

1. A total of 20 corn fields were randomly selected from a population of fields spread throughout the mid-western United States. The same variety was planted in each selected field, and the same basic management practices were employed for each field. Near the end of the growing season, five plots were randomly selected within each field. The insect damage done to each plot was determined according to the following strategy.

- i) 10 plants were randomly selected from each plot.
- ii) The amount of insect damage in each plant was rated as 0, 1, 2, 3, 4, or 5, with 0 indicating no damage through 5 indicating extreme damage.
- iii) The 10 ratings for each plot were averaged to get a single damage observation ( $y$ ) for each plot.

The 100 damage observations (20 fields, 5 plots per field) were analyzed using the following SAS code.

```
proc glm;  
  class field;  
  model y=field;  
run;
```

The sums of squares for *model* and *error* in SAS were 92.102 and 10.328, respectively.

- a) What are the degrees of freedom for the among-fields sum of squares?
- b) What are the degrees of freedom for plots within fields?
- c) Estimate of the variance component corresponding to among-field variation.
- d) Estimate the variance component corresponding to variation of plots within fields.
- e) Give a 95% confidence interval for the variance of plots within fields.
- f) Estimate the ratio of the variance among fields to the variance of plots within fields.
- g) Give a 95% confidence interval for the ratio of variances estimated in part (f). Can you conclude that one of the variance components is significantly larger than the other? Explain.
- h) Estimate the intraclass correlation coefficient.
- i) Is there evidence of field-to-field variation in susceptibility to insect damage? Give a test statistic, its degrees of freedom, an approximate  $p$ -value, and a conclusion.

2. A meat scientist is studying the effect of storage temperature on meat quality. The temperatures of interest are 34, 40, and 46 degrees Fahrenheit. Twelve coolers are available for the study. The three temperatures are randomly assigned to the twelve coolers in a completely randomized design. Two large cuts of fresh beef are stored in each cooler. After three days each member of a team of experts independently assigns a quality score to each cut of beef. The experts are not told about the storage conditions of each cut. The scores assigned by the team to each cut of beef are averaged to produce an overall quality score for each cut. Use the following SAS code and output to help you answer the questions below.

```
proc glm;
  class temp cooler quality;
  model quality=temp cooler(temp);
  random cooler(temp);
run;
```

The GLM Procedure  
 Dependent Variable: quality

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	??	14.02125000	??????????	6.81	0.0012
Error	??	2.24500000	??????????		
Corrected Total	??	16.26625000			

Source	DF	Type I SS	Mean Square	F Value	Pr > F
temp	??	7.83250000	??????????	20.93	0.0001
cooler(temp)	??	6.18875000	??????????	3.68	0.0196

Source	DF	Type III SS	Mean Square	F Value	Pr > F
temp	??	7.83250000	??????????	20.93	0.0001
cooler(temp)	??	6.18875000	??????????	3.68	0.0196

Source	Type III Expected Mean Square
temp	Var(Error) + ? Var(cooler(temp)) + Q(temp)
cooler(temp)	Var(Error) + ? Var(cooler(temp))

- Determine the degrees of freedom for *Model*, *Error*, *Corrected Total*, *temp*, and *cooler(temp)* for the output above. Although we haven't discussed the degrees of freedom for *Model* in class, it is the sum of the d.f. in the Type I portion of the output as usual.
- What number should replace the question marks in the *Type III Expected Mean Square* portion of the output?
- The temperature treatment means were 6.0500, 7.07500, and 5.7375 for temperatures of 34, 40, and 46 degrees F, respectively. Were there significant differences among the temperature means? Conduct one test to answer this question. Provide a test statistic, its degrees of freedom, an approximate *p*-value, and a conclusion.
- Determine the standard error of a treatment mean.
- Provide a 95% confidence interval for the mean of the 34 degree treatment.
- Provide a 95% confidence interval for the difference between the 40 degree treatment mean and the 34 degree treatment mean.
- Test for a difference between the mean for 40 degrees and the mean for 46 degrees. Provide a test statistic, its degrees of freedom, a *p*-value, and a conclusion.
- The model that SAS fit to the data involves a variance component that corresponds to variation of cuts of beef within coolers. Provide an estimate of that variance component.
- The model that SAS fit to the data involves a variance component that corresponds to variation of coolers within temperature treatment groups. Provide an estimate of that variance component.