Masticated Fuels Analyses: Square Root Transformation of Response Variables

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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

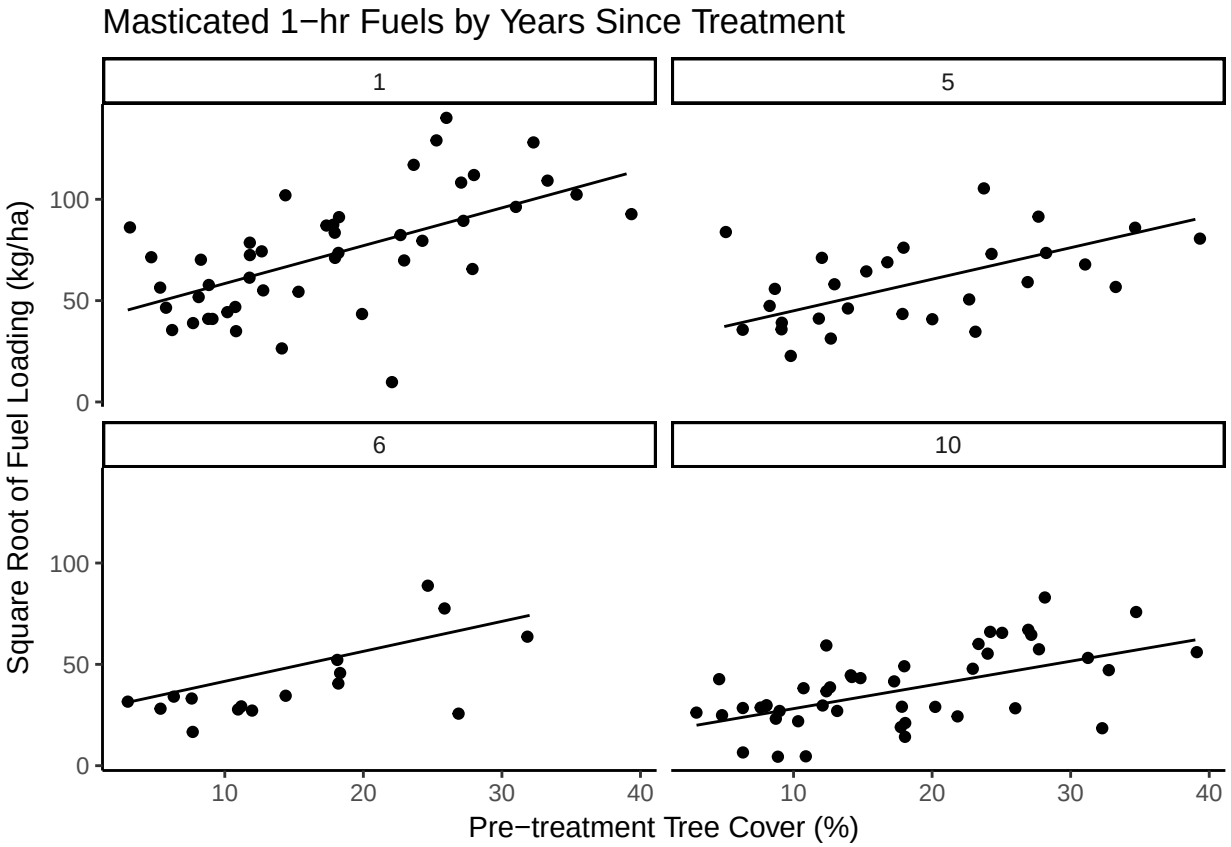
Masticated 1-hr fuels

Notes

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

Model

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

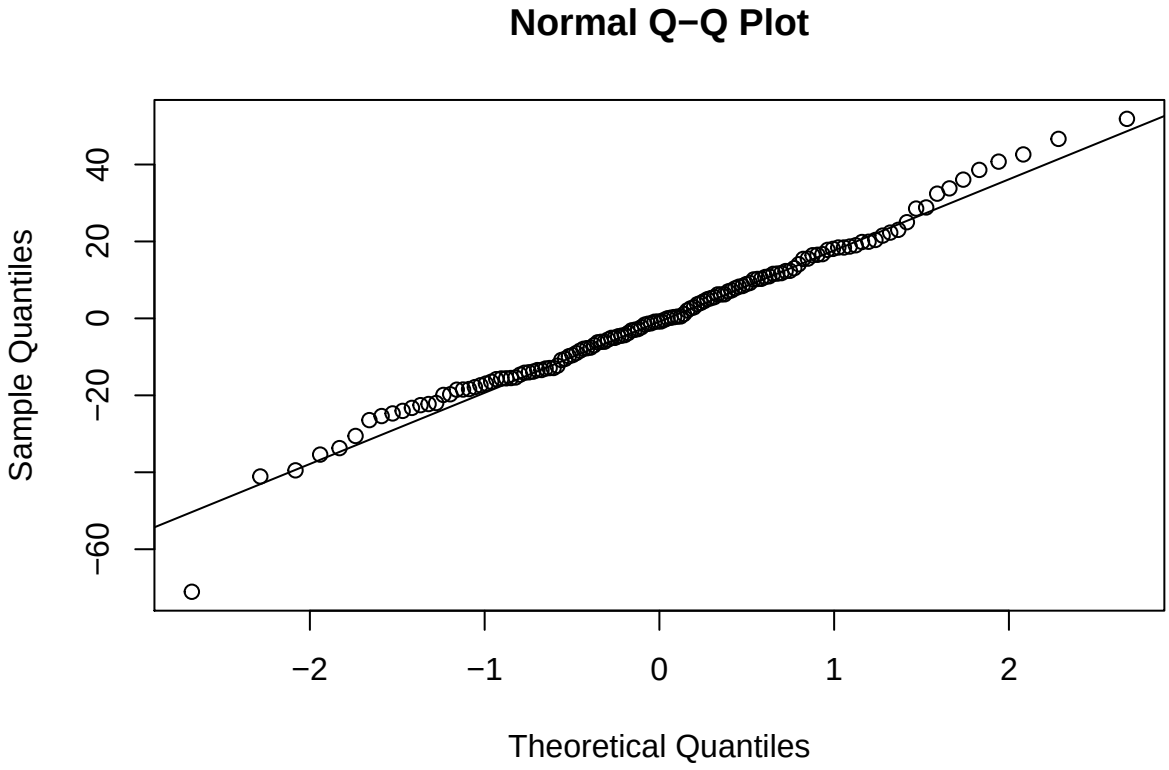


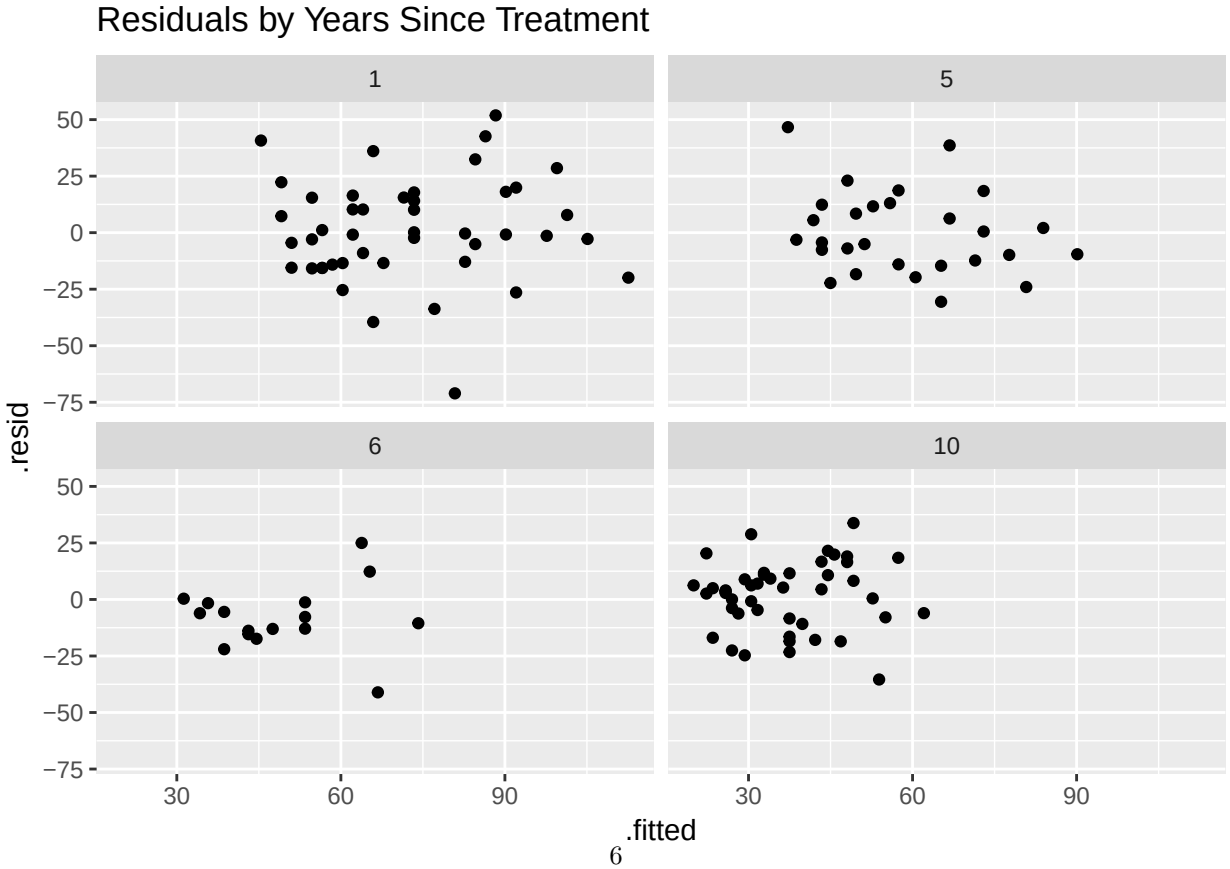
Inferences

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: sqrt(dwd_1hr) ~ pre_tree_cvr + yst + pre_tree_cvr:yst + (1 |
##     site)
##    Data: d
##
## REML criterion at convergence: 1169
##
## Scaled residuals:
##    Min     1Q Median     3Q    Max
## -3.725 -0.698 -0.042  0.610  2.719
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  site     (Intercept)   0       0.0
##  Residual             364      19.1
## Number of obs: 134, groups:  site, 3
##
## Fixed effects:
##                  Estimate Std. Error t value
## (Intercept)       42.3811     6.3976    6.62
## pre_tree_cvr       1.9438     0.3240    6.00
## yst               -2.5929     0.9697   -2.67
## pre_tree_cvr:yst  -0.0774     0.0493   -1.57
##
## Correlation of Fixed Effects:
##             (Intr) pr_tr_ yst
## pre_tre_cvr -0.888
## yst         -0.829  0.737
## pr_tr_cvr:y  0.735 -0.828 -0.888
```

```
##                  estimate     se  lower   upper tvalue  df   pvalue
## (Intercept)       42.3811 6.3976 29.842 54.9201   6.62 Inf 3.48e-11
## pre_tree_cvr       1.9438 0.3240  1.309  2.5788   6.00 Inf 1.98e-09
## yst               -2.5929 0.9697 -4.494 -0.6923  -2.67 Inf 7.50e-03
## pre_tree_cvr:yst  -0.0774 0.0493 -0.174  0.0191  -1.57 Inf 1.16e-01
```

QQPlot and Plotted Residuals

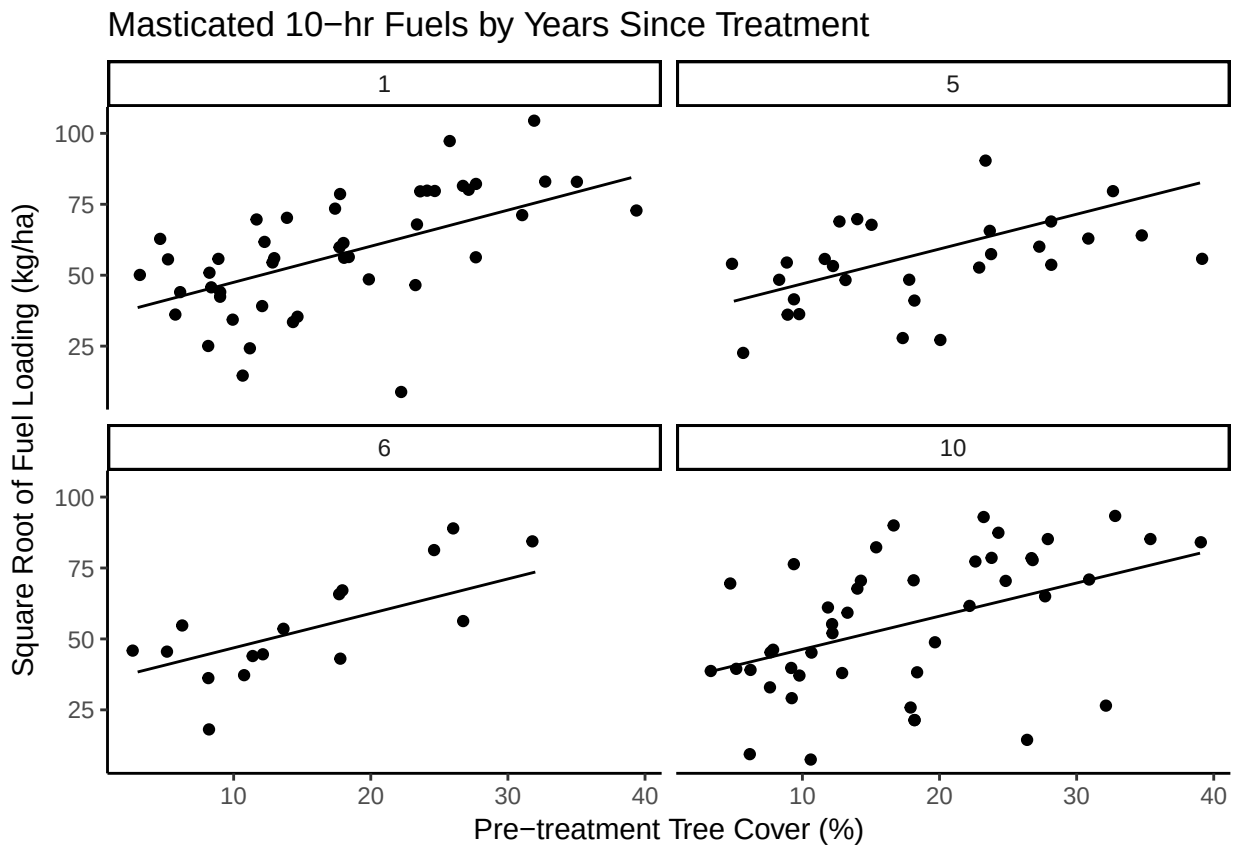




Masticated 10-hr fuels

Model

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

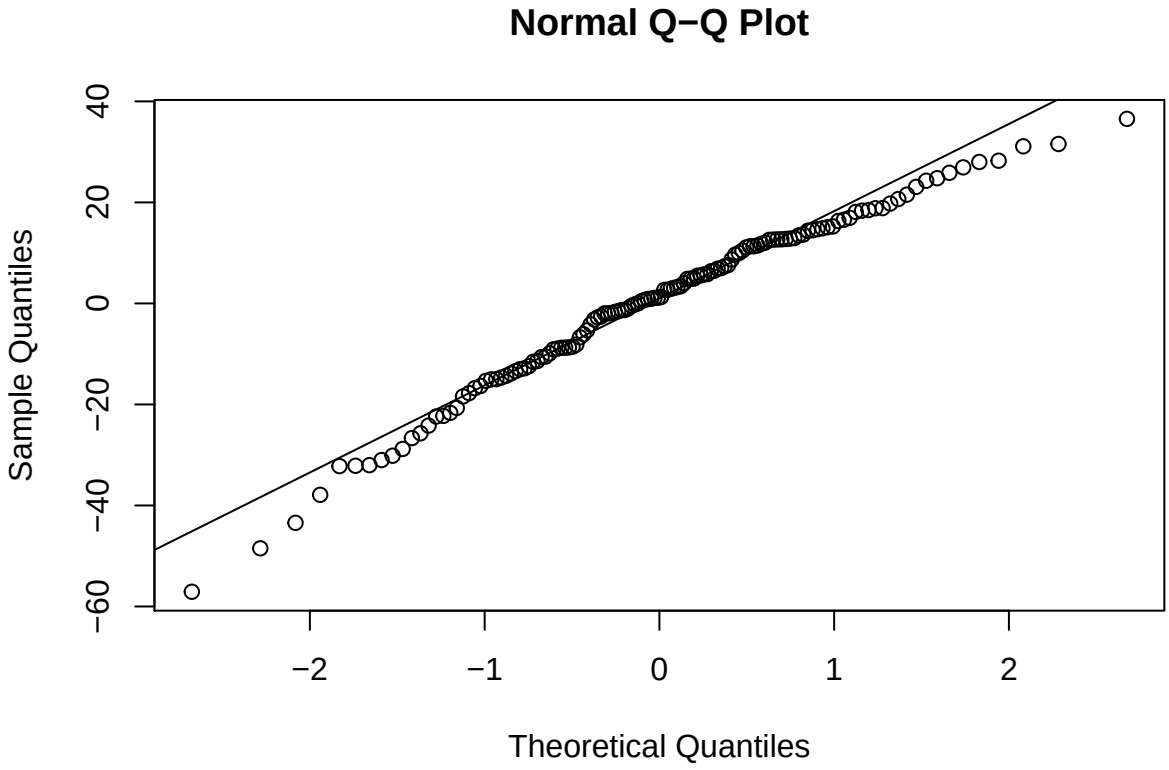


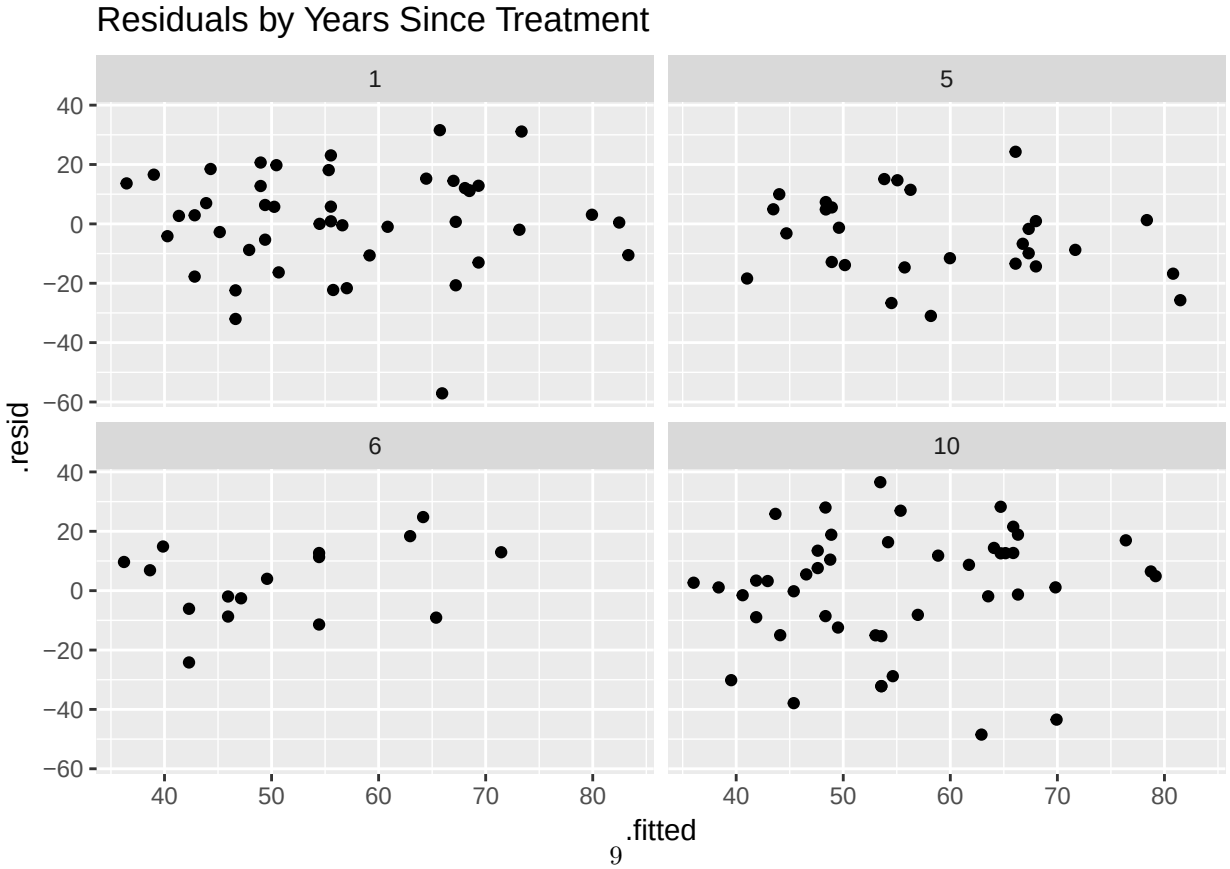
Inferences

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: sqrt(dwd_10hr) ~ pre_tree_cvr + yst + pre_tree_cvr:yst + (1 |
##     site)
##    Data: d
##
## REML criterion at convergence: 1149
##
## Scaled residuals:
##    Min     1Q Median     3Q    Max
## -3.261 -0.606  0.068  0.724  2.088
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  site     (Intercept)  12.3     3.51
##  Residual             306.4    17.50
## Number of obs: 134, groups:  site, 3
##
## Fixed effects:
##                  Estimate Std. Error t value
## (Intercept)       34.7821     6.2266    5.59
## pre_tree_cvr       1.2836     0.2984    4.30
## yst               -0.0139     0.8901   -0.02
## pre_tree_cvr:yst  -0.0115     0.0452   -0.25
##
## Correlation of Fixed Effects:
##             (Intr) pr_tr_ yst
## pre_tre_cvr -0.841
## yst         -0.781  0.733
## pr_tr_cvr:y  0.693 -0.825 -0.888
```

```
##                  estimate     se  lower   upper  tvalue  df   pvalue
## (Intercept)       34.7821 6.2266 22.578 46.9859  5.5861 Inf 2.32e-08
## pre_tree_cvr       1.2836 0.2984  0.699  1.8684  4.3017 Inf 1.70e-05
## yst               -0.0139 0.8901 -1.758  1.7306 -0.0156 Inf 9.88e-01
## pre_tree_cvr:yst  -0.0115 0.0452 -0.100  0.0771 -0.2537 Inf 8.00e-01
```

