Variability in tree height and diameter across different
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Contents

Setting up our R Workspace	5
Rationale and Research Questions	5
Data Wrangling	5
GGPlot Theme Setup	5
Linear Regressions	5
Correlation between Height and Diameter for all Species	5
Correlation between Height and Diameter taking Species of Interest into Account	7
Correlation between Height and Diameter taking Species of Interest and Plot ID into Account	8
ANOVA Tests	45
Mean Height Comparisons	45
Visualizing Interactions with Plot Differences	50
Dataset Information	52
Exploratory Analysis	53
Correlation between Height and Diameter taking Species of Interest and Plot ID into Account	53
Analysis	90
ANOVA Tests	90
Visualizing Interactions with Plot Differences	93
Question 1: <insert add="" additional="" and="" below,="" for="" here="" if="" needed="" question="" questions="" specific="" subsections=""></insert>	93
Question 2:	93
Summary and Conclusions	94
References	95

List of Tables

List of Figures

Setting up our R Workspace

[1] "/home/guest/Project/EDEProj_Arunkumar_Power_Rotbart_Valkenberg"

Rationale and Research Questions

The topic of tree heights was chosen because it is one of the main things that our group has in common; two of us are in the forestry program, while the other two are TFE concentrations. In addition, we all found a similar interest in discovering not only how tree heights vary with tree diameter and species, but also exploring these factors in a region unknown to us.

Alaska is home to a lush and vibrant ecosystem—one that is entirely foreign to North Carolina. Because of the freedom of this project, we wanted to take the opportunity to learn more about an entirely different variation of flora that was unknown to us. Our ignorance, combined with the dataset, including height, DBH, and species codes, motivated us to use this dataset to answer our questions. Additionally, the data comes from the United States Forest Service, which is a group we all have learned much about and wanted to interact with. This leads us to the main question of this research:

Q: How does tree height differ among specific tree species in Alaska, including white spruce, black spruce, lodgepole pine, and mountain hemlock? H0:The mean tree species height does not vary enough to be significant H1: The mean tree height differs significantly across species

Following questions to help us further understand the differences in these species would be: -How does this height vary with DBH? -How does this height vary with species? -How does this height vary with plot?

Data Wrangling

GGPlot Theme Setup

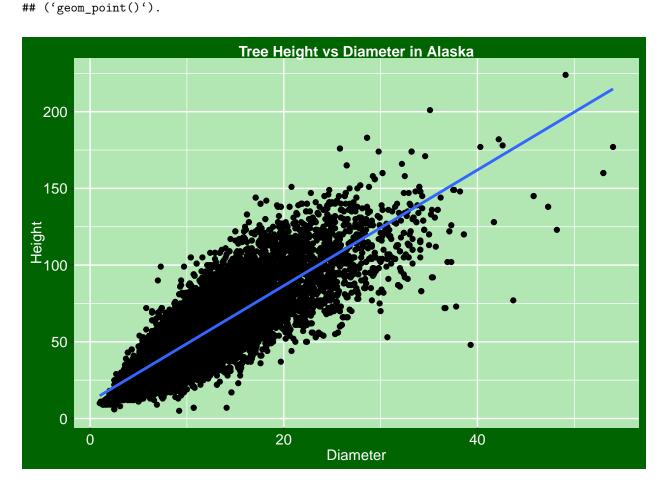
Linear Regressions

Correlation between Height and Diameter for all Species

```
#Linear Regression to see correlation between HT and DIA for all Species in Data
All.species.AK <- lm(HT ~ DIA, data = Ak_data.wrangled)
summary(All.species.AK)</pre>
```

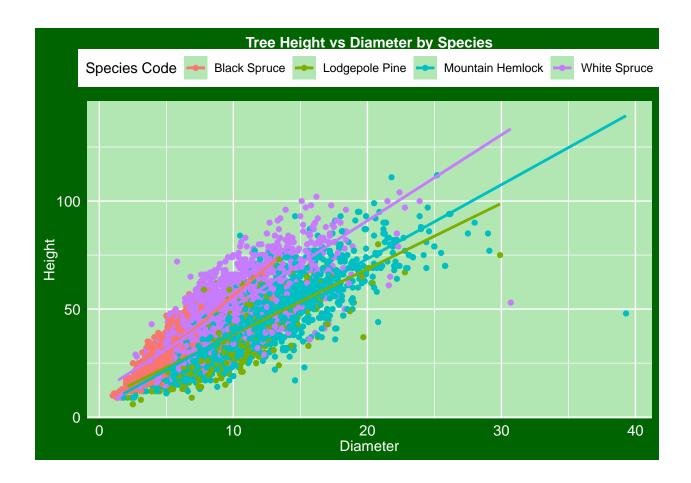
```
##
## lm(formula = HT ~ DIA, data = Ak_data.wrangled)
##
## Residuals:
##
        Min
                  1Q
                        Median
                                     3Q
                                              Max
## -111.375
              -8.166
                        -1.053
                                  7.420
                                           68.400
##
## Coefficients:
               Estimate Std. Error t value Pr(>|t|)
## (Intercept) 11.07053
                            0.21767
                                      50.86
                                               <2e-16 ***
## DIA
                            0.01703 221.54
                3.77365
                                               <2e-16 ***
```

```
## ---
## Signif. codes: 0 '*** 0.001 '** 0.01 '* 0.05 '.' 0.1 ' 1
## Residual standard error: 13.62 on 18598 degrees of freedom
     (89 observations deleted due to missingness)
## Multiple R-squared: 0.7252, Adjusted R-squared: 0.7252
## F-statistic: 4.908e+04 on 1 and 18598 DF, p-value: < 2.2e-16
ggplot(Ak_data.wrangled, aes(x = DIA, y = HT)) +
  geom_point() +
  geom_smooth(method = "lm", se = FALSE) +
  labs(title = "Tree Height vs Diameter in Alaska",
       x = "Diameter",
       y = "Height")
## 'geom_smooth()' using formula = 'y ~ x'
## Warning: Removed 89 rows containing non-finite outside the scale range
## ('stat_smooth()').
## Warning: Removed 89 rows containing missing values or values outside the scale range
```



Correlation between Height and Diameter taking Species of Interest into Account

```
#Linear Regression to see correlation between HT and DIA taking into account
#four species.
species.model <- lm(HT ~ DIA + Species, data = Species.wanted)</pre>
summary(species.model)
##
## Call:
## lm(formula = HT ~ DIA + Species, data = Species.wanted)
## Residuals:
      Min
               1Q Median
                              3Q
                                     Max
## -97.844 -5.147 -0.709
                           5.008 43.510
## Coefficients:
##
                         Estimate Std. Error t value Pr(>|t|)
## (Intercept)
                          ## DIA
                          3.65812
                                     0.02952 123.92 <2e-16 ***
                                     0.37384 -24.55 <2e-16 ***
## SpeciesLodgepole Pine
                         -9.17609
## SpeciesMountain Hemlock -9.14099
                                     0.31694 -28.84 <2e-16 ***
## SpeciesWhite Spruce
                           2.96974
                                     0.27624
                                              10.75
                                                       <2e-16 ***
## ---
## Signif. codes: 0 '*** 0.001 '** 0.01 '* 0.05 '.' 0.1 ' 1
##
## Residual standard error: 8.691 on 8534 degrees of freedom
    (82 observations deleted due to missingness)
## Multiple R-squared: 0.7087, Adjusted R-squared: 0.7086
## F-statistic: 5192 on 4 and 8534 DF, p-value: < 2.2e-16
ggplot(Species.wanted, aes(x = DIA, y = HT, color = Species)) +
 geom_point() +
 geom_smooth(method = "lm", se = FALSE) +
 labs(title = "Tree Height vs Diameter by Species",
      x = "Diameter",
      y = "Height",
      color = "Species Code")
## 'geom_smooth()' using formula = 'y ~ x'
## Warning: Removed 82 rows containing non-finite outside the scale range
## ('stat_smooth()').
## Warning: Removed 82 rows containing missing values or values outside the scale range
## ('geom_point()').
```



Correlation between Height and Diameter taking Species of Interest and Plot ID into Account

```
#Linear regression to see correlation between HT and DIA taking into account
#four species and plot ID
PlotandSpecies.model <- lm(HT ~ DIA + Species + PLOT, data = Species.wanted)
summary(PlotandSpecies.model)
##
## Call:
## lm(formula = HT ~ DIA + Species + PLOT, data = Species.wanted)
## Residuals:
                1Q Median
##
      Min
                                3Q
                                       Max
## -52.706 -2.531
                     0.000
                                    28.483
                             2.497
##
## Coefficients:
##
                            Estimate Std. Error t value Pr(>|t|)
## (Intercept)
                            30.74614
                                        3.12699
                                                 9.833 < 2e-16 ***
```

