Bird Beak Accuracy Assessment

Purpose

To quantitatively evaluate the accuracy of a classification and understand a simple difference/error matrix

Overview

Students sort birds into three possible classes based on each bird's beak: carnivores (meat eaters), herbivores (plant eaters), and omnivores (meat and plant eaters). Students compare their answers with a given set of validation data and generate a difference/error matrix. Students discuss how to improve their accuracy based on identifying specific mistakes they made as indicated by the difference/error matrix.

Student Outcomes

Science Concepts

Physical Science

Objects have observable properties that can be measured using these properties.
Objects have observable properties.

Life Science

Organisms relate to their environment.

Scientific Inquiry Abilities

Identify decision criteria for a classification system, and use it to classify birds.
Collect and interpret validations data.
Use numerical data for in describing and comparing the accuracy of the classification.
Identify answerable questions.
Design and conduct scientific investigations.
Use appropriate mathematics to analyze data.
Develop descriptions and predictions using evidence.
Recognize and analyze alternative explanations.
Communicate procedures, descriptions, and predictions.
Specific skills

Level

Middle, Secondary

Time

One class period

Materials and Tools

Master set of bird pictures
Master validation sheet
Overhead showing a sample bird classification work sheet
Set of bird pictures for each student group
Student Activity Guide for each student group

Preparation

Reproduce the student *Work Sheets* and the bird picture sets without the answers on the back.

Prerequisites

Ability to classify (see *Leaf Classification Learning Activity*)

Understanding of fractions and/or percentages

Background

In the *Leaf Classification Learning Activity*, students learned to create and use a classification system. In this activity, students will learn to determine how good of a job they did classifying objects into a system.

Scientists classify many features of our environment such as animal species, plant species, land cover types, and soils. The ability to classify (or group) is a fundamental mechanism for helping to organize and understand the natural world. One application of remote sensing is to create a land cover type map of an area using satellite data for the classification. Since this map may be used to make decisions, it is important to know the accuracy of it. Comparing the results of a classification to a highly accurate data set (called *validation data*) is called *accuracy* assessment. This comparison is represented in a table called a *difference/error matrix*. Accuracy percentages of the classification are computed from the matrix.

This learning activity will introduce these concepts with a very simple classification of birds using just the shape of their beaks. Each student or group will classify each of 10 birds as an herbivore, carnivore, or omnivore. Each student or group will generate a difference/error matrix by comparing their classification with the validation data (provided). GLOBE students will use this exact same process to assess the accuracy of the maps they derive from the satellite imagery of their GLOBE Study Site. Land Cover Sample Sites visited on the ground will be used as validation data to compare with the student map classification generated from classifying the satellite data.

Key Terms and Concepts

Accuracy: Accuracy is the degree of conformity to a standard or accepted value. This is not the same as precision. Precision is the closeness of several measures to each other or the repeatability of a measurement.

High accuracy and low precision

High accuracy and high precision

Low accuracy and high precision
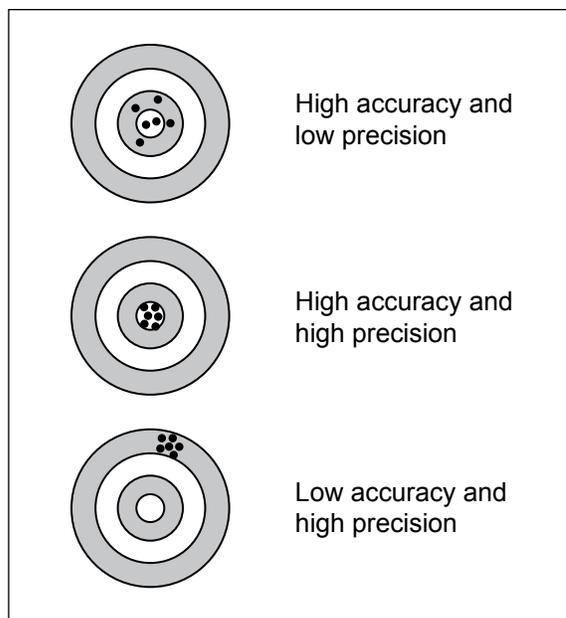
Difference/Error Matrix: A Difference/Error Matrix is a table of numbers organized in rows and columns that compares a classification to validation data. The columns represent the validation data while the rows represent the classification generated by students. A difference/error matrix is a very effective way to represent accuracy. Correct and incorrect classifications can be compared for each category and used to improve the accuracy of the original classification. See the *Accuracy Assessment Tutorial* in the *Biosphere Appendix.*

Validation Data: Validation data are data collected with a presumed high degree of accuracy. A classification of items (birds in this exercise) is compared to validation data: 1) to improve the decision criteria for the classification 2) to better understand the sources of error in the classification; and 3) to assess the accuracy of the classification data.

