KAS 2021

Morphological Plasticity in Wood Frogs and Green Frogs as Indicators of Eutrophication Levels

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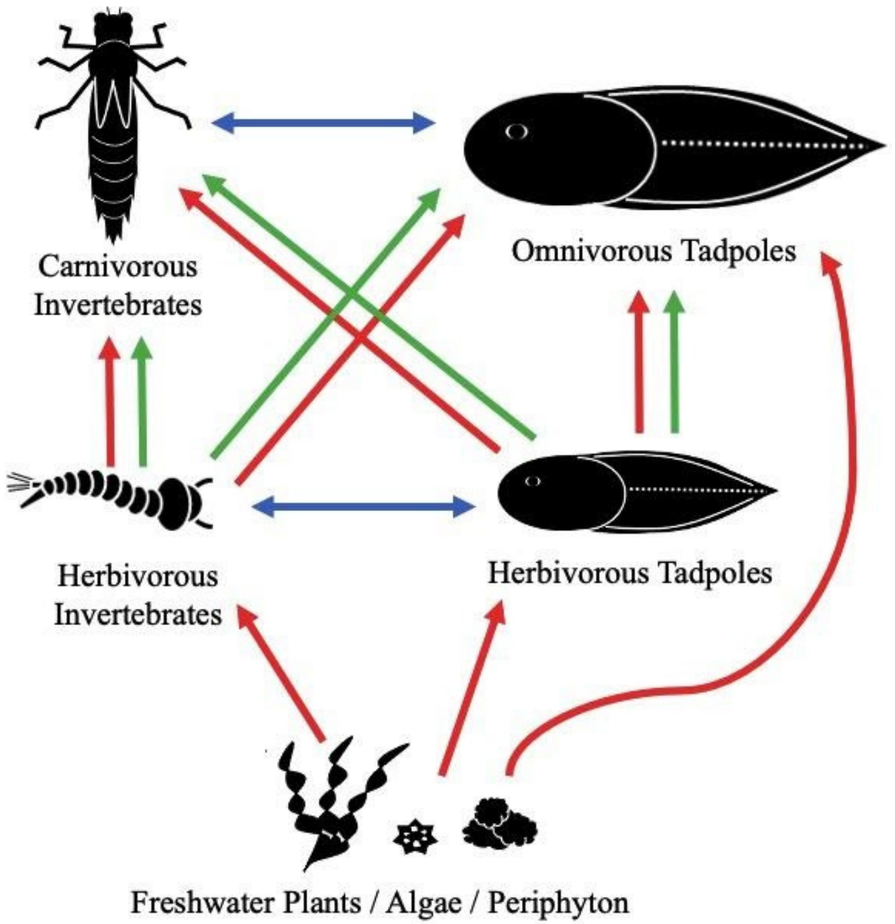
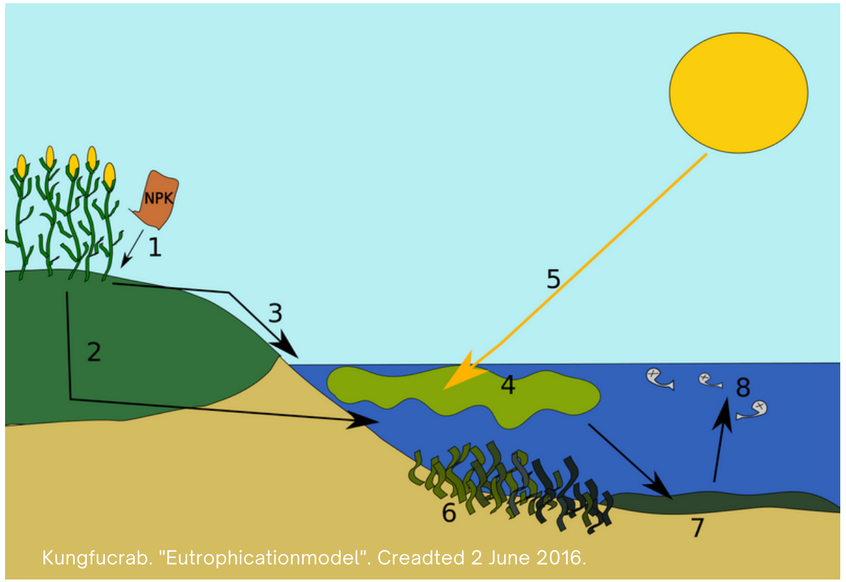


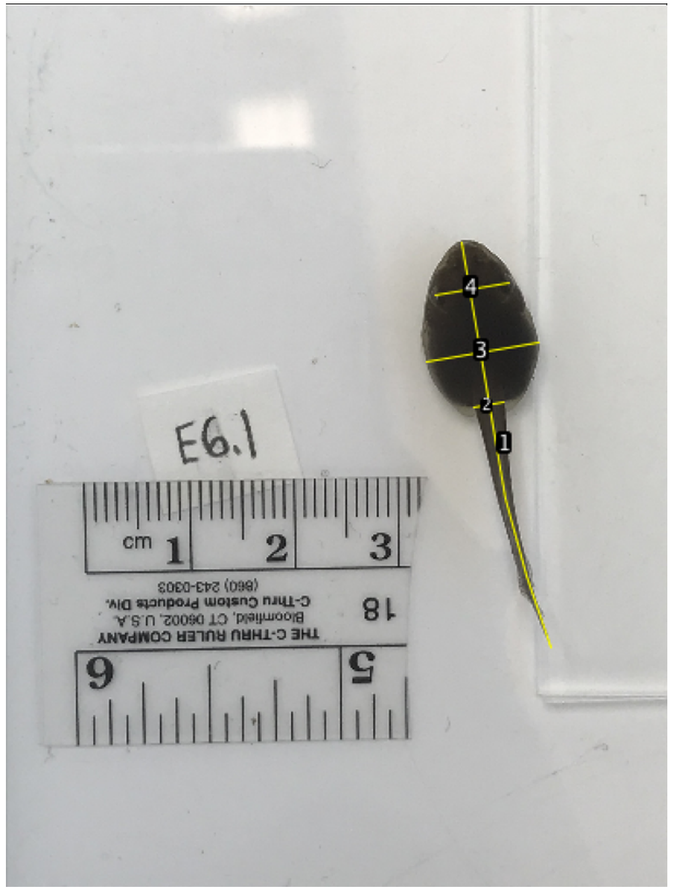
Brady Parlato. Thesis Proposal. Figure 1.

