GLM for count data: Poisson regression

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- Bernouilli / Binomial: `glm` (family `binomial / quasibinomial`)
- Counts: `glm` (family `poisson / quasipoisson`)

Poisson regression

- Response variable: Counts (0, 1, 2, 3...) - discrete

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Poisson regression

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- Link function: `log`

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$$N = e^{a+bx}$$

Example dataset: Seedling counts in quadrats

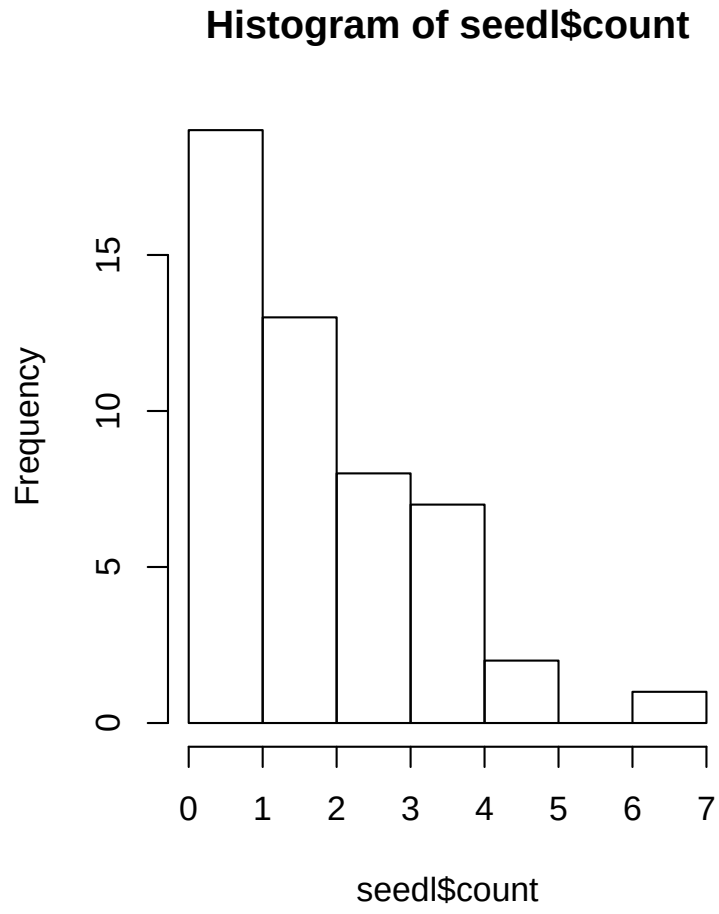
```
seedl <- read.csv("data-raw/seedlings.csv")
```

```
       X                count              row              col       
 Min.   : 1.00   Min.   :0.00   Min.   :1   Min.   : 1.0  
 1st Qu.:13.25   1st Qu.:1.00   1st Qu.:2   1st Qu.: 3.0  
 Median :25.50   Median :2.00   Median :3   Median : 5.5  
 Mean   :25.50   Mean   :2.14   Mean   :3   Mean   : 5.5  
 3rd Qu.:37.75   3rd Qu.:3.00   3rd Qu.:4   3rd Qu.: 8.0  
 Max.   :50.00   Max.   :7.00   Max.   :5   Max.   :10.0  
     light             area       
 Min.   : 2.571   Min.   :0.25  
 1st Qu.:26.879   1st Qu.:0.25  
 Median :47.493   Median :0.50  
 Mean   :47.959   Mean   :0.62  
 3rd Qu.:67.522   3rd Qu.:1.00  
 Max.   :99.135   Max.   :1.00  
```

