homework_7

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Homework 7

Statistical Inference

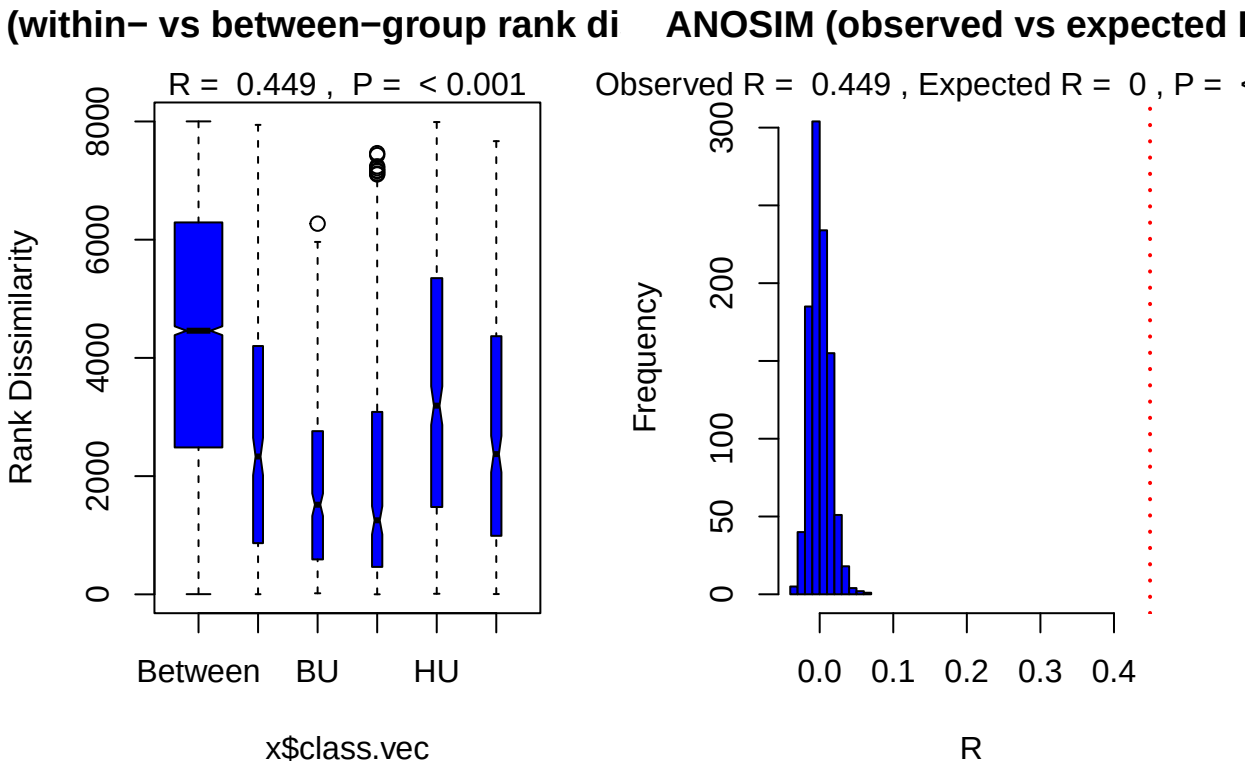
Question 1: Use the anosim function in R to run an ANOSIM on your response matrix, testing for among-group differences based on a categorical variable of your choice. If you do not have pre-determined categorical variables, you can generate them using a cluster analysis on an associated continuous predictor variable matrix. Provide a full statistical interpretation of your results.

```
trt_anosim <- anosim(env_std, dat$trt, permutations = 999, distance="euclidean")
            summary(trt_anosim)
```

```
##
## Call:
## anosim(x = env_std, grouping = dat$trt, permutations = 999, distance = "euclidean")
## Dissimilarity: euclidean
##
## ANOSIM statistic R: 0.449
##       Significance: 0.001
##
## Permutation: free
## Number of permutations: 999
##
## Upper quantiles of permutations (null model):
##    90%    95%  97.5%    99%
## 0.0175 0.0234 0.0299 0.0384
##
## Dissimilarity ranks between and within classes:
##         0%    25%    50%     75% 100%    N
## Between  3 2485.0 4460.0 6292.00 8001 6449
## BS       2  868.0 2332.0 4200.00 7942  276
## BU      18  591.0 1516.0 2761.00 6271  325
## HB       1  466.5 1252.5 3080.50 7464  300
## HU      10 1477.5 3192.0 5349.50 7990  351
## UU       5  992.0 2372.5 4365.25 7667  300
```

```
par(mfrow=c(1,2))
        plot(trt_anosim)
```

```
## Press return for next plot
```



