Phosphorus Loads from Coeur d'Alene Lake's Tributaries

STATE OF IDAHO
DEPARTMENT OF
ENVIRONMENTAL QUALITY

Basin Environmental Improvement
Project Commission
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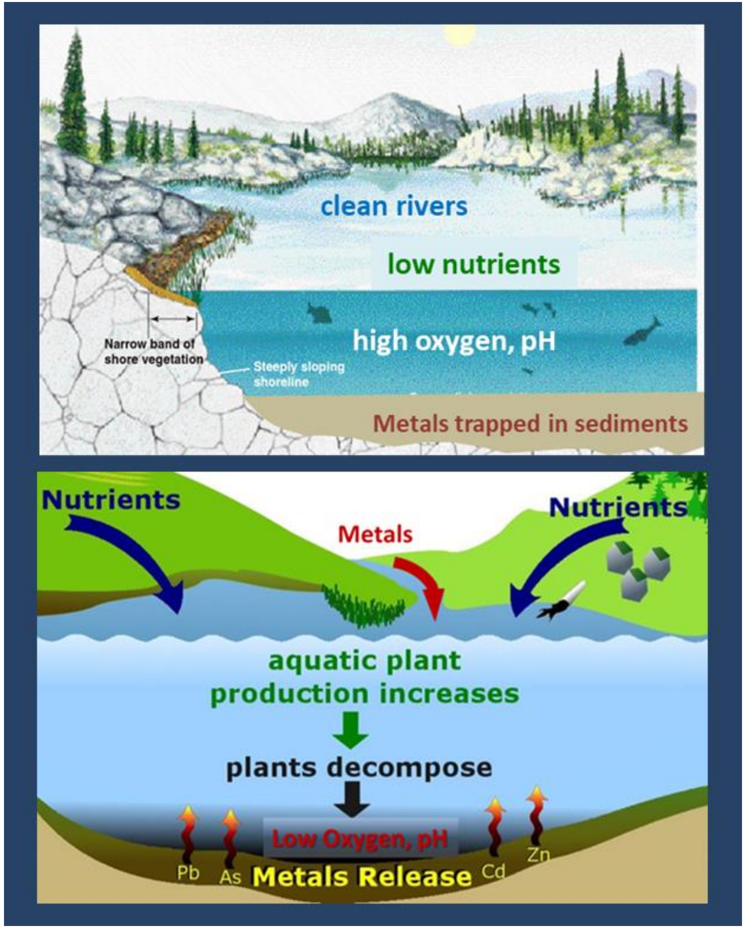
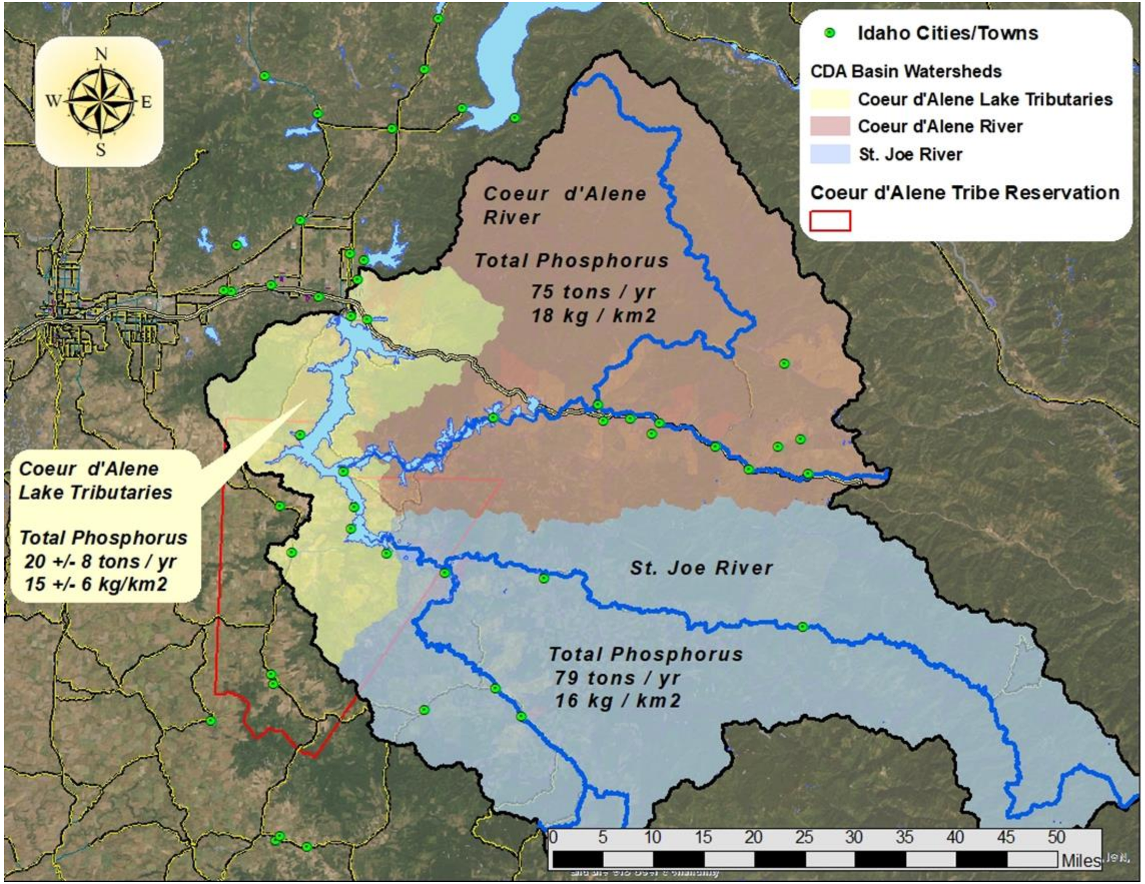
Why Monitor Phosphorus?

- Phosphorus is an important factor that influences metal mobility in CDA Lake
    - Nutrients promote algae growth
    - Decomposition of algae lowers O2 and pH in the lake's deeper waters
    - Lower O2, pH can promote release of metals from sediments
- Many sources of phosphorus to the lake
- Need good data to quantify loads and prioritize management actions



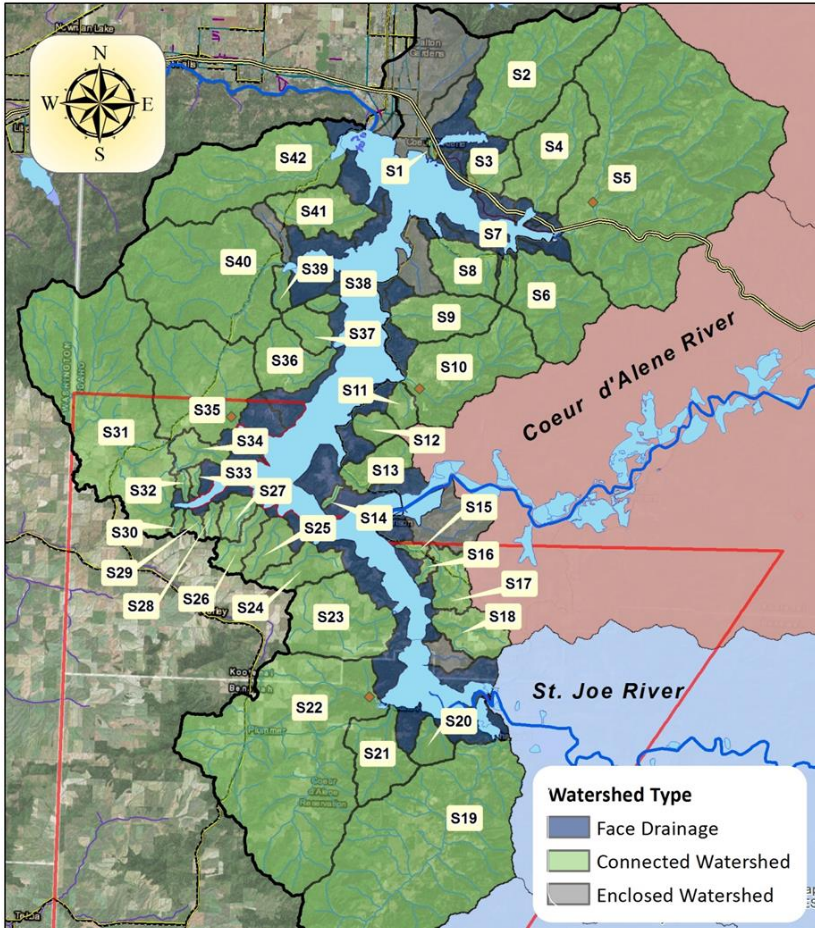
Why monitor the tributaries?

