Masticated Fuels Analyses: No Transformation of Response Variable

Sam Wozniak

June 6, 2018

Contents

Notes

Years since treatment is treated as a factor. This means that the effect of year since treatment is not an incremental increase (or decrease) from 0 to 1, 1 to 2, or 2 to 3 years since treatment. Instead, there is an effect of year since treatment for each year relative to the reference year (1 yst for downed woody debris, and pre-treatment for all other response variables).

For dead fuels (masticated downed woody debris and tree litter + duff), pre-treatment tree cover is used as an explanatory variable.

For live response variables (e.g. herbaceous fuels, perennial grass cover, shrub cover, tree cover, tree density), pre-treatment Tree Dominance Index (TDI) is used as an explanatory variable. TDI is used instead of pre-treatment tree cover because the response of living plants over time depends upon the relative competition between plant functional groups at the time of treatment.

Definitions of acronyms and abbreviations used in code

yst = years since treatment; 0 represents pre-treatment

TDI = Tree Dominance Index (pre-treatment tree cover/ (pre-treatment perennial grass cover + pre-t. shrub cover + pre-t. tree cover))

pre_tree_cvr = pre-treatment tree cover (%)

dwd_1hr = Downed woody debris of 1-hr class (< 1/4 in diameter)

dwd_10hr = Downed woody debris of 10-hr class (1/4 - 1 in diameter)

dwd_100_1000hr = Downed woody debris of 100-hr and 1000-hr classes (1-3 and 3+ inches diameter); these two fuel classes were combined because 1000-hr fuels are very infrequent (vast majority of subplots have 0 1000-hr fuels) on masticated sites

herb_ttl = live + dead herbaceous fuel loading

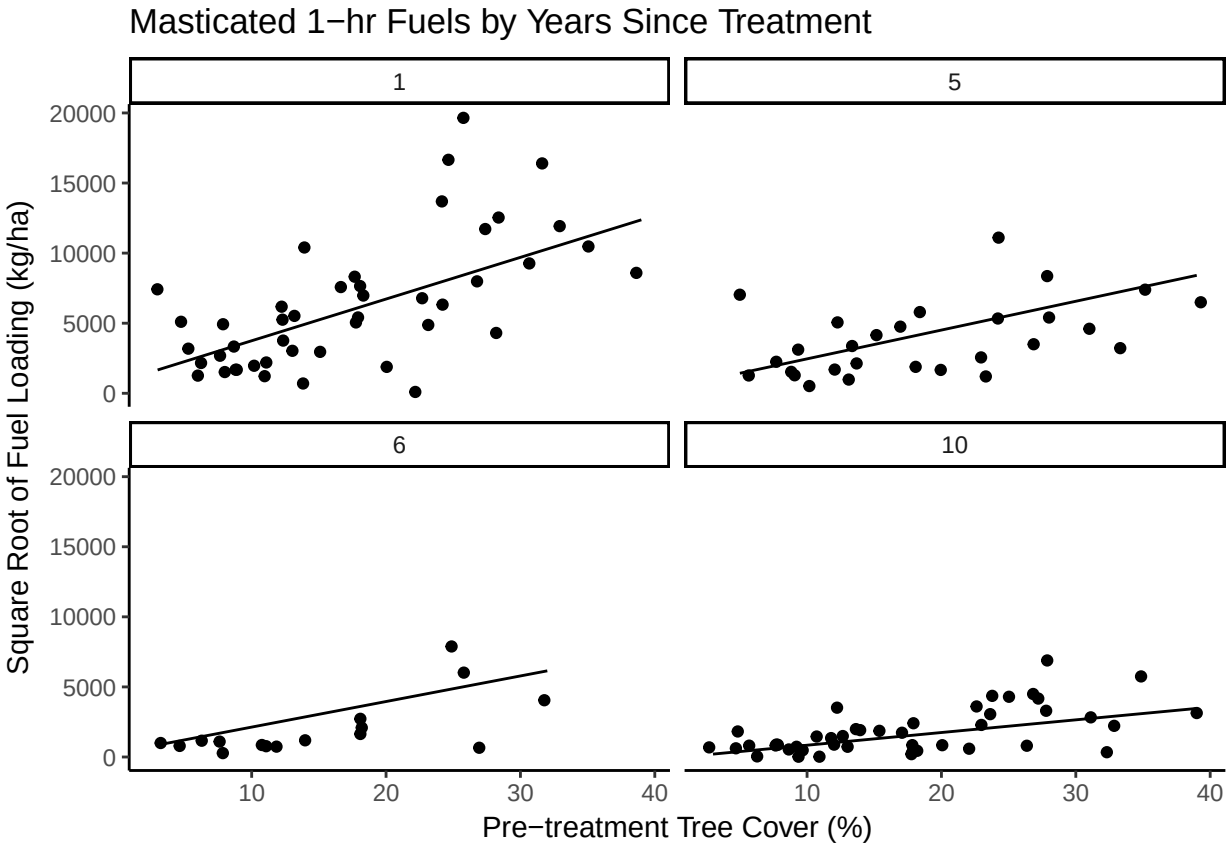
Masticated 1-hr fuels

Notes

Sampling at 5-6 years: 2/3 sites (GR, SC) were sampled 5 years since treatment, and 1/3 sites (ON) was sampled at 6 years post-treatment

Model

```
m <- lmer(dwd_1hr ~ pre_tree_cvr + yst + pre_tree_cvr:yst +
            (1|site), data = d)
```

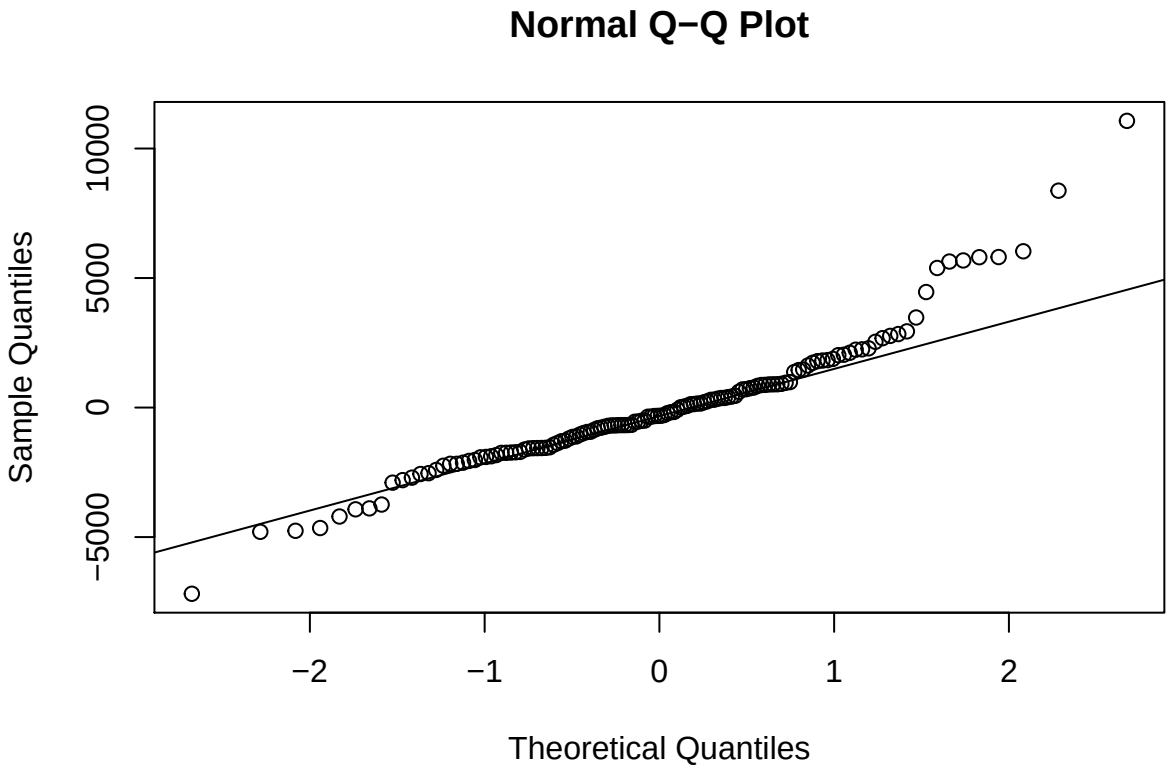


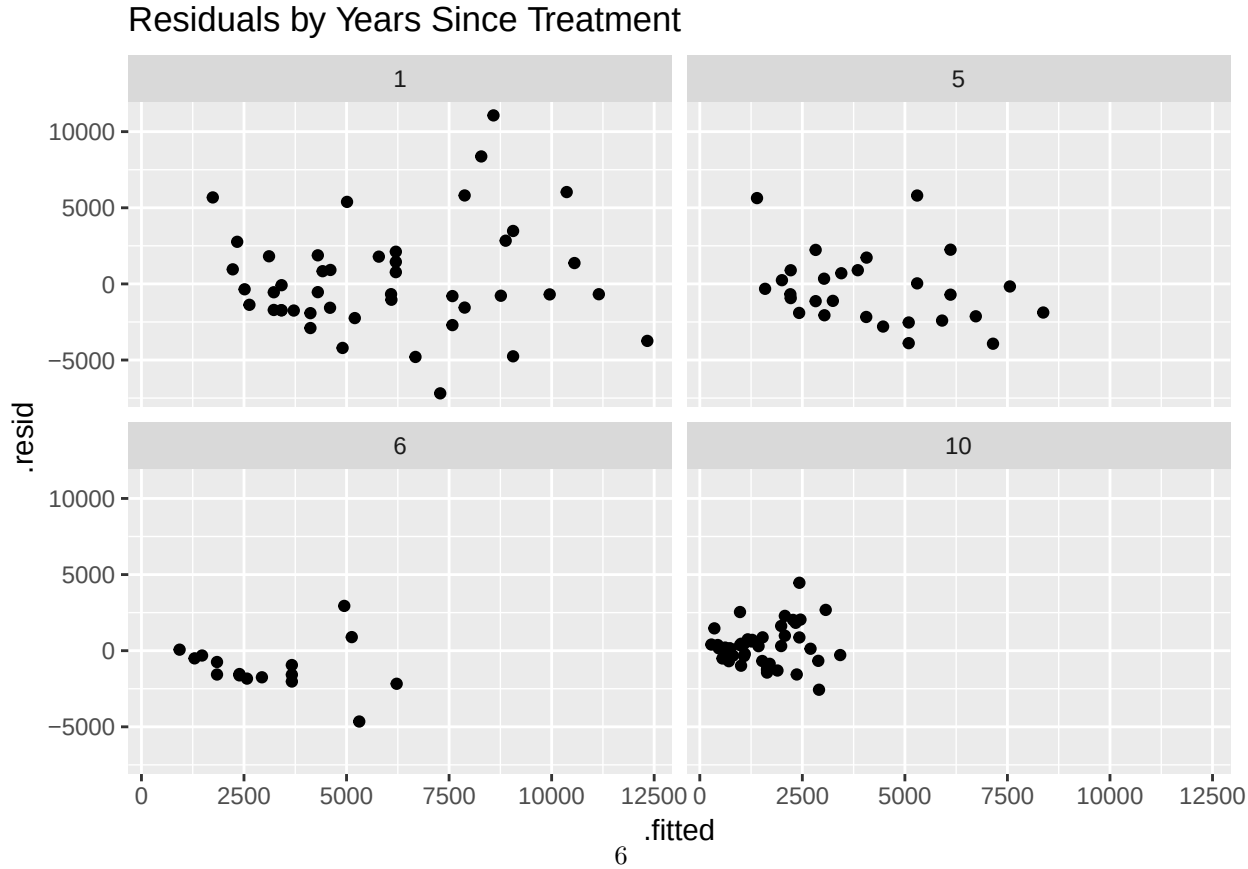
Inferences

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: dwd_1hr ~ pre_tree_cvr + yst + pre_tree_cvr:yst + (1 | site)
##    Data: d
##
## REML criterion at convergence: 2442
##
## Scaled residuals:
##    Min     1Q Median     3Q    Max
## -2.817 -0.611 -0.125  0.352  4.337
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  site     (Intercept)   27285   165
##  Residual             6510676  2552
## Number of obs: 134, groups:  site, 3
##
## Fixed effects:
##                  Estimate Std. Error t value
## (Intercept)        864.86     861.66    1.00
## pre_tree_cvr       320.50      43.38    7.39
## yst                -92.91     129.72   -0.72
## pre_tree_cvr:yst   -23.00       6.59   -3.49
##
## Correlation of Fixed Effects:
##             (Intr) pr_tr_ yst
## pre_tre_cvr -0.883
## yst         -0.823  0.736
## pr_tr_cvr:y  0.730 -0.827 -0.888
```

```
##                  estimate     se  lower  upper tvalue  df   pvalue
## (Intercept)         864.9 861.66 -824.0 2553.7  1.004 Inf 3.16e-01
## pre_tree_cvr        320.5  43.38  235.5  405.5  7.389 Inf 1.48e-13
## yst                 -92.9 129.72 -347.2  161.3 -0.716 Inf 4.74e-01
## pre_tree_cvr:yst    -23.0   6.59  -35.9  -10.1 -3.491 Inf 4.82e-04
```

QQPlot and Plotted Residuals

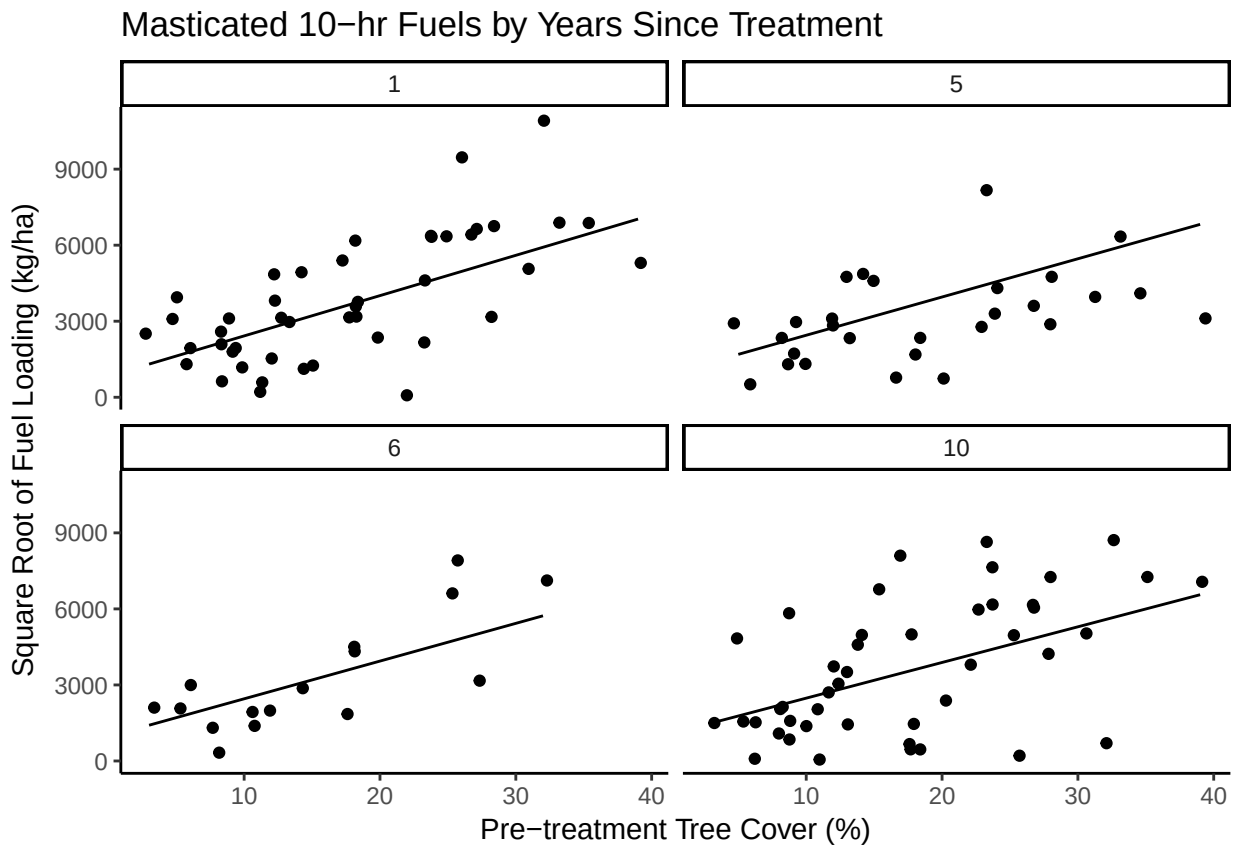




Masticated 10-hr fuels

Model