0.03073 91.370 < 2e-16 ***

0.48891 15.327 < 2e-16 ***

1.35069 -2.428 0.015206 *

1.18682 -1.010 0.312657

2.80759

-3.27957

7.49339

DIA

SpeciesLodgepole Pine

SpeciesWhite Spruce

SpeciesMountain Hemlock -1.19838

```
## PLOT18
                            -21.84715
                                         4.38616 -4.981 6.49e-07 ***
## PLOT26
                            -8.10317
                                         3.93024
                                                  -2.062 0.039271 *
                            -17.56976
                                         3.98395
## PLOT33
                                                  -4.410 1.05e-05 ***
## PLOT69
                            -3.50780
                                         6.29244
                                                  -0.557 0.577230
## PLOT107
                           -21.74433
                                         4.36308
                                                  -4.984 6.40e-07 ***
## PLOT120
                                                  -4.831 1.39e-06 ***
                           -21.18157
                                         4.38457
                                                  -4.239 2.28e-05 ***
## PLOT171
                           -16.88215
                                         3.98284
                                                  -9.137 < 2e-16 ***
## PLOT216
                           -36.55902
                                         4.00117
## PLOT229
                           -10.11582
                                         4.99431
                                                  -2.025 0.042859 *
## PLOT256
                           -21.81692
                                         3.98274
                                                  -5.478 4.46e-08 ***
## PLOT281
                             1.99835
                                         3.72939
                                                   0.536 0.592089
                                                  -6.975 3.37e-12 ***
## PLOT341
                            -30.41209
                                         4.36045
## PLOT362
                           -21.62531
                                         4.22250
                                                  -5.121 3.12e-07 ***
## PLOT407
                            -2.26803
                                         3.78148
                                                  -0.600 0.548678
## PLOT412
                                                  -5.969 2.51e-09 ***
                            -26.02618
                                         4.36033
## PLOT469
                            -18.67211
                                         4.49476
                                                  -4.154 3.31e-05 ***
## PLOT496
                            11.89662
                                         6.26815
                                                   1.898 0.057747 .
## PLOT545
                           -15.89143
                                         6.18084
                                                  -2.571 0.010160 *
                           -22.06232
## PLOT554
                                         3.78452
                                                  -5.830 5.82e-09 ***
## PLOT561
                            -23.34067
                                         3.84306
                                                  -6.073 1.32e-09 ***
## PLOT630
                           -14.73043
                                         6.18225
                                                  -2.383 0.017214 *
## PLOT662
                                                  -3.660 0.000254 ***
                           -16.04697
                                         4.38467
## PLOT734
                           -20.84715
                                                  -4.753 2.05e-06 ***
                                         4.38616
## PLOT759
                           -21.49840
                                         3.55784
                                                  -6.043 1.60e-09 ***
## PLOT810
                           -22.00829
                                         4.36107
                                                  -5.047 4.62e-07 ***
## PLOT844
                           -19.39674
                                         3.78250
                                                  -5.128 3.01e-07 ***
## PLOT848
                            -9.34924
                                         4.49380
                                                  -2.080 0.037520 *
## PLOT864
                           -25.34119
                                         3.77381
                                                  -6.715 2.04e-11 ***
## PLOT937
                           -26.71815
                                         4.35769
                                                  -6.131 9.22e-10 ***
## PLOT940
                            -4.26726
                                         4.05019
                                                  -1.054 0.292107
## PLOT942
                            -24.43433
                                         4.49498
                                                  -5.436 5.65e-08 ***
## PLOT945
                            -6.24679
                                         3.80416
                                                  -1.642 0.100618
## PLOT965
                            -9.66034
                                         4.35733
                                                  -2.217 0.026655 *
                                                  -3.771 0.000164 ***
## PLOT1000
                           -16.44808
                                         4.36160
## PLOT1011
                            -19.80432
                                         3.77626
                                                  -5.244 1.62e-07 ***
## PLOT1030
                                                   0.120 0.904523
                             0.46742
                                         3.89667
## PLOT1031
                            -2.81609
                                         6.25933
                                                  -0.450 0.652796
## PLOT1032
                           -23.16892
                                         6.18239
                                                  -3.748 0.000180 ***
## PLOT1060
                                         4.54026
                                                  -4.658 3.25e-06 ***
                            -21.14916
## PLOT1079
                           -28.63918
                                         4.36276
                                                  -6.564 5.62e-11 ***
## PLOT1088
                            -1.85077
                                         4.99413
                                                  -0.371 0.710955
## PLOT1162
                           -15.99440
                                         4.38461
                                                  -3.648 0.000266 ***
## PLOT1171
                            -5.72774
                                         6.25953
                                                  -0.915 0.360203
## PLOT1173
                                         3.55866
                                                  -4.730 2.29e-06 ***
                           -16.83275
## PLOT1201
                            -27.44283
                                         3.93038
                                                  -6.982 3.19e-12 ***
## PLOT1216
                                                  -5.252 1.55e-07 ***
                            -23.02908
                                         4.38511
## PLOT1227
                             8.04516
                                         4.35812
                                                   1.846 0.064935 .
## PLOT1295
                            -23.36584
                                         6.16364
                                                  -3.791 0.000151 ***
## PLOT1382
                            -25.01242
                                         4.22204
                                                  -5.924 3.30e-09 ***
## PLOT1397
                            -27.81609
                                         6.25933
                                                  -4.444 8.98e-06 ***
                                                  -3.598 0.000323 ***
## PLOT1418
                            -22.17343
                                         6.16303
## PLOT1472
                           -26.85601
                                         4.49429
                                                  -5.976 2.41e-09 ***
## PLOT1490
                           -18.65184
                                         4.36049
                                                  -4.277 1.92e-05 ***
## PLOT1508
                            -17.57219
                                         3.93089
                                                 -4.470 7.94e-06 ***
```

```
## PLOT1525
                             -8.27661
                                          3.77467 -2.193 0.028366 *
## PLOT1528
                            -13.65968
                                         3.59048
                                                   -3.804 0.000143 ***
## PLOT1529
                            -26.85161
                                          4.08054
                                                   -6.580 5.05e-11 ***
## PLOT1543
                            -16.00442
                                          4.05754
                                                   -3.944 8.08e-05 ***
## PLOT1549
                            -20.01119
                                         6.18219
                                                   -3.237 0.001214 **
## PLOT1604
                                         3.93024
                             -3.60579
                                                   -0.917 0.358941
## PLOT1699
                             -6.89557
                                         4.38405
                                                   -1.573 0.115795
## PLOT1720
                            -15.94182
                                          6.18141
                                                   -2.579 0.009930 **
## PLOT1735
                            -18.33297
                                         4.38542
                                                   -4.180 2.95e-05 ***
## PLOT1739
                            -21.73676
                                          4.38501
                                                   -4.957 7.34e-07 ***
## PLOT1768
                            -17.58879
                                          4.35839
                                                   -4.036 5.51e-05 ***
## PLOT1833
                            -24.39114
                                          4.35740
                                                   -5.598 2.26e-08 ***
## PLOT1893
                            -21.77507
                                         4.49374
                                                   -4.846 1.29e-06 ***
                                                   -5.673 1.46e-08 ***
## PLOT1968
                            -27.64660
                                          4.87343
## PLOT2190
                                                   -4.766 1.92e-06 ***
                            -29.36911
                                          6.16220
## PLOT2261
                            -18.49069
                                         3.55780
                                                   -5.197 2.08e-07 ***
## PLOT2368
                            -14.32612
                                         4.49393
                                                   -3.188 0.001440 **
## PLOT2374
                            -26.69285
                                          4.36033
                                                   -6.122 9.79e-10 ***
## PLOT2414
                            -21.71887
                                          4.38551
                                                   -4.952 7.51e-07 ***
## PLOT2418
                            -22.25094
                                         4.38566
                                                   -5.074 4.01e-07 ***
## PLOT2428
                            -21.25753
                                         3.77627
                                                   -5.629 1.88e-08 ***
## PLOT2476
                                                   -0.992 0.321096
                             -6.13423
                                         6.18194
## PLOT2504
                                                   -6.022 1.81e-09 ***
                            -27.06631
                                          4.49452
## PLOT2516
                              8.21380
                                         3.93154
                                                    2.089 0.036727 *
## PLOT2583
                             -4.26416
                                         4.49706
                                                  -0.948 0.343056
## PLOT2630
                            -19.20360
                                         6.18292
                                                   -3.106 0.001905 **
## PLOT2677
                            -28.98102
                                         4.35793
                                                   -6.650 3.16e-11 ***
## PLOT2682
                            -27.50259
                                         5.00489
                                                   -5.495 4.05e-08 ***
## PLOT2692
                            -11.89557
                                          4.38405
                                                   -2.713 0.006677 **
## PLOT2699
                            -19.88635
                                          4.35938
                                                   -4.562 5.16e-06 ***
## PLOT2757
                            -20.03926
                                          3.77656
                                                   -5.306 1.16e-07 ***
## PLOT2760
                            -19.46865
                                          4.89556
                                                   -3.977 7.06e-05 ***
## PLOT2771
                            -11.99668
                                          6.29315
                                                   -1.906 0.056654 .
                                                   -4.284 1.86e-05 ***
## PLOT2775
                            -18.08736
                                          4.22173
## PLOT2778
                            -12.59861
                                          3.55897
                                                   -3.540 0.000403 ***
## PLOT2846
                            -21.93280
                                         3.93037
                                                   -5.580 2.50e-08 ***
## PLOT2892
                            -18.37921
                                          4.38633
                                                   -4.190 2.82e-05 ***
## PLOT2896
                                                    0.138 0.890140
                              0.56315
                                          4.07692
## PLOT2913
                            -27.98735
                                                   -6.423 1.43e-10 ***
                                         4.35756
## PLOT2917
                            -19.92212
                                         3.77480
                                                   -5.278 1.35e-07 ***
## PLOT2921
                              1.96205
                                          4.35996
                                                    0.450 0.652715
## PLOT2942
                                          4.49515
                                                   -3.375 0.000743 ***
                            -15.16949
## PLOT2943
                             -9.72971
                                          4.35779
                                                   -2.233 0.025601 *
## PLOT2972
                             -7.80367
                                         3.55848
                                                   -2.193 0.028344 *
## PLOT3006
                            -23.07787
                                          6.26000
                                                   -3.687 0.000229 ***
                                                   -3.651 0.000263 ***
## PLOT3007
                            -13.44900
                                          3.68365
## PLOT3019
                            -10.88979
                                          4.89550
                                                   -2.224 0.026152 *
## PLOT3025
                            -26.15724
                                          3.84300
                                                   -6.806 1.09e-11 ***
## PLOT3094
                             -9.18858
                                          3.39762
                                                   -2.704 0.006860 **
## PLOT3104
                             -8.23152
                                          3.80470
                                                   -2.164 0.030538 *
                            -9.95810
                                                   -1.591 0.111695
## PLOT3125
                                          6.25967
## PLOT3139
                            -8.70047
                                          3.93057
                                                   -2.214 0.026895 *
## PLOT3151
                            -31.92839
                                         3.98271
                                                   -8.017 1.27e-15 ***
## PLOT3176
                             -5.18476
                                          3.93308 -1.318 0.187468
```

```
6.18080
## PLOT3213
                            -16.39928
                                                  -2.653 0.007991 **
## PLOT3310
                            -25.81218
                                         4.08043
                                                  -6.326 2.68e-10 ***
                            -10.34562
## PLOT3351
                                          4.89573
                                                   -2.113 0.034622 *
## PLOT3415
                            -28.98428
                                          4.49468
                                                   -6.449 1.21e-10 ***
## PLOT3436
                             -9.52123
                                         3.80447
                                                   -2.503 0.012351 *
                                                   -6.467 1.07e-10 ***
## PLOT3452
                            -23.82732
                                         3.68453
## PLOT3462
                            -24.88002
                                         4.36026
                                                   -5.706 1.21e-08 ***
## PLOT3476
                            -18.69166
                                         3.68513
                                                   -5.072 4.04e-07 ***
## PLOT3477
                            -15.52818
                                          3.78271
                                                   -4.105 4.09e-05 ***
## PLOT3567
                            -14.47140
                                          4.50447
                                                   -3.213 0.001321 **
## PLOT3590
                            -25.54663
                                          4.54044
                                                   -5.626 1.91e-08 ***
                                                   -5.809 6.58e-09 ***
## PLOT3601
                            -25.31762
                                          4.35836
## PLOT3629
                            -17.22782
                                         4.38525
                                                   -3.929 8.63e-05 ***
## PLOT3641
                             -6.93363
                                          4.53974
                                                   -1.527 0.126730
## PLOT3653
                            -12.04814
                                          3.78360
                                                   -3.184 0.001458 **
## PLOT3711
                             -6.63831
                                         4.35751
                                                   -1.523 0.127702
## PLOT3725
                             -9.48364
                                         4.35825
                                                   -2.176 0.029589 *
## PLOT3765
                            -22.24280
                                          6.16393
                                                   -3.609 0.000310 ***
## PLOT3785
                            -20.15772
                                          4.35726
                                                   -4.626 3.79e-06 ***
## PLOT3788
                            -28.59791
                                         4.51434
                                                   -6.335 2.53e-10 ***
## PLOT3805
                            -21.71706
                                         4.35890
                                                   -4.982 6.45e-07 ***
## PLOT3842
                                                   -1.933 0.053311 .
                             -8.42168
                                          4.35739
                                                   -7.395 1.58e-13 ***
## PLOT3875
                            -27.90641
                                         3.77349
## PLOT3947
                            -12.58355
                                         4.35776
                                                   -2.888 0.003894 **
## PLOT4116
                            -7.90265
                                         3.71394
                                                  -2.128 0.033388 *
## PLOT4160
                            -14.97075
                                          3.93206
                                                   -3.807 0.000142 ***
## PLOT4241
                            -20.20812
                                                   -4.147 3.41e-05 ***
                                          4.87327
## PLOT4247
                              0.62565
                                         4.35726
                                                    0.144 0.885829
## PLOT4251
                            -15.02385
                                          4.38438
                                                   -3.427 0.000615 ***
## PLOT4272
                            -11.74162
                                         3.51303
                                                   -3.342 0.000835 ***
## PLOT4277
                            -19.72411
                                          4.38659
                                                   -4.496 7.03e-06 ***
## PLOT4324
                            -28.06828
                                         4.35843
                                                   -6.440 1.28e-10 ***
## PLOT4332
                            -18.99524
                                          4.22514
                                                   -4.496 7.05e-06 ***
                                                   -4.739 2.20e-06 ***
## PLOT4334
                            -20.78301
                                         4.38582
## PLOT4395
                             -2.10733
                                          4.87281
                                                   -0.432 0.665417
## PLOT4452
                            -27.31129
                                         4.49530
                                                   -6.076 1.30e-09 ***
## PLOT4458
                            -11.75388
                                         3.47844
                                                   -3.379 0.000732 ***
## PLOT4494
                            -19.20469
                                         3.80536
                                                   -5.047 4.61e-07 ***
## PLOT4534
                                          4.38474
                                                   -3.520 0.000435 ***
                            -15.43288
## PLOT4561
                            -20.27169
                                         3.68342
                                                   -5.503 3.86e-08 ***
## PLOT4647
                            -20.49069
                                          4.38569
                                                   -4.672 3.04e-06 ***
## PLOT4659
                            -14.02992
                                          4.22429
                                                   -3.321 0.000901 ***
## PLOT4675
                             -2.62214
                                         3.73956
                                                   -0.701 0.483209
## PLOT4787
                                         4.35832
                                                   -3.565 0.000367 ***
                            -15.53622
## PLOT4792
                            -25.36495
                                         4.49415
                                                   -5.644 1.73e-08 ***
## PLOT4839
                             -5.65836
                                          6.25931
                                                   -0.904 0.366032
## PLOT4855
                            -11.61653
                                          3.78189
                                                   -3.072 0.002138 **
## PLOT4865
                              0.23794
                                         4.38364
                                                    0.054 0.956715
## PLOT4945
                            -16.78991
                                          4.49597
                                                   -3.734 0.000190 ***
## PLOT5034
                            -26.84969
                                          4.35825
                                                   -6.161 7.67e-10 ***
## PLOT5113
                            -22.23757
                                          4.35885
                                                   -5.102 3.46e-07 ***
## PLOT5148
                            -11.27744
                                         6.29310
                                                   -1.792 0.073174 .
## PLOT5193
                            -11.66739
                                         4.38414
                                                  -2.661 0.007803 **
## PLOT5252
                            -20.65925
                                          4.35806 -4.740 2.18e-06 ***
```

```
## PLOT5326
                            -14.64191
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                                                   -3.879 0.000106 ***
## PLOT5363
                            -29.54249
                                          6.29238
                                                   -4.695 2.72e-06 ***
## PLOT5431
                            -20.47672
                                          3.98334
                                                   -5.141 2.82e-07 ***
## PLOT5439
                            -24.74280
                                                   -6.552 6.11e-11 ***
                                          3.77650
## PLOT5465
                            -19.21859
                                          3.77851
                                                   -5.086 3.75e-07 ***
                            -22.24831
## PLOT5556
                                          4.27028
                                                   -5.210 1.95e-07 ***
## PLOT5574
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                                                   -5.416 6.32e-08 ***
## PLOT5578
                            -18.52377
                                          3.93026
                                                   -4.713 2.49e-06 ***
## PLOT5589
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                                          3.45553
                                                   -3.156 0.001606 **
## PLOT5612
                            -16.78933
                                          4.38509
                                                   -3.829 0.000130 ***
## PLOT5701
                            -27.67407
                                          3.93175
                                                   -7.039 2.14e-12 ***
## PLOT5737
                            -13.80029
                                          3.66848
                                                   -3.762 0.000170 ***
## PLOT5817
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                                          3.93062
                                                   -0.273 0.784519
## PLOT5861
                                                   -5.945 2.91e-09 ***
                            -25.90532
                                          4.35766
## PLOT5900
                            -16.52465
                                          4.35817
                                                   -3.792 0.000151 ***
## PLOT5955
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                                          3.51328
                                                   -0.734 0.462796
## PLOT5961
                                          4.35729
                                                    0.289 0.772875
                              1.25763
## PLOT5965
                            -18.55116
                                          3.68151
                                                   -5.039 4.80e-07 ***
## PLOT6000
                            -22.24100
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                                                   -6.084 1.24e-09 ***
## PLOT6030
                            -26.22403
                                          3.93140
                                                   -6.670 2.76e-11 ***
## PLOT6034
                            -11.47381
                                          4.99404
                                                   -2.298 0.021621 *
## PLOT6060
                            -19.37915
                                          3.56112
                                                   -5.442 5.46e-08 ***
                                                   -4.109 4.02e-05 ***
## PLOT6089
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## PLOT6090
                             -1.00109
                                          4.35765
                                                   -0.230 0.818307
## PLOT6107
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                                                   -4.886 1.05e-06 ***
## PLOT6109
                            -14.97651
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                                                   -3.415 0.000641 ***
## PLOT6193
                                                   -3.358 0.000790 ***
                            -13.74498
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## PLOT6222
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                                                   -2.910 0.003625 **
## PLOT6233
                            -18.75947
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                                                   -3.752 0.000177 ***
## PLOT6244
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                                          4.38542
                                                   -4.408 1.06e-05 ***
## PLOT6249
                            -28.14779
                                          3.93171
                                                   -7.159 9.00e-13 ***
## PLOT6300
                             -2.20506
                                          4.35730
                                                   -0.506 0.612831
## PLOT6335
                            -21.47913
                                          4.38548
                                                   -4.898 9.92e-07 ***
## PLOT6376
                            -16.23922
                                          3.72464
                                                   -4.360 1.32e-05 ***
## PLOT6380
                            -16.81155
                                          3.78312
                                                   -4.444 8.98e-06 ***
                                                   -7.245 4.83e-13 ***
## PLOT6385
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## PLOT6461
                            -15.96603
                                          4.38387
                                                   -3.642 0.000273 ***
## PLOT6483
                            -21.56315
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                                          4.87246
                                          4.35730
                                                   -4.641 3.54e-06 ***
## PLOT6625
                            -20.22186
## PLOT6665
                            -13.21517
                                          3.55827
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## PLOT6670
                            -24.92736
                                          4.87335
                                                   -5.115 3.23e-07 ***
## PLOT6701
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                                                   -3.868 0.000111 ***
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## PLOT6738
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                                                   -5.285 1.30e-07 ***
                            -24.09664
                                          4.35978
                                                   -5.527 3.38e-08 ***
## PLOT6765
## PLOT6793
                             -9.97051
                                          4.24894
                                                   -2.347 0.018976 *
                                                   -7.436 1.17e-13 ***
## PLOT6924
                            -28.06305
                                          3.77412
## PLOT6968
                              3.49564
                                          3.55779
                                                    0.983 0.325874
## PLOT6976
                            -10.84300
                                          4.38401
                                                   -2.473 0.013412 *
## PLOT6978
                            -20.80090
                                          4.38528
                                                   -4.743 2.15e-06 ***
## PLOT7028
                            -12.46684
                                          4.35758
                                                   -2.861 0.004237 **
                            -20.76621
## PLOT7042
                                          4.38474
                                                   -4.736 2.23e-06 ***
## PLOT7086
                            -13.09794
                                          4.49386
                                                   -2.915 0.003573 **
## PLOT7088
                            -21.79385
                                          4.35797
                                                   -5.001 5.85e-07 ***
## PLOT7148
                            -20.70098
                                          4.38609
                                                  -4.720 2.41e-06 ***
```

```
## PLOT7178
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                                          4.38525
                                                   -3.853 0.000118 ***
## PLOT7196
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                                          4.38363
                                                   -1.290 0.196935
## PLOT7245
                            -21.37810
                                          3.44094
                                                   -6.213 5.52e-10 ***
## PLOT7274
                                          6.29306
                                                    1.366 0.171988
                              8.59626
## PLOT7495
                            -17.11977
                                          6.16424
                                                   -2.777 0.005497 **
## PLOT7514
                            -19.99782
                                          4.35882
                                                   -4.588 4.56e-06 ***
## PLOT7517
                             -9.35863
                                          6.25996
                                                   -1.495 0.134963
## PLOT7574
                            -25.87370
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                                                   -5.933 3.13e-09 ***
## PLOT7578
                            -12.99002
                                          3.98641
                                                   -3.259 0.001125 **
## PLOT7599
                             -8.86089
                                          4.38381
                                                   -2.021 0.043292 *
## PLOT7612
                            -20.57271
                                          6.18206
                                                   -3.328 0.000880 ***
## PLOT7686
                            -26.38808
                                          4.49438
                                                   -5.871 4.53e-09 ***
                            -23.14833
## PLOT7720
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                                                   -5.151 2.67e-07 ***
## PLOT7725
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## PLOT7802
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                                                   -8.793 < 2e-16 ***
## PLOT7841
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## PLOT7849
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## PLOT7869
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## PLOT7885
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                                                   -1.350 0.176967
## PLOT7968
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                                          4.35797
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## PLOT8024
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                                                   -4.329 1.52e-05 ***
## PLOT8060
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                                          4.49435
                                                   -3.578 0.000348 ***
## PLOT8087
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## PLOT8105
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## PLOT8109
                            -14.79794
                                          4.54060
                                                   -3.259 0.001124 **
## PLOT8173
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## PLOT8175
                                                   -3.757 0.000174 ***
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## PLOT8219
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                                                   -3.873 0.000108 ***
## PLOT8266
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                                          3.73758
                                                   -3.214 0.001316 **
## PLOT8291
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                                                   -3.950 7.88e-05 ***
## PLOT8297
                            -18.79909
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                                                   -4.313 1.63e-05 ***
## PLOT8299
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## PLOT8321
                            -21.36133
                                          6.18317
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## PLOT8329
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## PLOT8382
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                                                   -3.630 0.000285 ***
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## PLOT8394
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## PLOT8428
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## PLOT8434
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                                                   -2.824 0.004758 **
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## PLOT8473
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## PLOT8623
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## PLOT8663
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## PLOT8736
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## PLOT8752
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## PLOT8816
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## PLOT8825
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## PLOT8861
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## PLOT8919
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                                                   -4.047 5.24e-05 ***
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## PLOT8940
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## PLOT8973
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                                                   -4.599 4.33e-06 ***
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## PLOT9029
                            -1.80365
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## PLOT9086
                            -24.11582
                                          3.93068
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## PLOT9111
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## PLOT9168
                            -10.95971
                                          4.38421
                                                  -2.500 0.012450 *
```

```
## PLOT9220
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## PLOT9231
                            -13.91237
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                                                   -3.173 0.001516 **
## PLOT9287
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## PLOT9290
                            -19.34292
                                          3.93024
                                                   -4.922 8.79e-07 ***
## PLOT9322
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                                          3.56269
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## PLOT9348
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                                                   -2.360 0.018307 *
## PLOT9375
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                                          3.89668
                                                   -3.212 0.001326 **
## PLOT9455
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                                          3.55954
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## PLOT9465
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                                          4.35729
                                                    0.914 0.360805
## PLOT9476
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                                          4.38404
                                                   -3.495 0.000477 ***
## PLOT9510
                            -21.90418
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## PLOT9522
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                                          4.38517
                                                   -3.537 0.000408 ***
## PLOT9547
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## PLOT9633
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## PLOT9641
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## PLOT9665
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                                                   -3.371 0.000753 ***
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## PLOT9703
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## PLOT9757
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## PLOT9810
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## PLOT9824
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## PLOT9825
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## PLOT9852
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## PLOT9855
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## PLOT9860
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## PLOT9910
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## PLOT9938
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## PLOT9956
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## PLOT9999
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## PLOT10006
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## PLOT10062
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## PLOT10350
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## PLOT10399
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## PLOT10483
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## PLOT10494
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## PLOT10545
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                                                   -6.202 5.92e-10 ***
                                                   -4.966 7.01e-07 ***
## PLOT10547
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## PLOT10631
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                                                   -3.791 0.000151 ***
## PLOT10655
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## PLOT10658
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## PLOT10662
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## PLOT10726
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## PLOT10727
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## PLOT10729
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## PLOT10733
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## PLOT10781
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## PLOT10789
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## PLOT10928
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## PLOT10929
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## PLOT10944
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## PLOT10963
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## PLOT10979
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## PLOT10993
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## PLOT11039
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## PLOT11052
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                                                  -0.911 0.362560
```

```
## PLOT11087
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                                                  -3.199 0.001388 **
## PLOT11143
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## PLOT11166
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## PLOT11229
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## PLOT11234
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## PLOT11261
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## PLOT11265
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## PLOT11282
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## PLOT11303
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## PLOT11332
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                                                   -6.171 7.18e-10 ***
## PLOT11350
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## PLOT11374
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## PLOT11400
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## PLOT11420
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## PLOT11439
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## PLOT11453
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## PLOT11454
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## PLOT11477
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## PLOT11520
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## PLOT11530
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## PLOT11637
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## PLOT11681
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## PLOT11744
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## PLOT11786
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## PLOT11849
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## PLOT11921
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## PLOT11946
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## PLOT11998
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## PLOT12000
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## PLOT12043
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## PLOT12072
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## PLOT12137
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## PLOT12141
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## PLOT12154
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                                          6.28774
                                                   -5.447 5.31e-08 ***
## PLOT12175
                                                   -7.493 7.60e-14 ***
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                                         3.93179
## PLOT12187
                            -16.93586
                                         4.35727
                                                   -3.887 0.000103 ***
## PLOT12236
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## PLOT12265
                                          3.98409
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## PLOT12390
                                                   -3.320 0.000906 ***
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## PLOT12470
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## PLOT12552
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                                                   -0.807 0.419663
## PLOT12597
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## PLOT12603
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## PLOT12685
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                                                   -3.420 0.000631 ***
                                                   -2.311 0.020873 *
## PLOT12700
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## PLOT12734
                            -16.20179
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                                                   -3.716 0.000204 ***
## PLOT12746
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## PLOT12774
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                                                   -5.764 8.60e-09 ***
## PLOT12884
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                                                   -2.646 0.008168 **
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                                                   -4.590 4.52e-06 ***
## PLOT12900
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## PLOT12917
                            -21.68129
                                         4.36007
                                                  -4.973 6.77e-07 ***
## PLOT12921
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                                                  -5.780 7.79e-09 ***
## PLOT12992
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                                                  -4.350 1.38e-05 ***
```

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## PLOT13074
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## PLOT13082
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                                                   -3.310 0.000939 ***
## PLOT13133
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                                          3.93149
                                                   -4.392 1.14e-05 ***
## PLOT13135
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                                                    1.244 0.213434
## PLOT13194
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                                          4.38504
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## PLOT13317
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                                                   -8.664 < 2e-16 ***
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## PLOT13466
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## PLOT13497
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## PLOT13521
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## PLOT13539
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## PLOT13627
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                                                   -3.233 0.001233 **
## PLOT13633
                            -14.17524
                                          4.38517
## PLOT13643
                            -23.82848
                                          4.53971
                                                   -5.249 1.58e-07 ***
                                                   -4.593 4.45e-06 ***
## PLOT13679
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## PLOT13720
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## PLOT13817
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## PLOT13835
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                                                   -4.389 1.16e-05 ***
                            -16.30280
## PLOT13856
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## PLOT13865
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## PLOT13871
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## PLOT13880
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## PLOT13914
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## PLOT13933
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## PLOT13949
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                                                   -3.145 0.001671 **
## PLOT13964
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## PLOT13973
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                                                   -4.422 9.94e-06 ***
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## PLOT14058
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## PLOT14072
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## PLOT14108
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## PLOT14131
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## PLOT14138
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## PLOT14200
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## PLOT14278
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## PLOT14331
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## PLOT14337
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## PLOT14352
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## PLOT14360
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## PLOT14389
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## PLOT14424
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## PLOT14499
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## PLOT14509
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## PLOT14515
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## PLOT14517
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## PLOT14540
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## PLOT14607
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## PLOT14614
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## PLOT14700
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## PLOT14710
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## PLOT14756
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## PLOT14765
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## PLOT14773
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## PLOT14775
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```

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## PLOT14832
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## PLOT14885
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## PLOT14889
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## PLOT14935
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## PLOT14951
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## PLOT14983
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## PLOT14991
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## PLOT14992
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## PLOT15137
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## PLOT15201
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## PLOT15337
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## PLOT15343
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## PLOT15401
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## PLOT15482
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## PLOT15528
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## PLOT15536
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## PLOT15588
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## PLOT15613
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## PLOT15625
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## PLOT15633
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## PLOT15710
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## PLOT15725
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## PLOT15773
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## PLOT15793
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## PLOT15817
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## PLOT15824
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## PLOT15846
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## PLOT15864
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## PLOT15977
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## PLOT15993
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## PLOT16062
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## PLOT16103
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## PLOT16115
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## PLOT16258
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## PLOT16262
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## PLOT16284
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## PLOT16307
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## PLOT16332
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## PLOT16435
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## PLOT16469
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## PLOT16476
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```

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## PLOT16590
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## PLOT16622
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## PLOT16643
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## PLOT16737
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## PLOT16769
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## PLOT16782
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## PLOT16804
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## PLOT16901
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## PLOT16991
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## PLOT17050
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## PLOT17175
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## PLOT17210
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## PLOT17284
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## PLOT17288
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## PLOT17355
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## PLOT17365
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## PLOT17382
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## PLOT17383
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## PLOT17384
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## PLOT17397
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## PLOT17400
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## PLOT17415
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## PLOT17475
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## PLOT17476
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## PLOT17488
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## PLOT17508
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## PLOT17535
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## PLOT17596
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## PLOT17601
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## PLOT17743
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## PLOT17811
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## PLOT17854
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## PLOT17919
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## PLOT17931
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## PLOT17940
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## PLOT18000
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## PLOT18009
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## PLOT18188
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## PLOT18200
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## PLOT18233
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```

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## PLOT18342
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## PLOT18389
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## PLOT18397
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## PLOT18409
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## PLOT18480
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## PLOT18859
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## PLOT18918
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## PLOT18955
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## PLOT19021
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## PLOT19108
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## PLOT19148
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## PLOT19220
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## PLOT19223
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## PLOT19252
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                                                   -8.575 < 2e-16 ***
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## PLOT19279
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## PLOT19339
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                                                   -3.205 0.001355 **
## PLOT19388
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                                                   -5.764 8.57e-09 ***
## PLOT19399
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## PLOT19415
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## PLOT19494
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## PLOT19511
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## PLOT19580
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## PLOT19587
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                                                   -4.283 1.87e-05 ***
## PLOT19609
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## PLOT19673
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## PLOT19713
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## PLOT19722
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                                                   -2.243 0.024909 *
## PLOT19760
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## PLOT19764
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## PLOT19766
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## PLOT19800
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                                                   -2.841 0.004515 **
                                                   -5.900 3.82e-09 ***
## PLOT19860
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## PLOT19923
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                                                   -0.590 0.554956
## PLOT19950
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## PLOT19960
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## PLOT19972
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                                                   -6.583 4.97e-11 ***
                            -25.26271
## PLOT20001
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                                                   -6.341 2.43e-10 ***
## PLOT20061
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                                                   -5.350 9.10e-08 ***
## PLOT20223
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                                          4.38545
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## PLOT20393
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                                                  -4.387 1.17e-05 ***
```