This output shows that there is a significant difference in environmental variables between treatments (p=0.001), and that the effect size is moderate (R=0.449). The dissimilarity ranks tell us that BU sites are more similar to each other (median rank 1516), and HU sites have more variability among them (median rank 3192).

Question 2: Now use the adonis2 function to run a PERMANOVA on the same response matrix and using the same categorical variable. What does the statistical output say about among-group differences?

```
trt_perm <- adonis2(env_std ~ dat$trt, permutations = 999, method = "euclidean")
        trt_perm
```

```
## Permutation test for adonis under reduced model
## Permutation: free
## Number of permutations: 999
##
## adonis2(formula = env_std ~ dat$trt, permutations = 999, method = "euclidean")
##            Df SumOfSqs      R2      F Pr(>F)
## Model       4   585.09 0.29022 12.471  0.001 ***
## Residual  122  1430.91 0.70978
## Total     126  2016.00 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

This shows that treatment is responsible for 29% (R2=0.29022) of the variation in environmental conditions across sites, at a significance level of p=0.001. Treatment is a statistically significant predictor of variation.

Question 3: Compare ANOSIM and PERMANOVA in terms of their assumptions, sensitivity to data structure, and when each method might be more appropriate for ecological data analysis. Which method do you feel is most appropriate for your data based on its structure and the study question(s) of interest?

ANOSIM uses rank differences, and assumes acorss-group dissimilarity is larger than within-group. It can be sensitive to large within-group variation. It is often more explanatory since it uses rank and cant give precise variance quantities.

PERMANOVA is flexible but assumes homogeneity of variance among groups, and is also sensitive to difference in within-group variance. It can be used to test differences in means of groups rather than using ranks.

I think PERMANOVA is more useful for me because I can compare treatment group means and get treatment effect size.

Question 4: Run a SIMPER analysis on your dataset to identify the descriptors contributing the most to dissimilarity among two or more groups of your choice. What does this say about your ecological system?

```
trt_simper <- simper(env_std, dat$trt)
            summary(trt_simper)
```

```
##
## Contrast: BS_HB
##
##              average        sd     ratio       ava       avb cumsum     p
## fwd_cov      4.97000 123.47000   0.04025   0.32310  -1.12740  0.162 0.041 *
## decay_cl     4.23000 106.60000   0.03969  -0.55820   0.04270  0.300 0.049 *
## elev         3.60000  87.24000   0.04127  -0.03430   0.32270  0.417 0.038 *
## stumps       3.35900  83.10000   0.04042   0.35430   0.75450  0.527 0.042 *
## jul_date     2.74900  73.45000   0.03743  -0.10780  -0.35940  0.617 0.054 .
## char_cl      1.93800  48.51000   0.03996   0.56450   1.07730  0.680 0.049 *
## dwd_count    1.89600  51.61000   0.03674   0.54960   0.34260  0.742 0.055 .
## dwd_cov      1.55500  42.54000   0.03655   0.37930  -0.58280  0.792 0.056 .
## size_cl      1.45600  35.46000   0.04105  -0.09270   0.04820  0.840 0.067 .
## length_cl    1.21400  31.09000   0.03904  -0.32560  -0.78470  0.879 0.083 .
## hum          1.15600  24.62000   0.04694   0.10660   0.02760  0.917 0.065 .
## logs         1.06700  30.47000   0.03501   0.38590  -0.46950  0.952 0.051 .
## soil_moist   0.63700  18.00000   0.03541  -0.08850  -0.14980  0.973 0.113
## veg_cov      0.51300  14.86000   0.03451  -0.40060  -0.29020  0.989 0.128
## temp         0.32900  10.31000   0.03192   0.02020  -0.33210  1.000 0.149
## canopy_cov   0.00000   0.00000       NaN  -0.72840  -0.72840  1.000    NA
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Contrast: BS_UU
##
##             average       sd    ratio      ava      avb cumsum     p
```