```
m <- lmer(dwd_10hr ~ pre_tree_cvr + yst + pre_tree_cvr:yst +
            (1|site), data = d)
```

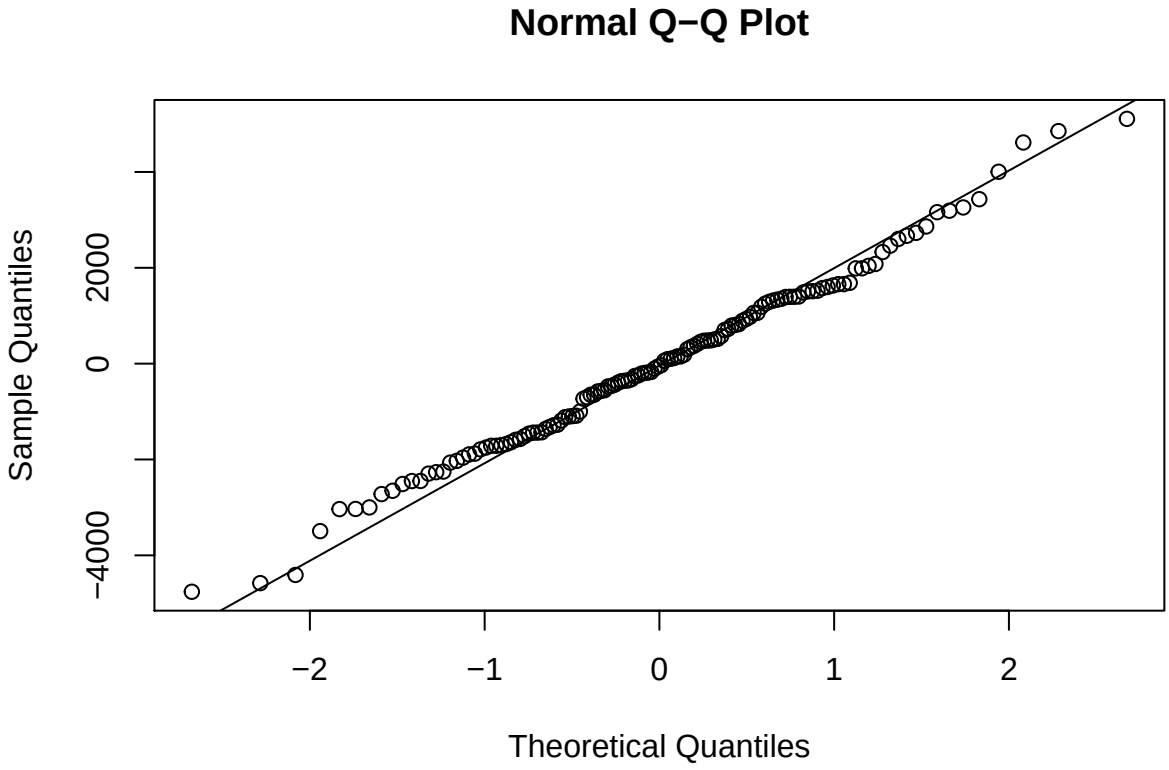


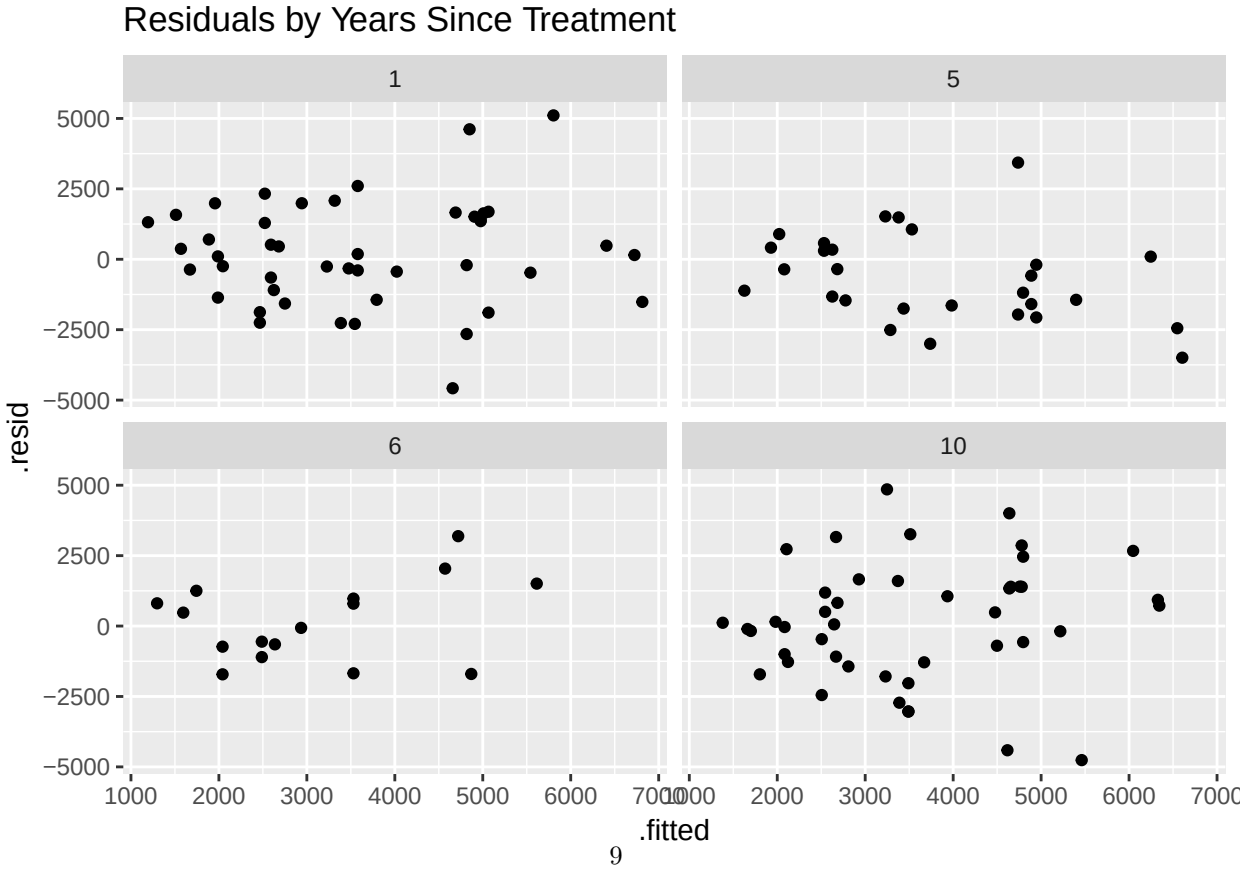
Inferences

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: dwd_10hr ~ pre_tree_cvr + yst + pre_tree_cvr:yst + (1 | site)
##    Data: d
##
## REML criterion at convergence: 2368
##
## Scaled residuals:
##    Min     1Q Median     3Q    Max
## -2.505 -0.745 -0.026  0.700  2.688
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  site     (Intercept)  135768   368
##  Residual             3611869  1900
## Number of obs: 134, groups:  site, 3
##
## Fixed effects:
##                  Estimate Std. Error t value
## (Intercept)        804.18     673.60    1.19
## pre_tree_cvr       160.98      32.39    4.97
## yst                 26.75      96.64    0.28
## pre_tree_cvr:yst    -2.02       4.91   -0.41
##
## Correlation of Fixed Effects:
##             (Intr) pr_tr_ yst
## pre_tre_cvr -0.844
## yst         -0.783  0.733
## pr_tr_cvr:y  0.695 -0.825 -0.888
```

```
##                  estimate     se  lower   upper tvalue  df   pvalue
## (Intercept)        804.18 673.60 -516.1 2124.42  1.194 Inf 2.33e-01
## pre_tree_cvr       160.98  32.39   97.5  224.48  4.970 Inf 6.71e-07
## yst                 26.75  96.64 -162.6  216.15  0.277 Inf 7.82e-01
## pre_tree_cvr:yst    -2.02   4.91  -11.6    7.59 -0.413 Inf 6.80e-01
```

QQPlot and Plotted Residuals

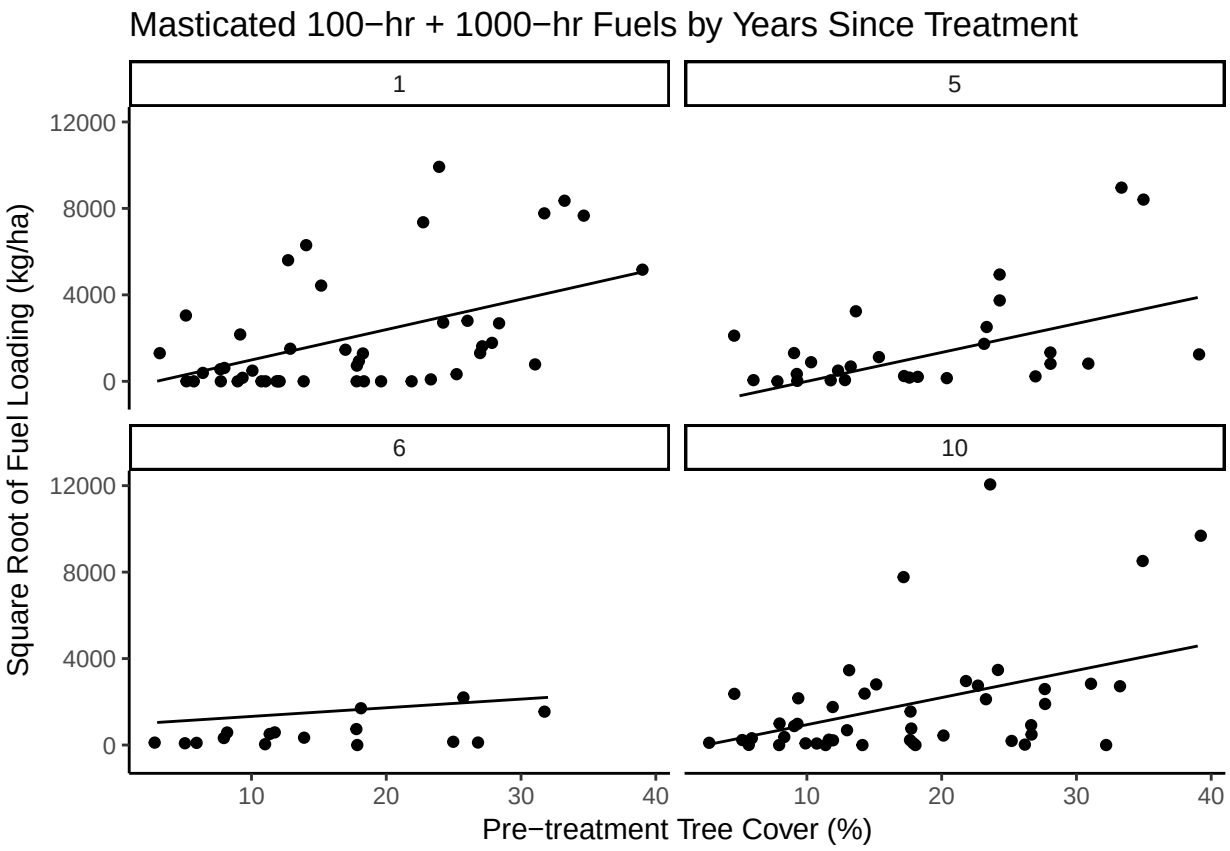




Masticated 100 + 1000-hr fuels

Model

```
m <- lmer(dwd_100_1000hr ~ pre_tree_cvr + factor(yst) + pre_tree_cvr:factor(yst) +
            (1|site), data = d)
```



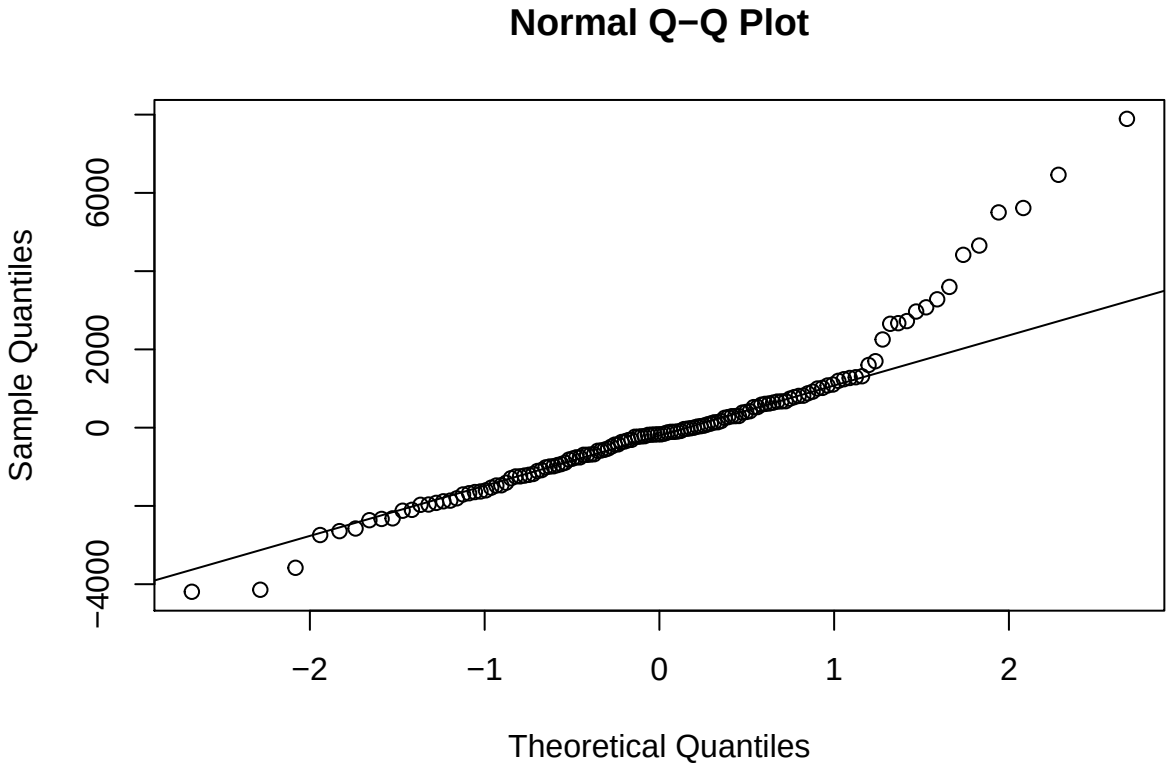
Inferences

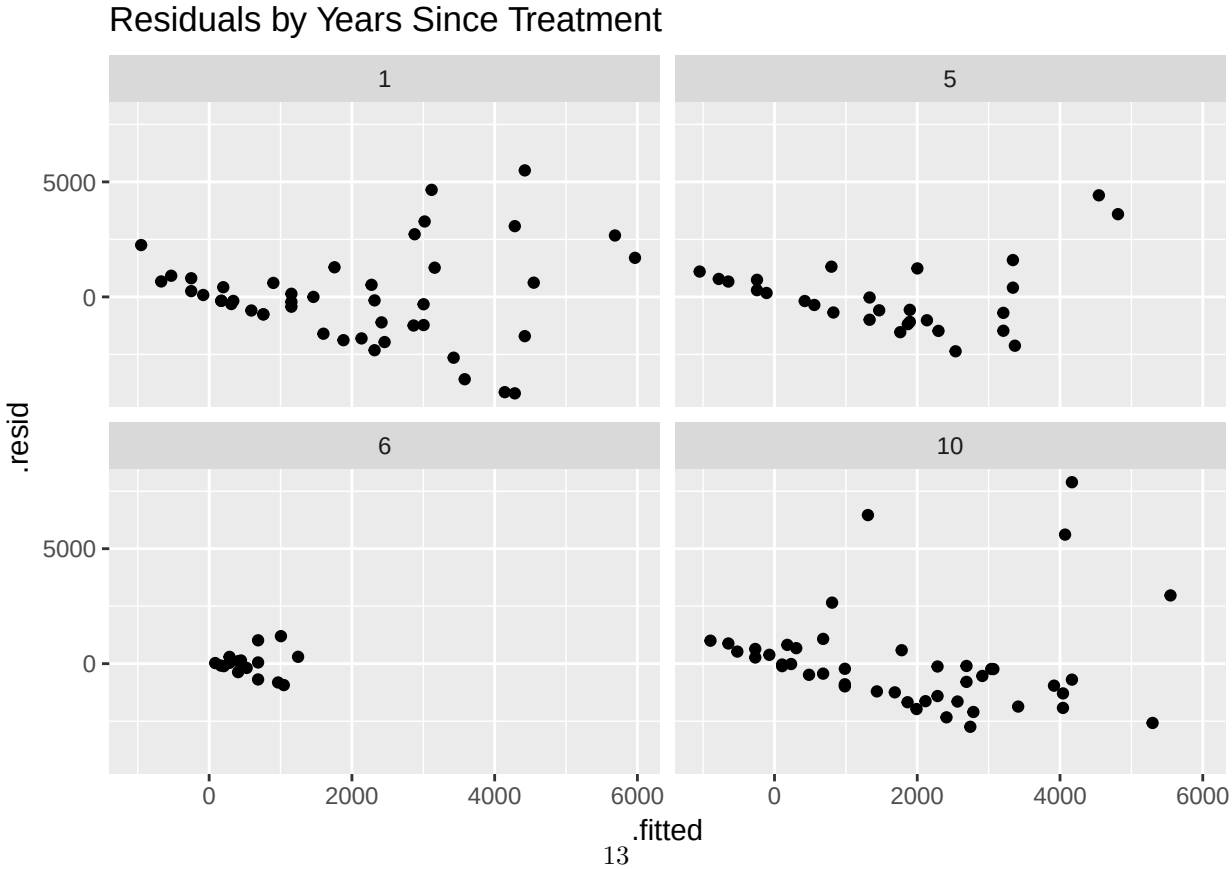
```
## Linear mixed model fit by REML ['lmerMod']
## Formula:
## dwd_100_1000hr ~ pre_tree_cvr + factor(yst) + pre_tree_cvr:factor(yst) +
##     (1 | site)
##    Data: d
##
## REML criterion at convergence: 2315
##
## Scaled residuals:
##    Min     1Q Median     3Q    Max
## -2.168 -0.552 -0.088  0.341  4.080
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  site     (Intercept) 1769357  1330
##  Residual             3740175  1934
## Number of obs: 134, groups:  site, 3
##
## Fixed effects:
##                             Estimate Std. Error t value
## (Intercept)                   -414.5      995.5   -0.42
## pre_tree_cvr                   140.3       32.2    4.36
## factor(yst)5                  -926.5     1060.5   -0.87
## factor(yst)6                  1338.4     1188.5    1.13
## factor(yst)10                   99.5      887.5    0.11
## pre_tree_cvr:factor(yst)5       -6.5       51.0   -0.13
## pre_tree_cvr:factor(yst)6    -100.3       65.6   -1.53
## pre_tree_cvr:factor(yst)10    -14.8       45.1   -0.33
##
## Correlation of Fixed Effects:
##             (Intr) pr_tr_ fct()5 fct()6 fc()10 p__:()5 p__:()6
## pre_tre_cvr -0.566
## factr(yst)5 -0.391  0.549
## factr(yst)6 -0.319  0.443  0.278
## fctr(yst)10 -0.446  0.622  0.418  0.373
## pr_tr_c:()5  0.357 -0.630 -0.888 -0.279 -0.392
## pr_tr_c:()6  0.278 -0.491 -0.269 -0.851 -0.305  0.309
## pr_tr_:()10  0.396 -0.701 -0.372 -0.332 -0.888  0.442   0.344
```

```
##                             estimate     se   lower  upper tvalue  df
## (Intercept)                   -414.5  995.5 -2365.7 1536.7 -0.416 Inf
## pre_tree_cvr                   140.3   32.2    77.3  203.4  4.362 Inf
## factor(yst)5                  -926.5 1060.5 -3005.1 1152.2 -0.874 Inf
## factor(yst)6                  1338.4 1188.5  -991.0 3667.8  1.126 Inf
## factor(yst)10                   99.5  887.6 -1640.1 1839.0  0.112 Inf
## pre_tree_cvr:factor(yst)5       -6.5   51.0  -106.5   93.5 -0.127 Inf
## pre_tree_cvr:factor(yst)6    -100.3   65.6  -228.8   28.2 -1.530 Inf
## pre_tree_cvr:factor(yst)10    -14.8   45.1  -103.1   73.6 -0.328 Inf
##                               pvalue
## (Intercept)                 6.77e-01
## pre_tree_cvr                1.29e-05
## factor(yst)5                3.82e-01
```

```
## factor(yst)6               2.60e-01
## factor(yst)10              9.11e-01
## pre_tree_cvr:factor(yst)5  8.99e-01
## pre_tree_cvr:factor(yst)6  1.26e-01
## pre_tree_cvr:factor(yst)10 7.43e-01
```

QQPlot and Plotted Residuals





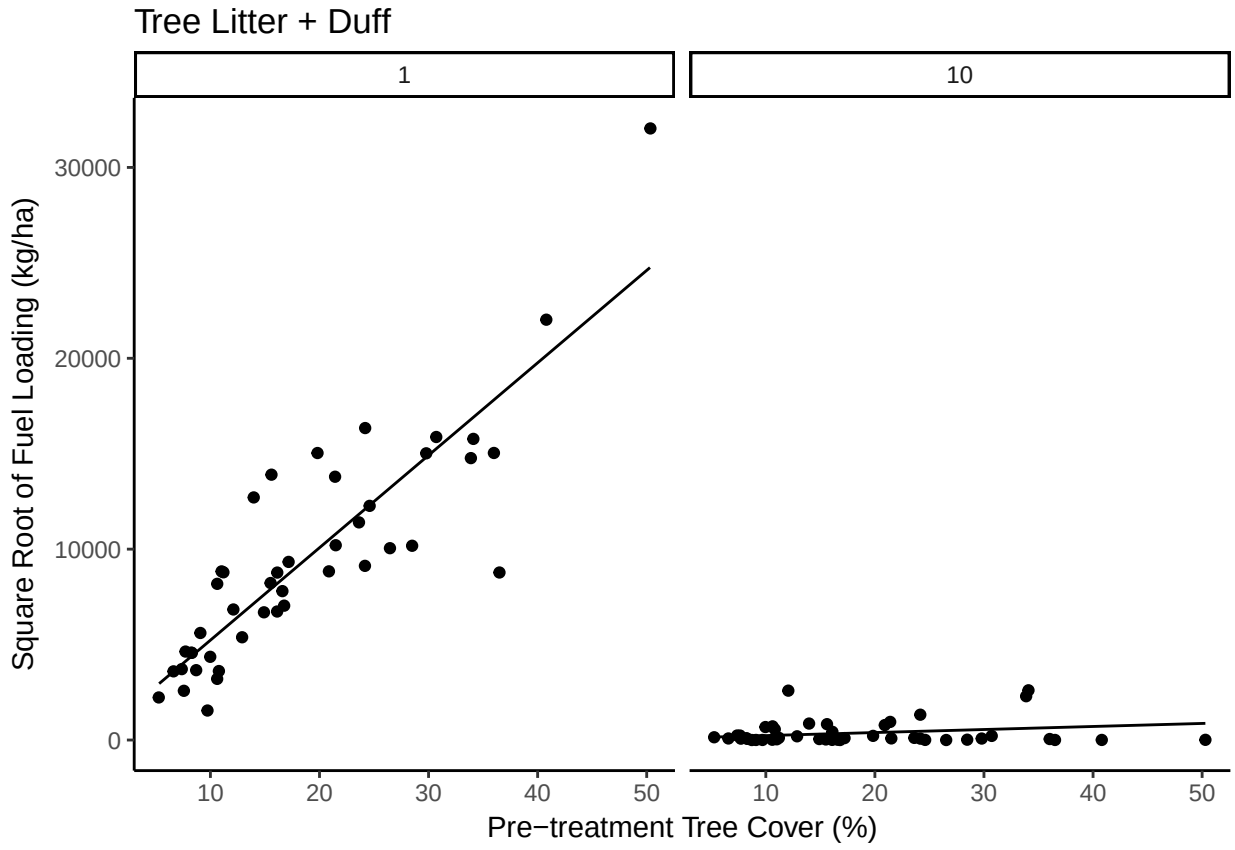
Tree Litter + Duff Fuels

Notes

In model code, 'duff' refers to tree litter + duff.