```
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## PLOT20459
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                                          4.04985
                                                   -4.764 1.93e-06 ***
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## PLOT20492
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## PLOT20524
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## PLOT20584
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                                                   -5.241 1.65e-07 ***
## PLOT20646
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## PLOT20658
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## PLOT20688
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## PLOT20709
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## PLOT20711
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## PLOT20760
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## PLOT20779
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## PLOT20816
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## PLOT20824
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## PLOT20836
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## PLOT20873
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## PLOT20921
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## PLOT20951
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## PLOT20962
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## PLOT21015
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## PLOT21138
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## PLOT21166
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## PLOT21167
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## PLOT21187
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## PLOT21205
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## PLOT21278
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## PLOT21296
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## PLOT21379
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## PLOT21501
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## PLOT21521
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## PLOT21540
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## PLOT21562
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## PLOT21564
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## PLOT21576
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## PLOT21597
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## PLOT21641
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## PLOT21645
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## PLOT21646
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## PLOT21683
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## PLOT21743
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## PLOT21763
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## PLOT21764
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## PLOT21788
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## PLOT21793
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## PLOT22113
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## PLOT22296
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## PLOT22346
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## PLOT22347
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## PLOT22399
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## PLOT22478
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## PLOT22493
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## PLOT22563
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## PLOT22601
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## PLOT22604
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## PLOT22659
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## PLOT22702
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## PLOT22704
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## PLOT22758
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## PLOT22828
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## PLOT22865
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## PLOT22904
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## PLOT22921
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## PLOT22959
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## PLOT23012
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## PLOT23035
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## PLOT23060
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## PLOT23066
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## PLOT23085
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## PLOT23111
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## PLOT23135
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## PLOT23140
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## PLOT23159
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## PLOT23187
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## PLOT23220
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## PLOT23292
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## PLOT23374
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## PLOT23384
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## PLOT23438
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## PLOT23450
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## PLOT23497
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## PLOT23561
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## PLOT23568
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## PLOT23569
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## PLOT23623
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## PLOT23680
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## PLOT23683
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## PLOT23710
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## PLOT23723
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## PLOT23730
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## PLOT23741
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## PLOT23745
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## PLOT23791
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## PLOT23796
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## PLOT23841
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```

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## PLOT23933
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## PLOT23957
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## PLOT23983
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## PLOT24009
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## PLOT24070
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## PLOT24073
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## PLOT24092
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## PLOT24109
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## PLOT24124
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## PLOT24168
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## PLOT24174
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## PLOT24238
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## PLOT24340
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## PLOT24344
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## PLOT24400
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## PLOT24514
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## PLOT24595
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## PLOT24603
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## PLOT24635
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## PLOT24707
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## PLOT24755
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## PLOT24782
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## PLOT24869
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## PLOT24891
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## PLOT24905
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## PLOT24973
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## PLOT25021
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## PLOT25054
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## PLOT25094
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## PLOT25346
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```

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                                                   -4.494 7.12e-06 ***
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## PLOT26233
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## PLOT26246
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## PLOT26288
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## PLOT26308
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## PLOT26321
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## PLOT26335
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## PLOT26368
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## PLOT26370
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                                                   -2.528 0.011496 *
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## PLOT26376
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## PLOT26393
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                                                   -2.225 0.026135 *
                                                  -5.353 8.95e-08 ***
## PLOT26413
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## PLOT26440
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                                                   -2.687 0.007237 **
## PLOT26443
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## PLOT26470
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## PLOT26486
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                                                   -4.057 5.03e-05 ***
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## PLOT26574
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## PLOT26625
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## PLOT26628
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## PLOT26650
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## PLOT26679
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## PLOT26699
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## PLOT26741
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## PLOT26756
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## PLOT26769
                                                   -2.145 0.032022 *
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## PLOT26777
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                                                   -3.358 0.000789 ***
## PLOT26821
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## PLOT26822
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                                                   -1.943 0.052104 .
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## PLOT26964
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## PLOT26983
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                                                   -3.272 0.001072 **
## PLOT26998
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## PLOT27141
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## PLOT27174
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                                                   -3.302 0.000966 ***
## PLOT27228
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                                                   -7.275 3.87e-13 ***
## PLOT27229
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## PLOT27293
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```

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## PLOT27335
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## PLOT27358
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                                                   -2.772 0.005585 **
## PLOT27385
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                                          4.38481
                                                   -3.912 9.26e-05 ***
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## PLOT27396
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## PLOT27402
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## PLOT27403
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## PLOT27458
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## PLOT27489
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## PLOT27542
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                                                   -3.465 0.000534 ***
## PLOT27589
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## PLOT27698
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## PLOT27744
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## PLOT27794
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## PLOT27806
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## PLOT27828
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## PLOT27913
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## PLOT27916
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## PLOT27923
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## PLOT27963
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## PLOT28052
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## PLOT28056
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## PLOT28072
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## PLOT28100
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## PLOT28148
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## PLOT28193
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## PLOT28204
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## PLOT28230
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## PLOT28283
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## PLOT28373
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## PLOT28466
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## PLOT28549
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## PLOT28553
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## PLOT28574
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## PLOT28644
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## PLOT28666
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## PLOT29170
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## PLOT29283
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## PLOT29359
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## PLOT29480
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## PLOT29546
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## PLOT29644
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## PLOT29722
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## PLOT29959
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## PLOT30003
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## PLOT30065
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## PLOT30121
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## PLOT30158
## PLOT30178
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## PLOT30223
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## PLOT30293
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## PLOT30297
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## PLOT30313
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## PLOT30348
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## PLOT30425
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## PLOT30504
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## PLOT30564
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## PLOT30590
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## PLOT30600
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## PLOT30649
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## PLOT30692
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## PLOT30724
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## PLOT30809
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## PLOT30853
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## PLOT30906
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## PLOT30943
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## PLOT30957
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## PLOT30971
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## PLOT31034
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```

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## PLOT31060
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## PLOT31063
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## PLOT31065
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## PLOT31121
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## PLOT31154
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## PLOT31178
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## PLOT31221
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## PLOT31236
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## PLOT31255
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## PLOT31279
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## PLOT31304
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## PLOT31336
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## PLOT31346
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## PLOT31350
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## PLOT31390
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## PLOT31412
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## PLOT31486
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## PLOT31633
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## PLOT31814
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## PLOT31947
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```

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## PLOT32346
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## PLOT32368
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## PLOT32377
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## PLOT32432
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## PLOT32443
                            -9.06828
                                          4.35843
                                                   -2.081 0.037506 *
## PLOT32460
                            -16.76621
                                          4.38474
                                                   -3.824 0.000133 ***
## PLOT32538
                            -20.01752
                                         4.38493
                                                   -4.565 5.08e-06 ***
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## PLOT32594
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## PLOT32600
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                                          4.10197
                                                   -6.584 4.94e-11 ***
## PLOT32621
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## PLOT32734
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                                                   -4.299 1.74e-05 ***
                            -18.84823
## PLOT32759
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                                          4.38474
                                                   -3.900 9.72e-05 ***
## PLOT32779
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                                          4.35823
                                                   -3.804 0.000144 ***
## PLOT32815
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                                                   -4.334 1.49e-05 ***
## PLOT32851
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                                         6.18166
                                                  -1.866 0.062017 .
## PLOT32888
                                                   -3.816 0.000137 ***
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## PLOT32970
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## PLOT32978
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                                          4.38382
                                                   -0.707 0.479411
## PLOT33079
                            -23.62980
                                         4.35830
                                                   -5.422 6.11e-08 ***
## PLOT33107
                            -26.19988
                                          3.73682
                                                   -7.011 2.60e-12 ***
                                                   -4.239 2.27e-05 ***
## PLOT33111
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## PLOT33300
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                                                   -5.331 1.01e-07 ***
## PLOT33347
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## PLOT33354
                            -14.78249
                                         3.72399
                                                   -3.970 7.28e-05 ***
## PLOT33359
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                                          3.93023
                                                   -7.070 1.71e-12 ***
## PLOT33438
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                                         4.38506
                                                   -3.698 0.000219 ***
## PLOT33478
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                                                   -2.766 0.005686 **
## PLOT33488
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                                          4.22233
                                                   -3.890 0.000101 ***
## PLOT33497
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                                                   -2.622 0.008771 **
                                                   -1.774 0.076148 .
## PLOT33508
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## PLOT33516
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## PLOT33650
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## PLOT33658
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## PLOT33780
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                                                  -2.645 0.008179 **
## PLOT33784
                            -8.46072
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                                                   -2.272 0.023118 *
## PLOT33868
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                                                   -5.869 4.61e-09 ***
## PLOT33896
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                                          4.38633
                                                  -4.646 3.45e-06 ***
## PLOT33955
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## PLOT33985
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                                                   -7.162 8.80e-13 ***
                                                   -3.237 0.001214 **
## PLOT34039
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## PLOT34074
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                                          3.93023
                                                   -6.014 1.91e-09 ***
## PLOT34161
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## PLOT34181
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                                                   -7.181 7.69e-13 ***
## PLOT34200
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                                                   -2.562 0.010443 *
## PLOT34238
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## PLOT34240
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                                         6.29274
                                                  -5.531 3.31e-08 ***
## PLOT34256
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## PLOT34258
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```

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## PLOT34279
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                                                  -7.331 2.55e-13 ***
## PLOT34282
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                                         3.84456
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## PLOT34330
                            -17.75988
                                         4.38539
                                                   -4.050 5.19e-05 ***
## PLOT34417
                                                   -4.282 1.88e-05 ***
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## PLOT34427
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                                         4.49472
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## PLOT34515
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                                                  -6.584 4.94e-11 ***
## PLOT34572
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## PLOT34581
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## PLOT34596
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## PLOT34606
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## PLOT34723
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## PLOT34725
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## PLOT34752
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## PLOT34803
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## PLOT34805
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## PLOT34822
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                                                   -2.326 0.020030 *
## PLOT34874
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                            -21.79457
## PLOT34884
                            -22.82402
                                          4.38569
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## PLOT34891
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## PLOT34928
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## PLOT34982
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## PLOT34995
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                                                   -3.593 0.000329 ***
## PLOT35018
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## PLOT35034
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## PLOT35043
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## PLOT35060
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## PLOT35084
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## PLOT35120
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## PLOT35129
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## PLOT35171
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## PLOT35245
                            -16.46033
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## PLOT35289
                            -20.04173
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## PLOT35296
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## PLOT35312
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## PLOT35401
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## PLOT35410
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## PLOT35438
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## PLOT35587
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## PLOT35589
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## PLOT35649
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## PLOT35704
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## PLOT35743
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## PLOT35765
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## PLOT35774
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## PLOT35776
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## PLOT35780
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## PLOT35861
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## PLOT35891
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## PLOT35902
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## PLOT35938
                            -27.49520
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                                                   -6.309 3.00e-10 ***
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## PLOT35939
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## PLOT35964
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## PLOT35981
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## PLOT36073
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```

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## PLOT36077
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## PLOT36095
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                                         4.49440
                                                  -4.590 4.52e-06 ***
## PLOT36137
                            -19.60030
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## PLOT36221
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                                                   -3.071 0.002140 **
## PLOT36262
                            -24.03598
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                                                   -6.110 1.05e-09 ***
                                                   -3.666 0.000249 ***
## PLOT36268
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## PLOT36276
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## PLOT36289
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## PLOT36309
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## PLOT36351
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## PLOT36466
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## PLOT36581
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## PLOT36603
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                                                   -4.351 1.37e-05 ***
## PLOT36611
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                                                   -2.280 0.022643 *
                                                   -3.089 0.002017 **
## PLOT36624
                            -19.43843
                                         6.29278
## PLOT36626
                            -16.15352
                                          4.54242
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## PLOT36646
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## PLOT36656
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## PLOT36710
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## PLOT36717
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## PLOT36744
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## PLOT36765
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## PLOT36797
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## PLOT36818
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## PLOT36819
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## PLOT36829
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## PLOT36915
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## PLOT36969
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## PLOT37004
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                                         3.77463
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## PLOT37005
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## PLOT37009
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                                                   -5.304 1.17e-07 ***
## PLOT37087
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                                         4.35905
                                                   -6.175 7.02e-10 ***
## PLOT37112
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## PLOT37113
                            -17.09954
                                         6.18156
                                                   -2.766 0.005687 **
## PLOT37125
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                            -25.15031
## PLOT37190
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                                         3.55771
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## PLOT37199
                             -9.09657
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## PLOT37267
                                                   -5.192 2.14e-07 ***
                            -22.77668
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                                                   -3.553 0.000384 ***
## PLOT37443
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## PLOT37488
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## PLOT37678
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## PLOT37695
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## PLOT37832
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## PLOT37877
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## PLOT37894
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## PLOT37927
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## PLOT37969
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## PLOT37980
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## PLOT38008
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## PLOT38094
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## PLOT38105
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                                          3.93025
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## PLOT38117
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## PLOT38135
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## PLOT38164
                             -9.02312
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                                                  -2.071 0.038415 *
```

```
## PLOT38202
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## PLOT38319
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## PLOT38357
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## PLOT38446
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## PLOT38451
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                                                   -5.839 5.50e-09 ***
## PLOT38494
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                                          4.38557
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## PLOT38542
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                                          3.77713
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## PLOT38571
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## PLOT38575
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## PLOT38583
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## PLOT38617
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                                                   -3.167 0.001546 **
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## PLOT38664
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## PLOT38669
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## PLOT38693
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## PLOT38864
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## PLOT38878
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## PLOT38896
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## PLOT38919
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## PLOT38927
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## PLOT38929
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## PLOT38944
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## PLOT39038
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## PLOT39089
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## PLOT39093
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## PLOT39116
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## PLOT39145
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## PLOT39170
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## PLOT39216
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## PLOT39234
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## PLOT39241
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## PLOT39255
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## PLOT39318
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## PLOT39399
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## PLOT39400
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## PLOT39452
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## PLOT39459
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## PLOT39536
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## PLOT39541
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## PLOT39543
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## PLOT39554
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## PLOT39619
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## PLOT39643
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## PLOT39714
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## PLOT39762
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## PLOT39764
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## PLOT39770
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## PLOT39799
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## PLOT39900
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## PLOT39969
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## PLOT39979
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## PLOT40035
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```

```
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## PLOT40064
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## PLOT40086
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## PLOT40089
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## PLOT40093
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## PLOT40219
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## PLOT40227
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## PLOT40312
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## PLOT40387
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## PLOT40424
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## PLOT40430
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## PLOT40475
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## PLOT40492
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## PLOT40856
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## PLOT40932
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## PLOT40957
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## PLOT40967
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## PLOT40981
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## PLOT41102
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## PLOT41116
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## PLOT41161
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## PLOT41183
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## PLOT41239
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## PLOT41267
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## PLOT41287
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## PLOT41300
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## PLOT41355
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## PLOT41381
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## PLOT41413
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## PLOT41483
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## PLOT41491
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## PLOT41545
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## PLOT41565
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## PLOT41579
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## PLOT41609
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## PLOT41642
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## PLOT41651
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## PLOT41682
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## PLOT41743
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## PLOT41746
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## PLOT41758
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## PLOT41822
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## PLOT41852
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## PLOT41943
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## PLOT41952
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## PLOT42035
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## PLOT42066
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## PLOT42087
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## PLOT42167
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## PLOT42199
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## PLOT42207
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## PLOT42259
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## PLOT42286
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## PLOT42303
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## PLOT42605
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## PLOT42614
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## PLOT42648
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## PLOT43996
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## PLOT44027
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## PLOT44072
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## PLOT44424
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## PLOT44430
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## PLOT44458
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## PLOT44480
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## PLOT44483
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## PLOT44496
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## PLOT44536
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## PLOT44542
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## PLOT45107
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## PLOT45187
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## PLOT45222
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## PLOT45289
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## PLOT45315
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## PLOT45323
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## PLOT46134
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## PLOT46267
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## PLOT47304
                            -29.51882
                                          3.72421
                                                   -7.926 2.63e-15 ***
## PLOT47309
                             -5.55410
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                                                   -1.274 0.202540
## PLOT47318
                            -32.05283
                                          4.10132
                                                   -7.815 6.34e-15 ***
## PLOT47391
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## PLOT47403
                            -12.17976
                                          3.77438
                                                   -3.227 0.001257 **
## PLOT47420
                              3.89828
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                                                    0.889 0.373889
## PLOT47487
                            -11.02442
                                          3.93414 -2.802 0.005090 **
```

```
## PLOT47504
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                                                  -2.575 0.010052 *
## PLOT47553
                                          3.59211
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## PLOT47564
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                                          6.25932
                                                   -4.329 1.52e-05 ***
## PLOT47575
                            -18.99082
                                                   -4.219 2.48e-05 ***
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## PLOT47582
                            -36.18717
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                                                   -8.305 < 2e-16 ***
## PLOT47629
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                                          4.38364
                                                   -1.923 0.054552 .
## PLOT47642
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                                                   -3.434 0.000599 ***
## PLOT47830
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## PLOT47945
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                                          4.35801
                                                   -5.340 9.59e-08 ***
## PLOT48011
                             -8.96603
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## PLOT48020
                            -17.04312
                                          3.59115
                                                   -4.746 2.12e-06 ***
## PLOT48050
                            -18.21625
                                          4.38506
                                                   -4.154 3.31e-05 ***
## PLOT48097
                            -22.48888
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## PLOT48103
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                                                   -6.406 1.60e-10 ***
## PLOT48127
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## PLOT48150
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                                                   -3.222 0.001281 **
## PLOT48176
                                          4.99396
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                            -23.76406
## PLOT48225
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                                          4.04961
                                                   -1.913 0.055777 .
## PLOT48233
                            -32.35734
                                          4.36628
                                                   -7.411 1.41e-13 ***
## PLOT48275
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## PLOT48334
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## PLOT48368
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                                                   -7.081 1.58e-12 ***
## PLOT48434
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## PLOT48461
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                                          3.49438
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## PLOT48482
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## PLOT48521
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## PLOT48528
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## PLOT48530
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## PLOT48550
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                                                   -3.085 0.002042 **
## PLOT48561
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## PLOT48562
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## PLOT48800
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## PLOT48816
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## PLOT48850
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## PLOT48883
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## PLOT48904
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## PLOT48916
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## PLOT48917
                                                   -4.802 1.60e-06 ***
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## PLOT48942
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## PLOT48948
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## PLOT48950
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## PLOT48956
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## PLOT49006
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## PLOT49069
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## PLOT49177
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## PLOT49207
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## PLOT49208
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                                                   -1.375 0.169146
## PLOT49217
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## PLOT49251
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## PLOT49262
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## PLOT49302
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## PLOT49305
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## PLOT49317
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## PLOT49349
                            -24.03158
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                                                  -6.651 3.14e-11 ***
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-19.45439
## PLOT49375
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## PLOT49381
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## PLOT49402
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## PLOT49403
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## PLOT49475
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## PLOT49485
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## PLOT49510
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## PLOT49550
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## PLOT49565
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## PLOT49568
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## PLOT49584
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## PLOT49585
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## PLOT49698
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## PLOT49711
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## PLOT49715
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## PLOT49742
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## PLOT49860
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## PLOT49874
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## PLOT49882
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## PLOT50157
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## PLOT50223
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## PLOT50247
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## PLOT50271
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## PLOT50318
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## PLOT50348
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## PLOT50359
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## PLOT50361
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## PLOT50381
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## PLOT50431
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## PLOT50434
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## PLOT50437
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## PLOT50498
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                                                   -2.298 0.021618 *
## PLOT50645
                             -8.68232
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                                                   -3.141 0.001693 **
## PLOT50687
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## PLOT50691
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## PLOT50772
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## PLOT50821
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## PLOT50900
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## PLOT51009
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## PLOT51161
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## PLOT51164
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                                         3.93676
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## PLOT51241
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## PLOT51249
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```

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## PLOT51278
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## PLOT51435
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## PLOT51483
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## PLOT51487
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## PLOT51496
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                                                   -5.186 2.21e-07 ***
## PLOT51548
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## PLOT51656
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## PLOT51669
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## PLOT51683
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## PLOT51711
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## PLOT51768
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## PLOT51890
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## PLOT51937
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## PLOT51972
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## PLOT51974
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                                                   -1.975 0.048273 *
## PLOT52012
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                                          4.38472
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## PLOT52042
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## PLOT52093
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## PLOT52117
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## PLOT52131
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## PLOT52136
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## PLOT52144
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## PLOT52186
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## PLOT52192
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## PLOT52204
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## PLOT52227
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## PLOT52261
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## PLOT52273
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## PLOT52308
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## PLOT52309
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## PLOT52314
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## PLOT52317
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## PLOT52365
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## PLOT52399
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## PLOT52437
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## PLOT52493
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## PLOT52570
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## PLOT52586
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## PLOT52636
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## PLOT52645
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## PLOT52658
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## PLOT52707
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## PLOT52710
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## PLOT52725
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## PLOT52776
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## PLOT52823
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## PLOT52827
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## PLOT52958
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## PLOT52964
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```

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## PLOT52967
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## PLOT52977
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## PLOT53035
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## PLOT53106
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## PLOT53126
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## PLOT53198
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## PLOT53294
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## PLOT53359
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## PLOT53377
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## PLOT53386
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## PLOT53393
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## PLOT53410
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## PLOT53462
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## PLOT53506
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## PLOT53615
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## PLOT53629
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## PLOT53655
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## PLOT53661
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## PLOT53762
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## PLOT53854
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## PLOT53862
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## PLOT53863
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## PLOT53881
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## PLOT53898
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## PLOT53945
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## PLOT54028
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## PLOT54069
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## PLOT54072
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## PLOT54133
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## PLOT54184
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## PLOT54190
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## PLOT54256
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                                                   -3.571 0.000358 ***
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## PLOT54295
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## PLOT54395
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## PLOT54480
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## PLOT54491
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## PLOT54560
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## PLOT54604
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## PLOT54611
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## PLOT54612
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## PLOT54681
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## PLOT54682
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## PLOT54712
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                                                  -3.981 6.94e-05 ***
```

