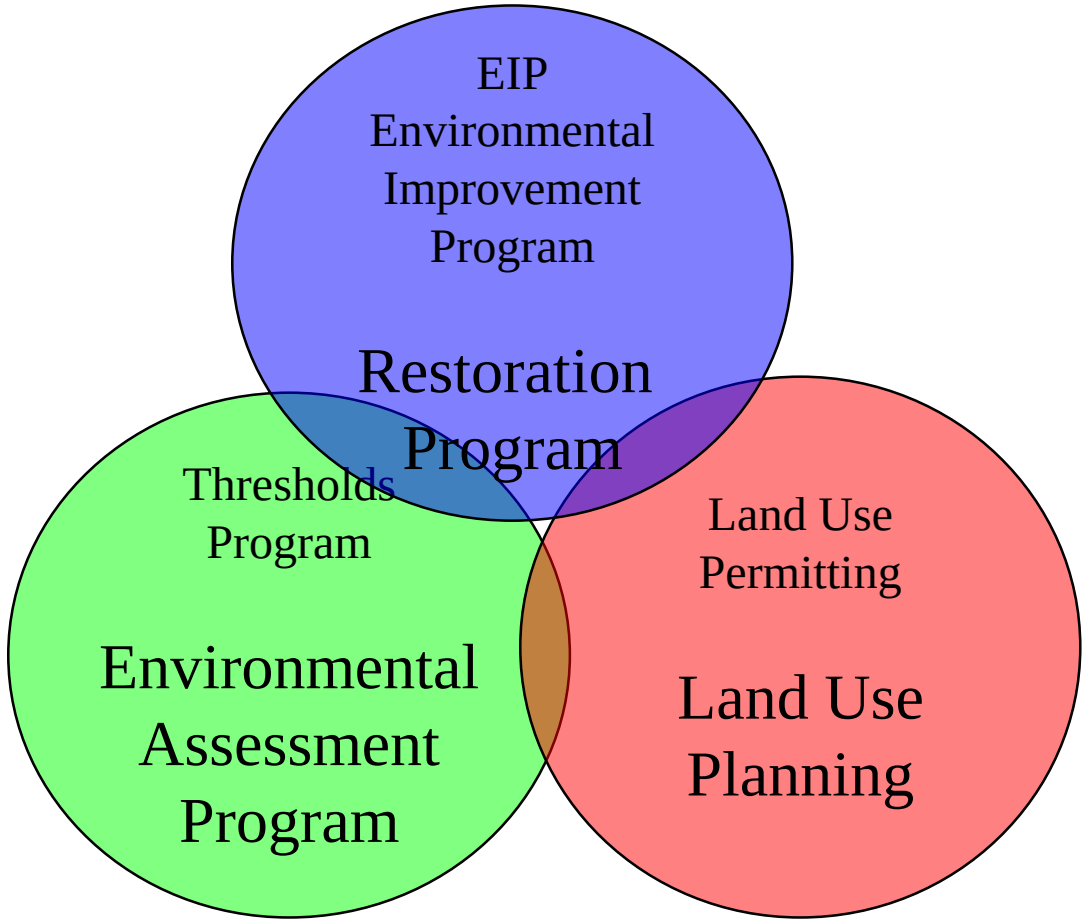
Background – Environmental Management

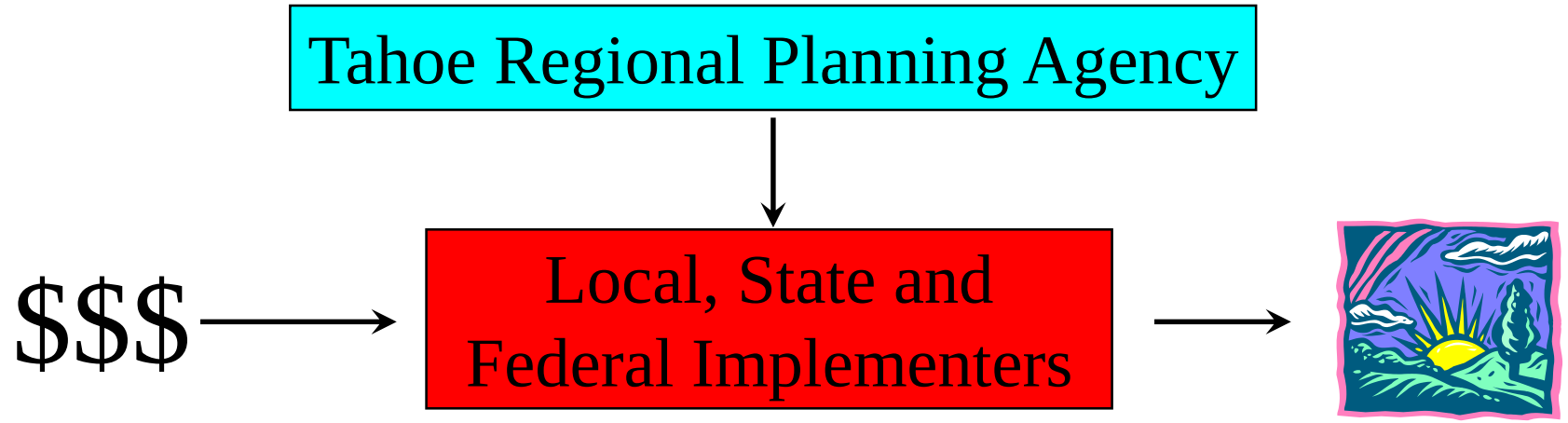


All three programs are led by the Tahoe Regional Planning Agency (TRPA), which is a bi-state planning entity created in the late 1960s to aid in maintaining Lake Tahoe's unique environmental qualities.

Background – Restoration Program

The EIP (Environmental Improvement Program 2000 - 2014)

- Nearly $1 billion effort for restoration efforts in Lake Tahoe
- Jointly funded effort by Federal, State and Local Entities
- Program coordinated by TRPA but implemented by other entities



Background – Restoration Program

Implementation of Best Management Practices (BMPs)

All property owners and stewards must install BMPs
This includes Federal, State and Municipal agencies as well as businesses, private companies and individual home owners.

All tributary watersheds well classified into three categories

- Priority 1 – Most Critical need for restoration (BMPs in place by 2000)
- Priority 2 – Restoration needed to improve Lake Condition (BMPs in place by 2007)
- Priority 3 – Restoration would have marginal impact on Lake (BMPs not required)