- Significant source:
  - 12 – 28 tons/yr (6-16%)
  - Proximity to lake
  - Potential to have higher fraction bioavailable-P
- Growing pressure from regional development
- Prior estimates were primarily from modeling
- Important data gap identified by NAS study



Design Challenges

- > 40 watersheds
- Additional face drainages
- Access limitations
- Inclement weather
- Large extent of annual variability
- Cannot directly monitor all streams
- Select representative watersheds
- Extrapolate via modeling



Lake Watersheds

Numbering represents individual watersheds that have been modeled in the past

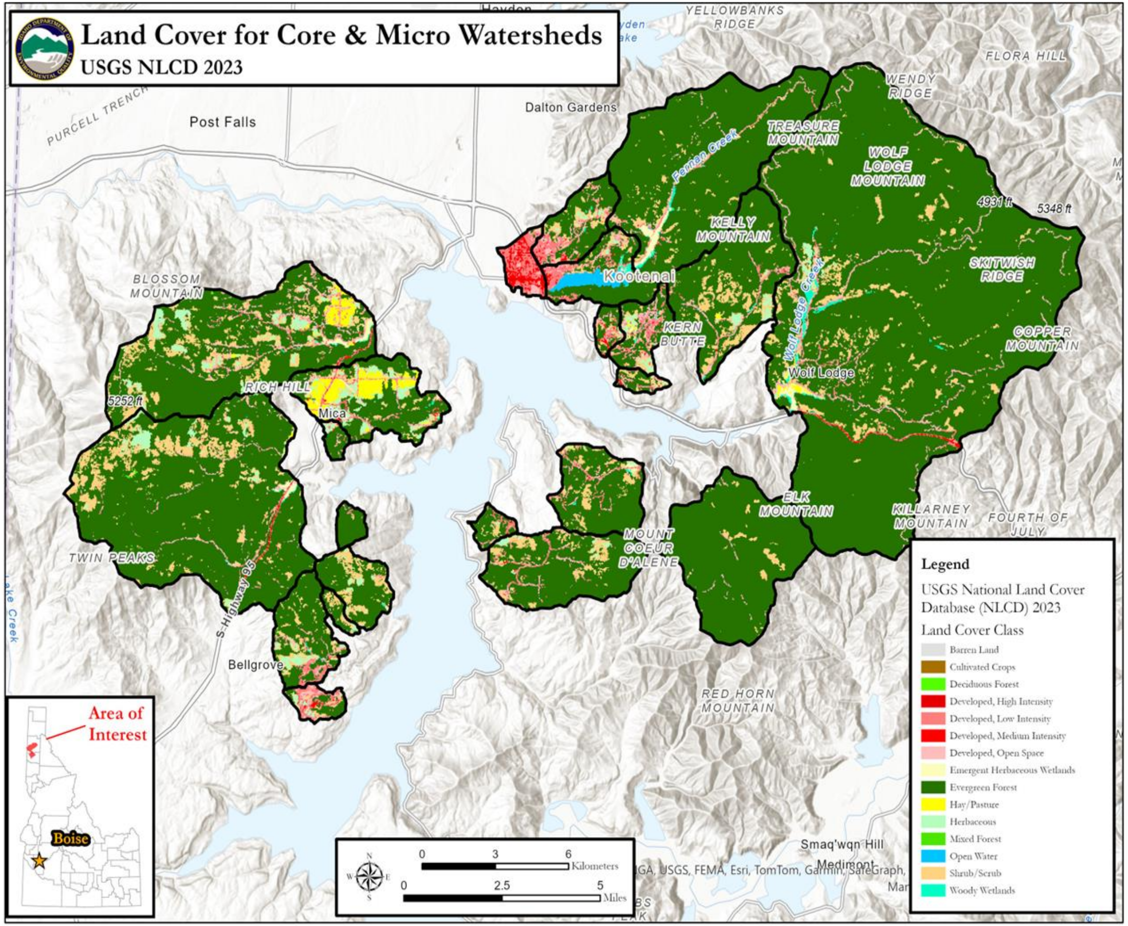
Monitored Watersheds

Study Plan

- Monitor 20 streams
- Representative dataset
- Monthly sampling
- Additional samples collected for runoff events

Outcome

- ~35% of lake watershed
- 40-50 samples per major stream (core watersheds)



Monitoring Plan

- All monitoring sites
  - Manual grab samples
  - Staff gage or equivalent
  - HOBO P/T loggers
- Additional at Wolf Lodge
  - Autosampler & bubbler
  - Hydrolab stream sonde
- Water Chemistry
  - Total P, ortho-P
  - Total N, NO3, SO4, Cl
  - turbidity
  - conductivity, pH

Load Estimator (LOADEST):

A FORTRAN Program for Estimating

Constituent Loads in Streams and Rivers

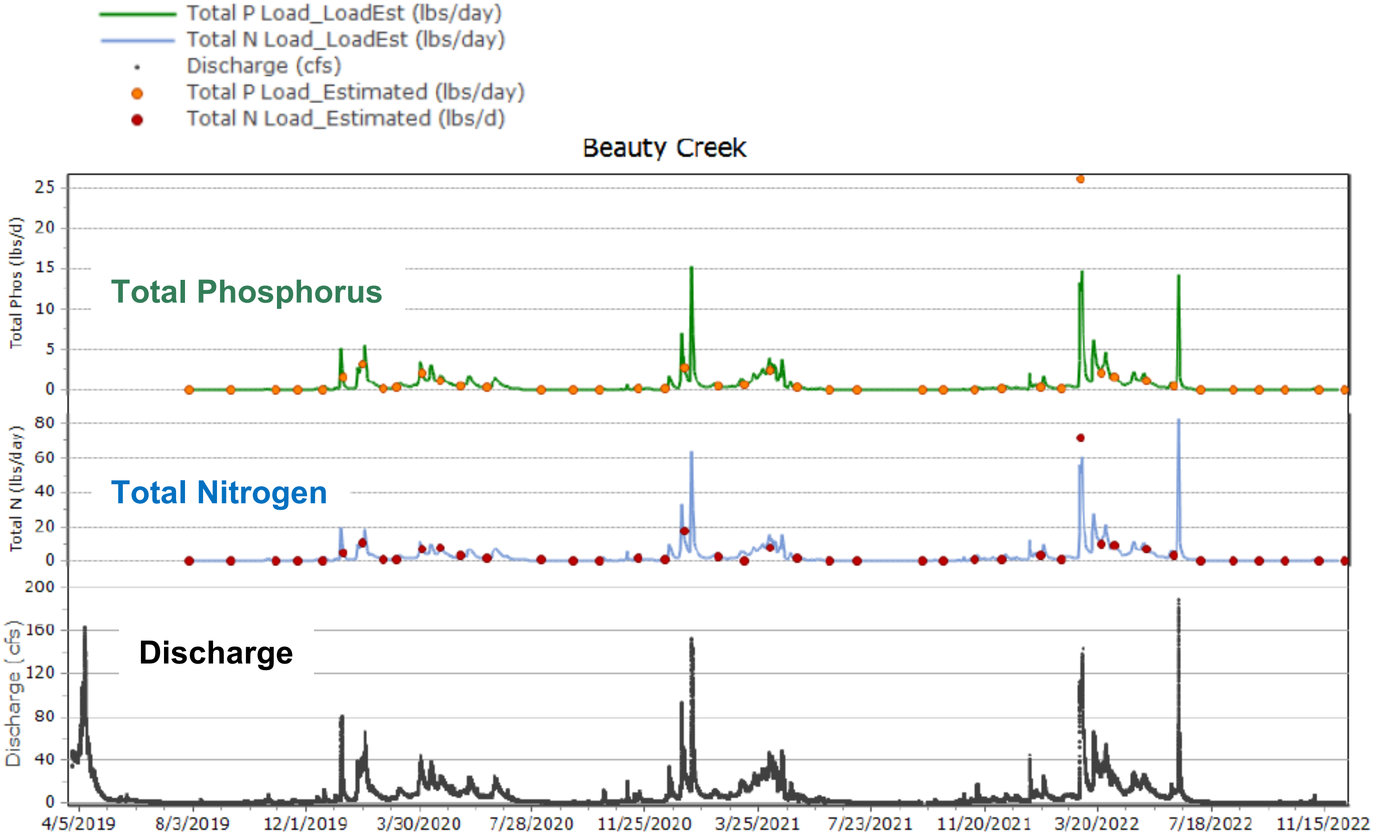
By Robert L. Runkel, Charles G. Crawford, and Timothy A. Cohn

