

Measuring Forest Tree Species Diversity

What is Species Diversity

Species diversity is measured through a combination of **species richness** (the number of species present) and **species evenness** (the relative abundance of each species). Species richness and evenness can be combined into a **single indicator**, and in ecology the **Shannon Index** is commonly used.

To measure the tree species diversity of a forest you need to know the total area of your forest and the area occupied by each species. This information may be available from inventory data or you might need to carry out a survey.

The area measurements can be in any units, as long as they are consistent, as the proportion is used calculate species diversity for the Shannon Index and species evenness.

If you have a list of smaller forest components you need to combine them to calculate the total area for each species, we provide two methods for doing this using Excel.

We provide step by step instructions for calculating the following in Microsoft Excel:

- Species Diversity (Shannon Index) Page 2
- Species richness Page 4
- Species Evenness: percentage area of the most dominant species Page 5
- Additional examples of Forest Tree Species Diversity Page 6
- Species area from a list Page 7

The Shannon Index

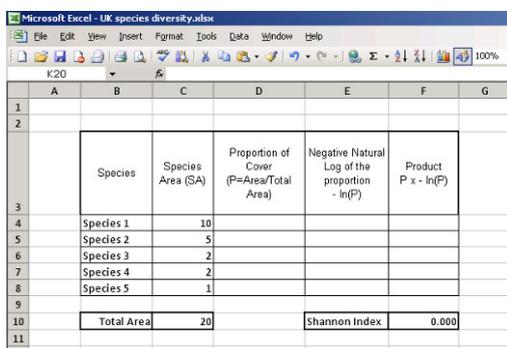
The Shannon Index combines species richness and evenness into a single indicator. You can calculate the Shannon Index in Microsoft Excel or other statistical or GIS software.

The scientific formula is

$$SI = - \sum_{i=1}^n p_i \cdot \ln p_i$$

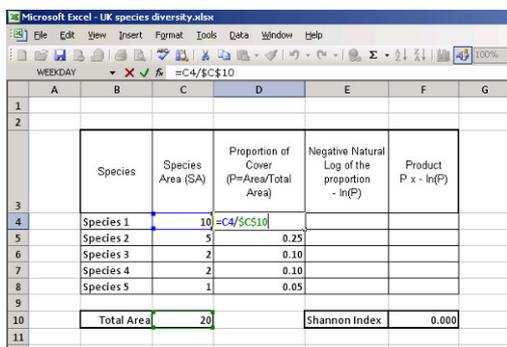
To calculate the Shannon Index using Excel:

- 1) Measure the total forest area (A) and the area of each species (SA) in the forest, either using a forest survey or inventory data. The measurements can be in any units, as long as they are consistent, as the proportion will be used to calculate the Shannon Index.



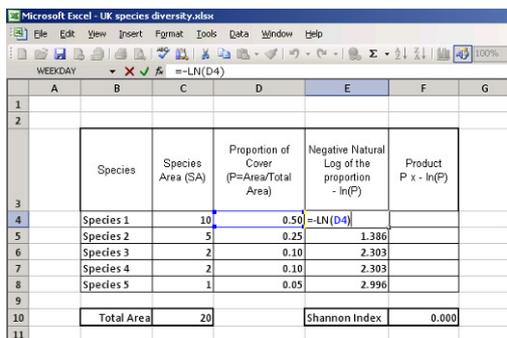
	A	B	C	D	E	F	G
1							
2							
3		Species	Species Area (SA)	Proportion of Cover (P=Area/Total Area)	Negative Natural Log of the proportion - ln(P)	Product P x -ln(P)	
4		Species 1	10				
5		Species 2	5				
6		Species 3	2				
7		Species 4	2				
8		Species 5	1				
9							
10		Total Area	20		Shannon Index	0.000	
11							

- 2) Calculate the proportion of each species (P). This is the area of each species divided by total area (P=SA/A)



	A	B	C	D	E	F	G
1							
2							
3		Species	Species Area (SA)	Proportion of Cover (P=Area/Total Area)	Negative Natural Log of the proportion - ln(P)	Product P x -ln(P)	
4		Species 1	10	=C4/\$C\$10			
5		Species 2	5	0.25			
6		Species 3	2	0.10			
7		Species 4	2	0.10			
8		Species 5	1	0.05			
9							
10		Total Area	20		Shannon Index	0.000	
11							