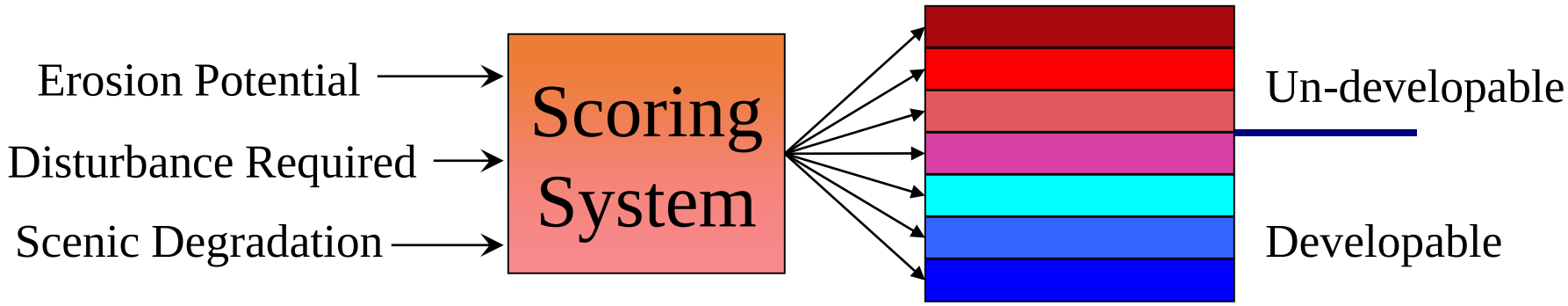
Background – Assessment Program

Threshold Evaluation

- The Thresholds Program was adopted by the TRPA in 1982 and was incorporated into the 20 Year Regional Plan in 1987.
- 9 categories of Thresholds were adopted, with 36 specific indicators being "measured" every 5 years.
- The purpose of the Threshold analysis is to assess environmental conditions within the Lake Tahoe basin and help direct planning and future restoration activities.

Background – Land Use Planning

Bailey System – Developed in 1984 for use by TRPA



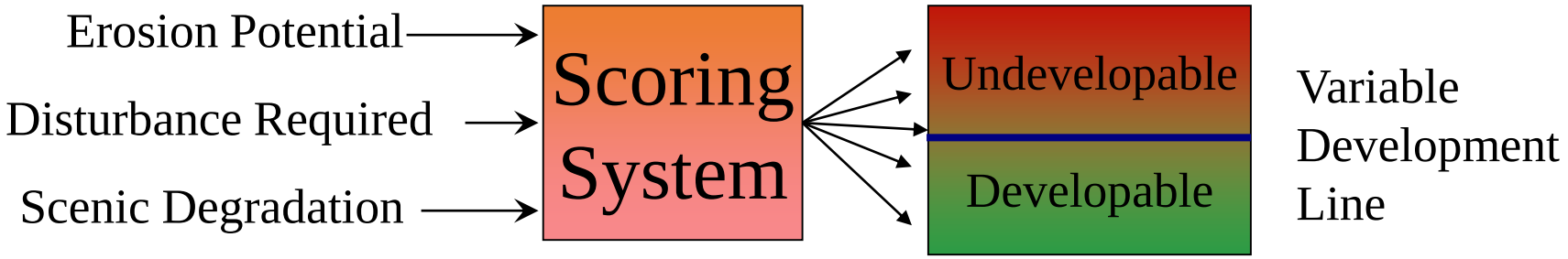
Bailey system integrated erosive potential of site in addition to amount of disturbance required to develop site with potential for scenic degradation to arrive at a classification.

Even if parcel was not developable, owner could sell impervious coverage.

Classification was in 1 of 7 categories Each category had an allowable percent of impervious coverage, but only categories 4, 5, 6 and 7 allowed development.

Background – Land Use Planning

IPES System – Developed in 1989 for use by TRPA



Initially, the development line was 780.
Incentives were developed that if implemented, the development line could be lowered.

Land owners can sell impervious coverage and IPES points on open market, and buy up to 10% of their IPES points to get over the line.

IPES stands for Individual Parcel Evaluation System. IPES uses the same factors as the Bailey System to classify the land's development capacity, but a score is developed for each parcel, ranging from 0 to 1250.

Background – Land Use Planning

Changes in IPES Development Line

- Over time, the IPES development line has dropped to:
  - ~350 in Washoe County, NV
  - ~500 in Douglas County, NV
  - Still at 780 in Placer and Eldorado Counties, CA
- Deals have been developed to allow lowering of line in California counties.
- Since the line can lower, a requirement of the system is periodic evaluation of the IPES program to assess if it is having a negative environmental impact.
- Value of impervious coverage and IPES points vary on the open market that is predominantly facilitated by Real Estate community.

Restoration Program Assessment

Question that needed to be answered by TRPA was:

Has the implementation of the IPES system caused any degradation to Lake Tahoe's clarity as compared to the Bailey system?