Techniques and Methods Book 4, Chapter A5

Beauty Creek Example

Measured vs modeled daily loads

- For TP, over all streams
  - 93.5% R^2
  - -0.9% bias
  - Underestimate max loads 1-5%
- Error stats vary by stream



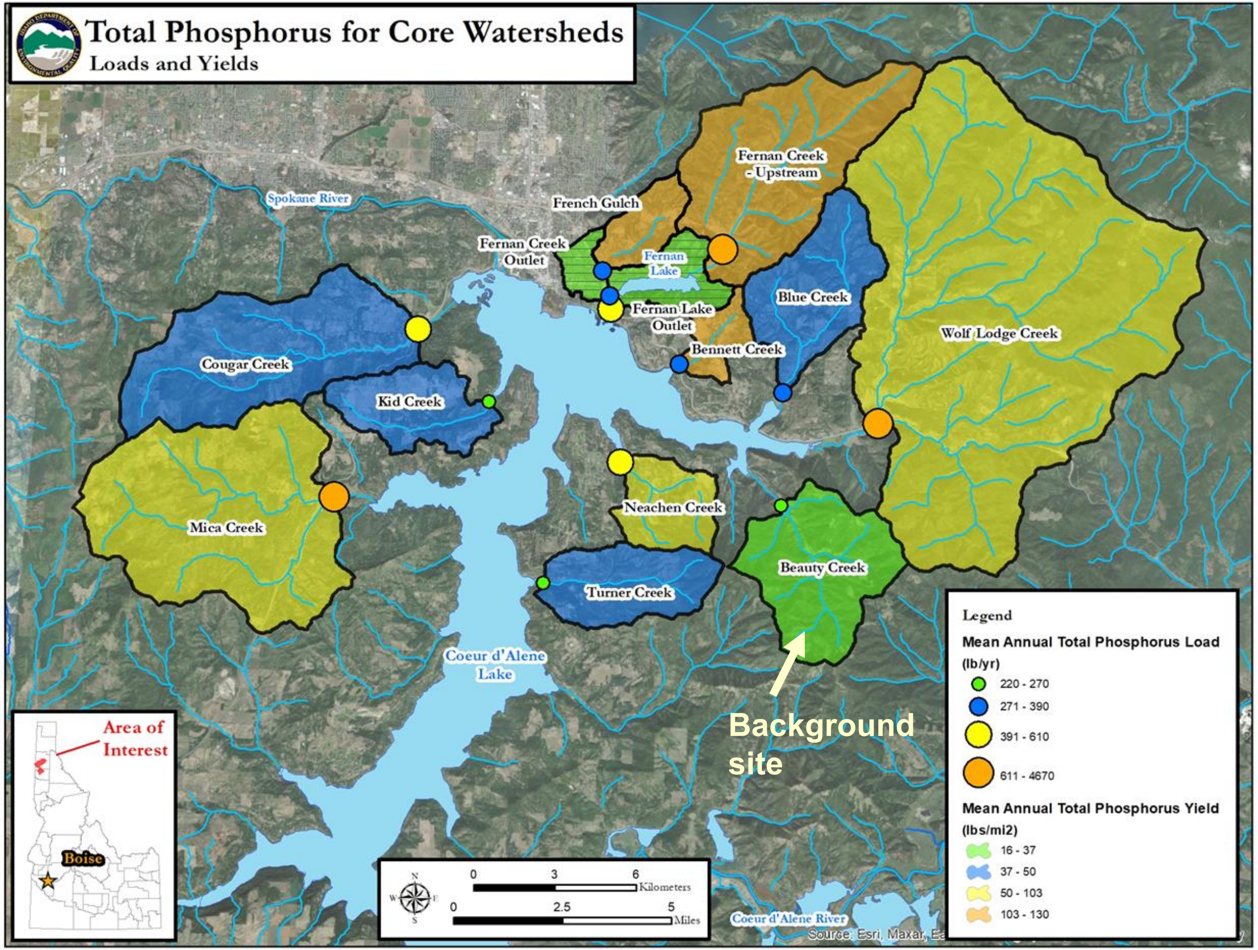
Total Phosphorus

Map of Load and Yield

- *Circles:* load (lb/yr)
- *Background:* yield (lb/mi^2)

Highest Priorities

- ***Load***: Wolf Lodge, Mica, Fernan (upstream of lake)
- ***Yield***: Bennett, French Gulch, Fernan (upstream)



Grey hash = stormwater influenced

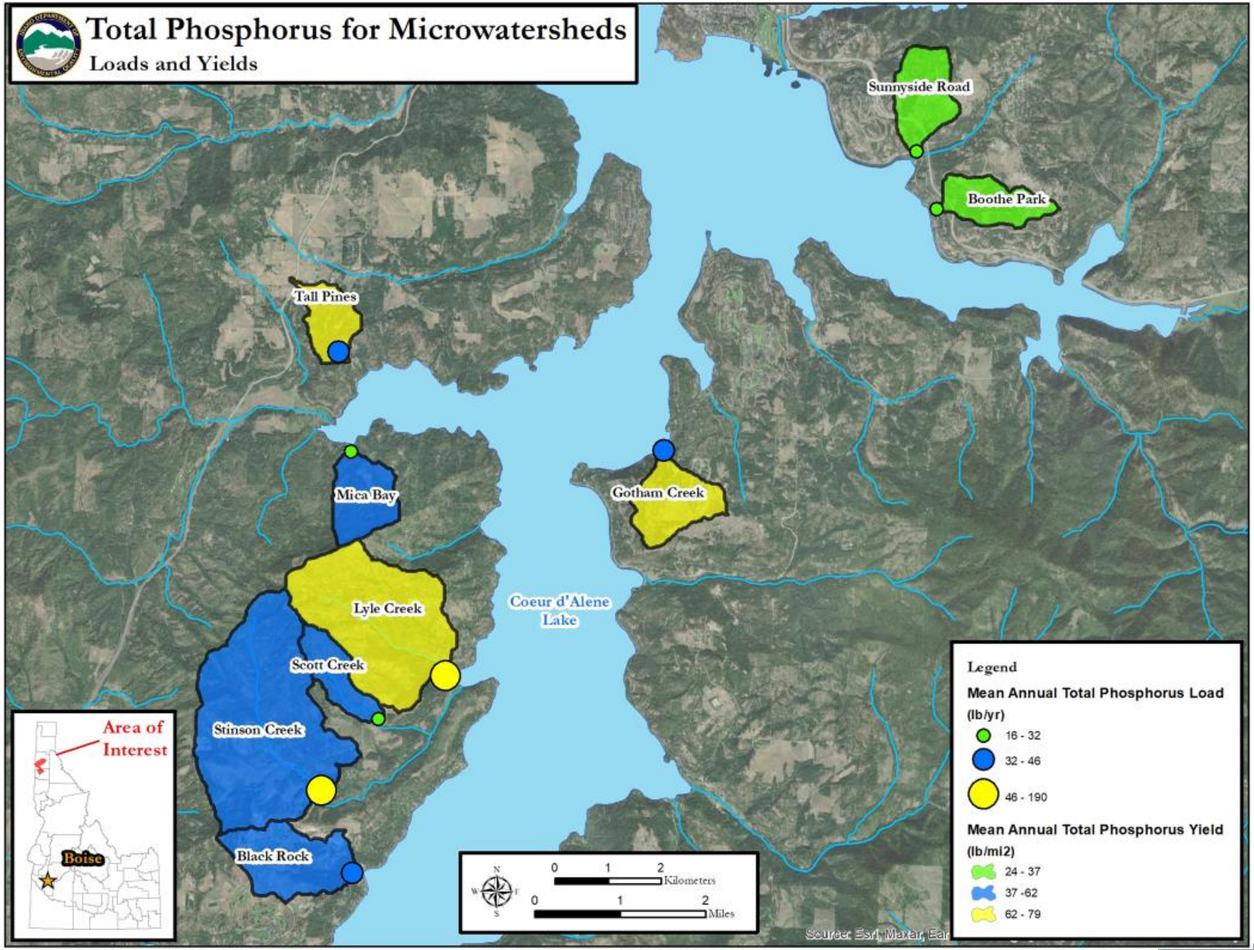
Total Phosphorus

Map of Load and Yield

- *Circles:* load (lb/yr)
- *Background:* yield (lb/mi^2)