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## PLOT54742
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## PLOT54777
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## PLOT54879
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                                                   -3.163 0.001566 **
## PLOT54895
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## PLOT54899
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## PLOT54920
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## PLOT55003
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## PLOT55017
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## PLOT55022
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                                                   -2.635 0.008425 **
## PLOT55049
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## PLOT55056
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## PLOT55151
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                                                   -4.177 2.99e-05 ***
## PLOT55193
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## PLOT55195
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## PLOT55204
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## PLOT55355
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## PLOT55369
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## PLOT55371
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## PLOT55373
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## PLOT55389
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## PLOT55390
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## PLOT55408
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## PLOT55409
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## PLOT55499
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## PLOT55500
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## PLOT55544
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## PLOT55563
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## PLOT55618
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## PLOT55628
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## PLOT55654
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## PLOT55742
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## PLOT55773
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## PLOT55801
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## PLOT55808
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## PLOT55828
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## PLOT55834
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## PLOT55847
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## PLOT55918
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## PLOT55947
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## PLOT56036
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## PLOT56038
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## PLOT56084
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## PLOT56109
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## PLOT56198
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## PLOT56201
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## PLOT56279
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## PLOT56281
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## PLOT56283
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## PLOT56398
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## PLOT56405
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## PLOT56406
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## PLOT56434
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## PLOT56483
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## PLOT56505
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## PLOT56539
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## PLOT56784
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## PLOT56918
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## PLOT57058
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## PLOT57106
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## PLOT57123
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## PLOT57170
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## PLOT57448
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## PLOT57517
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## PLOT57534
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## PLOT57547
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## PLOT57605
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## PLOT57630
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## PLOT57760
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## PLOT57897
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## PLOT57923
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## PLOT57934
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## PLOT58091
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## PLOT58261
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## PLOT58575
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## PLOT58607
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## PLOT58613
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## PLOT58708
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## PLOT58715
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## PLOT58729
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## PLOT58749
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## PLOT58770
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## PLOT58861
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## PLOT58887
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## PLOT58983
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## PLOT59038
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## PLOT59102
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## PLOT59675
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## PLOT59947
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## PLOT60053
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                                                   -3.043 0.002349 **
## PLOT60880
                                                   -3.420 0.000631 ***
                            -14.90118
                                          4.35737
## PLOT60887
                            -40.25457
                                          6.25935
                                                   -6.431 1.36e-10 ***
## PLOT60947
                            -23.49701
                                          4.38498
                                                   -5.359 8.67e-08 ***
## PLOT60954
                            -20.53974
                                          3.78293
                                                   -5.430 5.85e-08 ***
                             -4.06216
## PLOT60996
                                          6.25930
                                                   -0.649 0.516374
## PLOT61035
                            -17.09718
                                          3.53989
                                                   -4.830 1.40e-06 ***
## PLOT61061
                            -10.59169
                                          6.18097
                                                   -1.714 0.086650 .
## PLOT61062
                             -8.41318
                                          4.35861
                                                   -1.930 0.053619 .
## PLOT61063
                                                   -4.485 7.41e-06 ***
                            -19.54778
                                          4.35848
                                          4.38501
                                                   -4.425 9.80e-06 ***
## PLOT61085
                            -19.40343
## PLOT61092
                            -10.44553
                                          3.59026
                                                   -2.909 0.003633 **
## PLOT61098
                            -20.89448
                                          4.38525
                                                   -4.765 1.93e-06 ***
## PLOT61117
                                                   -3.736 0.000188 ***
                            -16.38554
                                          4.38551
## PLOT61122
                             -3.08383
                                          6.18077
                                                   -0.499 0.617838
                                                   -6.447 1.22e-10 ***
## PLOT61126
                            -24.39303
                                          3.78387
                            -18.33115
## PLOT61144
                                          4.87296
                                                   -3.762 0.000170 ***
                                                   -3.372 0.000750 ***
## PLOT61145
                            -11.68166
                                          3.46399
## PLOT61150
                            -16.80090
                                          4.38528
                                                   -3.831 0.000129 ***
## PLOT61205
                            -18.94525
                                          4.35874
                                                   -4.346 1.40e-05 ***
                                                   -4.532 5.95e-06 ***
## PLOT61252
                            -19.87136
                                          4.38488
## PLOT61299
                             -4.80308
                                          3.80392
                                                   -1.263 0.206755
## PLOT61302
                                          4.36007
                                                   -5.431 5.79e-08 ***
                            -23.68129
## PLOT61311
                            -14.04697
                                          4.38467
                                                   -3.204 0.001363 **
## PLOT61326
                            -12.36911
                                          4.35741
                                                   -2.839 0.004544 **
## PLOT61358
                            -19.14922
                                          4.35989
                                                  -4.392 1.14e-05 ***
```

```
## PLOT61377
                             -5.62531
                                          4.99491
                                                  -1.126 0.260118
## PLOT61387
                            -25.41950
                                          6.16265
                                                   -4.125 3.76e-05 ***
## PLOT61418
                            -30.22315
                                          6.26161
                                                   -4.827 1.42e-06 ***
## PLOT61420
                             -5.82330
                                          3.77410
                                                   -1.543 0.122887
## PLOT61540
                            -22.54959
                                          4.38506
                                                   -5.142 2.79e-07 ***
## PLOT61565
                            -27.60144
                                          4.35752
                                                   -6.334 2.54e-10 ***
## PLOT61580
                            -17.92552
                                          3.51319
                                                   -5.102 3.45e-07 ***
## PLOT61659
                            -11.33115
                                          3.55960
                                                   -3.183 0.001463 **
## PLOT61750
                              1.01454
                                          4.07767
                                                    0.249 0.803519
## PLOT61756
                            -23.11339
                                          3.98427
                                                   -5.801 6.89e-09 ***
## PLOT61799
                            -17.27749
                                          4.87460
                                                   -3.544 0.000396 ***
## PLOT61846
                            -20.35609
                                          4.38585
                                                   -4.641 3.53e-06 ***
## PLOT61894
                             -5.55846
                                          4.36003
                                                   -1.275 0.202401
                                                   -6.494 8.97e-11 ***
## PLOT61915
                            -27.73097
                                          4.27027
## PLOT61932
                                                   -2.818 0.004853 **
                            -12.35194
                                          4.38390
## PLOT61952
                            -20.83901
                                          4.36041
                                                   -4.779 1.80e-06 ***
## PLOT61967
                            -19.85612
                                          3.93121
                                                   -5.051 4.52e-07 ***
## PLOT61981
                            -26.58770
                                          4.36011
                                                   -6.098 1.14e-09 ***
## PLOT62051
                            -19.58790
                                          4.49375
                                                   -4.359 1.33e-05 ***
## PLOT62069
                            -26.92736
                                          4.35926
                                                   -6.177 6.92e-10 ***
## PLOT62101
                            -21.43990
                                          4.27112
                                                   -5.020 5.31e-07 ***
## PLOT62115
                                          4.38387
                                                   -1.589 0.112105
                             -6.96603
                                                   -4.994 6.07e-07 ***
## PLOT62117
                            -18.39248
                                          3.68294
## PLOT62188
                             -2.67299
                                          4.35733
                                                   -0.613 0.539602
## PLOT62211
                             -7.35829
                                          3.93555
                                                   -1.870 0.061570 .
## PLOT62272
                            -12.77625
                                          3.77647
                                                   -3.383 0.000721 ***
## PLOT62488
                                                   -2.075 0.038012 *
                             -9.32503
                                          4.49369
## PLOT62530
                              9.36673
                                          4.49864
                                                    2.082 0.037369 *
## PLOT62537
                            -10.50596
                                          3.80523
                                                   -2.761 0.005780 **
## PLOT62617
                                          3.80415
                                                   -3.857 0.000116 ***
                            -14.67371
## PLOT62621
                            -12.06595
                                          4.38367
                                                   -2.752 0.005931 **
## PLOT62659
                            -15.21553
                                          3.77376
                                                   -4.032 5.59e-05 ***
## PLOT62677
                            -18.48516
                                          3.55889
                                                   -5.194 2.12e-07 ***
                                                   -5.956 2.72e-09 ***
## PLOT62707
                            -20.93627
                                          3.51522
## PLOT62749
                                          3.54952
                                                   -3.794 0.000150 ***
                            -13.46530
## PLOT62763
                            -15.10297
                                          4.35899
                                                   -3.465 0.000534 ***
## PLOT62820
                            -13.54959
                                          4.38506
                                                   -3.090 0.002010 **
## PLOT62825
                                                   -1.868 0.061755 .
                            -8.14398
                                          4.35887
                                          6.18194
                                                   -3.742 0.000184 ***
## PLOT62830
                            -23.13423
## PLOT62847
                            -19.16678
                                          3.84441
                                                   -4.986 6.33e-07 ***
## PLOT62873
                            -21.98102
                                          6.16257
                                                   -3.567 0.000364 ***
## PLOT62890
                                          4.38399
                                                   -3.733 0.000191 ***
                            -16.36350
## PLOT62894
                            -13.15212
                                          4.38481
                                                   -2.999 0.002715 **
                            -23.17415
                                                   -5.282 1.32e-07 ***
## PLOT62897
                                          4.38710
## PLOT62973
                            -24.72448
                                          4.35740
                                                   -5.674 1.45e-08 ***
                                          4.07587
                                                   -3.060 0.002219 **
## PLOT63032
                            -12.47399
## PLOT63074
                            -23.08814
                                          4.27233
                                                   -5.404 6.74e-08 ***
## PLOT63109
                             -9.43236
                                          4.49478
                                                   -2.099 0.035898 *
## PLOT63136
                            -14.64950
                                          4.38446
                                                   -3.341 0.000839 ***
## PLOT63162
                            -24.12790
                                          4.38605
                                                   -5.501 3.92e-08 ***
## PLOT63166
                            -16.72141
                                          4.49438
                                                   -3.721 0.000200 ***
## PLOT63177
                            -25.21247
                                          4.49456
                                                   -5.610 2.11e-08 ***
## PLOT63238
                            -14.39658
                                          4.49411
                                                   -3.203 0.001364 **
## PLOT63273
                            -21.16556
                                          3.72353
                                                  -5.684 1.37e-08 ***
```

```
## PLOT63277
                           -20.30984
                                        4.38504 -4.632 3.70e-06 ***
## PLOT63314
                           -10.94755
                                        3.44811
                                                 -3.175 0.001506 **
## PLOT63373
                           -21.67136
                                        3.77400
                                                 -5.742 9.76e-09 ***
## PLOT63375
                                        4.35730
                                                 -0.335 0.737305
                            -1.46161
## PLOT63378
                           -18.57904
                                        4.38479
                                                 -4.237 2.29e-05 ***
## PLOT63405
                            12.91559
                                        6.26454
                                                  2.062 0.039275 *
## PLOT63429
                            -3.33857
                                        3.77364
                                                 -0.885 0.376346
## PLOT63473
                            -0.93767
                                        4.38363
                                                 -0.214 0.830629
## PLOT63583
                           -27.35319
                                        4.36137
                                                 -6.272 3.80e-10 ***
## PLOT63589
                           -11.78861
                                        6.16226
                                                 -1.913 0.055787 .
## PLOT63640
                           -17.41499
                                        6.18188
                                                 -2.817 0.004860 **
## PLOT63642
                           -11.06343
                                        3.62628
                                                 -3.051 0.002291 **
## PLOT63698
                           -11.73474
                                        4.24931
                                                 -2.762 0.005768 **
## PLOT63719
                            -4.18168
                                        3.77678
                                                 -1.107 0.268245
## PLOT63757
                                        3.72389
                           -25.40807
                                                 -6.823 9.71e-12 ***
## PLOT63773
                           -21.96199
                                        6.29285
                                                  -3.490 0.000486 ***
## PLOT63775
                           -17.98174
                                        4.38599
                                                 -4.100 4.18e-05 ***
## PLOT63786
                           -14.15687
                                        3.84458
                                                 -3.682 0.000233 ***
## PLOT63818
                           -15.77464
                                        3.60442
                                                 -4.376 1.22e-05 ***
## PLOT63955
                           -17.91689
                                        4.35776
                                                 -4.111 3.98e-05 ***
## PLOT63959
                           -25.02276
                                        4.38585
                                                 -5.705 1.21e-08 ***
## PLOT63988
                                                 -3.546 0.000394 ***
                           -21.92284
                                        6.18300
                                                 -4.292 1.79e-05 ***
## PLOT64010
                           -17.59864
                                        4.10016
## PLOT64063
                             1.06088
                                        6.25930
                                                   0.169 0.865418
## PLOT64065
                           -16.08555
                                        3.78114
                                                 -4.254 2.13e-05 ***
## PLOT64076
                           -16.28926
                                        6.25948
                                                 -2.602 0.009280 **
## PLOT64145
                            -8.30722
                                        3.80510
                                                 -2.183 0.029057 *
                                                 -4.020 5.87e-05 ***
## PLOT64153
                           -25.16622
                                        6.25959
## PLOT64204
                           -18.81878
                                        4.10529
                                                 -4.584 4.64e-06 ***
## PLOT64212
                           -21.46309
                                        4.10592
                                                 -5.227 1.77e-07 ***
## PLOT64249
                           -26.79385
                                        4.35797
                                                 -6.148 8.29e-10 ***
## PLOT64269
                            -8.31041
                                        3.93293
                                                 -2.113 0.034635 *
## PLOT64295
                           -17.86503
                                        3.80615
                                                 -4.694 2.74e-06 ***
                                                 -4.249 2.18e-05 ***
## PLOT64323
                           -18.63161
                                        4.38486
## PLOT64345
                           -20.26587
                                        3.98368
                                                 -5.087 3.73e-07 ***
## PLOT64384
                           -18.08855
                                        3.93370
                                                 -4.598 4.34e-06 ***
## PLOT64407
                           -22.72250
                                        3.93029
                                                 -5.781 7.75e-09 ***
## PLOT64414
                           -13.20679
                                                 -3.581 0.000345 ***
                                        3.68818
                                        4.35726
                                                 -1.910 0.056194 .
## PLOT64443
                            -8.32177
## PLOT64463
                           -21.64789
                                        3.93061
                                                 -5.508 3.78e-08 ***
## PLOT64465
                            -8.92450
                                        3.93304
                                                 -2.269 0.023294 *
## PLOT67852
                           -25.98140
                                        4.04920
                                                 -6.416 1.49e-10 ***
                           -24.16731
## PLOT67854
                                        3.93023
                                                 -6.149 8.25e-10 ***
## PLOT67857
                           -26.51744
                                        4.49387 -5.901 3.80e-09 ***
## Signif. codes: 0 '*** 0.001 '** 0.01 '* 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 5.337 on 6600 degrees of freedom
     (82 observations deleted due to missingness)
## Multiple R-squared: 0.9151, Adjusted R-squared: 0.8901
## F-statistic: 36.69 on 1938 and 6600 DF, p-value: < 2.2e-16
```

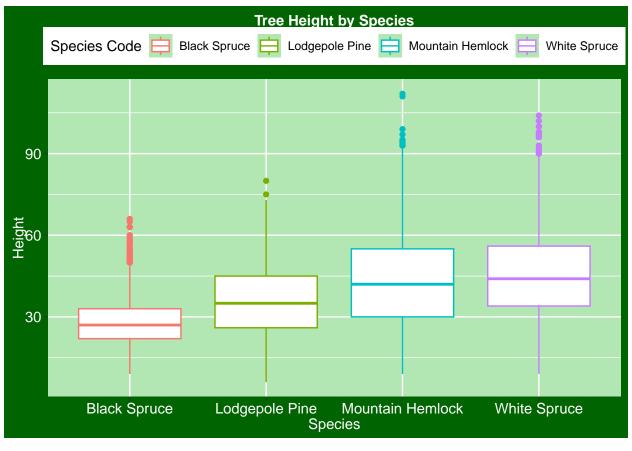
ANOVA Tests

```
#ANOVA with species interaction
species.model.anova <- aov(HT ~ DIA + Species,</pre>
                          data = Species.wanted)
summary(species.model.anova)
##
                Df Sum Sq Mean Sq F value Pr(>F)
## DIA
                 1 1351652 1351652 17894.8 <2e-16 ***
                              72300
                                     957.2 <2e-16 ***
## Species
                 3 216899
## Residuals
              8534 644599
                                 76
## Signif. codes: 0 '*** 0.001 '** 0.01 '* 0.05 '.' 0.1 ' 1
## 82 observations deleted due to missingness
#ANOVA with species and plot interaction
PlotandSpecies.model.anova <- aov(HT ~ DIA + Species + PLOT,
                                  data = Species.wanted)
summary(PlotandSpecies.model.anova)
##
                Df Sum Sq Mean Sq
                                    F value Pr(>F)
## DIA
                 1 1351652 1351652 47462.200 <2e-16 ***
## Species
                 3 216899
                             72300 2538.752 <2e-16 ***
              1934 456641
                               236
                                        8.291 <2e-16 ***
## PLOT
## Residuals
              6600 187958
                                28
## ---
## Signif. codes: 0 '*** 0.001 '** 0.01 '* 0.05 '.' 0.1 ' 1
```

The ANOVA results suggest that diameter has the highest influence on tree height, as expected. Additionally, it suggests that both species and plot number have a significant influence on tree height. The influence of plot is smaller than that of diameter and tree species. These results will be explored further in the following sections.

Mean Height Comparisons

82 observations deleted due to missingness



```
#Mean Height of Black Spruce compared to Mean Height of White Spruce
b.w.spruces <- Species.wanted %>%
  filter(SPCD %in% c(94, 95))
BlackvWhiteSpruce <- aov(HT~Species, data = b.w.spruces)</pre>
summary.aov(BlackvWhiteSpruce)
                 Df Sum Sq Mean Sq F value Pr(>F)
##
## Species
                 1 363941 363941
                                      2077 <2e-16 ***
## Residuals 4951 867673
                               175
## Signif. codes: 0 '*** 0.001 '** 0.01 '* 0.05 '.' 0.1 ' ' 1
#Mean Height of White Spruce compared to Mean Height of Lodgepole Pine
w.spruce.l.pine <- Species.wanted %>%
 filter(SPCD %in% c(94, 108))
WhiteSprucevLodgePine <- aov(HT~Species, data = w.spruce.l.pine)</pre>
summary.aov(WhiteSprucevLodgePine)
##
                 Df Sum Sq Mean Sq F value Pr(>F)
## Species
                1 59934 59934
                                   257.6 <2e-16 ***
## Residuals 3669 853755
                               233
```

Signif. codes: 0 '*** 0.001 '** 0.01 '* 0.05 '.' 0.1 ' 1

```
#Mean Height of Lodgepole Pine compared to Mean Height of Mountain Hemlock
1.pine.m.hemlock <- Species.wanted %>%
  filter(SPCD %in% c(108, 264))
LodgePinevMountHemlock <- aov(HT~Species, data = 1.pine.m.hemlock)</pre>
summary.aov(LodgePinevMountHemlock)
##
                Df Sum Sq Mean Sq F value Pr(>F)
                            33524
                                    129.7 <2e-16 ***
## Species
                  1 33524
## Residuals
              3666 947667
                               259
## ---
## Signif. codes: 0 '*** 0.001 '** 0.01 '* 0.05 '.' 0.1 ' 1
#Mean Height of Black Spruce compared to Mean Height of Mountain Hemlock
b.spruce.m.hemlock <- Species.wanted %>%
  filter(SPCD %in% c(95, 264))
BlackSprucevMountHemlock <- aov(HT~Species, data = b.spruce.m.hemlock)
summary.aov(BlackSprucevMountHemlock)
##
                Df Sum Sq Mean Sq F value Pr(>F)
                 1 270470 270470
## Species
                                     1392 <2e-16 ***
## Residuals 4948 961585
                              194
## Signif. codes: 0 '*** 0.001 '** 0.01 '* 0.05 '.' 0.1 ' 1
#Mean Height of Black Spruce compared to Mean Height of Lodgepole Pine
b.spruce.l.pine <- Species.wanted %>%
 filter(SPCD %in% c(95, 108))
BlackSprucevLodgePine <- aov(HT~Species, data = b.spruce.l.pine)</pre>
summary.aov(BlackSprucevLodgePine)
                Df Sum Sq Mean Sq F value Pr(>F)
                 1 38618
## Species
                            38618
                                    361.7 <2e-16 ***
## Residuals
              3052 325847
                              107
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.05 '.' 0.1 ' ' 1
#Mean Height of White Spruce compared to Mean Height of Mountain Hemlock
w.spruce.m.hemlock <- Species.wanted %>%
 filter(SPCD %in% c(95, 108))
WhiteSprucevMountHemlock <- aov(HT~Species, data = w.spruce.m.hemlock)
summary.aov(WhiteSprucevMountHemlock)
                Df Sum Sq Mean Sq F value Pr(>F)
## Species
                 1 38618
                            38618
                                    361.7 <2e-16 ***
## Residuals 3052 325847
                              107
## Signif. codes: 0 '*** 0.001 '** 0.01 '* 0.05 '.' 0.1 ' 1
```