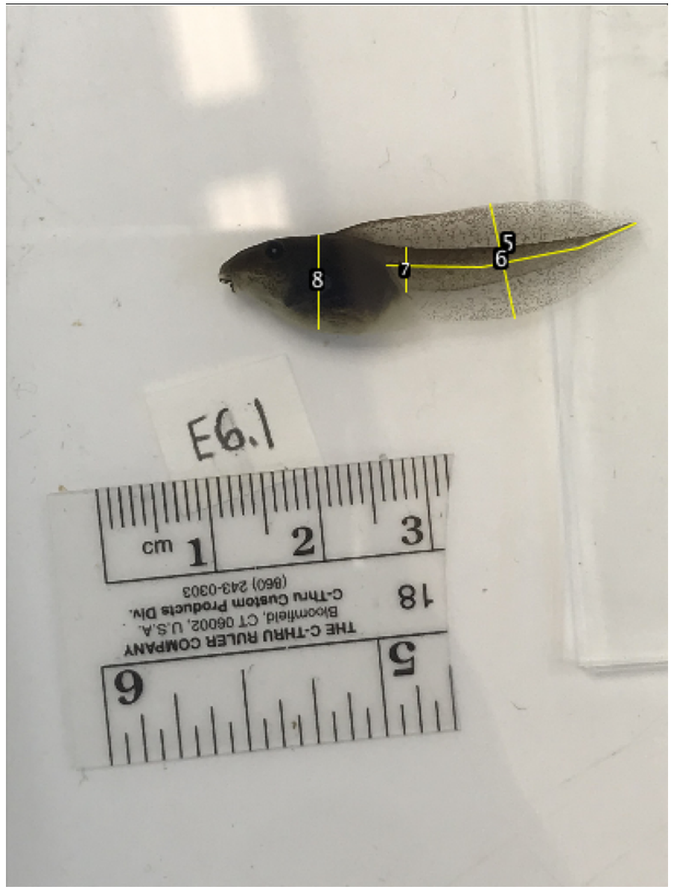


Non-Lethal effects:
Behavioral, Physiological, Morphological

Eutrophication

Initiated by excess nutrients
Stage 1: Bottom-up control
Stage 2: Alterations in trophic interactions
Results in trophic cascades





Morphological Plasticity

Characteristics:

Tail Length
Tail Muscle Height
Tail Width
Head Height
Total Length
Tail Width
Head Width
Interocular Distance
Tail Depth
- (Length/Height)

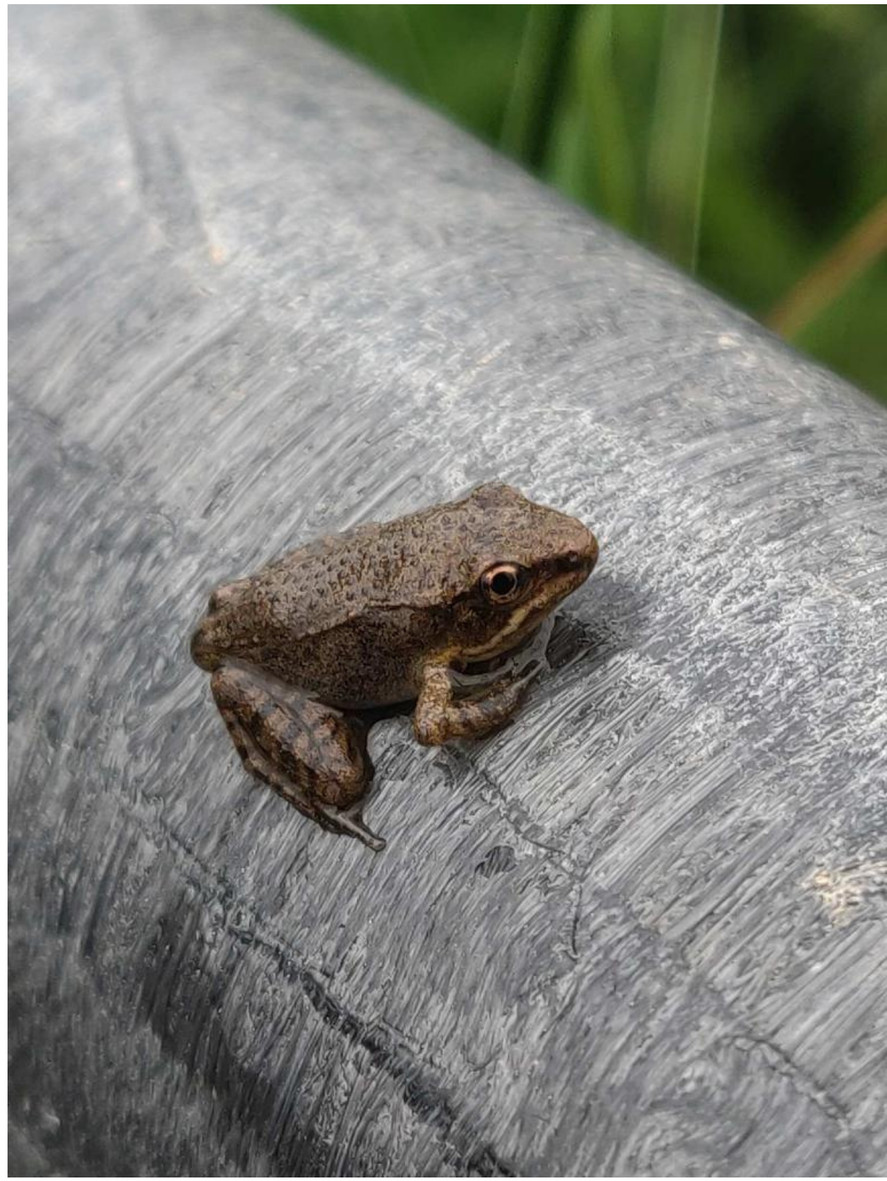
Objectives

01

Understand and replicate indicators of varying predator-prey relationships in Wood Frogs and Green Frogs

