Figures

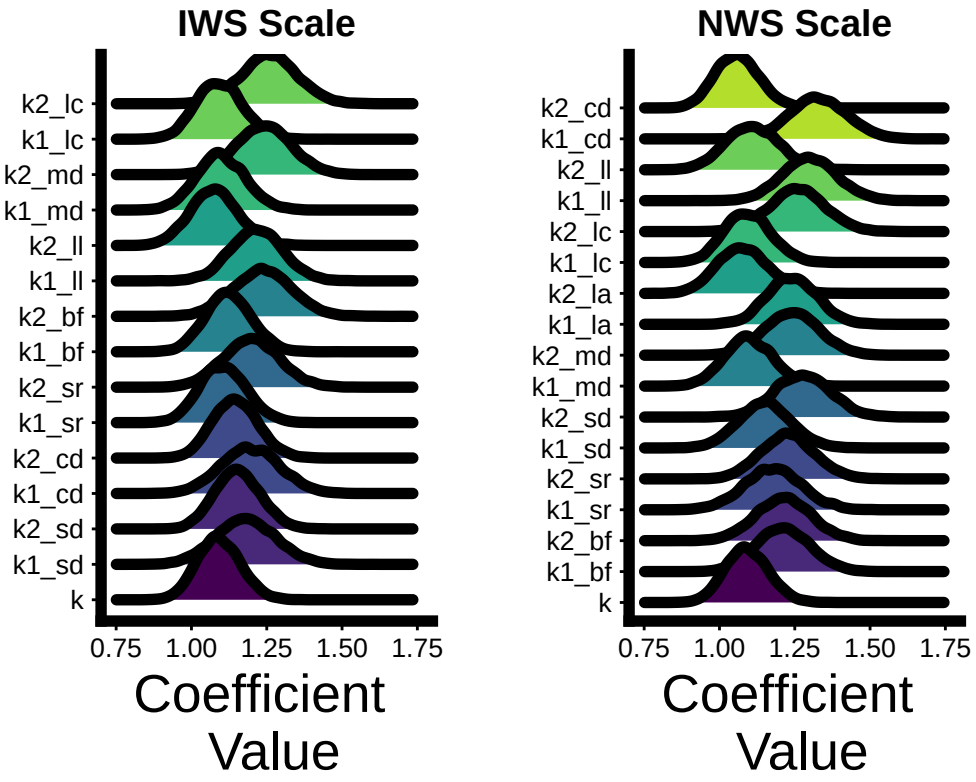


Abb	Scale	Metric	Split Value	Delta k
cd	nws	Closest lake distance	2776.81	0.27
ll	nws	Average Link Length	2237.34	0.19
lc	misc	Lake Connection	NA	0.17
la	nws	Upstream lake area	153.50	0.16
md	misc	Max Depth	19.81	0.15
ll	iws	Average Link Length	2177.08	0.14
sd	nws	Stream density	10.40	0.13
bf	iws	Baseflow	63.76	0.12
sr	iws	Stream order ratio	0.67	0.10
cd	iws	Closest lake distance	3773.61	0.05
sr	nws	Stream order ratio	0.47	0.05
sd	iws	Stream density	4.43	0.03
bf	nws	Baseflow	52.94	0.00

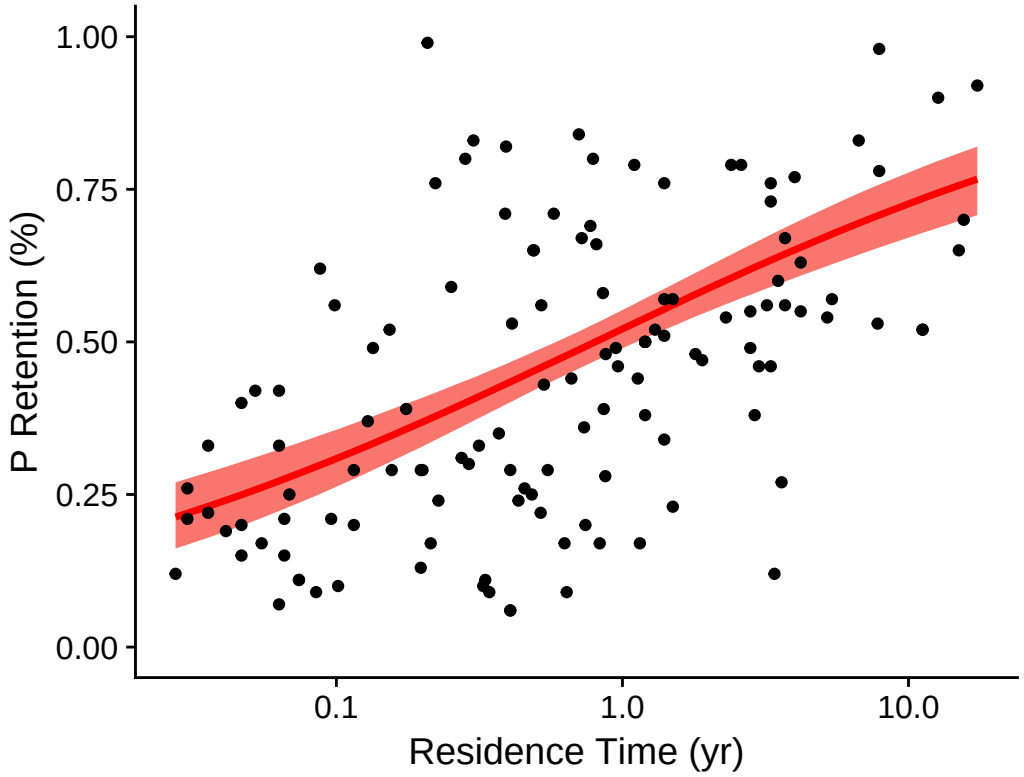
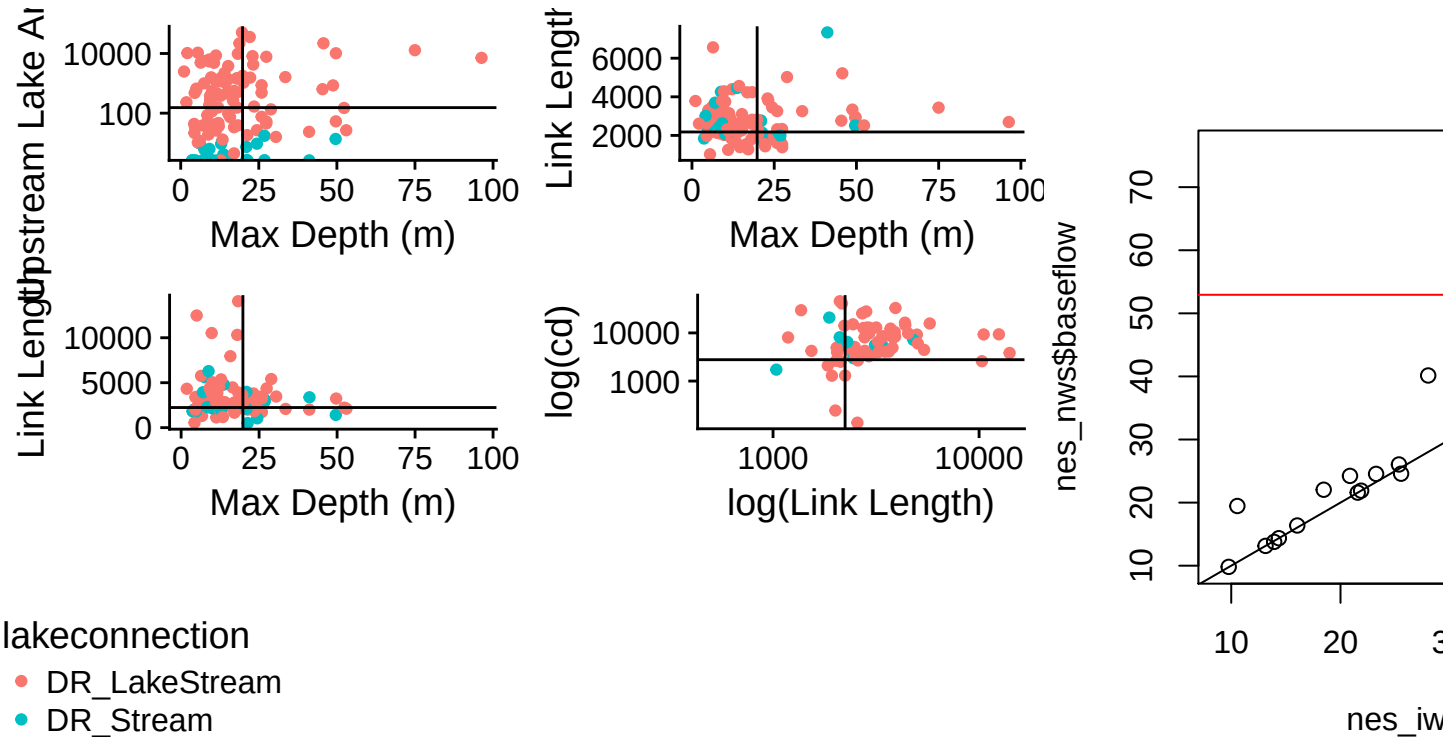


Figure 1: Median and central 95% interval estimates from the non-hierarchical model posterior relative to raw data.



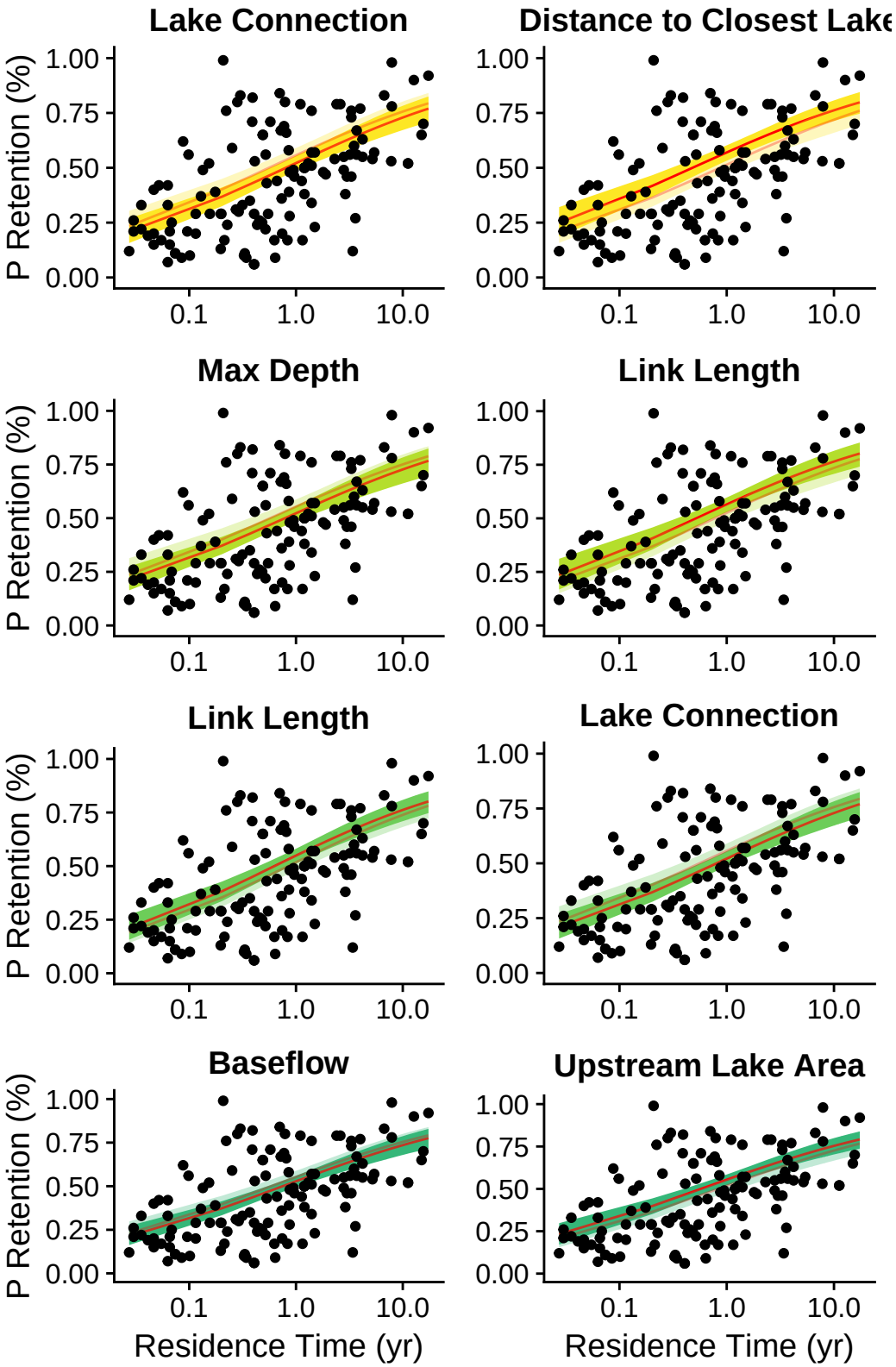
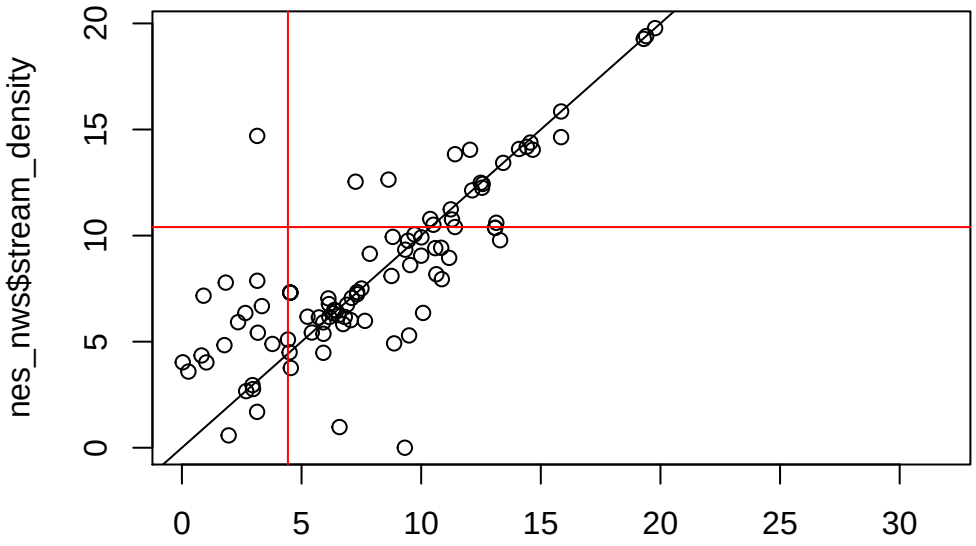
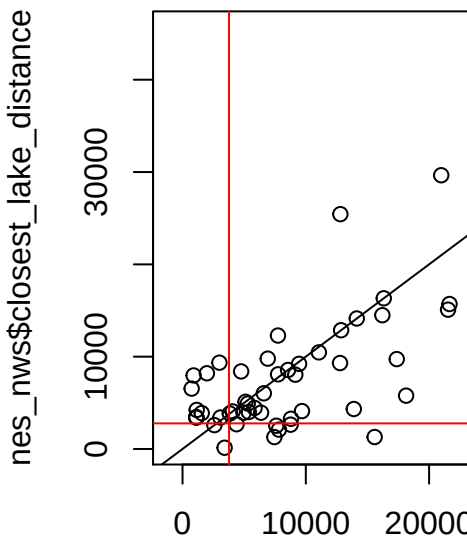
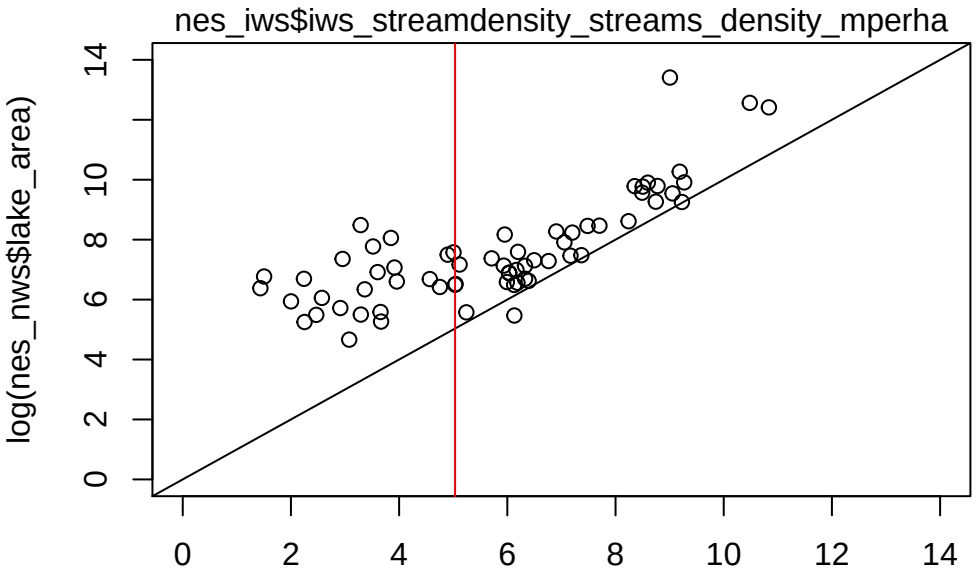


Figure 2: Median and central 95% interval estimates from the hierarchical model posteriors relative to raw data. Dark lines and shaded polygons represent the estimates from the lower of the two partition groups (see Table 1)







log(nes_iws$upstream_lakes_4ha_area_ha)

```
## Simple feature collection with 10 features and 64 fields
## geometry type:  POINT
## dimension:      XY
## bbox:           xmin: -93.8 ymin: 37.73056 xmax: -82.72667 ymax: 44.19667
## epsg (SRID):    4326
## proj4string:    +proj=longlat +datum=WGS84 +no_defs
##        nhdid nesid lagoslakeid         gnis_name   lg_long   lg_lat
## 1  120031525  1712        7396 Crab Orchard Lake -89.07619 37.71966
## 10 155390760  3930      138003              <NA> -82.72595 41.09289
## 5  155641463  1846        2830         Olin Lake -85.39263 41.56223
## 9   32671150  2750         902      Madison Lake -93.80103 44.18874
## 6  155642757  1836        3991      Lake Wawasee -85.70626 41.40364
## 7  155639076  1853        4044        Lake James -85.04249 41.70994
## 3  155351274  1837        3708      Webster Lake -85.68041 41.32607
## 4  150994582  1857        1674     Hamilton Lake -84.91820 41.54926
```

```
## 2  155351279  1844        3505   Tippecanoe Lake -85.76313 41.32621
## 8  145333723  2699        6340        Zukey Lake -83.84571 42.45049
##     nes_long  nes_lat pdf pagenum     state              name
## 1  -89.14167 37.73056 475      86  ILLINOIS CRAB ORCHARD LAKE
## 10 -82.72667 41.10278 475     192      OHIO      HOLIDAY LAKE
## 5  -85.39611 41.56361 475     126   INDIANA         OLIN LAKE
## 9  -93.80000 44.19667 474     118 MINNESOTA      MADISON LAKE
## 6  -85.67917 41.39278 475     132   INDIANA      WAWASEE LAKE
## 7  -85.02444 41.69278 475     119   INDIANA        JAMES LAKE
## 3  -85.67444 41.32861 475     133   INDIANA      WEBSTER LAKE
## 4  -84.91833 41.54028 475     116   INDIANA     HAMILTON LAKE
## 2  -85.77972 41.32944 475     130   INDIANA   LAKE TIPPECANOE
## 8  -83.85000 42.45000 474      72  MICHIGAN   STRAWBERRY LAKE
##                county   lake_type drainage_area surface_area mean_depth
## 1  JACKSON MILLIAMSON IMPOUNDMENT        520.60        28.19        3.0
## 10              HURON IMPOUNDMENT         35.70         0.91        3.9
## 5            LAGRANGE     NATURAL         15.00         0.42       11.7
## 9           BLUE EARTH     NATURAL         61.64         4.50        4.0
## 6            KOSCIUSKO     NATURAL         94.20        12.38        6.7
## 7              STEUBEN     NATURAL        123.80         4.18        7.3
## 3            KOSCIUSKO     NATURAL        126.70         2.37        2.1
## 4              