EDA

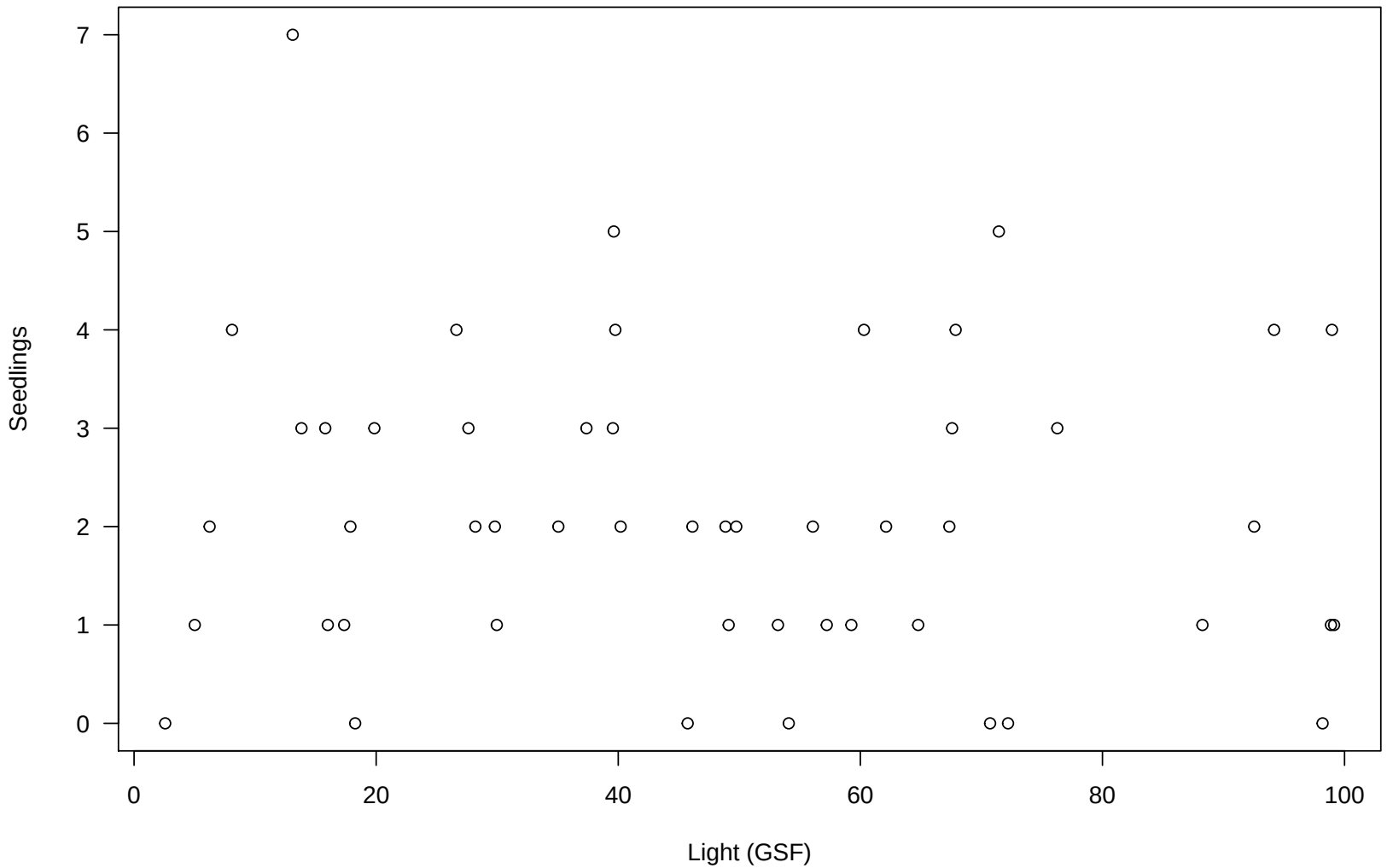
```
table(seedl$count)
```

```
 0  1  2  3  4  5  7
 7 12 13  8  7  2  1
```



Q: Relationship between Nseedlings and light?

```
plot(seedl$light, seedl$count, las = 1, xlab = "Light (GSF)", yl
```



Let's fit model (Poisson regression)

```r
seedl.glm <- glm(count ~ light, data = seedl, family = poisson(link="log"))
summary(seedl.glm)
```

```
Call:
glm(formula = count ~ light, family = poisson(link = "log"),
    data = seedl)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-2.1906  -0.8466  -0.1110   0.5220   2.4577

Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept)  0.881805   0.188892   4.668 3.04e-06 ***
light       -0.002576   0.003528  -0.730    0.465
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for poisson family taken to be 1)

    Null deviance: 63.029  on 49  degrees of freedom
Residual deviance: 62.492  on 48  degrees of freedom
AIC: 182.03

Number of Fisher Scoring iterations: 5
```

Interpreting Poisson regression output

Parameter estimates (log scale):

```
coef(seedl.glm)
```

```
 (Intercept)        light
 0.881805022 -0.002575656
```