Model

```
m <- lmer(duff ~ factor(yst) + pre_tree_cvr + factor(yst):pre_tree_cvr +
            (1|site), data = d)
```

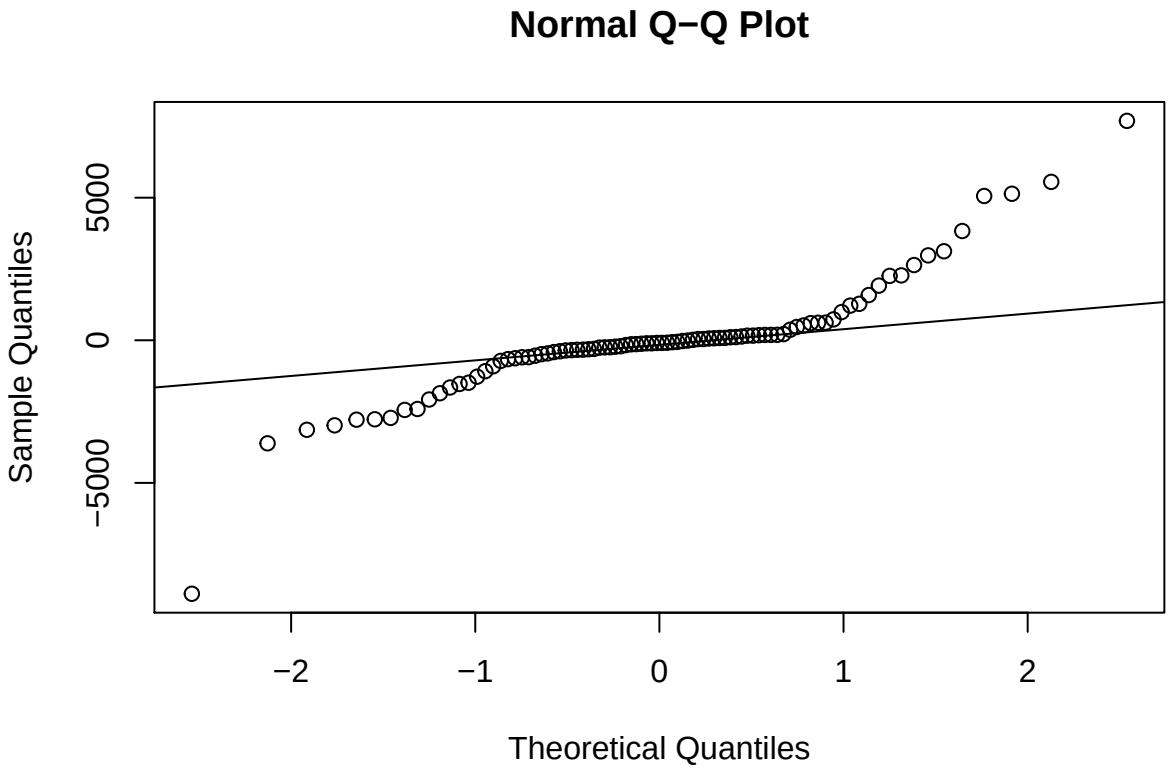


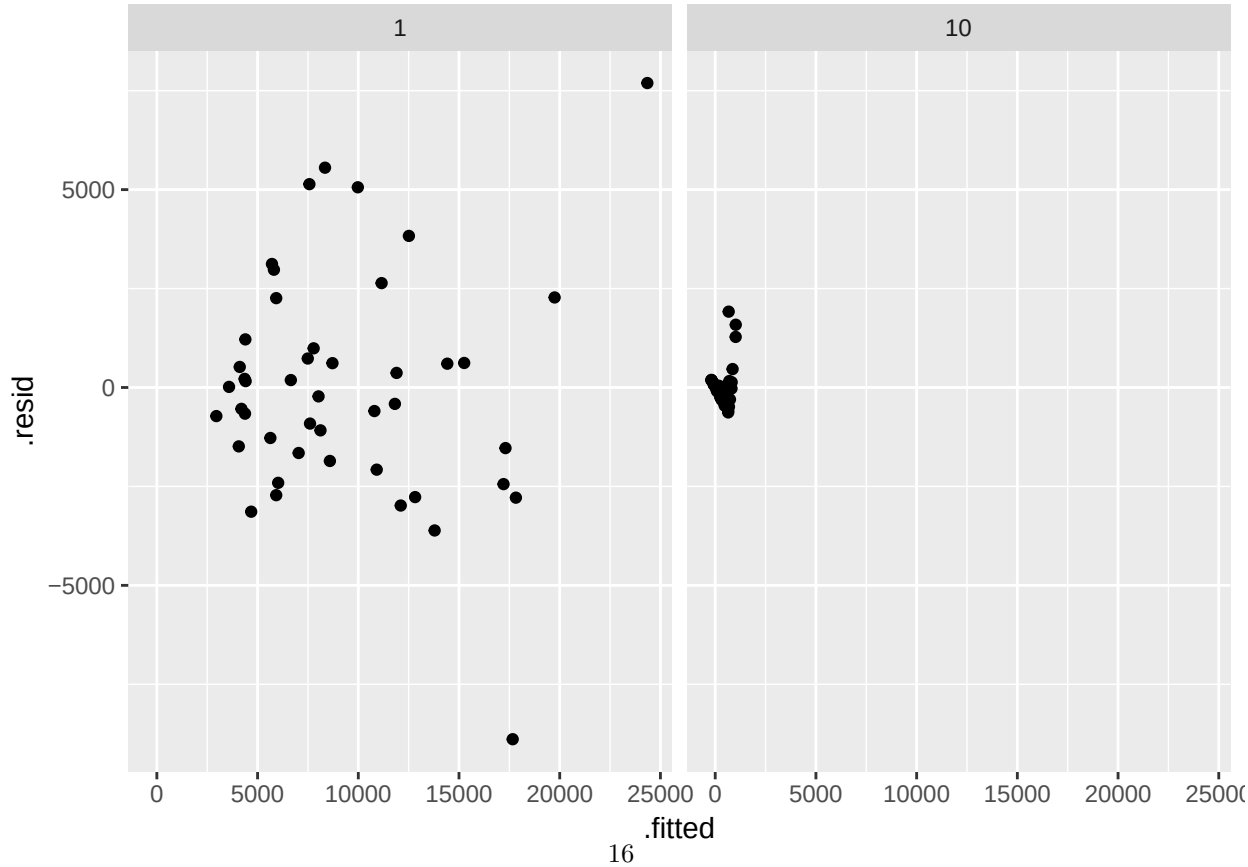
Inferences

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: duff ~ factor(yst) + pre_tree_cvr + factor(yst):pre_tree_cvr +
##     (1 | site)
##    Data: d
##
## REML criterion at convergence: 1586
##
## Scaled residuals:
##    Min     1Q Median     3Q    Max
## -4.233 -0.251 -0.044  0.100  3.664
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  site     (Intercept)  259789   510
##  Residual             4409367  2100
## Number of obs: 90, groups:  site, 3
##
## Fixed effects:
##                             Estimate Std. Error t value
## (Intercept)                    387.0      715.3    0.54
## factor(yst)10                 -314.6      907.8   -0.35
## pre_tree_cvr                   484.4       30.6   15.82
## factor(yst)10:pre_tree_cvr    -468.5       42.6  -11.01
##
## Correlation of Fixed Effects:
##             (Intr) fc()10 pr_tr_
## fctr(yst)10 -0.635
## pre_tre_cvr -0.799  0.607
## fctr()10:__  0.554 -0.873 -0.695
```

```
##                             estimate    se lower upper  tvalue  df   pvalue
## (Intercept)                      387 715.3 -1015  1789   0.541 Inf 5.88e-01
## factor(yst)10                   -315 907.8 -2094  1465  -0.347 Inf 7.29e-01
## pre_tree_cvr                     484  30.6   424   544  15.821 Inf 2.23e-56
## factor(yst)10:pre_tree_cvr      -468  42.6  -552  -385 -11.006 Inf 3.58e-28
```

QQPlot and Plotted Residuals





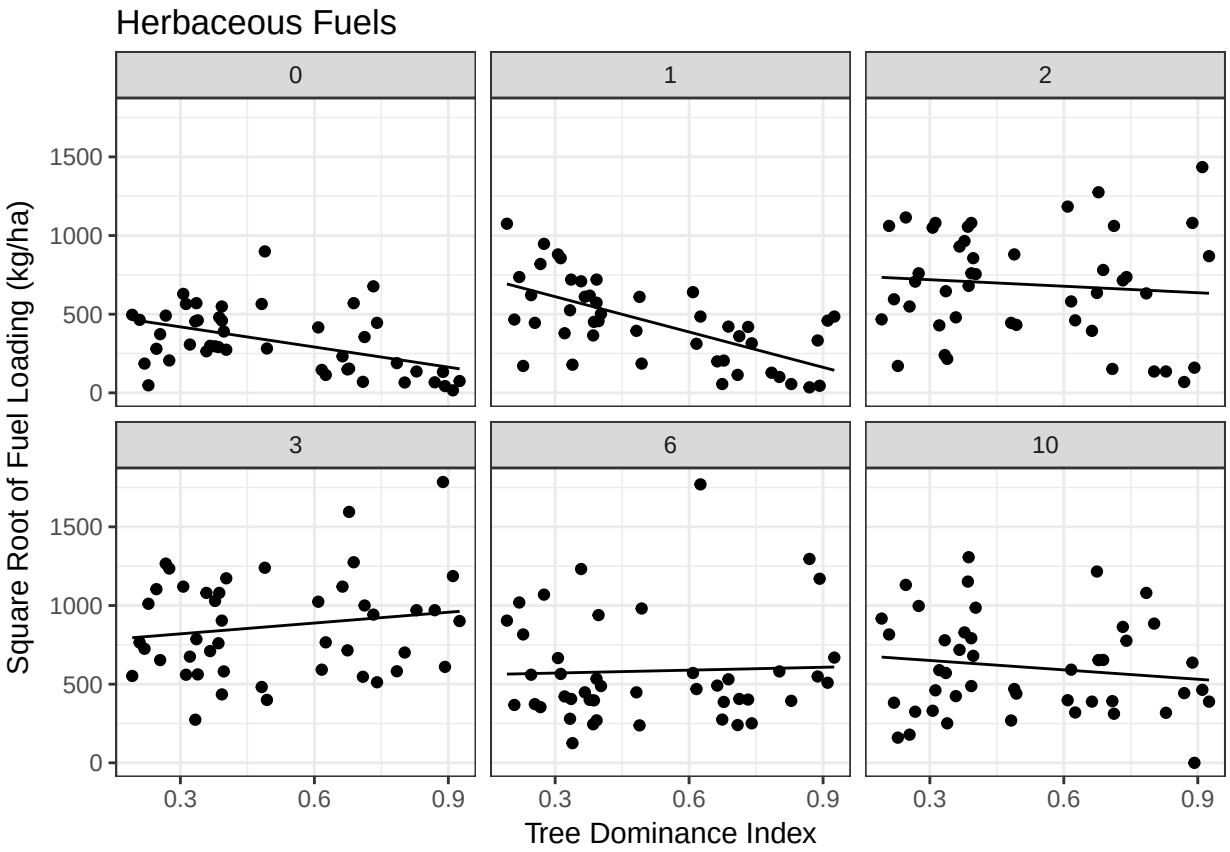
Herbaceous fuel loading (live + dead)

Notes:

*Investigate value of zero at Onaqui, yst = 10

Model

```
m <- lmer(herb_ttl ~ TDI + factor(yst) + factor(yst):TDI +
            (1|site), data = l)
```



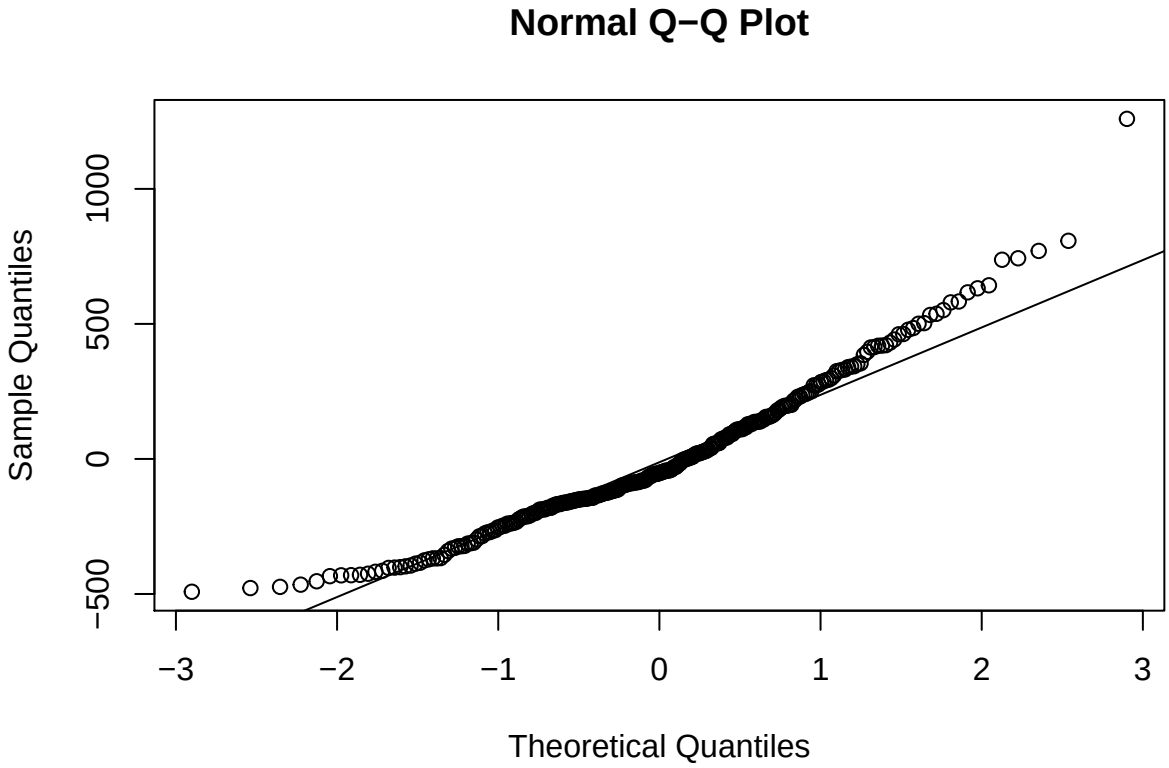
Inferences

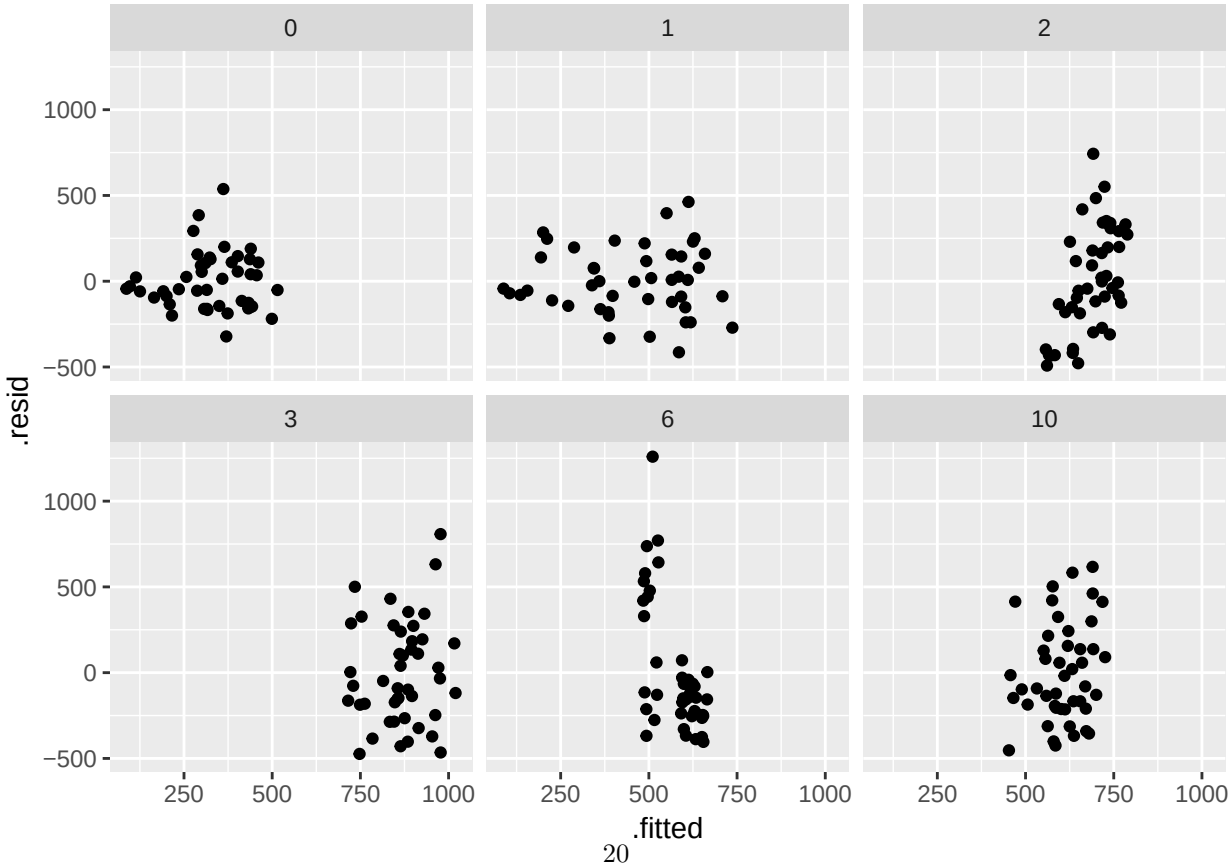
```
## Linear mixed model fit by REML ['lmerMod']
## Formula: herb_ttl ~ TDI + factor(yst) + factor(yst):TDI + (1 | site)
##    Data: l
##
## REML criterion at convergence: 3667
##
## Scaled residuals:
##    Min     1Q Median     3Q    Max
## -1.723 -0.633 -0.179  0.547  4.411
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  site     (Intercept)  5861     76.6
##  Residual             81480    285.4
## Number of obs: 269, groups:  site, 3
##
## Fixed effects:
##                   Estimate Std. Error t value
## (Intercept)         547.16     114.66    4.77
## TDI                -426.38     188.52   -2.26
## factor(yst)1        288.86     149.45    1.93
## factor(yst)2        213.24     149.45    1.43
## factor(yst)3        204.08     149.45    1.37
## factor(yst)6          5.11     149.88    0.03
## factor(yst)10       162.97     149.45    1.09
## TDI:factor(yst)1   -322.19     266.35   -1.21
## TDI:factor(yst)2    288.60     266.35    1.08
## TDI:factor(yst)3    655.12     266.35    2.46
## TDI:factor(yst)6    487.63     268.61    1.82
## TDI:factor(yst)10   227.60     266.35    0.85
##
## Correlation of Fixed Effects:
##             (Intr) TDI    fct()1 fct()2 fct()3 fct()6 fc()10 TDI:f()1
## TDI         -0.845
## factr(yst)1 -0.652  0.647
## factr(yst)2 -0.652  0.647  0.500
## factr(yst)3 -0.652  0.647  0.500  0.500
## factr(yst)6 -0.650  0.645  0.499  0.499  0.499
## fctr(yst)10 -0.652  0.647  0.500  0.500  0.500  0.499
## TDI:fctr()1  0.597 -0.706 -0.915 -0.458 -0.458 -0.456 -0.458
## TDI:fctr()2  0.597 -0.706 -0.458 -0.915 -0.458 -0.456 -0.458  0.500
## TDI:fctr()3  0.597 -0.706 -0.458 -0.458 -0.915 -0.456 -0.458  0.500
## TDI:fctr()6  0.591 -0.700 -0.454 -0.454 -0.454 -0.915 -0.454  0.496
## TDI:fct()10  0.597 -0.706 -0.458 -0.458 -0.458 -0.456 -0.915  0.500
##             TDI:()2 TDI:()3 TDI:()6
## TDI
## factr(yst)1
## factr(yst)2
## factr(yst)3
## factr(yst)6
## fctr(yst)10
## TDI:fctr()1
```