STEUBEN     NATURAL         42.80         3.25        6.3
## 2            KOSCIUSKO     NATURAL        292.70         3.11       11.3
## 8          LIVINGSTONE     NATURAL        914.27         1.04        6.7
##    total_inflow retention_time retention_time_units alkalinity
## 1          3.40          288.0                 days         53
## 10         0.40          103.0                 days        127
## 5          0.14            1.1                years        190
## 9          0.20            3.3                years        131
## 6          0.80            3.5                years        126
## 7          1.13          312.0                 days        182
## 3          1.20           49.0                 days        196
## 4          0.36            1.8                years        156
## 2          2.74          148.0                 days        171
## 8          6.20           13.0                 days        188
##    conductivity secchi    tp   po4   tin    tn p_pnt_source_muni
## 1           265    0.5 0.082 0.013 0.200 0.910             20880
## 10          546    0.9 0.125 0.034 0.575 2.335              6250
## 5           403    2.5 0.012 0.003 1.460 1.775                NA
## 9           305    0.9 0.050 0.020 0.680    NA                NA
## 6           330    3.4 0.012 0.003 0.210 1.010               125
## 7           389    3.7 0.016 0.005 0.190 0.830                NA
## 3           412    1.8 0.025 0.005 0.790 1.590               240
## 4           343    2.2 0.033 0.018 0.720 1.280                NA
## 2           412    2.8 0.019 0.005 0.195 1.030                NA
## 8           488    2.0 0.068 0.049 0.530    NA              1524
##    p_pnt_source_industrial p_pnt_source_septic p_nonpnt_source p_total
## 1                       