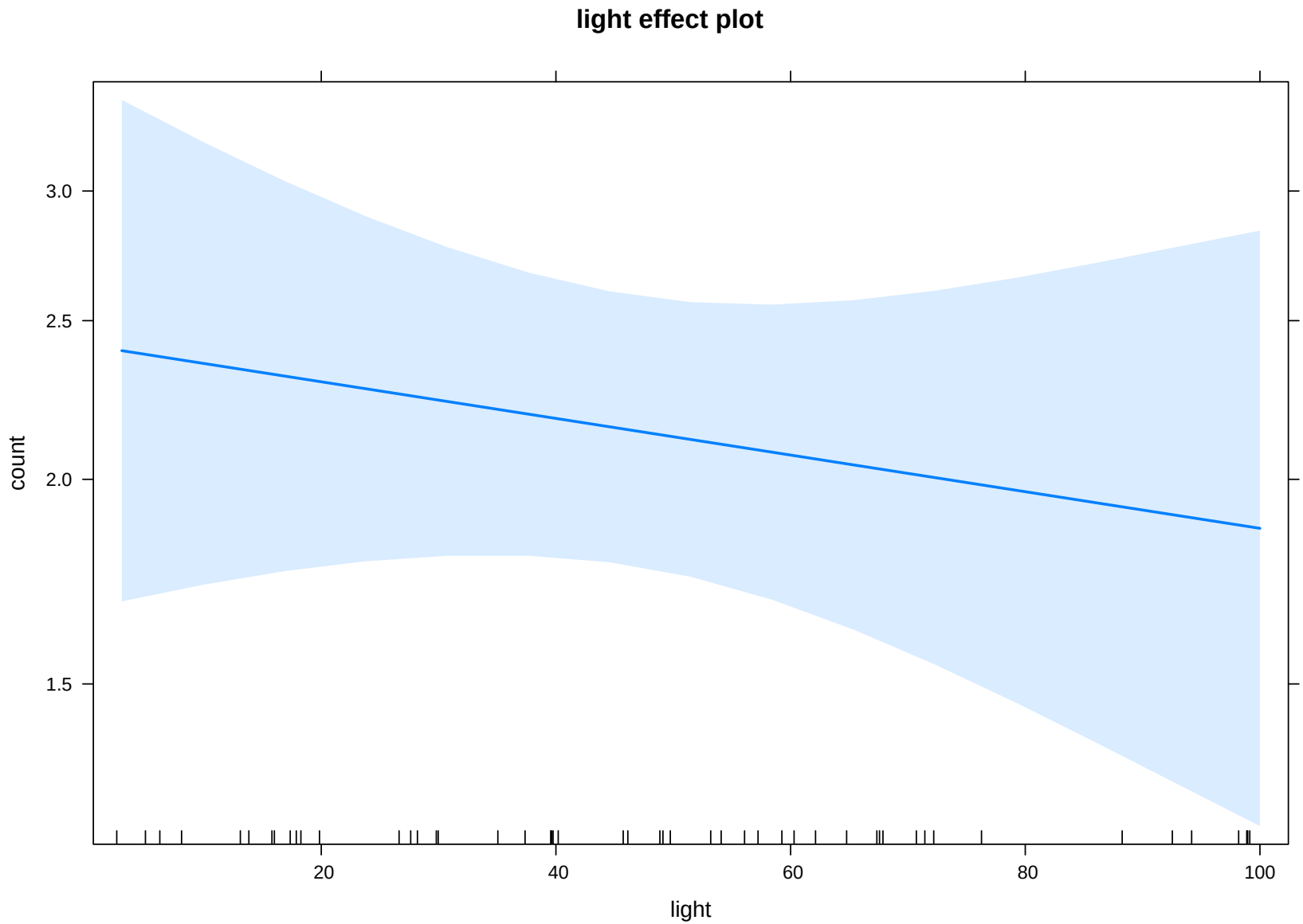
We need to back-transform: apply the inverse of the logarithm

```
exp(coef(seedl.glm))
```

```
(Intercept)       light
  2.4152554   0.9974277
```

