Field Based Methodology for Deriving Water Quality Benchmarks

(Draft report April 2010)

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July 21, 2010

Development of benchmark based on three key decisions

1. Followed EPA's methodology for developing Water Quality Criteria that has been used for 25 years

2. Used field data rather than laboratory toxicity test results

3. Selected an effect that is clearly adverse: the extirpation of genera.

Approach for Deriving Conductivity Advisory Level

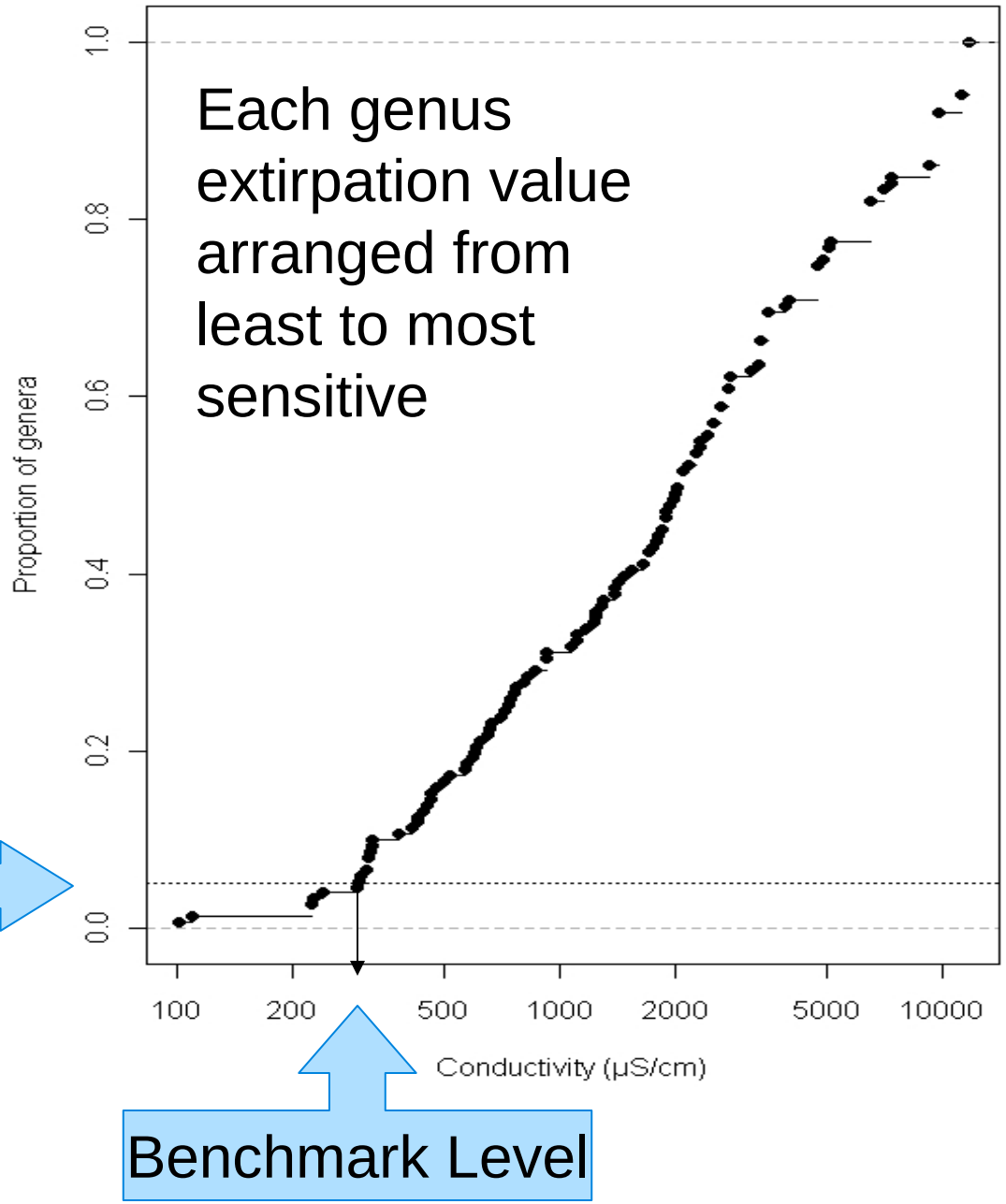
Long standing U.S. EPA procedure for developing water quality criteria

