Title: “Variation of Pollution Level by Stream Orders” Author: “Harry Huang*, Alex Busato, Mesa Ashton“” Date: “April 22, 2019” output: html_document: df_print: paged toc: yes toc_depth: ‘3’ pdf_document: toc: yes toc_depth: 3 editor_options: chunk_output_type: console —

Overview

The **question** is: How do pollution levels change from low order streams to high order streams?

The **hypothesis** is: Lower order streams (headwaters) will tend to have less pollution than high order streams (large rivers).

The **prediction** is: If pollution levels are directly related to stream order then in low order streams we would expect to find a lower average biotic index whereas higher order streams will have a higher average biotic index.

Data Management

In order to streamline the analysis, the data must be loaded and subsetted for our purposes. The master-sheet was augmented with an average biotic index column (which calculated the average polution tolerance for each location based on values given in the biotix index information sheet) in excel prior to being converted to a CSV file. The names under the “Location” column were made consistent, with the same areas made to be spelled and capatilized the same way so the R program would be able to identify them. “Hufnagle Park” was also corrected to “Bull Run”.

```
# this is a code chunk

# remove old variables from your current environment
rm(list = ls())

# check working directory and set
getwd()
```

```
## [1] "C:/Users/Harry Huang/Desktop/BIOL208_Rlab"
```

```
setwd("C:\\Users\\Harry Huang\\Desktop\\BIOL208_Rlab")  #CHANGE THIS TO THE PATH TO YOUR FOLDER
getwd()  #check to make sure it worked
```

```
## [1] "C:/Users/Harry Huang/Desktop/BIOL208_Rlab"
```

```
# this is a code chunk

# read in the csv file using read.csv. Note that the filename
# is a character variable and must have quotes!
StreamData <- read.csv("StreamEcology.csv")
StreamData  #if loaded properly, typing this should show me the data
```

```
##    Date.retrieved.from.water Group.. Leaf.Pack.Number            Location
## 1                     4.8.19      NA              397  before natural area
## 2                   4/8/2019      NA              113 before natural area 
## 3                   4/3/2019      NA              224        Buffalo Creek
## 4                   4/3/2019      NA              279        Buffalo Creek
## 5                   4/3/2019      NA              136        Buffalo Creek
## 6                   4/3/2019      NA              309        Buffalo Creek
## 7                   4/3/2019      NA              327        Buffalo Creek
## 8                                 NA              264          Golf Course
## 9                   4/3/2019       9              277          Golf Course
## 10                  4/3/2019      NA              282          Golf course
## 11                  4/4/2019      NA              319          Golf Course
## 12                  4/3/2019      NA              391          Golf course
## 13                  4/3/2019      NA              392          Golf Course
## 14                  4/3/2019      NA              314          Golf Course
## 15                  4/3/2019      NA              141          Golf Course
## 16                  4/3/2019      NA              199             Bull Run
## 17                  4/3/2019      NA              318             Bull Run
## 18                  4/3/2019      NA              256             Bull Run
## 19                  4/3/2019      NA               21           Laurel Run
## 20                  4/8/2019      20              142           Laurel Run
## 21                  4/3/2019      NA              270           Laurel Run
## 22                  4/3/2019      NA              226           Laurel Run
## 23                  4/3/2019      NA               12           Laurel Run
## 24                  4/3/2019      NA               NA           Laurel Run
## 25                  4/3/2019      NA              313           Laurel Run
## 26                  4/8/2019      NA              118           Miller Run
## 27                  4/8/2019      NA              268           Miller Run
## 28                  4/8/2019      NA              322           Miller Run
## 29                  4/8/2019      NA              227           Miller Run
## 30                  4/8/2019      NA               68           Miller Run
## 31                  4/8/2019      NA              316           Miller Run
## 32                  4/8/2019      NA              147           Miller Run
## 33                  4/3/2019      13              162           Miller Run
## 34                  4/8/2019       7              166           Miller Run
## 35                  4/8/2019      NA              109           Miller Run
## 36                  4/8/2019      NA              335              NA Pond
## 37                  4/8/2019      NA              394              NA Pond
## 38                  4/8/2019      NA              196              NA Pond
## 39                                NA              153              NA Pond
## 40                  4/8/2019      NA              393              NA Pond
## 41                  4/8/2019      NA              112              NA Pond
## 42                  4/3/2019      11              792           Spring Run
## 43                  4/3/2019      NA              340           Spring Run
## 44                  4/3/2019      NA              180           Spring Run
## 45                     3-Apr      NA              226           Spring Run
## 46                  4/3/2019      NA              312           Spring Run
## 47                  4/3/2019      NA              390           Spring Run
## 48                  4/3/2019      NA              262          Spring Run 
## 49                  4/8/2019      NA               32            Stony Run
## 50                  4/8/2019      NA              271            Stony Run
## 51                  4/7/2019      NA              113            Stony Run
## 52                     8-Apr      NA              152            Stony Run
## 53                  4/8/2019      NA              159            Stony Run
```

```
## 53                4/8/2019      NA            199           Stony Run
## 54                4/8/2019      NA            121           Stony Run
## 55                4/8/2019      NA            138           Stony Run
## 56                4/8/2019      NA            166           Stony Run
## 57                              NA             NA              #NAME?
## 58                4/8/2019      NA            254
## 59                4/8/2019      NA            345
## 60                4/8/2019      NA            306
## 61                4/8/2019      NA            117
## 62                4/8/2019      NA            146
##    Pond.Creek
## 1      Bridge
## 2      Bridge
## 3       Creek
## 4       Creek
## 5       Creek
## 6       Creek
## 7       Creek
## 8        Pond
## 9        Pond
## 10       pond
## 11       Pond
## 12       pond
## 13       Pond
## 14       Pond
## 15       Pond
## 16      Creek
## 17      creek
## 18       Pond
## 19      creek
## 20      creek
## 21      Creek
## 22      creek
## 23      creek
## 24      creek
## 25      creek
## 26     Bridge
## 27      creek
## 28      Creek
## 29      Creek
## 30      Creek
## 31      creek
## 32      Creek
## 33      Creek
## 34     creek
## 35     Creek
## 36       Pond
## 37       Pond
## 38       Pond
## 39       Pond
## 40       Pond
## 41       Pond
## 42       Pond
## 43       Pond
## 44       Pond
```