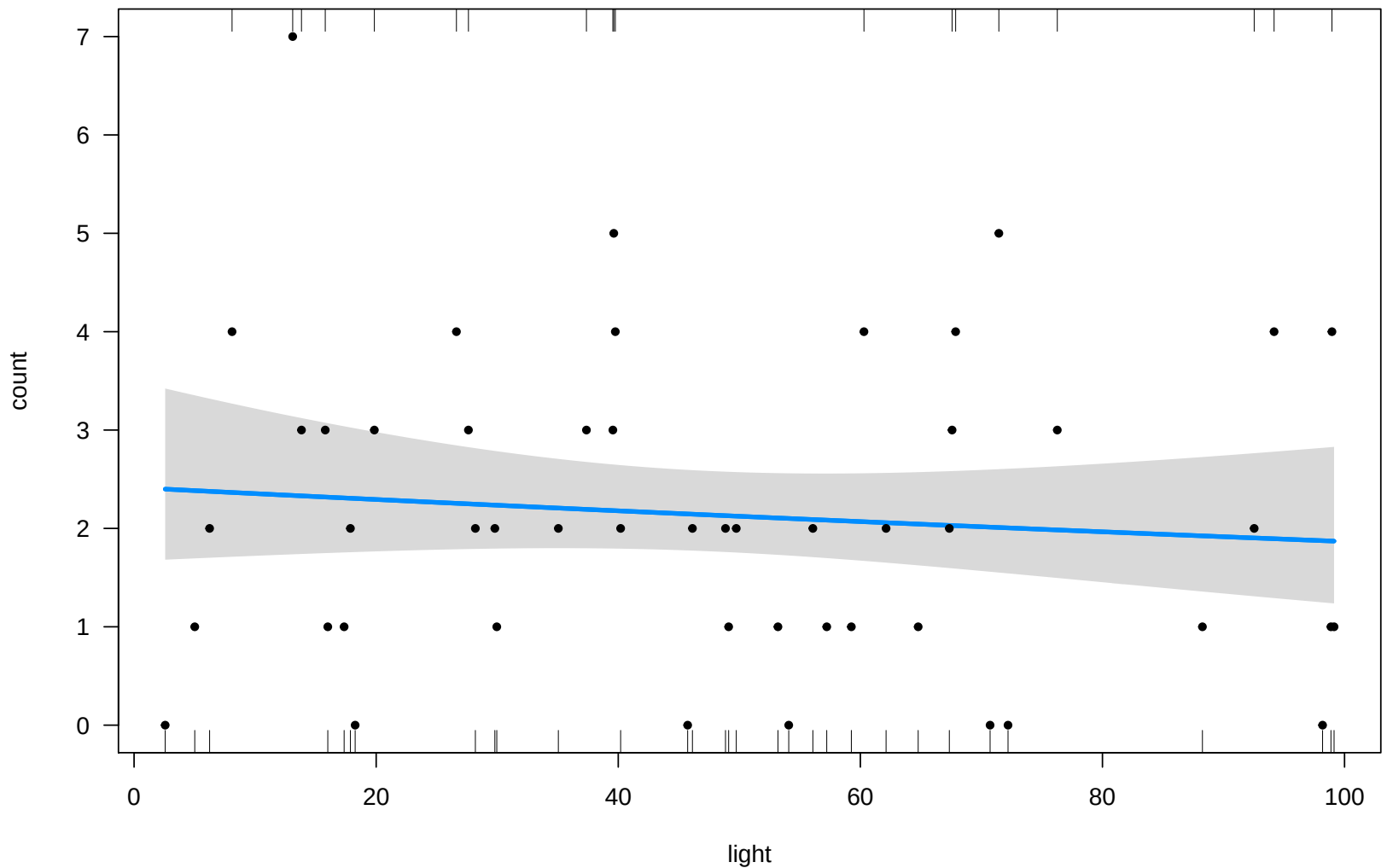
So what's the relationship between Nseedlings and light?

```
plot(allEffects(seedl.glm))
```