- Lab-based Toxicity Testing
  - standard method for deriving Water Quality Criteria
  - end-points well-established (LC_{50} and chronic value)
  - confounding variables more easily controlled
  - fewer species tested; species may not occur in field
  - conditions differ from field

Adapted procedure to use *field data* from Central Appalachia streams

- Field Data
  - uses native species acclimated to local conditions
  - many more species evaluated
  - conditions realistic and relevant
  - must account for confounding variables

Field Derived SSD



Process for Developing Field Based Benchmark

1. Estimate XC_{95}s for each genus
   (level above which a genus is rarely observed).

2. Develop a distribution of the XC_{95}s.

3. Find the conductivity level corresponding to the 5^{th} percentile.

Process for Developing Field Based Benchmark

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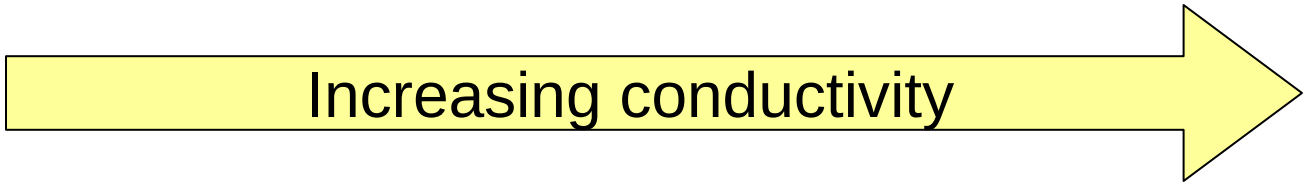
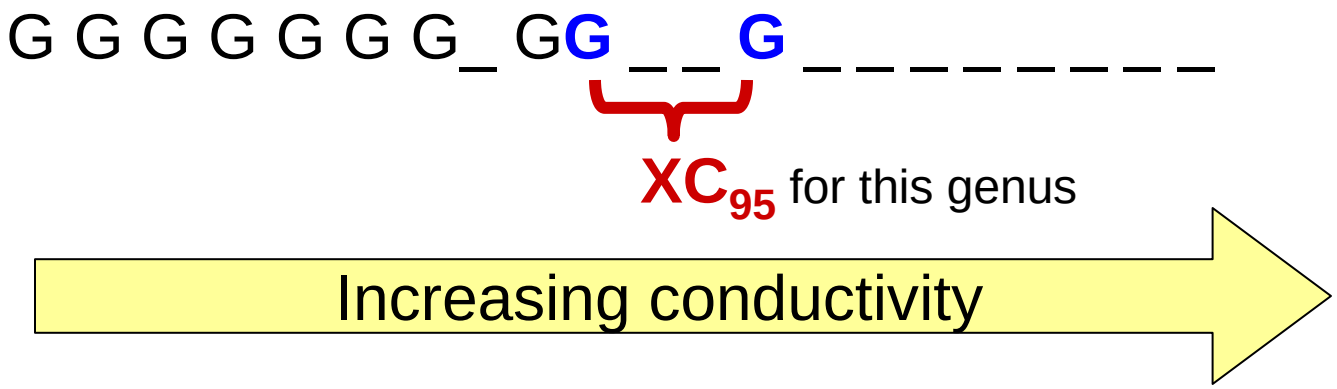


Rank all observations of a genus with respect to conductivity.

Adjust for unequal sampling effort along the conductivity gradient by weighting observations.