Reality - There was no program in place to monitor:

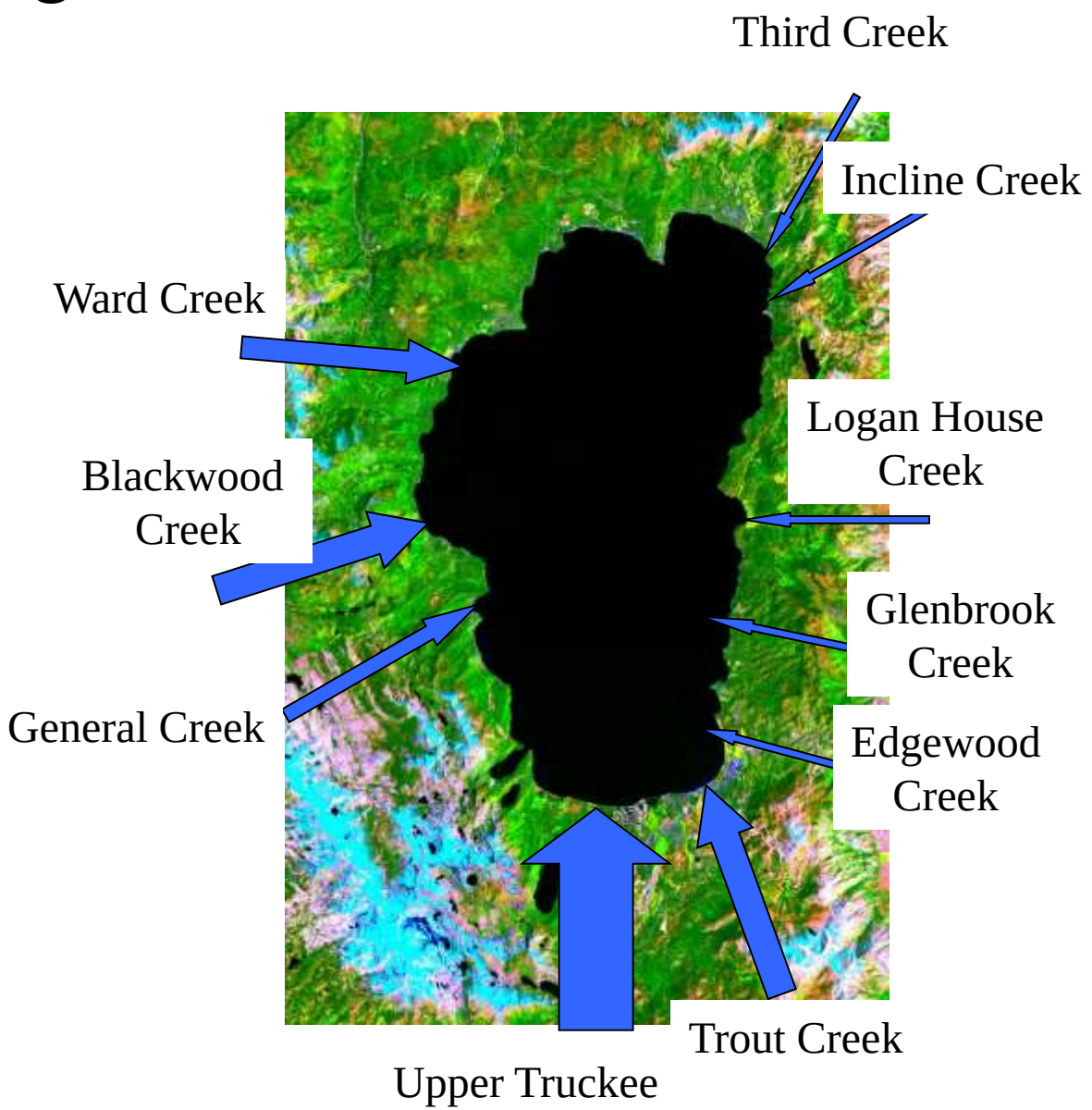
- What development occurred because of the change in the systems
- Specifics of individual parcel impacts on sediment or nutrient loading

Question had to be rephrased as:

Have there been any identifiable changes in the sediment loading characteristics to Lake Tahoe since the change in the development system occurred?