02

Relate the prevalence of these indicators to eutrophication levels

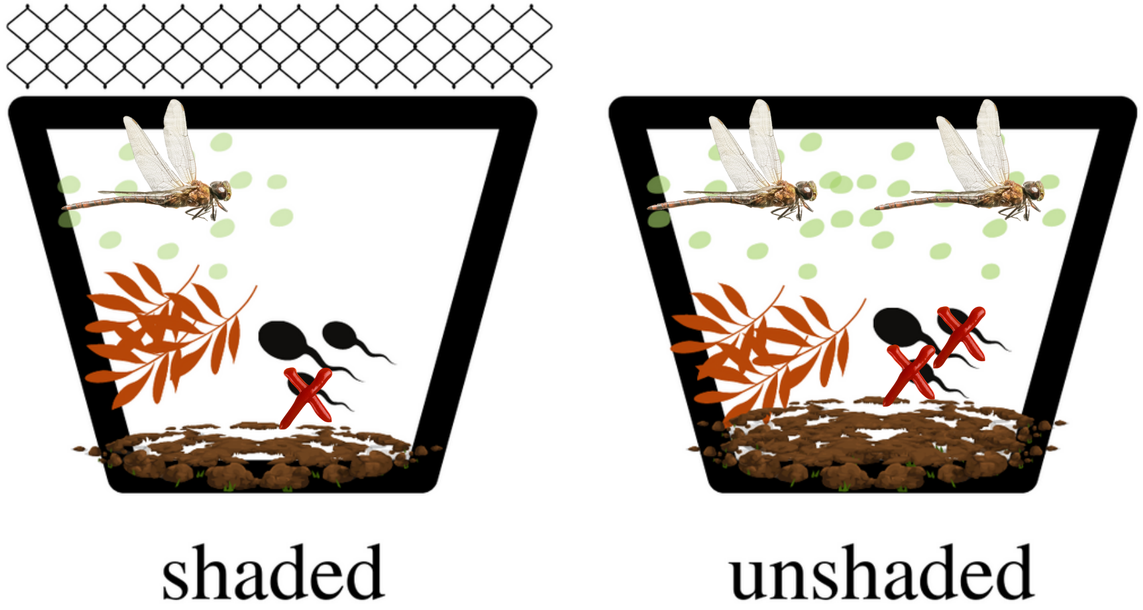


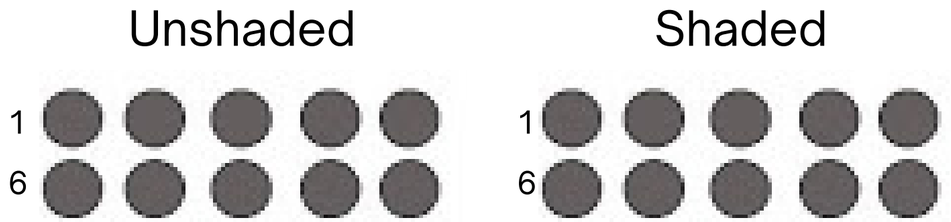
Sandra Elliot. Taylor Fork Ecological Area. Taken May 29.

Study Site

Taylor Fork Ecological Area

Exposure Treatment





Brady Parlato. Thesis Proposal. Figure 3, modified.

Environmental Data:
Relative Primary Productivity, Dissolved Oxygen, Temperature, Algal Growth

Exposure Treatment

Morphological Characteric ANOVAs

```
 Response gosnerStage :
           Df Sum Sq Mean Sq F value    Pr(>F)
treatment   1 530.81  530.81  293.17 < 2.2e-16 ***
Residuals  89 161.15    1.81
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

```
 Response tailLength :
           Df  Sum Sq Mean Sq F value    Pr(>F)
treatment   1  938.09  938.09  60.167 1.367e-11 ***
Residuals  89 1387.64   15.59
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

```
 Response tailFinHeight :
           Df  Sum Sq Mean Sq F value   Pr(>F)
treatment   1  19.485 19.4847  11.157 0.001225 **
Residuals  89 155.430  1.7464
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

```
 Response tailMuscleHeight :
           Df Sum Sq Mean Sq F value    Pr(>F)
treatment   1 34.490  34.490  54.071 9.029e-11 ***
Residuals  89 56.771   0.638
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

```
 Response headHeight :
           Df Sum Sq Mean Sq F value Pr(>F)
treatment   1   6355  6355.5   0.737 0.3929
Residuals  89 767502  8623.6
```

```
 Response totalLength :
           Df Sum Sq Mean Sq F value    Pr(>F)
treatment   1 1134.8 1134.83  45.806 1.341e-09 ***
Residuals  89 2205.0   24.77
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

```
 Response tailMuscleWidth :
           Df Sum Sq Mean Sq F value    Pr(>F)
treatment   1 25.594 25.5936  116.18 < 2.2e-16 ***
Residuals  89 19.606  0.2203
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

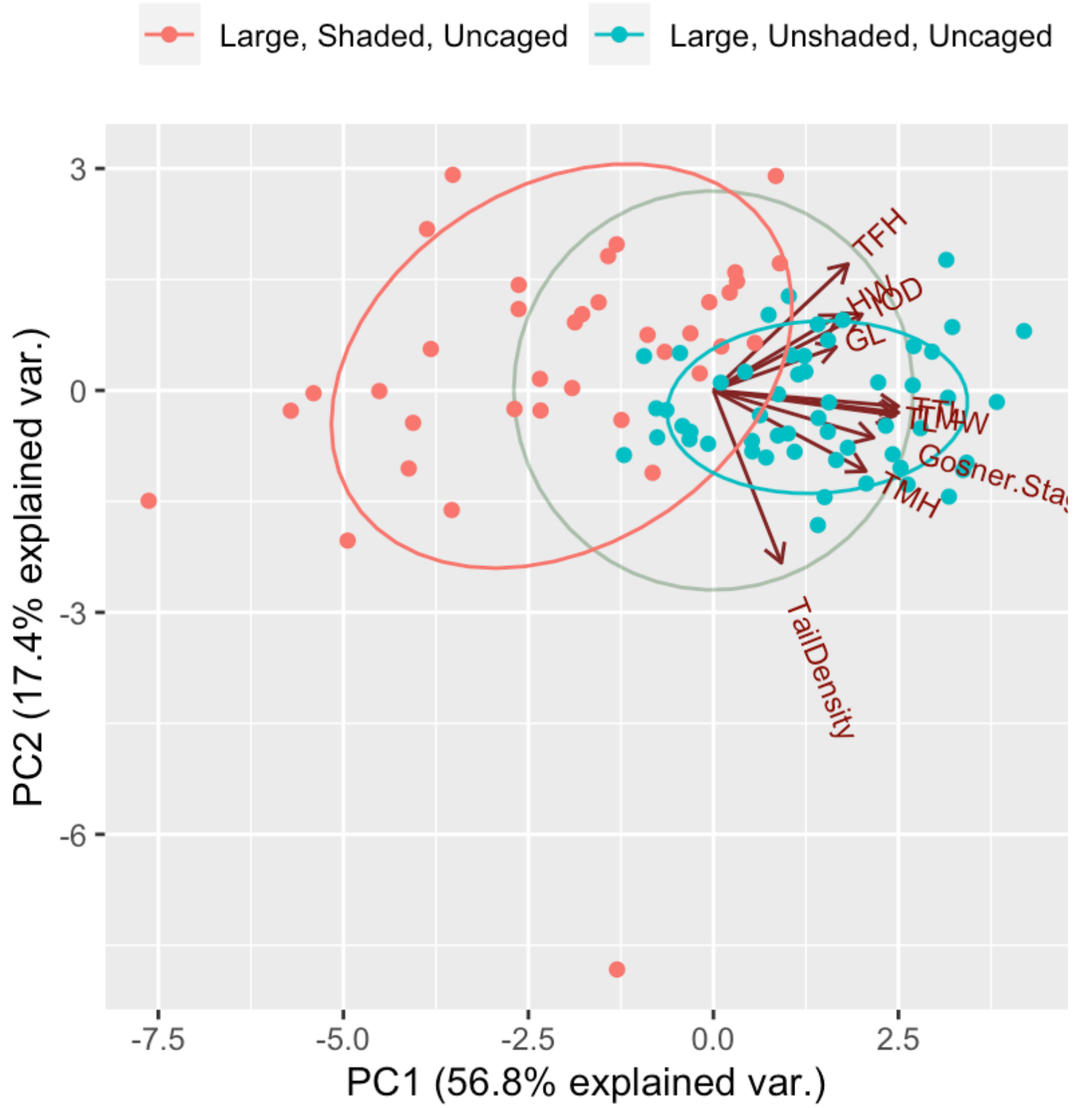
```
 Response headWidth :
           Df  Sum Sq Mean Sq F value   Pr(>F)
treatment   1  18.835 18.8348  10.716 0.001514 **
Residuals  89 156.434  1.7577
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Exposure Treatment

Abiotic Characteric ANOVAs