Process for Developing Field Based Benchmark



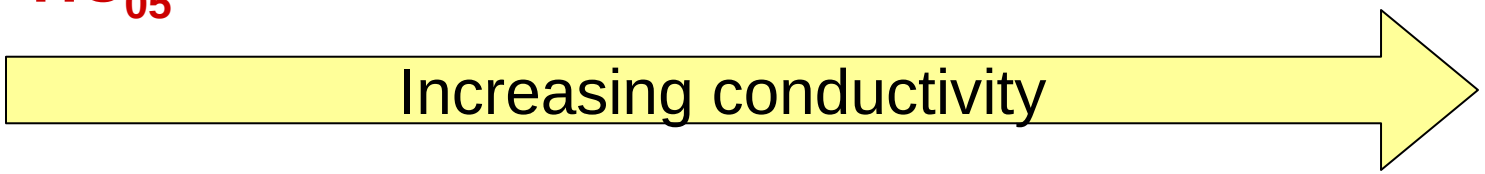
Estimate the XC_{95}, the conductivity level above which a genus is effectively gone from the system (the 95th percentile of occurrences of the genus).

Repeat for all genera occurring in ≥30 sites and at least once in a reference site.

Process for Developing Field Based Benchmark

XC_{95}

HC_{05}



Develop the sensitivity distribution by rank ordering the XC_{95} values with respect to conductivity for all genera.

HC_{05} = the conductivity corresponding to the 5th percentile on the sensitivity distribution; intended to protect 95% of species.

Used West Virginia Data Set Trimmed to Reduce Influence of Other Variables

Removed sites

- With pH <6
  - reflects acid mine drainage
  - Water Quality Criterion already available, pH >6.5
- With conductivities >1000 µs/cm, chloride >250 and sulfate <125 mg/L
  - Different ionic mixtures have different biological effects
- From large rivers
  - sampling protocols were different

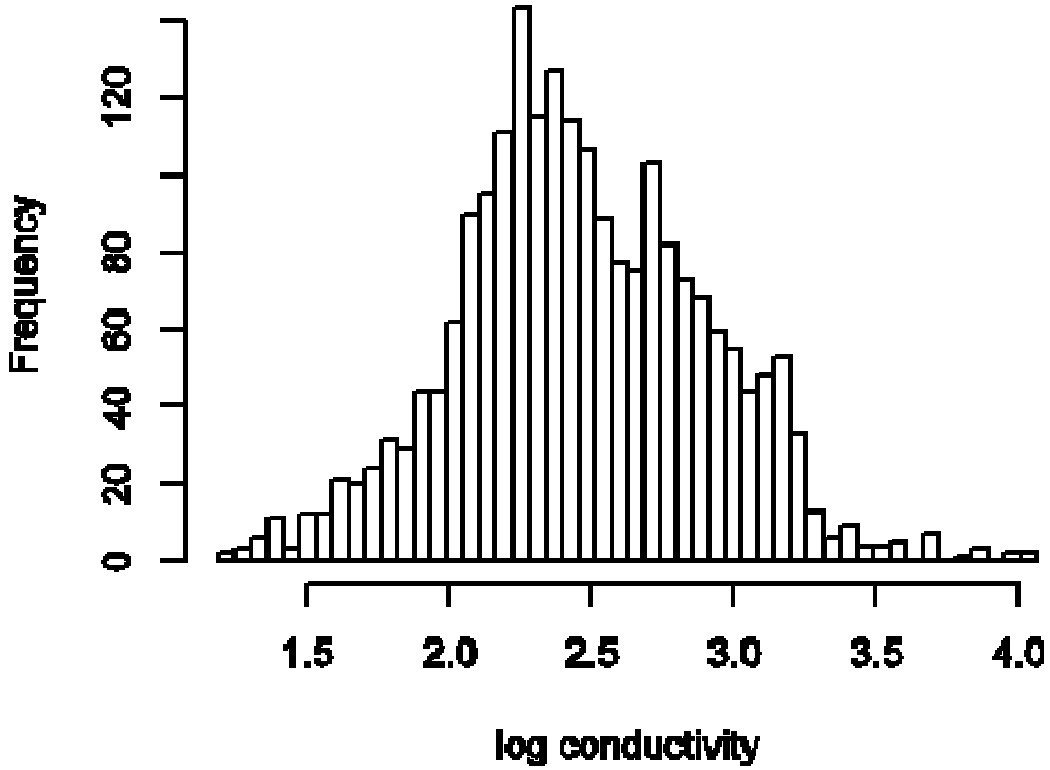
Other variables considered

- Habitat quality, organic enrichment, temperature, nutrients, pH >8.5, deposited sediment, lack of headwaters, stream size, Se
- Effect on results minimal. No action taken

Process for Developing Field Based Benchmark

Step 1 details.
Adjust for unequal sampling effort along the conductivity gradient by weighting observations.