Contrast with core watersheds

- All have low range load
- Have mid-to-low range yield
- Low yield on north-shore, developed watersheds



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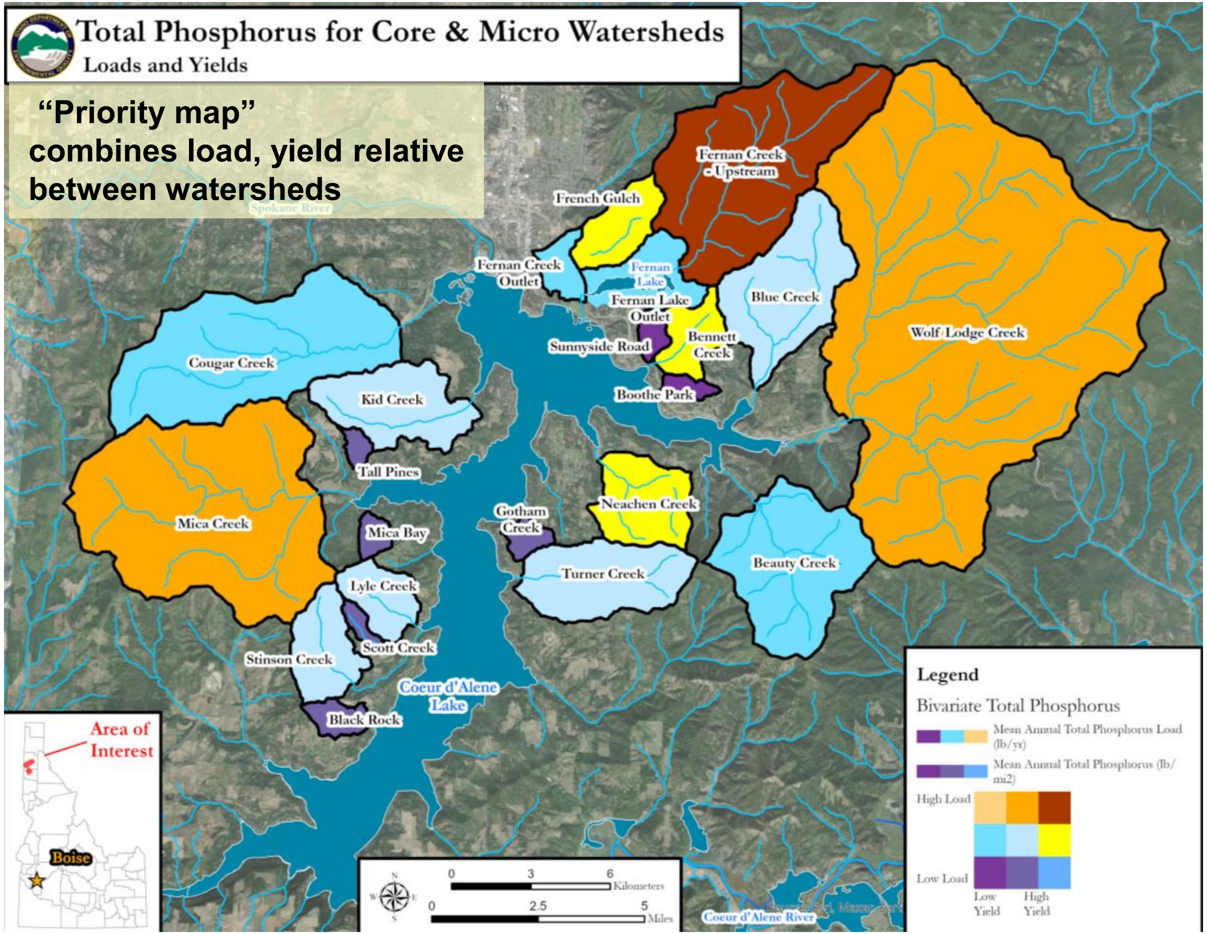
Phosphorus Priorities

- **Top**: Fernan Creek, upstream
- **Load**: Wolf Lodge Creek, Mica Creek
- **Yield**: Bennett, Neachen, French Gulch

Sum of CDA Lake Tributaries

- *Prior model-based studies*: estimate ~20 ± 8 tons TP/yr
- *Extrapolate these data*: estimate ~14 ± 5.5 tons TP/yr
- *Preliminary modeling*: total estimated ~17 tons/yr



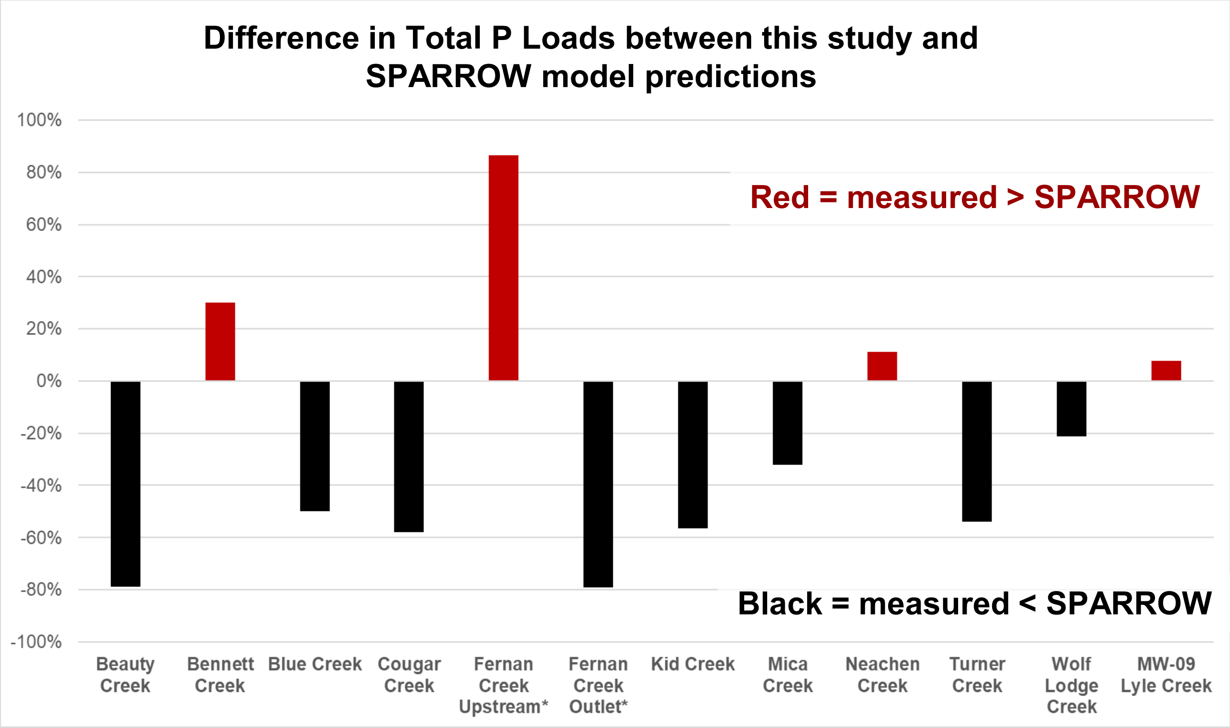
Warmer colors = higher priority

How do Total P Results Compare with Nutrient Models?