```
## 45        Pond
## 46        pond
## 47        pond
## 48        Pond
## 49       Creek
## 50       Creek
## 51       creek
## 52       Creek
## 53       Creek
## 54       Creek
## 55       Creek
## 56       Creek
## 57
## 58       Creek
## 59       Creek
## 60      Creek
## 61      creek
## 62       creek
##                                                          Site.Description
## 1                                                       briddge over creek
## 2                                                       bridge over creek 
## 3                                               Country/farm area under road
## 4                                              Creek in country under bridge
## 5                                              Creek in country under bridge
## 6                                             Creek in country under bridge 
## 7                                                            Creek in Park
## 8                                                         Golf course pond
## 9                                                         Golf course pond
## 10                                                        golf course pond
## 11                                                       Golf Course Pond 
## 12                                               golf course pond with algae
## 13                                                      Pond on golf course
## 14                                                      Pond on golf course
## 15                                                  Pond on the golf course
## 16                                                           Creek in park
## 17                                                       Creek in the park
## 18                                                            Pond in park
## 19                                         flowing creek surrounded by woods
## 20                                                         creek in a park
## 21                                                           Creek in park
## 22                                                           creek in park
## 23                                                           creek in park
## 24                                                           creek in park
## 25                                                           creek in park
## 26                                                       Bridge over creak
## 27                                                       bridge over creek
## 28                                                       Bridge over creek
## 29                                                                   Creek
## 30                                                         Creek on campus
## 31                                                              Natatorium
## 32                                                On campus near parking lot
## 33                                                    Under bridge/Country 
## 34                                                      bridge over creek 
## 35                                                         Creek on campus
```

```
## 35                                                        Creek on campus
## 36                                                   Pond in natural area
## 37                                                   Pond in Nature Area
## 38                                                   Pond in Nature Area
## 39                                                   Pond in Nature Area
## 40                                                   Pond in Nature Area
## 41                                                   Pond in Nature Area
## 42                                                   Human impacted pond
## 43                                                   Human impacted pond
## 44                                                   Human impacted pond
## 45                                                   Human impacted pond
## 46                                                   Human impacted pond
## 47                                                   Human impacted pond
## 48                                                   Human impacted pond
## 49                                                      Cold rocky creek
## 50 Cold, rocky run through hemlock/deciduous forest. Minimal human impact.
## 51                                                                 creek
## 52                                                                 Creek
## 53                                                                 Creek
## 54                                                         creek in park
## 55                                                       Creek on campus
## 56                                     Wooded area with large creeks
## 57                                                                      
## 58                                                     Bridge over creek
## 59                                                     bridge over creek
## 60                                                     Bridge over creek
## 61                                                    bridge over creek 
## 62                                                      brige over creek
##    Initial.leaf.mass final.leaf.mass                         Who.sorted.
## 1                10g           7.6 g                         Belinda Wan
## 2                10g           8.7 g                     Katie McCartney
## 3                10g            7.9g                     Kameron Winters
## 4                10g           11.3g     Stefan Toomey, Christian Yanes
## 5                10g            6.8g  Jenny Waters and Heather Wetreich
## 6                10g             8.7                      Emily Van Beek
## 7                10g            8.1g                        Alex Dessoye
## 8                10g            6.7g      Clara Mankowski, Abby Fisher
## 9                10g            6.9g                        Casey Morrow
## 10               10g            11.6                          Sarah Knox
## 11               10g            6.5g                        Joshua Mejia
## 12               10g          21.5 g                       Elyse Nissley
## 13               10g            5.4g                      Alyssa Peeples
## 14               10g            5.9g                        Shannon Love
## 15               10g            8.1g 10 - Defne Sement , Gryff Griffin 
## 16               10g            6.7g                           Hope, Jon
## 17              10g              7.8                      Marcela, Chris
## 18               10g            7.6g                     Liam and Jimin 
## 19              10 g           9.1 g                     McKayla Charney
## 20               10g           8.4 g                       maddy desisto
## 21               10g            9.5g                         Abike Beke
## 22               10g            6.2g                      Justin Falcone
## 23               10g          9.639g                         Paige Caine
## 24               10g            1.3g                      Dillon Duttera
## 25               10g             9.7                          Kyle Fouke
## 26              10 g          12.0 g                    Abigail McMullin
```