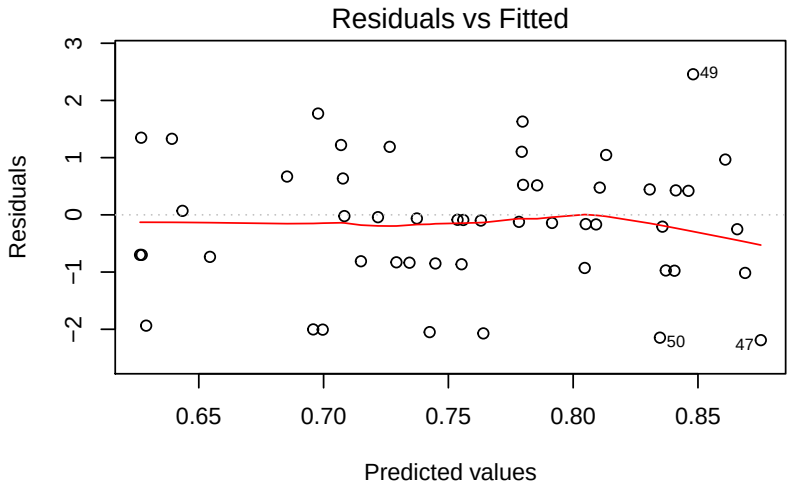


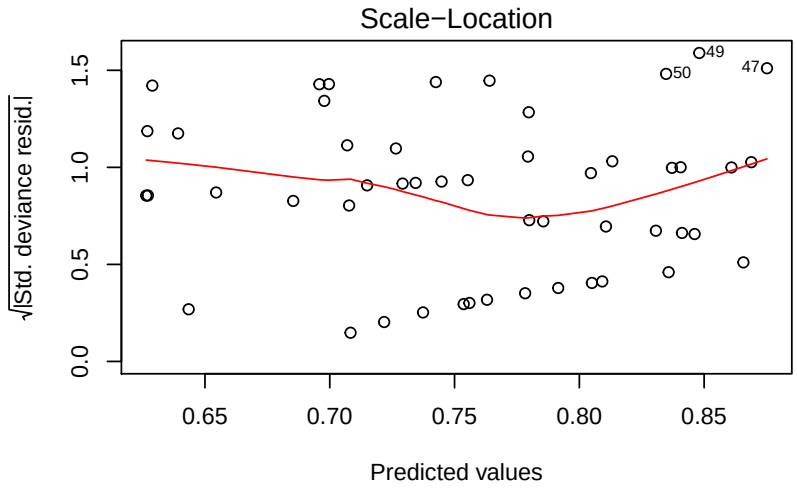
Using visreg

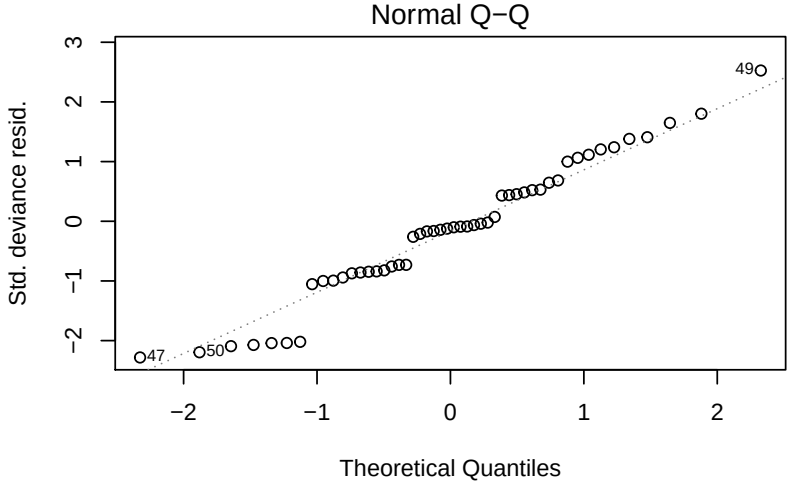
```
visreg(seedl.glm, scale = "response", ylim = c(0, 7))
points(count ~ light, data = seedl, pch = 20)
```