```
#Because the anova test shows that all results are significant,
#a pairwise comparison between species can be conducted to show the confidence
#interval, p-value and difference in each species
TukeyResults1 <- TukeyHSD(WhiteSprucevLodgePine)</pre>
TukeyResults2 <- TukeyHSD(LodgePinevMountHemlock)</pre>
TukeyResults3 <- TukeyHSD(BlackSprucevMountHemlock)</pre>
TukeyResults4 <- TukeyHSD(BlackSprucevLodgePine)</pre>
TukeyResults5 <- TukeyHSD(BlackSprucevLodgePine)</pre>
TukeyResults6 <- TukeyHSD(BlackSprucevLodgePine)</pre>
TukeyResults1
     Tukey multiple comparisons of means
##
       95% family-wise confidence level
##
## Fit: aov(formula = HT ~ Species, data = w.spruce.l.pine)
##
## $Species
##
                                    diff
                                               lwr
                                                        upr p adj
## White Spruce-Lodgepole Pine 9.442757 8.289179 10.59634
TukeyResults2
     Tukey multiple comparisons of means
##
##
       95% family-wise confidence level
##
## Fit: aov(formula = HT ~ Species, data = 1.pine.m.hemlock)
## $Species
##
                                        diff
                                                            upr p adj
## Mountain Hemlock-Lodgepole Pine 7.063093 5.847069 8.279118
TukeyResults3
##
     Tukey multiple comparisons of means
##
       95% family-wise confidence level
## Fit: aov(formula = HT ~ Species, data = b.spruce.m.hemlock)
##
## $Species
##
                                      diff
                                                 lwr
                                                          upr p adj
## Mountain Hemlock-Black Spruce 14.89889 14.11595 15.68182
TukeyResults4
##
     Tukey multiple comparisons of means
##
       95% family-wise confidence level
## Fit: aov(formula = HT ~ Species, data = b.spruce.l.pine)
##
```

```
## $Species
                                   diff
##
                                             lwr
                                                       upr p adj
## Lodgepole Pine-Black Spruce 7.835792 7.027957 8.643627
TukeyResults5
##
     Tukey multiple comparisons of means
##
       95% family-wise confidence level
##
## Fit: aov(formula = HT ~ Species, data = b.spruce.l.pine)
##
## $Species
                                   diff
                                             lwr
                                                       upr p adj
## Lodgepole Pine-Black Spruce 7.835792 7.027957 8.643627
TukeyResults6
##
     Tukey multiple comparisons of means
##
       95% family-wise confidence level
##
## Fit: aov(formula = HT ~ Species, data = b.spruce.l.pine)
## $Species
                                   diff
                                                       upr p adj
## Lodgepole Pine-Black Spruce 7.835792 7.027957 8.643627
TukeyResults1_df <- as.data.frame(TukeyResults1$Species) %>%
  mutate(Comparison = "White Spruce vs Lodgepole Pine")
TukeyResults2_df <- as.data.frame(TukeyResults2$Species) %>%
  mutate(Comparison = "Lodgepole Pine vs Mountain Hemlock")
TukeyResults3_df <- as.data.frame(TukeyResults3$Species) %>%
  mutate(Comparison = "Black Spruce vs Mountain Hemlock")
TukeyResults4_df <- as.data.frame(TukeyResults4$Species) %>%
  mutate(Comparison = "Black Spruce vs Lodgepole Pine")
TukeyResults5_df <- as.data.frame(TukeyResults1$Species) %>%
  mutate(Comparison = "White Spruce vs Black Spruce")
TukeyResults6_df <- as.data.frame(TukeyResults1$Species) %>%
  mutate(Comparison = "White Spruce vs Mountain Hemlock")
all_TukeyResults <- bind_rows(TukeyResults1_df,TukeyResults2_df, TukeyResults3_df, TukeyResults4_df, Tu
print(all_TukeyResults)
##
                                        diff
                                                    lwr
                                                              upr
                                                                         p adj
## White Spruce-Lodgepole Pine...1 9.442757 8.289179 10.596335 8.369286e-09
```

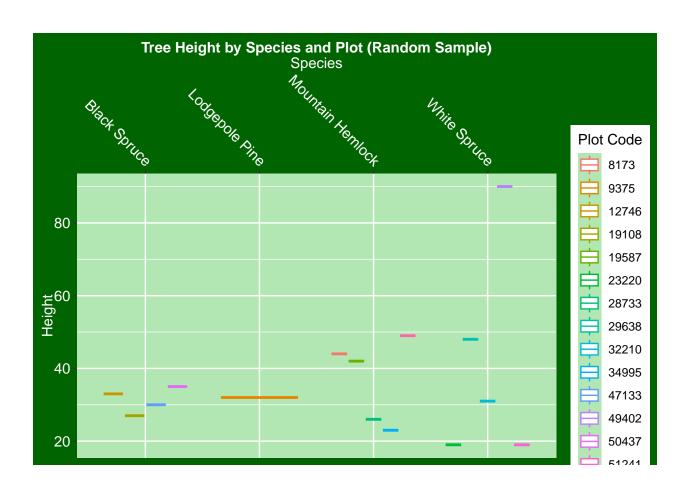
14.898886 14.115947 15.681825 3.501914e-09

Mountain Hemlock-Lodgepole Pine 7.063093 5.847069 8.279118 8.252223e-09

Mountain Hemlock-Black Spruce

```
7.835792 7.027957 8.643627 0.000000e+00
## Lodgepole Pine-Black Spruce
## White Spruce-Lodgepole Pine...5 9.442757 8.289179 10.596335 8.369286e-09
## White Spruce-Lodgepole Pine...6 9.442757 8.289179 10.596335 8.369286e-09
##
                                                          Comparison
## White Spruce-Lodgepole Pine...1
                                      White Spruce vs Lodgepole Pine
## Mountain Hemlock-Lodgepole Pine Lodgepole Pine vs Mountain Hemlock
## Mountain Hemlock-Black Spruce
                                    Black Spruce vs Mountain Hemlock
## Lodgepole Pine-Black Spruce
                                      Black Spruce vs Lodgepole Pine
## White Spruce-Lodgepole Pine...5
                                        White Spruce vs Black Spruce
## White Spruce-Lodgepole Pine...6
                                        White Spruce vs Black Spruce
```

Visualizing Interactions with Plot Differences



Dataset Information

Data was collected using both remote sensing and ground sampling. Remote sensing was used to group the trees into classes based on similar strata, and used stratum weight as well as known total area to estimate population totals. Ground sampling was done via plots to cover a one-acre sample area, with those plots either being new or re-measurements of old plots. Among the variables measured were tree diameter, height, and species, all three being very important to our research questions and subsequent analysis.

Once we downloaded the dataset, our process of data wrangling involved differentiating the trees by species. We placed a special emphasis on this due to how the dataset only provides species codes, not the the names of the species themselves. Therefore, we filtered for the four most common species, changing their codes into their species names in a new separate column. We also turned everything in this species column to a factor in order to for it to fit in the analysis.

Item Name	Value
INVYR	Year of inventory
SPCD	Species code
DIA	Diameter at breast height (in)
HT	Total height (ft)
AGEDIA	Tree age at diameter (years)
METHOD	Method for determining site index (1:collected
	this inventory 2:collected last inventory
	3:estimated 4:height-intercept method this
	inventory)
SITREE_FVS	Site index of tree (height that tree is expected to
	attain at reference age)
$SIBASE_FVS$	Site index base age (Set in years to the closest
	rotation/culmination year of mean annual
	increment)

Exploratory Analysis

graphs for variables of interest, maps, basic stuff people might want to know about the data

Correlation between Height and Diameter taking Species of Interest and Plot ID into Account

```
#Linear regression to see correlation between HT and DIA taking into account
#four species and plot ID
PlotandSpecies.model <- lm(HT ~ DIA + Species + PLOT, data = Species.wanted)
summary(PlotandSpecies.model)</pre>
```

```
##
## Call:
## lm(formula = HT ~ DIA + Species + PLOT, data = Species.wanted)
##
## Residuals:
##
      Min
                1Q Median
                                3Q
                                       Max
                             2.497
## -52.706 -2.531
                    0.000
                                    28.483
##
## Coefficients:
##
                            Estimate Std. Error t value Pr(>|t|)
## (Intercept)
                            30.74614
                                        3.12699
                                                  9.833 < 2e-16 ***
## DIA
                             2.80759
                                        0.03073 91.370
                                                         < 2e-16 ***
## SpeciesLodgepole Pine
                            -3.27957
                                        1.35069
                                                -2.428 0.015206 *
## SpeciesMountain Hemlock -1.19838
                                        1.18682
                                                -1.010 0.312657
## SpeciesWhite Spruce
                             7.49339
                                        0.48891
                                                15.327 < 2e-16 ***
## PLOT18
                           -21.84715
                                        4.38616
                                                -4.981 6.49e-07 ***
## PLOT26
                                        3.93024 -2.062 0.039271 *
                            -8.10317
## PLOT33
                           -17.56976
                                        3.98395 -4.410 1.05e-05 ***
## PLOT69
                                        6.29244
                            -3.50780
                                                -0.557 0.577230
                                        4.36308 -4.984 6.40e-07 ***
## PLOT107
                           -21.74433
## PLOT120
                           -21.18157
                                        4.38457 -4.831 1.39e-06 ***
## PLOT171
                           -16.88215
                                        3.98284 -4.239 2.28e-05 ***
## PLOT216
                           -36.55902
                                        4.00117 -9.137 < 2e-16 ***
                           -10.11582
## PLOT229
                                        4.99431 -2.025 0.042859 *
## PLOT256
                                        3.98274 -5.478 4.46e-08 ***
                           -21.81692
## PLOT281
                             1.99835
                                        3.72939
                                                 0.536 0.592089
## PLOT341
                           -30.41209
                                        4.36045 -6.975 3.37e-12 ***
## PLOT362
                           -21.62531
                                        4.22250 -5.121 3.12e-07 ***
## PLOT407
                           -2.26803
                                        3.78148 -0.600 0.548678
## PLOT412
                                        4.36033 -5.969 2.51e-09 ***
                           -26.02618
## PLOT469
                           -18.67211
                                        4.49476
                                                -4.154 3.31e-05 ***
## PLOT496
                                        6.26815
                                                  1.898 0.057747 .
                           11.89662
## PLOT545
                           -15.89143
                                        6.18084
                                                -2.571 0.010160 *
## PLOT554
                           -22.06232
                                        3.78452
                                                -5.830 5.82e-09 ***
## PLOT561
                           -23.34067
                                        3.84306
                                                -6.073 1.32e-09 ***
## PLOT630
                           -14.73043
                                        6.18225
                                                -2.383 0.017214 *
## PLOT662
                           -16.04697
                                        4.38467 -3.660 0.000254 ***
## PLOT734
                           -20.84715
                                        4.38616 -4.753 2.05e-06 ***
## PLOT759
                           -21.49840
                                        3.55784 -6.043 1.60e-09 ***
```

```
## PLOT810
                            -22.00829
                                         4.36107 -5.047 4.62e-07 ***
## PLOT844
                                                  -5.128 3.01e-07 ***
                            -19.39674
                                         3.78250
## PLOT848
                            -9.34924
                                         4.49380
                                                   -2.080 0.037520 *
## PLOT864
                            -25.34119
                                         3.77381
                                                   -6.715 2.04e-11 ***
## PLOT937
                            -26.71815
                                         4.35769
                                                   -6.131 9.22e-10 ***
## PLOT940
                                                  -1.054 0.292107
                            -4.26726
                                         4.05019
## PLOT942
                            -24.43433
                                         4.49498
                                                  -5.436 5.65e-08 ***
## PLOT945
                            -6.24679
                                         3.80416
                                                   -1.642 0.100618
## PLOT965
                            -9.66034
                                         4.35733
                                                   -2.217 0.026655 *
## PLOT1000
                            -16.44808
                                         4.36160
                                                  -3.771 0.000164 ***
## PLOT1011
                            -19.80432
                                         3.77626
                                                   -5.244 1.62e-07 ***
## PLOT1030
                              0.46742
                                         3.89667
                                                   0.120 0.904523
## PLOT1031
                             -2.81609
                                         6.25933
                                                  -0.450 0.652796
                                                   -3.748 0.000180 ***
## PLOT1032
                            -23.16892
                                         6.18239
## PLOT1060
                            -21.14916
                                         4.54026
                                                   -4.658 3.25e-06 ***
## PLOT1079
                            -28.63918
                                         4.36276
                                                   -6.564 5.62e-11 ***
## PLOT1088
                            -1.85077
                                         4.99413
                                                   -0.371 0.710955
## PLOT1162
                            -15.99440
                                         4.38461
                                                   -3.648 0.000266 ***
## PLOT1171
                                                   -0.915 0.360203
                            -5.72774
                                         6.25953
## PLOT1173
                            -16.83275
                                         3.55866
                                                   -4.730 2.29e-06 ***
## PLOT1201
                            -27.44283
                                         3.93038
                                                  -6.982 3.19e-12 ***
## PLOT1216
                            -23.02908
                                                  -5.252 1.55e-07 ***
                                         4.38511
## PLOT1227
                                                    1.846 0.064935 .
                              8.04516
                                         4.35812
## PLOT1295
                            -23.36584
                                         6.16364
                                                   -3.791 0.000151 ***
## PLOT1382
                            -25.01242
                                         4.22204
                                                  -5.924 3.30e-09 ***
## PLOT1397
                            -27.81609
                                         6.25933
                                                   -4.444 8.98e-06 ***
## PLOT1418
                            -22.17343
                                         6.16303
                                                   -3.598 0.000323 ***
## PLOT1472
                            -26.85601
                                         4.49429
                                                   -5.976 2.41e-09 ***
## PLOT1490
                                                  -4.277 1.92e-05 ***
                            -18.65184
                                         4.36049
## PLOT1508
                            -17.57219
                                         3.93089
                                                  -4.470 7.94e-06 ***
## PLOT1525
                            -8.27661
                                         3.77467
                                                   -2.193 0.028366 *
## PLOT1528
                            -13.65968
                                         3.59048
                                                   -3.804 0.000143 ***
## PLOT1529
                            -26.85161
                                         4.08054
                                                   -6.580 5.05e-11 ***
                                                   -3.944 8.08e-05 ***
## PLOT1543
                            -16.00442
                                         4.05754
## PLOT1549
                            -20.01119
                                         6.18219
                                                   -3.237 0.001214 **
## PLOT1604
                                         3.93024
                                                  -0.917 0.358941
                             -3.60579
## PLOT1699
                            -6.89557
                                         4.38405
                                                  -1.573 0.115795
## PLOT1720
                            -15.94182
                                                  -2.579 0.009930 **
                                         6.18141
## PLOT1735
                            -18.33297
                                         4.38542
                                                   -4.180 2.95e-05 ***
## PLOT1739
                                                  -4.957 7.34e-07 ***
                            -21.73676
                                         4.38501
## PLOT1768
                            -17.58879
                                         4.35839
                                                   -4.036 5.51e-05 ***
## PLOT1833
                            -24.39114
                                         4.35740
                                                  -5.598 2.26e-08 ***
## PLOT1893
                            -21.77507
                                         4.49374
                                                   -4.846 1.29e-06 ***
## PLOT1968
                                         4.87343
                                                  -5.673 1.46e-08 ***
                            -27.64660
## PLOT2190
                            -29.36911
                                         6.16220
                                                   -4.766 1.92e-06 ***
## PLOT2261
                                                   -5.197 2.08e-07 ***
                            -18.49069
                                         3.55780
## PLOT2368
                            -14.32612
                                         4.49393
                                                   -3.188 0.001440 **
## PLOT2374
                            -26.69285
                                         4.36033
                                                   -6.122 9.79e-10 ***
## PLOT2414
                            -21.71887
                                         4.38551
                                                   -4.952 7.51e-07 ***
## PLOT2418
                            -22.25094
                                         4.38566
                                                   -5.074 4.01e-07 ***
## PLOT2428
                            -21.25753
                                         3.77627
                                                   -5.629 1.88e-08 ***
## PLOT2476
                            -6.13423
                                         6.18194
                                                  -0.992 0.321096
## PLOT2504
                            -27.06631
                                         4.49452
                                                  -6.022 1.81e-09 ***
## PLOT2516
                              8.21380
                                         3.93154
                                                    2.089 0.036727 *
```

```
## PLOT2583
                            -4.26416
                                          4.49706
                                                  -0.948 0.343056
## PLOT2630
                            -19.20360
                                         6.18292
                                                   -3.106 0.001905 **
## PLOT2677
                            -28.98102
                                          4.35793
                                                   -6.650 3.16e-11 ***
## PLOT2682
                            -27.50259
                                         5.00489
                                                   -5.495 4.05e-08 ***
## PLOT2692
                            -11.89557
                                         4.38405
                                                   -2.713 0.006677 **
## PLOT2699
                            -19.88635
                                         4.35938
                                                   -4.562 5.16e-06 ***
## PLOT2757
                            -20.03926
                                         3.77656
                                                   -5.306 1.16e-07 ***
## PLOT2760
                            -19.46865
                                         4.89556
                                                   -3.977 7.06e-05 ***
## PLOT2771
                            -11.99668
                                         6.29315
                                                   -1.906 0.056654 .
## PLOT2775
                            -18.08736
                                          4.22173
                                                   -4.284 1.86e-05 ***
## PLOT2778
                            -12.59861
                                         3.55897
                                                   -3.540 0.000403 ***
## PLOT2846
                            -21.93280
                                         3.93037
                                                   -5.580 2.50e-08 ***
## PLOT2892
                            -18.37921
                                         4.38633
                                                   -4.190 2.82e-05 ***
## PLOT2896
                              0.56315
                                          4.07692
                                                    0.138 0.890140
## PLOT2913
                            -27.98735
                                         4.35756
                                                   -6.423 1.43e-10 ***
## PLOT2917
                            -19.92212
                                          3.77480
                                                   -5.278 1.35e-07 ***
## PLOT2921
                                         4.35996
                                                    0.450 0.652715
                              1.96205
## PLOT2942
                            -15.16949
                                          4.49515
                                                   -3.375 0.000743 ***
## PLOT2943
                            -9.72971
                                          4.35779
                                                   -2.233 0.025601 *
## PLOT2972
                             -7.80367
                                         3.55848
                                                   -2.193 0.028344 *
## PLOT3006
                            -23.07787
                                         6.26000
                                                   -3.687 0.000229 ***
## PLOT3007
                                                   -3.651 0.000263 ***
                            -13.44900
                                         3.68365
## PLOT3019
                            -10.88979
                                          4.89550
                                                   -2.224 0.026152 *
## PLOT3025
                            -26.15724
                                          3.84300
                                                   -6.806 1.09e-11 ***
## PLOT3094
                            -9.18858
                                          3.39762
                                                  -2.704 0.006860 **
## PLOT3104
                            -8.23152
                                          3.80470
                                                   -2.164 0.030538 *
## PLOT3125
                            -9.95810
                                                   -1.591 0.111695
                                          6.25967
## PLOT3139
                            -8.70047
                                          3.93057
                                                   -2.214 0.026895 *
## PLOT3151
                            -31.92839
                                         3.98271
                                                   -8.017 1.27e-15 ***
## PLOT3176
                                          3.93308
                                                   -1.318 0.187468
                            -5.18476
## PLOT3213
                            -16.39928
                                          6.18080
                                                   -2.653 0.007991 **
## PLOT3310
                            -25.81218
                                         4.08043
                                                   -6.326 2.68e-10 ***
## PLOT3351
                            -10.34562
                                          4.89573
                                                   -2.113 0.034622 *
                            -28.98428
## PLOT3415
                                          4.49468
                                                   -6.449 1.21e-10 ***
## PLOT3436
                             -9.52123
                                          3.80447
                                                   -2.503 0.012351 *
                                                   -6.467 1.07e-10 ***
## PLOT3452
                            -23.82732
                                         3.68453
## PLOT3462
                            -24.88002
                                          4.36026
                                                   -5.706 1.21e-08 ***
## PLOT3476
                            -18.69166
                                                   -5.072 4.04e-07 ***
                                         3.68513
## PLOT3477
                                          3.78271
                                                   -4.105 4.09e-05 ***
                            -15.52818
                                                   -3.213 0.001321 **
## PLOT3567
                            -14.47140
                                         4.50447
## PLOT3590
                            -25.54663
                                          4.54044
                                                   -5.626 1.91e-08 ***
## PLOT3601
                                         4.35836
                                                   -5.809 6.58e-09 ***
                            -25.31762
## PLOT3629
                            -17.22782
                                         4.38525
                                                   -3.929 8.63e-05 ***
## PLOT3641
                                                  -1.527 0.126730
                            -6.93363
                                          4.53974
## PLOT3653
                            -12.04814
                                         3.78360
                                                   -3.184 0.001458 **
                                                   -1.523 0.127702
## PLOT3711
                             -6.63831
                                          4.35751
## PLOT3725
                            -9.48364
                                         4.35825
                                                   -2.176 0.029589 *
## PLOT3765
                            -22.24280
                                          6.16393
                                                   -3.609 0.000310 ***
## PLOT3785
                            -20.15772
                                          4.35726
                                                   -4.626 3.79e-06 ***
## PLOT3788
                            -28.59791
                                          4.51434
                                                   -6.335 2.53e-10 ***
## PLOT3805
                            -21.71706
                                          4.35890
                                                   -4.982 6.45e-07 ***
## PLOT3842
                            -8.42168
                                          4.35739
                                                  -1.933 0.053311 .
## PLOT3875
                            -27.90641
                                         3.77349
                                                  -7.395 1.58e-13 ***
## PLOT3947
                            -12.58355
                                         4.35776 -2.888 0.003894 **
```

