Generalized Models for Discrete Data

In many situations the results of an experiment may be recorded as binary or categorical, e.g. the presence or absence of a trait, a positive or negative reaction for viral resistance, or the position of an insect in a plant canopy. In other cases, the responses may be recorded as counts, such as the number of larvae per plant, the number of resistant plants from a cross pollination, or the number of weeds per square meter. Procedures in SAS such as PROC CATMOD are often utilized to analyze this type of data. Those procedures, however, assume that the total number of experimental units are constant or fixed (also known as fixed marginal totals). For example, suppose an experiment was conducted to see if an insect had a preference for the top or bottom of a leaf. A categorical analysis would assume a fixed number of insects were available for each leaf and those insects could be freely distributed on either side of the leaf, but nowhere else. In a laboratory setting or caged field study, this condition could be enforced. However, in an open field trial, the number of insects per leaf would be variable. The insects might fall off the leaf, move across leaves or simply disappear from the experiment.

In that case, the data is categorical (top or bottom), but the total number of insects per leaf is variable.

Similarly, when conducting weeds counts in a herbicide trial, the number of weeds found in randomly thrown quadrats will not be constant or fixed. The numbers are instead open ended with values ranging from 0 to some unknown upper limit. Again, these data are discrete counts, but the total number of weeds will vary, even within a treatment.

In situations such as these, an alternative statistical model, the Generalized Linear Model, is more appropriate. The SAS procedure which utilizes this model is PROC GENMOD. GENMOD is designed to correctly handle both data with fixed marginal totals as well as variable discrete data such as counts.

Example Data

This data comes from an experiment designed to test the effects of osmotic pressure when transferring foreign DNA to plant cells with a “gene gun”. Five levels of osmotic pressure were used: 0.0, 0.2, 0.4, 0.6, and 1.0 molar concentrations. Three replications of two flower cultivars (Mum and PJM) were subjected to these treatments in a completely random design. Each replication contained eight explants. The transferred gene was for beta-glucuronidase (GUS) expression. Explants responding positively to the transfer displayed blue spots after incubation while negative explants did not. The following SAS code reads in the data as: CULT (cultivar), TREAT (osmotic treatment), EXPLANT (explant ID), GUS (1= positive transgenic, 0=negative transgenic), and SPOTS (the number of positive spots present).

```
DATA OSMOTIC;
       INPUT CULT $ TREAT  EXPLANT GUS
SPOTS;
       CARDS;
Mum      0.0      1       1       4
Mum      0.0      2       1       3
Mum      0.0      3       1       16
Mum      0.0      4       1       4
Mum      0.0      5       1       6
Mum      0.0      6       1       8
Mum      0.0      7       1       8
Mum      0.0      8       1       3
Mum      0.0      1       1       3
Mum      0.0      2       1       7
Mum      0.0      3       1       1
Mum      0.0      4       0       0
Mum      0.0      5       1       4
Mum      0.0      6       1       1
Mum      0.0      7       1       1
Mum      0.0      8       1       2
Mum      0.0      1       1       2
Mum      0.0      2       0       0
Mum      0.0      3       1       13
Mum      0.0      4       1       5
Mum      0.0      5       0       0
Mum      0.0      6       0       0
Mum      0.0      7       0       0
Mum      0.0      8       0       0
Mum      0.2      1       1       19
Mum      0.2      2       1       14
Mum      0.2      3       1       1
Mum      0.2      4       1       9
Mum      0.2      5       1       17
Mum      0.2      6       1       14
Mum      0.2      7       1       4
Mum      0.2      8       1       9
Mum      0.2      1       1       15
Mum      0.2      2       1       29
Mum      0.2      3       1       13
Mum      0.2      4       1       14
Mum      0.2      5       1       23
Mum      0.2      6       1       10
Mum      0.2      7       1       8
Mum      0.2      8       1       40
Mum      0.2      1       1       34
Mum      0.2      2       1       43
Mum      0.2      3       1       52
Mum      0.2      4       1       56
Mum      0.2      5       1       26
Mum      0.2      6       1       70
Mum      0.2      7       1       63
Mum      0.2      8       1       66
Mum      0.4      1       1       4
Mum      0.4      2       0       0
Mum      0.4      3       1       1
Mum      0.4      4       1       4
Mum      0.4      5       1       4
Mum      0.4      6       1       7
Mum      0.4      7       1       9
Mum      0.4      8       1       1
Mum      0.4      1       1       94
Mum      0.4      2       1       32
Mum      0.4      3       1       10
Mum      0.4      4       1       6
Mum      0.4      5       1       15
Mum      0.4      6       1       5
Mum      0.4      7       1       53
Mum      0.4      8       1       3
Mum      0.4      1       1       21
Mum      0.4      2       1       25
Mum      0.4      3       1       8
Mum      0.4      4       1       7
Mum      0.4      5       1       13
Mum      0.4      6       1       22
Mum      0.4      7       1       7
Mum      0.4      8       .       .
Mum      0.6      1       1       7
Mum      0.6      2       1       6
Mum      0.6      3       1       1
Mum      0.6      4       1       3
Mum      0.6      5       1       6
Mum      0.6      6       1       1
Mum      0.6      7       1       11
Mum      0.6      8       1       18
Mum      0.6      1       1       56
Mum      0.6      2       1       23
Mum      0.6      3       1       26
Mum      0.6      4       1       10
```