Divide the observation of a genus by the number of observations within a conductivity bin.



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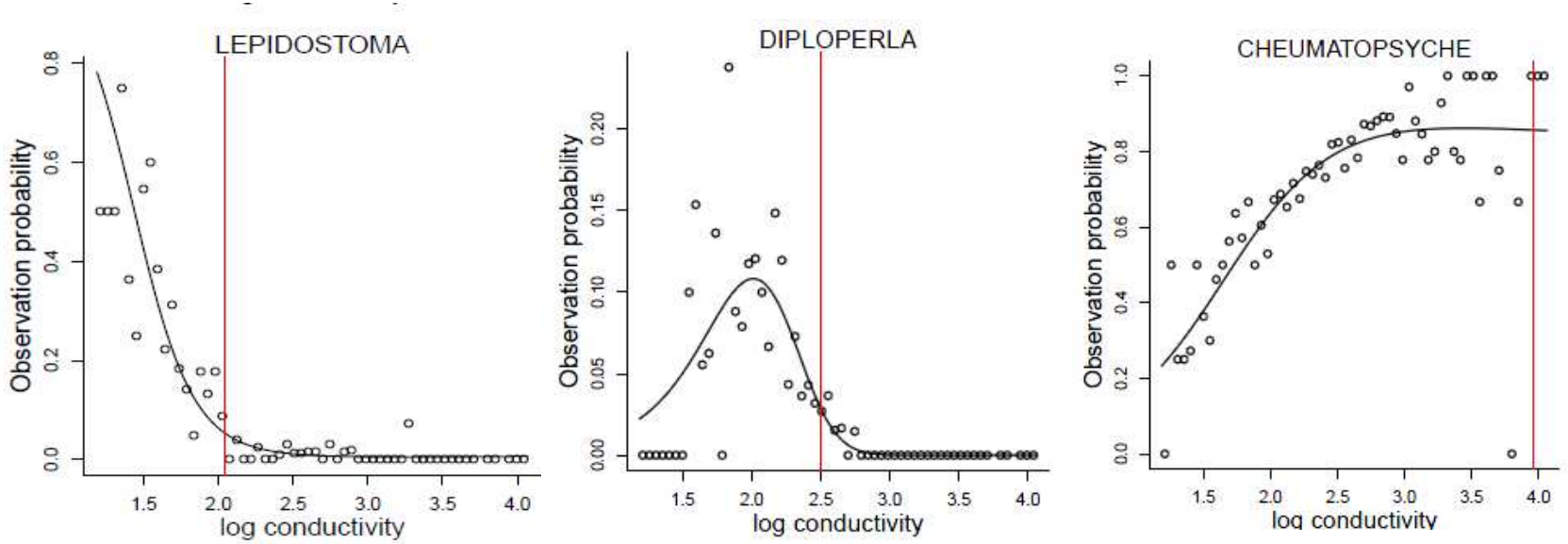
Representative Distributions of Occurrence