- 3) Take the natural log (ln) of the proportion of each species; multiply by -1 (-ln(P))



	A	B	C	D	E	F	G
1							
2							
3		Species	Species Area (SA)	Proportion of Cover (P=Area/Total Area)	Negative Natural Log of the proportion - ln(P)	Product P x -ln(P)	
4		Species 1	10	0.50	=LN(D4)		
5		Species 2	5	0.25	1.386		
6		Species 3	2	0.10	2.303		
7		Species 4	2	0.10	2.303		
8		Species 5	1	0.05	2.996		
9							
10		Total Area	20		Shannon Index	0.000	
11							



4) Multiply $-\ln(P)$ by P ($-\ln(P)*P$)

	A	B	C	D	E	F	G
1							
2							
3		Species	Species Area (SA)	Proportion of Cover (P=Area/Total Area)	Negative Natural Log of the proportion - ln(P)	Product P x - ln(P)	
4		Species 1	10	0.50	0.693	=D4*E4	
5		Species 2	5	0.25	1.386	0.347	
6		Species 3	2	0.10	2.303	0.230	
7		Species 4	2	0.10	2.303	0.230	
8		Species 5	1	0.05	2.996	0.150	
9							
10		Total Area	20		Shannon Index	1.303	
11							

5) Sum the values of $-P*\ln(P)$ to give the Shannon Index

	A	B	C	D	E	F	G	H
1								
2								
3		Species	Species Area (SA)	Proportion of Cover (P=Area/Total Area)	Negative Natural Log of the proportion - ln(P)	Product P x - ln(P)		
4		Species 1	10	0.50	0.693	0.347		
5		Species 2	5	0.25	1.386	0.347		
6		Species 3	2	0.10	2.303	0.230		
7		Species 4	2	0.10	2.303	0.230		
8		Species 5	1	0.05	2.996	0.150		
9								
10		Total Area	20		Shannon Index	=SUM(F4:F8)		
11								

In this example the Shannon Index is 1.30

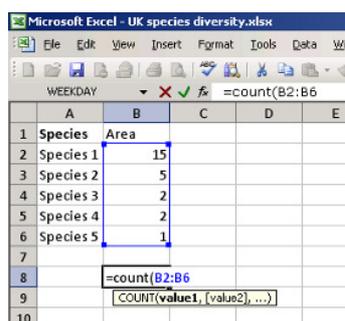
	A	B	C	D	E	F	G
1							
2							
3		Species	Species Area (SA)	Proportion of Cover (P=Area/Total Area)	Negative Natural Log of the proportion - ln(P)	Product P x - ln(P)	
4		Species 1	10	0.50	0.693	0.347	
5		Species 2	5	0.25	1.386	0.347	
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8		Species 5	1	0.05	2.996	0.150	
9							
10		Total Area	20		Shannon Index	1.303	
11							

Species Richness

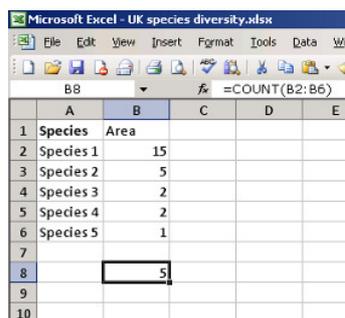
Species richness is the number of species present in the forest. For small datasets it can be counted manually. For larger datasets one way is to use the Excel COUNT function.

To Measure species richness:

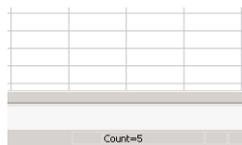
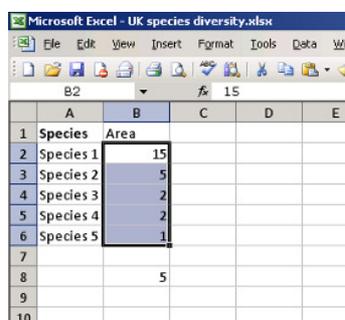
- 1) Type '=count(' and select the area values of your species, where the area is >0 then close the bracket with ')'



In this example the species richness is 5



- 2) Alternatively, select the area values of your species (where the area is >0) and in the bottom right hand corner the data statistics are shown. Right click over the data statistic and select 'Count'.