```
## PLOT4116
                             -7.90265
                                          3.71394 -2.128 0.033388 *
## PLOT4160
                            -14.97075
                                          3.93206
                                                   -3.807 0.000142 ***
## PLOT4241
                            -20.20812
                                          4.87327
                                                   -4.147 3.41e-05 ***
## PLOT4247
                              0.62565
                                          4.35726
                                                    0.144 0.885829
## PLOT4251
                            -15.02385
                                          4.38438
                                                   -3.427 0.000615 ***
## PLOT4272
                            -11.74162
                                          3.51303
                                                   -3.342 0.000835 ***
## PLOT4277
                            -19.72411
                                          4.38659
                                                   -4.496 7.03e-06 ***
## PLOT4324
                            -28.06828
                                          4.35843
                                                   -6.440 1.28e-10 ***
## PLOT4332
                            -18.99524
                                          4.22514
                                                   -4.496 7.05e-06 ***
## PLOT4334
                            -20.78301
                                          4.38582
                                                   -4.739 2.20e-06 ***
## PLOT4395
                             -2.10733
                                          4.87281
                                                   -0.432 0.665417
                                                   -6.076 1.30e-09 ***
## PLOT4452
                            -27.31129
                                          4.49530
## PLOT4458
                            -11.75388
                                          3.47844
                                                   -3.379 0.000732 ***
## PLOT4494
                                                   -5.047 4.61e-07 ***
                            -19.20469
                                          3.80536
## PLOT4534
                                          4.38474
                                                   -3.520 0.000435 ***
                            -15.43288
## PLOT4561
                            -20.27169
                                          3.68342
                                                   -5.503 3.86e-08 ***
## PLOT4647
                            -20.49069
                                          4.38569
                                                   -4.672 3.04e-06 ***
## PLOT4659
                            -14.02992
                                          4.22429
                                                   -3.321 0.000901 ***
                                          3.73956
                                                   -0.701 0.483209
## PLOT4675
                            -2.62214
## PLOT4787
                            -15.53622
                                          4.35832
                                                   -3.565 0.000367 ***
## PLOT4792
                            -25.36495
                                          4.49415
                                                   -5.644 1.73e-08 ***
## PLOT4839
                                          6.25931
                                                   -0.904 0.366032
                             -5.65836
                                                   -3.072 0.002138 **
## PLOT4855
                            -11.61653
                                          3.78189
## PLOT4865
                              0.23794
                                          4.38364
                                                    0.054 0.956715
## PLOT4945
                            -16.78991
                                          4.49597
                                                   -3.734 0.000190 ***
## PLOT5034
                            -26.84969
                                          4.35825
                                                   -6.161 7.67e-10 ***
## PLOT5113
                            -22.23757
                                                   -5.102 3.46e-07 ***
                                          4.35885
                                                   -1.792 0.073174 .
## PLOT5148
                            -11.27744
                                          6.29310
                                                   -2.661 0.007803 **
## PLOT5193
                            -11.66739
                                          4.38414
## PLOT5252
                            -20.65925
                                          4.35806
                                                   -4.740 2.18e-06 ***
## PLOT5326
                            -14.64191
                                          3.77420
                                                   -3.879 0.000106 ***
## PLOT5363
                            -29.54249
                                          6.29238
                                                   -4.695 2.72e-06 ***
## PLOT5431
                            -20.47672
                                          3.98334
                                                   -5.141 2.82e-07 ***
## PLOT5439
                            -24.74280
                                          3.77650
                                                   -6.552 6.11e-11 ***
## PLOT5465
                            -19.21859
                                          3.77851
                                                   -5.086 3.75e-07 ***
## PLOT5556
                            -22.24831
                                          4.27028
                                                   -5.210 1.95e-07 ***
## PLOT5574
                            -21.56877
                                          3.98271
                                                   -5.416 6.32e-08 ***
## PLOT5578
                                                   -4.713 2.49e-06 ***
                            -18.52377
                                          3.93026
## PLOT5589
                                                   -3.156 0.001606 **
                            -10.90590
                                          3.45553
## PLOT5612
                            -16.78933
                                          4.38509
                                                   -3.829 0.000130 ***
                                                   -7.039 2.14e-12 ***
## PLOT5701
                            -27.67407
                                          3.93175
## PLOT5737
                                                   -3.762 0.000170 ***
                            -13.80029
                                          3.66848
## PLOT5817
                             -1.07481
                                          3.93062
                                                   -0.273 0.784519
## PLOT5861
                                                   -5.945 2.91e-09 ***
                            -25.90532
                                          4.35766
## PLOT5900
                            -16.52465
                                          4.35817
                                                   -3.792 0.000151 ***
                                                   -0.734 0.462796
## PLOT5955
                             -2.57978
                                          3.51328
                                          4.35729
## PLOT5961
                              1.25763
                                                    0.289 0.772875
## PLOT5965
                            -18.55116
                                          3.68151
                                                   -5.039 4.80e-07 ***
## PLOT6000
                            -22.24100
                                          3.65557
                                                   -6.084 1.24e-09 ***
## PLOT6030
                            -26.22403
                                          3.93140
                                                   -6.670 2.76e-11 ***
## PLOT6034
                            -11.47381
                                          4.99404
                                                   -2.298 0.021621 *
## PLOT6060
                            -19.37915
                                          3.56112
                                                   -5.442 5.46e-08 ***
## PLOT6089
                            -18.01752
                                          4.38493
                                                   -4.109 4.02e-05 ***
## PLOT6090
                             -1.00109
                                          4.35765
                                                  -0.230 0.818307
```

```
## PLOT6107
                            -21.42655
                                         4.38539
                                                   -4.886 1.05e-06 ***
## PLOT6109
                            -14.97651
                                         4.38504
                                                   -3.415 0.000641 ***
## PLOT6193
                            -13.74498
                                          4.09328
                                                   -3.358 0.000790 ***
## PLOT6222
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## PLOT6233
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                                                   -3.752 0.000177 ***
## PLOT6244
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                                                   -4.408 1.06e-05 ***
## PLOT6249
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## PLOT6300
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## PLOT6335
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                                                   -4.898 9.92e-07 ***
## PLOT6376
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## PLOT6380
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                                          3.78312
                                                   -4.444 8.98e-06 ***
## PLOT6385
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                                         3.72502
                                                   -7.245 4.83e-13 ***
## PLOT6461
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## PLOT6483
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## PLOT6625
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## PLOT6665
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## PLOT6670
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## PLOT6701
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## PLOT6738
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                                          4.38517
                                                   -5.285 1.30e-07 ***
## PLOT6765
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                                                   -5.527 3.38e-08 ***
## PLOT6793
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## PLOT6924
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## PLOT6968
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## PLOT6976
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                                                   -2.473 0.013412 *
## PLOT6978
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                                          4.38528
                                                   -4.743 2.15e-06 ***
## PLOT7028
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                                         4.35758
                                                   -2.861 0.004237 **
## PLOT7042
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                                                   -4.736 2.23e-06 ***
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## PLOT7086
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                                                   -2.915 0.003573 **
                                                   -5.001 5.85e-07 ***
## PLOT7088
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## PLOT7148
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## PLOT7178
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                                                   -3.853 0.000118 ***
## PLOT7196
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## PLOT7245
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## PLOT7274
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                                                    1.366 0.171988
## PLOT7495
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                                                   -2.777 0.005497 **
## PLOT7514
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## PLOT7517
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## PLOT7574
                                                   -5.933 3.13e-09 ***
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## PLOT7578
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                                                   -3.259 0.001125 **
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## PLOT7599
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                                         4.38381
## PLOT7612
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                                         6.18206
                                                   -3.328 0.000880 ***
## PLOT7686
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                            -26.38808
## PLOT7720
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                                                   -5.151 2.67e-07 ***
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                                                   -3.927 8.68e-05 ***
## PLOT7725
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## PLOT7802
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## PLOT7841
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## PLOT7849
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## PLOT7869
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## PLOT7885
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## PLOT7968
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## PLOT8024
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## PLOT8060
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                                         4.49435
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## PLOT8087
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## PLOT8105
                            -20.51413
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                                                  -4.519 6.33e-06 ***
```

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## PLOT8173
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                            -14.77202
## PLOT8175
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## PLOT8219
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## PLOT8266
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                                                   -3.214 0.001316 **
## PLOT8291
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## PLOT8297
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## PLOT8299
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## PLOT8321
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## PLOT8329
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## PLOT8382
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## PLOT8394
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## PLOT8428
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## PLOT8434
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## PLOT8473
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## PLOT8623
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## PLOT8663
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## PLOT8736
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## PLOT8752
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## PLOT8809
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## PLOT8816
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## PLOT8825
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## PLOT8919
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## PLOT8940
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## PLOT9086
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## PLOT9168
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## PLOT9220
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## PLOT9231
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## PLOT9287
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## PLOT9290
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## PLOT9322
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## PLOT9348
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## PLOT9476
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## PLOT9547
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## PLOT9633
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## PLOT9641
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## PLOT9665
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## PLOT9703
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## PLOT9825
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## PLOT9855
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## PLOT9910
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## PLOT9938
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## PLOT9956
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## PLOT9999
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## PLOT10006
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## PLOT10062
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## PLOT10350
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## PLOT10399
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## PLOT10483
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## PLOT10494
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## PLOT10545
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## PLOT10547
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## PLOT10631
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## PLOT10655
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## PLOT10658
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## PLOT10662
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## PLOT10726
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## PLOT10727
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## PLOT10729
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## PLOT10733
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## PLOT10781
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## PLOT10789
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## PLOT10928
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## PLOT10929
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## PLOT10944
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## PLOT10963
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## PLOT10979
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## PLOT10993
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## PLOT11039
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## PLOT11052
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## PLOT11087
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## PLOT11166
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## PLOT11229
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## PLOT11234
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## PLOT11261
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## PLOT11265
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## PLOT11282
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## PLOT11300
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## PLOT11303
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## PLOT11332
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## PLOT11374
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## PLOT11400
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## PLOT11420
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## PLOT11439
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## PLOT11453
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## PLOT11454
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## PLOT11477
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## PLOT11520
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## PLOT11530
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## PLOT11637
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## PLOT11681
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## PLOT11744
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## PLOT11946
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## PLOT11998
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## PLOT12000
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## PLOT12043
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## PLOT12552
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## PLOT12603
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## PLOT12734
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## PLOT12746
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## PLOT12992
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## PLOT13082
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## PLOT13133
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## PLOT13194
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## PLOT13466
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## PLOT13880
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## PLOT13914
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## PLOT13933
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## PLOT13949
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                                          4.38509 -3.145 0.001671 **
```

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## PLOT13964
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## PLOT13973
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## PLOT14058
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                                          3.93437
                            -16.85347
## PLOT14072
                                                   -3.843 0.000123 ***
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## PLOT14100
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## PLOT14108
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## PLOT14131
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## PLOT14138
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## PLOT14200
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## PLOT14278
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## PLOT14331
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## PLOT14337
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## PLOT14352
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## PLOT14360
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## PLOT14389
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## PLOT14424
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## PLOT14474
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## PLOT14499
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## PLOT14509
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## PLOT14515
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## PLOT14517
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## PLOT14540
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                                                   -6.390 1.78e-10 ***
## PLOT14607
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## PLOT14614
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                                                   -4.418 1.01e-05 ***
## PLOT14700
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                                                   -1.748 0.080570 .
## PLOT14710
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## PLOT14756
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                                                   -3.192 0.001418 **
## PLOT14765
                            -23.38196
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## PLOT14773
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## PLOT14775
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## PLOT14790
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## PLOT14811
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## PLOT14832
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## PLOT14885
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## PLOT14889
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## PLOT14935
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## PLOT14951
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## PLOT14983
                            -22.02727
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## PLOT14991
                                                   -4.154 3.31e-05 ***
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## PLOT14992
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## PLOT15047
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## PLOT15137
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## PLOT15201
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                                                   -3.513 0.000446 ***
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## PLOT15282
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## PLOT15335
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## PLOT15337
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## PLOT15343
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## PLOT15363
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## PLOT15401
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## PLOT15528
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                                                   -4.648 3.42e-06 ***
## PLOT15536
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## PLOT15588
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```

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## PLOT15613
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## PLOT15625
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## PLOT15725
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## PLOT15773
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## PLOT15793
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## PLOT15817
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## PLOT15864
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## PLOT15977
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## PLOT15993
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## PLOT16062
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## PLOT16115
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## PLOT16258
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## PLOT16262
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## PLOT16284
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## PLOT16476
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## PLOT16590
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## PLOT16622
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## PLOT17076
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## PLOT17288
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## PLOT17355
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## PLOT17365
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## PLOT17382
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## PLOT17383
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## PLOT17400
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## PLOT17415
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## PLOT17475
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## PLOT17476
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## PLOT17488
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## PLOT17508
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## PLOT17535
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## PLOT17596
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## PLOT17601
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## PLOT17743
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## PLOT17811
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## PLOT17854
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## PLOT17931
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## PLOT17940
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## PLOT17958
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## PLOT18000
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## PLOT18005
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## PLOT18009
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## PLOT18038
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## PLOT18063
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## PLOT18111
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## PLOT18183
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## PLOT18188
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## PLOT18200
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## PLOT18233
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## PLOT18340
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## PLOT18342
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## PLOT18389
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## PLOT18397
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## PLOT18409
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## PLOT18480
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## PLOT18580
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## PLOT18650
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## PLOT18715
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## PLOT18718
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## PLOT18720
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## PLOT18839
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## PLOT18913
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## PLOT18918
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## PLOT18945
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## PLOT18955
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## PLOT19021
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## PLOT19051
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```

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## PLOT19252
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## PLOT19279
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## PLOT19339
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## PLOT19388
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## PLOT19511
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## PLOT19580
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## PLOT19587
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## PLOT19713
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## PLOT19760
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## PLOT19764
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## PLOT19960
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## PLOT19972
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## PLOT20061
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## PLOT20760
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## PLOT20779
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## PLOT20816
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## PLOT20824
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## PLOT20836
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                                          4.38496
                                                   -5.000 5.89e-07 ***
                                                   -5.214 1.91e-07 ***
## PLOT20873
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## PLOT20921
                                          4.35905
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## PLOT20951
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                                                   -3.593 0.000329 ***
## PLOT20962
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                                                   -3.082 0.002067 **
## PLOT21015
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                                                   -2.125 0.033648 *
## PLOT21138
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                                                   -3.255 0.001138 **
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## PLOT21166
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                                                  -2.937 0.003321 **
## PLOT21167
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                                                  -4.123 3.79e-05 ***
## PLOT21187
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                                          4.35871 -1.997 0.045837 *
```

```
## PLOT21205
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                                                  -3.514 0.000445 ***
## PLOT21278
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                                         4.38467
                                                  -4.344 1.42e-05 ***
                                                  -4.304 1.70e-05 ***
## PLOT21296
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## PLOT21379
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                            -19.73215
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## PLOT21501
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                                         3.77521
                                                  -2.575 0.010044 *
## PLOT21521
                                                  -7.149 9.65e-13 ***
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## PLOT21540
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                                         4.38536
                                                  -4.299 1.74e-05 ***
## PLOT21562
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                                                  -7.177 7.89e-13 ***
## PLOT21564
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                                         4.35748
                                                  -2.366 0.018018 *
## PLOT21576
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## PLOT21597
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## PLOT21637
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## PLOT21641
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## PLOT21645
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## PLOT21646
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## PLOT21657
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                                                   -4.087 4.42e-05 ***
## PLOT21683
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                                                  -3.707 0.000212 ***
## PLOT21702
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                                                  -3.577 0.000349 ***
                                                  -2.303 0.021312 *
## PLOT21743
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## PLOT21763
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## PLOT21764
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## PLOT21788
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## PLOT21793
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## PLOT21818
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## PLOT21872
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## PLOT21884
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## PLOT21908
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## PLOT22038
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## PLOT22113
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## PLOT22242
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## PLOT22290
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## PLOT22291
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## PLOT22296
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                                                  -4.505 6.75e-06 ***
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## PLOT22303
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## PLOT22346
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                                                  -1.289 0.197396
## PLOT22347
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## PLOT22399
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                                                  -4.753 2.05e-06 ***
## PLOT22478
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## PLOT22493
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## PLOT22563
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## PLOT22575
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## PLOT22601
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## PLOT22604
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## PLOT22659
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## PLOT22695
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## PLOT22702
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                            -21.28293
## PLOT22704
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## PLOT22758
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## PLOT22828
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## PLOT22865
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## PLOT22904
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## PLOT22921
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## PLOT22959
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## PLOT23012
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```

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## PLOT23060
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                                          3.77475
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                                                   -3.406 0.000663 ***
## PLOT23066
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## PLOT23085
                                                   -6.733 1.80e-11 ***
                            -26.47337
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## PLOT23111
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                                          3.80462
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## PLOT23135
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                                          4.49520
                                                   -3.342 0.000836 ***
## PLOT23140
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                                                   -4.621 3.89e-06 ***
## PLOT23159
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## PLOT23187
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## PLOT23220
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## PLOT23292
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## PLOT23374
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## PLOT23384
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## PLOT23438
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## PLOT23450
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## PLOT23497
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## PLOT23561
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## PLOT23568
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## PLOT23569
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## PLOT23623
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## PLOT23680
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## PLOT23683
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## PLOT23710
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## PLOT23723
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## PLOT23730
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## PLOT23741
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## PLOT23745
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## PLOT23791
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## PLOT23796
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## PLOT23841
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## PLOT23933
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## PLOT23957
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## PLOT23983
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## PLOT24009
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## PLOT24070
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## PLOT24073
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## PLOT24092
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## PLOT24109
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## PLOT24124
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## PLOT24174
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## PLOT24238
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## PLOT24340
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## PLOT24344
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## PLOT24361
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## PLOT24400
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## PLOT24410
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## PLOT24514
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## PLOT24595
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## PLOT24603
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## PLOT24628
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## PLOT24635
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## PLOT24707
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## PLOT24755
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```

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## PLOT24764
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## PLOT24782
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## PLOT24787
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## PLOT24809
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                                                    0.297 0.766788
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## PLOT24843
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## PLOT24855
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## PLOT24869
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## PLOT24891
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## PLOT24905
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## PLOT24973
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## PLOT25021
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## PLOT25054
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## PLOT25067
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## PLOT25094
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## PLOT25104
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## PLOT25203
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## PLOT25223
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## PLOT25315
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## PLOT25346
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## PLOT25361
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## PLOT25371
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## PLOT25542
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## PLOT25563
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## PLOT25590
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## PLOT25612
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## PLOT25638
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## PLOT25684
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## PLOT25696
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## PLOT25729
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## PLOT25742
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## PLOT25828
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## PLOT25832
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## PLOT25840
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## PLOT25878
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## PLOT25880
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## PLOT25935
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## PLOT26008
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## PLOT26012
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## PLOT26015
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## PLOT26021
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## PLOT26027
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## PLOT26168
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## PLOT26246
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## PLOT26308
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## PLOT26335
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```