Restoration Program Assessment

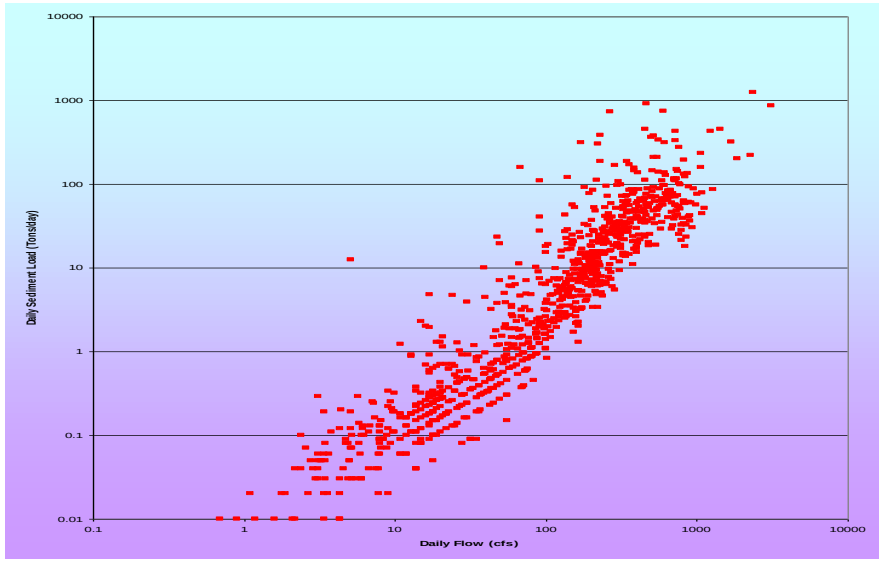
There are 10 stream gages with sediment gaging records that extended into the time periods needed for this analysis (pre – 1989 to post 1989)



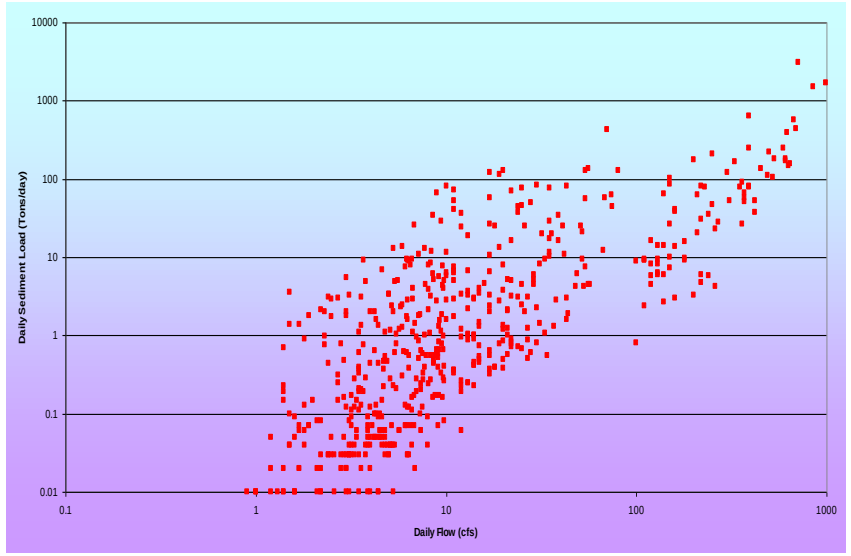
The annual sediment loads from these streams range from a high of 9,000 tons to a low of 5 tons.

Restoration Program Assessment

Sediment load or concentration data cannot be used directly to address this question, because suspended sediment concentration is correlated with flow rate.



