Water resource responses in beetle-killed catchments in north-central Colorado

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Beetles aren't new

- Populations are endemic
  - Older or damaged trees attacked
  - Less than 2% tree mortality rate
  - High beetle mortality rates
- Beetle epidemic
  - More trees - site disturbance or climate response
  - High tree mortality rate
  - Low beetle mortality rate

Not the first time in Colorado

- 1939 spruce blowdown, beetles increased
- White River and Elk River comparison
  - Pre-epidemic 1937-40
  - Epidemic 1941-1946 in White River
  - Post epidemic 1947-1951
- First study to look at insect/defoliation effects on streamflow (Love, 1955)
- Used snow course and streamflow data

White River Plateau revisited

- Beetles or increased precipitation?
- Bethlahmy 1974 &1975
- Added Yampa River and longer period of record
- Annual water yield increased ~10%
- Peak flow increased ~27% on White
- Low flows increased ~15%
- Largest annual increases:15 years later 1956-1960

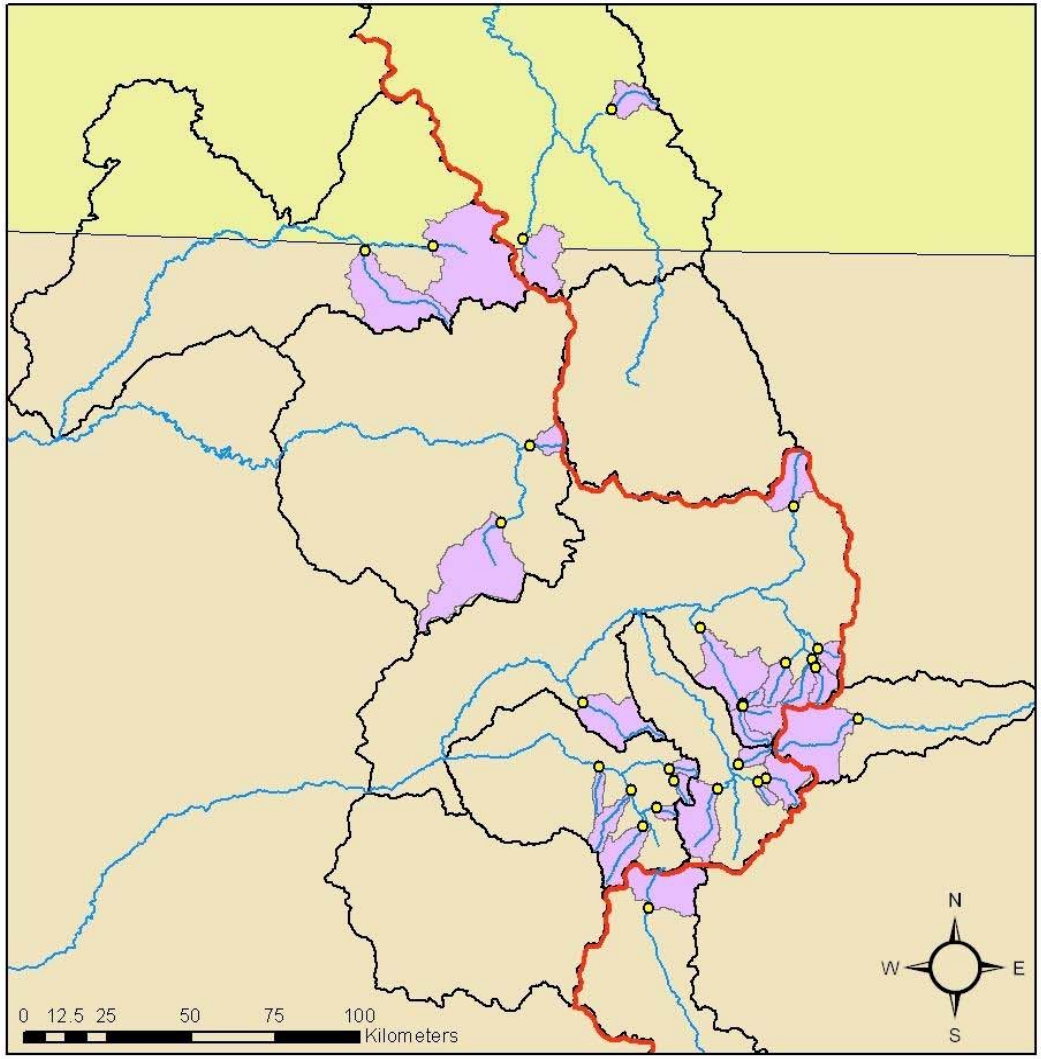
Quick Review

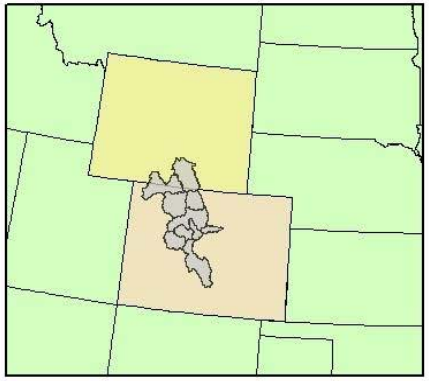
- Beetle-kill effects are similar to harvesting
- Timber harvesting decreases interception and evapotranspiration
- Threshold of response is 20% basal area removal for detection
- Response is proportional to area harvested clearcut or thinned
- Increase yield on rising limb