QQPlot and Plotted Residuals

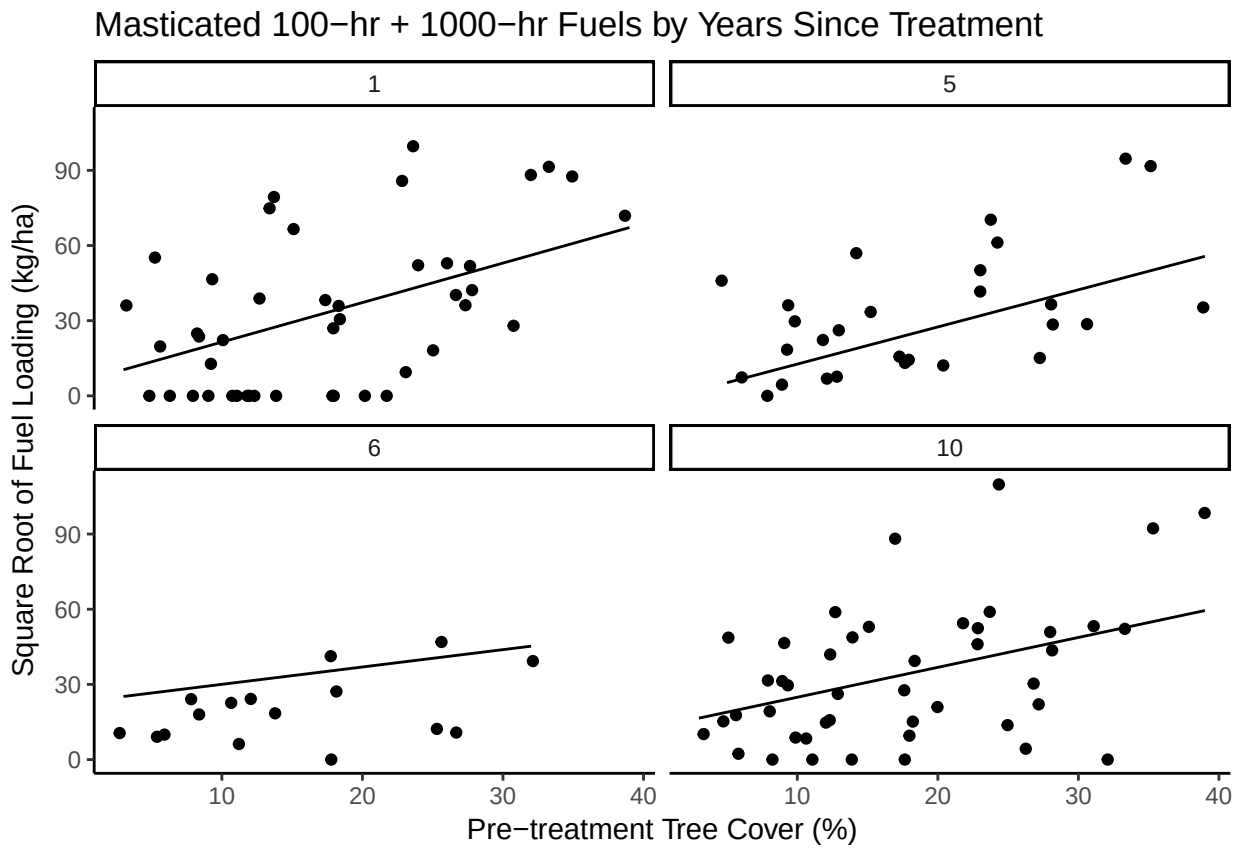




Masticated 100 + 1000-hr fuels

Model

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



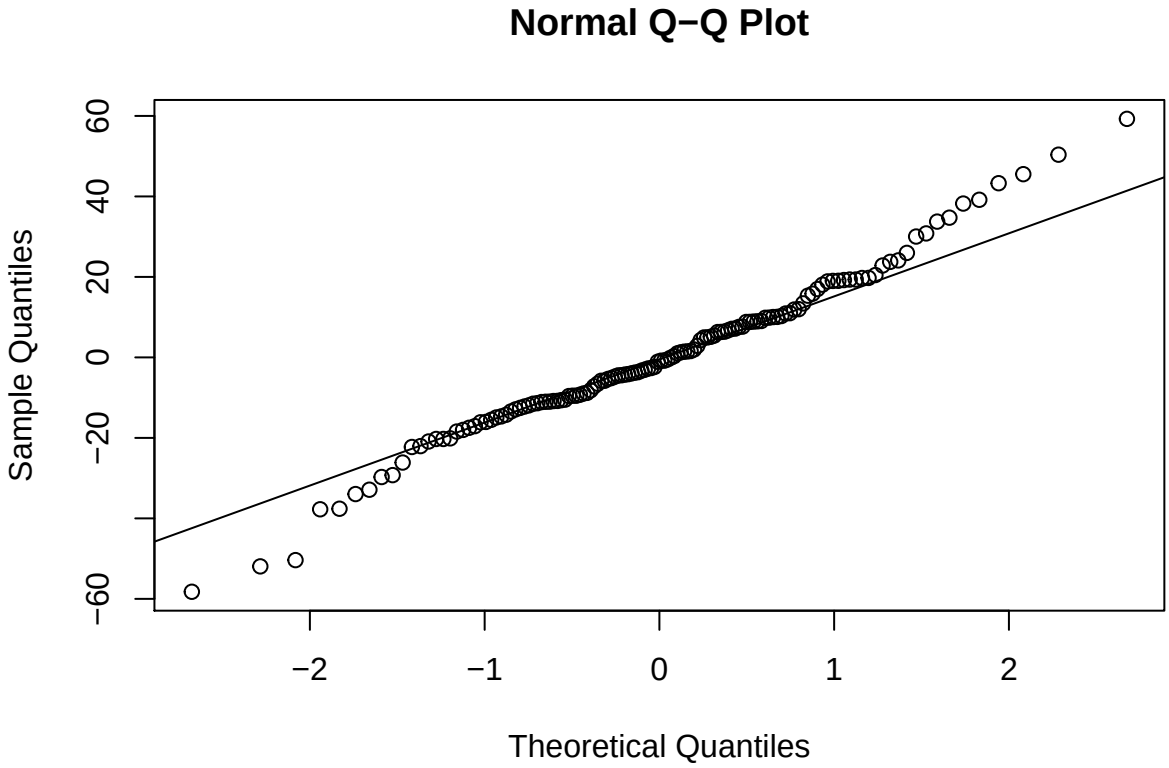
Inferences

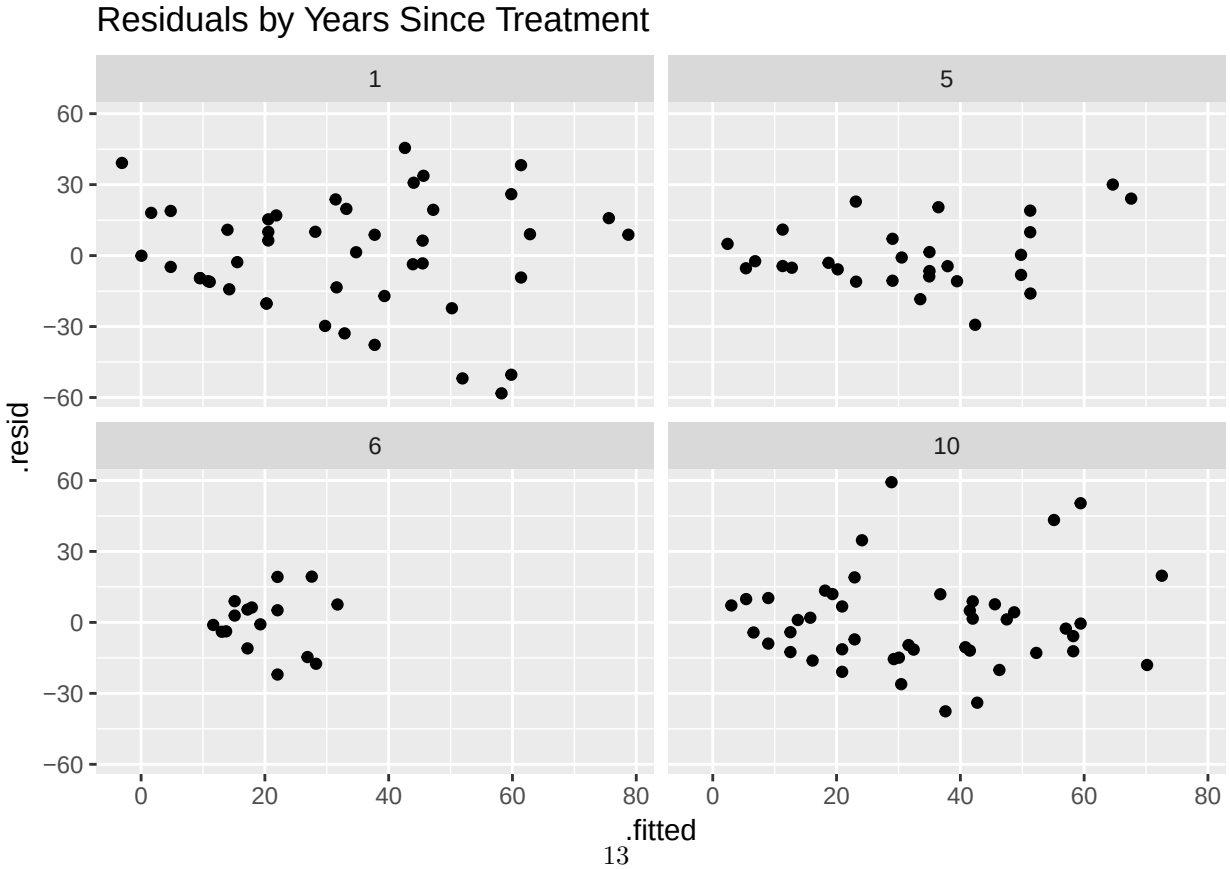
```
## Linear mixed model fit by REML ['lmerMod']
## Formula:
## sqrt(dwd_100_1000hr) ~ pre_tree_cvr + factor(yst) + pre_tree_cvr:factor(yst) +
##     (1 | site)
##    Data: d
##
## REML criterion at convergence: 1166
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -2.8880 -0.5494 -0.0472  0.4989  2.9395
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  site     (Intercept) 271      16.5
##  Residual             407      20.2
## Number of obs: 134, groups:  site, 3
##
## Fixed effects:
##                             Estimate Std. Error t value
## (Intercept)                   5.6938    11.5789    0.49
## pre_tree_cvr                  1.5764     0.3355    4.70
## factor(yst)5                 -7.8511    11.0623   -0.71
## factor(yst)6                 17.4086    12.3947    1.40
## factor(yst)10                 7.2472     9.2538    0.78
## pre_tree_cvr:factor(yst)5    -0.0937     0.5319   -0.18
## pre_tree_cvr:factor(yst)6    -0.8844     0.6837   -1.29
## pre_tree_cvr:factor(yst)10   -0.3834     0.4700   -0.82
##
## Correlation of Fixed Effects:
##             (Intr) pr_tr_ fct()5 fct()6 fc()10 p__:()5 p__:()6
## pre_tre_cvr -0.508
## factr(yst)5 -0.351  0.549
## factr(yst)6 -0.286  0.442  0.277
## fctr(yst)10 -0.400  0.622  0.418  0.373
## pr_tr_c:()5  0.320 -0.630 -0.887 -0.279 -0.392
## pr_tr_c:()6  0.249 -0.491 -0.270 -0.850 -0.305  0.309
## pr_tr_:()10  0.355 -0.700 -0.372 -0.332 -0.888  0.442   0.344
```

```
##                             estimate     se   lower  upper tvalue  df
## (Intercept)                   5.6938 11.579 -17.000 28.388  0.492 Inf
## pre_tree_cvr                  1.5764  0.335   0.919  2.234  4.699 Inf
## factor(yst)5                 -7.8511 11.062 -29.533 13.831 -0.710 Inf
## factor(yst)6                 17.4086 12.395  -6.885 41.702  1.405 Inf
## factor(yst)10                 7.2472  9.254 -10.890 25.384  0.783 Inf
## pre_tree_cvr:factor(yst)5    -0.0937  0.532  -1.136  0.949 -0.176 Inf
## pre_tree_cvr:factor(yst)6    -0.8844  0.684  -2.224  0.456 -1.294 Inf
## pre_tree_cvr:factor(yst)10   -0.3834  0.470  -1.305  0.538 -0.816 Inf
##                               pvalue
## (Intercept)                  6.23e-01
## pre_tree_cvr                 2.61e-06
## factor(yst)5                 4.78e-01
```

```
## factor(yst)6               1.60e-01
## factor(yst)10              4.34e-01
## pre_tree_cvr:factor(yst)5  8.60e-01
## pre_tree_cvr:factor(yst)6  1.96e-01
## pre_tree_cvr:factor(yst)10 4.15e-01
```