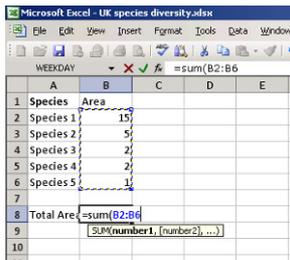


Species Evenness

Species evenness describes the relative abundance of each species. The percentage area of the most dominant species can be helpful in understanding evenness.

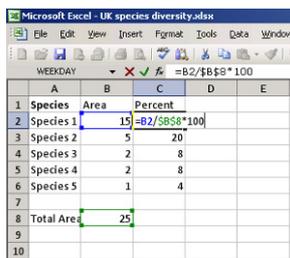
To calculate the percentage area of the most dominant species:

- 1) Calculate the total area of all the species: Total Area = sum(range)



Species	Area
Species 1	15
Species 2	5
Species 3	2
Species 4	2
Species 5	1
Total Area	=sum(B2:B6)

- 2) Calculate the percent cover of all the species: Percent = species area/total area*100

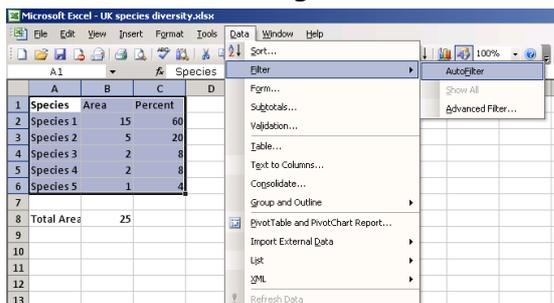
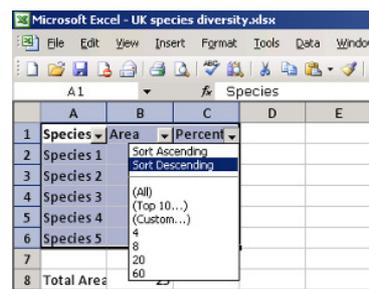


Species	Area	Percent
Species 1	15	=B2/\$B\$8*100
Species 2	5	20
Species 3	2	8
Species 4	2	8
Species 5	1	4
Total Area	25	

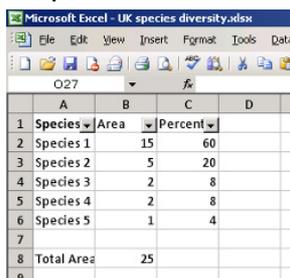
- 3) Sort your data:

Select your data and turn on Autofilter: Data -> Filter -> Autofilter

Select 'Sort Descending'

The first species is the most abundant (in this example Species 1), and the values correspond to the area and percent cover of the most dominant species (60%).



Species	Area	Percent
Species 1	15	60
Species 2	5	20
Species 3	2	8
Species 4	2	8
Species 5	1	4
Total Area	25	

Additional Examples of Forest Tree Species Diversity

Species	Species Area (SA)	Proportion of Cover (P=SA/A)	Negative Natural Log of P -ln(P)	Product P * -ln(P)
Species 1	10	0.50	0.693	0.347
Species 2	5	0.25	1.386	0.347
Species 3	2	0.10	2.303	0.230
Species 4	2	0.10	2.303	0.230
Species 5	1	0.05	2.996	0.150
Forest Area (A)	20		Shannon Index	1.303

Species Richness	5
Percent of Dominant Species	50%
Shannon Index	1.303

Species	Species Area (SA)	Proportion of Cover (P=SA/A)	Negative Natural Log of P -ln(P)	Product P * -ln(P)
Species 1	15	0.75	0.288	0.216
Species 2	5	0.25	1.386	0.347
Species 3	0	0.00	0.000	0.000
Species 4	0	0.00	0.000	0.000
Species 5	0	0.00	0.000	0.000
Forest Area (A)	20		Shannon Index	0.562

Species Richness	2
Percent of Dominant Species	75%
Shannon Index	0.562

Species	Species Area (SA)	Proportion of Cover (P=SA/A)	Negative Natural Log of P -ln(P)	Product P * -ln(P)
Species 1	4	0.20	1.609	0.322
Species 2	4	0.20	1.609	0.322
Species 3	4	0.20	1.609	0.322
Species 4	4	0.20	1.609	0.322
Species 5	4	0.20	1.609	0.322
Forest Area (A)	20		Shannon Index	1.609