Research Methods

- Beetle area damage mapping by USDA Forest Service from 1994 to present
- Using watersheds with long-term USGS records
- Map beetle-killed area over time and space
- Using a paired watershed study approach, with analysis of covariance and ICSS
- Water quality sampling in select watersheds

Locations of Study Watersheds

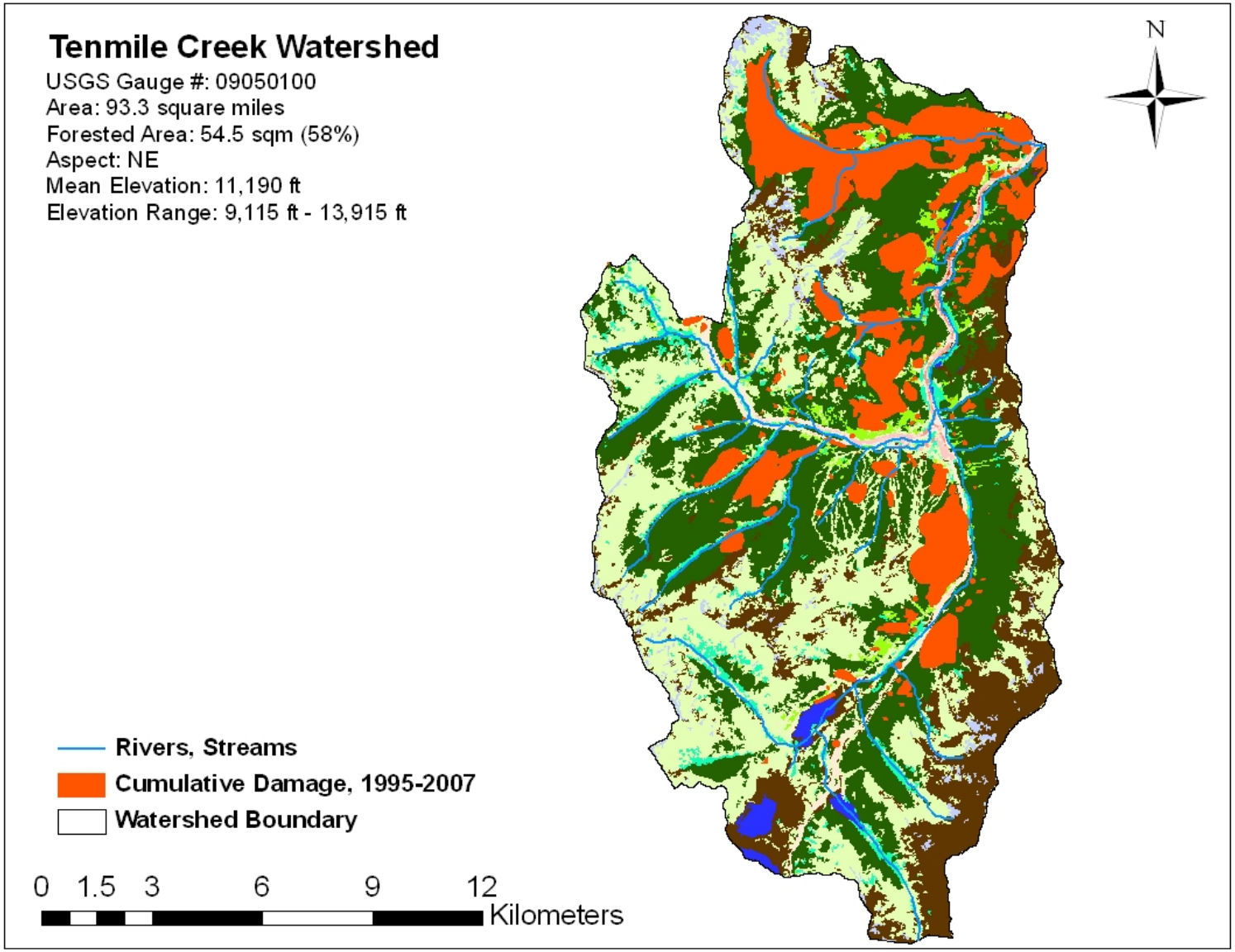




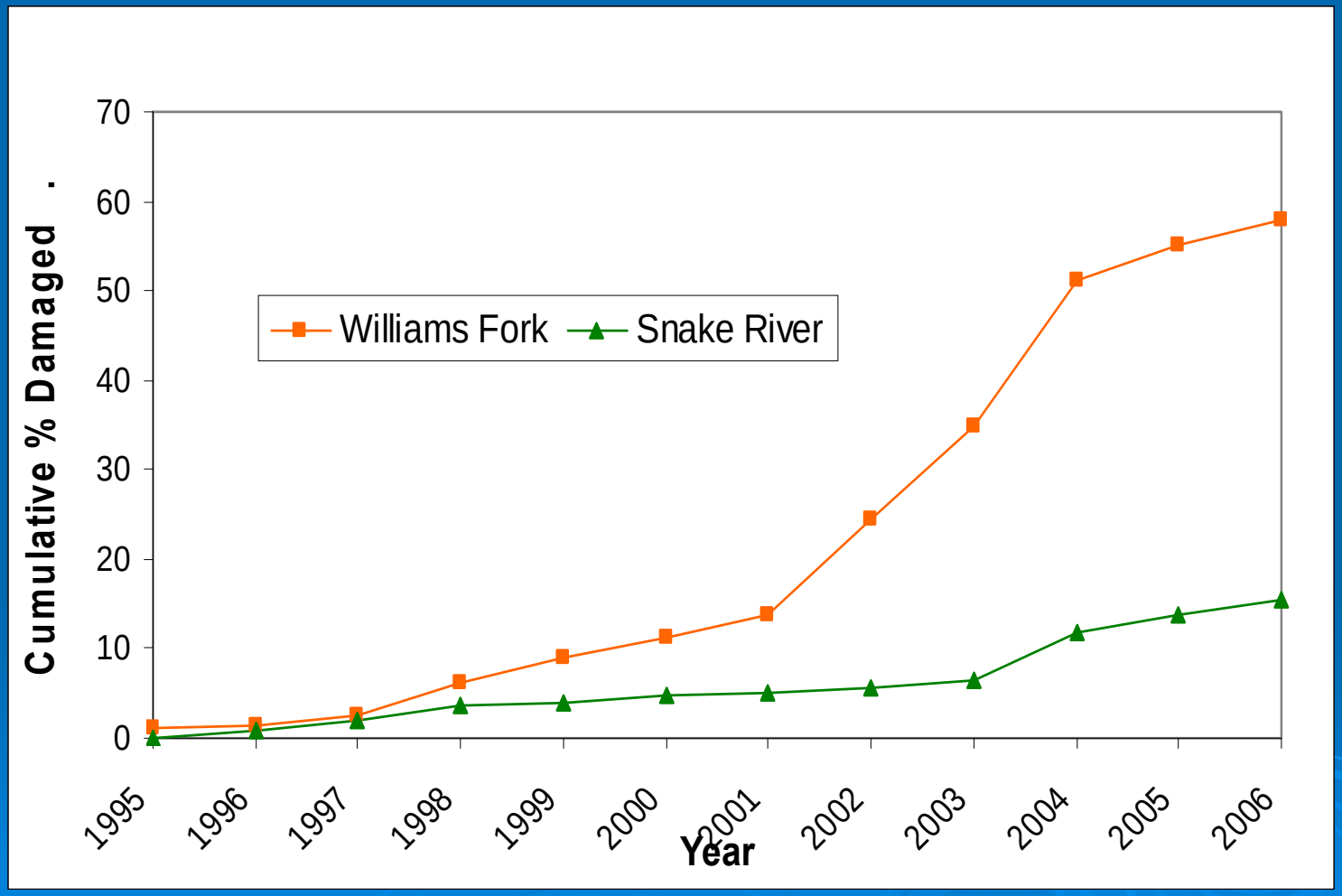
Legend

- Gauges
- Rivers
- Continental Divide
- 8-Digit Hydrologic Units
- Study Watersheds
- Colorado
- Wyoming