ID's streams where TP load is higher than expected

Have sources that landscape-based modeling cannot account for

- *Most streams*: Measured < SPARROW
- *Some higher-yield streams*:
  - Fernan, Bennett
  - Neachen, Lyle
  - Can't evaluate French Gulch



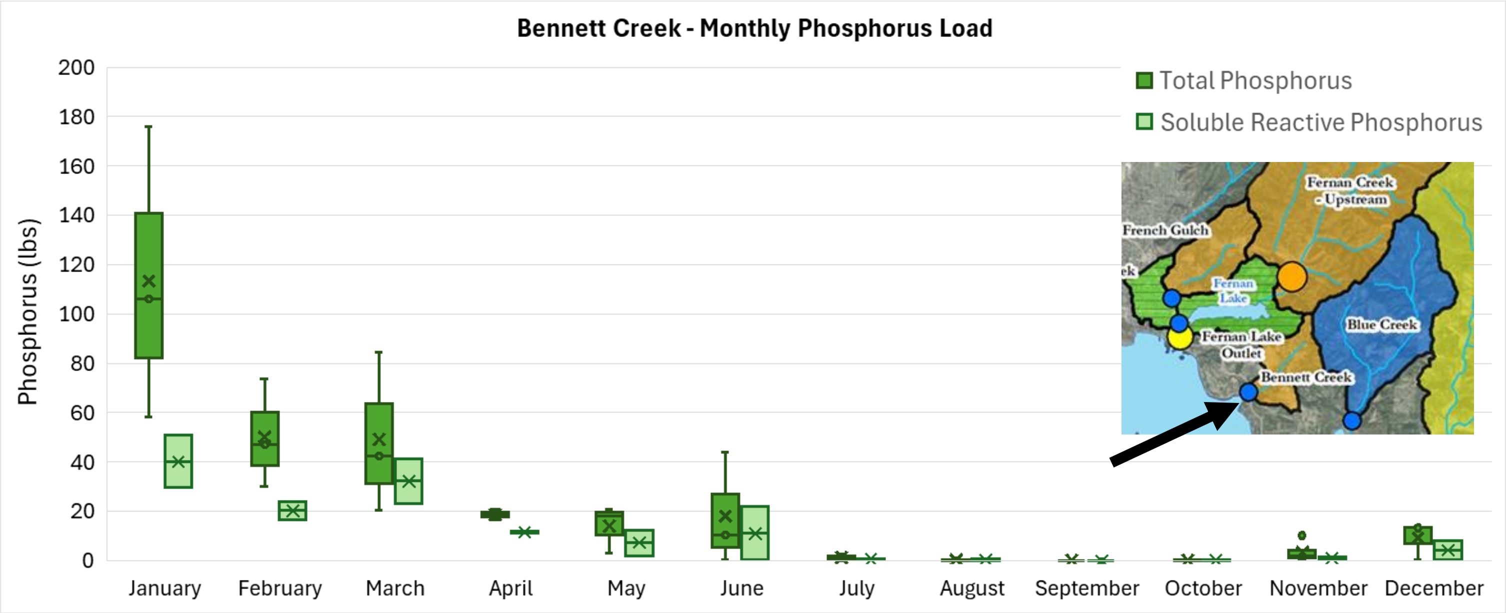
no SPARROW prediction for French Gulch

SPARROW: USGS geospatial model, Wise and Johnson (2013)

Seasonality

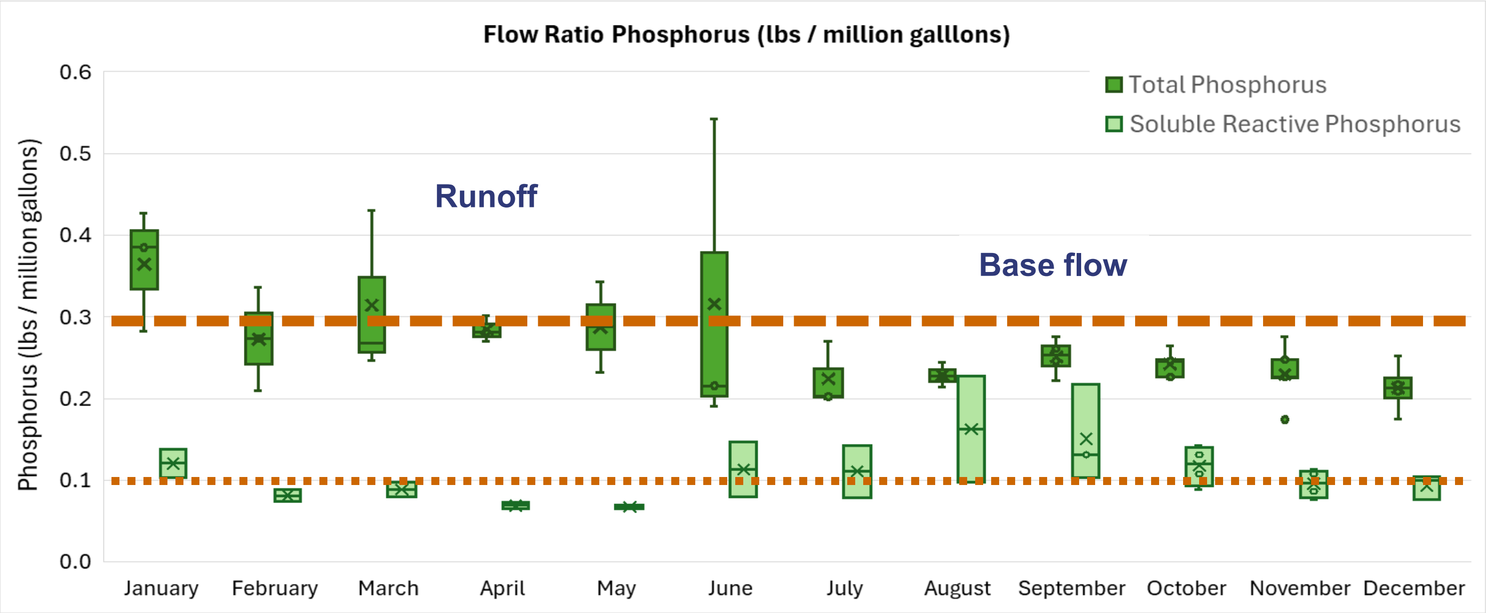
- Link the timing of tributary's nutrient load to timing of lake productivity
- Helps ID nutrient sources
- Sets the sampling schedule
- Establish comparability with other datasets

Phosphorus



- Highest average loads from tributaries in Jan, March. Elevated for April - Jun
- Large extent of annual variability
- Individual streams have different patterns

Seasonality in the Phosphorus Source



- Average monthly load normalized to average monthly discharge.
- Total phosphorus higher lbs/million gallon during runoff. Lower during base flow.
- Reverse trend for reactive phosphorus.