QQPlot and Plotted Residuals





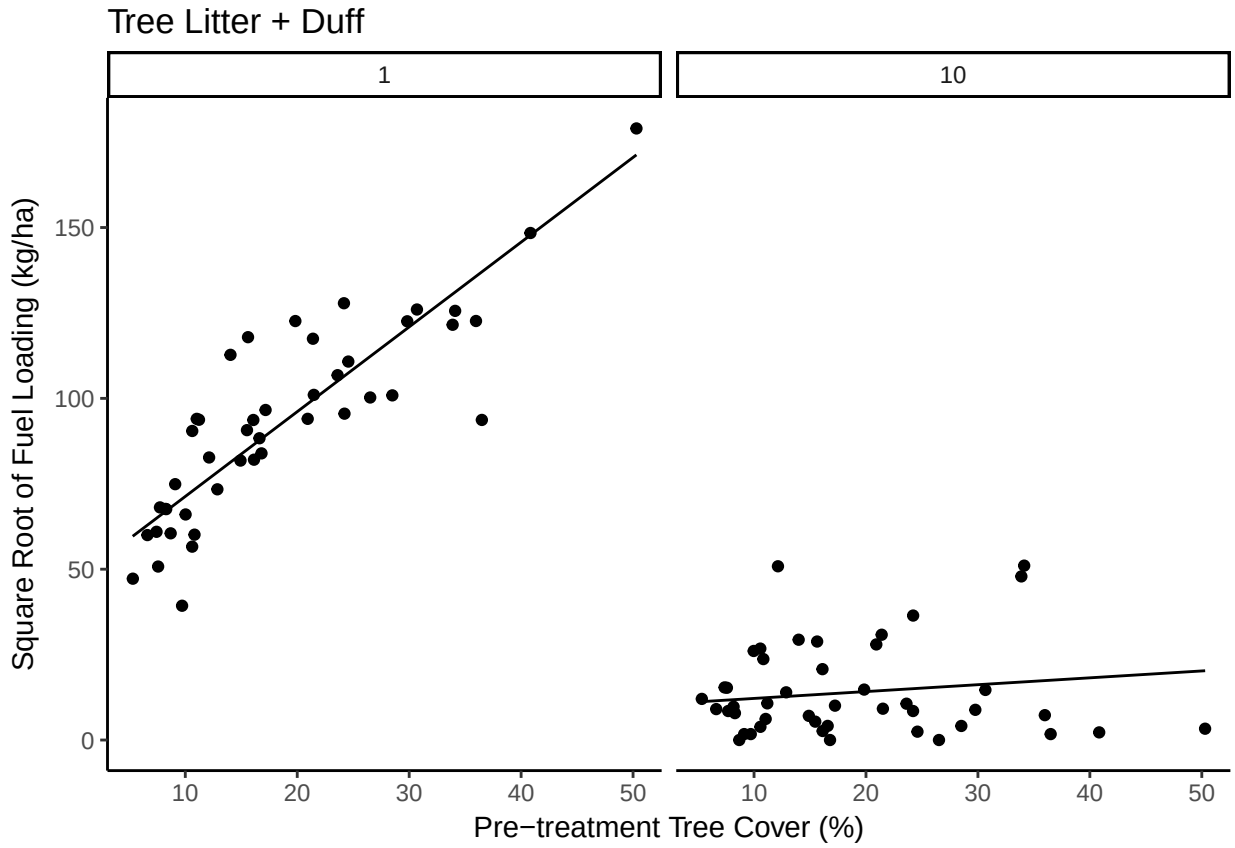
Tree Litter + Duff Fuels

Notes

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

Model

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

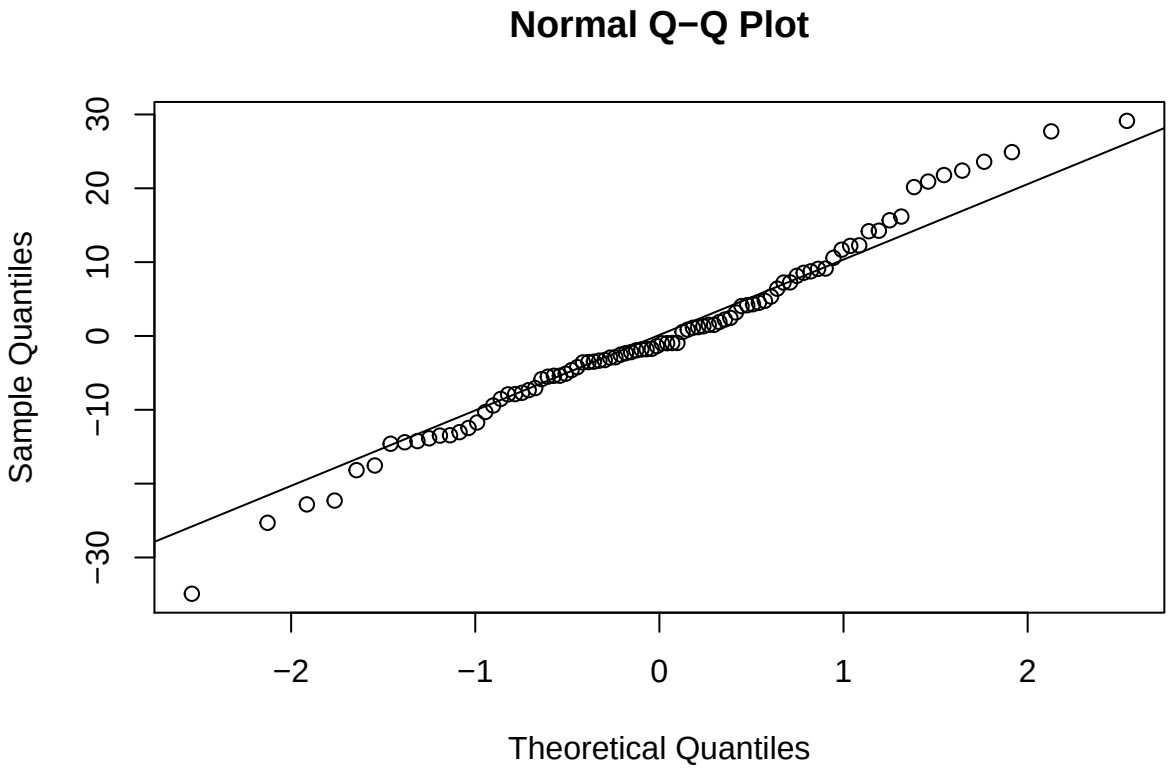


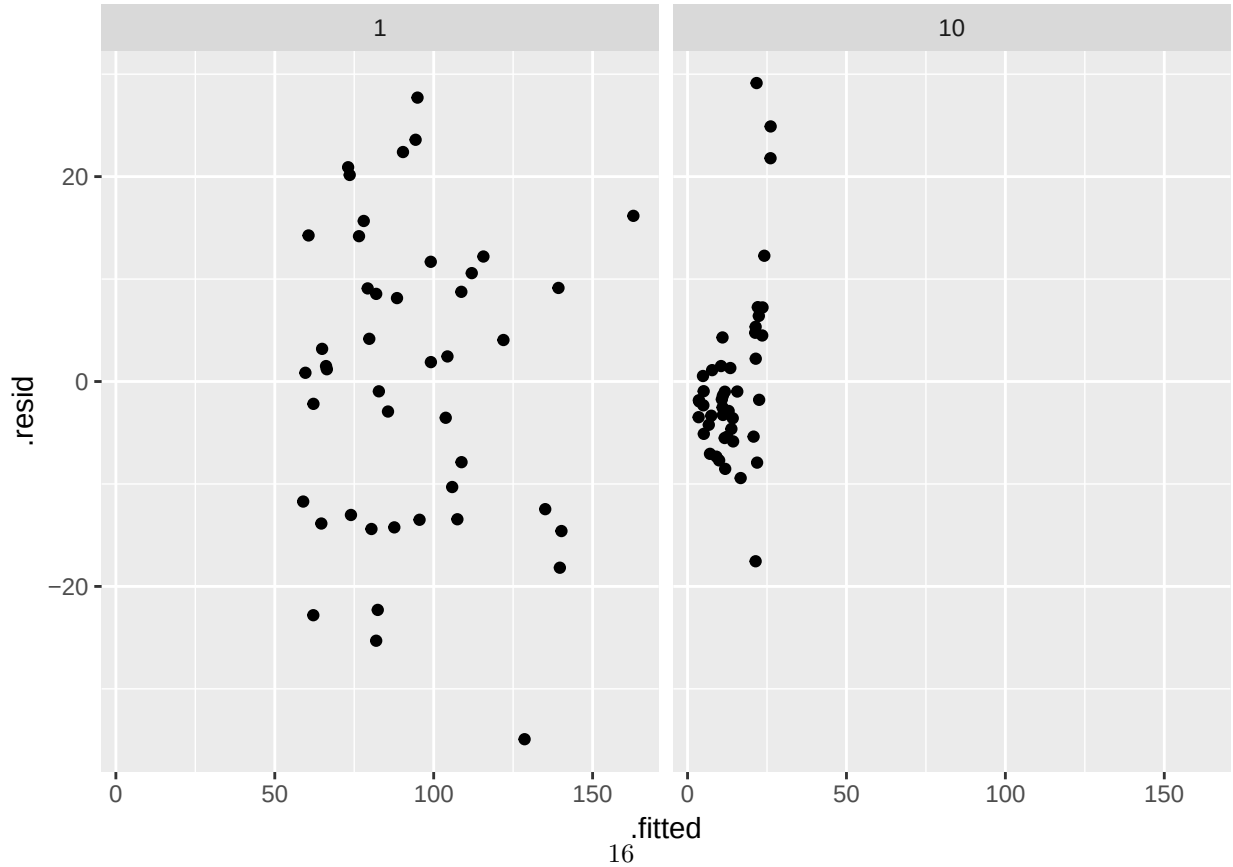
Inferences

```
## Linear mixed model fit by REML ['lmerMod']
## Formula:
## sqrt(duff) ~ factor(yst) + pre_tree_cvr + factor(yst):pre_tree_cvr +
##     (1 | site)
##    Data: d
##
## REML criterion at convergence: 706
##
## Scaled residuals:
##    Min     1Q Median     3Q    Max
## -2.834 -0.548 -0.096  0.570  2.365
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  site     (Intercept)  82.5     9.08
##  Residual             151.8    12.32
## Number of obs: 90, groups:  site, 3
##
## Fixed effects:
##                             Estimate Std. Error t value
## (Intercept)                   46.486      6.508    7.14
## factor(yst)10                -36.324      5.327   -6.82
## pre_tree_cvr                   2.481      0.181   13.69
## factor(yst)10:pre_tree_cvr    -2.280      0.250   -9.13
##
## Correlation of Fixed Effects:
##             (Intr) fc()10 pr_tr_
## fctr(yst)10 -0.409
## pre_tre_cvr -0.521  0.601
## fctr()10:__  0.357 -0.873 -0.689
```

```
##                             estimate    se  lower  upper tvalue  df
## (Intercept)                    46.49 6.508  33.73  59.24   7.14 Inf
## factor(yst)10                 -36.32 5.327 -46.76 -25.88  -6.82 Inf
## pre_tree_cvr                    2.48 0.181   2.13   2.84  13.69 Inf
## factor(yst)10:pre_tree_cvr     -2.28 0.250  -2.77  -1.79  -9.13 Inf
##                               pvalue
## (Intercept)                 9.16e-13
## factor(yst)10               9.15e-12
## pre_tree_cvr                1.25e-42
## factor(yst)10:pre_tree_cvr  7.00e-20
```

QQPlot and Plotted Residuals





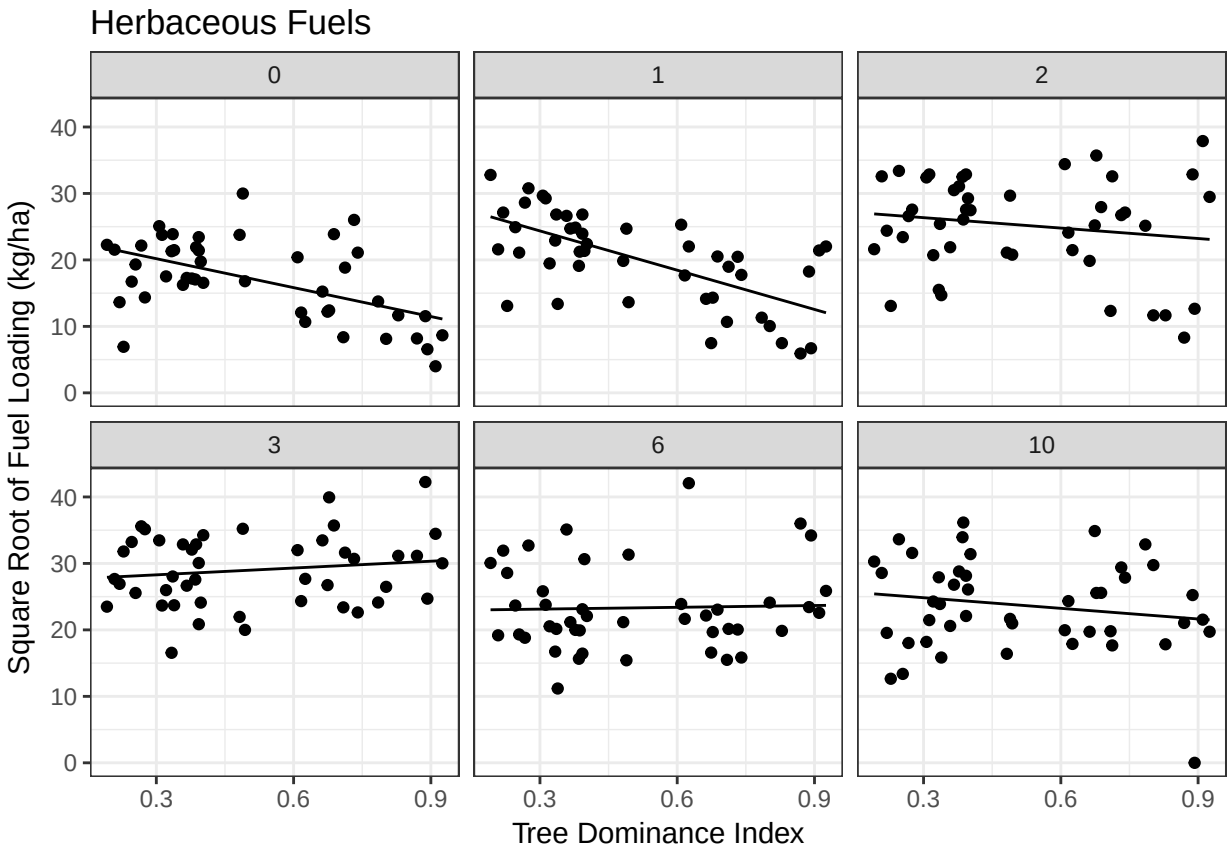
Herbaceous fuel loading (live + dead)

Notes:

*Investigate value of zero at Onaqui, yst = 10

Model

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



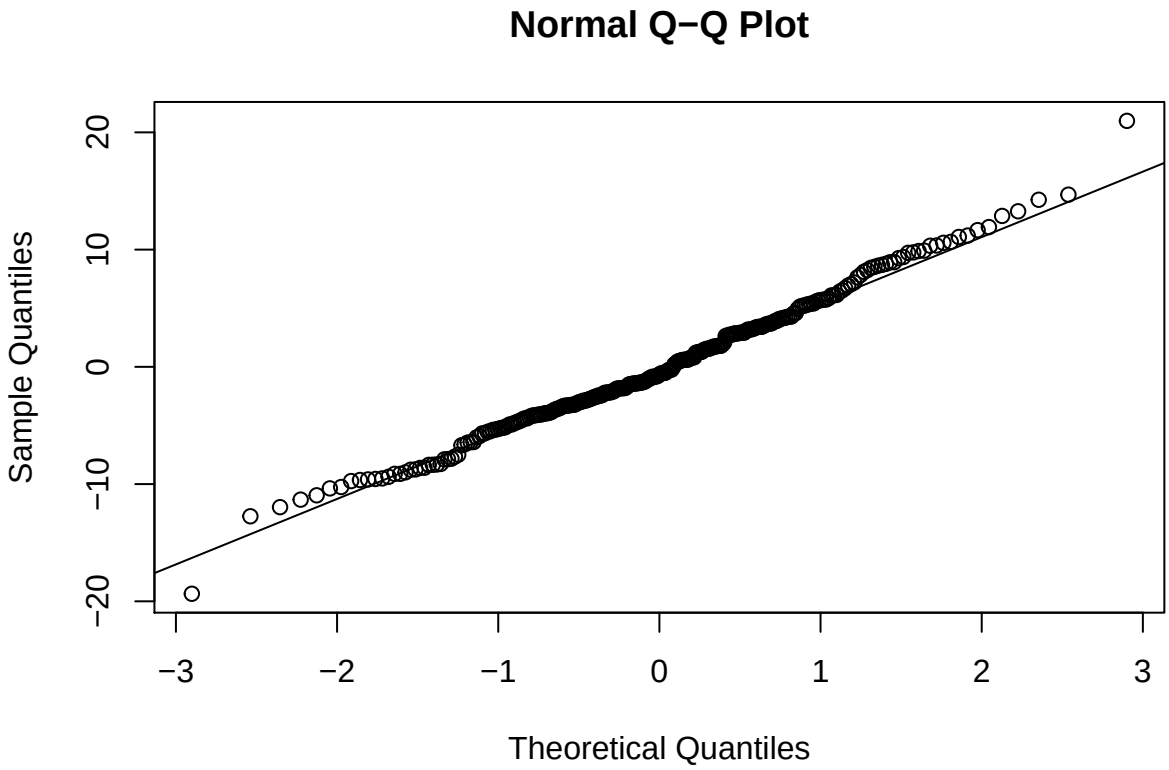
Inferences

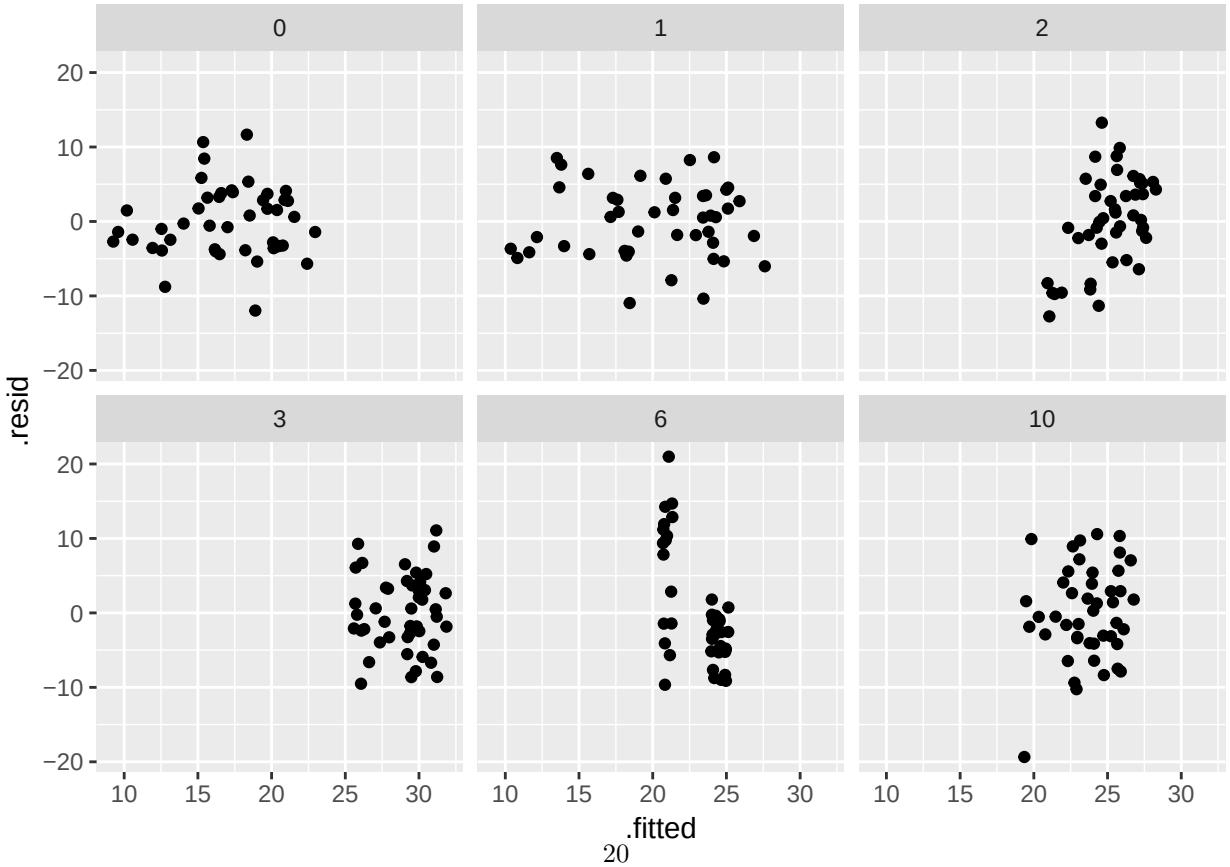
```
## Linear mixed model fit by REML ['lmerMod']
## Formula: sqrt(herb_ttl) ~ TDI + factor(yst) + factor(yst):TDI + (1 | site)
##    Data: l
##
## REML criterion at convergence: 1679
##
## Scaled residuals:
##    Min     1Q Median     3Q    Max
## -3.253 -0.650 -0.109  0.616  3.526
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  site     (Intercept)  4.51    2.12
##  Residual             35.40    5.95
## Number of obs: 269, groups:  site, 3
##
## Fixed effects:
##                   Estimate Std. Error t value
## (Intercept)          24.54       2.52    9.72
## TDI                 -14.51       3.93   -3.69
## factor(yst)1          5.73       3.12    1.84
## factor(yst)2          3.39       3.12    1.09
## factor(yst)3          2.72       3.12    0.87
## factor(yst)6         -1.68       3.12   -0.54
## factor(yst)10         1.91       3.12    0.61
## TDI:factor(yst)1     -5.18       5.55   -0.93
## TDI:factor(yst)2      9.28       5.55    1.67
## TDI:factor(yst)3     17.93       5.55    3.23
## TDI:factor(yst)6     15.41       5.60    2.75
## TDI:factor(yst)10     9.18       5.55    1.65
##
## Correlation of Fixed Effects:
##             (Intr) TDI    fct()1 fct()2 fct()3 fct()6 fc()10 TDI:f()1
## TDI         -0.800
## factr(yst)1 -0.617  0.647
## factr(yst)2 -0.617  0.647  0.500
## factr(yst)3 -0.617  0.647  0.500  0.500
## factr(yst)6 -0.615  0.645  0.499  0.499  0.499
## fctr(yst)10 -0.617  0.647  0.500  0.500  0.500  0.499
## TDI:fctr()1  0.565 -0.706 -0.915 -0.458 -0.458 -0.456 -0.458
## TDI:fctr()2  0.565 -0.706 -0.458 -0.915 -0.458 -0.456 -0.458  0.500
## TDI:fctr()3  0.565 -0.706 -0.458 -0.458 -0.915 -0.456 -0.458  0.500
## TDI:fctr()6  0.560 -0.700 -0.454 -0.454 -0.454 -0.915 -0.454  0.496
## TDI:fct()10  0.565 -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)          24.54 2.52  19.591 29.48  9.723 Inf 2.40e-22
## TDI                 -14.51 3.93 -22.211 -6.81 -3.692 Inf 2.23e-04
## factor(yst)1          5.73 3.12  -0.376 11.84  1.839 Inf 6.59e-02
## factor(yst)2          3.39 3.12  -2.717  9.49  1.088 Inf 2.77e-01
## factor(yst)3          2.72 3.12  -3.386  8.83  0.873 Inf 3.83e-01
## factor(yst)6         -1.68 3.12  -7.808  4.44 -0.539 Inf 5.90e-01
## factor(yst)10         1.91 3.12  -4.201  8.01  0.612 Inf 5.41e-01
## TDI:factor(yst)1     -5.18 5.55 -16.059  5.70 -0.932 Inf 3.51e-01
## TDI:factor(yst)2      9.28 5.55  -1.600 20.16  1.672 Inf 9.46e-02
## TDI:factor(yst)3     17.93 5.55   7.043 28.81  3.229 Inf 1.24e-03
## TDI:factor(yst)6     15.41 5.60   4.440 26.39  2.753 Inf 5.91e-03
## TDI:factor(yst)10     9.18 5.55  -1.706 20.06  1.653 Inf 9.84e-02
```