Upper Truckee River
Sediment load versus Flow



Third Creek
Sediment load versus Flow

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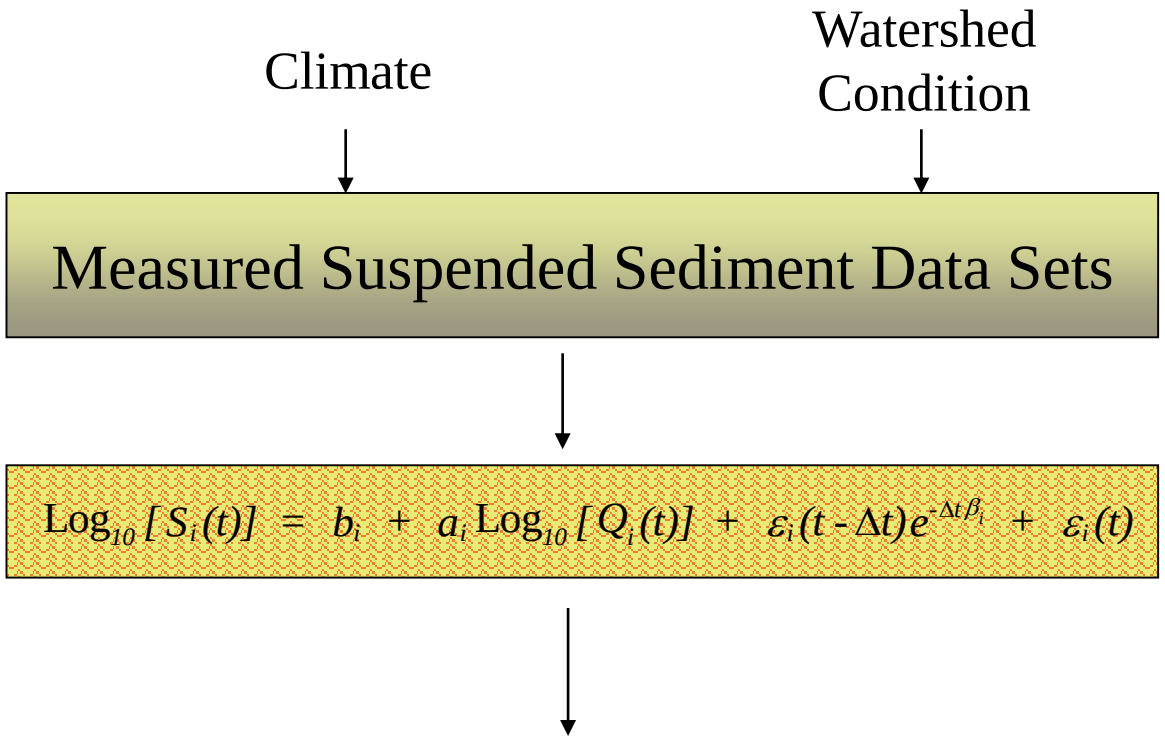
Restoration Program Assessment

To over come this, we need to analyze the changes in the relationship between flow and sediment load, as opposed to changes in sediment load.



The filter used is a functional relationship between stream flow and sediment load

Remove effects due to variability in stream flow

Restoration Program Assessment

To determine if a change in the relationship occurred, two approaches were used.

Approach 1: Change Detection Analysis

- Data split into 2 periods, these being 1 – Bailey System; and 2 – IPES;
- Null Hypothesis to be tested is conditions worsened under IPES;
- Hypothesis is tested through statistical analysis of model parameters.

Approach 2: Trend Detection Analysis

- Yearly data are used to determine time series of model parameters;
- Trends in model parameters are analyzed (+/-);
- Significance level of trends are determined through statistical analysis.