```
 Response primaryProductivity :
            Df Sum Sq Mean Sq F value Pr(>F)
tankID       1  16.93  16.928  0.5539 0.4663
Residuals   18 550.13  30.563

 Response dissolvedOxygen :
            Df  Sum Sq Mean Sq F value   Pr(>F)
tankID       1  708.05  708.05  10.415 0.004675 **
Residuals   18 1223.76   67.99
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

 Response temperature :
            Df Sum Sq Mean Sq F value    Pr(>F)
tankID       1 23.113 23.1125  86.223 2.759e-08 ***
Residuals   18  4.825  0.2681
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

 Response algalMass :
            Df Sum Sq Mean Sq F value Pr(>F)
tankID       1    4.5   4.512  0.0248 0.8767
Residuals   18 3281.5 182.303
```

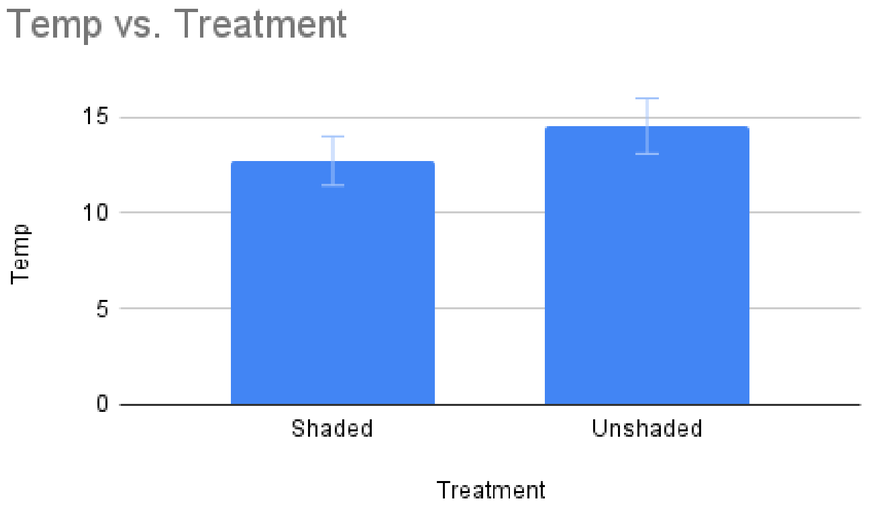
Exposure Treatment

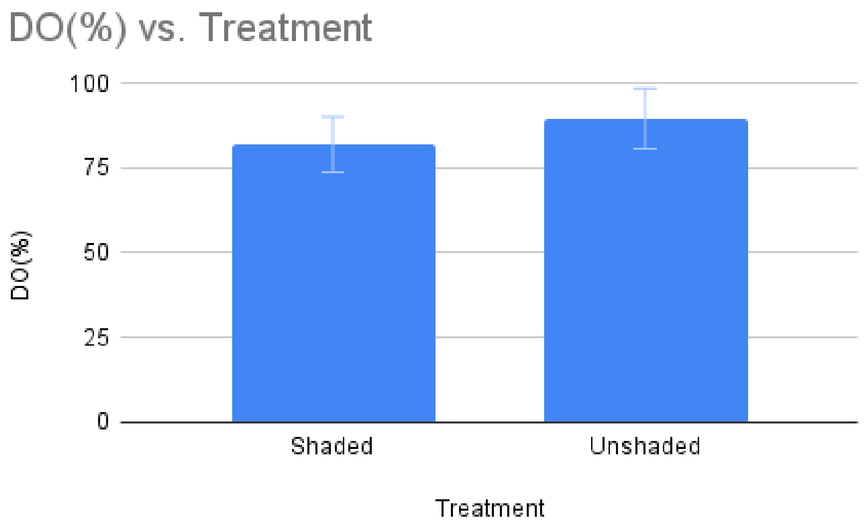


Exposure Treatment

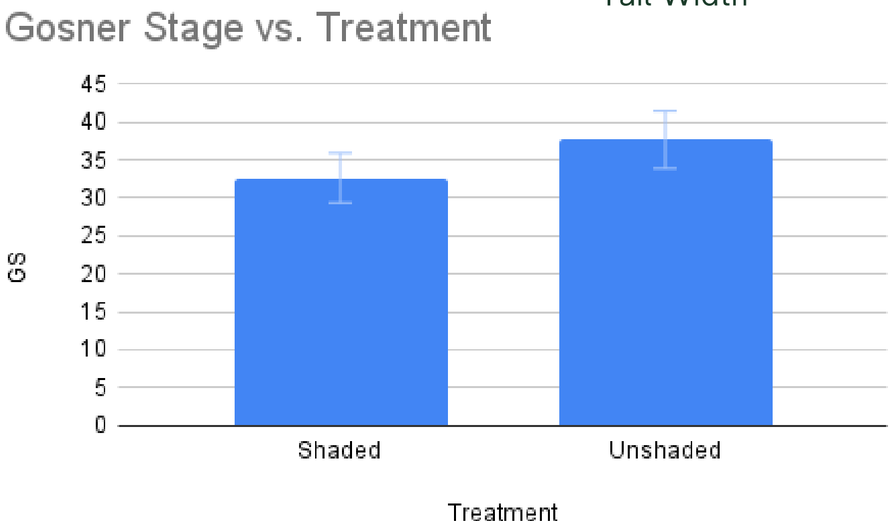
Characteristics:
Tail Length
Tail Muscle Height
Tail Width