```
## decay_cl    0.37190  6.07300  0.06123 -0.55820  0.80640  0.135 0.165
## canopy_cov  0.29760  6.04600  0.04922 -0.72840  1.61970  0.243 0.147
## char_cl     0.24230  4.37900  0.05534  0.56450 -1.18050  0.331 0.252
## dwd_cov     0.23790  2.85800  0.08324  0.37930  0.22980  0.417 0.229
## length_cl   0.22190  3.86500  0.05742 -0.32560  1.06110  0.497 0.233
## jul_date    0.22170  3.19400  0.06942 -0.10780 -0.15710  0.578 0.215
## elev        0.19380  3.40000  0.05701 -0.03430 -0.51300  0.648 0.308
## fwd_cov     0.17980  2.20100  0.08170  0.32310  0.38000  0.713 0.225
## veg_cov     0.16670  5.02400  0.03318 -0.40060  0.21880  0.774 0.298
## stumps      0.16330  3.26900  0.04996  0.35430 -0.88210  0.833 0.281
## soil_moist  0.14800  3.12800  0.04732 -0.08850  0.26670  0.886 0.285
## size_cl     0.12390  2.99100  0.04142 -0.09270  0.08040  0.931 0.436
## temp        0.09940  2.72300  0.03652  0.02020  0.07590  0.968 0.347
## hum         0.09870  2.47200  0.03991  0.10660  0.12990  1.003 0.337
## dwd_count   0.04950  3.75100  0.01319  0.54960 -0.56540  1.021 0.383
## logs       -0.05840  3.21800 -0.01815  0.38590  0.29170  1.000 0.546
##
## Contrast: BS_HU
##
##             average       sd    ratio      ava      avb cumsum     p
## dwd_cov     0.05757  4.31400  0.01334  0.37930  0.12520 -0.033 0.426
## canopy_cov  0.00065  0.00600  0.11665 -0.72840 -0.72540 -0.034 0.437
## fwd_cov    -0.05430  2.77300 -0.01958  0.32310  0.65440 -0.002 0.505
## soil_moist -0.06796  2.99900 -0.02266 -0.08850  0.04710  0.037 0.532
## elev       -0.08343  3.81400 -0.02187 -0.03430  0.54530  0.085 0.689
## veg_cov    -0.09866  3.06200 -0.03222 -0.40060 -0.25360  0.142 0.648
## hum        -0.11831  2.66500 -0.04439  0.10660 -0.00660  0.210 0.655
## jul_date   -0.12462  3.45100 -0.03611 -0.10780  0.25610  0.282 0.635
## stumps     -0.13219  3.38100 -0.03910  0.35430  0.61510  0.358 0.627
## decay_cl   -0.13667  2.64400 -0.05170 -0.55820 -0.75650  0.437 0.645
## dwd_count  -0.14316  3.23300 -0.04429  0.54960  0.45650  0.520 0.600
## temp       -0.14403  2.58000 -0.05583  0.02020  0.02300  0.603 0.714
## size_cl    -0.14679  2.99900 -0.04895 -0.09270 -0.05920  0.688 0.744
## length_cl  -0.15668  2.49100 -0.06291 -0.32560 -0.59120  0.778 0.644
## logs       -0.15886  3.42300 -0.04641  0.38590 -0.10640  0.870 0.631
## char_cl    -0.22616  3.93900 -0.05742  0.56450 -1.09430  1.000 0.797
##
## Contrast: BS_BU
##
##              average        sd     ratio       ava       avb cumsum     p
## stumps      0.115550  7.801000  0.014811  0.354300 -0.843100  0.141 0.330
## length_cl   0.113430  4.632000  0.024490 -0.325600  0.648600  0.280 0.299
## dwd_cov     0.108130  8.008000  0.013502  0.379300 -0.140800  0.412 0.359
## size_cl     0.089900  7.403000  0.012145 -0.092700  0.023400  0.522 0.464
## hum         0.081670  4.537000  0.018002  0.106600 -0.242900  0.622 0.363
## elev        0.070380  5.300000  0.013279 -0.034300 -0.351600  0.708 0.463
## decay_cl    0.062760  6.045000  0.010382 -0.558200  0.484400  0.784 0.396
## canopy_cov  0.048520  6.379000  0.007606 -0.728400  0.568700  0.844 0.367
## char_cl     0.040120  1.653000  0.024263  0.564500  0.714600  0.893 0.449
## jul_date    0.029420  8.148000  0.003611 -0.107800  0.330200  0.928 0.430
## veg_cov     0.021580  6.662000  0.003239 -0.400600  0.701800  0.955 0.492
## logs        0.020450  5.993000  0.003413  0.385900 -0.074700  0.980 0.424
## temp        0.015060  5.277000  0.002853  0.020200  0.203800  0.998 0.489
## dwd_count   0.014040  9.740000  0.001441  0.549600 -0.767100  1.015 0.435
```