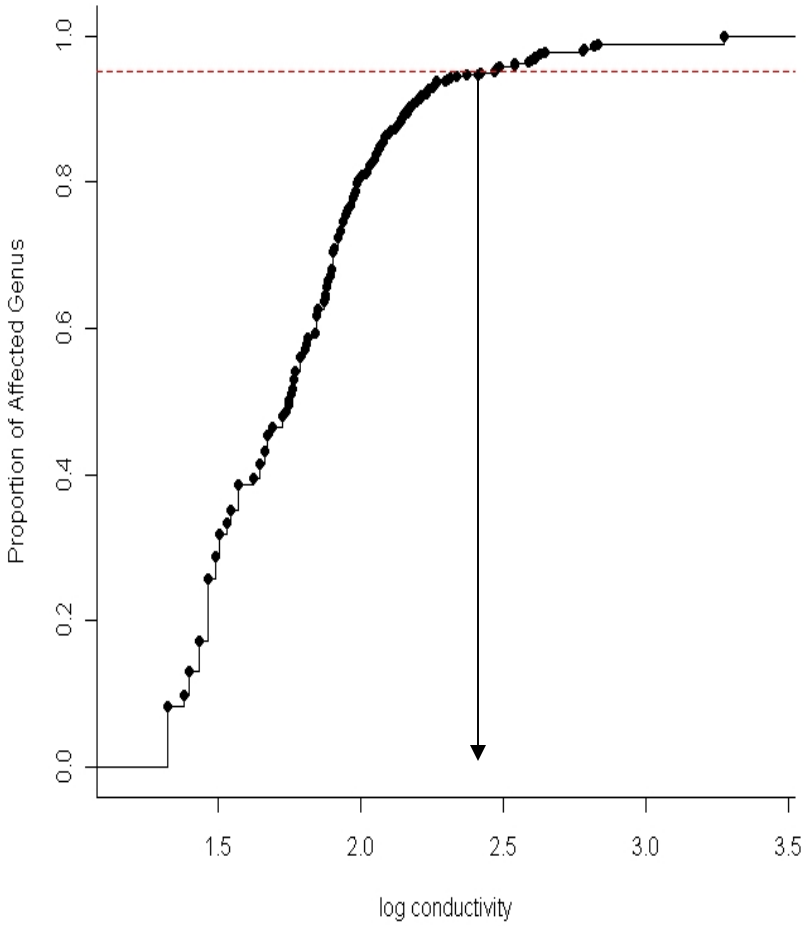


Conductivity Benchmark

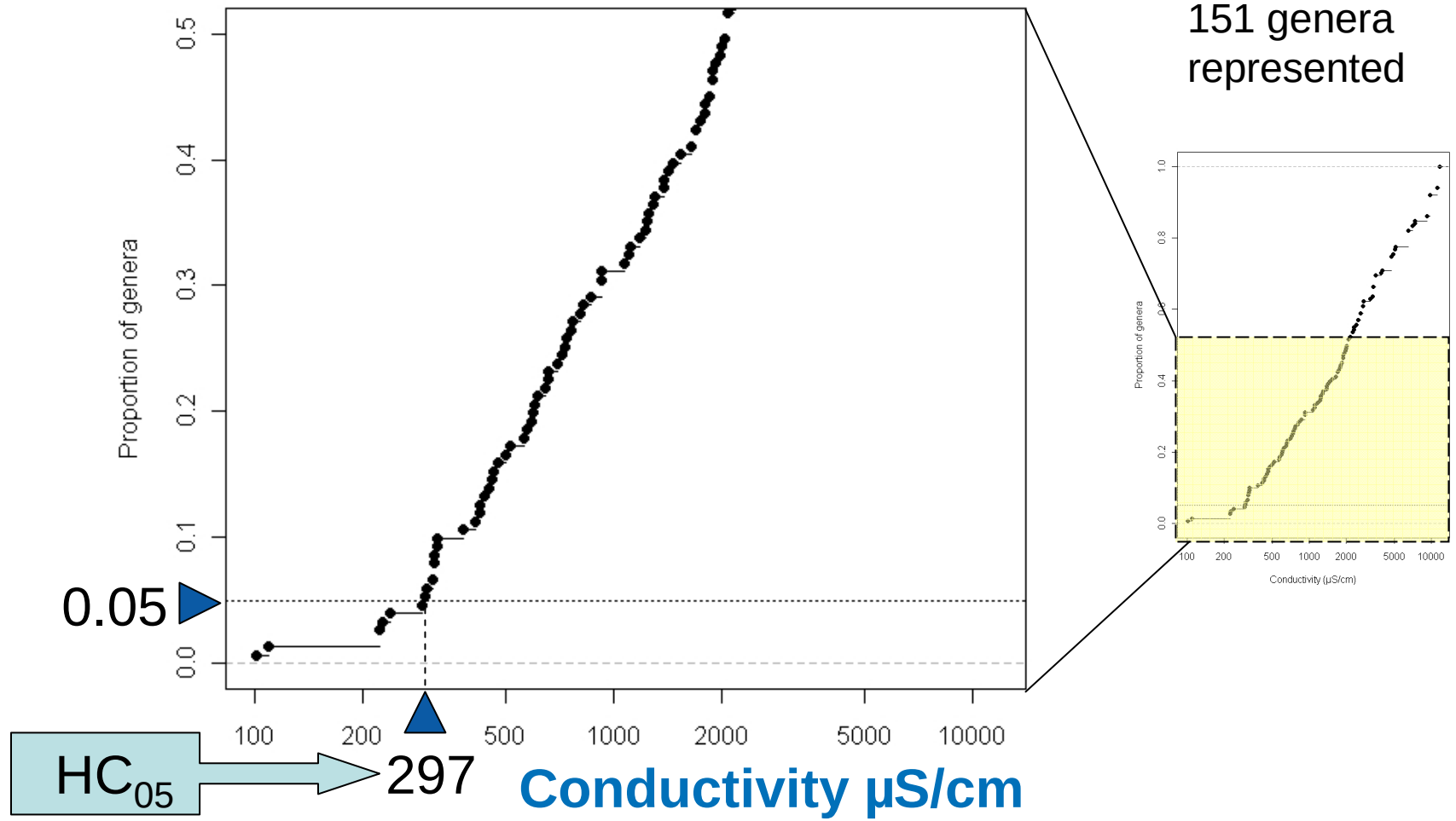
Process for Developing Field Based Benchmark