Head Height
Total Length
Tail Width
Head Width
Interocular Distance
Tail Depth
- (Length/Height)

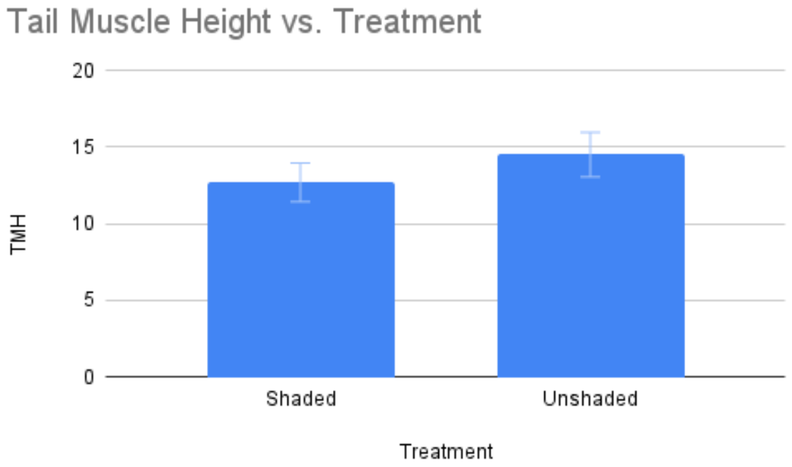
Abiotic Characteristics





Morphological Characteristics



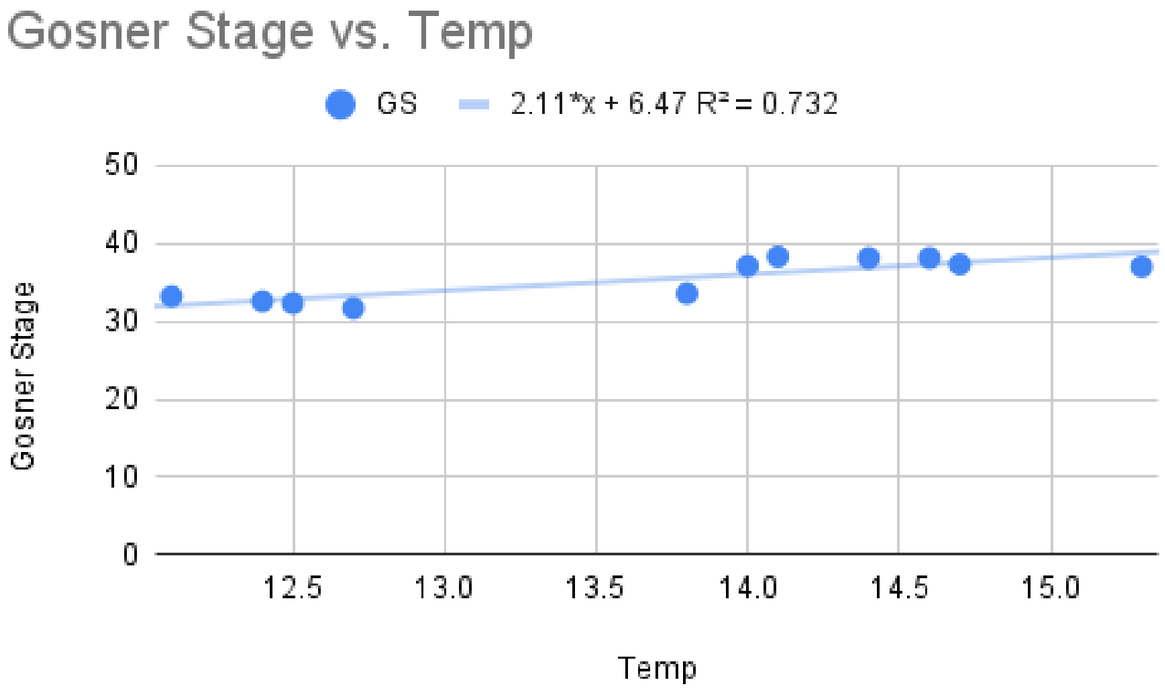


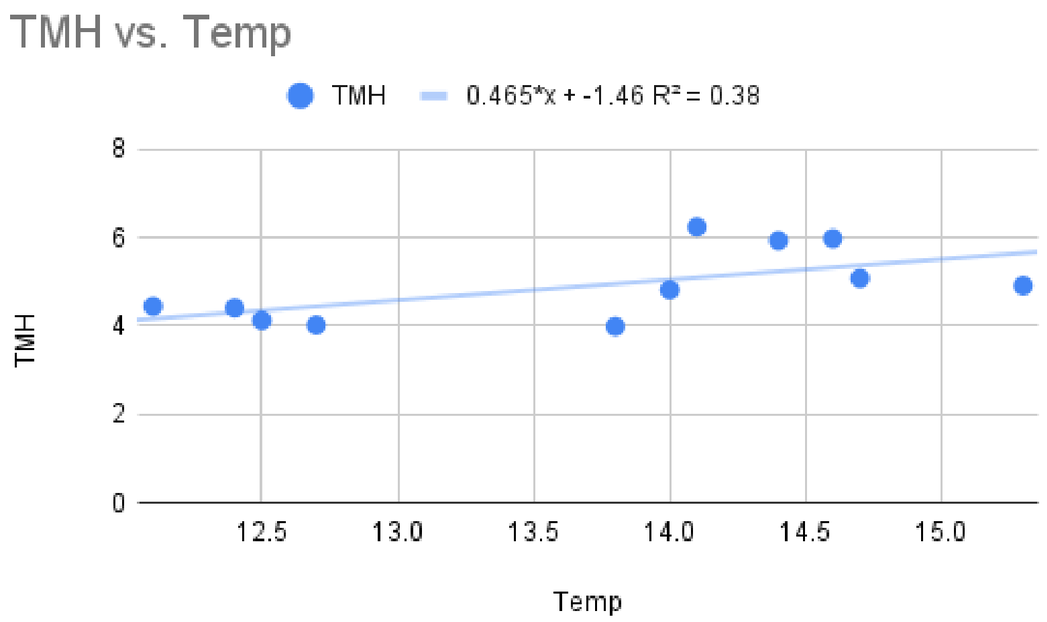
Similar to other morphological characteristics

Exposure Treatment

Characteristics:
Tail Length
Tail Muscle Height
Tail Width
Head Height
Total Length
Tail Width
Head Width
Interocular Distance
Tail Depth
- (Length/Height)

Relationshps between morphological and abiotic characteristics

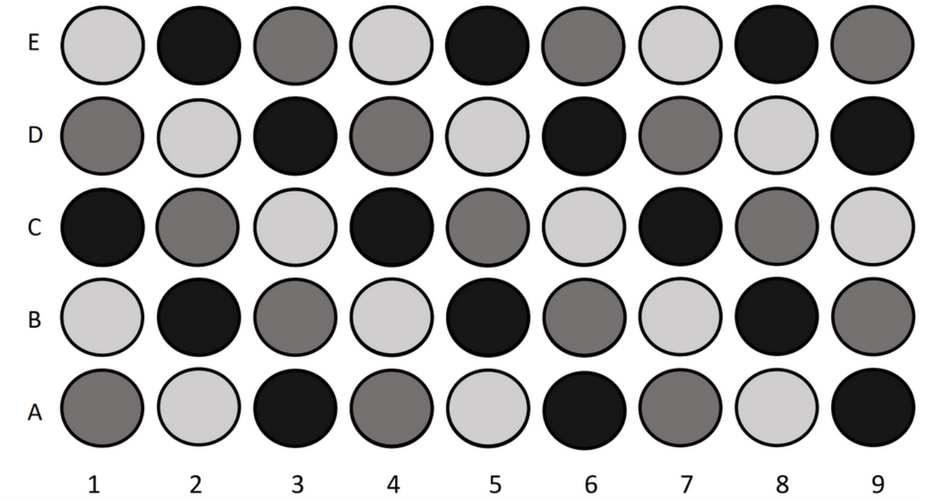




Dissolved oxygen did not statistically significantly influence development or morphological characteristics

Environmental Data:
Nitrogen Concentration, Relative Primary Productivity, Temperature, Dissolved Oxygen

Fertilizer Treatment



Sandra Elliott. Thesis Proposal. Figure 3.

Fertilizer Treatment

Morphological Characteric ANOVAs