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## PLOT26443
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## PLOT26625
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## PLOT26628
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## PLOT26650
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## PLOT26741
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## PLOT26756
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## PLOT26769
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## PLOT26777
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## PLOT26821
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## PLOT26822
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## PLOT27228
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## PLOT27229
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## PLOT27293
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## PLOT27335
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                                                   -2.772 0.005585 **
## PLOT27385
                            -17.15212
                                          4.38481
                                                   -3.912 9.26e-05 ***
## PLOT27396
                            -11.45998
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## PLOT27402
                            -16.78882
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                                                   -4.492 7.16e-06 ***
## PLOT27403
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                                          6.29383
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## PLOT27458
                            -18.41852
                                          3.77355
                                                   -4.881 1.08e-06 ***
## PLOT27489
                                          3.93027
                                                   -3.587 0.000337 ***
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## PLOT27542
                                                   -3.465 0.000534 ***
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## PLOT27589
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## PLOT27698
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## PLOT27744
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## PLOT27794
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                                                   -5.375 7.92e-08 ***
## PLOT27806
                                                   -4.660 3.22e-06 ***
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                                          4.38560
## PLOT27828
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                                          4.49368
                                                   -6.011 1.95e-09 ***
                                                   -4.140 3.51e-05 ***
## PLOT27856
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## PLOT27913
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                                                   -3.379 0.000733 ***
## PLOT27916
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                                                   -3.787 0.000154 ***
                                          4.35799
## PLOT27923
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## PLOT27963
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                                          6.26036
                                                   -4.011 6.10e-05 ***
## PLOT28052
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                                                   -5.016 5.42e-07 ***
## PLOT28056
                            -16.17524
                                          4.38517
                                                   -3.689 0.000227 ***
## PLOT28072
                            -17.11111
                                          4.38491
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## PLOT28100
                            -14.62457
                                          4.35770 -3.356 0.000795 ***
```

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                                                  -1.253 0.210091
## PLOT28193
                            -26.50459
                                         4.36302
                                                  -6.075 1.31e-09 ***
## PLOT28194
                            -20.59837
                                          4.49462
                                                   -4.583 4.67e-06 ***
## PLOT28204
                            -25.21444
                                          4.35848
                                                   -5.785 7.58e-09 ***
## PLOT28230
                             -7.92357
                                         3.78185
                                                   -2.095 0.036195 *
## PLOT28283
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## PLOT28373
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## PLOT28384
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## PLOT28402
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                                                   -4.101 4.16e-05 ***
## PLOT28421
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## PLOT28457
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                                                   -2.843 0.004484 **
                                                   -4.468 8.03e-06 ***
## PLOT28466
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## PLOT28549
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## PLOT28553
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                                          3.77883
                                                   -2.260 0.023847 *
## PLOT28574
                                                   -3.352 0.000806 ***
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## PLOT28644
                            -15.89267
                                          6.16308
                                                   -2.579 0.009939 **
                                                   -3.522 0.000432 ***
## PLOT28666
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## PLOT28733
                            -28.45208
                                          3.68089
                                                   -7.730 1.24e-14 ***
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## PLOT28766
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## PLOT28787
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## PLOT28800
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## PLOT28878
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## PLOT28900
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## PLOT28975
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## PLOT28979
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## PLOT28982
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## PLOT28991
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## PLOT29052
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## PLOT29071
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## PLOT29170
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## PLOT29194
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## PLOT29259
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## PLOT29283
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## PLOT29341
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## PLOT29359
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## PLOT29394
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## PLOT29407
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## PLOT29430
                                                   -2.013 0.044189 *
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## PLOT29480
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## PLOT29501
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                                          4.99553
                                                    0.970 0.331864
## PLOT29506
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## PLOT29546
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                                                   -2.843 0.004477 **
## PLOT29559
                                                  -2.644 0.008203 **
                            -16.34562
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## PLOT29638
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                                                   -5.216 1.89e-07 ***
                                                   -2.899 0.003751 **
## PLOT29644
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## PLOT29687
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## PLOT29722
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## PLOT29815
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## PLOT29959
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## PLOT30003
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## PLOT30065
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## PLOT30073
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```

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## PLOT30121
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## PLOT30148
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## PLOT30158
                            -20.42655
                                          4.38539
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## PLOT30178
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## PLOT30223
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## PLOT30294
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## PLOT30297
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## PLOT30313
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## PLOT30348
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## PLOT30425
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## PLOT30491
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## PLOT30504
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## PLOT30594
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## PLOT30723
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## PLOT30724
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## PLOT30809
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## PLOT30853
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## PLOT30906
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## PLOT30943
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## PLOT30957
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## PLOT30980
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## PLOT31021
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## PLOT31034
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## PLOT31052
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## PLOT31056
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## PLOT31060
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## PLOT31063
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## PLOT31065
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## PLOT31121
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## PLOT31154
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## PLOT31178
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## PLOT31201
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## PLOT31221
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## PLOT31236
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## PLOT31279
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## PLOT31286
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## PLOT31291
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## PLOT31304
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## PLOT31336
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## PLOT31346
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## PLOT31350
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## PLOT31390
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## PLOT31412
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## PLOT31415
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## PLOT31458
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                                                  -2.279 0.022692 *
```

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## PLOT31486
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## PLOT31509
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## PLOT31531
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## PLOT31533
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## PLOT31633
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## PLOT31648
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## PLOT31666
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## PLOT31679
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## PLOT31713
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## PLOT31714
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## PLOT31730
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## PLOT31749
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## PLOT31760
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## PLOT31775
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## PLOT31814
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## PLOT31815
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## PLOT31868
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## PLOT31897
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## PLOT31947
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## PLOT31982
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## PLOT32028
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                                                   -3.125 0.001787 **
## PLOT32042
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## PLOT32051
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## PLOT32055
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## PLOT32083
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## PLOT32106
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## PLOT32119
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## PLOT32136
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## PLOT32194
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## PLOT32210
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## PLOT32252
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## PLOT32346
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## PLOT32368
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## PLOT32377
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## PLOT32396
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## PLOT32424
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## PLOT32432
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## PLOT32443
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## PLOT32538
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## PLOT32594
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## PLOT32600
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## PLOT32734
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## PLOT32978
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```

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## PLOT33111
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## PLOT33354
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## PLOT33488
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## PLOT33497
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## PLOT33508
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## PLOT33650
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## PLOT33780
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## PLOT33784
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## PLOT33868
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## PLOT33896
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## PLOT33955
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## PLOT33985
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## PLOT34161
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## PLOT34181
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                                                   -7.181 7.69e-13 ***
## PLOT34200
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## PLOT34238
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                                                   -2.562 0.010443 *
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## PLOT34240
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                                         6.29274
                                                   -5.531 3.31e-08 ***
## PLOT34256
                            -27.63918
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## PLOT34258
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                                                   -2.712 0.006710 **
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## PLOT34279
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## PLOT34282
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                                         3.84456
                                                   -2.446 0.014485 *
## PLOT34330
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                                          4.38539
                                                   -4.050 5.19e-05 ***
## PLOT34417
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                                                   -4.282 1.88e-05 ***
## PLOT34427
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## PLOT34515
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## PLOT34572
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## PLOT34581
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                                                  -4.809 1.55e-06 ***
## PLOT34596
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                                                   -4.552 5.40e-06 ***
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## PLOT34606
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## PLOT34723
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## PLOT34725
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## PLOT34752
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                                                   -4.741 2.17e-06 ***
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## PLOT34803
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## PLOT34805
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                                                    0.097 0.922725
                                                   -2.326 0.020030 *
## PLOT34822
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                            -21.79457
                                         4.38605
## PLOT34874
                                                   -4.969 6.90e-07 ***
## PLOT34884
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                                                   -5.204 2.01e-07 ***
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## PLOT34891
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## PLOT34928
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                                                   -7.369 1.93e-13 ***
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## PLOT34982
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                                                   -3.304 0.000959 ***
## PLOT34995
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                                                  -8.642 < 2e-16 ***
## PLOT35018
                            -15.75465
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                                                  -3.593 0.000329 ***
## PLOT35034
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                                          4.38710 -4.978 6.57e-07 ***
```

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## PLOT35043
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## PLOT35060
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## PLOT35084
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                                                   -3.286 0.001022 **
## PLOT35120
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## PLOT35129
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                                                   -1.434 0.151674
## PLOT35171
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                                                   -2.574 0.010071 *
## PLOT35245
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                                                   -4.064 4.88e-05 ***
## PLOT35289
                            -20.04173
                                          4.38408
                                                   -4.571 4.93e-06 ***
## PLOT35296
                            -14.84642
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                                                   -3.933 8.46e-05 ***
## PLOT35312
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## PLOT35401
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## PLOT35410
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                                                   -3.619 0.000297 ***
## PLOT35438
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## PLOT35587
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## PLOT35589
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                                                   -0.968 0.333053
## PLOT35649
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                                                   -1.587 0.112484
## PLOT35704
                                                   -3.166 0.001552 **
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## PLOT35743
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## PLOT35765
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## PLOT35774
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## PLOT35776
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## PLOT35780
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## PLOT35861
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## PLOT35891
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## PLOT35902
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                                                  -2.434 0.014966 *
## PLOT35938
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## PLOT35939
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## PLOT35964
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## PLOT35981
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## PLOT36073
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## PLOT36077
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## PLOT36095
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## PLOT36137
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## PLOT36221
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## PLOT36262
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## PLOT36268
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## PLOT36289
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## PLOT36309
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## PLOT36351
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## PLOT36466
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## PLOT36603
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## PLOT36611
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## PLOT36624
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## PLOT36626
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## PLOT36646
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## PLOT36797
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## PLOT36915
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## PLOT36969
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## PLOT37004
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## PLOT37005
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## PLOT37009
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## PLOT37113
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## PLOT37125
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## PLOT37190
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## PLOT37199
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## PLOT37443
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## PLOT37488
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## PLOT37678
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## PLOT37695
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## PLOT37832
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## PLOT37877
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## PLOT37894
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## PLOT37927
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## PLOT37980
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## PLOT38008
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## PLOT38094
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## PLOT38105
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## PLOT38117
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## PLOT38135
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## PLOT38164
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## PLOT38202
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## PLOT38319
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## PLOT38571
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## PLOT38575
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## PLOT38583
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## PLOT38617
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## PLOT38669
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## PLOT38693
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## PLOT38751
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## PLOT38864
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## PLOT38878
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## PLOT38896
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## PLOT38919
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## PLOT38927
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## PLOT38929
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## PLOT38944
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## PLOT39038
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## PLOT39089
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```

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## PLOT39116
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## PLOT39145
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## PLOT39170
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## PLOT39216
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## PLOT39234
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## PLOT39241
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## PLOT39255
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## PLOT39318
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## PLOT39399
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## PLOT39400
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## PLOT39452
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## PLOT39459
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## PLOT39543
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## PLOT39764
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## PLOT39770
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## PLOT39799
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## PLOT39969
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## PLOT40035
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## PLOT40062
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## PLOT40064
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## PLOT40089
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## PLOT40093
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## PLOT40219
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## PLOT40227
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## PLOT40270
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## PLOT40312
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## PLOT40856
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## PLOT40932
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## PLOT40957
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## PLOT40967
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```

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## PLOT41239
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## PLOT41565
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## PLOT41609
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                                         3.72375
                                                   -6.838 8.76e-12 ***
## PLOT41642
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                                                  -1.209 0.226770
## PLOT41651
                            -25.27858
                                         4.35874
                                                  -5.800 6.96e-09 ***
                                                   -7.451 1.05e-13 ***
## PLOT41682
                            -32.47732
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## PLOT41743
                            -21.51631
                                         4.54283
                                                   -4.736 2.22e-06 ***
## PLOT41746
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                                                  -0.551 0.581940
## PLOT41758
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                            -23.45419
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## PLOT41822
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                                         3.46517
                                                   -6.050 1.53e-09 ***
## PLOT41852
                                                  -2.297 0.021655 *
                            -9.30195
                                         4.04977
## PLOT41943
                            -8.08075
                                         3.78281
                                                  -2.136 0.032701 *
## PLOT41952
                            -27.04298
                                         4.36202
                                                  -6.200 6.00e-10 ***
## PLOT42035
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## PLOT42066
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## PLOT42087
                              8.68455
                                         6.16212
                                                   1.409 0.158780
## PLOT42106
                            -18.74941
                                         6.18105
                                                  -3.033 0.002428 **
## PLOT42129
                            -1.12533
                                         4.07706
                                                   -0.276 0.782545
## PLOT42167
                            -14.21625
                                         4.38506
                                                   -3.242 0.001193 **
## PLOT42199
                            -25.88635
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                                                   -5.938 3.03e-09 ***
## PLOT42207
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                                                    0.417 0.676542
## PLOT42259
                                         3.55787
                                                   -4.621 3.90e-06 ***
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                                                  -2.061 0.039357 *
## PLOT42286
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## PLOT42303
                            -16.56893
                                         4.35819
                                                   -3.802 0.000145 ***
## PLOT42316
                            -15.15412
                                                   -4.273 1.96e-05 ***
                                         3.54669
## PLOT42361
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                                                   -2.694 0.007073 **
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## PLOT42366
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                                                  -6.267 3.92e-10 ***
## PLOT42429
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                                                   -6.888 6.19e-12 ***
## PLOT42446
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## PLOT42496
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                                         4.38626
                                                   -4.537 5.81e-06 ***
## PLOT42544
                                                  -4.629 3.74e-06 ***
                            -17.47470
                                         3.77488
## PLOT42605
                            -17.40488
                                         4.35788
                                                  -3.994 6.57e-05 ***
                                                   -4.880 1.09e-06 ***
## PLOT42614
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## PLOT42629
                            -26.81282
                                         6.26235
                                                   -4.282 1.88e-05 ***
## PLOT42648
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                                                  -4.169 3.10e-05 ***
                            -36.86540
## PLOT42670
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                                                   -8.461 < 2e-16 ***
## PLOT42691
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                                                    1.297 0.194605
## PLOT42749
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                                         5.03862
                                                  -5.243 1.63e-07 ***
## PLOT42812
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                                                  -4.308 1.67e-05 ***
## PLOT42892
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## PLOT42920
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                                                  -1.137 0.255686
```

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## PLOT43011
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## PLOT43017
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                                         6.26019
                                                  -1.650 0.099059 .
## PLOT43026
                                                   -2.678 0.007416 **
                            -12.04121
                                          4.49572
## PLOT43085
                             -7.20687
                                                  -1.166 0.243651
                                         6.18078
## PLOT43120
                            -36.81609
                                         4.22141
                                                   -8.721 < 2e-16 ***
## PLOT43166
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                                         4.38414
                                                  -2.357 0.018445 *
## PLOT43195
                            -23.27246
                                         3.93024
                                                  -5.921 3.35e-09 ***
## PLOT43202
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## PLOT43210
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## PLOT43284
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                                          4.35788
                                                   -1.054 0.291721
## PLOT43290
                            -25.30279
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## PLOT43311
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                                                   -4.156 3.28e-05 ***
## PLOT43317
                            -15.36408
                                         4.49817
                                                   -3.416 0.000640 ***
## PLOT43332
                            -13.08273
                                         4.27053
                                                   -3.063 0.002197 **
## PLOT43484
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                                                   -2.524 0.011638 *
## PLOT43597
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## PLOT43663
                            -16.40789
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                                                   -3.614 0.000303 ***
## PLOT43711
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## PLOT43744
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## PLOT43757
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## PLOT43772
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## PLOT43842
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## PLOT43859
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## PLOT43887
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## PLOT43903
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## PLOT43917
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                                                   -3.555 0.000380 ***
## PLOT43925
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## PLOT43996
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                                         4.35866
                                                   -5.252 1.55e-07 ***
## PLOT44027
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## PLOT44072
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## PLOT44257
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## PLOT44300
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                                                   -2.928 0.003425 **
## PLOT44314
                             -4.61844
                                          4.49388
                                                   -1.028 0.304121
## PLOT44400
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                                                   -2.664 0.007732 **
## PLOT44424
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## PLOT44430
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## PLOT44458
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## PLOT44460
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## PLOT44461
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## PLOT44472
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## PLOT44480
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## PLOT44483
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## PLOT44496
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## PLOT44515
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## PLOT44536
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## PLOT44542
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## PLOT44567
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## PLOT44571
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## PLOT44653
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## PLOT44655
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## PLOT44745
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## PLOT44771
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## PLOT44820
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## PLOT44856
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## PLOT44888
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## PLOT44932
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## PLOT44949
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## PLOT44957
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## PLOT45043
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## PLOT45089
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## PLOT45095
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## PLOT45107
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## PLOT45129
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## PLOT45165
                            -14.15844
                                          4.38429
                                                   -3.229 0.001247 **
## PLOT45187
                            -12.52232
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## PLOT45222
                            -15.23414
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## PLOT45231
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## PLOT45282
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## PLOT45289
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## PLOT45315
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## PLOT45323
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## PLOT45337
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## PLOT45342
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## PLOT45400
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                                                   -5.981 2.33e-09 ***
## PLOT45431
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## PLOT45540
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                                                   -3.816 0.000137 ***
## PLOT45553
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## PLOT45586
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                                                   -2.667 0.007681 **
## PLOT45599
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## PLOT45629
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                                                   -2.991 0.002787 **
                                                   -2.889 0.003873 **
## PLOT45667
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## PLOT45694
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## PLOT45706
                            -20.01119
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## PLOT45760
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## PLOT45827
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## PLOT45892
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## PLOT45933
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## PLOT45935
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## PLOT45952
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                                          3.93040
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## PLOT46092
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## PLOT46097
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                                                   -3.286 0.001020 **
## PLOT46121
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## PLOT46134
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                                                   -4.512 6.55e-06 ***
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## PLOT46135
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## PLOT46187
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## PLOT46219
                                                   -2.049 0.040522 *
                             -8.98283
                                          4.38446
## PLOT46267
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                                          3.72596
                                                   -4.535 5.85e-06 ***
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## PLOT46314
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## PLOT46329
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## PLOT46368
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## PLOT46405
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## PLOT46408
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## PLOT46422
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## PLOT46431
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## PLOT46462
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## PLOT46465
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                                          4.49930
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## PLOT46525
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                                          3.72701
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## PLOT46540
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                                                  -4.714 2.48e-06 ***
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## PLOT46596
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                                                  -3.401 0.000676 ***
## PLOT46601
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## PLOT46698
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## PLOT46707
                                                   -3.027 0.002483 **
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## PLOT46713
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## PLOT46790
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## PLOT46813
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## PLOT46831
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## PLOT46848
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## PLOT46968
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## PLOT46972
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## PLOT47020
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## PLOT47049
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## PLOT47096
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## PLOT47099
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## PLOT47110
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## PLOT47133
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## PLOT47149
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## PLOT47150
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## PLOT47215
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## PLOT47255
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## PLOT47267
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## PLOT47302
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## PLOT47304
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## PLOT47309
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## PLOT47318
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## PLOT47391
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## PLOT47403
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## PLOT47420
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## PLOT47487
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## PLOT47504
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## PLOT47553
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## PLOT47564
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## PLOT47575
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## PLOT47582
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## PLOT47629
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## PLOT47642
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## PLOT47830
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## PLOT47945
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## PLOT48011
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## PLOT48020
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## PLOT48050
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## PLOT48097
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## PLOT48103
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## PLOT48127
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## PLOT48150
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## PLOT48176
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## PLOT48275
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## PLOT48368
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## PLOT48434
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## PLOT48461
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```