Mum	0.6	5	1	10
Mum	0.6	6	1	12
Mum	0.6	7	1	17
Mum	0.6	8	1	69
Mum	0.6	1	1	67
Mum	0.6	2	1	27
Mum	0.6	3	1	57
Mum	0.6	4	1	25
Mum	0.6	5	1	16
Mum	0.6	6	1	60
Mum	0.6	7	1	20
Mum	0.6	8	1	11
Mum	1	1	1	1
Mum	1	2	0	0
Mum	1	3	1	1
Mum	1	4	1	1
Mum	1	5	0	0
Mum	1	6	0	0
Mum	1	7	1	1
Mum	1	8	0	0
Mum	1	1	0	0
Mum	1	2	1	1
Mum	1	3	1	1
Mum	1	4	1	1
Mum	1	5	0	0
Mum	1	6	1	8
Mum	1	7	1	6
Mum	1	8	1	3
Mum	1	1	1	14
Mum	1	2	1	2
Mum	1	3	1	2
Mum	1	4	1	2
Mum	1	5	1	2
PJM	0.2	7	0	0
PJM	0.2	8	0	0
PJM	0.2	1	.	.
PJM	0.2	2	.	.
PJM	0.2	3	0	0
PJM	0.2	4	1	1
PJM	0.2	5	0	0
PJM	0.2	6	0	0
PJM	0.2	7	0	0
PJM	0.2	8	0	0
PJM	0.2	1	1	1
Mum	1	6	1	5
Mum	1	7	1	3
Mum	1	8	1	4
PJM	0.0	1	.	.
PJM	0.0	2	.	.
PJM	0.0	3	0	0
PJM	0.0	4	1	1
PJM	0.0	5	0	0
PJM	0.0	6	0	0
PJM	0.0	7	0	0
PJM	0.0	8	0	0
PJM	0.0	1	.	.
PJM	0.0	2	.	.
PJM	0.0	3	1	1
PJM	0.0	4	0	0
PJM	0.0	5	1	4
PJM	0.0	6	1	1
PJM	0.0	7	0	0
PJM	0.0	8	0	0
PJM	0.0	1	0	0
PJM	0.0	2	0	0
PJM	0.0	3	0	0
PJM	0.0	4	1	2
PJM	0.0	5	0	0
PJM	0.0	6	1	1
PJM	0.0	7	0	0
PJM	0.0	8	1	1
PJM	0.2	1	.	.
PJM	0.2	2	.	.
PJM	0.2	3	.	.
PJM	0.2	4	0	0
PJM	0.2	5	0	0
PJM	0.2	6	0	0
PJM	0.2	2	1	1
PJM	0.2	3	0	0
PJM	0.2	4	0	0
PJM	0.2	5	0	0
PJM	0.2	6	0	0
PJM	0.2	7	.	.
PJM	0.2	8	.	.
PJM	0.4	1	.	.
PJM	0.4	2	1	1
PJM	0.4	3	0	0
PJM	0.4	4	0	0

```
PJM     0.4     5       0       0
PJM     0.4     6       0       0
PJM     0.4     7       0       0
PJM     0.4     8       .       .
PJM     0.4     1       .       .
PJM     0.4     2       .       .
PJM     0.4     3       0       0
PJM     0.4     4       0       0
PJM     0.4     5       0       0
PJM     0.4     6       0       0
PJM     0.4     7       0       0
PJM     0.4     8       0       0
PJM     0.4     1       .       .
PJM     0.4     2       .       .
PJM     0.4     3       .       .
PJM     0.4     4       1       3
PJM     0.4     5       1       2
PJM     0.4     6       0       0
PJM     0.4     7       .       .
PJM     0.4     8       .       .
PJM     0.6     1       .       .
PJM     0.6     2       .       .
PJM     0.6     3       .       .
PJM     0.6     4       0       0
PJM     0.6     5       0       0
PJM     0.6     6       0       0
PJM     0.6     7       0       0
PJM     0.6     8       0       0
PJM     0.6     1       .       .
PJM     0.6     2       .       .
PJM     0.6     3       .       .
PJM     0.6     4       0       0
PJM     0.6     5       1       1
PJM     0.6     6       0       0
PJM     0.6     7       0       0
PJM     0.6     8       0       0
PJM     0.6     1       0       0
PJM     0.6     2       0       0
PJM     0.6     3       0       0
PJM     0.6     4       0       0
PJM     0.6     5       0       0
PJM     0.6     6       0       0
PJM     0.6     7       .       .
PJM     0.6     8       .       .
PJM     1       1       0       0
PJM     1       2       0       0
PJM     1       3       0       0
PJM     1       4       0       0
PJM     1       5       0       0
PJM     1       6       0       0
PJM     1       7       0       0
PJM     1       8       0       0
PJM     1       1       .       .
PJM     1       2       1       5
PJM     1       3       0       0
PJM     1       4       0       0
PJM     1       5       0       0
PJM     1       6       0       0
PJM     1       7       0       0
PJM     1       8       0       0
PJM     1       1       0       0
PJM     1       2       0       0
PJM     1       3       0       0
PJM     1       4       0       0
PJM     1       5       0       0
PJM     1       6       0       0
PJM     1       7       0       0
PJM     1       8       0       0
;
```