```
## TDI:fctr()2
## TDI:fctr()3  0.500
## TDI:fctr()6  0.496   0.496
## TDI:fct()10  0.500   0.500   0.496
```

```
##                   estimate  se   lower  upper  tvalue  df   pvalue
## (Intercept)         547.16 115  322.43  771.9  4.7719 Inf 1.83e-06
## TDI                -426.38 189 -795.88  -56.9 -2.2617 Inf 2.37e-02
## factor(yst)1        288.86 149   -4.06  581.8  1.9328 Inf 5.33e-02
## factor(yst)2        213.24 149  -79.68  506.2  1.4268 Inf 1.54e-01
## factor(yst)3        204.08 149  -88.84  497.0  1.3655 Inf 1.72e-01
## factor(yst)6          5.11 150 -288.65  298.9  0.0341 Inf 9.73e-01
## factor(yst)10       162.97 149 -129.95  455.9  1.0904 Inf 2.76e-01
## TDI:factor(yst)1   -322.19 266 -844.23  199.9 -1.2096 Inf 2.26e-01
## TDI:factor(yst)2    288.60 266 -233.44  810.6  1.0835 Inf 2.79e-01
## TDI:factor(yst)3    655.12 266  133.08 1177.2  2.4596 Inf 1.39e-02
## TDI:factor(yst)6    487.63 269  -38.84 1014.1  1.8154 Inf 6.95e-02
## TDI:factor(yst)10   227.60 266 -294.44  749.6  0.8545 Inf 3.93e-01
```

QQPlot and Residuals





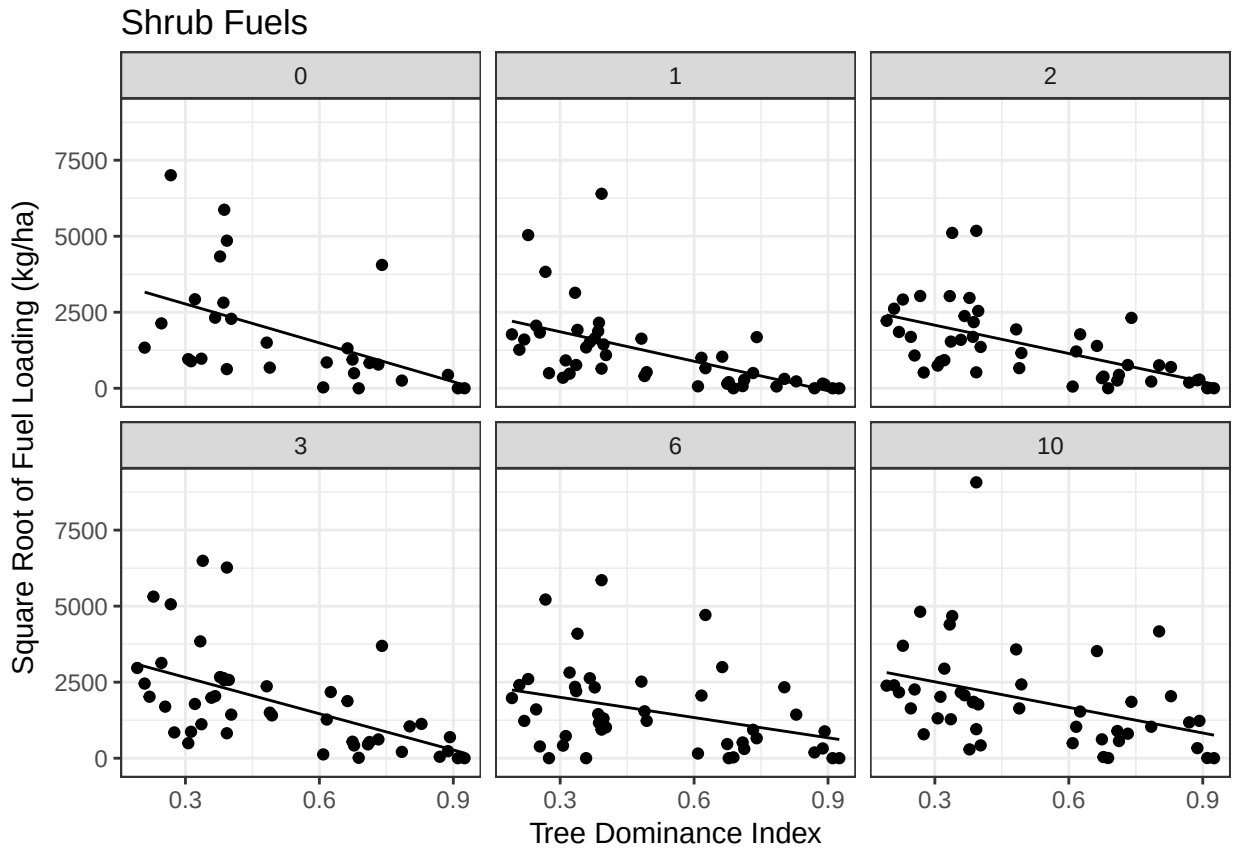
Shrub Fuels

*Data error: two values of zero at Years since treatment = 6 & TDI ~ 0.3; zero values are incorrect (JP-ON-GC-006, JP-ON-GC-010 have high shrub volumes but zero biomass)

*Missing data: no shrub data for Onaqui when YST = 0 (calendar year = 2006)

Model

```
m <- lmer(shrub_fuel ~ TDI + factor(yst) + factor(yst):TDI +
            (1|site), data = l2)
```



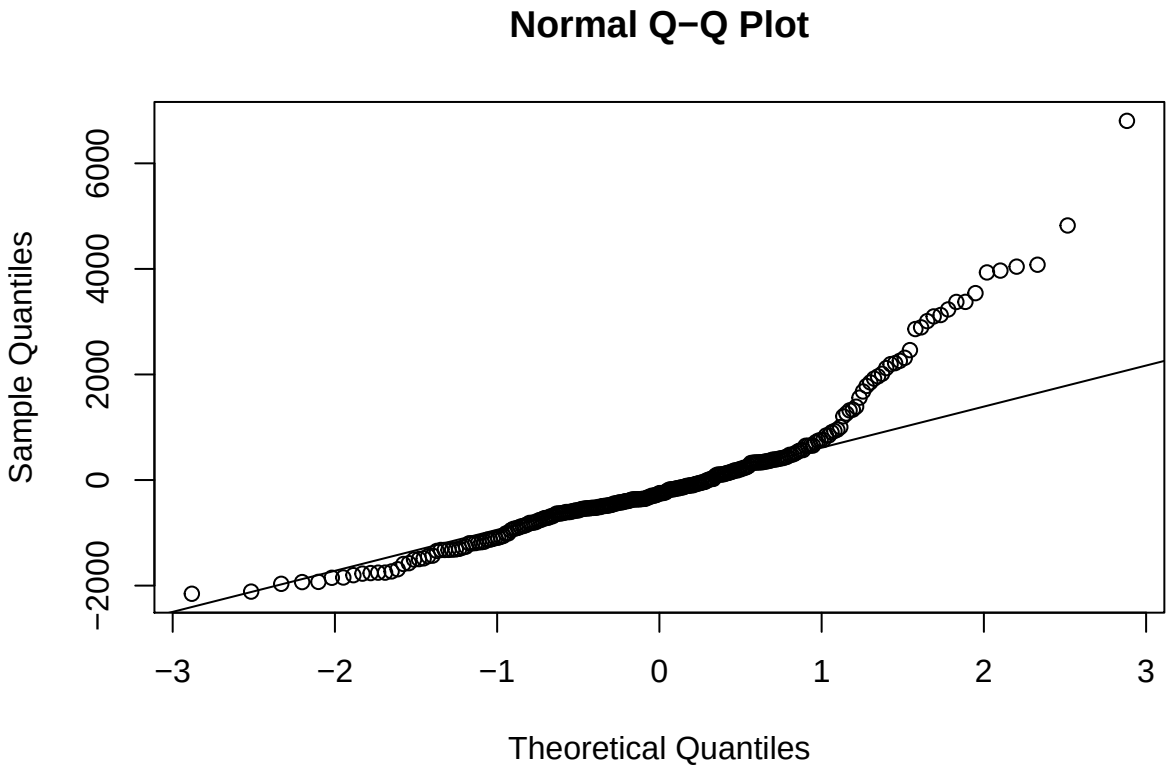
Inferences

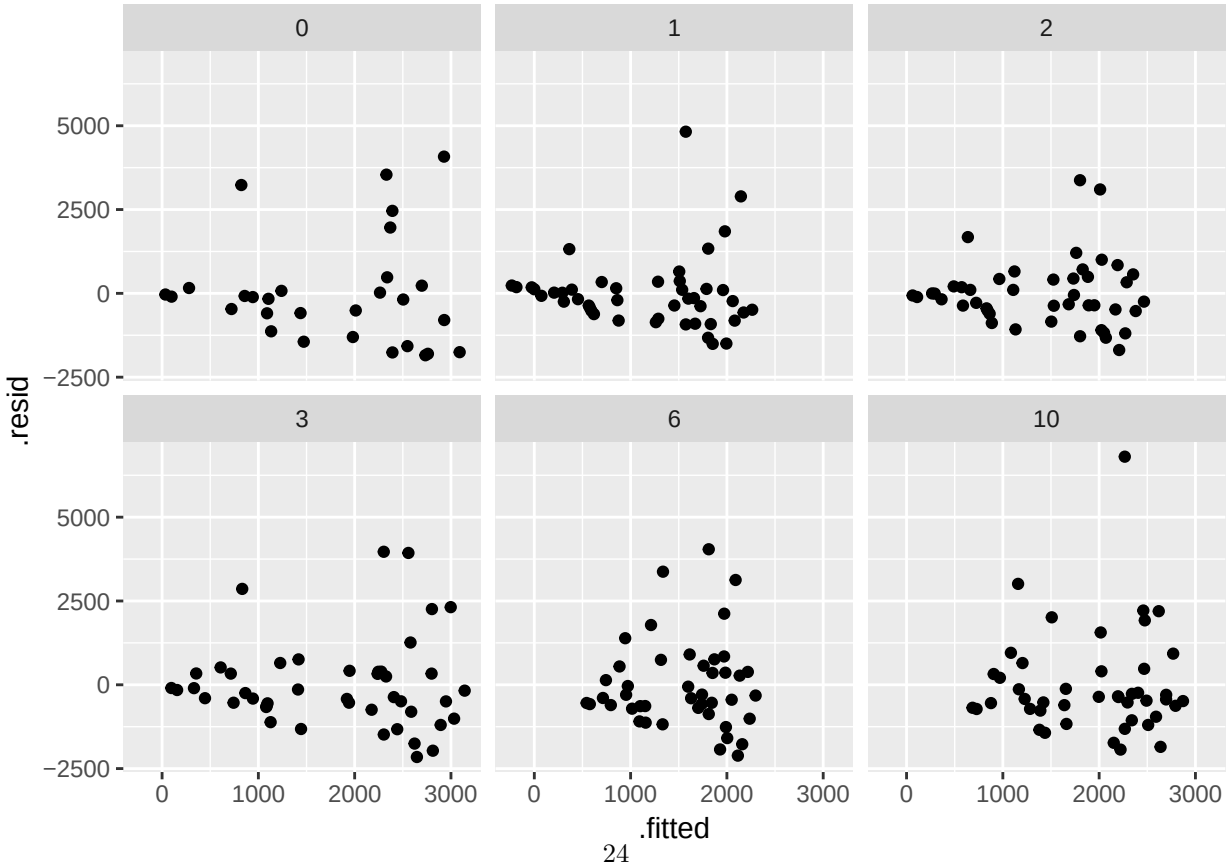
```
## Linear mixed model fit by REML ['lmerMod']
## Formula: shrub_fuel ~ TDI + factor(yst) + factor(yst):TDI + (1 | site)
##    Data: l2
##
## REML criterion at convergence: 4180
##
## Scaled residuals:
##    Min     1Q Median     3Q    Max
## -1.614 -0.516 -0.186  0.270  5.097
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  site     (Intercept)   12063   110
##  Residual             1782497  1335
## Number of obs: 253, groups:  site, 3
##
## Fixed effects:
##                   Estimate Std. Error t value
## (Intercept)           4052        672    6.03
## TDI                  -4265       1175   -3.63
## factor(yst)1         -1225        832   -1.47
## factor(yst)2         -1046        832   -1.26
## factor(yst)3          -201        832   -0.24
## factor(yst)6         -1384        833   -1.66
## factor(yst)10         -698        832   -0.84
## TDI:factor(yst)1      1034       1468    0.70
## TDI:factor(yst)2      1162       1468    0.79
## TDI:factor(yst)3       285       1468    0.19
## TDI:factor(yst)6      2046       1477    1.38
## TDI:factor(yst)10     1458       1468    0.99
##
## Correlation of Fixed Effects:
##             (Intr) TDI    fct()1 fct()2 fct()3 fct()6 fc()10 TDI:f()1
## TDI         -0.923
## factr(yst)1 -0.801  0.745
## factr(yst)2 -0.801  0.745  0.647
## factr(yst)3 -0.801  0.745  0.647  0.647
## factr(yst)6 -0.799  0.743  0.646  0.646  0.646
## fctr(yst)10 -0.801  0.745  0.647  0.647  0.647  0.646
## TDI:fctr()1  0.739 -0.800 -0.923 -0.597 -0.597 -0.595 -0.597
## TDI:fctr()2  0.739 -0.800 -0.597 -0.923 -0.597 -0.595 -0.597  0.640
## TDI:fctr()3  0.739 -0.800 -0.597 -0.597 -0.923 -0.595 -0.597  0.640
## TDI:fctr()6  0.734 -0.795 -0.593 -0.593 -0.593 -0.922 -0.593  0.636
## TDI:fct()10  0.739 -0.800 -0.597 -0.597 -0.597 -0.595 -0.923  0.640
##             TDI:()2 TDI:()3 TDI:()6
## TDI
## factr(yst)1
## factr(yst)2
## factr(yst)3
## factr(yst)6
## fctr(yst)10
## TDI:fctr()1
```

```
## TDI:fctr()2
## TDI:fctr()3  0.640
## TDI:fctr()6  0.636   0.636
## TDI:fct()10  0.640   0.640   0.636
```

```
##                    estimate   se lower upper tvalue  df   pvalue
## (Intercept)            4052  672  2735  5368  6.033 Inf 1.61e-09
## TDI                   -4265 1175 -6568 -1961 -3.629 Inf 2.84e-04
## factor(yst)1          -1225  832 -2855   406 -1.472 Inf 1.41e-01
## factor(yst)2          -1047  832 -2677   584 -1.258 Inf 2.08e-01
## factor(yst)3           -201  832 -1832  1429 -0.242 Inf 8.09e-01
## factor(yst)6          -1384  833 -3017   250 -1.660 Inf 9.68e-02
## factor(yst)10          -698  832 -2329   932 -0.839 Inf 4.01e-01
## TDI:factor(yst)1       1034 1468 -1845  3912  0.704 Inf 4.81e-01
## TDI:factor(yst)2       1162 1468 -1716  4040  0.791 Inf 4.29e-01
## TDI:factor(yst)3        285 1468 -2594  3163  0.194 Inf 8.46e-01
## TDI:factor(yst)6       2046 1477  -850  4941  1.385 Inf 1.66e-01
## TDI:factor(yst)10      1458 1468 -1420  4336  0.993 Inf 3.21e-01
```

QQPlot and Residuals





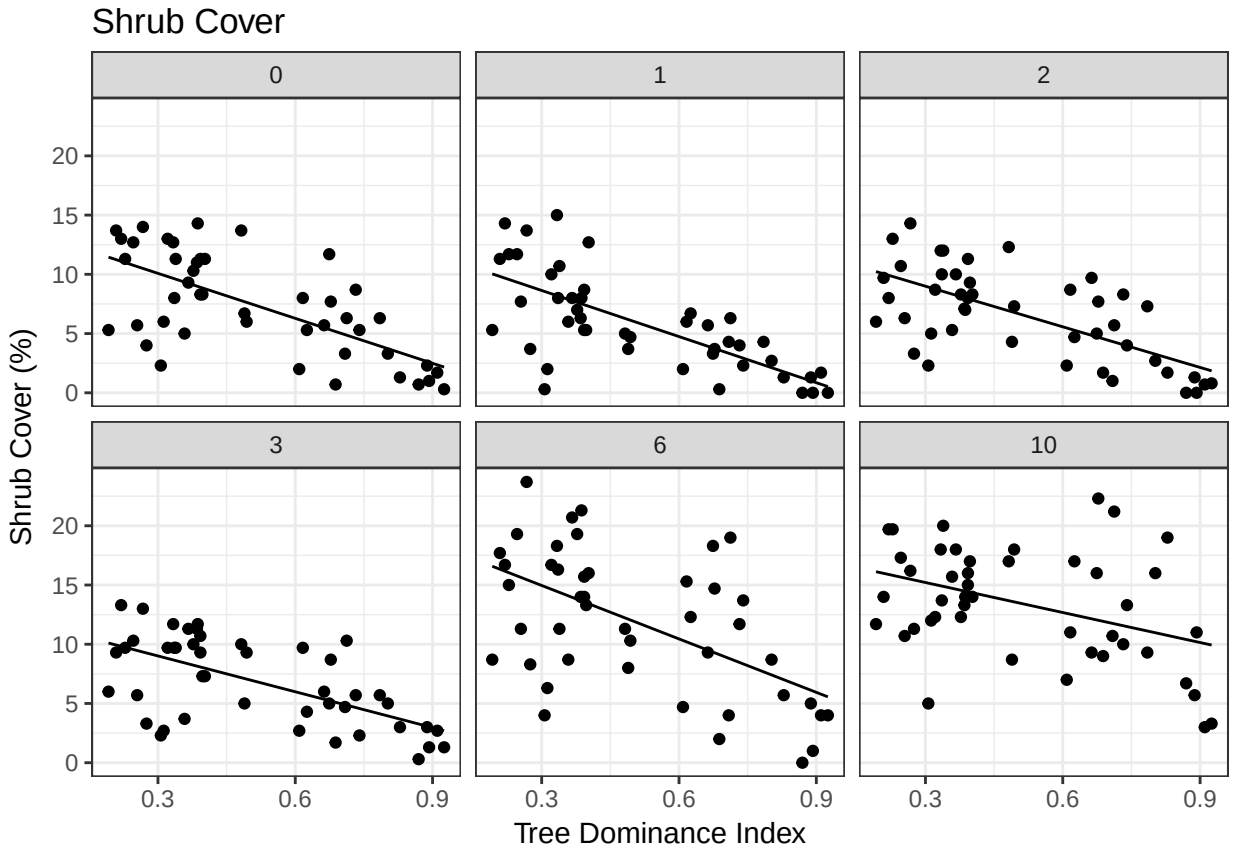
Shrub Cover

Notes

Shrub cover increase when yst = 6 for site = SC & GR but decrease in herb biomass

Model