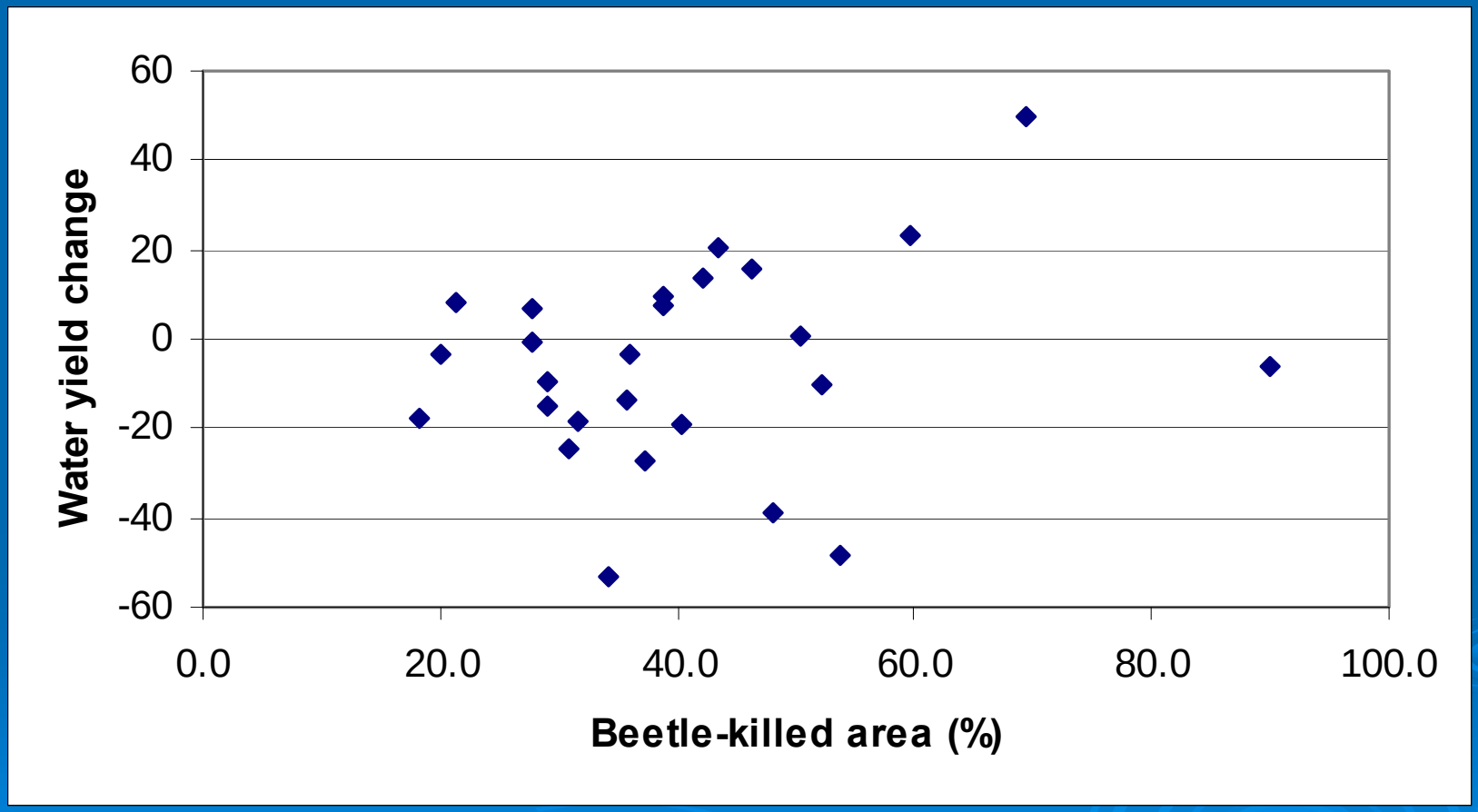
Sources:
- 8-digit HUC's and Rivers from USGS National Hydrography Dataset website, http://nhd.usgs.gov/data.html
- Gauge locations from USGS National Water Information System website, http://waterdata.usgs.gov/nwis


Tenmile Creek Watershed
USGS Gauge #: 09050100
Area: 93.3 square miles
Forested Area: 54.5 sqm (58%)
Aspect: NE
Mean Elevation: 11,190 ft
Elevation Range: 9,115 ft - 13,915 ft
N
Rivers, Streams
Cumulative Damage, 1995-2007
Watershed Boundary
0 1.5 3 6 9 12
Kilometers