Step 2 details.

Estimate the conductivity level above which each genus is effectively gone from the system as the 95th percentile of occurrences of the genus. This level is called the extirpation concentration (XC_{95}).



Sensitivity Distribution of Invertebrate Genera



Conductivity Benchmark

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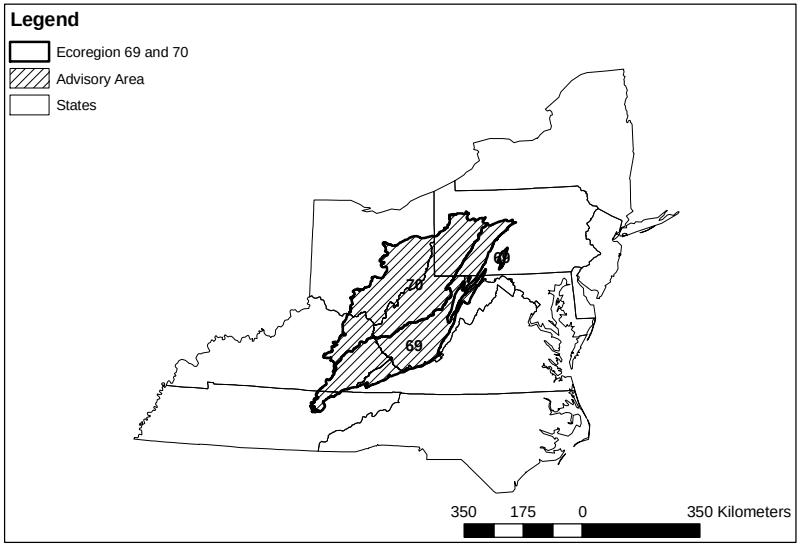
Hazardous Concentration