Species Richness	5
Percent of Dominant Species	25%
Shannon Index	1.609

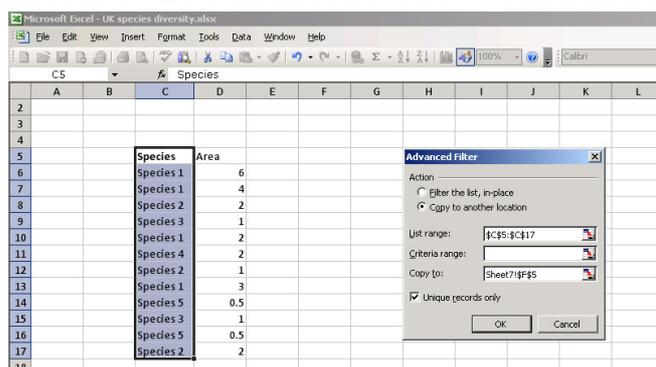
Calculating Species Area

If you have species areas data for smaller components or sub-compartments of your forest, such as from forest inventory records like the Sub-Compartment Database, you will need to calculate the total area of each species present in your forest. There are several ways to do this:

- For small forest areas and small numbers of species you can do this manually
- You can use ArcGIS or other spatial software
- Other statistical packages such as R
- In Microsoft Excel using the SUMIF function (see below, A)
- In Microsoft Excel using PivotTable (see below, B)

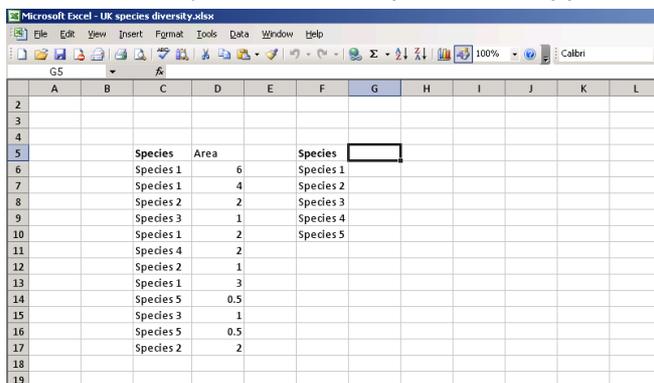
A) Using SUMIF to calculate species area

- 1) Arrange your data so that species names and area are visible in two columns
- 2) Summarise the list of all the species in your data:
 - i. Select the cells containing all the species names
 - ii. From the Data menu select Filter -> Advanced Filter



- Select 'Copy to another location'
- The 'List Range' is your species list
- Select an empty square in an empty column to 'Copy to'
- Check the box for 'Unique Records Only'
- Select 'OK'

iii. A summary list of all the species will appear



Species	Area	Species
Species 1	6	Species 1
Species 1	4	Species 2
Species 2	2	Species 3
Species 3	1	Species 4
Species 1	2	Species 5
Species 4	2	
Species 2	1	
Species 1	3	
Species 5	0.5	
Species 3	1	
Species 5	0.5	
Species 2	2	



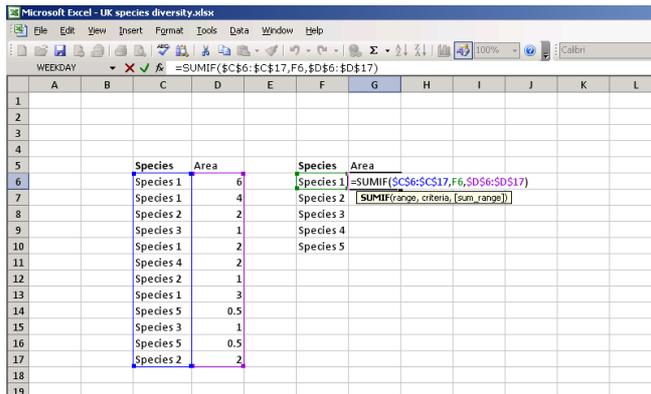
- 3) Calculate the area of each species using SUMIF
 - i. In the cell opposite your first species enter the formula
=SUMIF(range, criteria, sum_range)

With the field values defined as:

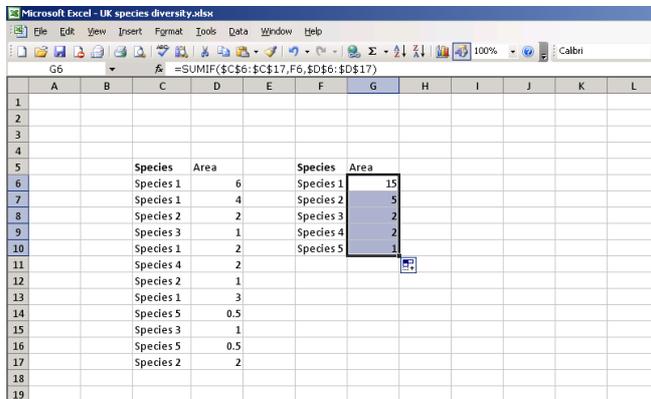
range = the cells containing the original, long list of species names

criteria = the cell reference for the species name in the summary list of species, calculated in step 2.

sum_range = the cells containing the original long list of area values



- ii. Copy the formula for each species.

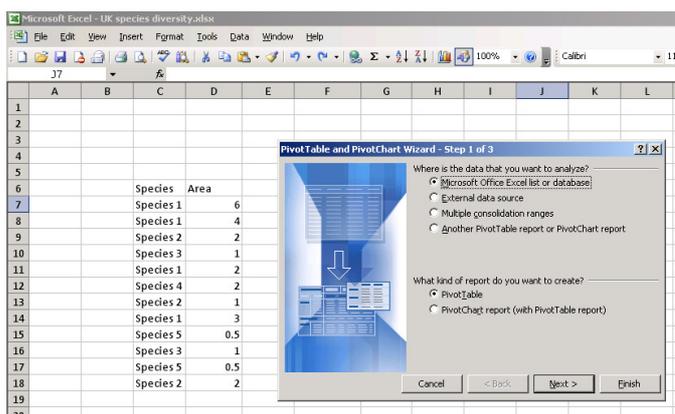


This provides the full list of species and their area

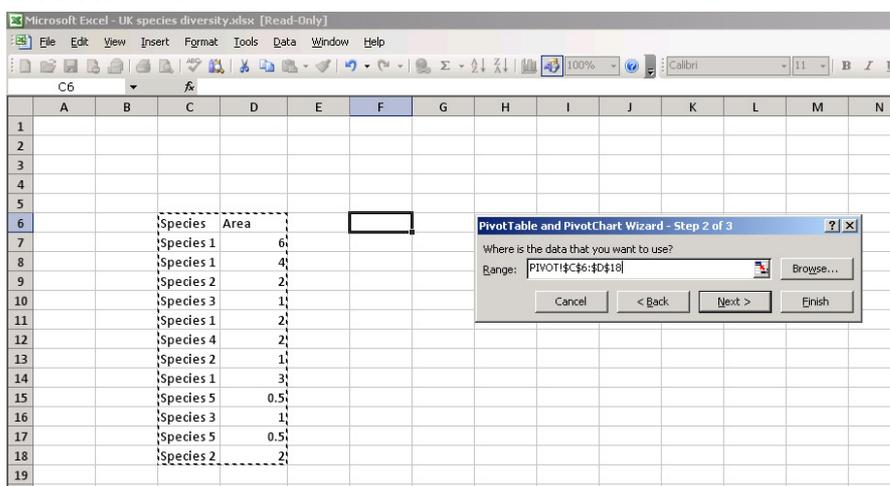
Species	Area
Species 1	15
Species 2	5
Species 3	2
Species 4	2
Species 5	1

