Homework for Lesson 12

A study of recover of plants in Burned vs. Unburned areas involved repeated measurements of the same plots over a 15 month period. The floral count data, in stacked format, is in the Excel file ‘Flora.xlsx’ and is also shown below.

1. Plot the data, as response vs. time for each treatment level.



[used scatter plot in minitab with category as trt and plot]

1. Run a repeated measures ANOVA, and determine which covariance structure to use (you can base your decision on AICC values). Consider the Variance Components, Unstructured, Compound Symmetry, and Spatial Power covariance structures (the repeated measures are not equally spaced in time).

|  |
| --- |
| **Split-Plot in Time** |

**The Mixed Procedure**

| **Number of Observations** | |
| --- | --- |
| **Number of Observations Read** | 72 |
| **Number of Observations Used** | 72 |
| **Number of Observations Not Used** | 0 |

| **Type 3 Analysis of Variance** | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Source** | **DF** | **Sum of Squares** | **Mean Square** | **Expected Mean Square** | **Error Term** | **Error DF** | **F Value** | **Pr > F** |
| **trt** | 1 | 9964.013889 | 9964.013889 | Var(Residual) + 4 Var(plot(trt)) + Q(trt,trt\*time) | MS(plot(trt)) | 16 | 44.73 | <.0001 |
| **time** | 3 | 496.041667 | 165.347222 | Var(Residual) + Q(time,trt\*time) | MS(Residual) | 48 | 7.41 | 0.0004 |
| **trt\*time** | 3 | 434.597222 | 144.865741 | Var(Residual) + Q(trt\*time) | MS(Residual) | 48 | 6.49 | 0.0009 |
| **plot(trt)** | 16 | 3564.055556 | 222.753472 | Var(Residual) + 4 Var(plot(trt)) | MS(Residual) | 48 | 9.99 | <.0001 |
| **Residual** | 48 | 1070.611111 | 22.304398 | Var(Residual) | . | . | . | . |

| **Fit Statistics** | |
| --- | --- |
| **-2 Res Log Likelihood** | 434.7 |
| **AIC (Smaller is Better)** | 438.7 |
| **AICC (Smaller is Better)** | 438.9 |
| **BIC (Smaller is Better)** | 440.5 |

| **Type 3 Tests of Fixed Effects** | | | | |
| --- | --- | --- | --- | --- |
| **Effect** | **Num DF** | **Den DF** | **F Value** | **Pr > F** |
| **trt** | 1 | 16 | 44.73 | <.0001 |
| **time** | 3 | 48 | 7.41 | 0.0004 |
| **trt\*time** | 3 | 48 | 6.49 | 0.0009 |

|  |
| --- |
| **Compound Symmetry** |

**The Mixed Procedure**

| **Fit Statistics** | |
| --- | --- |
| **-2 Res Log Likelihood** | 434.7 |
| **AIC (Smaller is Better)** | 438.7 |
| **AICC (Smaller is Better)** | 438.9 |
| **BIC (Smaller is Better)** | 440.5 |

| **Type 3 Tests of Fixed Effects** | | | | |
| --- | --- | --- | --- | --- |
| **Effect** | **Num DF** | **Den DF** | **F Value** | **Pr > F** |
| **trt** | 1 | 16 | 44.73 | <.0001 |
| **time** | 3 | 48 | 7.41 | 0.0004 |
| **trt\*time** | 3 | 48 | 6.49 | 0.0009 |

|  |
| --- |
| **Variance Components** |

**The Mixed Procedure**

| **Model Information** | |
| --- | --- |
| **Data Set** | WORK.FLORA |
| **Dependent Variable** | resp |
| **Covariance Structure** | Variance Components |
| **Subject Effect** | plot(trt) |
| **Estimation Method** | REML |
| **Residual Variance Method** | Parameter |
| **Fixed Effects SE Method** | Kenward-Roger |
| **Degrees of Freedom Method** | Kenward-Roger |

| **Fit Statistics** | |
| --- | --- |
| **-2 Res Log Likelihood** | 473.3 |
| **AIC (Smaller is Better)** | 475.3 |
| **AICC (Smaller is Better)** | 475.3 |
| **BIC (Smaller is Better)** | 476.2 |

| **Type 3 Tests of Fixed Effects** | | | | |
| --- | --- | --- | --- | --- |
| **Effect** | **Num DF** | **Den DF** | **F Value** | **Pr > F** |
| **trt** | 1 | 64 | 137.59 | <.0001 |
| **time** | 3 | 64 | 2.28 | 0.0874 |
| **trt\*time** | 3 | 64 | 2.00 | 0.1228 |