Restoration Program Assessment

Change Detection Analysis:

Upper Truckee River **-** IPES Line = 780; Major restoration work completed by 2000

Third Creek – IPES Line = 350; Some restoration work completed by 2000

	Upper Truckee River		Third Creek	
Period	Exponential Parameter (*a*)	Factor Parameter(*b*)	*Exponential Parameter(a)*	*Factor Parameter(b)*
Bailey System	1.5237	-2.4313	1.4787	-1.9337
IPES Program	1.4244	-2.3235	1.5565	-1.3692
Significance Level (α)	**0.02**	0.15	0.29	**<0.001**

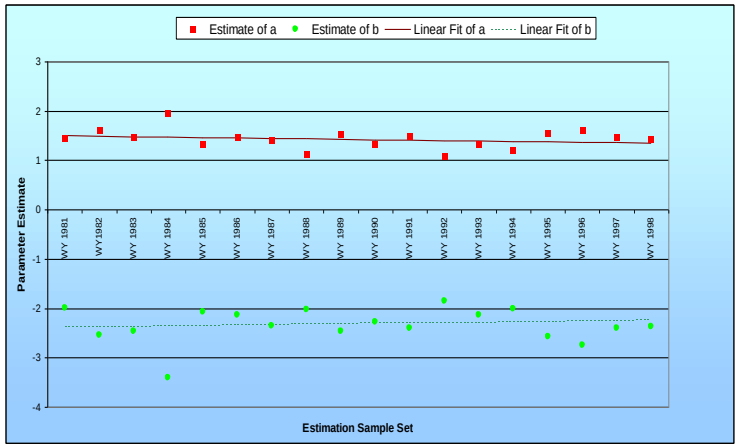
Restoration Program Assessment

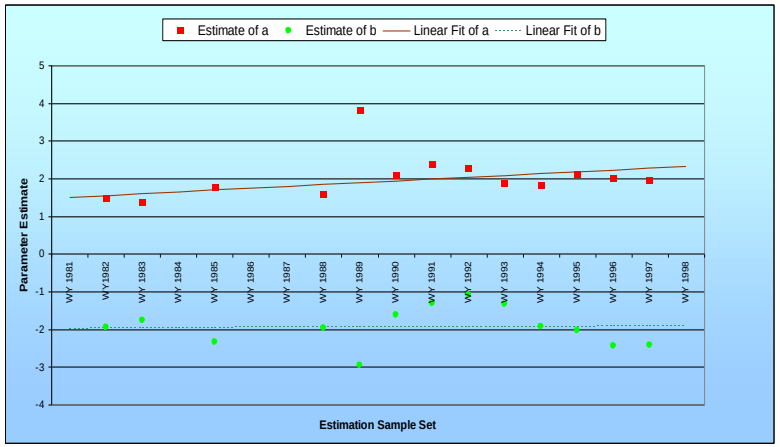
Trend Detection Analysis:

Upper Truckee River - IPES Line = 780; Major restoration work completed by 2000

Third Creek – IPES Line = 350; Some restoration work completed by 2000

	Upper Truckee River			
Period	Slope of Parameter (*a*)	Significance Level	Slope of Parameter (*b*)	Significance Level
Upper Truckee River	-0.00878	0.35	0.00773	> 0.4
Third Creek	0.0485	0.29	0.00435	**0.1**