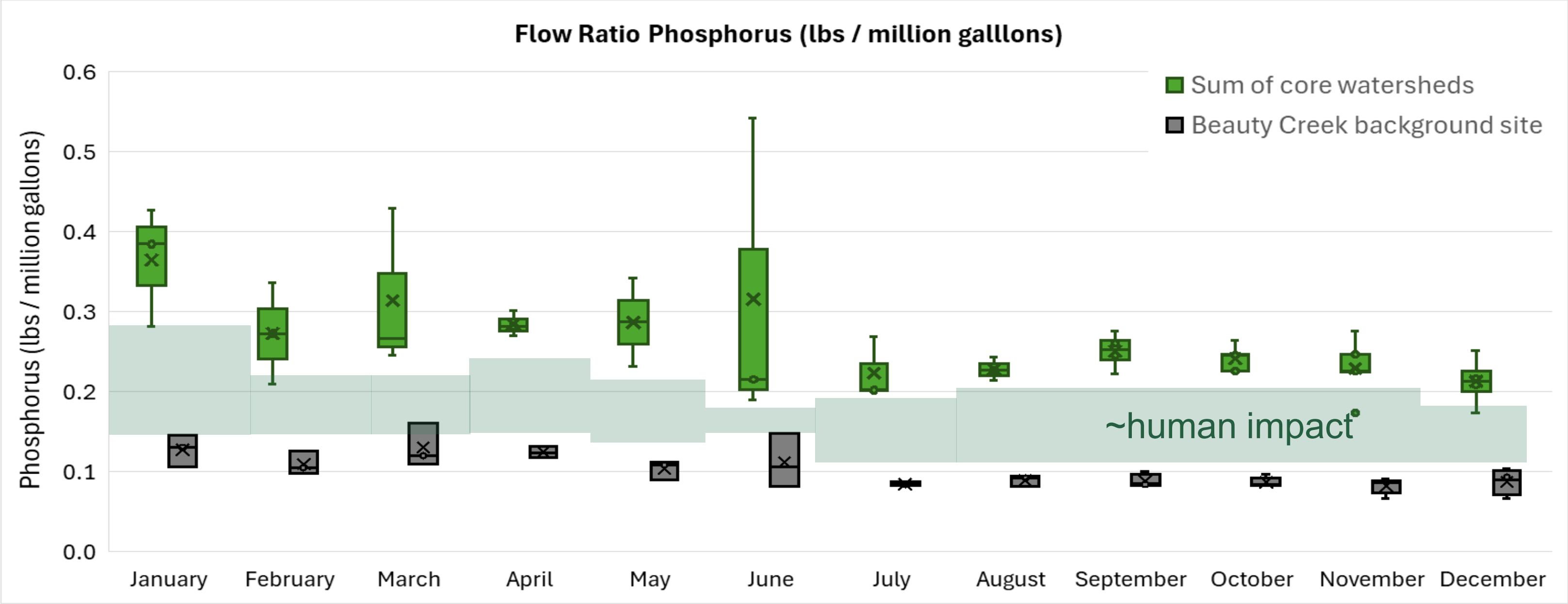
Human Influences

- Important issue
- Can roughly estimate
- Assume similar soils, geology, background load for all streams
- Compare each stream to a background site
- Account for the differences in discharge
- Estimate average excess phosphorus relative to the background site.


Beauty Creek


French Gulch

Discharge Normalized Loads to Estimate Extent of Human Influence



- Beauty Creek is the background site (annual average ~0.13 lbs/million gal)
- *Other streams*: 0.13-0.79 lbs/million gal (average over all streams ~0.38)
- Assume differences are dominantly human influence

Rough Estimate

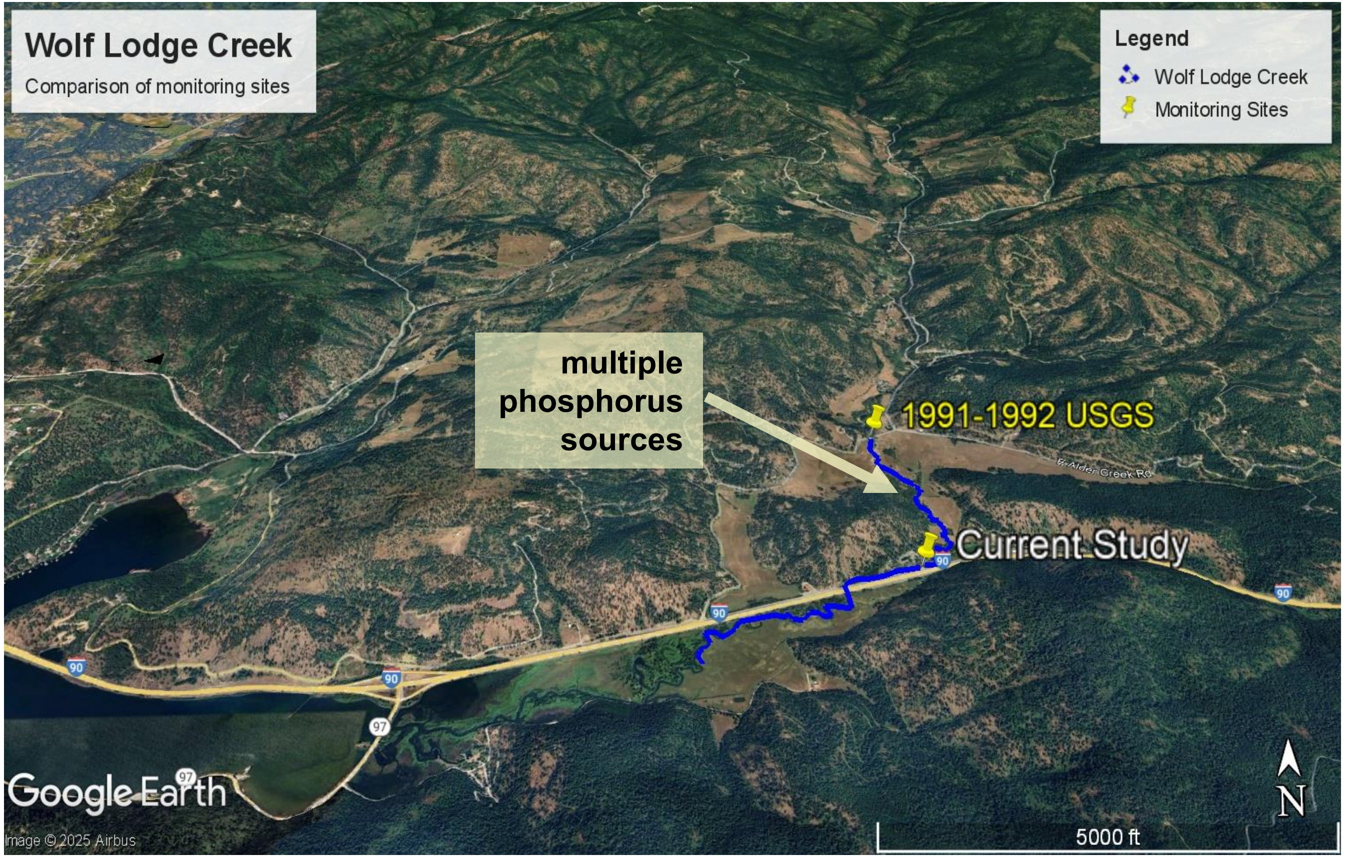
- 3-year averages
- Total load from monitored streams: 9,580 lbs/yr
- Excess vs Beauty Ck over all streams: 5,300 lbs/yr
- Excess vs Beauty Ck *up to* ~50% of total P
- Significant potential for human influence

- Rough estimate
- Multiple factors contribute.
- Need a more comprehensive analysis.

Change over Time

Wolf Lodge Creek

- USGS 1991-92:
  - 0.09 lbs/million gal
  - Upstream site
  - P-sources in between
- Current:
  - 0.33 lbs/million gal
  - > 3x higher
  - *at a different site*



Change over Time

Overall Subbasin load

- USGS estimated 10.5 ± 2.5 tons/yr in 1991-1992
- *Current*: Extrapolate monitored streams
  - ~14 ± 5.5 tons/yr
  - average 60 lb/mi^2
- *Current*: Estimate from preliminary stream network modeling
  - ~17 tons/yr
- ~30 - 60% higher today

Summary

Phosphorus Management Priorities

- Fernan Creek, upstream
- *Next tier, Load*: Wolf Lodge Creek, Mica Creek
- *Next tier, Yield*: Bennett Creek, French Gulch, Neachen Ck.
- Current estimate for total load over all streams is consistent with prior modeling estimates.

Trends

- Likely seeing an influence of development on phosphorus loads
- Timing coincides with elevated chlorophyll-a in northern lake
- P-loads are highly variable
- Multiple factors influence P-loads

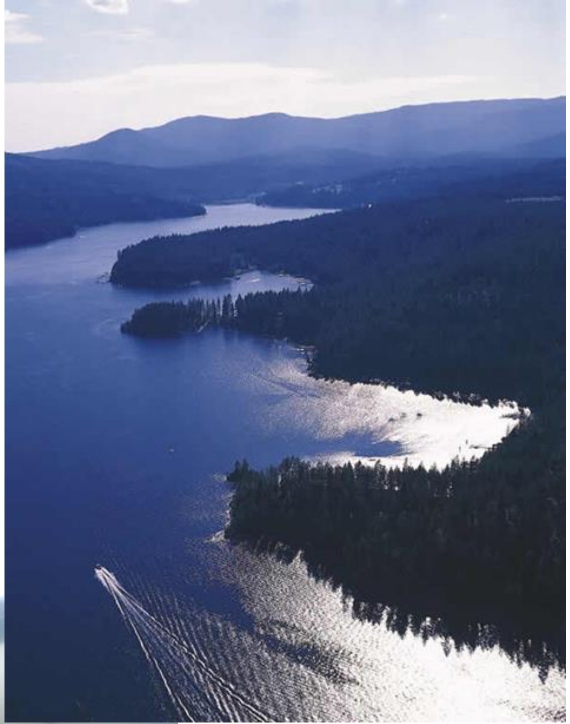
Path Forward

Technical Work

- Better understand drivers of P-loading, influences of development
- Evaluate results from recent stream network modeling
- Better utilize flow-normalization of nutrient loads to identify, evaluate trends

Nutrient Management

- Incorporate findings into prioritization process
- Evaluate benefits of recently completed projects
    - Cougar, Mica, Wolf Lodge Creeks



Thank you

Craig Cooper, PhD
Craig.cooper@deq.idaho.gov

Percent Reactive P, N

- Wide range in proportion of bioavailable phosphorus
- Relatively high percent of reactive phosphorus and nitrogen
- French Gulch has the highest % reactive P, N.