NA                  15           58460   79355
## 10                      NA                  35            1365    7650
## 5                       NA                  NA             340     340
## 9                       45                 667             889    1601
## 6                       NA                 135            1110    1370
## 7                       NA                  85            1335    1420
## 3                       NA                  40            2195    2475
```

```
## 4                     NA                 55            975    1030
## 2                     NA                 50           3365    3415
## 8                     NA                 59           7973    9556
##    n_pnt_source_muni n_pnt_source_industrial n_pnt_source_septic
## 1              62600                     NA                570
## 10             18740                     NA               1385
## 5                 NA                     NA                 NA
## 9                 NA                     63               1995
## 6                745                     NA              10105
## 7                 NA                     NA               6195
## 3               1445                     NA               3145
## 4                 NA                     NA               3955
## 2                 NA                     NA               3805
## 8              13379                     NA               2240
##    n_nonpnt_source n_total p_total_out p_percent_retention
## 1           303900  367070       16160                0.80
## 10           42480   62605        1495                0.80
## 5            14550   14550          70                0.79
## 9            48218   50277         385                0.76
## 6            97145  107995         550                0.60
## 7            49995   56190         590                0.58
## 3           119115  123705        1250                0.49
## 4            35105   39060         540                0.48
## 2           208515  212320        2410                0.29
## 8           218245  233864        7447                0.22
##    p_surface_area_loading n_total_out n_percent_retention
## 1                    2.82      164625                  55
## 10                   8.41       28635                  54
## 5                    0.81        9000                  38
## 9                    0.36       19351                  62
## 6                    0.11       41360                  62
## 7                    0.34       30490                  46
## 3                    1.04       94115                  24
## 4                    0.32       18455                  53
## 2                    1.10      171350                  19
## 8                    9.19      203932                  13
##    n_surface_area_loading lakeconnection hu12_zoneid
## 1                    13.0  DR_LakeStream   HU12_1311
## 10                   68.8  DR_LakeStream   HU12_7429
## 5                    34.6      DR_Stream   HU12_6020
## 9                    11.2  DR_LakeStream   HU12_9908
## 6                     8.7  DR_LakeStream   HU12_6031
## 7                    13.4  DR_LakeStream   HU12_6399
## 3                    52.2  DR_LakeStream   HU12_6123
## 4                    12.0  DR_LakeStream   HU12_6310
## 2                    68.3  DR_LakeStream   HU12_6123
## 8                   224.9  DR_LakeStream  HU12_12519
##    upstream_lakes_4ha_area_ha meandepth maxdepth
## 1                    997.5000    2.7737   7.4981
## 10                    21.7000        NA   4.4000
## 5                      9.5000   11.6000  24.4000
## 9                    153.5000        NA  18.0000
## 6                    166.9000    6.7000  23.5000
## 7                    559.1000   11.0000  17.1000
```