|  |
| --- |
| **Spatial Power** |

**The Mixed Procedure**

| **Model Information** | |
| --- | --- |
| **Data Set** | WORK.FLORA |
| **Dependent Variable** | resp |
| **Covariance Structure** | Spatial Power |
| **Subject Effect** | plot(trt) |
| **Estimation Method** | REML |
| **Residual Variance Method** | Profile |
| **Fixed Effects SE Method** | Kenward-Roger |
| **Degrees of Freedom Method** | Kenward-Roger |

| **Covariance Parameter Estimates** | | |
| --- | --- | --- |
| **Cov Parm** | **Subject** | **Estimate** |
| **SP(POW)** | plot(trt) | 0.9655 |
| **Residual** |  | 84.2485 |

| **Fit Statistics** | |
| --- | --- |
| **-2 Res Log Likelihood** | 416.3 |
| **AIC (Smaller is Better)** | 420.3 |
| **AICC (Smaller is Better)** | 420.5 |
| **BIC (Smaller is Better)** | 422.0 |

| **Type 3 Tests of Fixed Effects** | | | | |
| --- | --- | --- | --- | --- |
| **Effect** | **Num DF** | **Den DF** | **F Value** | **Pr > F** |
| **trt** | 1 | 16.3 | 36.21 | <.0001 |
| **time** | 3 | 46.9 | 7.30 | 0.0004 |
| **trt\*time** | 3 | 46.9 | 5.51 | 0.0025 |

|  |
| --- |
| **Unstructured** |

**The Mixed Procedure**

| **Model Information** | |
| --- | --- |
| **Data Set** | WORK.FLORA |
| **Dependent Variable** | resp |
| **Covariance Structure** | Unstructured |
| **Subject Effect** | plot(trt) |
| **Estimation Method** | REML |
| **Residual Variance Method** | None |
| **Fixed Effects SE Method** | Kenward-Roger |
| **Degrees of Freedom Method** | Kenward-Roger |

| **Fit Statistics** | |
| --- | --- |
| **-2 Res Log Likelihood** | 397.9 |
| **AIC (Smaller is Better)** | 417.9 |
| **AICC (Smaller is Better)** | 422.0 |
| **BIC (Smaller is Better)** | 426.8 |

| **Type 3 Tests of Fixed Effects** | | | | |
| --- | --- | --- | --- | --- |
| **Effect** | **Num DF** | **Den DF** | **F Value** | **Pr > F** |
| **trt** | 1 | 16 | 44.73 | <.0001 |
| **time** | 3 | 14 | 4.33 | 0.0235 |
| **trt\*time** | 3 | 14 | 9.86 | 0.0009 |

|  |
| --- |
| **Autoregressive Lag 1** |

**The Mixed Procedure**

| **Model Information** | |
| --- | --- |
| **Data Set** | WORK.FLORA |
| **Dependent Variable** | resp |
| **Covariance Structure** | Autoregressive |
| **Subject Effect** | plot(trt) |
| **Estimation Method** | REML |
| **Residual Variance Method** | Profile |
| **Fixed Effects SE Method** | Kenward-Roger |
| **Degrees of Freedom Method** | Kenward-Roger |

| **Fit Statistics** | |
| --- | --- |
| **-2 Res Log Likelihood** | 431.5 |
| **AIC (Smaller is Better)** | 435.5 |
| **AICC (Smaller is Better)** | 435.7 |
| **BIC (Smaller is Better)** | 437.2 |

| **Type 3 Tests of Fixed Effects** | | | | |
| --- | --- | --- | --- | --- |
| **Effect** | **Num DF** | **Den DF** | **F Value** | **Pr > F** |
| **trt** | 1 | 15.7 | 41.03 | <.0001 |
| **time** | 3 | 46.2 | 7.56 | 0.0003 |
| **trt\*time** | 3 | 46.2 | 3.39 | 0.0257 |

|  |
| --- |
| **Covariance Summary** |

| **Obs** | **Descr** | **CS** | **VC** | **SP** | **AR1** | **UN** |
| --- | --- | --- | --- | --- | --- | --- |
| **1** | -2 Res Log Likelihood | 434.7 | 473.3 | 416.3 | 431.5 | 397.9 |
| **2** | AIC (Smaller is Better) | 438.7 | 475.3 | 420.3 | 435.5 | 417.9 |
| **3** | AICC (Smaller is Better) | 438.9 | 475.3 | 420.5 | 435.7 | 422.0 |
| **4** | BIC (Smaller is Better) | 440.5 | 476.2 | 422.0 | 437.2 | 426.8 |

Considering the AICC for the Variance Components, Unstructured, Compound Symmetry, and Spatial Power covariance structures, **we choose Spatial Power**

To Submit to the Dropbox:

1. Show the process of your decision making and the Type 3 fixed effects for your final model.

The selected model is **Spatial Power** covariance structure. Smaller or more negative values of AICC indicate better fit to the data. The process amounts to trying various candidate structures and then selecting the covariance structure producing the smallest or most negative values.