B) Using PivotTable to calculate species area

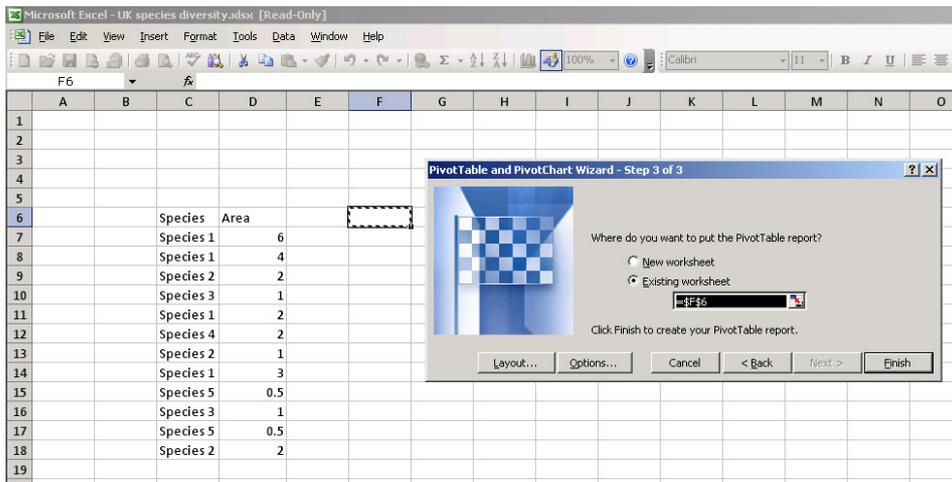
- 1) Arrange your data so that species names and area are visible in two columns
- 2) From the Data tab select 'PivotTable and PivotChart Report'
- 3) In the Menu box that appears, for Step 1 of 3
 - i. Select the data source as a 'Microsoft Office Excel list or database'
 - ii. The report type is 'PivotTable'
 - iii. Select Next



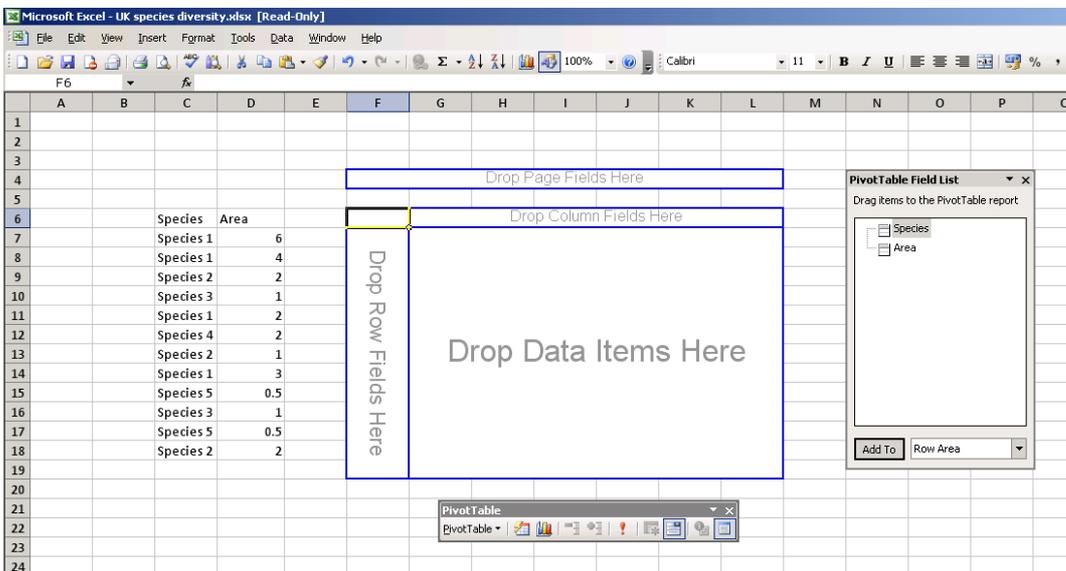
- 4) In step 2 of 3, select the data range.
 - i. The data range is the list of species names and their area values, including the data headings
 - ii. Select Next



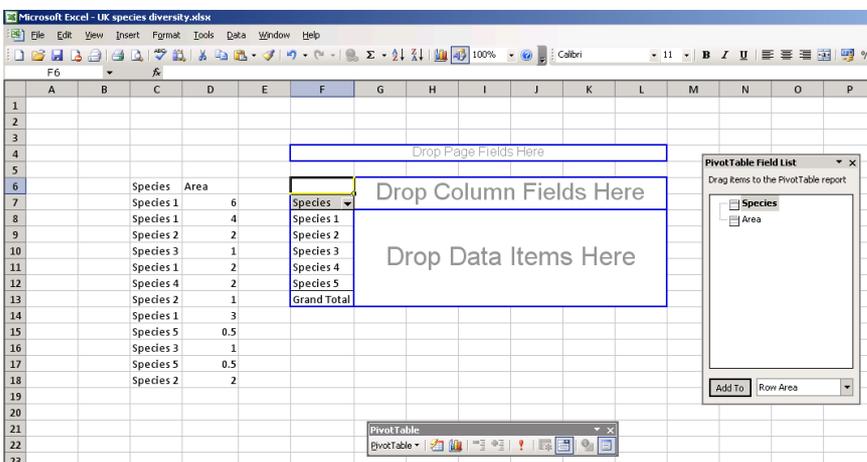
- 5) In step 3 of 3 you can choose to display the PivotTable in the current worksheet or a new worksheet
 - i. In this example we select the current worksheet
 - ii. Select Finish