```
m <- lmer(can_cover_pt_shrub ~ TDI + factor(yst) + factor(yst):TDI +
            (1|site), data = l)
```



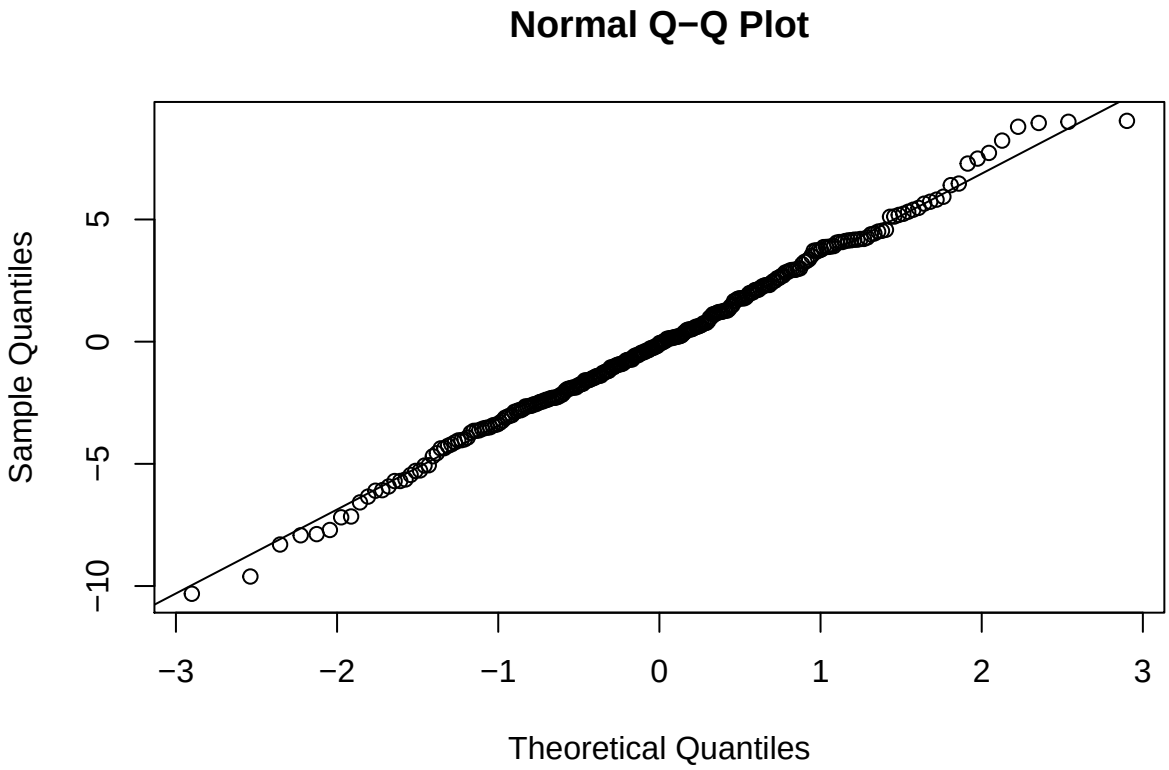
Inferences

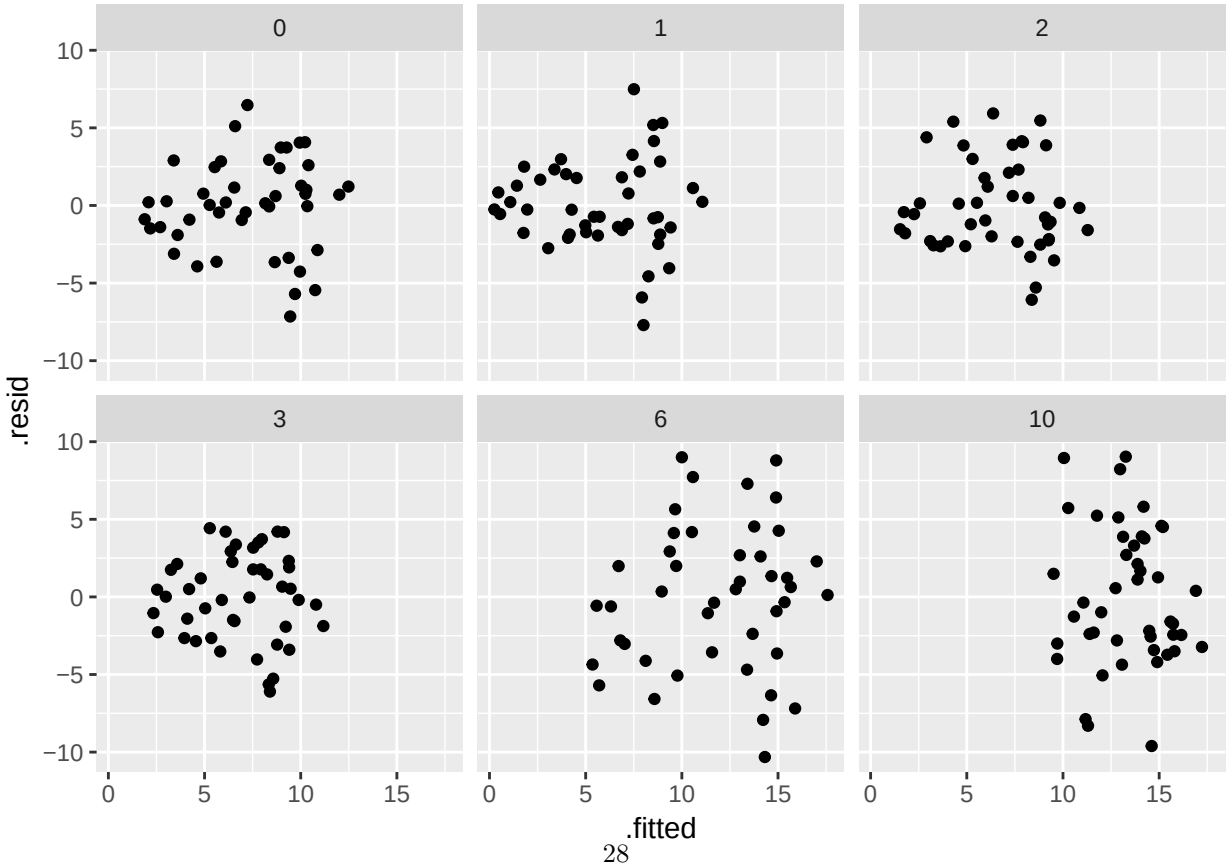
```
## Linear mixed model fit by REML ['lmerMod']
## Formula: can_cover_pt_shrub ~ TDI + factor(yst) + factor(yst):TDI + (1 |
##     site)
##    Data: l
##
## REML criterion at convergence: 1419
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -2.8711 -0.6439 -0.0168  0.6460  2.5146
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  site     (Intercept)  1.3     1.14
##  Residual             12.9     3.59
## Number of obs: 269, groups:  site, 3
##
## Fixed effects:
##                   Estimate Std. Error t value
## (Intercept)         13.879      1.485    9.35
## TDI                -12.657      2.373   -5.33
## factor(yst)1        -1.350      1.881   -0.72
## factor(yst)2        -1.452      1.881   -0.77
## factor(yst)3        -1.843      1.881   -0.98
## factor(yst)6         5.591      1.887    2.96
## factor(yst)10        3.866      1.881    2.06
## TDI:factor(yst)1    -0.318      3.353   -0.09
## TDI:factor(yst)2     1.227      3.353    0.37
## TDI:factor(yst)3     2.575      3.353    0.77
## TDI:factor(yst)6    -2.379      3.381   -0.70
## TDI:factor(yst)10    4.211      3.353    1.26
##
## Correlation of Fixed Effects:
##             (Intr) TDI    fct()1 fct()2 fct()3 fct()6 fc()10 TDI:f()1
## TDI         -0.821
## factr(yst)1 -0.633  0.647
## factr(yst)2 -0.633  0.647  0.500
## factr(yst)3 -0.633  0.647  0.500  0.500
## factr(yst)6 -0.631  0.645  0.499  0.499  0.499
## fctr(yst)10 -0.633  0.647  0.500  0.500  0.500  0.499
## TDI:fctr()1  0.580 -0.706 -0.915 -0.458 -0.458 -0.456 -0.458
## TDI:fctr()2  0.580 -0.706 -0.458 -0.915 -0.458 -0.456 -0.458  0.500
## TDI:fctr()3  0.580 -0.706 -0.458 -0.458 -0.915 -0.456 -0.458  0.500
## TDI:fctr()6  0.575 -0.700 -0.454 -0.454 -0.454 -0.915 -0.454  0.496
## TDI:fct()10  0.580 -0.706 -0.458 -0.458 -0.458 -0.456 -0.915  0.500
##             TDI:()2 TDI:()3 TDI:()6
## TDI
## factr(yst)1
## factr(yst)2
## factr(yst)3
## factr(yst)6
## fctr(yst)10
```

```
## TDI:fctr()1
## TDI:fctr()2
## TDI:fctr()3  0.500
## TDI:fctr()6  0.496   0.496
## TDI:fct()10  0.500   0.500   0.496
```

```
##                    estimate   se   lower upper  tvalue  df   pvalue
## (Intercept)          13.879 1.49  10.968 16.79  9.3453 Inf 9.17e-21
## TDI                 -12.657 2.37 -17.308 -8.01 -5.3334 Inf 9.64e-08
## factor(yst)1         -1.350 1.88  -5.037  2.34 -0.7178 Inf 4.73e-01
## factor(yst)2         -1.452 1.88  -5.139  2.23 -0.7719 Inf 4.40e-01
## factor(yst)3         -1.843 1.88  -5.530  1.84 -0.9796 Inf 3.27e-01
## factor(yst)6          5.591 1.89   1.893  9.29  2.9636 Inf 3.04e-03
## factor(yst)10         3.866 1.88   0.179  7.55  2.0552 Inf 3.99e-02
## TDI:factor(yst)1     -0.318 3.35  -6.889  6.25 -0.0947 Inf 9.25e-01
## TDI:factor(yst)2      1.227 3.35  -5.345  7.80  0.3658 Inf 7.14e-01
## TDI:factor(yst)3      2.575 3.35  -3.996  9.15  0.7682 Inf 4.42e-01
## TDI:factor(yst)6     -2.379 3.38  -9.006  4.25 -0.7035 Inf 4.82e-01
## TDI:factor(yst)10     4.211 3.35  -2.361 10.78  1.2559 Inf 2.09e-01
```

QQPlot and Plotted Residuals

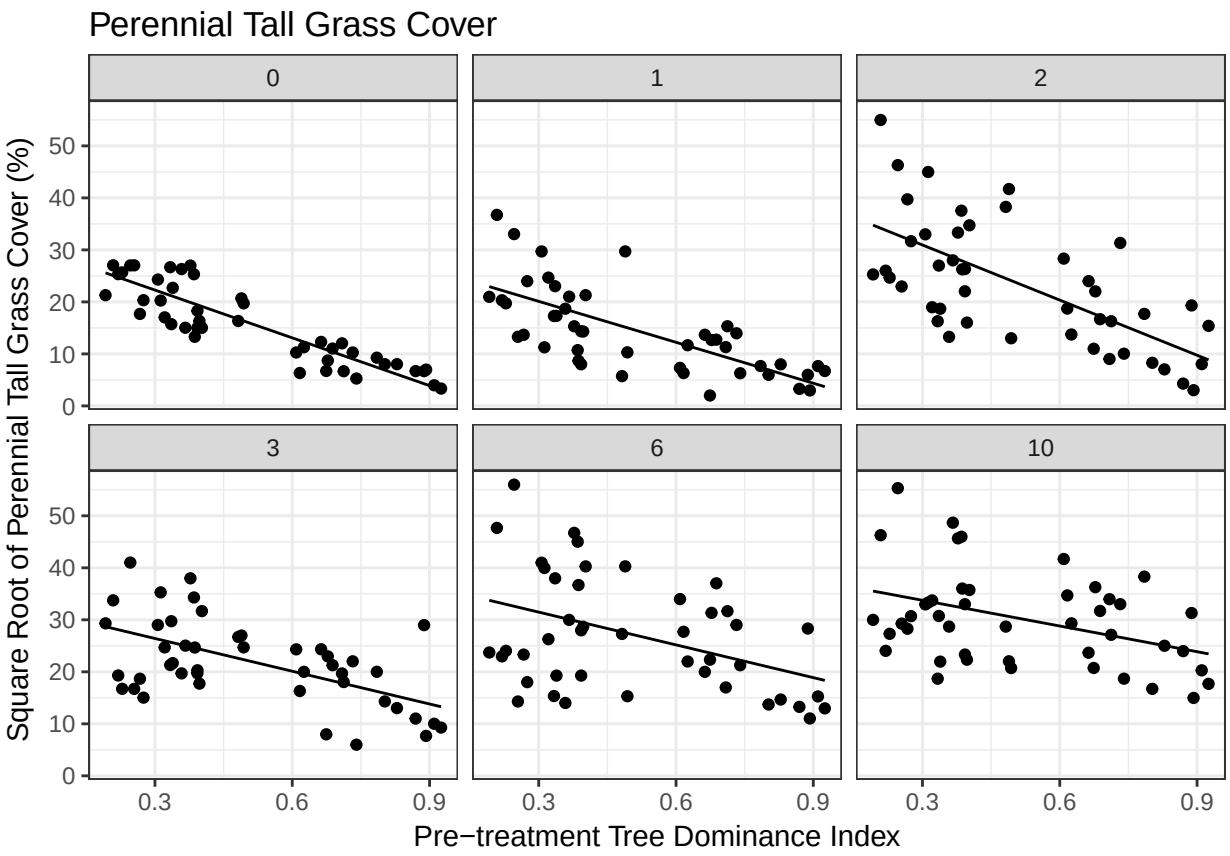




Perennial Grass Cover

Model

```
m <- lmer(can_cover_pt_pgrass ~ TDI + factor(yst) + factor(yst):TDI +
            (1|site), data = l)
```



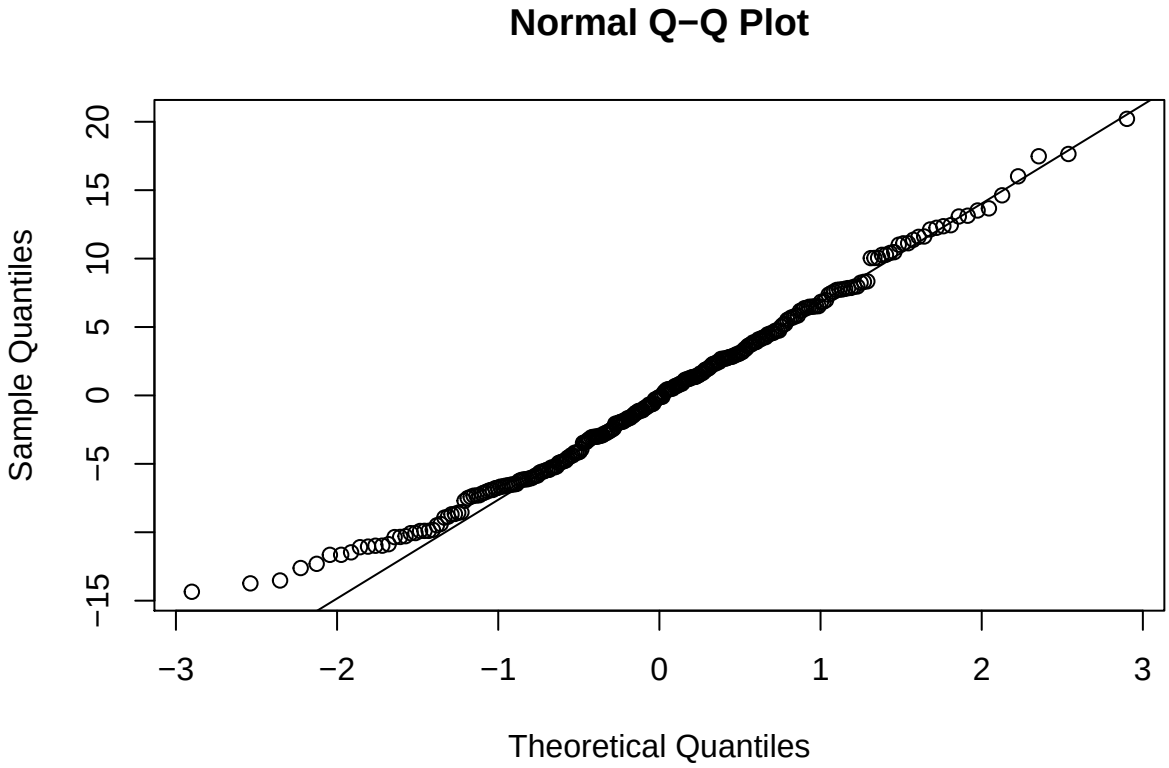
Inferences

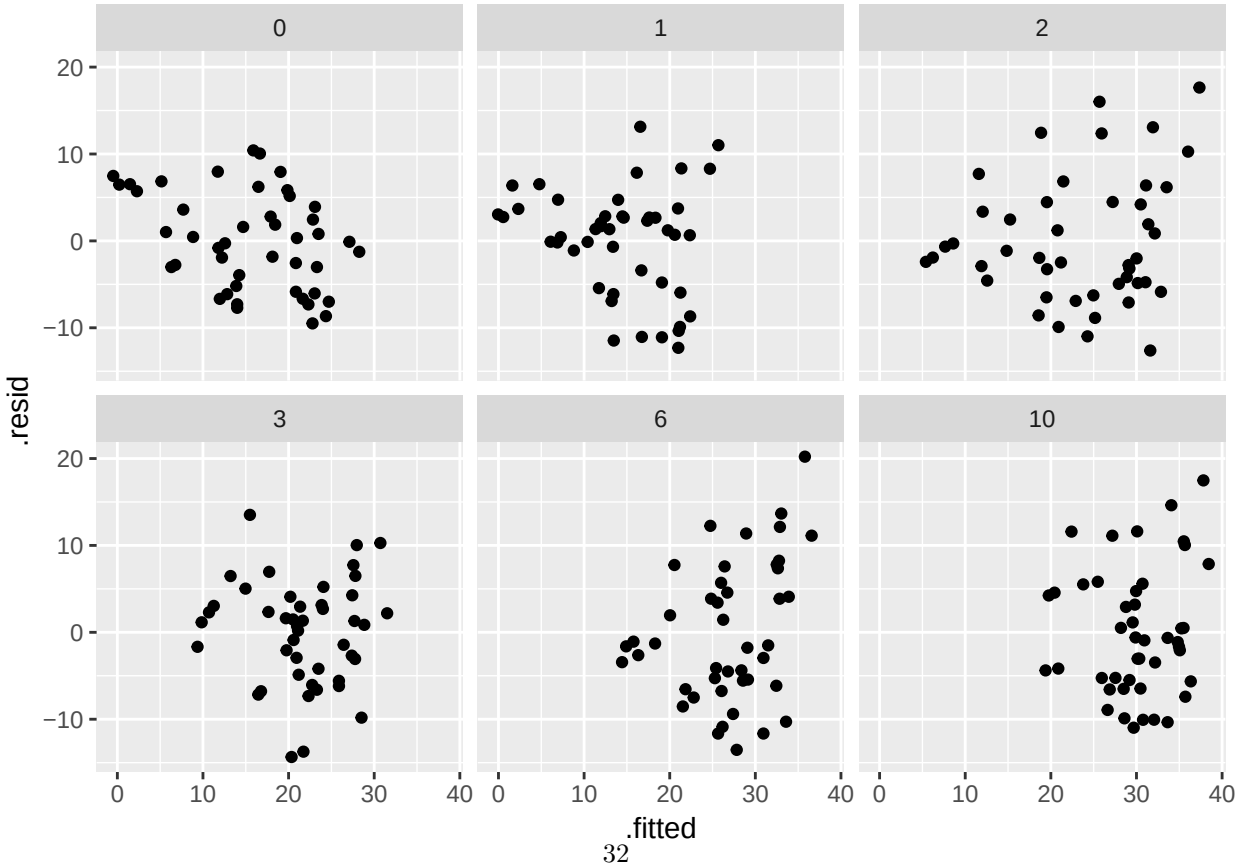
```
## Linear mixed model fit by REML ['lmerMod']
## Formula: can_cover_pt_pgrass ~ TDI + factor(yst) + factor(yst):TDI + (1 |
##     site)
##    Data: l
##
## REML criterion at convergence: 1757
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -2.0806 -0.7650 -0.0169  0.6467  2.9307
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  site     (Intercept) 17.2     4.15
##  Residual             47.6     6.90
## Number of obs: 269, groups:  site, 3
##
## Fixed effects:
##                   Estimate Std. Error t value
## (Intercept)          31.46       3.50    8.98
## TDI                 -30.63       4.56   -6.72
## factor(yst)1         -3.48       3.61   -0.96
## factor(yst)2         10.08       3.61    2.79
## factor(yst)3          1.25       3.61    0.35
## factor(yst)6          6.31       3.62    1.74
## factor(yst)10         7.23       3.61    2.00
## TDI:factor(yst)1      4.38       6.44    0.68
## TDI:factor(yst)2     -4.70       6.44   -0.73
## TDI:factor(yst)3      9.63       6.44    1.50
## TDI:factor(yst)6      9.63       6.49    1.48
## TDI:factor(yst)10    14.15       6.44    2.20
##
## Correlation of Fixed Effects:
##             (Intr) TDI    fct()1 fct()2 fct()3 fct()6 fc()10 TDI:f()1
## TDI         -0.668
## factr(yst)1 -0.515  0.647
## factr(yst)2 -0.515  0.647  0.500
## factr(yst)3 -0.515  0.647  0.500  0.500
## factr(yst)6 -0.514  0.645  0.499  0.499  0.499
## fctr(yst)10 -0.515  0.647  0.500  0.500  0.500  0.499
## TDI:fctr()1  0.472 -0.706 -0.915 -0.458 -0.458 -0.456 -0.458
## TDI:fctr()2  0.472 -0.706 -0.458 -0.915 -0.458 -0.456 -0.458  0.500
## TDI:fctr()3  0.472 -0.706 -0.458 -0.458 -0.915 -0.456 -0.458  0.500
## TDI:fctr()6  0.468 -0.700 -0.454 -0.454 -0.454 -0.915 -0.454  0.496
## TDI:fct()10  0.472 -0.706 -0.458 -0.458 -0.458 -0.456 -0.915  0.500
##             TDI:()2 TDI:()3 TDI:()6
## TDI
## factr(yst)1
## factr(yst)2
## factr(yst)3
## factr(yst)6
## fctr(yst)10
```