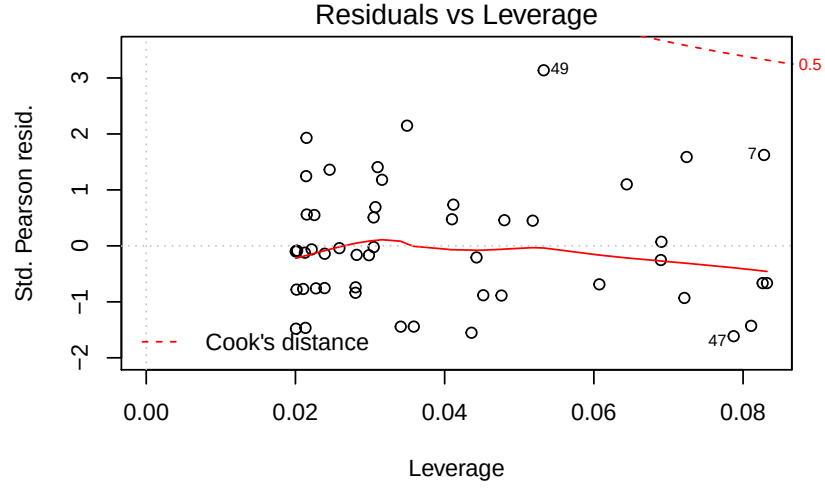


Poisson regression: model checking



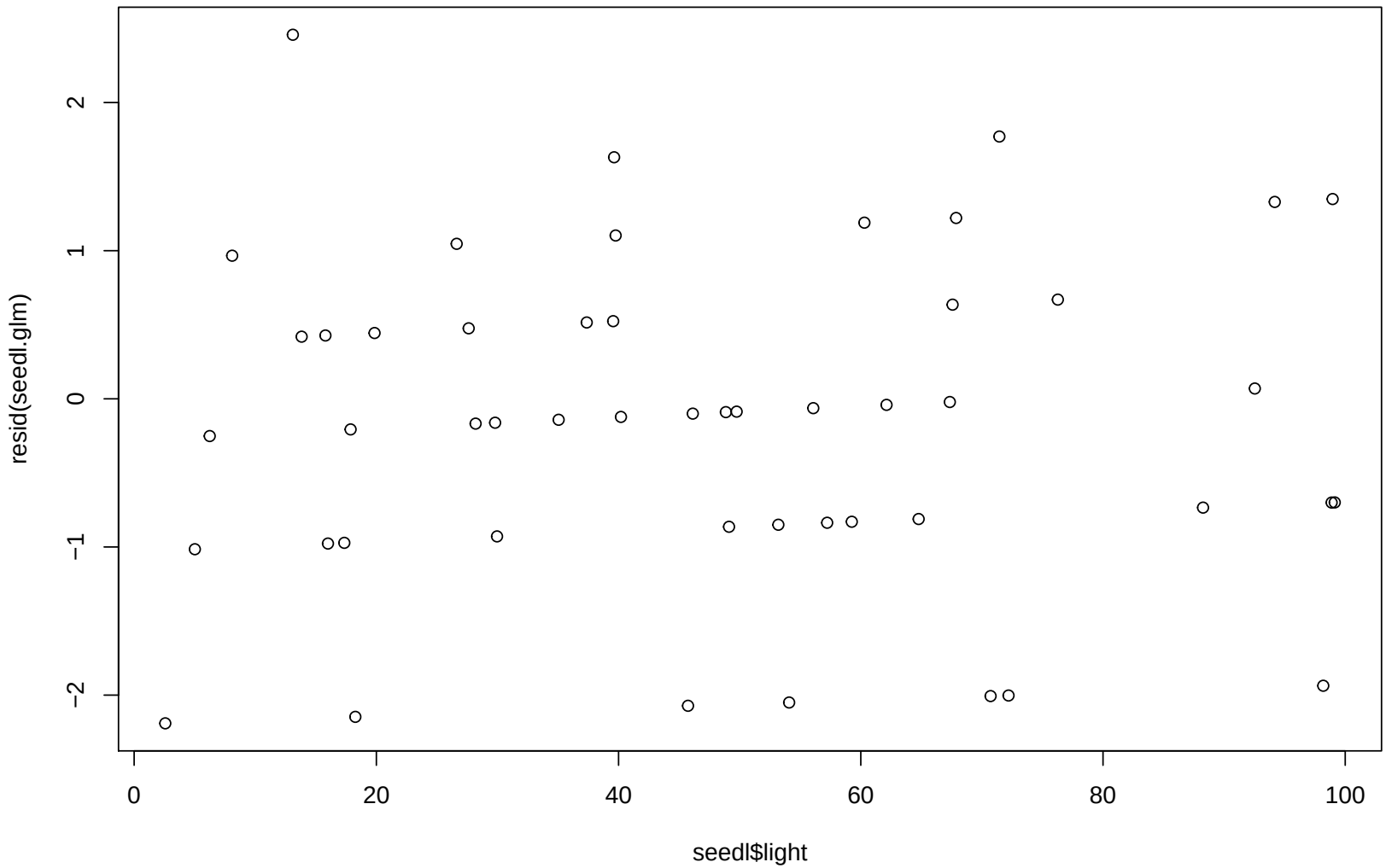






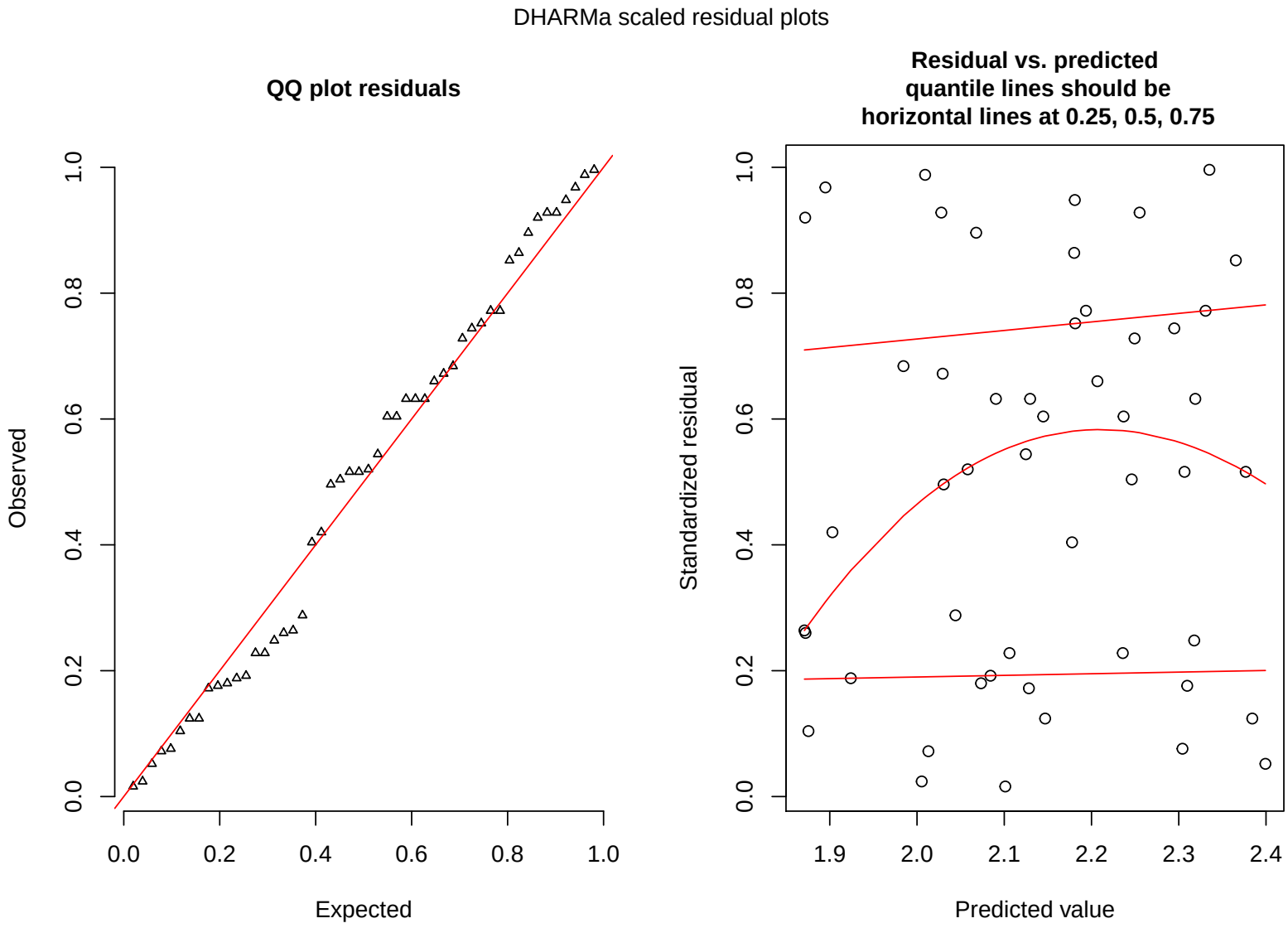
Is there pattern of residuals along predictor?

```
plot(seedl$light, resid(seedl.glm))
```



Residuals diagnostics with DHARMa

```
simulateResiduals(seedl.glm, plot = TRUE)
```



Poisson regression: Overdispersion

Always check overdispersion with count data

```
simres <- simulateResiduals(seedl.glm, refit = TRUE)
testOverdispersion(simres)
```

```
    DHARMa nonparametric overdispersion test via comparison to
    simulation under H0 = fitted model

data:  simres
dispersion = 1.1574, p-value = 0.196
alternative hypothesis: overdispersion
```