iii. The empty PivotTable will appear

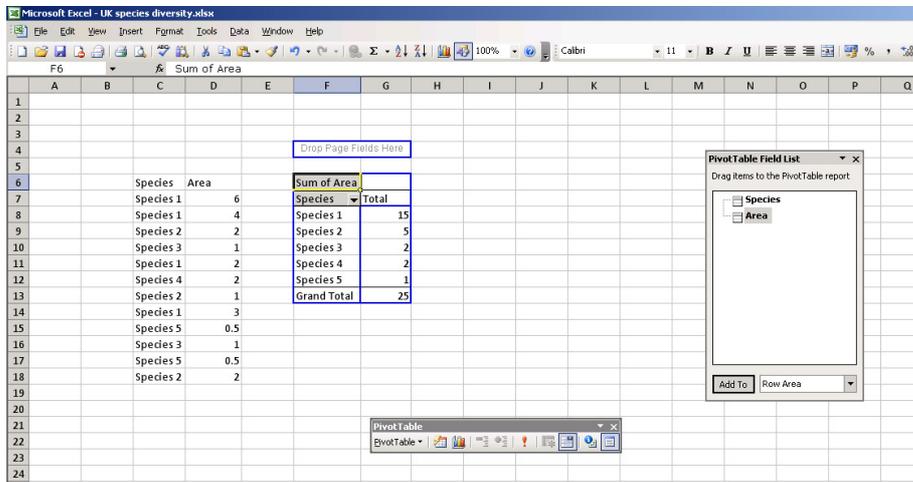


6) From the 'PivotTable Field List' drag 'Species' into the empty PivotTable where it says 'Drop Row Fields Here'

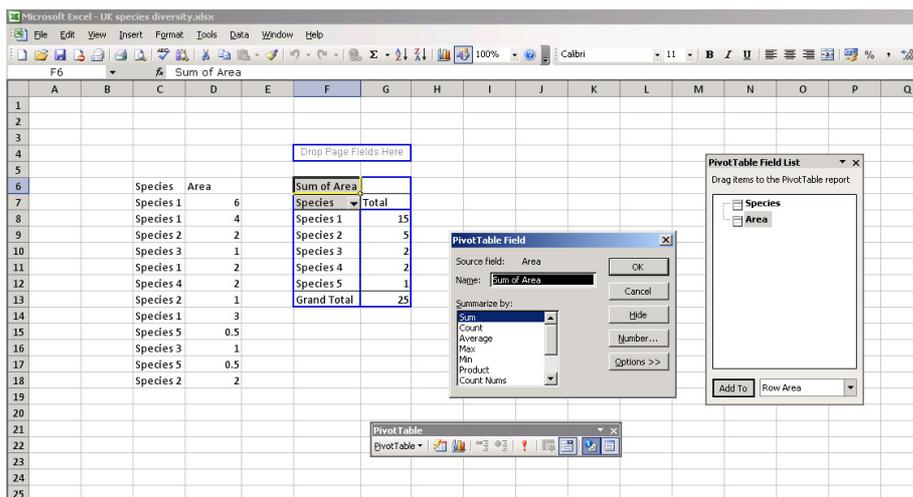




From the 'PivotTable Field List' drag 'Area' into the empty PivotTable where it says 'Drop Data Items Here'



- 7) Select 'Area' in the 'PivotTable Field List' and then click on the 'Field Settings' button on the 'PivotTable Wizard'. Under 'Summarize by' make sure that 'Sum' is selected and select OK.



Close the 'PivotTable Wizard' and 'PivotTable Field List'.

This provides the list of species and the area of each species in the forest.