```
 Response tailLength :
            Df Sum Sq Mean Sq F value    Pr(>F)
treatment    2 1126.0  563.01  28.806 2.513e-10 ***
Residuals   87 1700.4   19.54
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

```
 Response tailFinHeight :
            Df  Sum Sq Mean Sq F value   Pr(>F)
treatment    2  84.647  42.324  29.299 1.87e-10 ***
Residuals   87 125.673   1.445
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

```
 Response tailMuscleHeight :
            Df Sum Sq Mean Sq F value    Pr(>F)
treatment    2 25.340 12.6702  30.969 6.972e-11 ***
Residuals   87 35.594  0.4091
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

```
 Response headHeight :
            Df  Sum Sq Mean Sq F value    Pr(>F)
treatment    2  67.638  33.819  26.055 1.358e-09 ***
Residuals   87 112.922   1.298
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

```
 Response totalLength :
            Df Sum Sq Mean Sq F value   Pr(>F)
treatment    2 5080.4 2540.21  39.707 5.59e-13 ***
Residuals   87 5565.8   63.97
---
```

```
 Response tailMuscleWidth :
            Df Sum Sq Mean Sq F value    Pr(>F)
treatment    2 48.603 24.3014  43.495 8.061e-14 ***
Residuals   87 48.609  0.5587
---
```

```
 Response headWidth :
            Df Sum Sq Mean Sq F value    Pr(>F)
treatment    2 154.73  77.366   30.37 9.906e-11 ***
Residuals   87 221.63   2.547
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’
```

```
 Response tailDensity :
            Df  Sum Sq Mean Sq F value   Pr(>F)
treatment    2  1.7001 0.85003  7.2964 0.001176 **
Residuals   87 10.1355 0.11650
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’
```

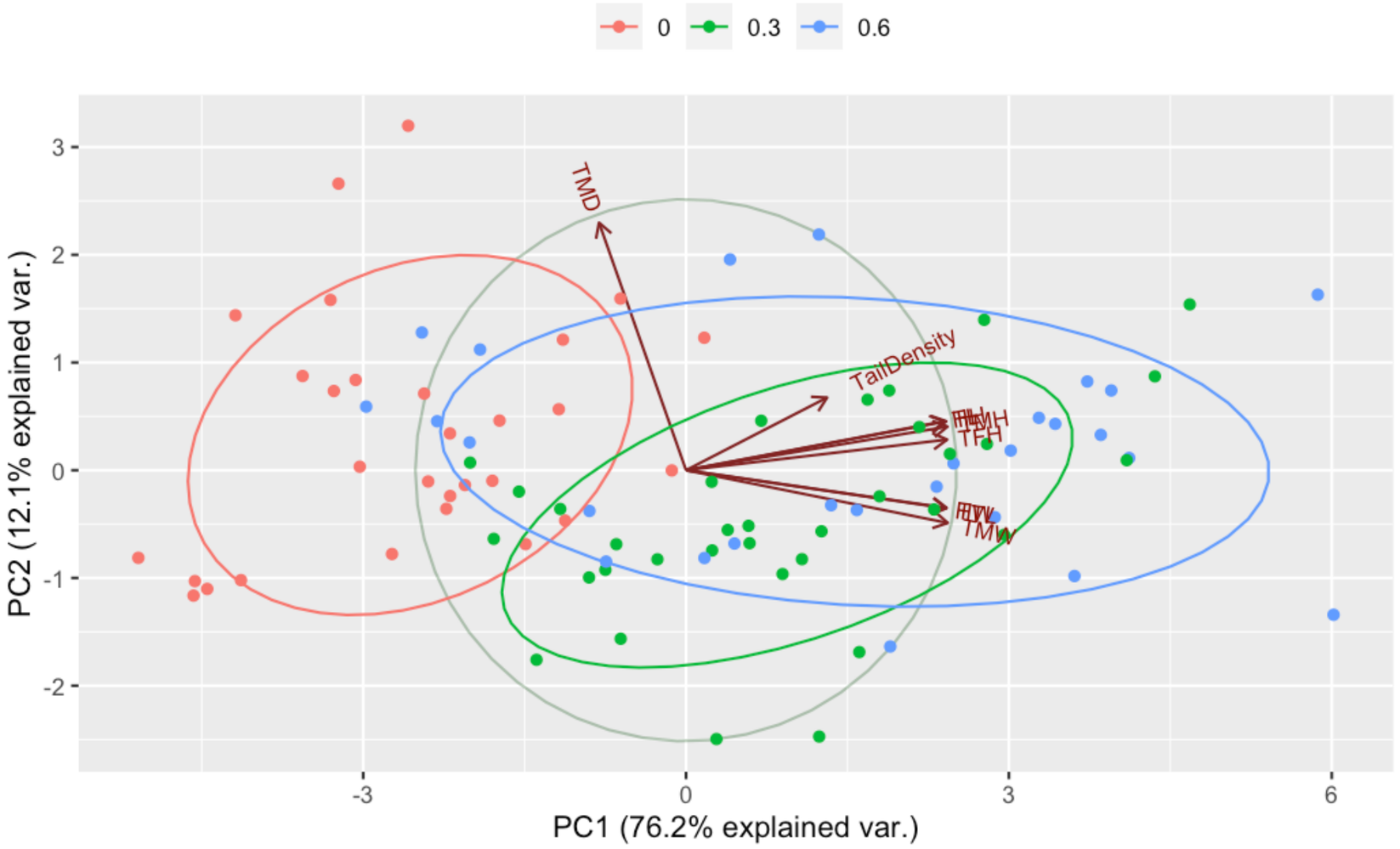
Fertilizer Treatment

Abiotic Characteric ANOVAs

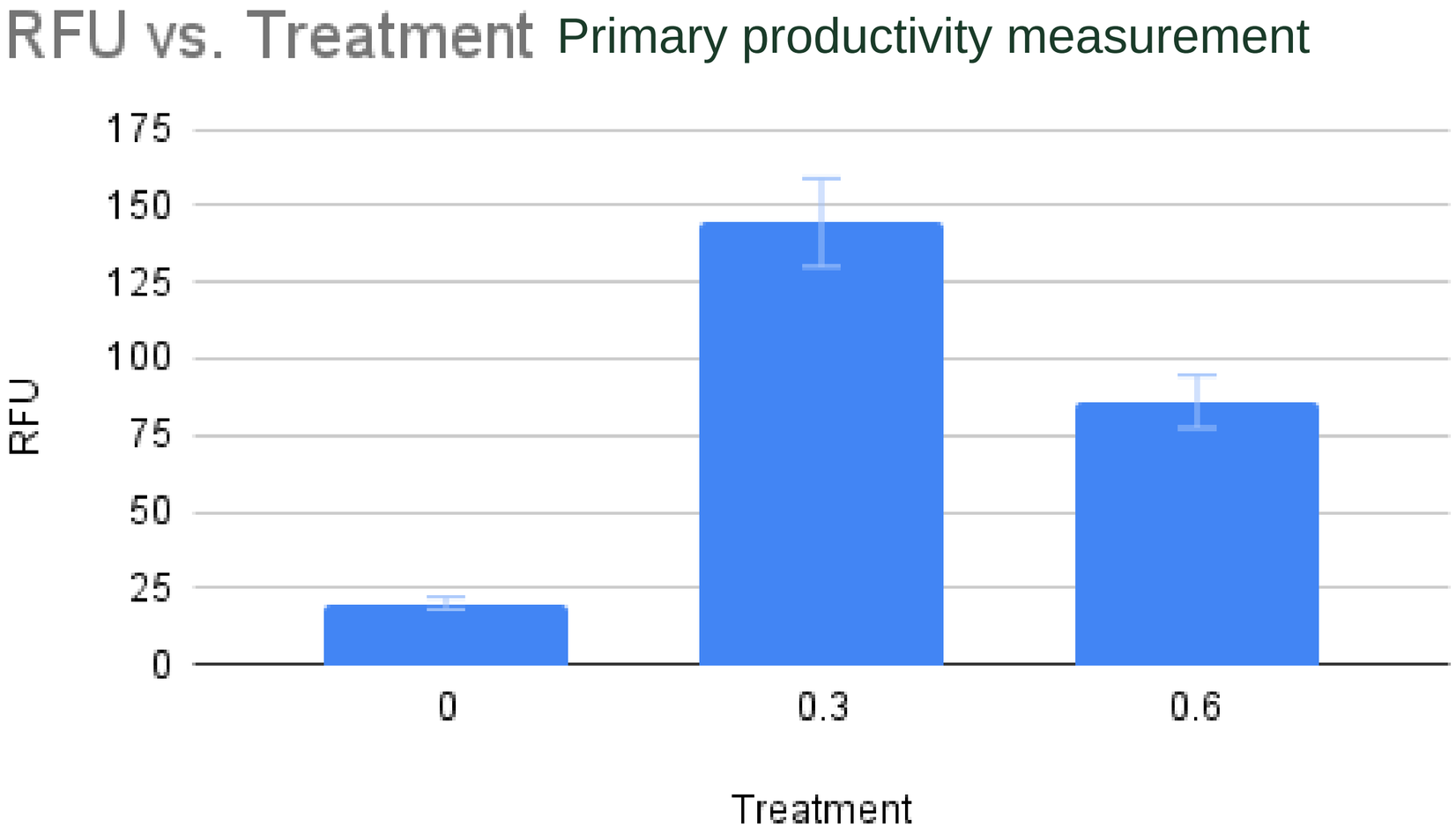
```
 Response temperature :
            Df  Sum Sq  Mean Sq F value Pr(>F)
treatment    2 0.04213 0.021065  0.9763 0.3981
Residuals   16 0.34524 0.021577