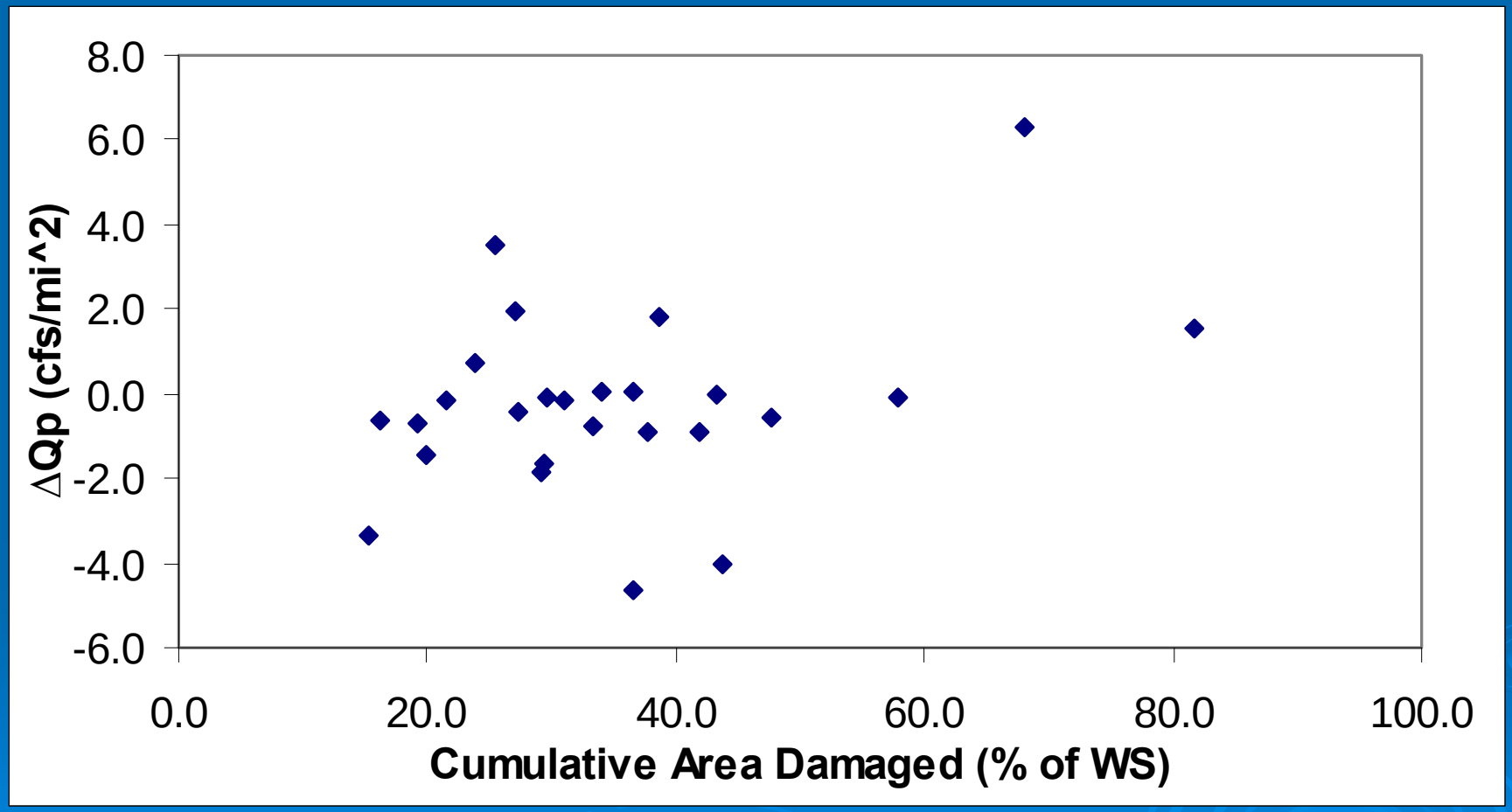
Cumulative damage by year



Annual water yield change