```
## 26           10 g      12.0 g                 Abigail McMullin
## 27            10g       11.0g                      Harry Huang
## 28            10g          5g                      Mesa Ashton
## 29           10 g        6.52                     Ashley Blair
## 30            10g         9.8                   Serissa Baxter
## 31            10g        7.3g                     payton capes
## 32           10 g       8.0 g                      Shawna Vice
## 33            10g       7.22g                    Robert, Palma
## 34           10 g       7.4 g                          Anna C.
## 35            10g         6.5                     Chiara Evans
## 36            10g        7.8g                     Bryanna Yost
## 37            10g       6.6 g                    Alivia Hunter
## 38            10g                                Rebecca Kelly
## 39            10g         6.7                Isabelle DeZenzo
## 40            10g         6.5                      Kara Checke
## 41            10g        6.7g                   Hannah Grillo
## 42            10g       11.2g                  Kaitlin Kennedy
## 43            10g        11.7                       Megan Maar
## 44            10g        7.3g                        Joe Scott
## 45            10g        6.2g                    Michael Ling
## 46            10g        8.4g                Liutauras Repsys
## 47            10g        5.9g                    Michael Ling
## 48            10g        7.9g                      Chase Hoehn
## 49            10g         6.3                         Go Ogata
## 50            10g        6.2g                      Alex Busato
## 51            10g        2.9g          Lindsey B and Julia B
## 52            10g         6.2                     Gabby Kessel
## 53            10g        7.5g                      P.J. Strahm
## 54      unmatched        8.8g          Max Malika, Abby Turco
## 55            10g         8.1                  Kendyll Hazzard
## 56            10g          7g                 Riley McDonnell
## 57
## 58            10g        9.35                   Kelsey Bordash
## 59            10g        21.7  Caroline Saef and Kristin Smith
## 60            10g        9.2g                     Ally Johnson
## 61            10g        6.2g                       Sarah Bain
## 62            10g        6.6g                   Natalie Slupe
##    X.mayflies. X.stoneflies. X.caddisflies. X.netspinner.caddisflies.
## 1           13             0              0                         0
## 2           NA             2             NA                        NA
## 3            3            NA             NA                        NA
## 4           11            NA              1                        NA
## 5            8            NA             NA                        NA
## 6            0             0              1                         0
## 7            1            16              3                        NA
## 8           11            NA             NA                        NA
## 9            4            NA             NA                        NA
## 10          NA            NA             NA                        NA
## 11          NA            NA              1                        NA
## 12           2            NA             NA                        NA
## 13           1            NA             NA                        NA
## 14           2            NA             NA                        NA
## 15           4            NA             NA                        NA
## 16           2             0              0                         0
## 17          NA            NA              4                        NA
```

```
## 17          NA          NA           4                          NA
## 18          17          NA          NA                          NA
## 19         136           0          28                           0
## 20          66          23           3                          NA
## 21          14           3           0                          NA
## 22          22           1           2                          NA
## 23          36           3          NA                          NA
## 24          25           1          NA                          NA
## 25          57          29          12                          NA
## 26           1          NA          NA                          NA
## 27           6          NA          NA                          NA
## 28           0           0           2                          NA
## 29          NA          NA          NA                           1
## 30           0           0           0                           8
## 31          NA          NA          NA                           1
## 32           1          NA          NA                          NA
## 33          NA          NA          NA                          NA
## 34           4          NA          NA                          NA
## 35          NA          NA           2                          NA
## 36          NA          NA          NA                          NA
## 37           8           3          21                          NA
## 38           1          NA           3                          NA
## 39           4          NA          NA                          NA
## 40          NA          NA           1                          NA
## 41          NA          NA          NA                          NA
## 42           4           1          NA                          NA
## 43           2          NA          NA                          NA
## 44           9          NA          NA                          NA
## 45          NA          NA          NA                          NA
## 46           8          NA           1                          NA
## 47           3          NA          NA                          NA
## 48          15          NA          NA                          NA
## 49           6           1          10                           4
## 50          21           3           5                           1
## 51          47           2          11                          NA
## 52          12           3           4                          NA
## 53           5          16          12                          NA
## 54          75          NA           8                           1
## 55           1           5          23                           1
## 56           8           1          38                           2
## 57          NA          NA          NA                          NA
## 58           1          NA          NA                          NA
## 59           4          NA           3                          NA
## 60          NA          NA          NA                          NA
## 61          NA          NA          NA                          NA
## 62           5          NA          NA                          NA
##    X.dragonflies. X.damselflies. X.hellgrammites. X.alderflies. Dobsonfly
## 1               0              0                0             1         0
## 2              NA             NA               NA            NA        NA
## 3              NA              2               NA             2        NA
## 4              NA              2               NA            NA        NA
## 5              NA              1               NA            NA        NA
## 6               0              3                0             0        NA
## 7              NA             NA               NA            NA        NA
## 8              NA              2               NA            NA        NA
```