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## PLOT48482
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## PLOT48521
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## PLOT48528
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## PLOT48550
                            -13.44372
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## PLOT48561
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## PLOT48562
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## PLOT48816
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## PLOT48850
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                                                   -4.570 4.97e-06 ***
## PLOT48883
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## PLOT48904
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## PLOT48916
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## PLOT48917
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## PLOT48942
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## PLOT48948
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## PLOT48950
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## PLOT48956
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## PLOT49006
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## PLOT49069
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## PLOT49177
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## PLOT49207
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## PLOT49208
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## PLOT49217
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## PLOT49251
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## PLOT49262
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## PLOT49302
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## PLOT49305
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## PLOT49317
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## PLOT49349
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## PLOT49375
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                                                   -4.329 1.52e-05 ***
## PLOT49381
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                                                   -6.148 8.29e-10 ***
## PLOT49402
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## PLOT49403
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## PLOT49475
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## PLOT49485
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## PLOT49510
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## PLOT49550
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## PLOT49565
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## PLOT49568
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## PLOT49584
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## PLOT49585
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## PLOT49698
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## PLOT49711
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## PLOT49715
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## PLOT49742
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## PLOT49793
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## PLOT49810
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## PLOT49860
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                                                   -5.941 2.98e-09 ***
## PLOT49874
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## PLOT49882
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## PLOT49892
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## PLOT50141
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## PLOT50157
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## PLOT50223
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## PLOT50247
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## PLOT50271
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## PLOT50282
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## PLOT50318
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## PLOT50348
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## PLOT50359
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## PLOT50361
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## PLOT50381
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## PLOT50431
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## PLOT50434
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## PLOT50437
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## PLOT50498
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## PLOT50645
                                                   -2.298 0.021618 *
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## PLOT50687
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## PLOT50691
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## PLOT50772
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## PLOT50821
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## PLOT50845
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## PLOT50996
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## PLOT51009
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## PLOT51161
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## PLOT51164
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## PLOT51241
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## PLOT51249
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## PLOT51278
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## PLOT51435
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## PLOT51483
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## PLOT51487
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## PLOT51496
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## PLOT51548
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## PLOT51656
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## PLOT51669
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## PLOT51768
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## PLOT51974
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## PLOT52012
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## PLOT52136
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## PLOT52144
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## PLOT52261
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## PLOT52267
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## PLOT52273
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## PLOT52308
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## PLOT52309
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## PLOT52314
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## PLOT52317
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## PLOT52365
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## PLOT52399
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## PLOT52437
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## PLOT52493
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## PLOT52570
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## PLOT52586
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## PLOT52636
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## PLOT52645
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## PLOT52658
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## PLOT52710
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## PLOT52725
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## PLOT52776
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## PLOT52823
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## PLOT52827
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## PLOT52844
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## PLOT52872
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## PLOT52958
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## PLOT52964
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## PLOT52967
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## PLOT52977
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## PLOT53035
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## PLOT53072
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## PLOT53106
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## PLOT53198
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## PLOT53294
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## PLOT53359
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## PLOT53377
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## PLOT53386
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## PLOT53393
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## PLOT53399
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## PLOT53462
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## PLOT53655
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## PLOT53661
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## PLOT53663
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## PLOT53738
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## PLOT53799
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## PLOT53840
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## PLOT53854
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## PLOT53862
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## PLOT53863
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## PLOT53881
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## PLOT53945
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## PLOT54028
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## PLOT54069
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## PLOT54072
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## PLOT54256
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## PLOT54295
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## PLOT54395
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## PLOT54480
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## PLOT54712
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## PLOT54777
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## PLOT54879
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## PLOT54895
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## PLOT54920
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                                                  -4.126 3.74e-05 ***
```

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-10.80427
## PLOT55500
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## PLOT55544
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## PLOT55563
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## PLOT55618
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## PLOT55628
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## PLOT55654
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## PLOT55773
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## PLOT55808
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## PLOT55828
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## PLOT55834
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## PLOT55847
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## PLOT55907
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## PLOT55918
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## PLOT55947
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## PLOT55958
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## PLOT56009
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## PLOT56028
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## PLOT56036
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## PLOT56038
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## PLOT56084
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## PLOT56109
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## PLOT56116
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## PLOT56145
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## PLOT56198
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                                                   -5.347 9.26e-08 ***
                                          3.78209
                                                   -5.789 7.41e-09 ***
## PLOT56201
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## PLOT56279
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## PLOT56281
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## PLOT56283
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## PLOT56329
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## PLOT56398
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                                                   -3.812 0.000139 ***
## PLOT56405
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## PLOT56406
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## PLOT56434
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## PLOT56483
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## PLOT56505
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## PLOT56539
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## PLOT56567
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## PLOT56581
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## PLOT56612
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## PLOT56665
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## PLOT56679
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## PLOT56761
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## PLOT56775
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## PLOT56784
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## PLOT56826
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## PLOT56834
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## PLOT56896
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## PLOT56918
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## PLOT56932
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## PLOT56979
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## PLOT57057
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## PLOT57058
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```

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## PLOT57106
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## PLOT57123
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## PLOT57170
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## PLOT57211
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## PLOT57237
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## PLOT57322
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## PLOT57402
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## PLOT57412
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## PLOT57416
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## PLOT57448
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## PLOT57466
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## PLOT57517
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## PLOT57534
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## PLOT57546
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## PLOT57547
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## PLOT57561
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## PLOT57605
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## PLOT57760
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## PLOT57897
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## PLOT57923
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## PLOT57934
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## PLOT58091
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## PLOT58093
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## PLOT58257
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## PLOT58341
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## PLOT58409
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## PLOT58436
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## PLOT58598
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## PLOT58608
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## PLOT58635
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## PLOT58708
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## PLOT58729
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## PLOT58749
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## PLOT58837
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## PLOT58855
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## PLOT58856
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## PLOT58861
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## PLOT58871
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## PLOT58887
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## PLOT58890
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## PLOT58983
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## PLOT59026
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## PLOT59038
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## PLOT59089
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## PLOT59102
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## PLOT59115
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## PLOT59305
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## PLOT59376
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## PLOT59403
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## PLOT59452
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## PLOT59490
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## PLOT59584
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## PLOT59594
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## PLOT59602
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## PLOT59675
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## PLOT59707
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## PLOT59862
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## PLOT59869
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## PLOT59891
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## PLOT59908
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## PLOT59914
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## PLOT59947
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## PLOT59967
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## PLOT60009
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## PLOT60052
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## PLOT60053
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## PLOT60078
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## PLOT60159
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## PLOT60287
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## PLOT60406
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## PLOT60476
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## PLOT60488
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## PLOT60545
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```

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## PLOT60670
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## PLOT60701
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## PLOT60784
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## PLOT60880
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## PLOT60887
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## PLOT60954
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## PLOT60996
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## PLOT61035
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## PLOT61062
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## PLOT61063
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## PLOT61092
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## PLOT61098
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## PLOT61117
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## PLOT61122
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## PLOT61126
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## PLOT61144
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## PLOT61145
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## PLOT61150
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## PLOT61205
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## PLOT61252
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## PLOT61311
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## PLOT61326
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## PLOT61387
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## PLOT61418
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## PLOT61540
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## PLOT61565
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## PLOT61580
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## PLOT61799
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## PLOT61846
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## PLOT61932
                            -12.35194
                                          4.38390
                                                   -2.818 0.004853 **
## PLOT61952
                            -20.83901
                                          4.36041
                                                   -4.779 1.80e-06 ***
## PLOT61967
                            -19.85612
                                          3.93121
                                                   -5.051 4.52e-07 ***
## PLOT61981
                            -26.58770
                                          4.36011
                                                   -6.098 1.14e-09 ***
## PLOT62051
                            -19.58790
                                          4.49375
                                                   -4.359 1.33e-05 ***
## PLOT62069
                            -26.92736
                                          4.35926
                                                   -6.177 6.92e-10 ***
## PLOT62101
                            -21.43990
                                          4.27112
                                                   -5.020 5.31e-07 ***
## PLOT62115
                            -6.96603
                                          4.38387
                                                   -1.589 0.112105
## PLOT62117
                            -18.39248
                                          3.68294
                                                  -4.994 6.07e-07 ***
## PLOT62188
                             -2.67299
                                          4.35733 -0.613 0.539602
```

```
## PLOT62211
                             -7.35829
                                          3.93555
                                                   -1.870 0.061570 .
## PLOT62272
                                          3.77647
                                                   -3.383 0.000721 ***
                            -12.77625
## PLOT62488
                             -9.32503
                                          4.49369
                                                   -2.075 0.038012 *
## PLOT62530
                                          4.49864
                                                    2.082 0.037369 *
                              9.36673
## PLOT62537
                            -10.50596
                                          3.80523
                                                   -2.761 0.005780 **
## PLOT62617
                                          3.80415
                                                   -3.857 0.000116 ***
                            -14.67371
## PLOT62621
                            -12.06595
                                          4.38367
                                                   -2.752 0.005931 **
## PLOT62659
                            -15.21553
                                          3.77376
                                                   -4.032 5.59e-05 ***
## PLOT62677
                            -18.48516
                                          3.55889
                                                   -5.194 2.12e-07 ***
## PLOT62707
                            -20.93627
                                          3.51522
                                                   -5.956 2.72e-09 ***
## PLOT62749
                            -13.46530
                                          3.54952
                                                   -3.794 0.000150 ***
## PLOT62763
                            -15.10297
                                          4.35899
                                                   -3.465 0.000534 ***
## PLOT62820
                            -13.54959
                                          4.38506
                                                   -3.090 0.002010 **
                                                   -1.868 0.061755 .
## PLOT62825
                             -8.14398
                                          4.35887
## PLOT62830
                            -23.13423
                                          6.18194
                                                   -3.742 0.000184 ***
## PLOT62847
                            -19.16678
                                          3.84441
                                                   -4.986 6.33e-07 ***
## PLOT62873
                            -21.98102
                                          6.16257
                                                   -3.567 0.000364 ***
## PLOT62890
                            -16.36350
                                          4.38399
                                                   -3.733 0.000191 ***
## PLOT62894
                            -13.15212
                                          4.38481
                                                   -2.999 0.002715 **
## PLOT62897
                            -23.17415
                                          4.38710
                                                   -5.282 1.32e-07 ***
## PLOT62973
                            -24.72448
                                          4.35740
                                                   -5.674 1.45e-08 ***
## PLOT63032
                                          4.07587
                                                   -3.060 0.002219 **
                            -12.47399
                                                   -5.404 6.74e-08 ***
## PLOT63074
                            -23.08814
                                          4.27233
## PLOT63109
                             -9.43236
                                          4.49478
                                                   -2.099 0.035898 *
## PLOT63136
                            -14.64950
                                          4.38446
                                                   -3.341 0.000839 ***
## PLOT63162
                            -24.12790
                                          4.38605
                                                   -5.501 3.92e-08 ***
                                          4.49438
                                                   -3.721 0.000200 ***
## PLOT63166
                            -16.72141
                            -25.21247
## PLOT63177
                                          4.49456
                                                   -5.610 2.11e-08 ***
## PLOT63238
                            -14.39658
                                          4.49411
                                                   -3.203 0.001364 **
## PLOT63273
                            -21.16556
                                          3.72353
                                                   -5.684 1.37e-08 ***
## PLOT63277
                            -20.30984
                                          4.38504
                                                   -4.632 3.70e-06 ***
## PLOT63314
                            -10.94755
                                          3.44811
                                                   -3.175 0.001506 **
## PLOT63373
                            -21.67136
                                          3.77400
                                                   -5.742 9.76e-09 ***
## PLOT63375
                                          4.35730
                                                   -0.335 0.737305
                             -1.46161
## PLOT63378
                                          4.38479
                                                   -4.237 2.29e-05 ***
                            -18.57904
## PLOT63405
                             12.91559
                                          6.26454
                                                    2.062 0.039275 *
## PLOT63429
                             -3.33857
                                          3.77364
                                                   -0.885 0.376346
## PLOT63473
                                          4.38363
                                                   -0.214 0.830629
                             -0.93767
                            -27.35319
                                                   -6.272 3.80e-10 ***
## PLOT63583
                                          4.36137
## PLOT63589
                            -11.78861
                                          6.16226
                                                   -1.913 0.055787 .
## PLOT63640
                            -17.41499
                                          6.18188
                                                   -2.817 0.004860 **
## PLOT63642
                                          3.62628
                                                   -3.051 0.002291 **
                            -11.06343
## PLOT63698
                            -11.73474
                                          4.24931
                                                   -2.762 0.005768 **
## PLOT63719
                             -4.18168
                                          3.77678
                                                   -1.107 0.268245
## PLOT63757
                            -25.40807
                                          3.72389
                                                   -6.823 9.71e-12 ***
## PLOT63773
                            -21.96199
                                          6.29285
                                                   -3.490 0.000486 ***
                                          4.38599
## PLOT63775
                            -17.98174
                                                   -4.100 4.18e-05 ***
## PLOT63786
                            -14.15687
                                          3.84458
                                                   -3.682 0.000233 ***
## PLOT63818
                            -15.77464
                                          3.60442
                                                   -4.376 1.22e-05 ***
## PLOT63955
                            -17.91689
                                          4.35776
                                                   -4.111 3.98e-05 ***
## PLOT63959
                            -25.02276
                                          4.38585
                                                   -5.705 1.21e-08 ***
## PLOT63988
                            -21.92284
                                          6.18300
                                                   -3.546 0.000394 ***
## PLOT64010
                            -17.59864
                                          4.10016
                                                   -4.292 1.79e-05 ***
## PLOT64063
                              1.06088
                                          6.25930
                                                    0.169 0.865418
```

```
## PLOT64065
                            -16.08555
                                         3.78114
                                                   -4.254 2.13e-05 ***
## PLOT64076
                            -16.28926
                                         6.25948
                                                   -2.602 0.009280 **
                             -8.30722
## PLOT64145
                                         3.80510
                                                   -2.183 0.029057 *
## PLOT64153
                                         6.25959
                                                   -4.020 5.87e-05 ***
                            -25.16622
## PLOT64204
                            -18.81878
                                         4.10529
                                                   -4.584 4.64e-06 ***
## PLOT64212
                            -21.46309
                                         4.10592
                                                   -5.227 1.77e-07 ***
## PLOT64249
                            -26.79385
                                         4.35797
                                                   -6.148 8.29e-10 ***
## PLOT64269
                             -8.31041
                                         3.93293
                                                   -2.113 0.034635 *
## PLOT64295
                            -17.86503
                                         3.80615
                                                   -4.694 2.74e-06 ***
                            -18.63161
## PLOT64323
                                         4.38486
                                                   -4.249 2.18e-05 ***
## PLOT64345
                            -20.26587
                                         3.98368
                                                   -5.087 3.73e-07 ***
                                                   -4.598 4.34e-06 ***
## PLOT64384
                            -18.08855
                                         3.93370
## PLOT64407
                            -22.72250
                                         3.93029
                                                   -5.781 7.75e-09 ***
## PLOT64414
                                                   -3.581 0.000345 ***
                            -13.20679
                                         3.68818
## PLOT64443
                             -8.32177
                                         4.35726
                                                   -1.910 0.056194 .
## PLOT64463
                            -21.64789
                                         3.93061
                                                   -5.508 3.78e-08 ***
## PLOT64465
                             -8.92450
                                         3.93304
                                                   -2.269 0.023294 *
## PLOT67852
                            -25.98140
                                         4.04920
                                                   -6.416 1.49e-10 ***
## PLOT67854
                            -24.16731
                                         3.93023
                                                   -6.149 8.25e-10 ***
## PLOT67857
                            -26.51744
                                         4.49387
                                                   -5.901 3.80e-09 ***
##
                   0 '*** 0.001 '** 0.01 '* 0.05 '. ' 0.1 ' ' 1
## Signif. codes:
##
## Residual standard error: 5.337 on 6600 degrees of freedom
##
     (82 observations deleted due to missingness)
## Multiple R-squared: 0.9151, Adjusted R-squared:
## F-statistic: 36.69 on 1938 and 6600 DF, p-value: < 2.2e-16
```

Unfortunately, there are too many unique plots to visualize this linear regression, but the results indicate that, in general, plot and species have a significant influence on the height of the tree. These results will be confirmed with an ANOVA in the following analysis section.

Analysis

describe the results of the code but dont show it -apply to main hypothesis -hide codes and explain without them (this was sig different than this then show degrees of freedom etc, but add into explanation) -1 to 2 visulizations per argument

ANOVA Tests

```
##
                    Sum Sq Mean Sq F value Pr(>F)
                  1 1351652 1351652 17894.8 <2e-16 ***
## DIA
## Species
                  3
                     216899
                              72300
                                      957.2 <2e-16 ***
## Residuals
               8534
                     644599
                                 76
## ---
## Signif. codes: 0 '*** 0.001 '** 0.01 '* 0.05 '.' 0.1 ' 1
## 82 observations deleted due to missingness
##
                    Sum Sq Mean Sq
                                      F value Pr(>F)
## DIA
                  1 1351652 1351652 47462.200 <2e-16 ***
                              72300
                                     2538.752 <2e-16 ***
## Species
                  3
                     216899
## PLOT
               1934
                     456641
                                236
                                        8.291 <2e-16 ***
               6600
                                 28
## Residuals
                     187958
## Signif. codes: 0 '*** 0.001 '** 0.01 '* 0.05 '.' 0.1 ' 1
## 82 observations deleted due to missingness
```

The ANOVA results suggest that diameter has the highest influence on tree height, as expected. Additionally, it suggests that both species and plot number have a significant influence on tree height. The influence of plot is smaller than that of diameter and tree species. These results will be explored further in the following sections.

##ANOVA Test to Compare Mean Height Differences Between Species In order to properly understand the statistical differences present in mean species height, an ANOVA test will be conducted between each species in pairs.

```
##
                 Df Sum Sq Mean Sq F value Pr(>F)
                 1 363941
                           363941
                                     2077 <2e-16 ***
## Species
## Residuals
               4951 867673
                               175
## Signif. codes: 0 '***' 0.001 '**' 0.05 '.' 0.1 ' ' 1
##
                Df Sum Sq Mean Sq F value Pr(>F)
                            59934
                                    257.6 <2e-16 ***
## Species
                  1 59934
## Residuals
              3669 853755
                              233
## ---
## Signif. codes: 0 '*** 0.001 '** 0.01 '* 0.05 '.' 0.1 ' 1
##
                Df Sum Sq Mean Sq F value Pr(>F)
## Species
                            33524
                 1 33524
                                    129.7 <2e-16 ***
## Residuals
              3666 947667
                               259
## Signif. codes: 0 '*** 0.001 '** 0.01 '* 0.05 '.' 0.1 ' ' 1
```

```
##
                Df Sum Sq Mean Sq F value Pr(>F)
                                     1392 <2e-16 ***
## Species
                 1 270470
                           270470
## Residuals
              4948 961585
                              194
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.05 '.' 0.1 ' ' 1
                Df Sum Sq Mean Sq F value Pr(>F)
##
                    38618
                            38618
## Species
                                    361.7 <2e-16 ***
## Residuals
              3052 325847
                              107
## Signif. codes: 0 '***' 0.001 '**' 0.05 '.' 0.1 ' ' 1
                    Sum Sq Mean Sq F value
                Df
                                             Pr(>F)
## Species
                      7881
                              7881
                                     29.45 5.99e-08 ***
## Residuals
              5565 1489494
                               268
## Signif. codes: 0 '*** 0.001 '** 0.01 '* 0.05 '.' 0.1 ' ' 1
```

Each ANOVA pairing between species is significantly different, having a p value below 0. This means that the null hyptohesis is rejected, and the alternative hypothesis is accepted: tree height does vary significantly between species.

Because the anova test shows that all results are significant a pairwise comparison between species can be conducted using a Tukey Test HSD to show the confidence interval, p-value and difference in each species.

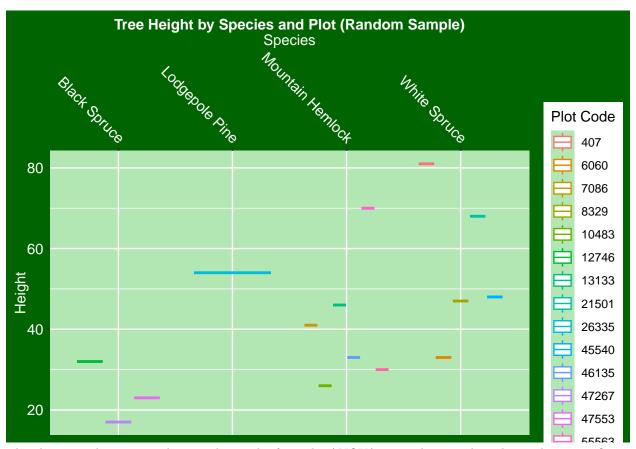
##Tukey Test HSD of Tree Species Mean Height Difference

```
Tukey multiple comparisons of means
##
##
       95% family-wise confidence level
##
## Fit: aov(formula = HT ~ Species, data = w.spruce.l.pine)
##
## $Species
##
                                    diff
                                                        upr p adj
## White Spruce-Lodgepole Pine 9.442757 8.289179 10.59634
     Tukey multiple comparisons of means
##
##
       95% family-wise confidence level
##
## Fit: aov(formula = HT ~ Species, data = 1.pine.m.hemlock)
##
## $Species
                                        diff
                                                  lwr
                                                            upr p adj
## Mountain Hemlock-Lodgepole Pine 7.063093 5.847069 8.279118
##
     Tukey multiple comparisons of means
       95% family-wise confidence level
##
##
## Fit: aov(formula = HT ~ Species, data = b.spruce.m.hemlock)
##
## $Species
##
                                      diff
                                                lwr
                                                          upr p adj
## Mountain Hemlock-Black Spruce 14.89889 14.11595 15.68182
```

```
##
     Tukey multiple comparisons of means
##
       95% family-wise confidence level
##
## Fit: aov(formula = HT ~ Species, data = b.spruce.l.pine)
##
##
  $Species
##
                                    diff
                                              lwr
                                                       upr p adj
## Lodgepole Pine-Black Spruce 7.835792 7.027957 8.643627
##
     Tukey multiple comparisons of means
##
       95% family-wise confidence level
##
## Fit: aov(formula = HT ~ Species, data = b.w.spruces)
##
##
  $Species
##
                                  diff
                                            lwr
                                                     upr p adj
## White Spruce-Black Spruce 17.27855 16.53523 18.02187
##
     Tukey multiple comparisons of means
##
       95% family-wise confidence level
##
  Fit: aov(formula = HT ~ Species, data = w.spruce.m.hemlock)
##
##
## $Species
##
                                      diff
                                               lwr
                                                         upr p adj
## White Spruce-Mountain Hemlock 2.379664 1.51996 3.239367 1e-07
##
                                         diff
                                                    lwr
                                                               upr
## White Spruce-Lodgepole Pine
                                     9.442757
                                               8.289179 10.596335 8.369286e-09
## Mountain Hemlock-Lodgepole Pine
                                     7.063093
                                               5.847069
                                                         8.279118 8.252223e-09
## Mountain Hemlock-Black Spruce
                                    14.898886 14.115947 15.681825 3.501914e-09
## Lodgepole Pine-Black Spruce
                                     7.835792
                                               7.027957
                                                         8.643627 0.000000e+00
## White Spruce-Black Spruce
                                    17.278550 16.535226 18.021873 2.937114e-09
  White Spruce-Mountain Hemlock
                                               1.519960
                                                         3.239367 5.994149e-08
                                     2.379664
##
                                                             Comparison
## White Spruce-Lodgepole Pine
                                        White Spruce vs Lodgepole Pine
## Mountain Hemlock-Lodgepole Pine Lodgepole Pine vs Mountain Hemlock
## Mountain Hemlock-Black Spruce
                                      Black Spruce vs Mountain Hemlock
## Lodgepole Pine-Black Spruce
                                        Black Spruce vs Lodgepole Pine
## White Spruce-Black Spruce
                                          White Spruce vs Black Spruce
## White Spruce-Mountain Hemlock
                                      White Spruce vs Mountain Hemlock
```

According to the Tukey HSD Test, the largest difference in tree height means is between black spruce and white spruce (17.28 feet), followed by the difference of Mountain Hemlock and Black Spruce (14.89 feet). The trees with the least mean height difference are White Spruce and Mountain Hemlock (2.38 feet). The confidence intervals between true differences in height ranged throughout species with the biggest confidence interval being Mountain Hemlock versus Lodgepole Pine with a lower bound of 5.84 feet and a higher bound of 10.59 feet. The smallest confidence interval was found between Mountain Hemlock and Black Spruce and Lodgepole Pine and Black Spruce (14.11 to 15.69 feet, and 7.03 and 8.64 feet, respectively). Lastly, all p-values have stayed statistically significant. This means we can reject the null hypothesis and accept the alternative hypothesis: tree species in Alaska do vary by height.

Visualizing Interactions with Plot Differences



This data visualization emphasizes the results from the ANOVA tests, showing that plot is also a significant influencing factor on tree height. There were too many unique plots to visualize the results from the linear regression or show all plots in this figure, but even this random sample reemphasizes the findings from our ANOVA test.

Question 1: <insert specific question here and add additional subsections for additional questions below, if needed>

Q: How does tree height vary across Alaska's forests? - How does this height vary with DBH? - How does this height vary with species? -How does this height vary with plot?

Question 2:

Summary and Conclusions

References

 $<\!\!$ add references here if relevant, otherwise delete this section> $\!\!$ #Appendix