Watershed	Percent Reactive Phosphorus	Percent Reactive Nitrogen
Beauty Creek	50%	16%
Bennett Creek	46%	80%
Blue Creek	38%	69%
Cougar Creek	36%	51%
Fernan Creek Upstream*	36%	--
Fernan Lake Outlet*	25%	--
French Gulch*	52%	71%
Fernan Creek Outlet*	38%	22%
Kid Creek	43%	58%
Mica Creek	40%	39%
Neachen Creek	47%	55%
Turner Creek	41%	52%
Wolf Lodge Creek	19%	33%
Average	*39%*	*50%*

Bioavailable Phosphorus

Map of Load and Yield

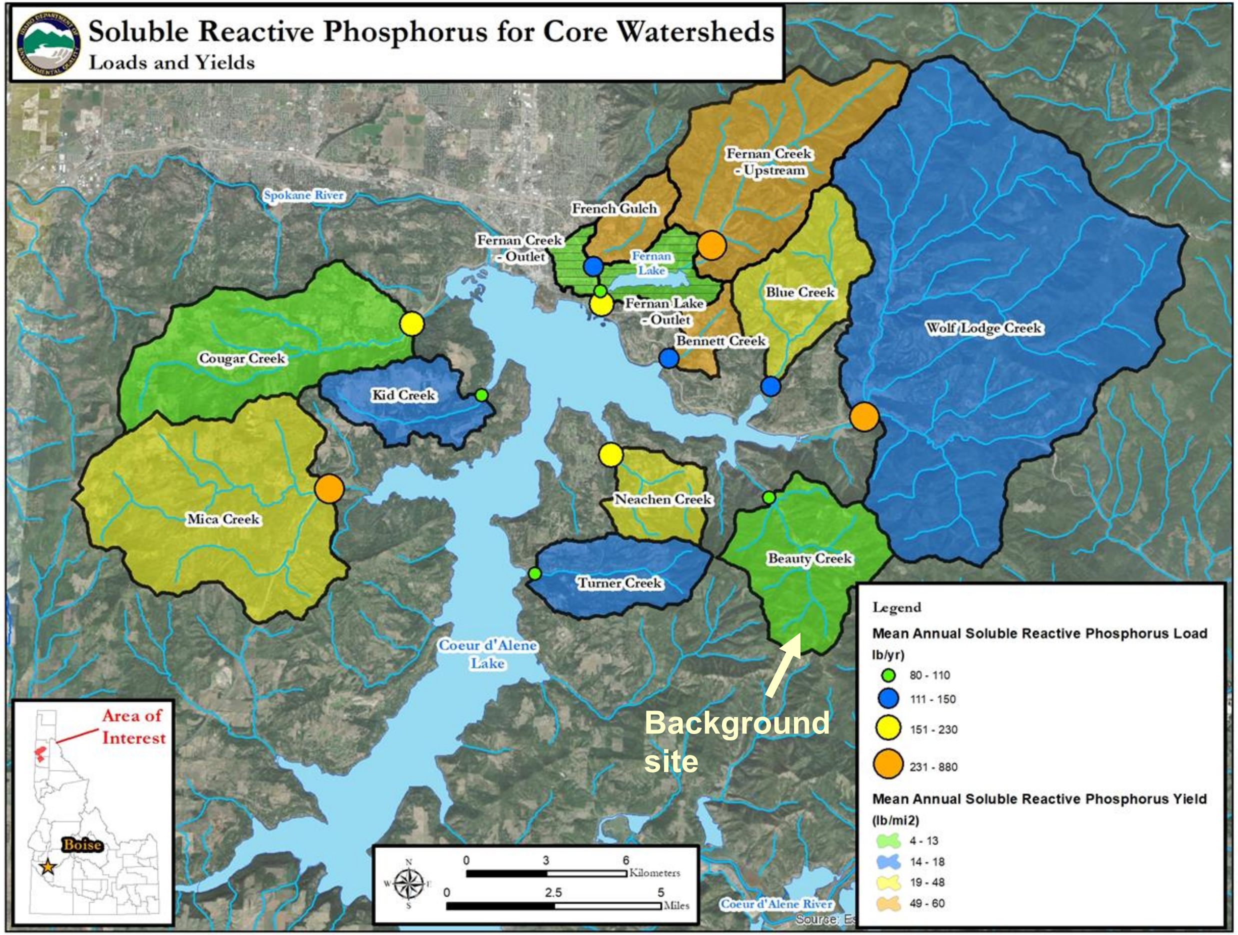
- *Circles:* load (lb/yr)
- *Background:* yield (lb/mi²)

Highest Impacts

- ***Load***: same as Total P
- ***Yield***: same as total P

Results similar to Total P

- Small differences
- Blue Creek higher yield
- Wolf Lodge lower yield



Grey hash = stormwater influenced

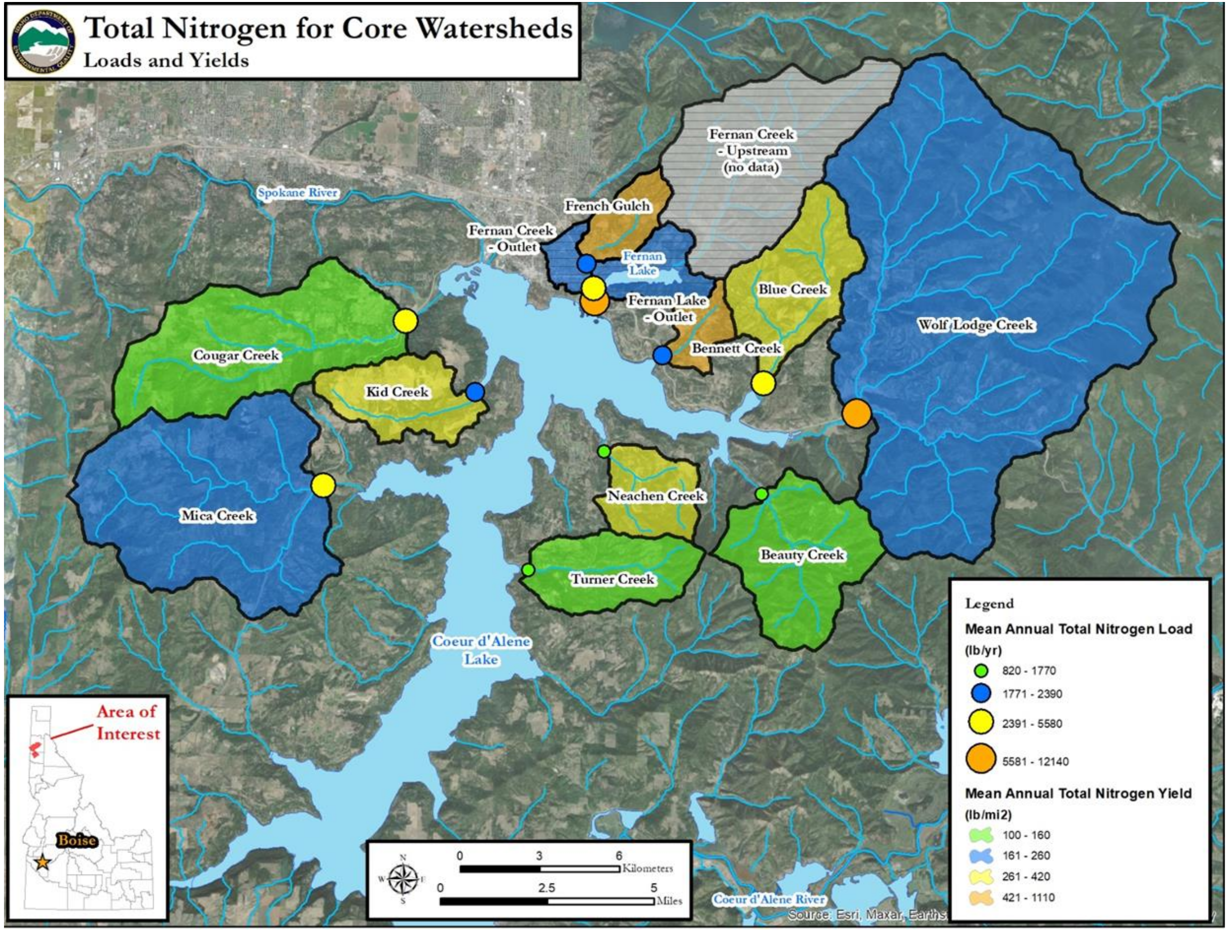
Total Nitrogen

Map of Load and Yield

- *Circles:* load (lb/yr)
- *Background:* yield (lb/mi^2)