```
## 8             NA              2               NA            NA        NA
## 9             NA             NA               NA            NA        NA
## 10             1              1               NA            NA        NA
## 11            NA             NA               NA            NA        NA
## 12            NA             NA               NA            NA        NA
## 13            NA             NA               NA            NA        NA
## 14            NA             NA               NA             3        NA
## 15            NA             NA               NA            NA        NA
## 16             0              0                0             0        NA
## 17            NA             NA               NA            NA        NA
## 18            NA              5               NA            NA        NA
## 19             0              0                0             0         0
## 20            NA             NA               NA            NA        NA
## 21             2              6               NA             1        NA
## 22            NA             23               NA            NA        NA
## 23             4              7               NA            NA        NA
## 24            NA             NA               NA            NA        NA
## 25            NA             NA               NA            NA        NA
## 26            NA              3               NA            NA        NA
## 27            NA             NA               NA            NA        NA
## 28            NA             NA               NA            NA        NA
## 29            NA             NA               NA            NA        NA
## 30             0              0                4             0         0
## 31            NA             NA               NA            NA        NA
## 32            NA             NA               NA            NA        NA
## 33            NA             NA               NA            NA        NA
## 34            NA              2               NA             3        NA
## 35            NA             NA               NA            NA        NA
## 36            NA             NA               NA            NA        NA
## 37            NA              5               NA            NA        NA
## 38            NA             NA               NA            NA        NA
## 39            NA             NA               NA            NA        NA
## 40            NA              5               NA            NA        NA
## 41            NA             NA               NA            NA        NA
## 42            NA             NA               NA            NA        NA
## 43            NA              2               NA            NA        NA
## 44             2             NA               NA            NA        NA
## 45            NA             NA               NA            NA        NA
## 46            NA             NA               NA            NA        NA
## 47            NA             NA               NA            NA        NA
## 48            NA              1               NA            NA        NA
## 49             6              0                0             0         0
## 50             0              1                0             0        NA
## 51            NA             11               NA            NA        NA
## 52             0              3               NA            NA        NA
## 53            NA             NA               NA            NA        NA
## 54            NA             NA               NA            22        NA
## 55             0              5               NA            NA        NA
## 56            NA             NA               NA            NA        NA
## 57            NA             NA               NA            NA        NA
## 58            NA              1               NA            NA        NA
## 59            NA              1               NA            NA        NA
## 60            NA              1               NA            NA         1
## 61            NA              4               NA            NA        NA
## 62            NA             NA               NA            NA        NA
```

```
##    X.beetles. Atherdicidae..watersnipe.flies. Chironomidae..midges.
## 1           1                               0                     4
## 2          NA                              NA                    NA
## 3          NA                              NA                     1
## 4          NA                              NA                    NA
## 5          NA                              NA                    NA
## 6           0                               0                     3
## 7          NA                              NA                    NA
## 8          NA                              NA                    11
## 9          NA                              NA                    NA
## 10         NA                              NA                     5
## 11         NA                              NA                    NA
## 12         NA                              NA                     2
## 13         NA                              NA                    NA
## 14         NA                              NA                    NA
## 15         NA                              NA                    NA
## 16          0                               0                     0
## 17          2                              NA                    NA
## 18         NA                              NA                     8
## 19          0                               0                     0
## 20         NA                              NA                    NA
## 21         NA                              NA                    NA
## 22         NA                              NA                     1
## 23         NA                              NA                    NA
## 24         NA                              NA                    NA
## 25         NA                              NA                    NA
## 26         NA                              NA                     5
## 27         NA                              NA                    NA
## 28          1                              NA                    NA
## 29         NA                              