So we run the analysis as a repeated measures ANOVA, which allows us to evaluate which covariance structure fits best. We get the following Summary Table:

| **Obs** | **Descr** | **CS** | **VC** | **SP** | **AR1** | **UN** |
| --- | --- | --- | --- | --- | --- | --- |
| **1** | -2 Res Log Likelihood | 434.7 | 473.3 | 416.3 | 431.5 | 397.9 |
| **2** | AIC (Smaller is Better) | 438.7 | 475.3 | 420.3 | 435.5 | 417.9 |
| **3** | **AICC (Smaller is Better)** | **438.9** | **475.3** | **420.5** | **435.7** | **422.0** |
| **4** | BIC (Smaller is Better) | 440.5 | 476.2 | 422.0 | 437.2 | 426.8 |

Using the AICC as our criteria, we would choose the Spatial Power (SP) covariance structure.

|  |
| --- |
| **Spatial Power** |

**The Mixed Procedure**

| **Model Information** | |
| --- | --- |
| **Data Set** | WORK.FLORA |
| **Dependent Variable** | resp |
| **Covariance Structure** | Spatial Power |
| **Subject Effect** | plot(trt) |
| **Estimation Method** | REML |
| **Residual Variance Method** | Profile |
| **Fixed Effects SE Method** | Kenward-Roger |
| **Degrees of Freedom Method** | Kenward-Roger |

| **Fit Statistics** | |
| --- | --- |
| **-2 Res Log Likelihood** | 416.3 |
| **AIC (Smaller is Better)** | 420.3 |
| **AICC (Smaller is Better)** | 420.5 |
| **BIC (Smaller is Better)** | 422.0 |

| **Type 3 Tests of Fixed Effects** | | | | |
| --- | --- | --- | --- | --- |
| **Effect** | **Num DF** | **Den DF** | **F Value** | **Pr > F** |
| **trt** | 1 | 16.3 | 36.21 | <.0001 |
| **time** | 3 | 46.9 | 7.30 | 0.0004 |
| **trt\*time** | 3 | 46.9 | 5.51 | 0.0025 |

1. Compare the F statististic and p-value for the Treatment effect between the VC and your final model. What impact did fitting the covariance structure have on significance?

**VC** covariance structure**:**

| **Type 3 Tests of Fixed Effects** | | | | |
| --- | --- | --- | --- | --- |
| **Effect** | **Num DF** | **Den DF** | **F Value** | **Pr > F** |
| **trt** | 1 | 64 | 137.59 | <.0001 |
| **time** | 3 | 64 | 2.28 | 0.0874 |
| **trt\*time** | 3 | 64 | 2.00 | 0.1228 |

With VC structure we see that the interaction and time are not significant. Only treatment is significant.

**SP** covariance structure**:**

| **Type 3 Tests of Fixed Effects** | | | | |
| --- | --- | --- | --- | --- |
| **Effect** | **Num DF** | **Den DF** | **F Value** | **Pr > F** |
| **trt** | 1 | 16.3 | 36.21 | <.0001 |
| **time** | 3 | 46.9 | 7.30 | 0.0004 |
| **trt\*time** | 3 | 46.9 | 5.51 | 0.0025 |

With SP structure we see that the interaction is significant. Therefore treatment, time and their interaction are all significant.

**Note**: Because the time intervals are not equally spaced, the AR(1) is not appropriate as a candidate. Instead, the spatial power covariance structure should be considered. To use the spatial power type, we have to have the following lines in the data step:

input trt $ time flora;

month=time;

The reason for this is that we want to specify Time as a categorical fixed effect in the model statement, but we also need a quantitative equivalent of these times to use in calculating the exponents of the spatial power covariances. Then we use the following syntax in proc mixed:

repeated time / subject = …. type = sp(pow)(month);

The absolute values of the differences in time will then replace the integer values we would use in the AR(1) structure.