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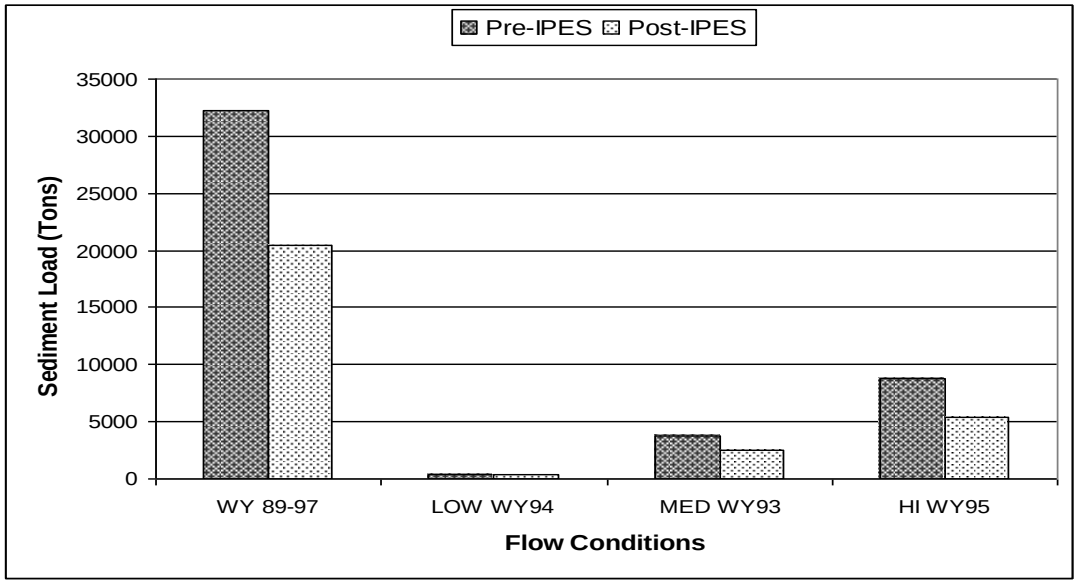
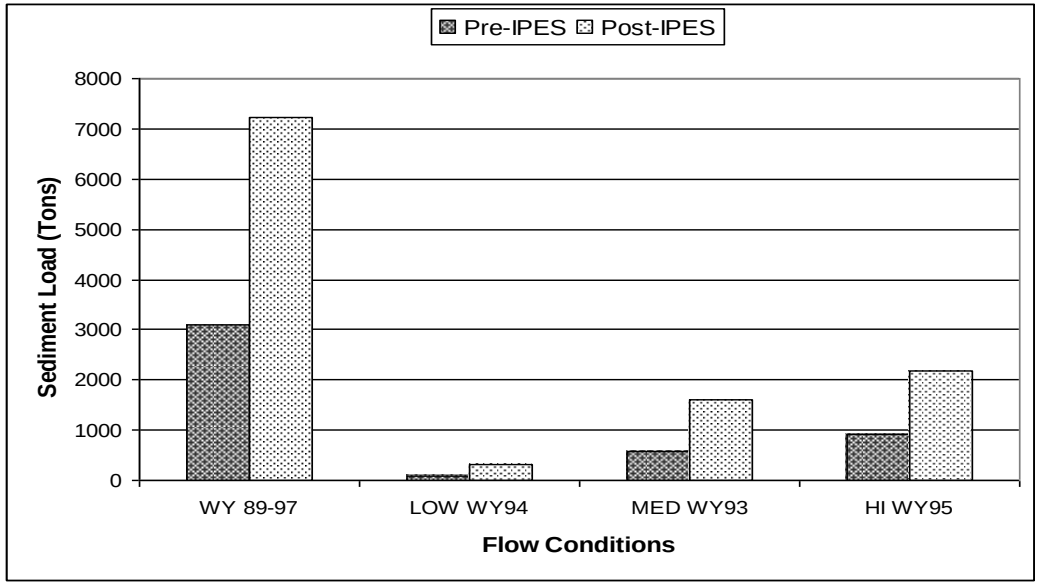
Restoration Program Assessment

Comparison of predicted sediment loads using pre- and post- IPES Period parameters for the Upper Truckee and Third Creek sediment loads to Lake Tahoe



Predicted Upper Truckee Loads



Predicted Third Creek Sediment Loads

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Summary

- Conditions appear to be improving in the Upper Truckee River Watershed.
- Conditions appear to be worsening in the Third Creek Watershed, possible causes are:
  - Development line has been lowered;
  - Fewer restoration projects have been undertaken;
  - Excessive sediment loading from upstream reservoir.
- Trend and change detection analysis can be used on "filtered" data to determine changes in watershed conditions, even under wide variation in climate regimes.
- More advanced statistical analysis procedures should be investigated for use in detecting changes in watershed conditions.