NA                    NA
## 30          0                               0                     0
## 31          2                               4                    NA
## 32         NA                              NA                     4
## 33         NA                              NA                    14
## 34         NA                              NA                     2
## 35         NA                              NA                    NA
## 36         NA                              NA                    NA
## 37          3                              NA                    NA
## 38          5                              NA                    NA
## 39         NA                              NA                    NA
## 40         15                              NA                    NA
## 41         NA                              NA                    NA
## 42         NA                              NA                     2
## 43         NA                              NA                    NA
## 44         NA                              NA                     3
## 45         NA                              NA                    10
## 46         NA                              NA                    NA
## 47         NA                              NA                    13
## 48         NA                              NA                     1
## 49          0                               0                    NA
## 50          4                               0                     0
## 51         NA                              NA                    NA
## 52         NA                              NA                    NA
## 53         NA                              NA                    NA
```

```
## 53         NA                             NA                    NA
## 54         NA                             NA                    NA
## 55         NA                             NA                    NA
## 56         NA                             NA                    NA
## 57         NA                             NA                    NA
## 58         NA                             NA                    NA
## 59         NA                             NA                     1
## 60         NA                             NA                    NA
## 61         NA                             NA                    NA
## 62         NA                             NA                    NA
##    Simuliidae..black.flies. Tipulidae..crane.flies. Unknown.type X.scuds.
## 1                         0                       0            0       12
## 2                        NA                      NA           NA        2
## 3                        NA                      NA           NA        9
## 4                        NA                      NA           NA       10
## 5                        NA                      NA           NA        7
## 6                         0                       0            0       33
## 7                        NA                      NA           NA       NA
## 8                        NA                      NA           NA        1
## 9                        NA                      NA           NA        8
## 10                       NA                      NA            1        1
## 11                       NA                      NA           NA       NA
## 12                       NA                      NA           NA       NA
## 13                       NA                      NA           NA        9
## 14                       NA                      NA            4       NA
## 15                       NA                      NA           NA       NA
## 16                        0                       0            0       36
## 17                       NA                       3           NA        1
## 18                       NA                      NA           NA       NA
## 19                        0                       0            1        0
## 20                       NA                      NA           NA       NA
## 21                       NA                      NA           NA        1
## 22                       NA                      NA           NA       NA
## 23                       NA                      NA           NA        9
## 24                       NA                      NA           NA       NA
## 25                       NA                      NA           NA       NA
## 26                       NA                      NA           NA       NA
## 27                       NA                      NA           NA       NA
## 28                       NA                      NA           NA       12
## 29                       NA                      NA           NA        4
## 30                        0                       0            6        0
## 31                       NA                      NA           12       NA
## 32                       NA                      NA           NA       20
## 33                       NA                      NA           NA        4
## 34                       NA                      NA           NA       NA
## 35                       NA                      NA           NA       17
## 36                       NA                      NA           NA       NA
## 37                       NA                      NA           NA       NA
## 38                       NA                      NA           NA       NA
## 39                       NA                      NA           NA       NA
## 40                       NA                      NA           NA       28
## 41                       NA                      NA           NA       12
## 42                       NA                      NA           NA       NA
## 43                       NA                      NA           NA       NA
## 44                       NA                      NA           NA        7
```

```
## 44                 NA                    NA         NA        7
## 45                  1                    NA          1       NA
## 46                 NA                    NA         NA       NA
## 47                 NA                    NA         NA       NA
## 48                 NA                    NA         NA       NA
## 49                 NA                    NA          2       NA
## 50                  0                     2          0        0
## 51                 NA                    NA         NA       NA
## 52                 NA                     1         NA       NA
## 53                 NA                    NA          1        1
## 54                 NA                    NA         NA       NA
## 55                 NA                    NA         NA       NA
## 56                 NA                    NA         NA       NA
## 57                 NA                    NA         NA       NA
## 58                 NA                    NA         NA       NA
## 59                 NA                    NA         NA        2
## 60                 NA                    NA          4       NA
## 61                 NA                    NA         NA       NA
## 62                 NA                    NA         NA       NA
##    X.aquatic.sowbug. X.crayfish. X.Worms. X.leeches.  