Highest Impacts

- ***Load***: Wolf Lodge Creek, Fernan Creek at CDA Lake
- ***Yield***: Bennett Creek, French Gulch
- ***Commonality with Total P***: Bennett Creek, French Gulch, Wolf Lodge Creek



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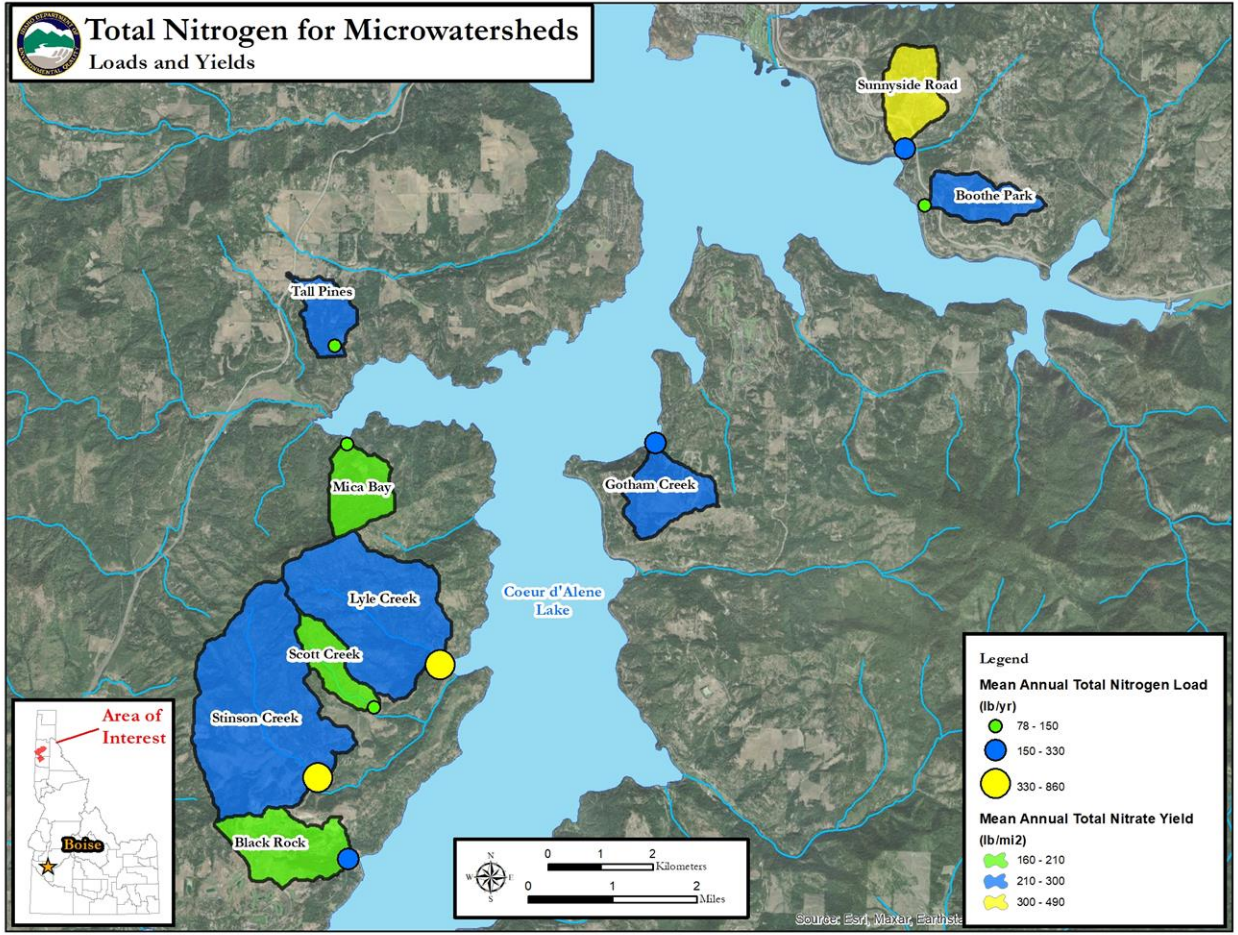
Total Nitrogen

Map of Load and Yield

- Same as before
- Grey = no data

Highest Impacts

- *Load:* Wolf Lodge, Fernan
- *Yield:* Bennett Creek, French Gulch
- ***Combined***: None
- Nitrogen is a lesser concern



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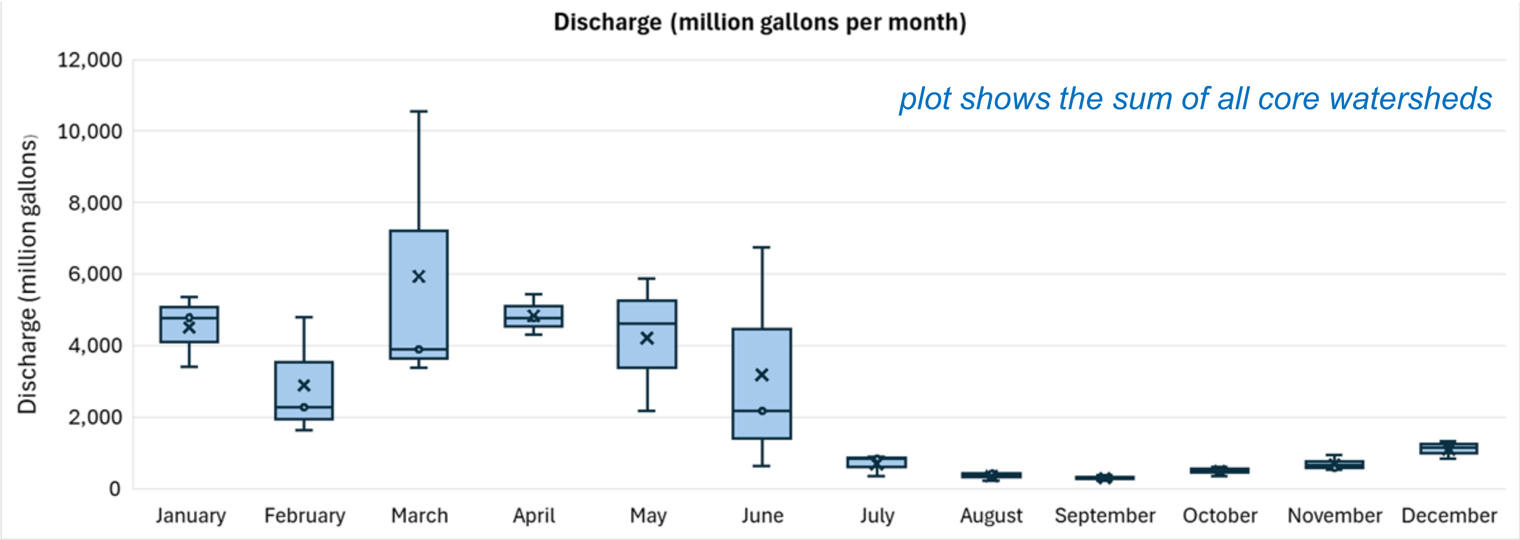
Seasonality



- Helps to link the tributary's nutrient contribution to timing of lake productivity
- Helps ID sources and establish comparability with other datasets
- Discharge has a "2-hump" annual pattern with significant annual variability