```
## TDI:fctr()1
## TDI:fctr()2
## TDI:fctr()3  0.500
## TDI:fctr()6  0.496   0.496
## TDI:fct()10  0.500   0.500   0.496
```

```
##                    estimate   se   lower  upper tvalue  df   pvalue
## (Intercept)           31.46 3.50  24.596  38.33  8.983 Inf 2.64e-19
## TDI                  -30.63 4.56 -39.555 -21.70 -6.723 Inf 1.78e-11
## factor(yst)1          -3.48 3.61 -10.560   3.59 -0.965 Inf 3.35e-01
## factor(yst)2          10.08 3.61   3.004  17.16  2.792 Inf 5.24e-03
## factor(yst)3           1.25 3.61  -5.831   8.32  0.345 Inf 7.30e-01
## factor(yst)6           6.31 3.62  -0.784  13.41  1.743 Inf 8.13e-02
## factor(yst)10          7.23 3.61   0.156  14.31  2.003 Inf 4.52e-02
## TDI:factor(yst)1       4.38 6.44  -8.229  17.00  0.681 Inf 4.96e-01
## TDI:factor(yst)2      -4.70 6.44 -17.313   7.91 -0.730 Inf 4.65e-01
## TDI:factor(yst)3       9.63 6.44  -2.981  22.24  1.497 Inf 1.34e-01
## TDI:factor(yst)6       9.63 6.49  -3.087  22.35  1.484 Inf 1.38e-01
## TDI:factor(yst)10     14.15 6.44   1.537  26.76  2.199 Inf 2.79e-02
```

QQPlot and Plotted Residuals





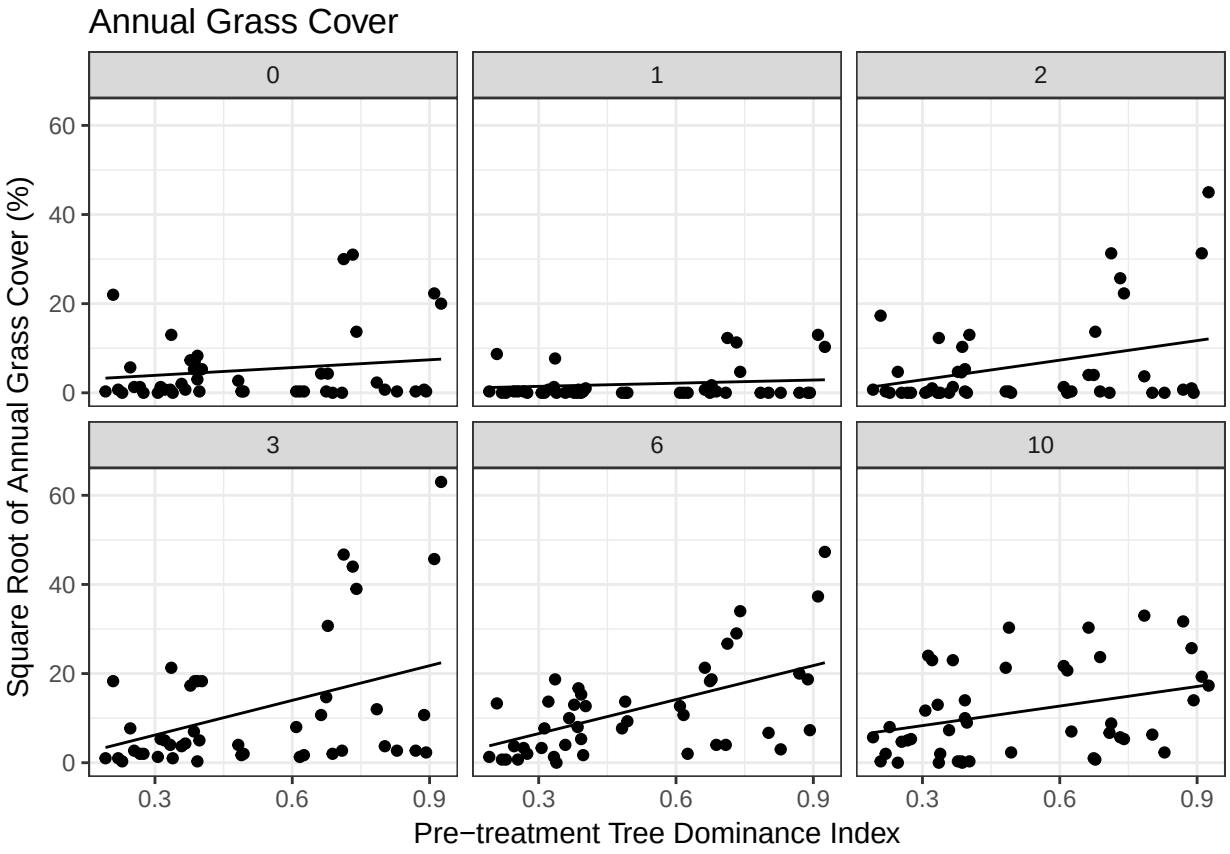
Annual Grass Cover

Notes

what is going on at Scipio in yst = 6,10? Decrease in annual grass cover

Model

```
m <- lmer(can_cover_pt_agrass ~ TDI + factor(yst) + factor(yst):TDI +
            (1|site), data = l)
```



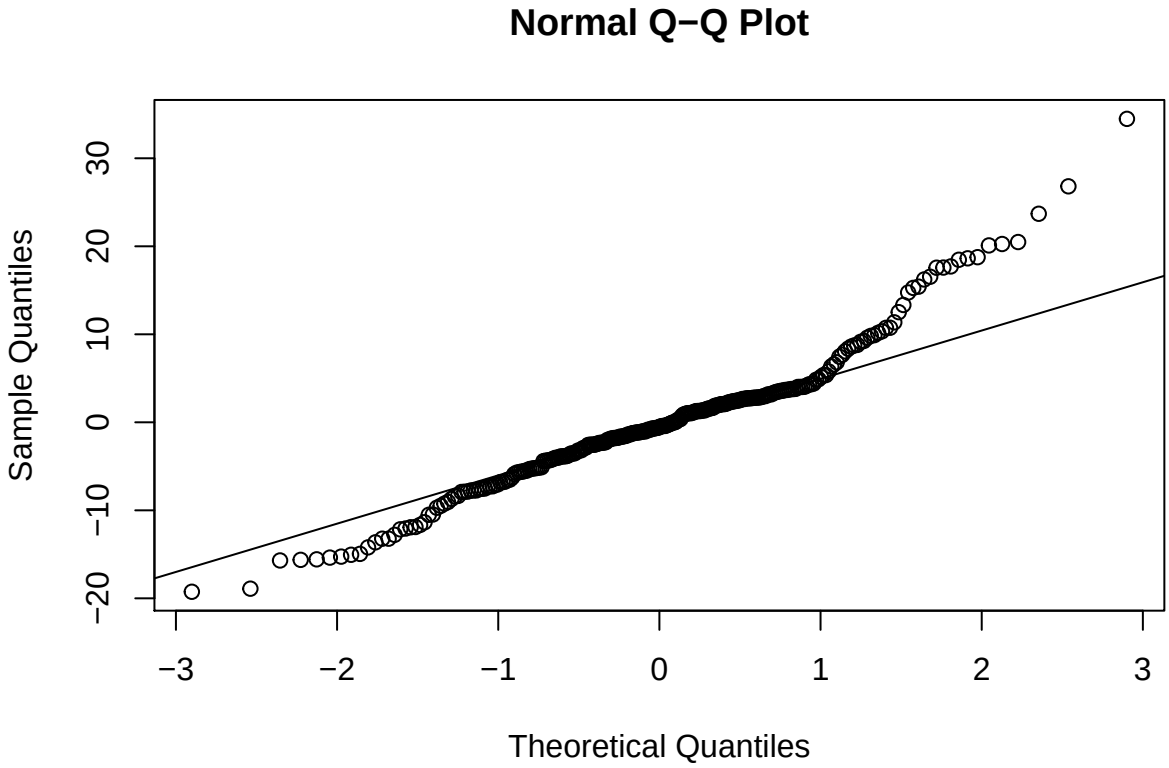
Inferences

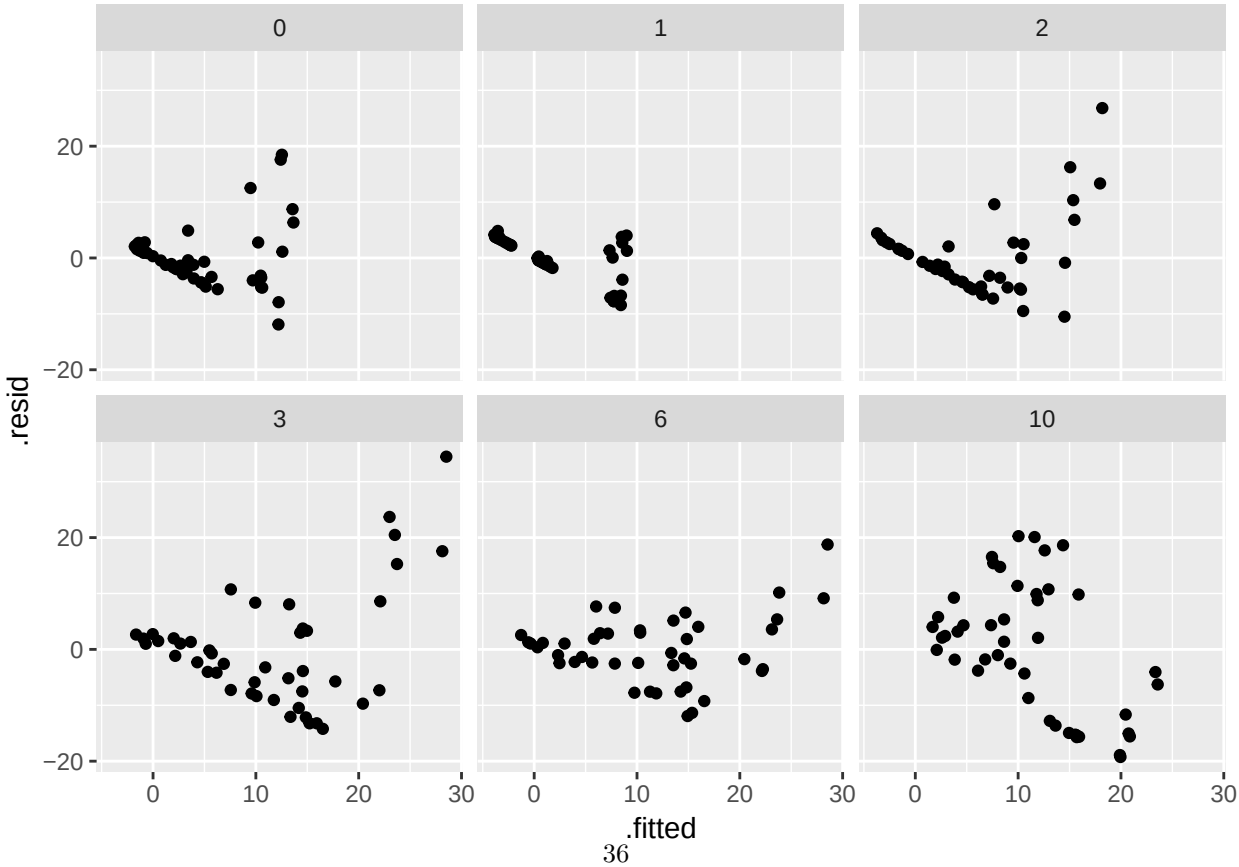
```
## Linear mixed model fit by REML ['lmerMod']
## Formula: can_cover_pt_agrass ~ TDI + factor(yst) + factor(yst):TDI + (1 |
##     site)
##    Data: l
##
## REML criterion at convergence: 1836
##
## Scaled residuals:
##    Min     1Q Median     3Q    Max
## -2.397 -0.528 -0.069  0.393  4.292
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  site     (Intercept) 32.7     5.72
##  Residual             64.5     8.03
## Number of obs: 269, groups:  site, 3
##
## Fixed effects:
##                   Estimate Std. Error t value
## (Intercept)           2.17       4.44    0.49
## TDI                   5.82       5.31    1.10
## factor(yst)1         -1.43       4.21   -0.34
## factor(yst)2         -3.64       4.21   -0.86
## factor(yst)3         -3.74       4.21   -0.89
## factor(yst)6         -3.26       4.22   -0.77
## factor(yst)10         1.76       4.21    0.42
## TDI:factor(yst)1     -3.46       7.50   -0.46
## TDI:factor(yst)2      8.83       7.50    1.18
## TDI:factor(yst)3     20.11       7.50    2.68
## TDI:factor(yst)6     19.61       7.56    2.60
## TDI:factor(yst)10     8.82       7.50    1.18
##
## Correlation of Fixed Effects:
##             (Intr) TDI    fct()1 fct()2 fct()3 fct()6 fc()10 TDI:f()1
## TDI         -0.613
## factr(yst)1 -0.473  0.647
## factr(yst)2 -0.473  0.647  0.500
## factr(yst)3 -0.473  0.647  0.500  0.500
## factr(yst)6 -0.472  0.645  0.499  0.499  0.499
## fctr(yst)10 -0.473  0.647  0.500  0.500  0.500  0.499
## TDI:fctr()1  0.433 -0.706 -0.915 -0.458 -0.458 -0.456 -0.458
## TDI:fctr()2  0.433 -0.706 -0.458 -0.915 -0.458 -0.456 -0.458  0.500
## TDI:fctr()3  0.433 -0.706 -0.458 -0.458 -0.915 -0.456 -0.458  0.500
## TDI:fctr()6  0.429 -0.700 -0.454 -0.454 -0.454 -0.915 -0.454  0.496
## TDI:fct()10  0.433 -0.706 -0.458 -0.458 -0.458 -0.456 -0.915  0.500
##             TDI:()2 TDI:()3 TDI:()6
## TDI
## factr(yst)1
## factr(yst)2
## factr(yst)3
## factr(yst)6
## fctr(yst)10
```

```
## TDI:fctr()1
## TDI:fctr()2
## TDI:fctr()3  0.500
## TDI:fctr()6  0.496   0.496
## TDI:fct()10  0.500   0.500   0.496
```

```
##                    estimate   se  lower upper tvalue  df  pvalue
## (Intercept)            2.17 4.44  -6.54 10.88  0.488 Inf 0.62582
## TDI                    5.82 5.31  -4.58 16.22  1.097 Inf 0.27265
## factor(yst)1          -1.43 4.21  -9.68  6.81 -0.341 Inf 0.73347
## factor(yst)2          -3.64 4.21 -11.88  4.61 -0.865 Inf 0.38720
## factor(yst)3          -3.74 4.21 -11.98  4.50 -0.890 Inf 0.37373
## factor(yst)6          -3.26 4.22 -11.53  5.00 -0.774 Inf 0.43902
## factor(yst)10          1.76 4.21  -6.48 10.01  0.419 Inf 0.67500
## TDI:factor(yst)1      -3.46 7.50 -18.15 11.23 -0.462 Inf 0.64442
## TDI:factor(yst)2       8.83 7.50  -5.86 23.52  1.178 Inf 0.23885
## TDI:factor(yst)3      20.11 7.50   5.42 34.80  2.683 Inf 0.00729
## TDI:factor(yst)6      19.61 7.56   4.80 34.43  2.595 Inf 0.00947
## TDI:factor(yst)10      8.82 7.50  -5.88 23.51  1.176 Inf 0.23956
```

QQPlot and Plotted Residuals





Notes on Tree Density and Cover

*Ask Scott–was tree density for trees > 50 cm measured at 1,2,3,6 yst?

*Should I break this down by species (JUOS vs PIED)?

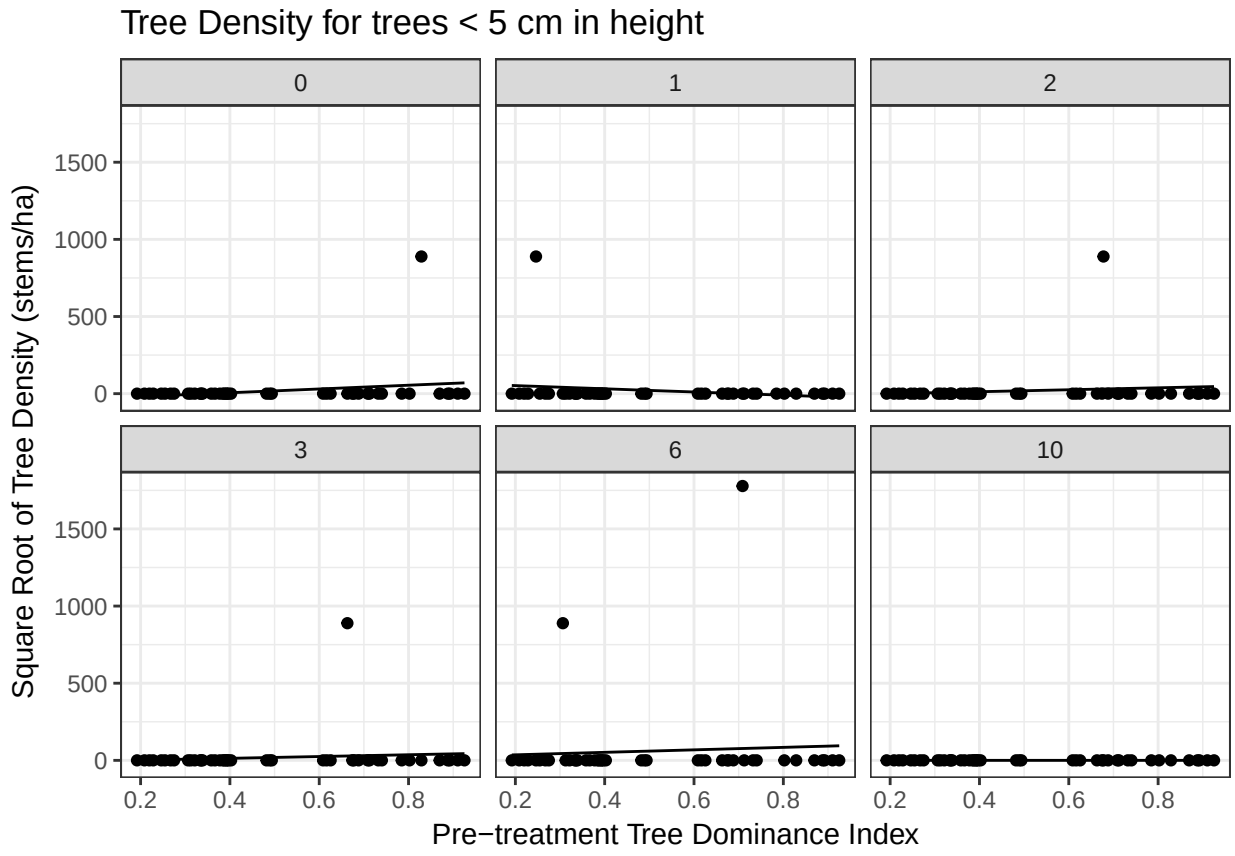
Tree Density for trees < 5 cm in height

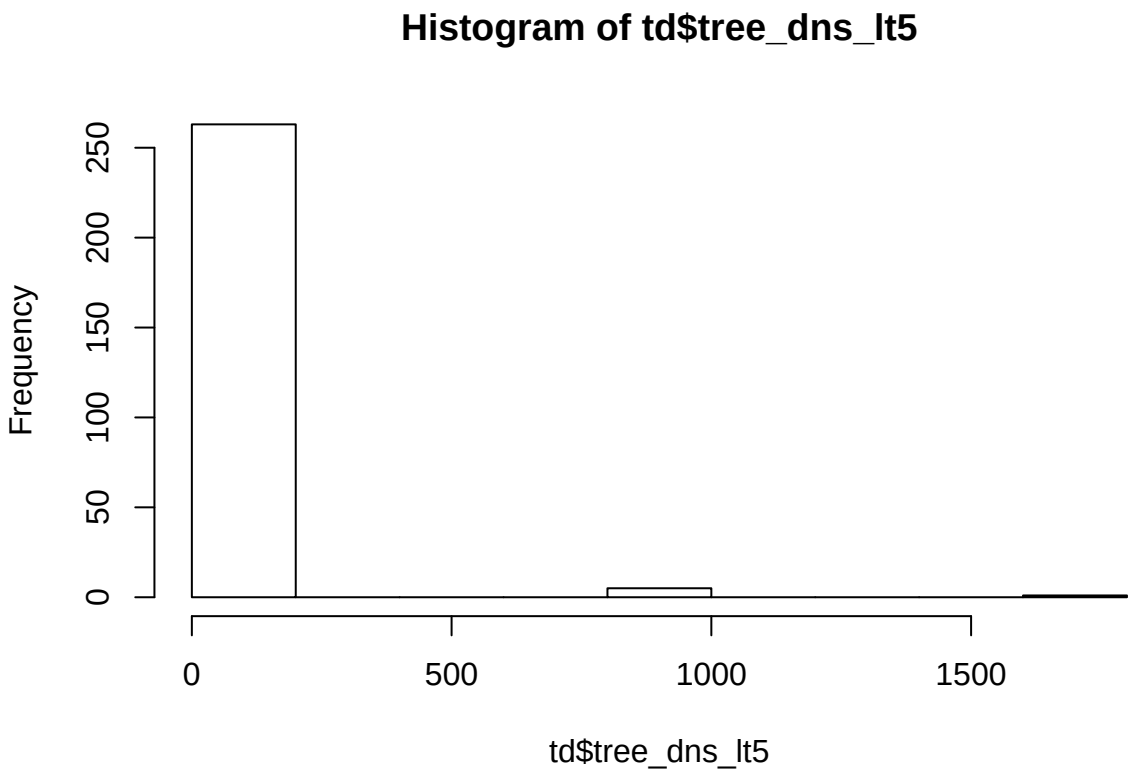
Notes

*Model and graph below are included to show that tree density for trees < 5cm should be excluded from analysis. Data is too coarse: if there was one tree < 5 cm found in a subplot, that converts to 889 trees/ha because of sampling density and scaling factor.

Model