```
## 3                   457.9000    2.1000  14.6000
## 4                    18.4104    6.4000  21.3000
## 2                  1297.0000    6.1000  11.0000
## 8                  3792.8000        NA  15.2000
##    iws_streamdensity_streams_density_mperha
## 1                                   15.8487
## 10                                  15.8500
## 5                                    7.8528
## 9                                    1.7769
## 6                                    6.8081
## 7                                    3.7840
## 3                                    2.6507
## 4                                    9.3350
## 2                                    6.1450
## 8                                    7.3194
##    iws_wl_allwetlandsdissolved_overlapping_area_pct
## 1                                            6.2293
## 10                                           7.0820
## 5                                           15.0061
## 9                                            6.3321
## 6                                            8.7051
## 7                                           11.5447
## 3                                            8.9389
## 4                                            4.2762
## 2                                            8.4002
## 8                                           17.8839
##    iws_lakes_overlapping_area_pct hu12_baseflowindex_mean
## 1                          0.1763                 13.9268
## 10                         0.1847                 21.8889
## 5                          0.7135                 63.7619
## 9                          0.0000                 48.8039
## 6                          0.2499                 60.5263
## 7                          0.3758                 61.8864
## 3                          1.9940                 55.6618
## 4                          0.1236                 43.9286
## 2                          0.0000                 55.6618
## 8                          0.3819                 68.6143
##    iws_nlcd1992_pct_81 iws_nlcd1992_pct_82 lake_area_ha link_length
## 1                36.15               11.47   2951.24696    2237.341
## 10               19.66               44.90     88.00516    1930.888
## 5                11.89               68.06     35.58213    1037.239
## 9                19.03               53.38    541.82844   10320.904
## 6                10.70               61.32   1398.07892    1844.822
## 7                13.59               41.15    745.44075    2021.059
## 3                11.13               42.12    257.24782    2567.328
## 4                32.83               41.22    317.35552    2007.701
## 2                20.14               45.23    336.69925    2129.097
## 8                12.46               21.37    174.15992    2580.123
##    stream_order_ratio closest_lake_distance num_up_lakes lake_area
## 1           0.5736842              1296.793            9 3917.6057
## 10          0.6875000              1290.591            2  106.0675
## 5           0.8181818              1725.797            2  190.9910
## 9           1.0000000              2584.226            2  661.6819
## 6           0.4038462              2098.086            9 1299.3028
```

```