X X.snails.
## 1                  8           1        5          1  0         0
## 2                 NA          NA        2          2 NA        NA
## 3                 16          NA        2         NA NA         1
## 4                 11          NA       NA          1 NA        NA
## 5                  9          NA       NA         NA  1        NA
## 6                  6           0        0          0  0         3
## 7                 NA          NA       NA         NA NA        NA
## 8                 NA          NA        2         NA NA        NA
## 9                 NA          NA        8         NA NA        NA
## 10                NA          NA        3         NA NA        NA
## 11                NA          NA       NA         NA NA         2
## 12                NA          NA       NA         NA NA        NA
## 13                 1          NA        1         NA NA        NA
## 14                NA          NA       NA         NA NA         5
## 15                NA          NA        2         NA  3        NA
## 16                 0           0        4          0  0         0
## 17                 1          NA        5         NA NA        NA
## 18                NA          NA        5         NA NA        NA
## 19                 0           0        3          0  0         0
## 20                NA          NA       NA         NA NA         1
## 21                NA          NA        1         NA NA        NA
## 22                NA           1       NA         NA NA        NA
## 23                NA          NA       NA         NA NA        NA
## 24                NA          NA       NA         NA NA        NA
## 25                NA          NA       NA         NA NA        NA
## 26                 6          NA       NA         NA NA         4
## 27                 3          NA       NA          2 NA         5
## 28                NA          NA        3         NA NA        NA
## 29                NA          NA        4         NA NA         6
## 30                 1           0        1          0  0         0
## 31                NA          NA       NA         NA  9         4
## 32                 3          NA        5          2 NA        NA
## 33                NA          NA        4         NA NA        NA
## 34                13          NA        1         NA NA        NA
## 35                 2          NA       NA         NA NA         8
```

```
## 36                12          NA       NA          7 NA         6
## 37                 7          NA        5          4  6         2
## 38                22          NA        3         15 NA        NA
## 39                NA          NA       NA          3  4         4
## 40                 7          NA       NA          1 13         5
## 41                16          NA        3         17 NA         1
## 42                NA          NA       NA         NA NA        NA
## 43                NA          NA       NA         NA NA        NA
## 44                NA          NA       NA         NA NA         1
## 45                NA          NA       NA         NA NA        NA
## 46                NA          NA       NA         NA  7        NA
## 47                 5          NA        2         NA NA        NA
## 48                NA          NA        3         NA NA        NA
## 49                 1          NA        3         NA NA        NA
## 50                 0           0        2          0  0         0
## 51                NA          NA       NA         NA NA        NA
## 52                NA          NA        2         NA NA        NA
## 53                NA          NA       NA         NA NA        NA
## 54                NA          NA       NA         NA NA        NA
## 55                21          NA       NA         NA  3        NA
## 56                NA          NA       NA         NA NA        NA
## 57                NA          NA       NA         NA NA        NA
## 58                NA          NA       NA          2 NA        NA
## 59                 2          NA       NA         NA NA        NA
## 60                NA          NA       NA         NA  1        NA
## 61                14          NA       NA          5 NA        NA
## 62                 2          NA       NA         NA NA         1
##                   X.1 Leech.Eggs Biotic.Index
## 1                   0          0  5.862222222
## 2                             NA         5.75
## 3                             NA  6.772222222
## 4                             NA          5.9
## 5                             NA  6.069230769
## 6                             NA  6.302040816
## 7                             NA          1.4
## 8                             NA  5.244444444
## 9                             NA         6.32
## 10                            NA  6.416666667
## 11                            NA          5.6
## 12                            NA          4.8
## 13                            NA  6.133333333
## 14                            NA  5.585714286
## 15                            NA  6.044444444
## 16                            NA  6.076190476
## 17                            NA          5.3
## 18                            NA  5.262857143
## 19                  0          0   3.55952381
## 20   1 crainfly larva         NA  2.967741935
## 21                            NA  4.335714286
## 22                            NA        5.156
## 23                            NA   4.26440678
## 24                            NA          3.5
## 25                            NA  2.732653061
## 26                            NA  6.873684211
```

```
## 27                  7         NA       6.0375
## 28                            NA  5.976470588
## 29                            NA  6.866666667
## 30                            NA          5.2
## 31                            NA  6.166666667
## 32                            NA  6.502857143
## 33                            NA  6.363636364
## 34                            NA        6.576
## 35                            NA  6.193103448
## 36                            NA         7.76
## 37                            NA  5.173770492
## 38                            54  7.545454545
## 39                            NA         6.56
## 40                            NA  6.813333333
## 41                            86  7.489795918
## 42                            NA  3.914285714
## 43                            NA          5.3
## 44                            NA  4.881818182
## 45                            NA            6
## 46                            NA        5.475
## 47                            NA  6.295652174
## 48                            NA         4.55
## 49                            NA          4.2
## 50 1 Salamander Larva         NA  3.617142857
## 51                            NA  3.929577465
## 52                            NA        3.896
## 53                            NA  2.274285714
## 54                            NA  3.635849057
## 55                            NA  5.169491525
## 56                            NA  2.983673469
## 57                            NA      #DIV/0!
## 58                            NA         6.65
## 59                            NA  4.907692308
## 60                            NA  6.228571429
## 61                            NA  7.826086957
## 62                            NA        5.125
```