QQPlot and Residuals





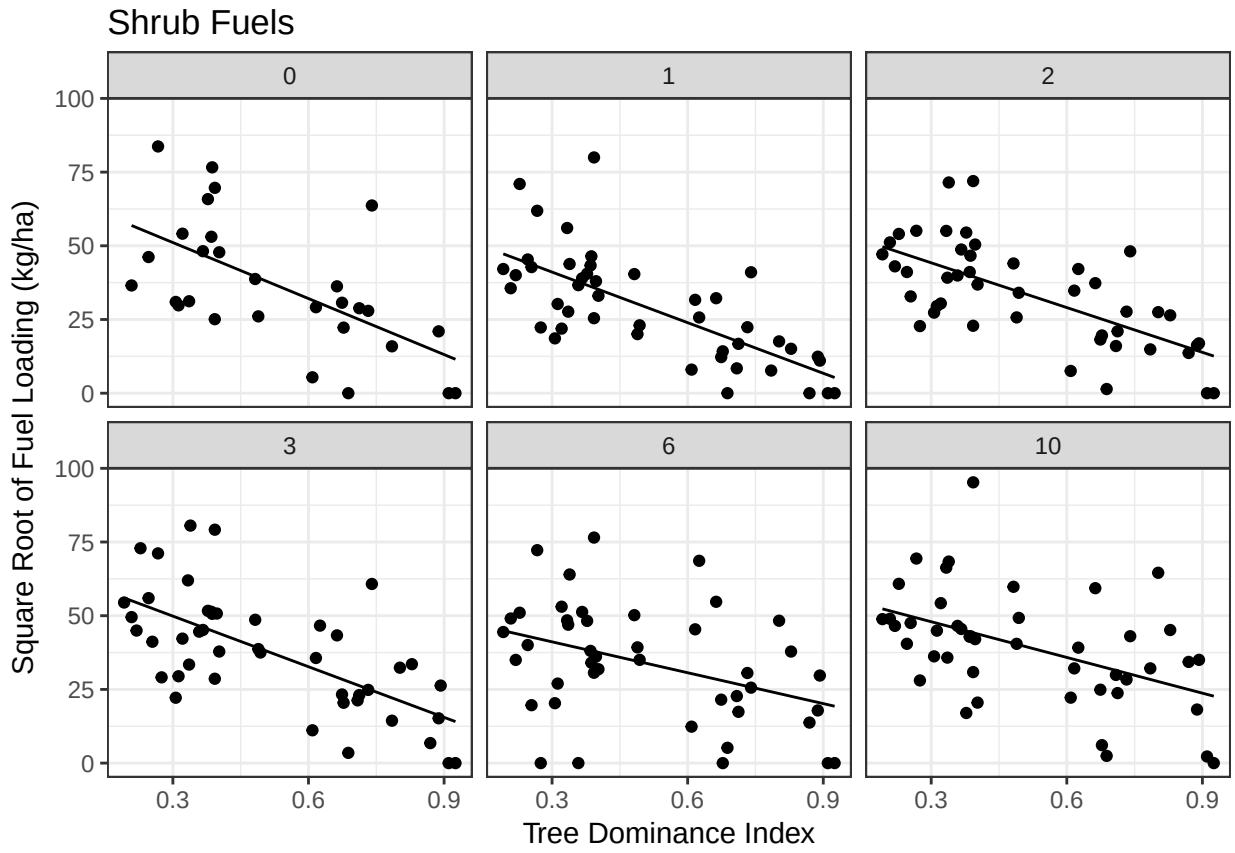
Shrub Fuels

*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(sqrt(shrub_fuel) ~ TDI + factor(yst) + factor(yst):TDI +
            (1|site), data = l2)
```



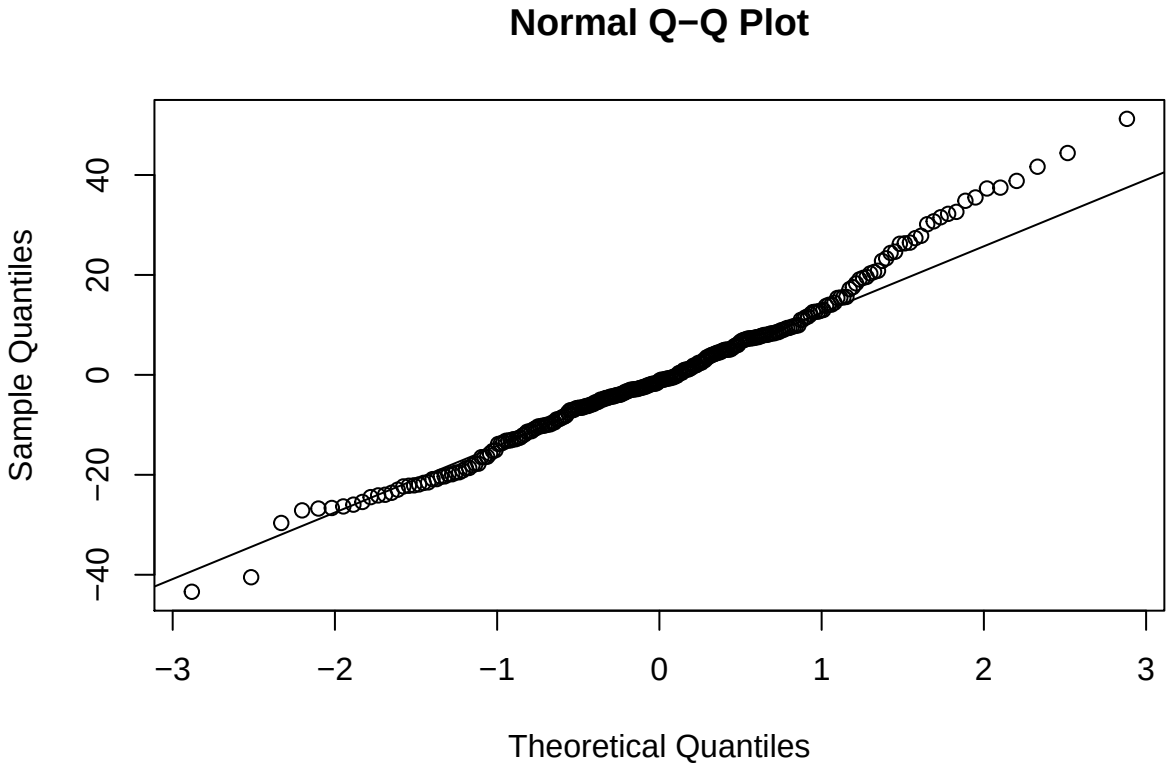
Inferences

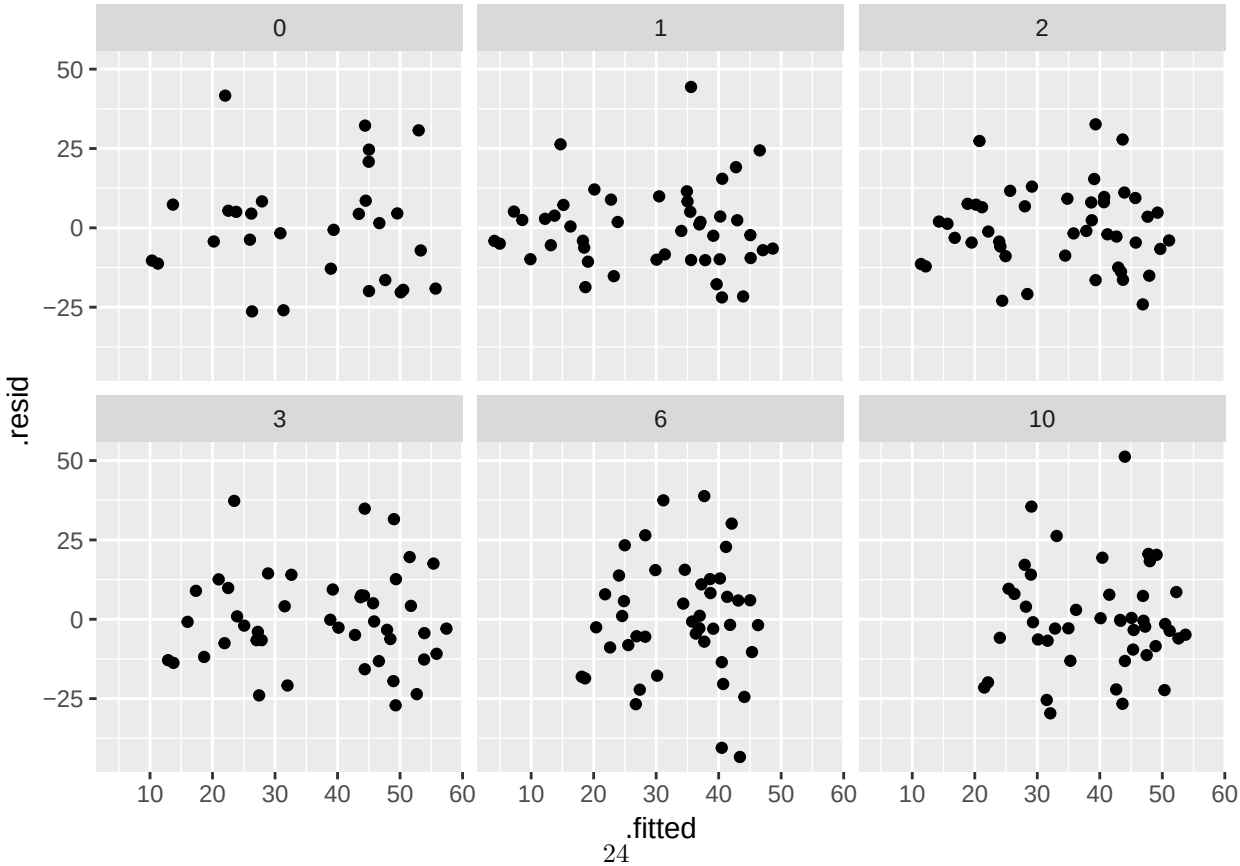
```
## Linear mixed model fit by REML ['lmerMod']
## Formula: sqrt(shrub_fuel) ~ TDI + factor(yst) + factor(yst):TDI + (1 |
##     site)
##    Data: l2
##
## REML criterion at convergence: 2040
##
## Scaled residuals:
##    Min     1Q Median     3Q    Max
## -2.762 -0.629 -0.074  0.514  3.260
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  site     (Intercept)   3.28    1.81
##  Residual             246.92   15.71
## Number of obs: 253, groups:  site, 3
##
## Fixed effects:
##                   Estimate Std. Error t value
## (Intercept)          70.10       7.94    8.82
## TDI                 -63.33      13.83   -4.58
## factor(yst)1        -11.85       9.80   -1.21
## factor(yst)2        -10.69       9.80   -1.09
## factor(yst)3         -3.07       9.80   -0.31
## factor(yst)6        -18.48       9.82   -1.88
## factor(yst)10       -10.02       9.80   -1.02
## TDI:factor(yst)1      6.11      17.28    0.35
## TDI:factor(yst)2     12.72      17.28    0.74
## TDI:factor(yst)3      6.10      17.28    0.35
## TDI:factor(yst)6     28.40      17.39    1.63
## TDI:factor(yst)10    22.94      17.28    1.33
##
## Correlation of Fixed Effects:
##             (Intr) TDI    fct()1 fct()2 fct()3 fct()6 fc()10 TDI:f()1
## TDI         -0.918
## factr(yst)1 -0.797  0.744
## factr(yst)2 -0.797  0.744  0.648
## factr(yst)3 -0.797  0.744  0.648  0.648
## factr(yst)6 -0.796  0.743  0.646  0.646  0.646
## fctr(yst)10 -0.797  0.744  0.648  0.648  0.648  0.646
## TDI:fctr()1  0.736 -0.800 -0.922 -0.596 -0.596 -0.595 -0.596
## TDI:fctr()2  0.736 -0.800 -0.596 -0.922 -0.596 -0.595 -0.596  0.640
## TDI:fctr()3  0.736 -0.800 -0.596 -0.596 -0.922 -0.595 -0.596  0.640
## TDI:fctr()6  0.731 -0.795 -0.593 -0.593 -0.593 -0.922 -0.593  0.636
## TDI:fct()10  0.736 -0.800 -0.596 -0.596 -0.596 -0.595 -0.922  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)           70.10  7.94  54.53  85.67  8.824 Inf 1.11e-18
## TDI                  -63.33 13.83 -90.44 -36.22 -4.578 Inf 4.69e-06
## factor(yst)1         -11.85  9.80 -31.05   7.36 -1.209 Inf 2.27e-01
## factor(yst)2         -10.69  9.80 -29.89   8.52 -1.091 Inf 2.75e-01
## factor(yst)3          -3.07  9.80 -22.28  16.13 -0.314 Inf 7.54e-01
## factor(yst)6         -18.48  9.82 -37.72   0.76 -1.883 Inf 5.98e-02
## factor(yst)10        -10.02  9.80 -29.23   9.19 -1.023 Inf 3.07e-01
## TDI:factor(yst)1       6.11 17.28 -27.77  39.99  0.354 Inf 7.24e-01
## TDI:factor(yst)2      12.72 17.28 -21.16  46.60  0.736 Inf 4.62e-01
## TDI:factor(yst)3       6.10 17.28 -27.77  39.98  0.353 Inf 7.24e-01
## TDI:factor(yst)6      28.40 17.39  -5.68  62.47  1.633 Inf 1.02e-01
## TDI:factor(yst)10     22.94 17.28 -10.94  56.81  1.327 Inf 1.85e-01
```

QQPlot and Residuals





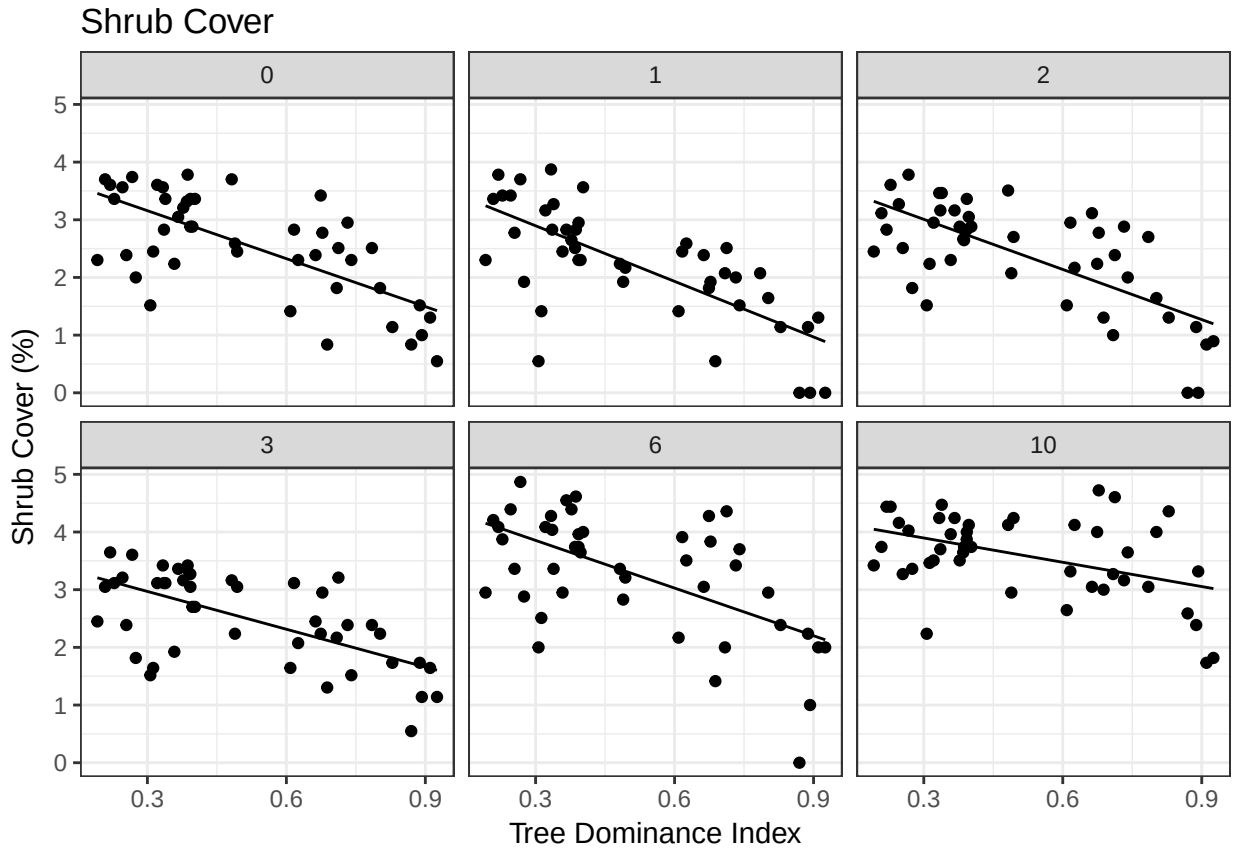
Shrub Cover

Notes

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

Model

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



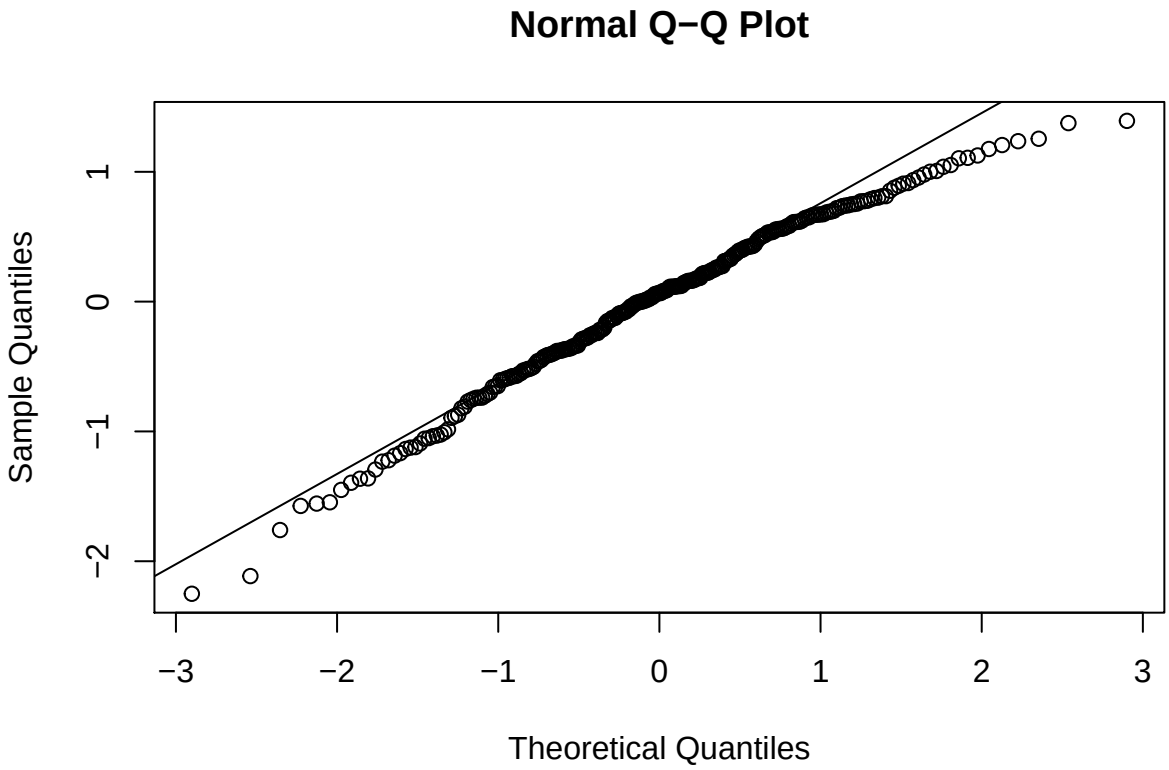
Inferences

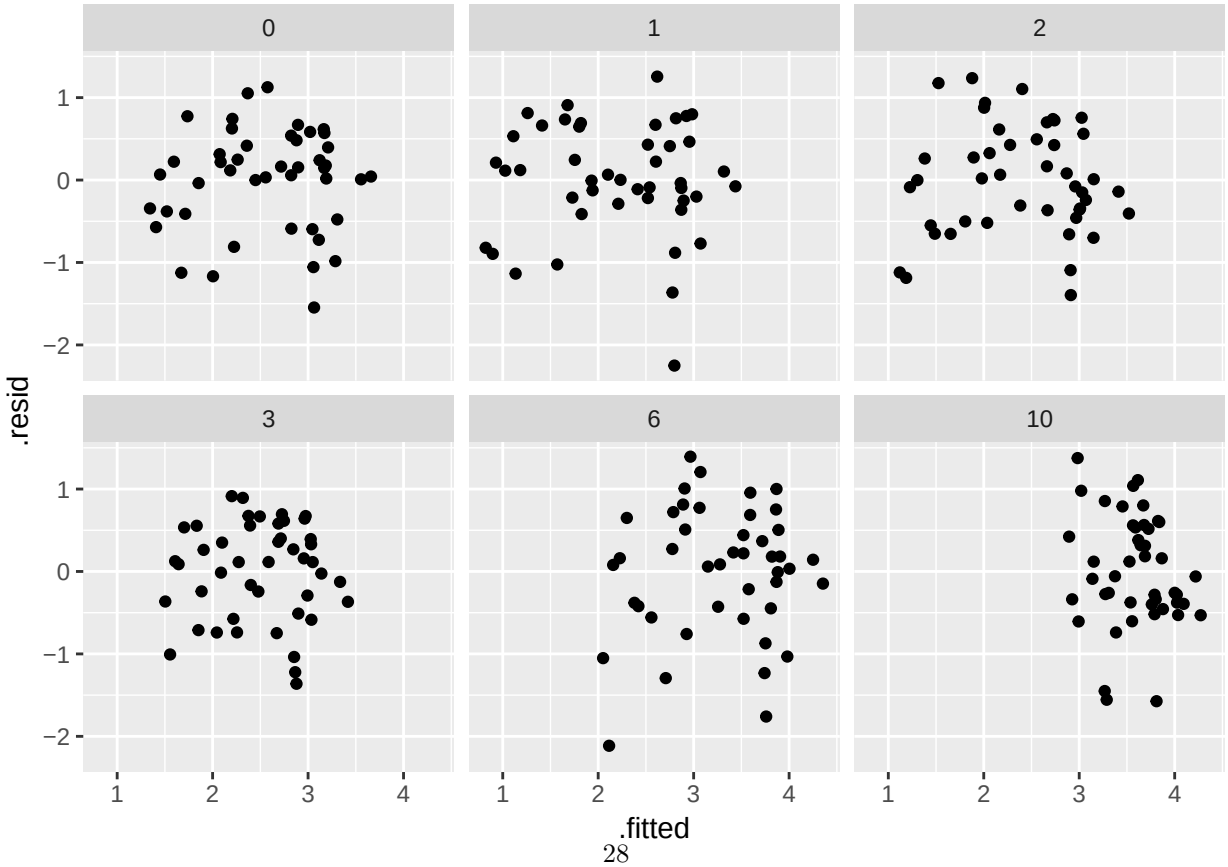
```
## Linear mixed model fit by REML ['lmerMod']
## Formula: sqrt(can_cover_pt_shrub) ~ TDI + factor(yst) + factor(yst):TDI +
##     (1 | site)
##    Data: l
##
## REML criterion at convergence: 565
##
## Scaled residuals:
##    Min     1Q Median     3Q    Max
## -3.302 -0.596  0.096  0.780  2.043
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  site     (Intercept) 0.0531   0.230
##  Residual             0.4647   0.682
## Number of obs: 269, groups:  site, 3
##
## Fixed effects:
##                   Estimate Std. Error t value
## (Intercept)         3.9894     0.2856   13.97
## TDI                -2.7727     0.4502   -6.16
## factor(yst)1       -0.1292     0.3569   -0.36
## factor(yst)2       -0.1123     0.3569   -0.31
## factor(yst)3       -0.3640     0.3569   -1.02
## factor(yst)6        0.6919     0.3579    1.93
## factor(yst)10       0.3279     0.3569    0.92
## TDI:factor(yst)1   -0.4409     0.6361   -0.69
## TDI:factor(yst)2   -0.1248     0.6361   -0.20
## TDI:factor(yst)3    0.5874     0.6361    0.92
## TDI:factor(yst)6    0.0171     0.6415    0.03
## TDI:factor(yst)10   1.3693     0.6361    2.15
##
## Correlation of Fixed Effects:
##             (Intr) TDI    fct()1 fct()2 fct()3 fct()6 fc()10 TDI:f()1
## TDI         -0.810
## factr(yst)1 -0.625  0.647
## factr(yst)2 -0.625  0.647  0.500
## factr(yst)3 -0.625  0.647  0.500  0.500
## factr(yst)6 -0.623  0.645  0.499  0.499  0.499
## fctr(yst)10 -0.625  0.647  0.500  0.500  0.500  0.499
## TDI:fctr()1  0.572 -0.706 -0.915 -0.458 -0.458 -0.456 -0.458
## TDI:fctr()2  0.572 -0.706 -0.458 -0.915 -0.458 -0.456 -0.458  0.500
## TDI:fctr()3  0.572 -0.706 -0.458 -0.458 -0.915 -0.456 -0.458  0.500
## TDI:fctr()6  0.567 -0.700 -0.454 -0.454 -0.454 -0.915 -0.454  0.496
## TDI:fct()10  0.572 -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)          3.9894 0.286  3.4297  4.549 13.9699 Inf 2.38e-44
## TDI                 -2.7727 0.450 -3.6551 -1.890 -6.1583 Inf 7.35e-10
## factor(yst)1        -0.1292 0.357 -0.8287  0.570 -0.3619 Inf 7.17e-01
## factor(yst)2        -0.1123 0.357 -0.8119  0.587 -0.3148 Inf 7.53e-01
## factor(yst)3        -0.3640 0.357 -1.0635  0.336 -1.0199 Inf 3.08e-01
## factor(yst)6         0.6919 0.358 -0.0096  1.393  1.9331 Inf 5.32e-02
## factor(yst)10        0.3279 0.357 -0.3716  1.027  0.9188 Inf 3.58e-01
## TDI:factor(yst)1    -0.4409 0.636 -1.6875  0.806 -0.6931 Inf 4.88e-01
## TDI:factor(yst)2    -0.1248 0.636 -1.3715  1.122 -0.1962 Inf 8.44e-01
## TDI:factor(yst)3     0.5874 0.636 -0.6593  1.834  0.9234 Inf 3.56e-01
## TDI:factor(yst)6     0.0171 0.641 -1.2402  1.274  0.0266 Inf 9.79e-01
## TDI:factor(yst)10    1.3693 0.636  0.1226  2.616  2.1528 Inf 3.13e-02
```

QQPlot and Plotted Residuals

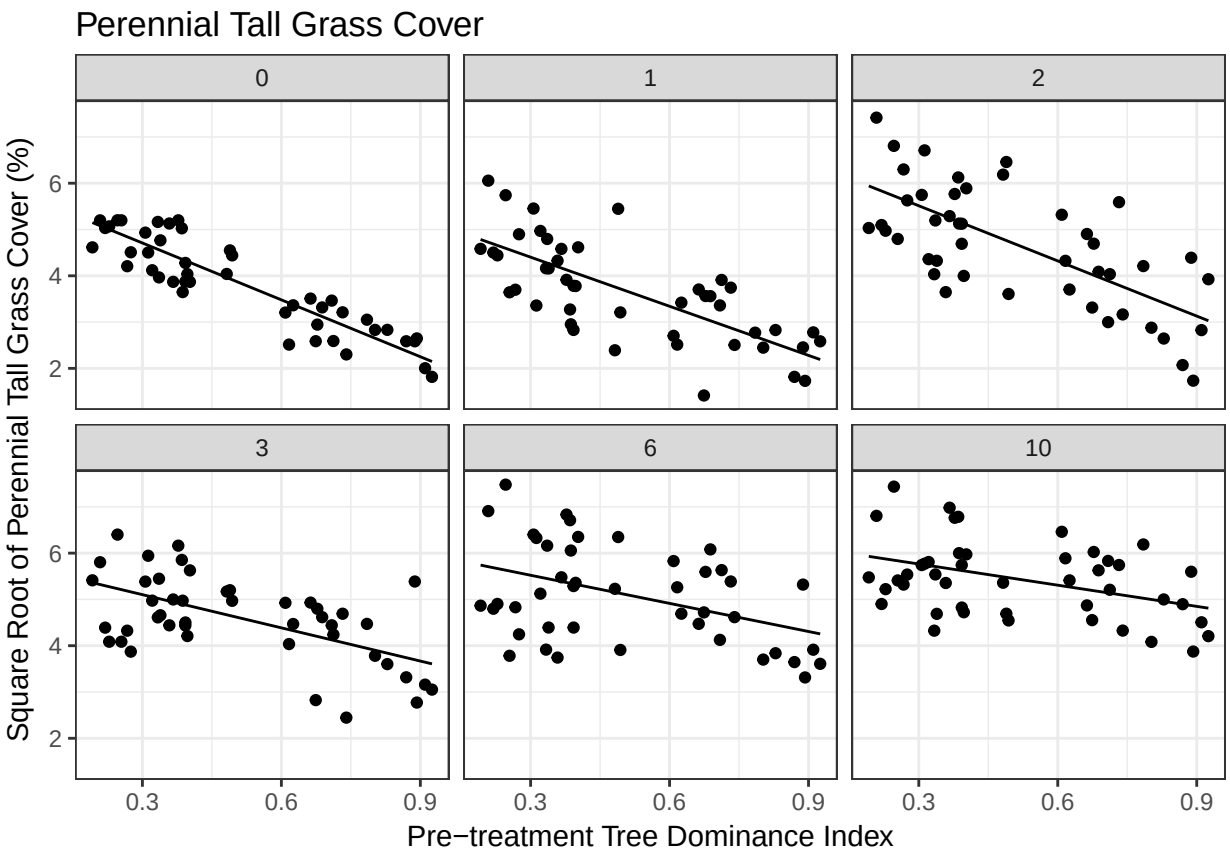