```
## soil_moist -0.004910  3.938000 -0.001247 -0.088500 -0.079600  1.009 0.466
## fwd_cov    -0.007710  6.786000 -0.001136  0.323100 -0.259100  1.000 0.454
##
## Contrast: HB_UU
##
##             average       sd    ratio      ava      avb cumsum     p
## length_cl   1.63330 48.85000  0.03344 -0.78470  1.06110  0.169 0.054 .
## size_cl     1.23990 34.76000  0.03567  0.04820  0.08040  0.298 0.099 .
## stumps      1.23890 36.29000  0.03413  0.75450 -0.88210  0.426 0.117
## soil_moist  1.15200 35.15000  0.03278 -0.14980  0.26670  0.546 0.052 .
## char_cl     0.87360 28.85000  0.03028  1.07730 -1.18050  0.636 0.130
## dwd_count   0.78030 22.47000  0.03472  0.34260 -0.56540  0.717 0.155
## canopy_cov  0.76540 27.86000  0.02747 -0.72840  1.61970  0.797 0.055 .
## jul_date    0.46540 13.17000  0.03534 -0.35940 -0.15710  0.845 0.120
## logs        0.36380 13.80000  0.02636 -0.46950  0.29170  0.883 0.158
## decay_cl    0.35600 10.78000  0.03302  0.04270  0.80640  0.920 0.191
## dwd_cov     0.20570 11.29000  0.01823 -0.58280  0.22980  0.941 0.255
## hum         0.17720  7.26000  0.02440  0.02760  0.12990  0.959 0.253
## elev        0.16530  9.94000  0.01663  0.32270 -0.51300  0.976 0.370
## fwd_cov     0.16490 11.57000  0.01425 -1.12740  0.38000  0.994 0.243
## temp        0.05180  5.31000  0.00975 -0.33210  0.07590  0.999 0.416
## veg_cov     0.01060  4.84000  0.00218 -0.29020  0.21880  1.000 0.509
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Contrast: HB_HU
##
##             average       sd    ratio      ava      avb cumsum     p
## soil_moist  0.16237  6.60100  0.02460 -0.14980  0.04710  0.293 0.277
## elev        0.16199  6.87200  0.02357  0.32270  0.54530  0.585 0.373
## hum         0.13355  6.28600  0.02124  0.02760 -0.00660  0.826 0.307
## size_cl     0.11648  5.08500  0.02291  0.04820 -0.05920  1.036 0.441
## char_cl     0.09518 10.87100  0.00876  1.07730 -1.09430  1.208 0.390
## logs        0.08893  5.88600  0.01511 -0.46950 -0.10640  1.368 0.372
## dwd_cov     0.08499  4.94100  0.01720 -0.58280  0.12520  1.522 0.418
## dwd_count   0.02918  6.42700  0.00454  0.34260  0.45650  1.574 0.405
## temp        0.02520  4.47600  0.00563 -0.33210  0.02300  1.620 0.481
## veg_cov     0.00949  5.03100  0.00189 -0.29020 -0.25360  1.637 0.523
## canopy_cov  0.00062  0.00800  0.07962 -0.72840 -0.72540  1.638 0.496
## decay_cl   -0.01751  7.91100 -0.00221  0.04270 -0.75650  1.606 0.511
## fwd_cov    -0.04636  6.35300 -0.00730 -1.12740  0.65440  1.523 0.532
## stumps     -0.08568  5.08200 -0.01686  0.75450  0.61510  1.368 0.593
## length_cl  -0.10153  1.93700 -0.05241 -0.78470 -0.59120  1.185 0.621
## jul_date   -0.10252  4.56800 -0.02244 -0.35940  0.25610  1.000 0.635
##
## Contrast: HB_BU
##
##             average       sd    ratio      ava      avb cumsum     p
## hum         0.95560 30.91600  0.03091  0.02760 -0.24290  0.232 0.090 .
## temp        0.80160 23.10100  0.03470 -0.33210  0.20380  0.427 0.057 .
## veg_cov     0.77370 26.62500  0.02906 -0.29020  0.70180  0.616 0.086 .
## char_cl     0.59370 17.02800  0.03486  1.07730  0.71460  0.760 0.184
## decay_cl    0.49090 21.12600  0.02324  0.04270  0.48440  0.879 0.147
## stumps      0.40350 26.32100  0.01533  0.75450 -0.84310  0.978 0.197
```