```
m <- lmer(tree_dns_lt5 ~ TDI + factor(yst) + factor(yst):TDI + (1|site),
          data = td)
```




Histogram of td$tree_dns_lt5
Frequency
0
50
100
150
200
250
0
500
1000
1500
td$tree_dns_lt5

Tree Density for trees between 5 and 50 cm in height

Model

```
m <- lmer(tree_dns_5_50 ~ TDI + factor(yst) + factor(yst):TDI + (1|site),
          data = td)
```

Inferences

```
summary(m)
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: tree_dns_5_50 ~ TDI + factor(yst) + factor(yst):TDI + (1 | site)
##    Data: td
##
## REML criterion at convergence: 3156
##
## Scaled residuals:
##    Min     1Q Median     3Q    Max
## -2.042 -0.710 -0.120  0.427  4.057
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  site     (Intercept)  3731     61.1
##  Residual             11033    105.0
## Number of obs: 269, groups:  site, 3
##
## Fixed effects:
##                   Estimate Std. Error t value
## (Intercept)          66.42      52.53    1.26
## TDI                  21.62      69.38    0.31
## factor(yst)1        -10.08      54.99   -0.18
## factor(yst)2         62.39      54.99    1.13
## factor(yst)3         60.36      54.99    1.10
## factor(yst)6         66.14      55.15    1.20
## factor(yst)10        -5.48      54.99   -0.10
## TDI:factor(yst)1     31.53      98.01    0.32
## TDI:factor(yst)2    -78.29      98.01   -0.80
## TDI:factor(yst)3    -43.05      98.01   -0.44
## TDI:factor(yst)6     67.38      98.84    0.68
## TDI:factor(yst)10    17.80      98.01    0.18
##
## Correlation of Fixed Effects:
##             (Intr) TDI    fct()1 fct()2 fct()3 fct()6 fc()10 TDI:f()1
## TDI         -0.679
## factr(yst)1 -0.523  0.647
## factr(yst)2 -0.523  0.647  0.500
## factr(yst)3 -0.523  0.647  0.500  0.500
## factr(yst)6 -0.522  0.645  0.499  0.499  0.499
## fctr(yst)10 -0.523  0.647  0.500  0.500  0.500  0.499
## TDI:fctr()1  0.479 -0.706 -0.915 -0.458 -0.458 -0.456 -0.458
## TDI:fctr()2  0.479 -0.706 -0.458 -0.915 -0.458 -0.456 -0.458  0.500
## TDI:fctr()3  0.479 -0.706 -0.458 -0.458 -0.915 -0.456 -0.458  0.500
## TDI:fctr()6  0.475 -0.700 -0.454 -0.454 -0.454 -0.915 -0.454  0.496
## TDI:fct()10  0.479 -0.706 -0.458 -0.458 -0.458 -0.456 -0.915  0.500
##             TDI:()2 TDI:()3 TDI:()6
## TDI
## factr(yst)1
## factr(yst)2
## factr(yst)3
## factr(yst)6
```

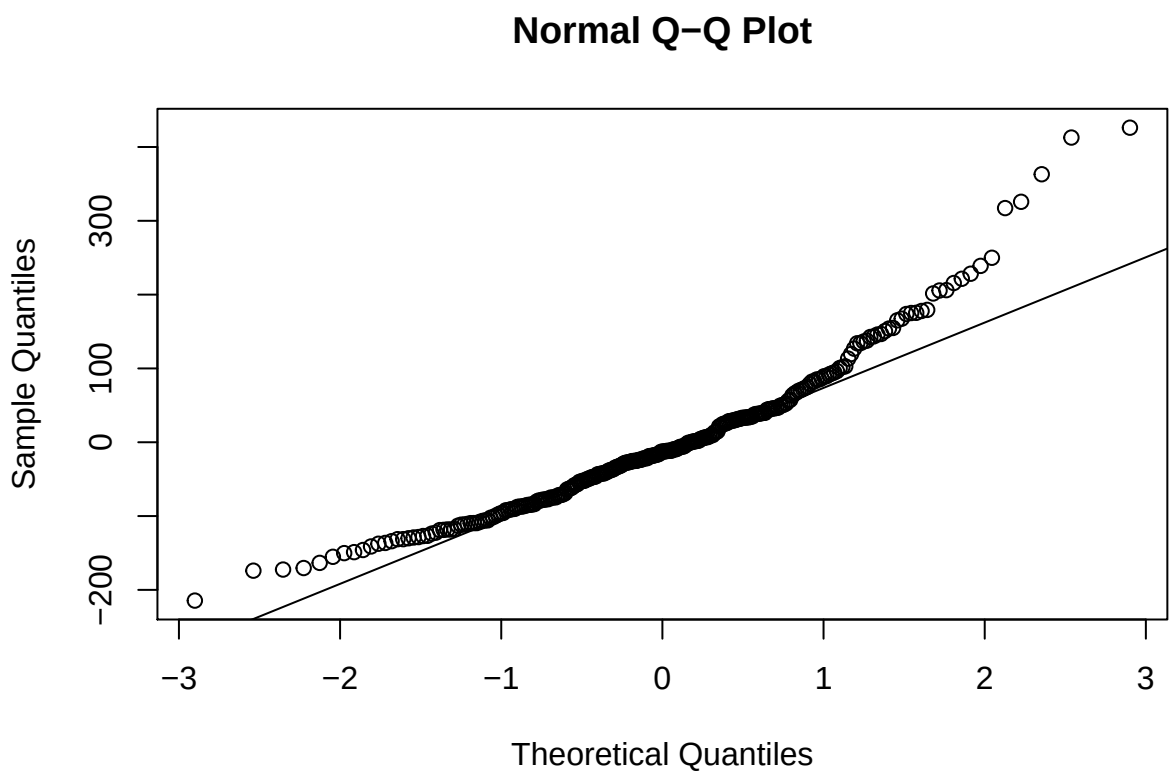
```
## fctr(yst)10
## TDI:fctr()1
## TDI:fctr()2
## TDI:fctr()3  0.500
## TDI:fctr()6  0.496   0.496
## TDI:fct()10  0.500   0.500   0.496
```

```
lincon(m)
```

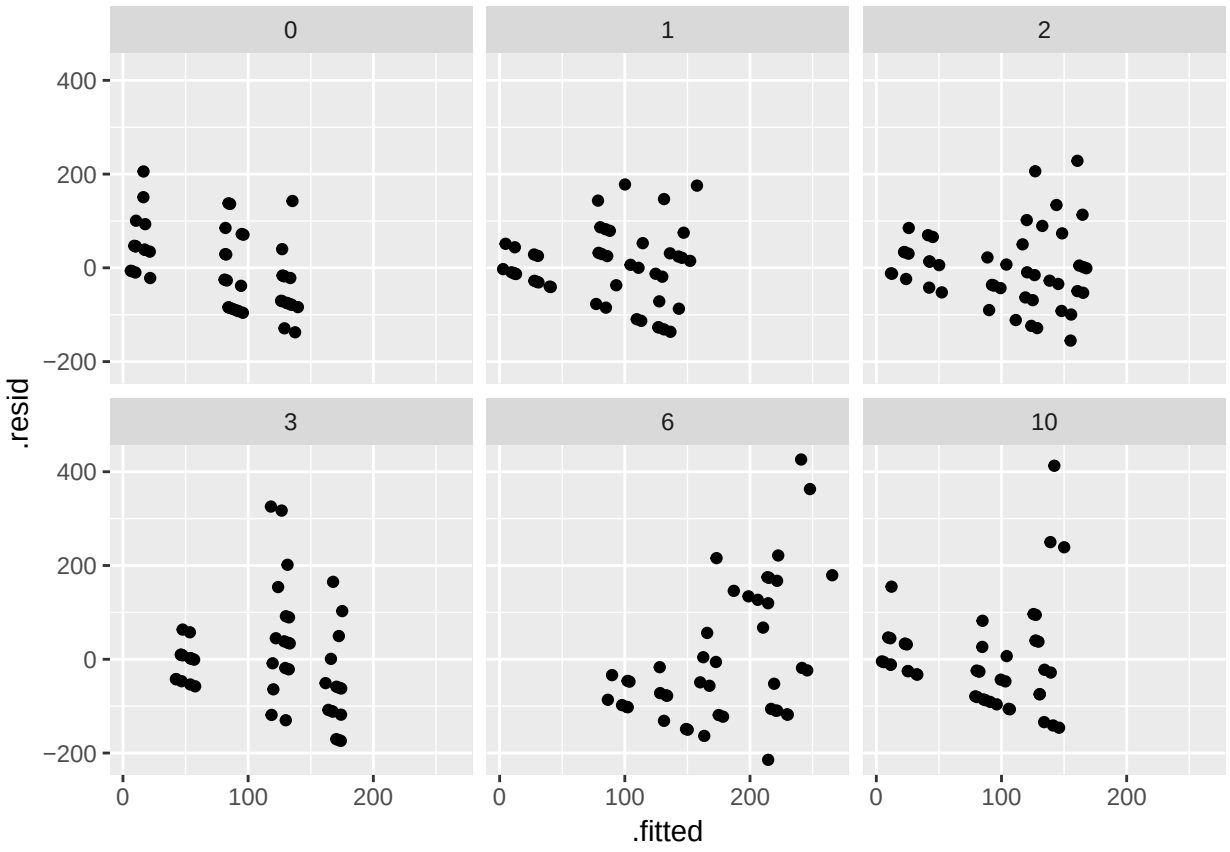
```
##                   estimate   se  lower upper  tvalue  df pvalue
## (Intercept)          66.42 52.5  -36.5 169.4  1.2644 Inf  0.206
## TDI                  21.62 69.4 -114.4 157.6  0.3116 Inf  0.755
## factor(yst)1        -10.08 55.0 -117.9  97.7 -0.1834 Inf  0.855
## factor(yst)2         62.39 55.0  -45.4 170.2  1.1345 Inf  0.257
## factor(yst)3         60.36 55.0  -47.4 168.1  1.0975 Inf  0.272
## factor(yst)6         66.14 55.2  -42.0 174.2  1.1992 Inf  0.230
## factor(yst)10        -5.48 55.0 -113.3 102.3 -0.0996 Inf  0.921
## TDI:factor(yst)1     31.53 98.0 -160.6 223.6  0.3217 Inf  0.748
## TDI:factor(yst)2    -78.29 98.0 -270.4 113.8 -0.7988 Inf  0.424
## TDI:factor(yst)3    -43.05 98.0 -235.1 149.0 -0.4393 Inf  0.660
## TDI:factor(yst)6     67.38 98.8 -126.3 261.1  0.6817 Inf  0.495
## TDI:factor(yst)10    17.80 98.0 -174.3 209.9  0.1817 Inf  0.856
```

QQPlot and Plotted Residuals

```
qqnorm(resid(m)); qqline(resid(m))
```




```
ggplot(m, aes(x = .fitted, y = .resid)) + geom_point() + facet_wrap(~yst)
```


0
1
2
3
6
10
400
200
0
−200
.resid
0
100
200
.fitted

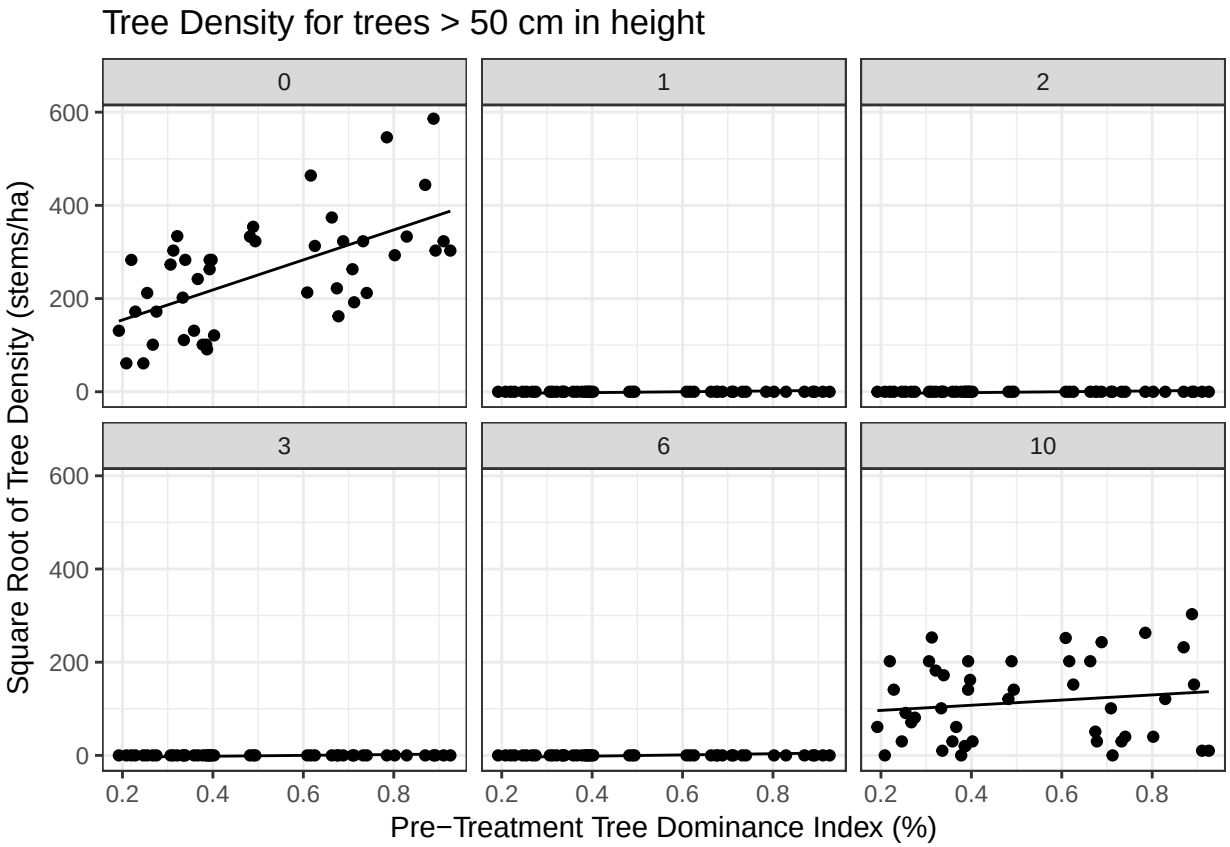
Tree Density for trees > 50 cm in height

Notes

*Ask Scott–was tree density for trees > 50 cm measured at 1,2,3,6 yst?

Model