Perennial Grass Cover

Model

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



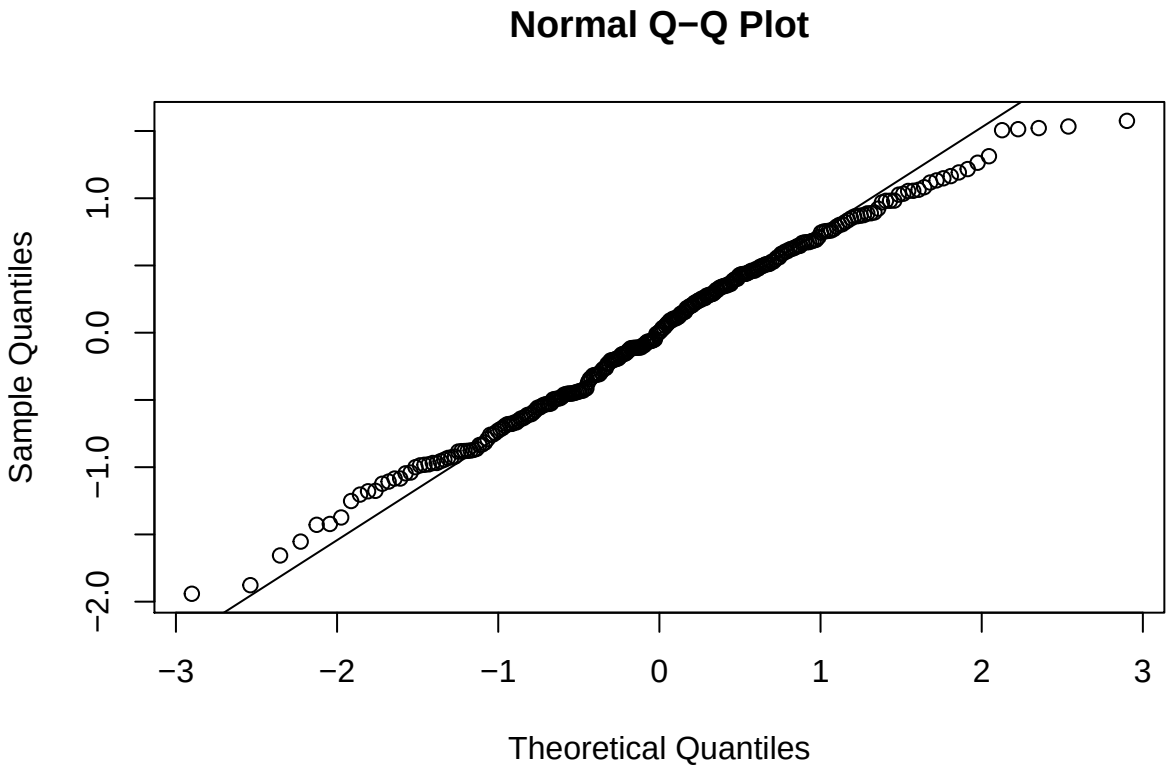
Inferences

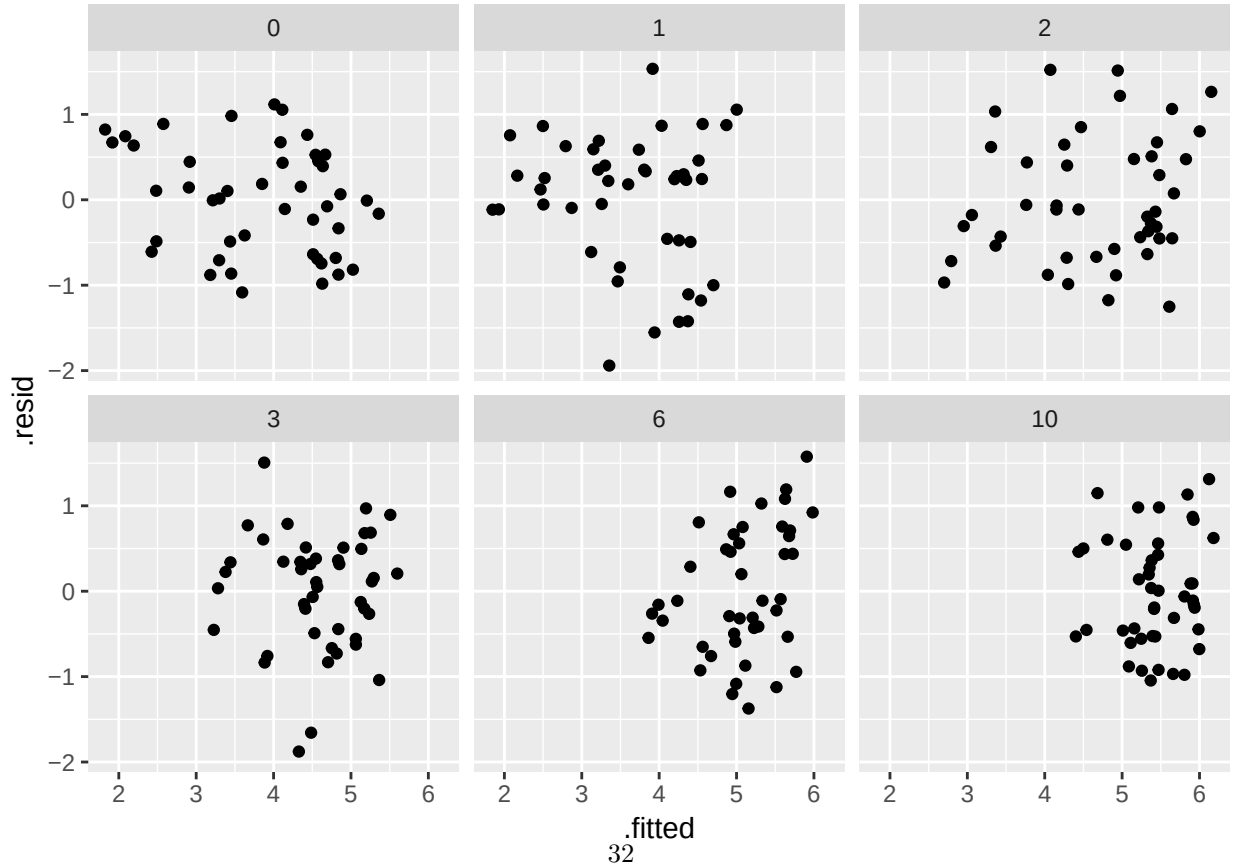
```
## Linear mixed model fit by REML ['lmerMod']
## Formula:
## sqrt(can_cover_pt_pgrass) ~ TDI + factor(yst) + factor(yst):TDI +
##     (1 | site)
##    Data: l
##
## REML criterion at convergence: 592
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -2.7133 -0.7341  0.0086  0.7131  2.2019
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  site     (Intercept) 0.166    0.407
##  Residual             0.512    0.715
## Number of obs: 269, groups:  site, 3
##
## Fixed effects:
##                   Estimate Std. Error t value
## (Intercept)          5.937      0.354   16.75
## TDI                 -4.095      0.473   -8.67
## factor(yst)1        -0.473      0.375   -1.26
## factor(yst)2         0.767      0.375    2.05
## factor(yst)3        -0.116      0.375   -0.31
## factor(yst)6         0.193      0.376    0.51
## factor(yst)10        0.286      0.375    0.76
## TDI:factor(yst)1     0.557      0.668    0.84
## TDI:factor(yst)2     0.124      0.668    0.19
## TDI:factor(yst)3     1.704      0.668    2.55
## TDI:factor(yst)6     2.069      0.673    3.07
## TDI:factor(yst)10    2.569      0.668    3.85
##
## Correlation of Fixed Effects:
##             (Intr) TDI    fct()1 fct()2 fct()3 fct()6 fc()10 TDI:f()1
## TDI         -0.685
## factr(yst)1 -0.529  0.647
## factr(yst)2 -0.529  0.647  0.500
## factr(yst)3 -0.529  0.647  0.500  0.500
## factr(yst)6 -0.527  0.645  0.499  0.499  0.499
## fctr(yst)10 -0.529  0.647  0.500  0.500  0.500  0.499
## TDI:fctr()1  0.484 -0.706 -0.915 -0.458 -0.458 -0.456 -0.458
## TDI:fctr()2  0.484 -0.706 -0.458 -0.915 -0.458 -0.456 -0.458  0.500
## TDI:fctr()3  0.484 -0.706 -0.458 -0.458 -0.915 -0.456 -0.458  0.500
## TDI:fctr()6  0.480 -0.700 -0.454 -0.454 -0.454 -0.915 -0.454  0.496
## TDI:fct()10  0.484 -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)           5.937 0.354  5.2425  6.632 16.754 Inf 5.34e-63
## TDI                  -4.095 0.473 -5.0216 -3.169 -8.666 Inf 4.48e-18
## factor(yst)1         -0.473 0.375 -1.2072  0.261 -1.263 Inf 2.07e-01
## factor(yst)2          0.767 0.375  0.0328  1.501  2.047 Inf 4.06e-02
## factor(yst)3         -0.116 0.375 -0.8504  0.618 -0.310 Inf 7.56e-01
## factor(yst)6          0.193 0.376 -0.5432  0.929  0.514 Inf 6.07e-01
## factor(yst)10         0.286 0.375 -0.4483  1.020  0.763 Inf 4.45e-01
## TDI:factor(yst)1      0.557 0.668 -0.7510  1.866  0.835 Inf 4.04e-01
## TDI:factor(yst)2      0.124 0.668 -1.1847  1.432  0.185 Inf 8.53e-01
## TDI:factor(yst)3      1.704 0.668  0.3952  3.012  2.552 Inf 1.07e-02
## TDI:factor(yst)6      2.069 0.673  0.7495  3.389  3.073 Inf 2.12e-03
## TDI:factor(yst)10     2.569 0.668  1.2610  3.878  3.849 Inf 1.19e-04
```

QQPlot and Plotted Residuals





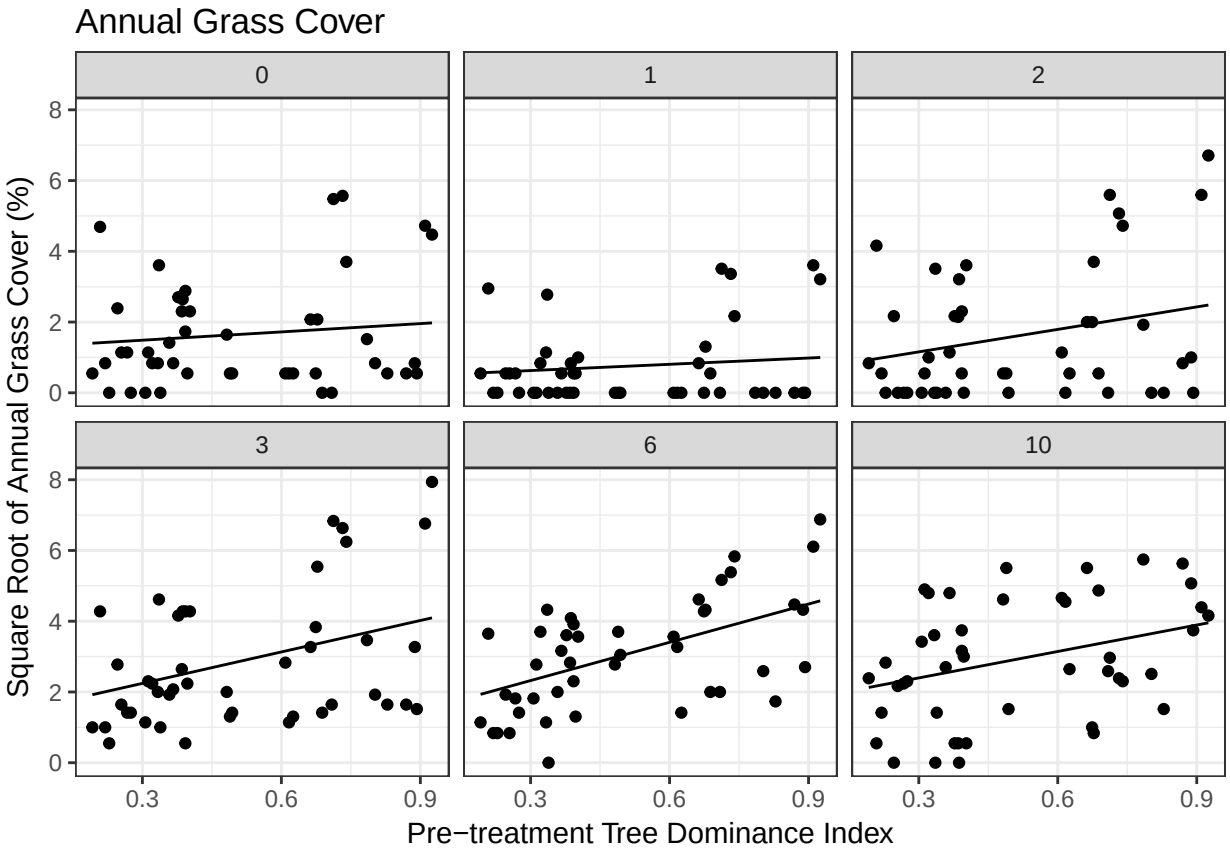
Annual Grass Cover

Notes

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

Model

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



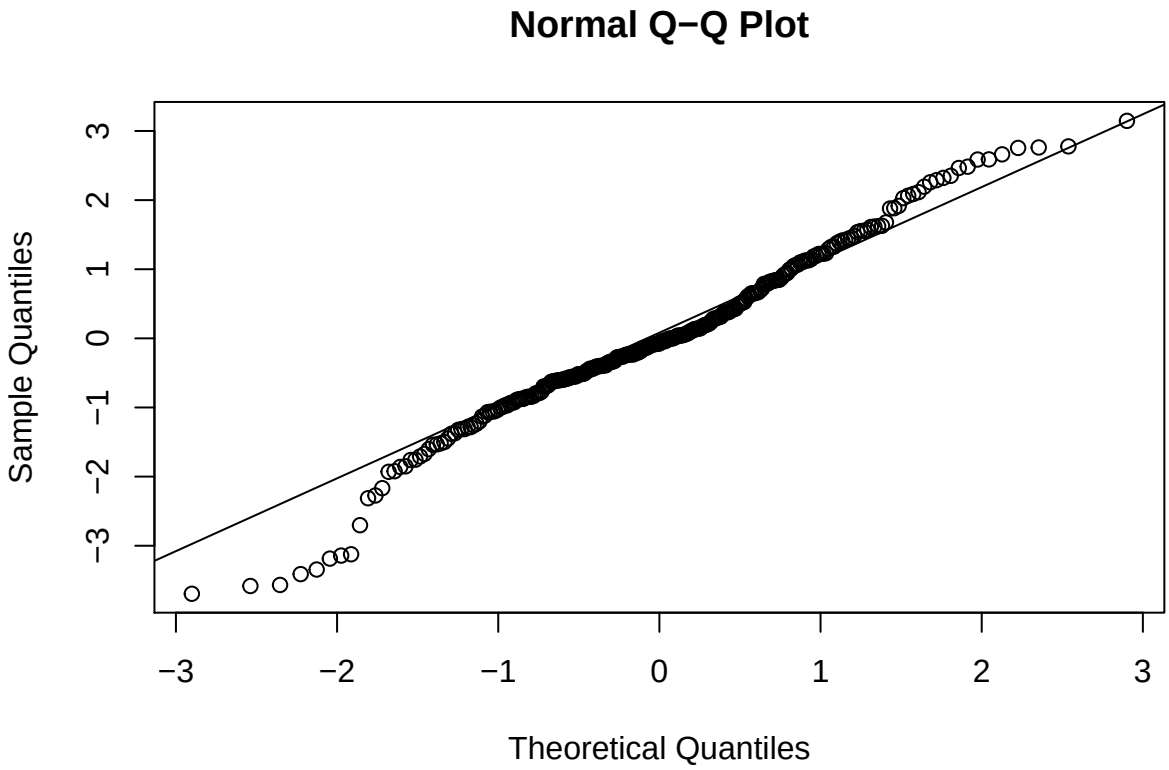
Inferences

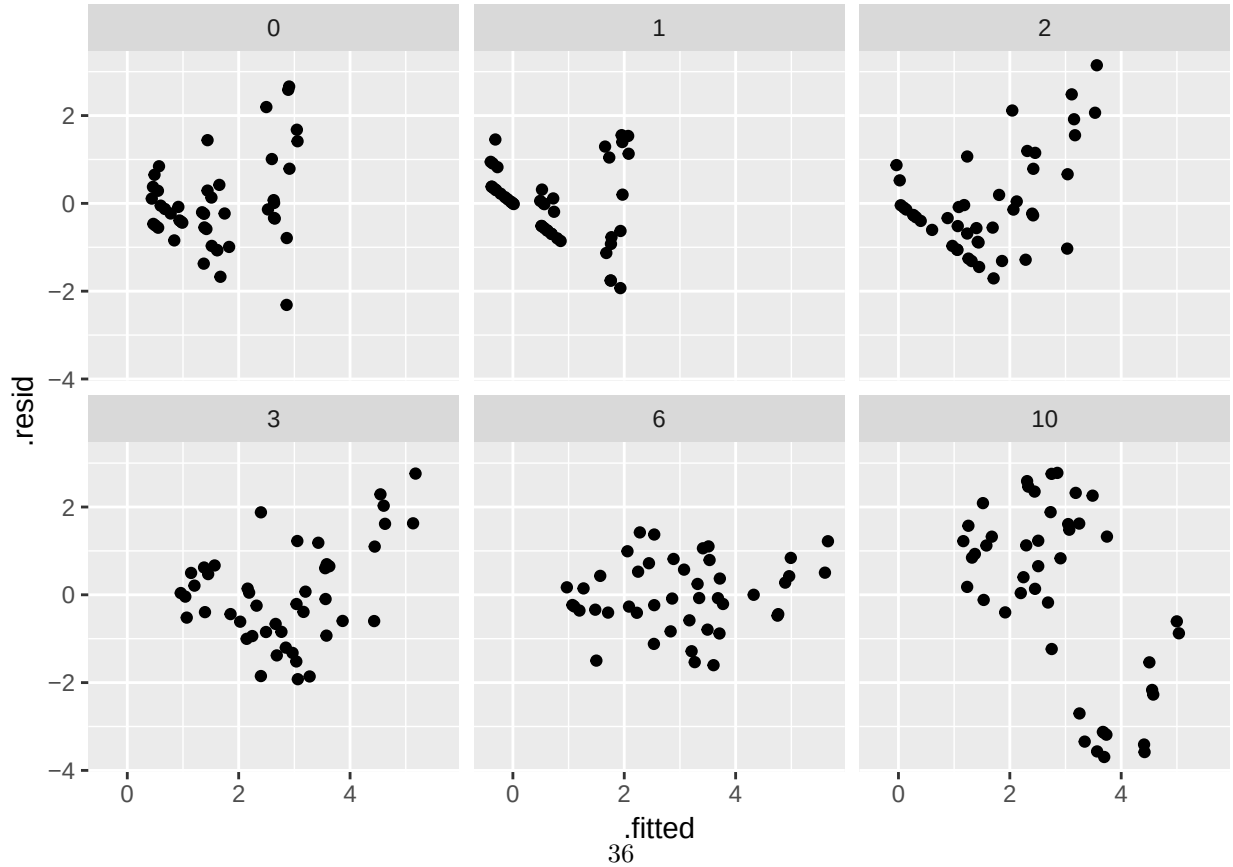
```
## Linear mixed model fit by REML ['lmerMod']
## Formula:
## sqrt(can_cover_pt_agrass) ~ TDI + factor(yst) + factor(yst):TDI +
##     (1 | site)
##    Data: l
##
## REML criterion at convergence: 886
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -2.9193 -0.4967 -0.0584  0.6260  2.4859
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  site     (Intercept) 1.07     1.04
##  Residual             1.60     1.27
## Number of obs: 269, groups:  site, 3
##
## Fixed effects:
##                   Estimate Std. Error t value
## (Intercept)         1.2521     0.7601    1.65
## TDI                 0.7820     0.8360    0.94
## factor(yst)1       -0.8006     0.6627   -1.21
## factor(yst)2       -0.7309     0.6627   -1.10
## factor(yst)3        0.1016     0.6627    0.15
## factor(yst)6       -0.0122     0.6646   -0.02
## factor(yst)10       0.3975     0.6627    0.60
## TDI:factor(yst)1   -0.1919     1.1810   -0.16
## TDI:factor(yst)2    1.3361     1.1810    1.13
## TDI:factor(yst)3    2.1807     1.1810    1.85
## TDI:factor(yst)6    2.8243     1.1910    2.37
## TDI:factor(yst)10   1.7095     1.1810    1.45
##
## Correlation of Fixed Effects:
##             (Intr) TDI    fct()1 fct()2 fct()3 fct()6 fc()10 TDI:f()1
## TDI         -0.565
## factr(yst)1 -0.436  0.647
## factr(yst)2 -0.436  0.647  0.500
## factr(yst)3 -0.436  0.647  0.500  0.500
## factr(yst)6 -0.435  0.645  0.499  0.499  0.499
## fctr(yst)10 -0.436  0.647  0.500  0.500  0.500  0.499
## TDI:fctr()1  0.399 -0.706 -0.915 -0.458 -0.458 -0.456 -0.458
## TDI:fctr()2  0.399 -0.706 -0.458 -0.915 -0.458 -0.456 -0.458  0.500
## TDI:fctr()3  0.399 -0.706 -0.458 -0.458 -0.915 -0.456 -0.458  0.500
## TDI:fctr()6  0.396 -0.700 -0.454 -0.454 -0.454 -0.915 -0.454  0.496
## TDI:fct()10  0.399 -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)          1.2521 0.760 -0.238 2.742  1.6474 Inf 0.0995
## TDI                  0.7820 0.836 -0.857 2.421  0.9354 Inf 0.3496
## factor(yst)1        -0.8006 0.663 -2.099 0.498 -1.2082 Inf 0.2270
## factor(yst)2        -0.7309 0.663 -2.030 0.568 -1.1030 Inf 0.2700
## factor(yst)3         0.1016 0.663 -1.197 1.400  0.1533 Inf 0.8781
## factor(yst)6        -0.0122 0.665 -1.315 1.290 -0.0183 Inf 0.9854
## factor(yst)10        0.3975 0.663 -0.901 1.696  0.5998 Inf 0.5486
## TDI:factor(yst)1    -0.1919 1.181 -2.507 2.123 -0.1625 Inf 0.8709
## TDI:factor(yst)2     1.3361 1.181 -0.979 3.651  1.1313 Inf 0.2579
## TDI:factor(yst)3     2.1807 1.181 -0.134 4.495  1.8465 Inf 0.0648
## TDI:factor(yst)6     2.8243 1.191  0.490 5.159  2.3713 Inf 0.0177
## TDI:factor(yst)10    1.7095 1.181 -0.605 4.024  1.4475 Inf 0.1478
```

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)?

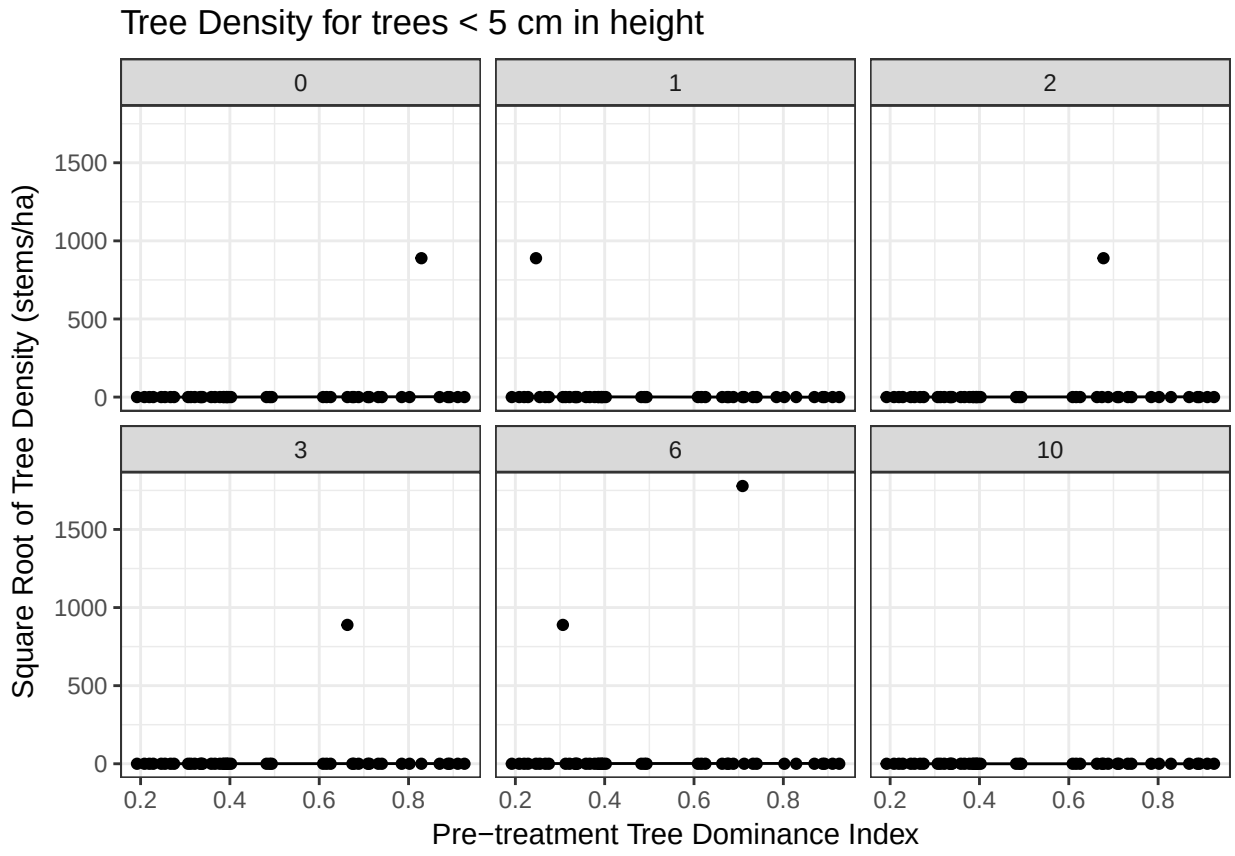
Tree Density for trees < 5 cm in height

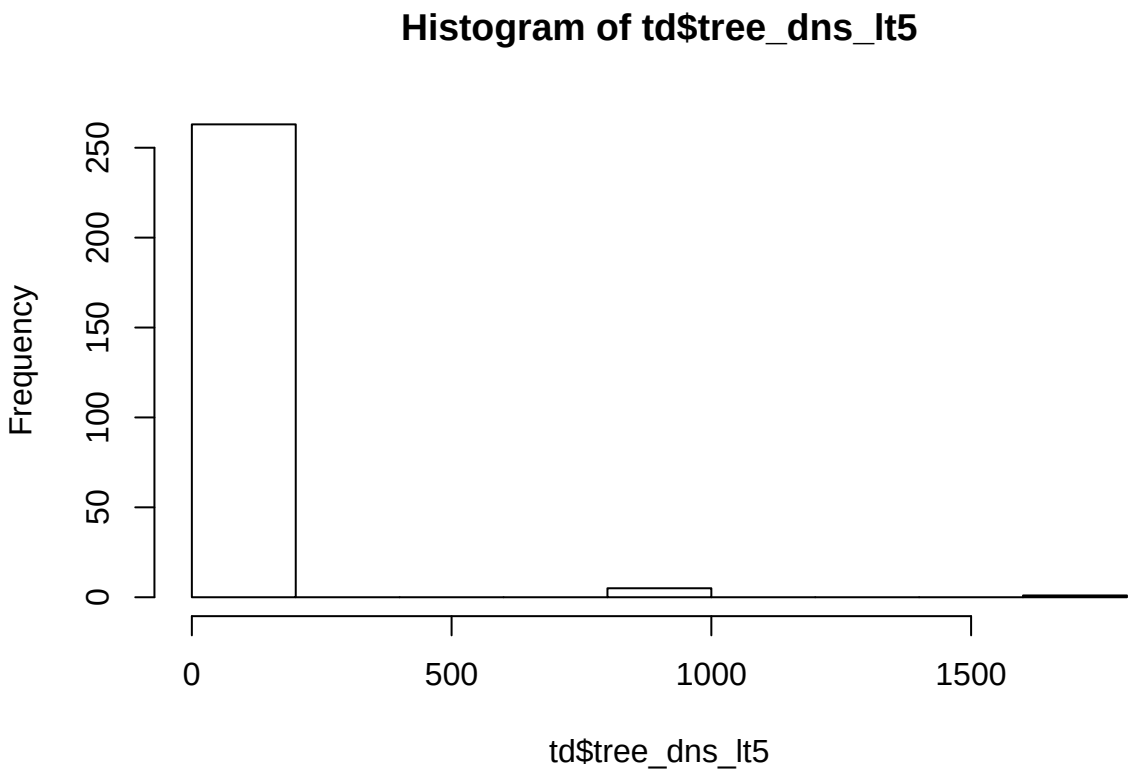
Notes

*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(sqrt(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
```