 Response dissolvedOxygen :
            Df Sum Sq Mean Sq F value Pr(>F)
treatment    2 1542.3  771.16   1.584 0.2357
Residuals   16 7789.3  486.83

 Response pH :
            Df Sum Sq Mean Sq F value Pr(>F)
treatment    2 1.0086 0.50429  1.1657 0.3368
Residuals   16 6.9214 0.43259
```

```
 Response rfu :
            Df Sum Sq Mean Sq F value Pr(>F)
treatment    2  49951 24975.6  4.1774 0.0347 *
Residuals   16  95660  5978.7
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05

 Response nc :
            Df  Sum Sq Mean Sq F value Pr(>F)
treatment    2  3.2927  1.6463  1.4799 0.2572
Residuals   16 17.7992  1.1124
```

Fertilizer Treatment



Fertilizer Treatment

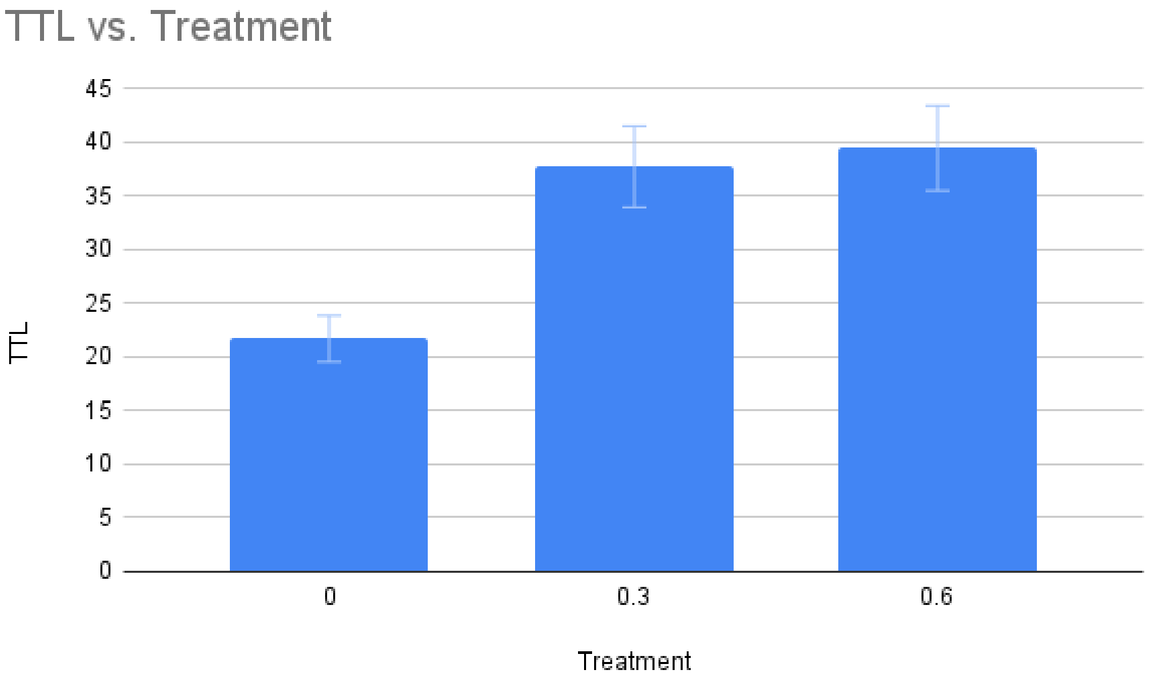


Fertilizer Treatment

Characteristics:

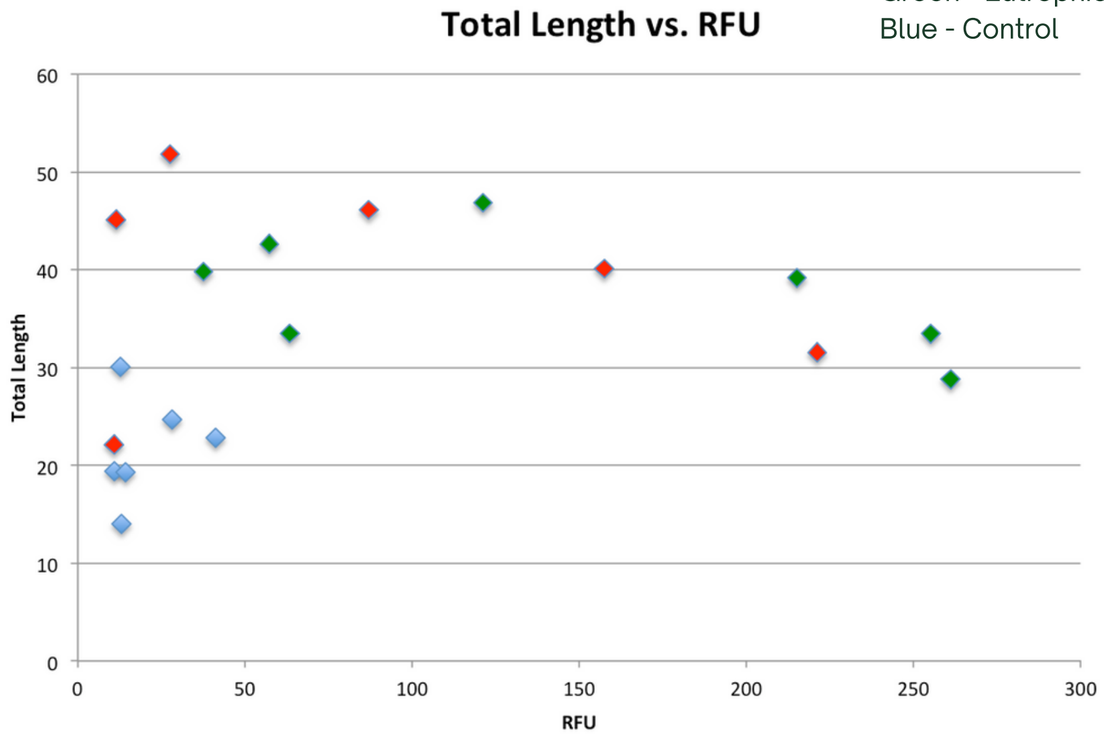
Tail Length
Tail Muscle Height
Tail Width
Head Height
Total Length
Tail Width
Head Width
Interocular Distance
Tail Depth
- (Length/Height)

Expected Relationship with Environmental Data



Similar to other morphological characteristics

Red- Hypertrophic
Green - Eutrophic
Blue - Control