```
m <- lmer(tree_dns_gt50 ~ TDI + factor(yst) + factor(yst):TDI + (1|site),
          data = td)
```



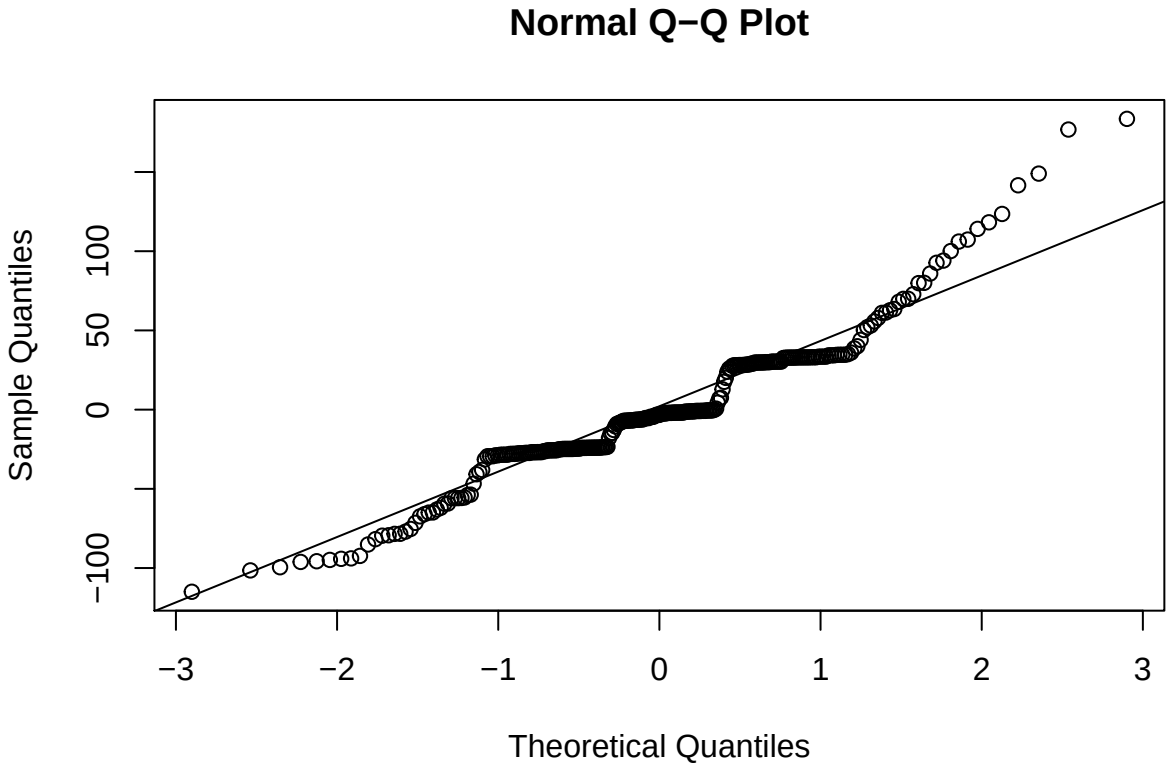
Inferences

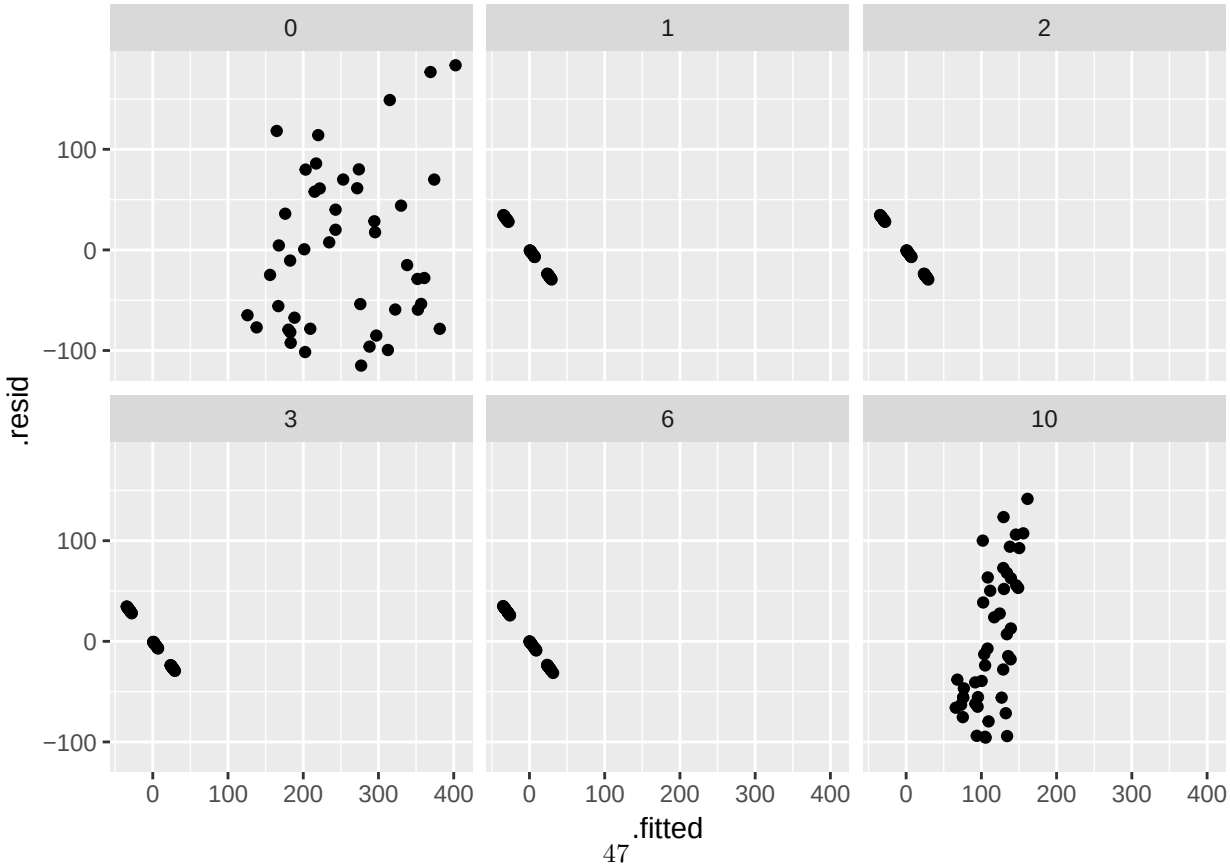
```
## Linear mixed model fit by REML ['lmerMod']
## Formula: tree_dns_gt50 ~ TDI + factor(yst) + factor(yst):TDI + (1 | site)
##    Data: td
##
## REML criterion at convergence: 2752
##
## Scaled residuals:
##    Min     1Q Median     3Q    Max
## -2.405 -0.538 -0.069  0.627  3.840
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  site     (Intercept)  872     29.5
##  Residual             2285     47.8
## Number of obs: 269, groups:  site, 3
##
## Fixed effects:
##                   Estimate Std. Error t value
## (Intercept)          89.74      24.59    3.65
## TDI                 322.06      31.57   10.20
## factor(yst)1        -95.29      25.03   -3.81
## factor(yst)2        -95.29      25.03   -3.81
## factor(yst)3        -95.29      25.03   -3.81
## factor(yst)6        -96.44      25.10   -3.84
## factor(yst)10        -4.31      25.03   -0.17
## TDI:factor(yst)1   -312.78      44.60   -7.01
## TDI:factor(yst)2   -312.78      44.60   -7.01
## TDI:factor(yst)3   -312.78      44.60   -7.01
## TDI:factor(yst)6   -309.23      44.98   -6.87
## TDI:factor(yst)10  -266.61      44.60   -5.98
##
## Correlation of Fixed Effects:
##             (Intr) TDI    fct()1 fct()2 fct()3 fct()6 fc()10 TDI:f()1
## TDI         -0.660
## factr(yst)1 -0.509  0.647
## factr(yst)2 -0.509  0.647  0.500
## factr(yst)3 -0.509  0.647  0.500  0.500
## factr(yst)6 -0.507  0.645  0.499  0.499  0.499
## fctr(yst)10 -0.509  0.647  0.500  0.500  0.500  0.499
## TDI:fctr()1  0.466 -0.706 -0.915 -0.458 -0.458 -0.456 -0.458
## TDI:fctr()2  0.466 -0.706 -0.458 -0.915 -0.458 -0.456 -0.458  0.500
## TDI:fctr()3  0.466 -0.706 -0.458 -0.458 -0.915 -0.456 -0.458  0.500
## TDI:fctr()6  0.462 -0.700 -0.454 -0.454 -0.454 -0.915 -0.454  0.496
## TDI:fct()10  0.466 -0.706 -0.458 -0.458 -0.458 -0.456 -0.915  0.500
##             TDI:()2 TDI:()3 TDI:()6
## TDI
## factr(yst)1
## factr(yst)2
## factr(yst)3
## factr(yst)6
## fctr(yst)10
## TDI:fctr()1
```

```
## TDI:fctr()2
## TDI:fctr()3  0.500
## TDI:fctr()6  0.496   0.496
## TDI:fct()10  0.500   0.500   0.496
```

```
##                   estimate   se  lower  upper tvalue  df   pvalue
## (Intercept)          89.74 24.6   41.5  137.9  3.649 Inf 2.63e-04
## TDI                 322.06 31.6  260.2  383.9 10.200 Inf 1.99e-24
## factor(yst)1        -95.29 25.0 -144.3  -46.2 -3.807 Inf 1.41e-04
## factor(yst)2        -95.29 25.0 -144.3  -46.2 -3.807 Inf 1.41e-04
## factor(yst)3        -95.29 25.0 -144.3  -46.2 -3.807 Inf 1.41e-04
## factor(yst)6        -96.44 25.1 -145.6  -47.2 -3.842 Inf 1.22e-04
## factor(yst)10        -4.31 25.0  -53.4   44.7 -0.172 Inf 8.63e-01
## TDI:factor(yst)1   -312.78 44.6 -400.2 -225.4 -7.012 Inf 2.34e-12
## TDI:factor(yst)2   -312.78 44.6 -400.2 -225.4 -7.012 Inf 2.34e-12
## TDI:factor(yst)3   -312.78 44.6 -400.2 -225.4 -7.012 Inf 2.34e-12
## TDI:factor(yst)6   -309.23 45.0 -397.4 -221.1 -6.874 Inf 6.23e-12
## TDI:factor(yst)10  -266.61 44.6 -354.0 -179.2 -5.977 Inf 2.27e-09
```

QQPlot and Plotted Residuals





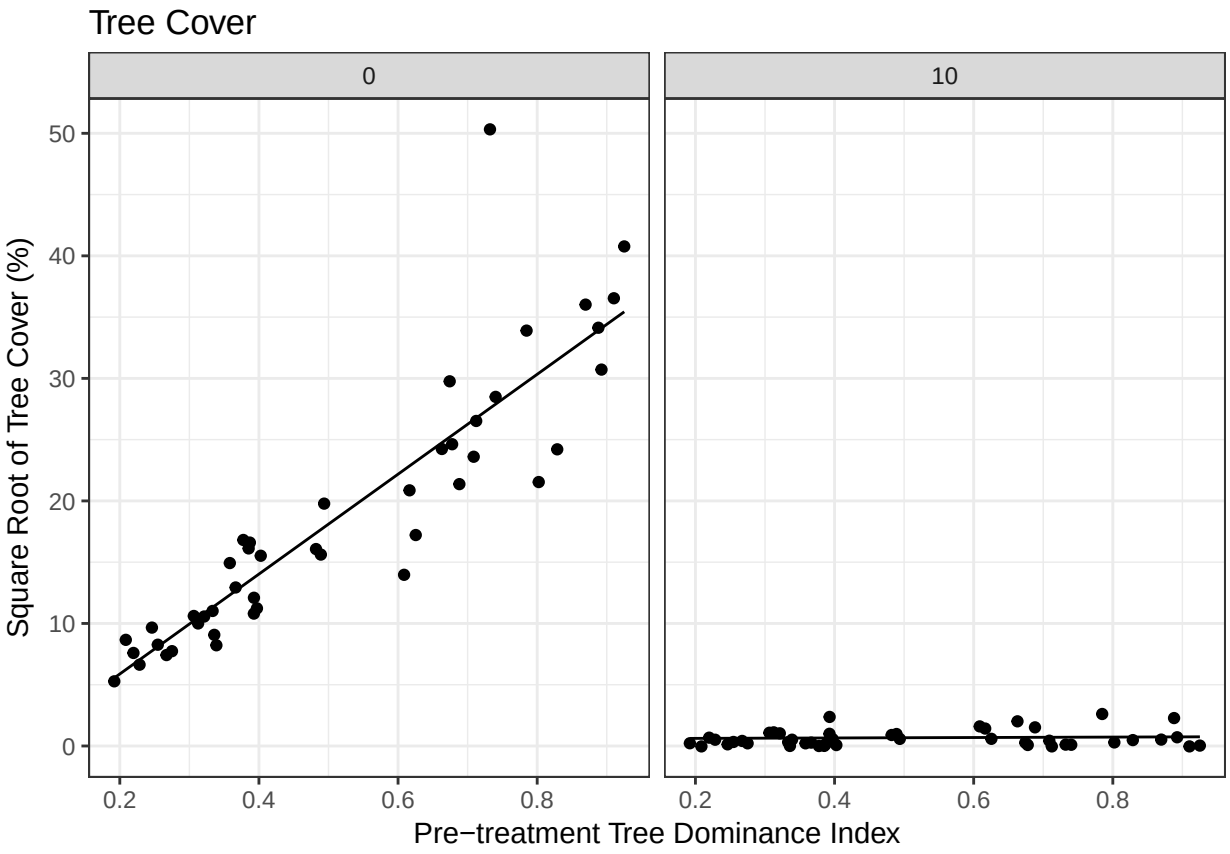
Tree Cover

Notes

*Method: measured canopy area of trees > 50 cm in height and divided by area of subplot

Model

```
m <- lmer(tree_cover_ttl ~ TDI + factor(yst) + factor(yst):TDI + (1|site),
          data = tcover)
```



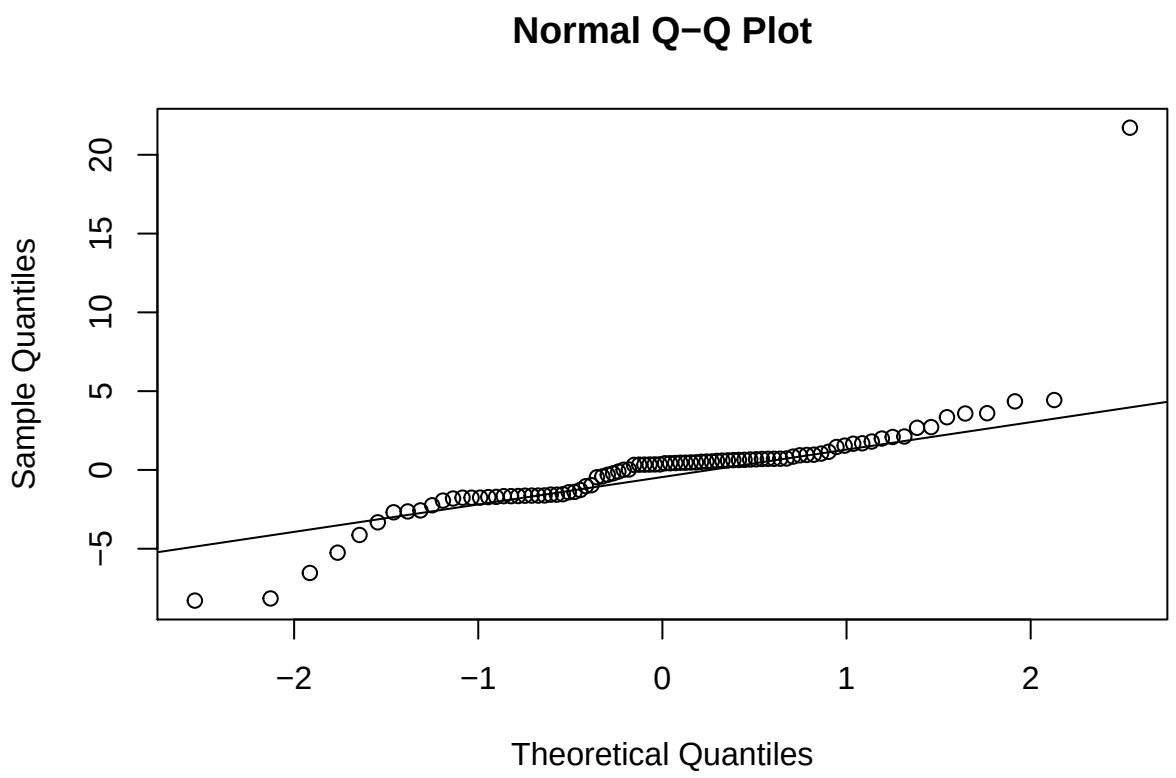
Inferences

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: tree_cover_ttl ~ TDI + factor(yst) + factor(yst):TDI + (1 | site)
##    Data: tcover
##
## REML criterion at convergence: 461
##
## Scaled residuals:
##    Min     1Q Median     3Q    Max
## -2.515 -0.493  0.118  0.219  6.588
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  site     (Intercept)  1.11    1.06
##  Residual             10.87    3.30
## Number of obs: 90, groups:  site, 3
##
## Fixed effects:
##                   Estimate Std. Error t value
## (Intercept)          -2.28       1.37   -1.66
## TDI                  40.76       2.18   18.69
## factor(yst)10         2.86       1.73    1.66
## TDI:factor(yst)10   -40.58       3.08  -13.19
##
## Correlation of Fixed Effects:
##             (Intr) TDI    fc()10
## TDI         -0.820
## fctr(yst)10 -0.631  0.646
## TDI:fct()10  0.578 -0.705 -0.915
```

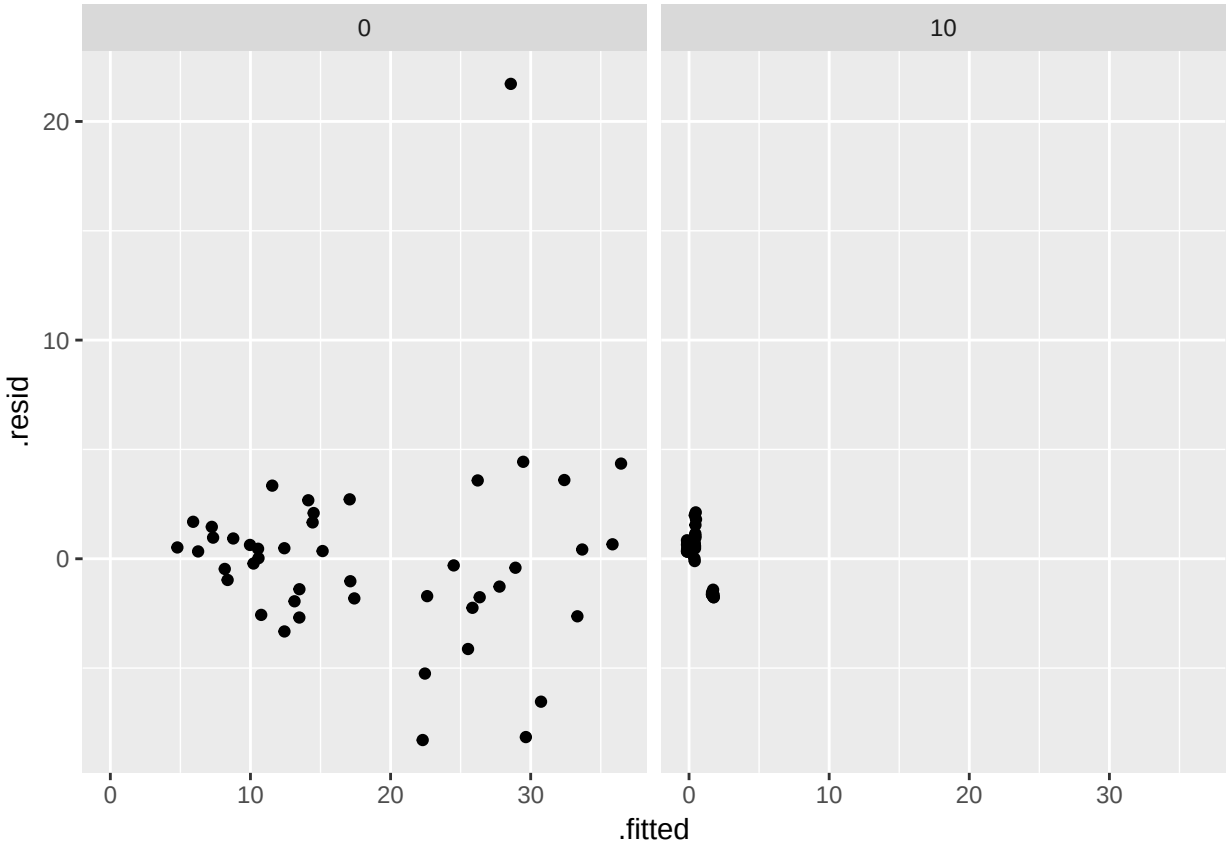
```
##                   estimate   se   lower   upper tvalue  df   pvalue
## (Intercept)          -2.28 1.37  -4.956   0.405  -1.66 Inf 9.61e-02
## TDI                  40.76 2.18  36.486  45.035  18.69 Inf 5.91e-78
## factor(yst)10         2.86 1.73  -0.523   6.243   1.66 Inf 9.75e-02
## TDI:factor(yst)10   -40.58 3.08 -46.614 -34.555 -13.19 Inf 9.71e-40
```

QQPlot and Plotted Residuals

```
qqnorm(resid(m)); qqline(resid(m))
```




```
ggplot(m, aes(x = .fitted, y = .resid)) + geom_point() +
  facet_wrap(~yst)
```


0
10
20
10
0
.resid
0
10
20
30
0
10
20
30
.fitted