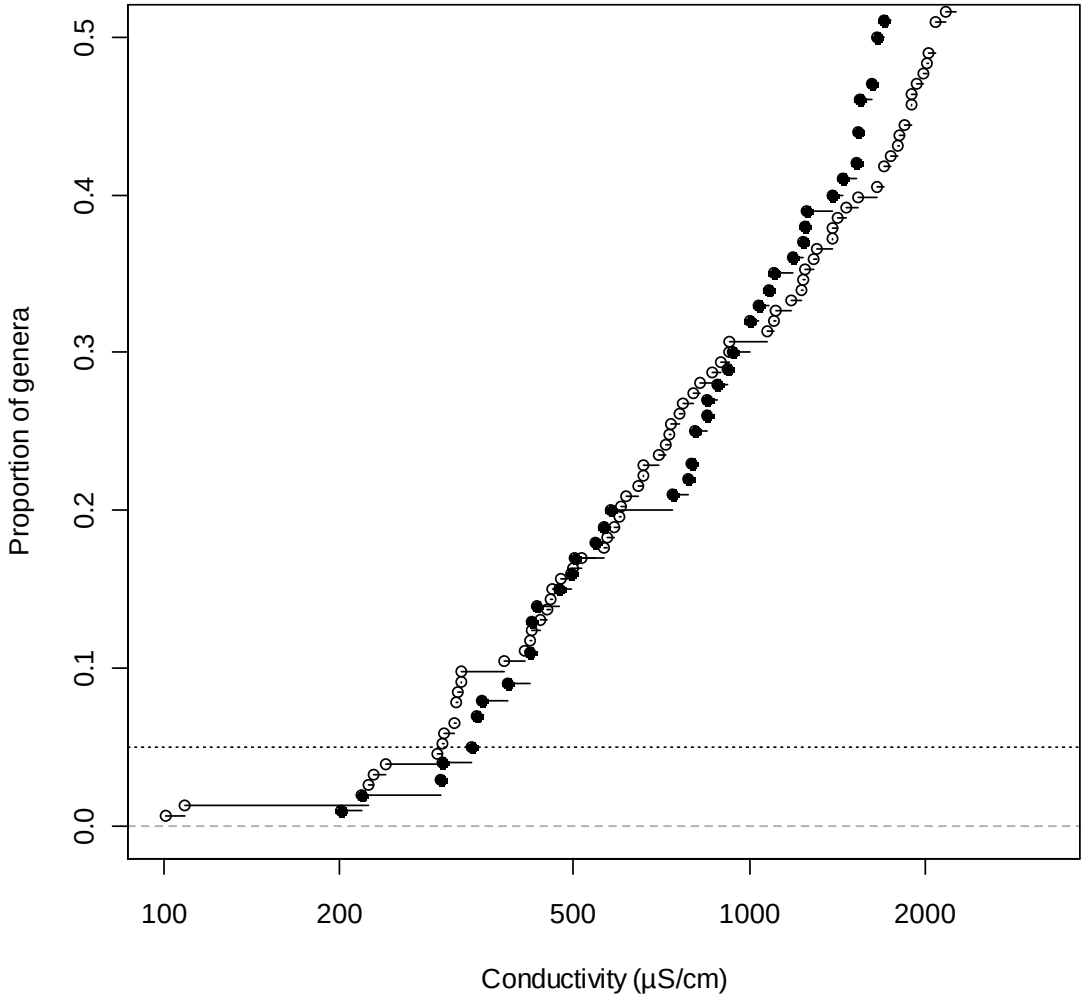
HC Level **(% species loss)**	**Point Estimate** (µS/cm)	**95% Confidence Interval** (µS/cm)
HC_{05}	297	225-305

Comparison of WV and KY Data

West Virginia	HC_{05}	Kentucky	HC_{05}
March – October	297 µS/cm (225-305)	February – October	319 µS/cm (180-439)



Removal of Potential Confounders



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Summary of Causal Evidence

Characteristic	Evidence	Score
Co-occurrence	Loss of genera occurs where conductivity is high even when potential confounding causes are low but is rare when conductivity is low.	+ + +
Preceding Causation	Sources of conductivity are present and are shown to increase stream conductivity in the region	+ + +
Interaction	Aquatic organisms are directly exposed to dissolved salts. Physiological studies document effects of ion imbalance.	+
Alteration	Characteristic genera and assemblages are affected at sites with higher conductivity.	+ +
Sufficiency	Increased exposure in both concentration and duration to salt affects invertebrates based on both field and laboratory analyses.	+ + +
Time order	Conductivity increases, and local extirpation occurs after mining permits are issued, but before and after data are not available.	NE

Recommended Conductivity Benchmark

300 micro Siemens per centimeter (µS/cm)

- Uses field data rather than lab-based bioassays
- Aims to protect 95% of invertebrate species living in Central Appalachian streams
- Advisory value is calculated using WV stream data; validated with KY data
- Limited to streams dominated by sulfate and bicarbonate ions at neutral to alkaline pH