```
## dwd_count   0.35690 26.74800  0.01334  0.34260 -0.76710  1.064 0.196
## elev        0.26210 14.12900  0.01855  0.32270 -0.35160  1.128 0.271
## length_cl   0.18150 18.81300  0.00965 -0.78470  0.64860  1.172 0.246
## canopy_cov  0.08040 13.30500  0.00604 -0.72840  0.56870  1.192 0.335
## soil_moist  0.03910 15.51600  0.00252 -0.14980 -0.07960  1.201 0.419
## jul_date   -0.04530  7.79100 -0.00582 -0.35940  0.33020  1.190 0.545
## size_cl    -0.06790 14.58100 -0.00465  0.04820  0.02340  1.174 0.691
## logs       -0.17510  8.18600 -0.02139 -0.46950 -0.07470  1.131 0.663
## dwd_cov    -0.22530  6.59200 -0.03418 -0.58280 -0.14080  1.076 0.766
## fwd_cov    -0.31360  4.59500 -0.06826 -1.12740 -0.25910  1.000 0.778
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Contrast: UU_HU
##
##              average        sd     ratio       ava       avb cumsum     p
## elev        -0.19300   8.44000  -0.02293  -0.51300   0.54530  0.002 0.821
## temp        -1.59100  40.95000  -0.03885   0.07590   0.02300  0.022 0.974
## veg_cov     -1.67000  43.66000  -0.03825   0.21880  -0.25360  0.043 0.973
## jul_date    -1.71400  46.93000  -0.03651  -0.15710   0.25610  0.064 0.950
## char_cl     -2.06300  52.91000  -0.03899  -1.18050  -1.09430  0.089 0.967
## hum         -2.59500  66.44000  -0.03905   0.12990  -0.00660  0.121 0.975
## fwd_cov     -2.91200  70.64000  -0.04122   0.38000   0.65440  0.157 0.987
## logs        -3.74800  98.92000  -0.03789   0.29170  -0.10640  0.204 0.959
## size_cl     -4.32900 115.02000  -0.03764   0.08040  -0.05920  0.257 0.962
## dwd_cov     -6.55000 172.68000  -0.03793   0.22980   0.12520  0.338 0.955
## soil_moist  -6.96300 181.11000  -0.03845   0.26670   0.04710  0.424 0.964
## stumps      -7.46700 198.05000  -0.03770  -0.88210   0.61510  0.516 0.947
## decay_cl    -8.19000 209.89000  -0.03902   0.80640  -0.75650  0.617 0.978
## dwd_count   -8.91500 232.28000  -0.03838  -0.56540   0.45650  0.727 0.959
## canopy_cov -10.43600 270.20000  -0.03862   1.61970  -0.72540  0.856 0.966
## length_cl  -11.63600 305.30000  -0.03811   1.06110  -0.59120  1.000 0.950
##
## Contrast: UU_BU
##
##             average       sd    ratio      ava      avb cumsum     p
## size_cl     0.17912  2.31000  0.07754  0.08040  0.02340  0.314 0.395
## soil_moist  0.12825  3.00800  0.04263  0.26670 -0.07960  0.540 0.292
## dwd_cov     0.08827  2.72400  0.03241  0.22980 -0.14080  0.695 0.390
## canopy_cov  0.07452  2.88000  0.02587  1.61970  0.56870  0.825 0.327
## char_cl     0.07074  3.93700  0.01797 -1.18050  0.71460  0.950 0.405
## dwd_count   0.04183  2.15000  0.01945 -0.56540 -0.76710  1.023 0.391
## temp        0.04107  2.33800  0.01757  0.07590  0.20380  1.095 0.447
## jul_date    0.03978  2.39300  0.01663 -0.15710  0.33020  1.165 0.410
## veg_cov     0.02312  1.81200  0.01276  0.21880  0.70180  1.205 0.511
## hum         0.01500  3.20400  0.00468  0.12990 -0.24290  1.232 0.462
## stumps      0.01471  1.24600  0.01180 -0.88210 -0.84310  1.258 0.448
## decay_cl   -0.00841  1.92200 -0.00438  0.80640  0.48440  1.243 0.484
## fwd_cov    -0.02155  2.32000 -0.00929  0.38000 -0.25910  1.205 0.467
## logs       -0.02932  2.88800 -0.01015  0.29170 -0.07470  1.154 0.483
## elev       -0.03625  2.51800 -0.01440 -0.51300 -0.35160  1.090 0.615
## length_cl  -0.05120  2.13400 -0.02400  1.06110  0.64860  1.000 0.508
##
## Contrast: HU_BU
```

