**Sampling effort and designs for detecting a temporal trend in regional brook trout abundance**

**Goal:**

Identify sampling effort and designs suitable for detecting regional abundance trend based on power analysis with simulations. More specifically, we will examine power of detecting a small change (e.g., 2.5%, 5% and 10% annual rate of decline) over a short period of time (e.g., 5 and 10 years) where power is defined as the percentage of simulations in which the effect size (95% credible interval) of the temporal linear trend term does not overlap with a value of zero. We focus on a small change over a short period because trout mangers are typically interested in declining a trend over a short period of time.

**Data and model:**

Power to detect a temporal trend depends on the degree of temporal variance (i.e., noise) in trout abundance. We need a regional data set to quantify temporal (and spatial) variance. A regional count data will be analyzed using a hierarchical model which includes an ecological process to model spatial and temporal patterns of abundance and a detection process based on three-pass depletion (e.g., N-mixture models). Young-of-the-year (YOY) and adult abundance will be analyzed independently.

**Simulation ideas:**

Simulation 1: Power of detecting a trend without any temporal covariates

* Abundance will be modeled as a function of overall mean, spatial random effect, temporal random effect and residual random effect. These empirically derived values will be used in simulations for detecting a linear temporal trend for each combination of annual rate of decline (e.g., 2.5%, 5% and 10% annual rate of decline) and study period (e.g., 5 and 10 years).

Simulation 2: Power of detecting a trend with seasonal weather covariates

* Seasonal weather covariates will be added to the model used in Simulation 1. This should decrease temporal variance (i.e., noise) in trout abundance and we will run another set of simulations with identical settings (annual rate of decline and study period)

Simulation 3: Distribution of 3-pass versus single-pass electrofishing surveys

* Assume as if a subset of sites were surveyed with single-pass electrofishing surveys (i.e., NA for count data in the second and third passes). This topic came up in a recent conversation with NC Wildlife Resources Commission.

Simulation 4: Power of different revisit designs (e.g. always revisit, never revisit, every other year visit, rotating after consecutive year revisit)

* Change revisit designs while keeping total sampling effort constant. This topic also came up while talking to NC Wildlife Resources Commission. Shenandoah NPS also appears to be experimenting with every other year visit versus consecutive year revisit designs.

**Expected outcomes:**

Simulation 1: Given high temporal variance in abundance that is typically observed in trout (e.g. Ham and Pearsons 2000), a large number of sites are required to confidently detect a small declining trend in abundance over a short time period. This may be possible only by combining data from multiple sources and building a regional data set, thus highlighting the importance of regional analysis and collaboration (which we do exactly).

Simulation 2: Addition of seasonal weather covariates would reduce unexplained temporal variance in abundance (e.g. Kanno et al. 2016) and would increase power to detect a linear trend. This would encourage monitoring of weather patterns (even stream temperature and flow) across the region and would also help set up our next paper – spatial heterogeneity in climate influence on trout abundance from GA to PA.

Simulation 3: Assuming that a good covariate for detection is available, 3-pass surveys would not be necessary for all sites; in fact, 3-pass surveys might be necessary at only a small subset of sites. If 10 sites are surveys for 5 years, a set of 50 sampling occasions are available to quantify the effect size of the detection covariate and this is not a small sample size. If not all sites need 3-pass surveys, state agencies can visit more sites with a single-pass survey to expand spatial coverage and this would be a big deal for them. It also highlights the importance and mechanism of hierarchical models in dealing with missing data.

Simulation 4: Dauwalter et al. (2010) report that power of four different revisit designs (always revisit, augmented serially alternating [two designs] and serially alternating) is similar and suggest that fishery managers have flexibility to choose a sampling design. I have done a quick-and-dirty simulation to reach the same conclusion a while back. This is another important sampling question for state agencies.