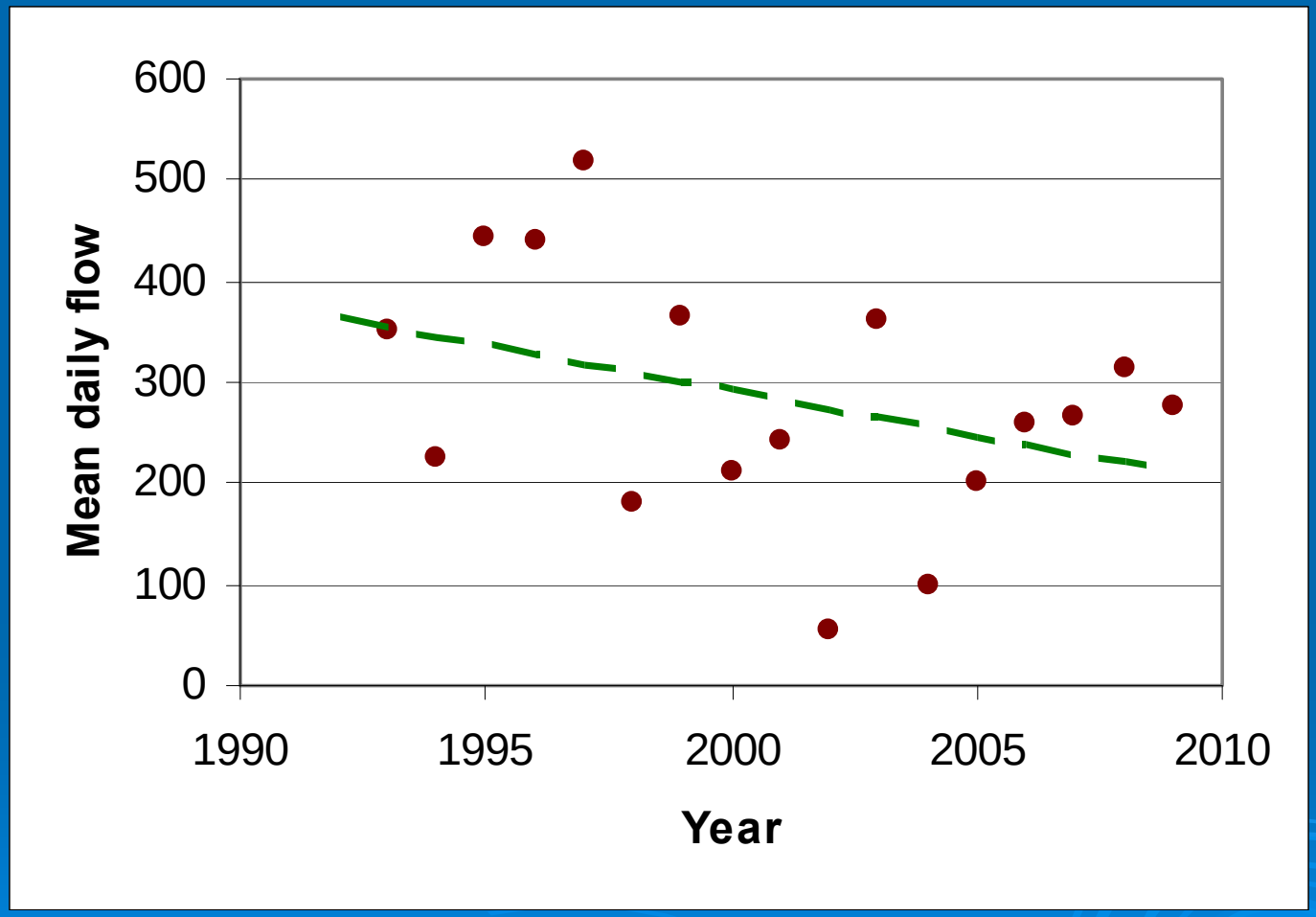
Change in peak flow



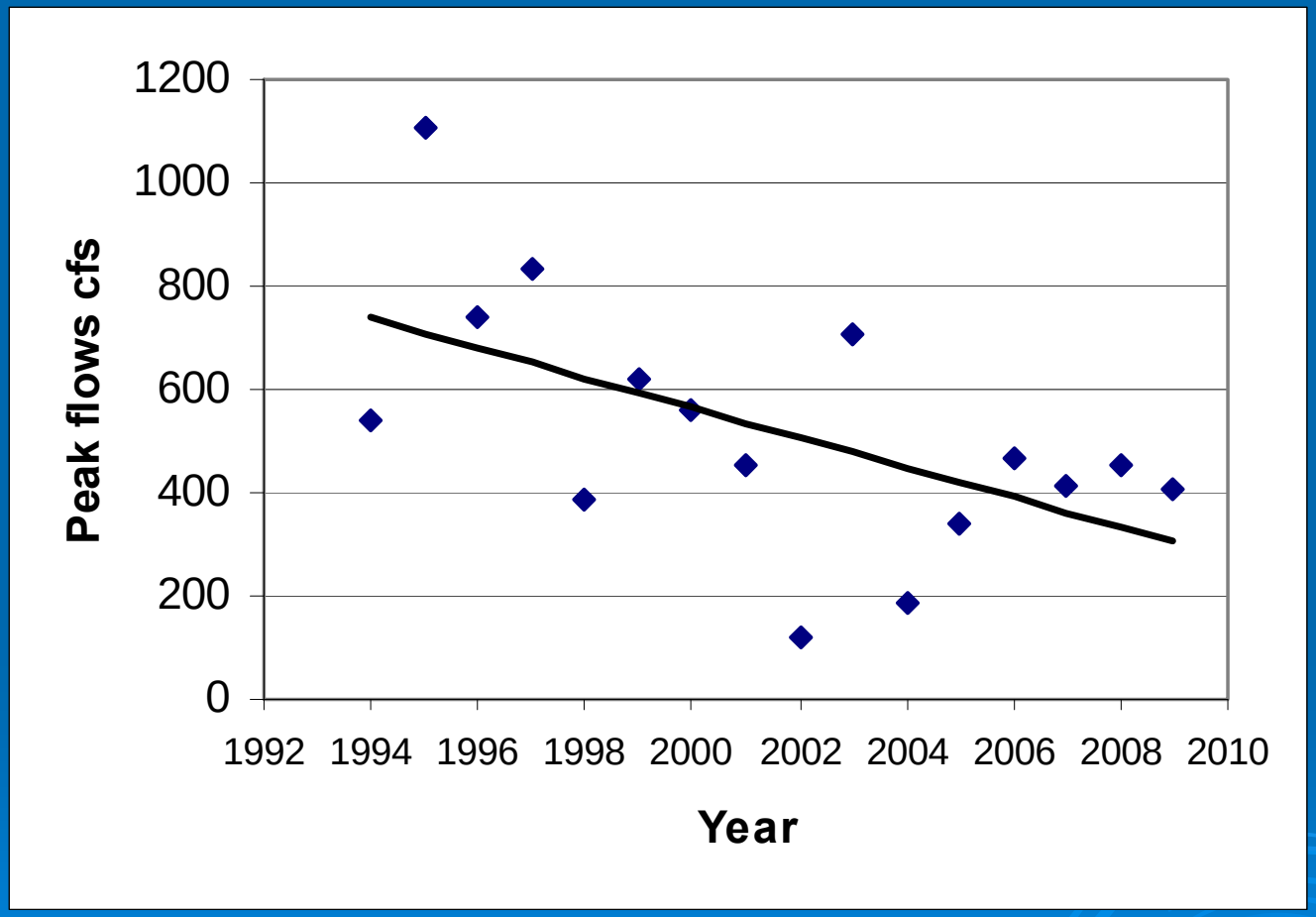
Stationarity of Q?