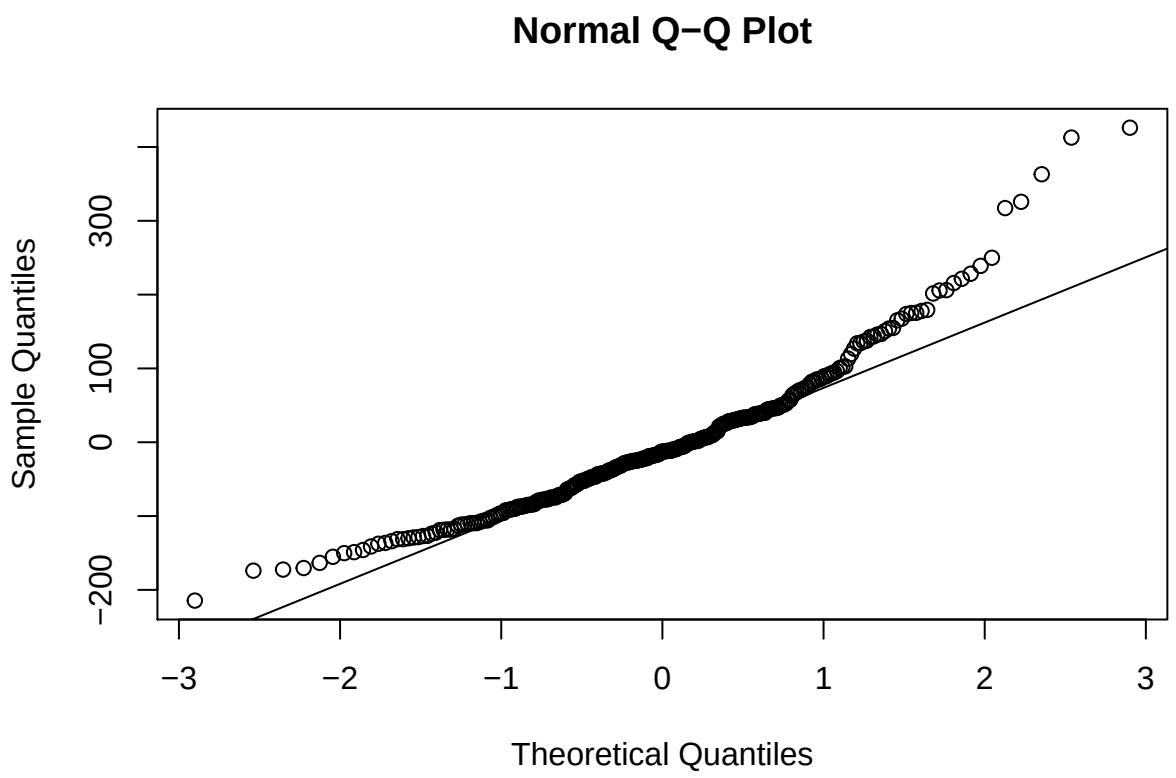
```
## fctr(yst)10
## TDI:fctr()1
## TDI:fctr()2
## TDI:fctr()3  0.500
## TDI:fctr()6  0.496   0.496
## TDI:fct()10  0.500   0.500   0.496
```

```
lincon(m)
```