Accounting for overdispersion in count data

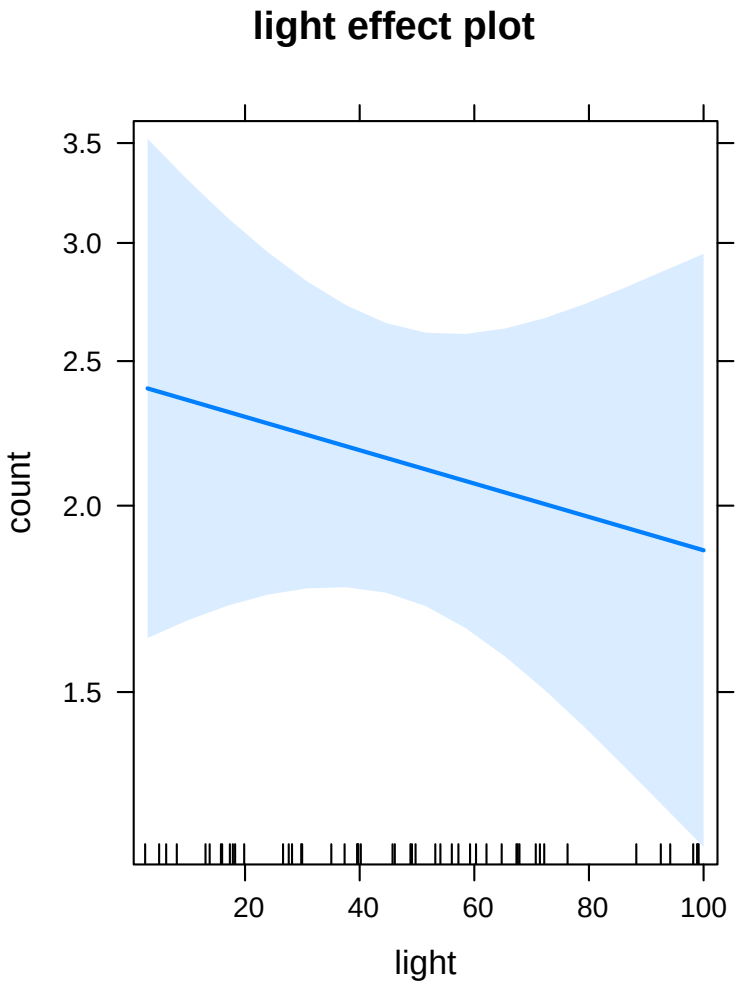
Use family quasipoisson

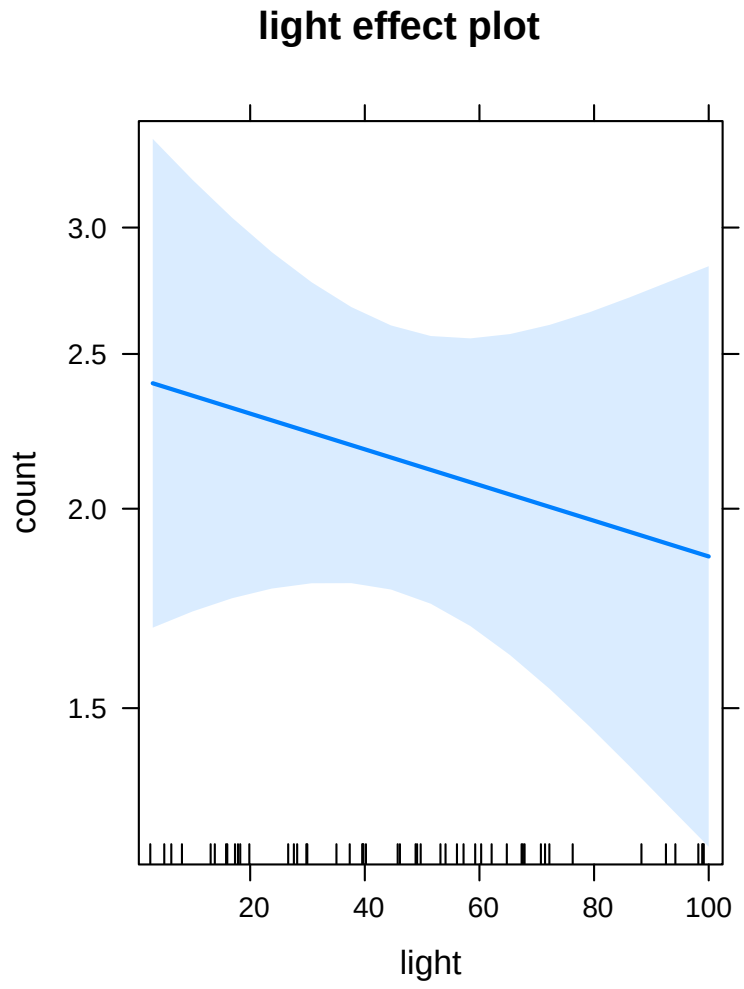
```
Call:
glm(formula = count ~ light, family = quasipoisson, data = seedl

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-2.1906  -0.8466  -0.1110   0.5220   2.4577

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.881805   0.201230   4.382 6.37e-05 ***
light       -0.002576   0.003758  -0.685    0.496
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for quasipoisson family taken to be 1.1349

    Null deviance: 63.029  on 49  degrees of freedom
Residual deviance: 62.492  on 48  degrees of freedom
```

Mean estimates do not change after accounting for overdispersion

```
 model: count ~ light

 light effect
light
       3        30        50        70       100
2.396665 2.235657 2.123408 2.016794 1.866826

 model: count ~ light

 light effect
light
       3        30        50        70       100
2.396665 2.235657 2.123408 2.016794 1.866826
```

But standard errors may change





What if survey plots have different area?

Avoid regression of ratios

seedlings/area $\sim$ light

J. R. Statist. Soc. A (1993)
156, *Part* 3, *pp.* 379–392

Spurious Correlation and the Fallacy of the Ratio Standard Revisited

By RICHARD A. KRONMAL†

Figure 1:

Use offset to standardise response variables in GLMs

```
seedl.offset <- glm(count ~ light, offset = seedl$area, data = s
summary(seedl.offset)
```

```
Call:
glm(formula = count ~ light, family = poisson, data = seedl,
    offset = seedl$area)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-2.6926  -0.8532   0.1491   0.5211   3.1051

Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept)  0.299469   0.185468   1.615    0.106
light       -0.004498   0.003441  -1.307    0.191

(Dispersion parameter for poisson family taken to be 1)

    Null deviance: 70.263  on 49  degrees of freedom
```

Note estimates now referred to area units

```
exp(coef(seedl.offset))
```

```
(Intercept)       light
  1.3491422   0.9955123
```