- Changes in streamflow from anecdotal observations of snowpack
- Measured changes in streamflow magnitude and timing
- Stationarity of streamflow records in Colorado and west?

Snake River – June flows



Snake River Peak Flows



Snowpack responses

- Move from catchment to plot
- Decreased interception and decreased evapotranspiration after beetles
- Increased forest canopy transmittance
- Snow water equivalent (SWE) is less under beetle-killed trees
- Air and snowpack temperatures are warmer and snowmelt begins earlier under beetles

Water quality

- Water quality sampling over time and watersheds
- Limited comparison to historical records
- Higher stream temperatures, particularly where riparian vegetation was pine
- Temperature increases of 2.0^0 C observed in stream segments
- Literature suggests N response
- Concern over state nutrient standards

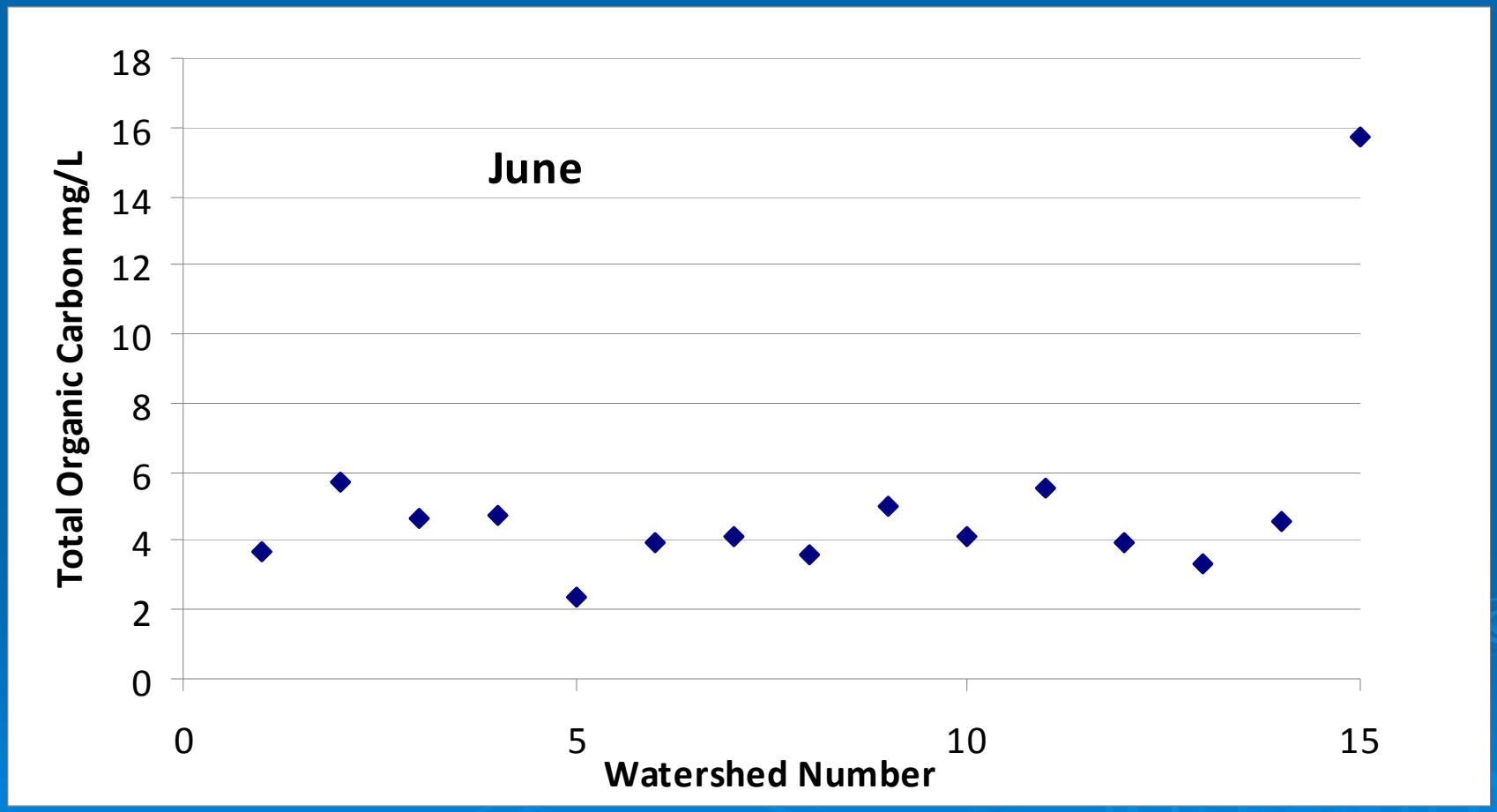
Water quality

- Background nitrate is quite low in forested watersheds
- Background N inputs ~2kg/ha/yr (NADP)
- Lack of processing of atmospheric inputs or change in microbial populations?