```
# load in dplyr
library(dplyr)
```

```
##
## Attaching package: 'dplyr'
```

```
## The following objects are masked from 'package:stats':
##
##     filter, lag
```

```
## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```
# what does the data look like?
dim(StreamData)  #gives the dimensions of the dataset (rows, columns)
```

```
## [1] 62 34
```

```
summary(StreamData)
```

```
##  Date.retrieved.from.water    Group..   Leaf.Pack.Number       Location
##  4/3/2019:27              Min.   : 7   Min.   : 12.0    Miller Run :10
##  4/8/2019:27              1st Qu.: 9   1st Qu.:145.0    Stony Run  : 8
##          : 3              Median :11   Median :240.5    Laurel Run : 7
##  3-Apr   : 1              Mean   :12   Mean   :237.2    Golf Course: 6
##  4.8.19  : 1              3rd Qu.:13   3rd Qu.:314.5    NA Pond    : 6
##  4/4/2019: 1              Max.   :20   Max.   :792.0    Spring Run : 6
##  (Other) : 2              NA's   :57   NA's   :2        (Other)    :19
##    Pond.Creek            Site.Description Initial.leaf.mass
##  Creek  :21   Human impacted pond: 7               : 1
##  Pond   :18   creek in park      : 5      10 g     : 5
##  creek  :11   Pond in Nature Area: 5      10g      :54
##  pond   : 4   Bridge over creek  : 3      10g      : 1
##  Bridge : 3   bridge over creek  : 3      unmatched: 1
##  creek  : 2   Creek              : 3
##  (Other): 3   (Other)            :36
##  final.leaf.mass                                Who.sorted.  X.mayflies.
##  6.2g   : 4      Michael Ling                       : 2   Min.   :  0.0
##  6.7g   : 3                                         : 1   1st Qu.:  2.0
##         : 2      10 - Defne Sement , Gryff Griffin : 1   Median :  5.0
##  5.9g   : 2      Abigail McMullin                   : 1   Mean   : 14.6
##  6.5    : 2      Abike Beke                         : 1   3rd Qu.: 13.5
##  7.3g   : 2      Alex Busato                        : 1   Max.   :136.0
##  (Other):47      (Other)                            :55   NA's   :15
##  X.stoneflies.    X.caddisflies.   X.netspinner.caddisflies.
##  Min.   : 0.000   Min.   : 0.000   Min.   :0.000
##  1st Qu.: 0.500   1st Qu.: 1.000   1st Qu.:0.000
##  Median : 2.000   Median : 3.000   Median :1.000
##  Mean   : 4.913   Mean   : 7.107   Mean   :1.583
##  3rd Qu.: 3.000   3rd Qu.:10.250   3rd Qu.:1.250
##  Max.   :29.000   Max.   :38.000   Max.   :8.000
##  NA's   :39       NA's   :34       NA's   :50
##  X.dragonflies.  X.damselflies.   X.hellgrammites. X.alderflies.
##  Min.   :0.000   Min.   : 0.000   Min.   :0.0000   Min.   : 0.000
##  1st Qu.:0.000   1st Qu.: 1.000   1st Qu.:0.0000   1st Qu.: 0.000
##  Median :0.000   Median : 2.000   Median :0.0000   Median : 0.500
##  Mean   :1.154   Mean   : 3.345   Mean   :0.5714   Mean   : 2.667
##  3rd Qu.:2.000   3rd Qu.: 5.000   3rd Qu.:0.0000   3rd Qu.: 2.250
##  Max.   :6.000   Max.   :23.000   Max.   :4.0000   Max.   :22.000
##  NA's   :49      NA's   :33       NA's   :55       NA's   :50
##    Dobsonfly     X.beetles.     Atherdicidae..watersnipe.flies.
##  Min.   :0.0   Min.   : 0.000   Min.   :0.0
##  1st Qu.:0.0   1st Qu.: 0.000   1st Qu.:0.0
##  Median :0.0   Median : 1.000   Median :0.0
##  Mean   :0.2   Mean   : 2.538   Mean   :0.5
##  3rd Qu.:0.0   3rd Qu.: 3.000   3rd Qu.:0.0
##  Max.   :1.0   Max.   :15.000   Max.   :4.0
##  NA's   :57    NA's   :49       NA's   :54
##  Chironomidae..midges. Simuliidae..black.flies. Tipulidae..crane.flies.
##  Min.   : 0.000        Min.   :0.0000           Min.   :0.00
##  1st Qu.: 1.000        1st Qu.:0.0000           1st Qu.:0.00
##  Median : 2.500        Median :0.0000           Median :0.00
##  Mean   : 4.091        Mean   :0.1429           Mean   :0.75
##  3rd Qu.: 5.000        3rd Qu.:0.0000           3rd Qu.:1.25
```

```
## 3rd Qu.: 5.000         3rd Qu.:0.0000           3rd Qu.:1.25
##  Max.   :14.000        Max.   :1.0000           Max.   :3.00
##  NA's   :40            NA's   :55               NA's   :54
##   Unknown.type       X.scuds.      X.aquatic.sowbug.  X.crayfish.
##  Min.   : 0.000   Min.   : 0.000   Min.   : 0.0      Min.   :0.0000
##  1st Qu.: 0.000   1st Qu.: 1.000   1st Qu.: 1.5      1st Qu.:0.0000
##  Median : 1.000   Median : 7.000   Median : 6.0      Median :0.0000
##  Mean   : 2.462   Mean   : 9.111   Mean   : 7.0      Mean   :0.2857
##  3rd Qu.: 4.000   3rd Qu.:12.000   3rd Qu.:11.5      3rd Qu.:0.5000
##  Max.   :12.000   Max.   :36.000   Max.   :22.0      Max.   :1.0000
##  NA's   :49       NA's   :35       NA's   :35        NA's   :55
##     X.Worms.    X.leeches.           X            X.snails.
##  Min.   :0    Min.   : 0.000   Min.   : 0.000   Min.   :0.000
##  1st Qu.:2    1st Qu.: 0.250   1st Qu.: 0.000   1st Qu.:1.000
##  Median :3    Median : 2.000   Median : 1.000   Median :2.000
##  Mean   :3    Mean   : 3.444   Mean   : 3.133   Mean   :2.682
##  3rd Qu.:4    3rd Qu.: 3.750   3rd Qu.: 5.000   3rd Qu.:4.750
##  Max.   :8    Max.   :17.000   Max.   :13.000   Max.   :8.000
##  NA's   :34   NA's   :44       NA's   :47       NA's   :40
##                  X.1       Leech.Eggs      Biotic.Index
##                    :57   Min.   : 0   5.3        : 2
##  0                 : 2   1st Qu.: 0   #DIV/0!    : 1
##  1 crainfly larva  : 1   Median :27   1.4        : 1
##  1 Salamander Larva: 1   Mean   :35   2.274285714: 1
##  7                 : 1   3rd Qu.:62   2.732653061: 1
##                          Max.   :86   2.967741935: 1
##                          NA's   :58   (Other)    :55
```

```
# We are only interested in four locations where the stream
# order was determined. Miller Run, Spring Run, Stony Run,
# Hufnagle Park (aka. Bull Run), and Buffalo Creek.
StreamDataFiltered <- select(StreamData, Location, Biotic.Index)
StreamDataFiltered.4Streams <- filter(StreamDataFiltered, Location ==
    "Bull Run" | Location == "Buffalo Creek" | Location == "Laurel Run" |
    Location == "Spring Run" | Location == "Stony Run")
StreamDataFiltered.4Streams
```

```
##          Location Biotic.Index
## 1  Buffalo Creek  6.772222222
## 2  Buffalo Creek          5.9
## 3  Buffalo Creek  6.069230769
## 4  Buffalo Creek  6.302040816
## 5  Buffalo Creek          1.4
## 6       Bull Run  6.076190476
## 7       Bull Run          5.3
## 8       Bull Run  5.262857143
## 9     Laurel Run   3.55952381
## 10    Laurel Run  2.967741935
## 11    Laurel Run  4.335714286
## 12    Laurel Run        5.156
## 13    Laurel Run   4.26440678
## 14    Laurel Run          3.5
## 15    Laurel Run  2.732653061
## 16    Spring Run  3.914285714
## 17    Spring Run          5.3
## 18    Spring Run  4.881818182
## 19    Spring Run            6
## 20    Spring Run        5.475
## 21    Spring Run  6.295652174
## 22     Stony Run          4.2
## 23     Stony Run  3.617142857
## 24     Stony Run  3.929577465
## 25     Stony Run        3.896
## 26     Stony Run  2.274285714
## 27     Stony Run  3.635849057
## 28     Stony Run  5.169491525
## 29     Stony Run  2.983673469
```