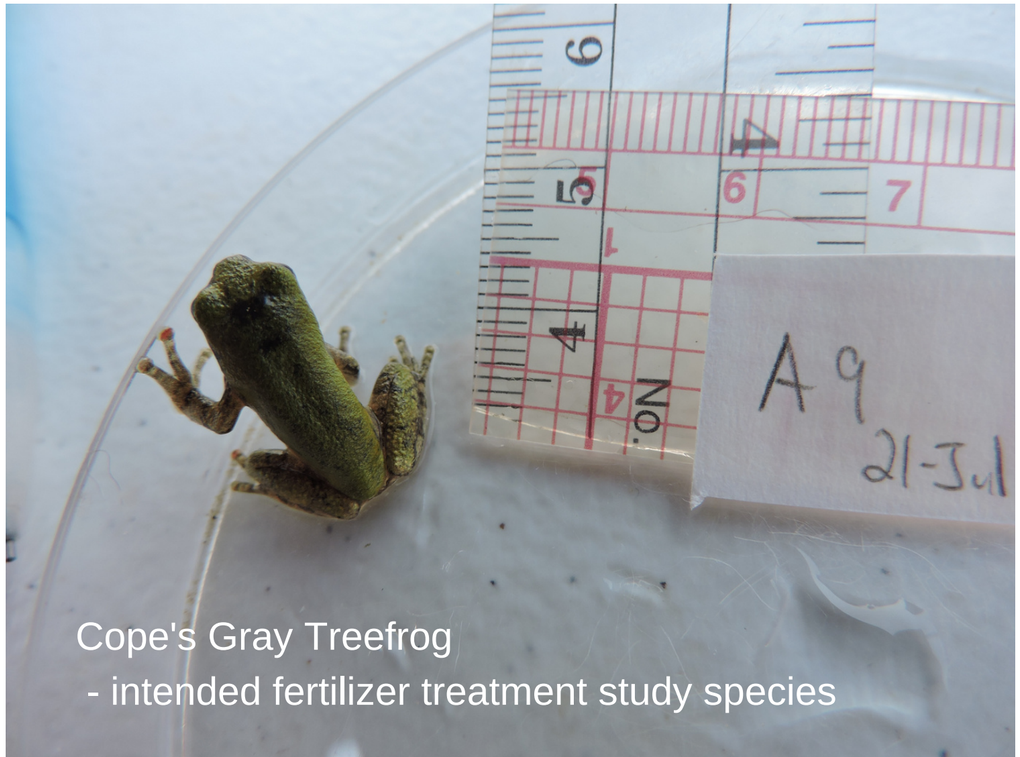


Conclusions

Environmental Variation	Increased UV exposure -> Increase in temperature Intermediate fertilization -> Increase in primary productivity (RFU)
Impact on Morphology	Increase in temperature -> Increase in tadpole size & tail fin depth Increase in temperature -> More rapid development Increase in PP -> Increase in tadpole size & tail fin depth - not correlated to post-treatment nutrient levels
Indicative of Eutrophication	Possibly induced a phytoplankton crash Possible that nutrients were used by system before sampling Could be indicative of increased predation or food availability

- Measure tadpoles from all tanks
- Analyze nutrient levels, primary productivity, & macroinvertebrates from time frames before and after tadpole sampling
- Use water with a previously set nitrate concentration
- More precise pre-treatment tadpole selection

Future Steps



Cope's Gray Treefrog
- intended fertilizer treatment study species

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Sources

Acknowledgements

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Questions?