ANOVAs II

Here we conduct ANOVAs of several common experimental designs. You already have practice with one-way, randomized block, and factorial analyses using our helicopter data. Those designs are very common and useful. Today we revisit those ANOVAs with other data sets and then try a split plot ANOVA. We assume you know which packages to load now for assumptions tests and data handling, as well as importing data, etc.

Parasite Loads on Fishes

Luque & Poulin (2007) reported ecto- and endoparasite loads on diverse fishes in freshwater and marine habitats of the Neotropical Americas. Here we ask – for the data in their Table 3 of fish species with the greatest parasite species richness – do freshwater fishes carry more parasite species than do marine fishes?

- Load and attach the `fishes.txt` data set from the course web site
- The Habitat column includes F = freshwater and M = marine. Are the total parasite loads (Total column) normally distributed for each habitat? Are the variances homogeneous?
- If so, compute a one-way ANOVA to compare total parasite loads between freshwater and marine families of fishes. If not, make data fit assumptions with transformations and then compute the ANOVA. Failing that, conduct a Wilcoxon test.

Fire Ant Nests

Next evaluate a data set (`ants.txt`, also on the course web page) showing the count of fire ant nests per quadrat in either forests or fields.

- Following the same basic procedures as for the fishes (above); is there a significant difference between habitats for the density of ant nests? Does it matter if you run a t-test here vs. an ANOVA?

A Factorial, Randomized Block Experiment

Next up: the `ponds.txt` data set on the course web page represents an experiment where whole wetlands were embedded in either intensive land use or seminatural lands, and cattle were exclosed with fence (or not), and prescribed fire was applied (or not; Boughton et al. 2011). The goal was to study the interactive effects of these common ranch practices on diversity (here D = $e^{H'}$ - see Jost 2006 for more details on how D is calculated). This experiment represents a three-way factorial design, with blocks, where treatments = pasture, fenced, and burned. By comparison, our helicopter experiment was a 2-way factorial with blocks.

- Follow the same basic approaches as above, but this time test for effect of the 3-way factorial, randomized block treatments on D.
- Make an interaction plot to examine the effects – can you interpret the results? What would you recommend to manage for greater D?

A Split-Plot Experiment

An experiment was conducted on wheat yield with 3 treatments: fields were irrigated or not, seed sowing density (low, medium, high density), and type of fertilizer applied (N, P, N+P). The data are in `yields.txt` on the course web page.

In this split-plot experiment, four big fields (blocks in the data) were each split in half, where one half of a field was irrigated and the other not irrigated (chosen randomly). Each irrigation plot was again split into 3 subplots, and a seed sowing treatments was randomly applied to each subplot. Finally, each sowing subplot was split again in thirds, and each third received one of the fertilizer treatments (randomly assigned). Oi! 3 splits!

The experiment is a factorial, but what makes this design different is progressive subdividing of fields. This means the Error term needs to be adjusted in the aov statement compared to the default. Notice how the Error term below has 3 layers – representing the 3 splits? Blocks contain irrigation choices, which themselves contain sowing densities)

In the interest of time, you can assume that assumptions are met – but you wouldn't dare do that with your own data, right? Shake your head and say "No way"...

- After attaching and looking at the yields data file, run this command:

```
correctmodel <- aov(yield ~ irrigation*density*fertilizer +
Error(block/irrigation/density))
summary(correctmodel)
```

- Notice how irrigation is evaluated relative to the block residuals?
- Notice how sowing density is evaluated relative to the block-and-irrigation residuals?
- And how the difference *among* fertilizer levels is finally evaluated relative to variance *within* those split-split-split plots?

Just to see what would happen if we failed to recognize the split-split-split plot design, try this simple factorial ANOVA, with the wrong error term:

```
wrongmodel <- aov(yield ~ irrigation*density*fertilizer)
summary(wrongmodel)
```

How would conclusions differ if you had not recognized the split plot design?
Make interaction plots for this experiment: what would be best to maximize yield?

If you can confidently design and analyze one-way, factorial, and split-plot experiments, you can already conduct a lot of research.

<u>References</u>

- Boughton EH, et al. 2015. Interactive effects of pasture management intensity, release from grazing, and prescribed fire on forty subtropical wetland plant assemblages. J. Applied Ecology 53:159-170.
- Jost, L. 2006. Entropy and diversity. Oikos 113:363-375.
- Luque, JL, Poulin, R. 2007. Metazoan parasite species richness in Neotropical fishes: hotspots and the geography of biodiversity. Parasitology 134:865–878.