Results

```r
# Load in ggplot2. If you don't have it, install it.
library(ggplot2)


# Make a barchart of the pollution tolerance/biotic index for
# each location

ggplot(StreamDataFiltered.4Streams, aes(fill = Location, y = Biotic.Index,
    x = Location)) + stat_summary(fun.y = "mean", geom = "bar") +
    xlab("Location") + ylab("Average Biotic Index") + theme(panel.grid.major = element_blank(),
    panel.grid.minor = element_blank(), panel.background = element_blank(),
    axis.line = element_line(colour = "black"))
```

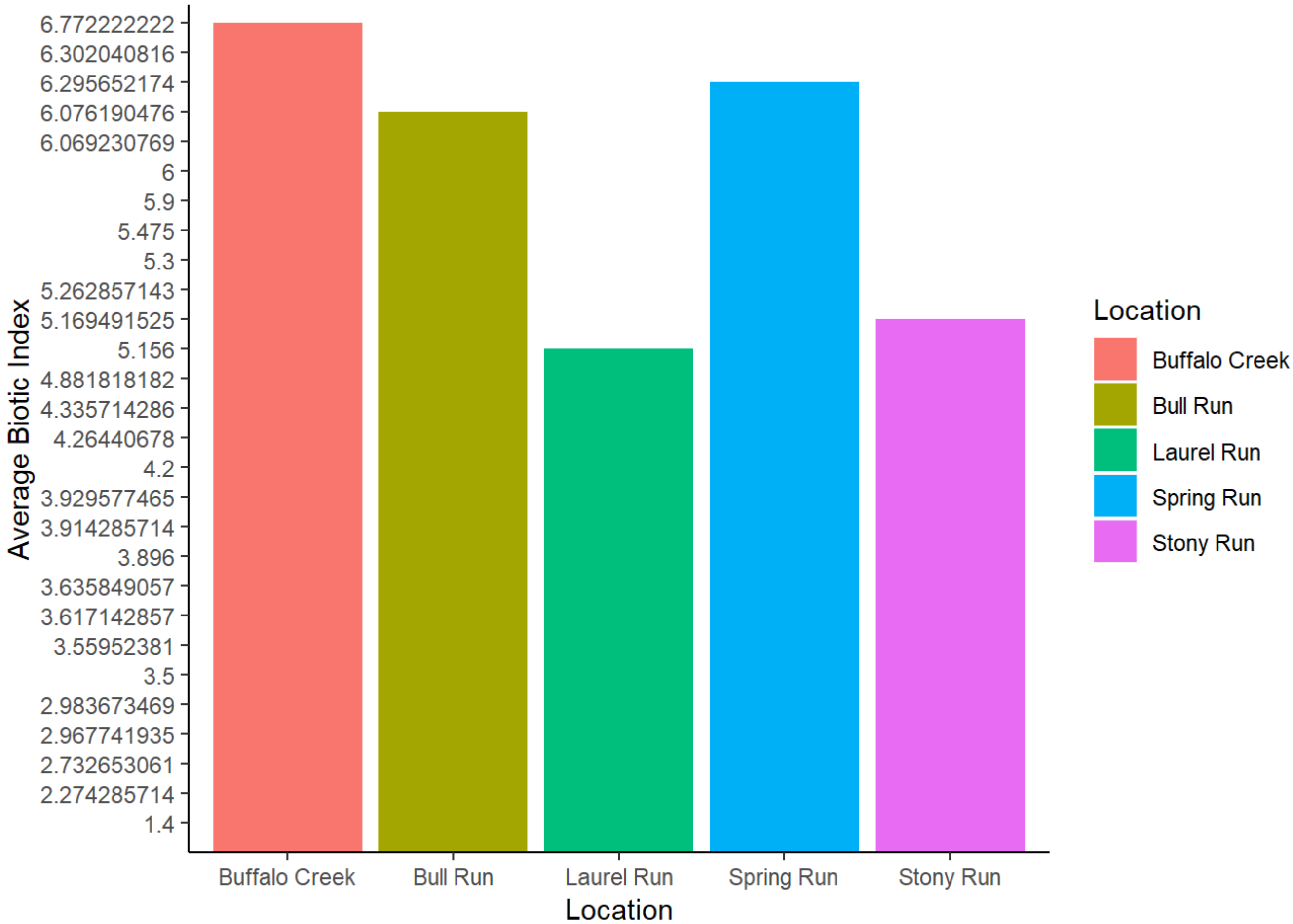

Figure 1 Average biotic index of different streams. Higher biotic index indicates higher pollution tolerance.

The biotic indexes of the selected streams shows clear distinctions in the average biotic index of each stream. Buffalo Creek, a second order stream, has the highest biotic index of all five streams. The rest of the streams are first order streams. Bull Run and Spring Run had very similar average biotic indicies, both falling just short of Buffalo Creek. Laurel Run and Stony Run had very similar biotic indexes and was well below Buffalo Creek (Figure 1).

Discussion

It is widely accepted that the type of macroinvertebrates can serve as indicators of environmental quality (Muralidharan, et. al, 2010) and stream pollution (Goodnight, 1973) through classification in a biotic index that indentifies the pollution tolerance of macroinvertebrates. Graphical anaylsis of the average biotic indicies of the streams showed that the second order creek had the highest biotic index when compared to four first order streams (figure 1). The data supports the hypothesis. While two of the first order streams, Bull Run and Spring Run, were close in biotic index, two other streams, Laurel Run and Stony Run, were not. The study is limited by the lack of data on other second order streams and by the ambiguity surrounding classifications of stream order. Stream order classification is relative and stream orders in this study were assigned by visual assessments of size and connected streams on Google Maps, introducing an element of human error. Additionally, stream order classification in this study did not take into account gradiations and exist at discreet levels due to the difficulties in classification. Pennslyvannia is also known for areas of mining which may unevenly affect certain streams through siltation and heavy metal contamination (Brun, 2005).

Works Cited

Muralidharan, M., Selvakumar, C., Sundar, S. and Raja, M., 2010. Macroinvertebrates as potential indicators of environmental quality. International Journal of Biological Technology, 1, pp.23-28.

Goodnight, C., 1973. 'The Use of Aquatic Macroinvertebrates as Indicators of Stream Pollution'. Transactions of the American Microscopical Society Vol. 92, No. 1 (Jan., 1973), pp. 1-13 (13 pages)

Bruns, D.A., 2005. Macroinvertebrate response to land cover, habitat, and water chemistry in a mining-impacted river ecosystem: A GIS watershed analysis. Aquatic Sciences, 67(4), pp.403-423.