## 7           0.5000000              2634.583           10 1244.8995
## 3           0.5636364               136.356           11  657.8508
## 4           0.5789474               244.082            1  304.2775
## 2           0.4923077              2518.879           22 1744.5044
## 8           0.4661017              2680.311           61 5512.8017
##    baseflow stream_density retention_time_yr      tp_in
## 1  13.77602      14.640835        0.78904110 0.74009722
## 10 21.88890      15.850000        0.28219178 0.60644977
## 5  63.76190       9.141896        1.10000000 0.07700949
## 9  48.80390       4.835758        3.30000000 0.25383688
## 6  59.39194       6.165340        3.50000000 0.05430302
## 7  60.67289       4.890415        0.85479452 0.03984770
## 3  52.94229       6.349963        0.13424658 0.06540145
## 4  43.92860       9.335000        1.80000000 0.09072524
## 2  52.21785       6.770994        0.40547945 0.03952151
## 8  66.97171       7.235326        0.03561644 0.04887400
##                        geometry
## 1  POINT (-89.14167 37.73056)
## 10 POINT (-82.72667 41.10278)
## 5  POINT (-85.39611 41.56361)
## 9      POINT (-93.8 44.19667)
## 6  POINT (-85.67917 41.39278)
## 7  POINT (-85.02444 41.69278)
## 3  POINT (-85.67444 41.32861)
## 4  POINT (-84.91833 41.54028)
## 2  POINT (-85.77972 41.32944)
## 8        POINT (-83.85 42.45)
```

```
## although coordinates are longitude/latitude, st_intersects assumes that they are planar
```

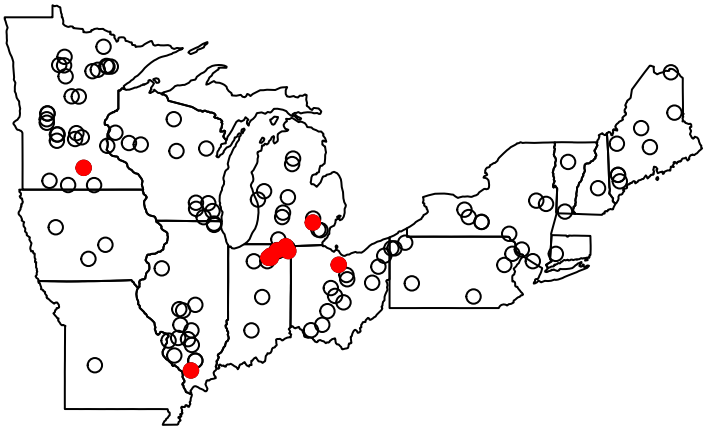


Table 2: Connectivity metric effects on lake processing.

metric	direction	k	connectivity	in_lake_processing	axis
lakeconnection	DR_Stream	higher	lower	higher	lake
upstream lake area	lower	higher	lower	higher	lake
link_length	lower	higher	lower	higher	stream
baseflow	higher	higher	lower	higher	stream
stream order ratio	higher	higher	lower	higher	stream
upstream lake distance	lower	higher	lower	higher	lake-stream
stream density	higher	higher	lower	higher	stream