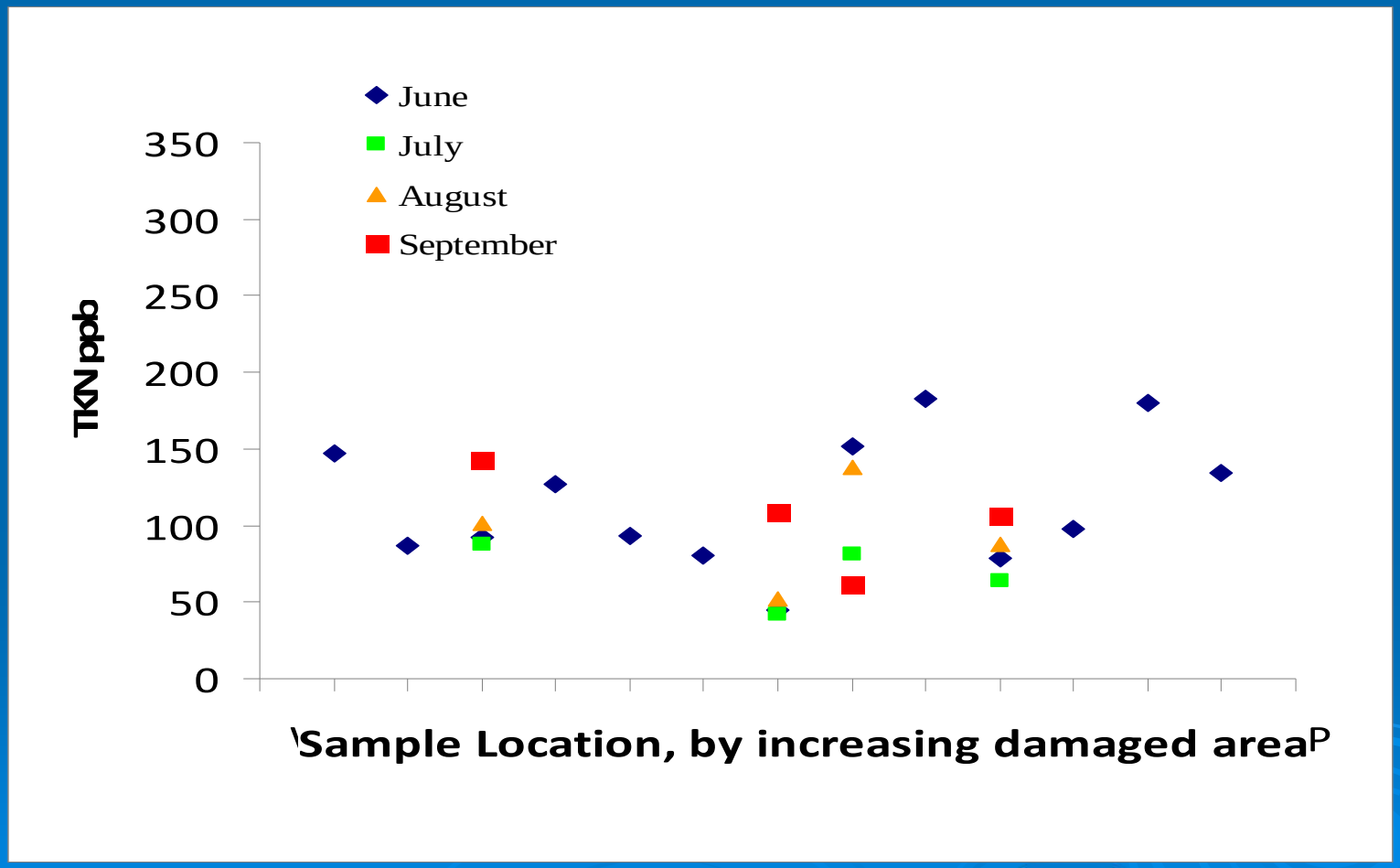
Water quality

- Nitrate from increased nitrification rates
  - Confirmed with incubation studies
  - Observed in forest openings
- Leaf cast has increased stream color and TOC
- Research on organic species of nitrogen and carbon

Total Organic Carbon



TKN in stream waters



Effects of improvement projects

- Harvesting schedule is aggressive
- Best management practices not always included
- Surface disturbance often results in soil erosion
- Openings and nitrification
- Streamside vegetation often harvested or removed

Summary

- Water resource responses are variable for annual yield and peak flow
- Recognize change in Colorado hydrology to separate beetle effects
- Understanding streamflow changes suggests need for computer models

Summary

- Water quality responses variable at watershed level, move to plot level for understanding of processes
- Forest health improvement projects (harvesting) may have more consequences than beetles alone
- Need for coordination