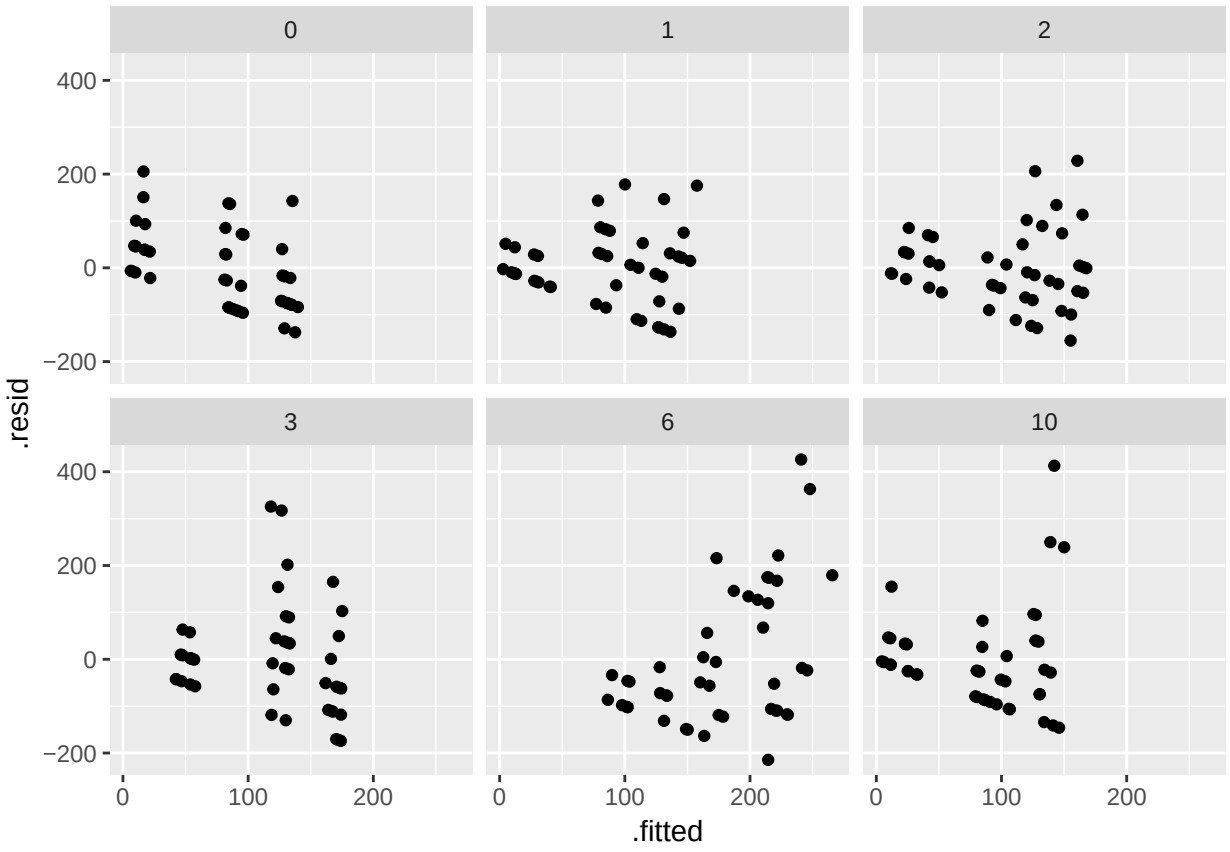
```
##                   estimate   se  lower upper  tvalue  df pvalue
## (Intercept)          66.42 52.5  -36.5 169.4  1.2644 Inf  0.206
## TDI                  21.62 69.4 -114.4 157.6  0.3116 Inf  0.755
## factor(yst)1        -10.08 55.0 -117.9  97.7 -0.1834 Inf  0.855
## factor(yst)2         62.39 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

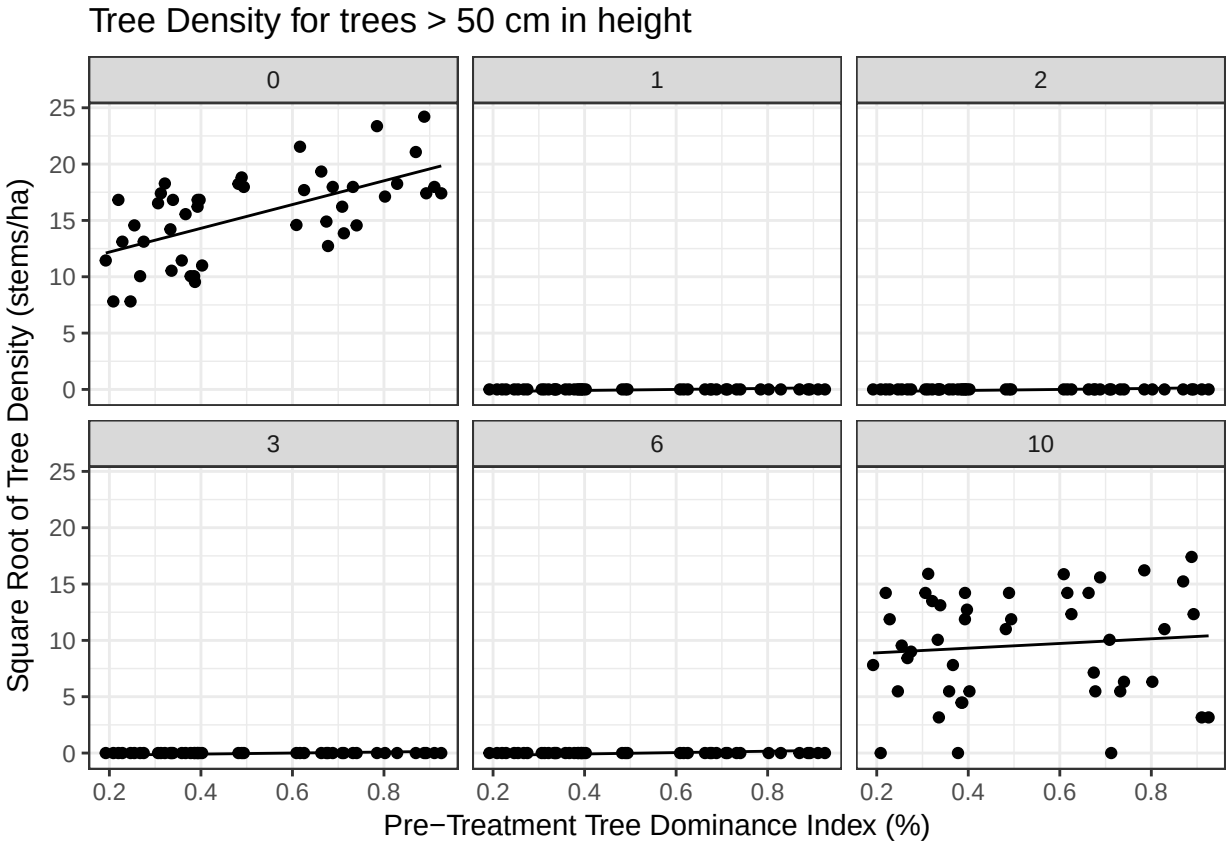
Tree Density for trees > 50 cm in height

Notes

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

Model

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



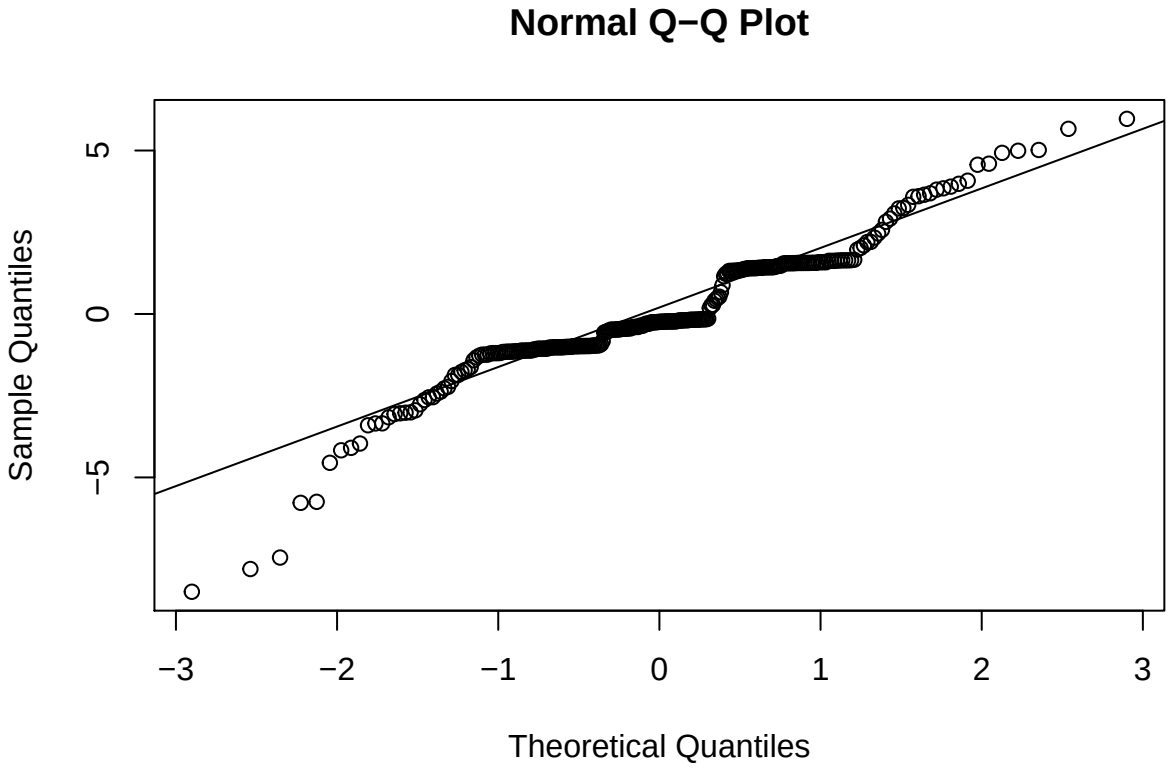
Inferences

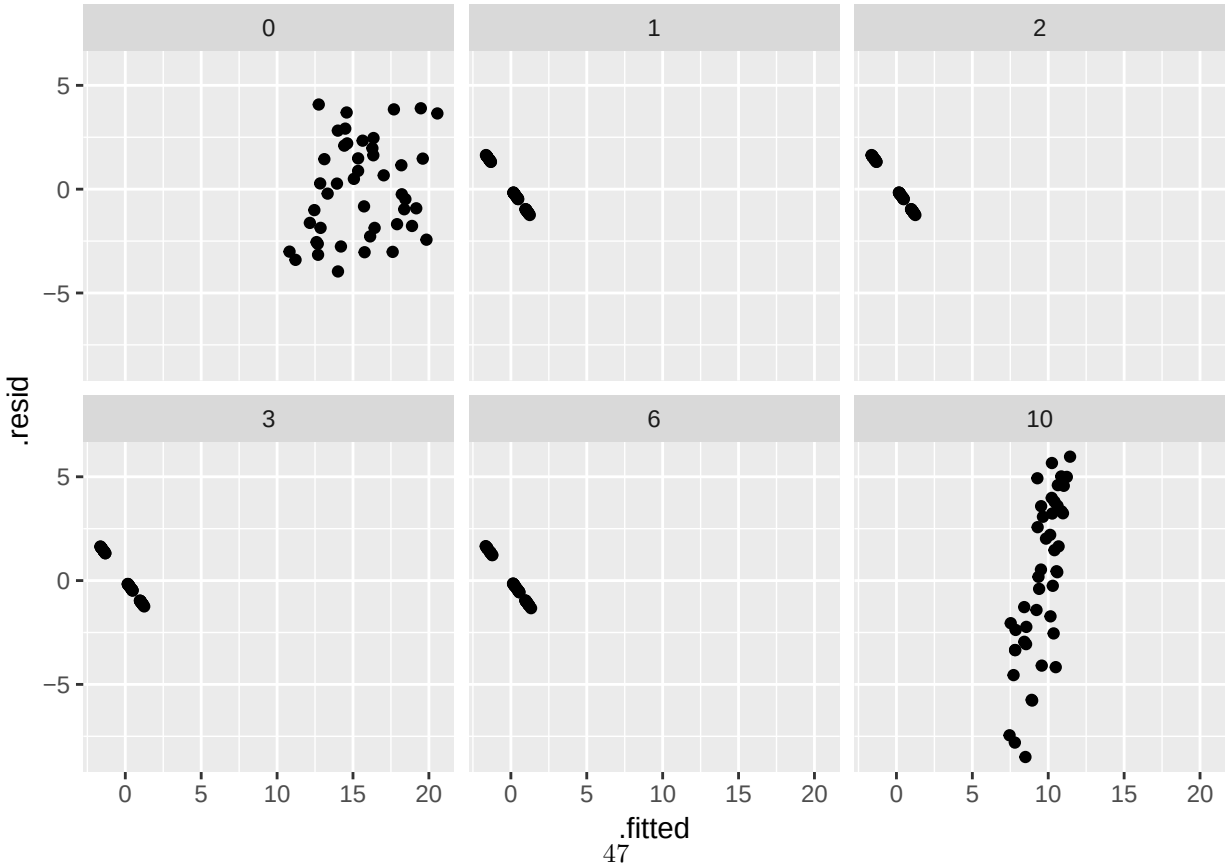
```
## Linear mixed model fit by REML ['lmerMod']
## Formula: sqrt(tree_dns_gt50) ~ TDI + factor(yst) + factor(yst):TDI + (1 |
##     site)
##    Data: td
##
## REML criterion at convergence: 1145
##
## Scaled residuals:
##    Min     1Q Median     3Q    Max
## -4.050 -0.491 -0.115  0.681  2.845
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  site     (Intercept) 1.8      1.34
##  Residual             4.4      2.10
## Number of obs: 269, groups:  site, 3
##
## Fixed effects:
##                   Estimate Std. Error t value
## (Intercept)          10.08       1.10    9.19
## TDI                  10.55       1.39    7.61
## factor(yst)1        -10.36       1.10   -9.43
## factor(yst)2        -10.36       1.10   -9.43
## factor(yst)3        -10.36       1.10   -9.43
## factor(yst)6        -10.40       1.10   -9.45
## factor(yst)10        -1.60       1.10   -1.46
## TDI:factor(yst)1    -10.09       1.96   -5.15
## TDI:factor(yst)2    -10.09       1.96   -5.15
## TDI:factor(yst)3    -10.09       1.96   -5.15
## TDI:factor(yst)6     -9.94       1.97   -5.04
## TDI:factor(yst)10    -8.47       1.96   -4.33
##
## Correlation of Fixed Effects:
##             (Intr) TDI    fct()1 fct()2 fct()3 fct()6 fc()10 TDI:f()1
## TDI         -0.649
## factr(yst)1 -0.500  0.647
## factr(yst)2 -0.500  0.647  0.500
## factr(yst)3 -0.500  0.647  0.500  0.500
## factr(yst)6 -0.499  0.645  0.499  0.499  0.499
## fctr(yst)10 -0.500  0.647  0.500  0.500  0.500  0.499
## TDI:fctr()1  0.458 -0.706 -0.915 -0.458 -0.458 -0.456 -0.458
## TDI:fctr()2  0.458 -0.706 -0.458 -0.915 -0.458 -0.456 -0.458  0.500
## TDI:fctr()3  0.458 -0.706 -0.458 -0.458 -0.915 -0.456 -0.458  0.500
## TDI:fctr()6  0.454 -0.700 -0.454 -0.454 -0.454 -0.915 -0.454  0.496
## TDI:fct()10  0.458 -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)           10.08 1.10   7.93 12.232   9.19 Inf 4.08e-20
## TDI                   10.55 1.39   7.83 13.262   7.61 Inf 2.73e-14
## factor(yst)1         -10.36 1.10 -12.51 -8.203  -9.43 Inf 4.18e-21
## factor(yst)2         -10.36 1.10 -12.51 -8.203  -9.43 Inf 4.18e-21
## factor(yst)3         -10.36 1.10 -12.51 -8.203  -9.43 Inf 4.18e-21
## factor(yst)6         -10.40 1.10 -12.56 -8.245  -9.45 Inf 3.55e-21
## factor(yst)10         -1.60 1.10  -3.75  0.551  -1.46 Inf 1.45e-01
## TDI:factor(yst)1     -10.09 1.96 -13.93 -6.254  -5.15 Inf 2.54e-07
## TDI:factor(yst)2     -10.09 1.96 -13.93 -6.254  -5.15 Inf 2.54e-07
## TDI:factor(yst)3     -10.09 1.96 -13.93 -6.254  -5.15 Inf 2.54e-07
## TDI:factor(yst)6      -9.94 1.97 -13.81 -6.072  -5.04 Inf 4.76e-07
## TDI:factor(yst)10     -8.47 1.96 -12.30 -4.631  -4.33 Inf 1.52e-05
```

QQPlot and Plotted Residuals





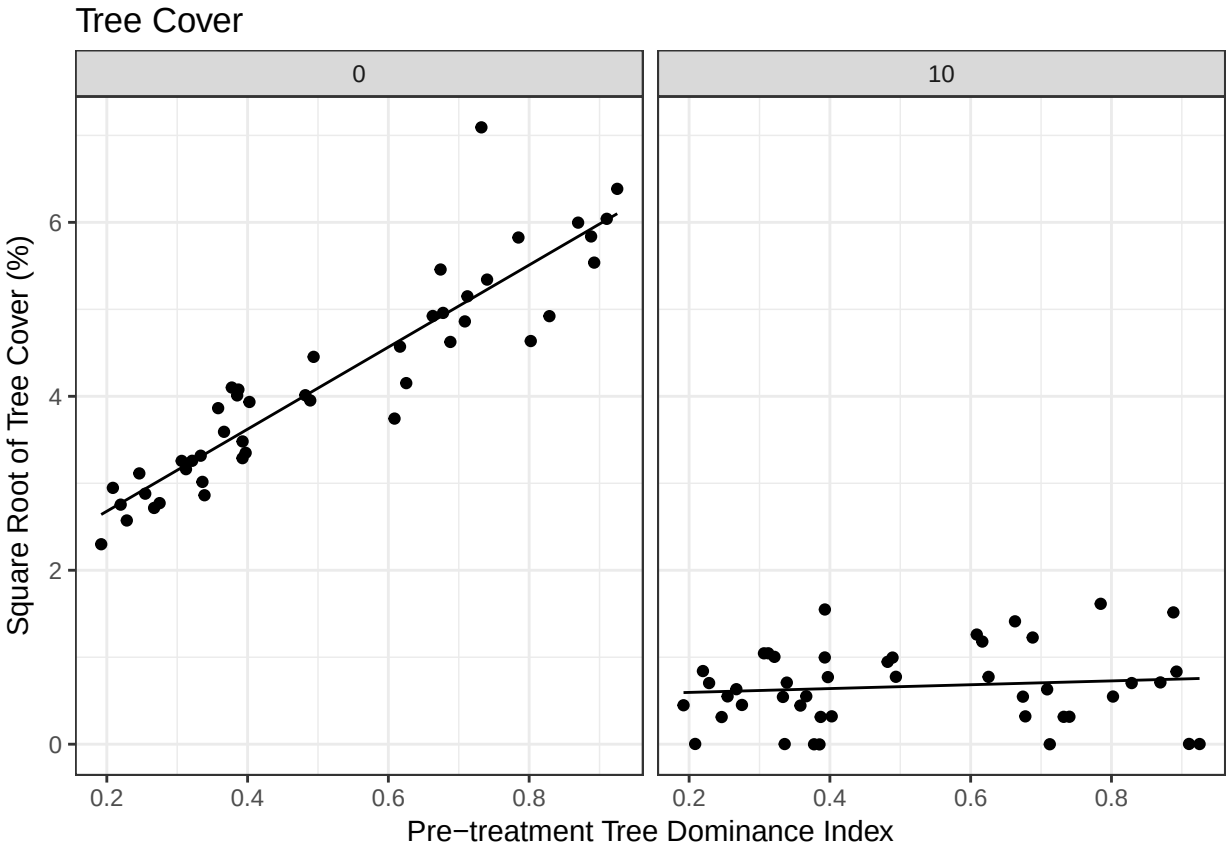
Tree Cover

Notes

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

Model

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



Inferences

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: sqrt(tree_cover_ttl) ~ TDI + factor(yst) + factor(yst):TDI +
##     (1 | site)
##    Data: tcover
##
## REML criterion at convergence: 114
##
## Scaled residuals:
##    Min     1Q Median     3Q    Max
## -2.285 -0.566 -0.003  0.558  4.458
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  site     (Intercept) 0.0193   0.139
##  Residual             0.1926   0.439
## Number of obs: 90, groups:  site, 3
##
## Fixed effects:
##                   Estimate Std. Error t value
## (Intercept)          1.735      0.182    9.55
## TDI                  4.718      0.290   16.25
## factor(yst)10       -1.183      0.230   -5.15
## TDI:factor(yst)10   -4.498      0.409  -10.98
##
## Correlation of Fixed Effects:
##             (Intr) TDI    fc()10
## TDI         -0.822
## fctr(yst)10 -0.633  0.646
## TDI:fct()10  0.579 -0.705 -0.915
```

```
##                   estimate    se lower  upper tvalue  df   pvalue
## (Intercept)           1.73 0.182  1.38  2.091   9.55 Inf 1.26e-21
## TDI                   4.72 0.290  4.15  5.287  16.25 Inf 2.08e-59
## factor(yst)10        -1.18 0.230 -1.63 -0.733  -5.15 Inf 2.60e-07
## TDI:factor(yst)10    -4.50 0.409 -5.30 -3.695 -10.98 Inf 4.60e-28
```

QQPlot and Plotted Residuals