```
##
##              average       sd    ratio      ava      avb cumsum     p
## dwd_cov      0.42600  7.56700  0.05629  0.12520 -0.14080  1.392 0.137
## elev         0.31250  5.51100  0.05671  0.54530 -0.35160  2.414 0.242
## size_cl      0.28170  9.51400  0.02961 -0.05920  0.02340  3.334 0.344
## veg_cov      0.27220  7.29700  0.03730 -0.25360  0.70180  4.224 0.231
## fwd_cov      0.18570  5.51700  0.03367  0.65440 -0.25910  4.831 0.227
## dwd_count    0.12950  5.99900  0.02159  0.45650 -0.76710  5.254 0.325
## soil_moist   0.09200 10.89300  0.00845  0.04710 -0.07960  5.555 0.371
## logs         0.04960  9.19300  0.00539 -0.10640 -0.07470  5.717 0.434
## jul_date    -0.04160  5.09900 -0.00816  0.25610  0.33020  5.581 0.568
## char_cl     -0.08480 11.80000 -0.00718 -1.09430  0.71460  5.304 0.677
## length_cl   -0.09130  7.25900 -0.01258 -0.59120  0.64860  5.006 0.615
## canopy_cov -0.10760  8.67500 -0.01240 -0.72540  0.56870  4.654 0.642
## decay_cl    -0.16550 10.21900 -0.01619 -0.75650  0.48440  4.113 0.705
## stumps      -0.22110  9.47100 -0.02335  0.61510 -0.84310  3.390 0.761
## hum         -0.36500 12.74900 -0.02863 -0.00660 -0.24290  2.198 0.834
## temp        -0.36640 13.17200 -0.02781  0.02300  0.20380  1.000 0.865
## Permutation: free
## Number of permutations: 999
```

A couple of interesting things that came out of this:

Harvest/Burn and Harvest/Unburned have minimal differences. This could be due to the fact that once trees are removed from the site, there isnt as much opportunity for the burn to leave a visible impact.

Harvest/Burn and Burn/Unharvested are significantly different, with humidity, temperature, and veg cover as contributors, suggesting that unharvested sites can buffer microclimate in a way that harvested sites cant.

Harvest/Burn and Control sites are statistically different with wood length and size contributing, which is good to see, knowing that they are very different on the ground.

Harvest/Burn and Burn/Salvage are slightly significantly different with decay class, fine woody debris, and elevation contributing. This is what I hypothesized, yay!

Question 5: Discuss the rationale behind using permutation tests in multivariate data analysis. Why are these tests particularly useful in ecological studies, and what limitations should be considered when interpreting results?

Permutation tests are helpful in ecology because they dont make a lot of assumptions about normality, variance, or linearity, which is particularly necessary for often messy ecological data. Permutations also handle complex interactions and lots of zeros pretty well. Limitations include needing a large sample size to be powerful and being computationally intensive.