Pre-Activity Discussion Questions

To prepare your students, discuss the following questions before starting the activity:

- Why do we organize or sort objects into groups?
- How do we sort these objects?
- Name three examples of objects that are commonly sorted into groups.

Activity Adaptations

1. A visual interpretation can be used instead of mathematically calculating the overall accuracy.
    - Layout a 3-cell x 3-cell grid on a sheet of paper numbered like the cells in the difference/error matrix. Visually represent the number of birds in each box by either graphing or physically stacking blocks in the boxes. The tallest columns should be along the diagonal of the grid.
    - If the class has access to computer spreadsheets, a 3-D graph can be created to represent the answers. Figure LAND-BI-1 shows the data from the example difference/error matrix graphed in a 3-D format.
2. The entire class can also create one difference/error matrix together on the board.

Figure LAND-BI-1: 3D Difference/Error Matrix of Sample Bird Classification Data
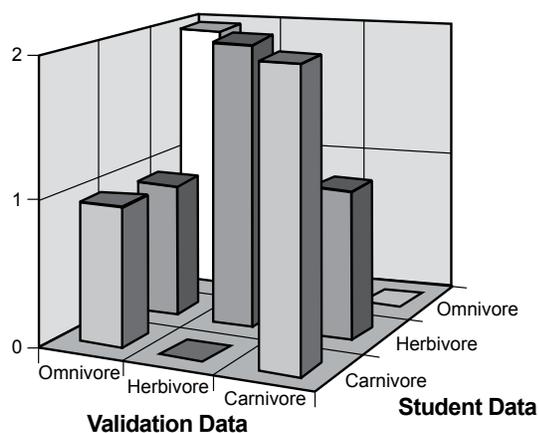
Assessment

1. Discuss the results of the activity with the following questions:
    a. How did different students' results vary?
    b. Why do students think this happened?
    c. What other classifications might be compared using a difference/error matrix (e.g., maps identifying land cover for a specific location versus carefully checking the same location in person).
2. Add two more data pairs (classification and validation data) and ask students to put these in the error matrix and recalculate any changes in accuracy.
3. Ask students to explain:
    a. how the difference/error matrix is constructed
    b. how data is entered
    c. how to calculate the overall accuracy
4. Examine your difference/error matrix to identify the most common errors.
5. For advanced students, explain the difference between user and producer accuracy.

References
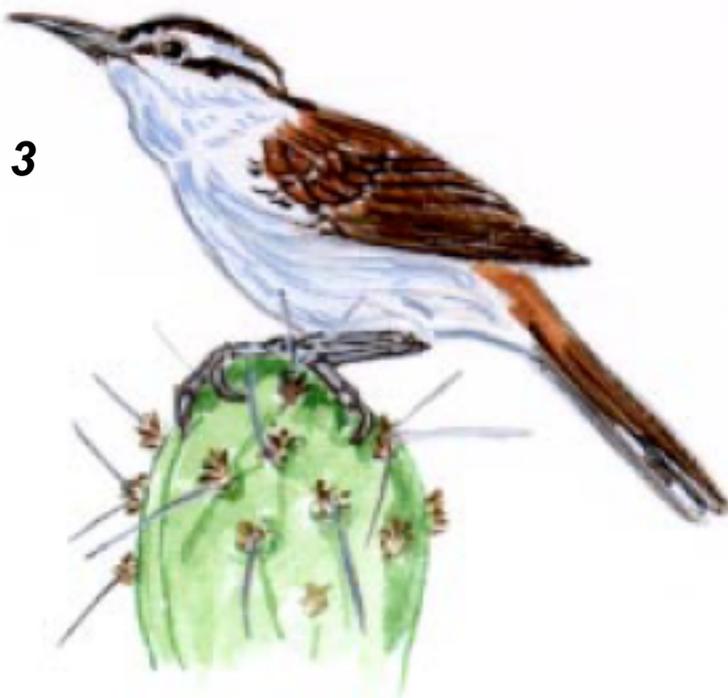
Peterson's Field Guide to Birds

Audubon Field Guides

The Illustrated Encyclopedia of Birds: The Definitive Reference to Birds of the World. Consultant-in Chief Dr. C. Perrins. New York: Prentice Hall Press, 1990.

Check local resources for regional guides

Acknowledgment
Art by Linda Isaacson

1

2

3

4

2. European Starling
(*Sturnus vulgaris*)

This bird (21 cm in size) lives in open woods, parks, and gardens in Europe and Western Asia, and has been introduced to North America, South America, Southern Australia and New Zealand. It eats both plants and animals.

Classification:

OMNIVORE

1. Western Greenfinch
(*Carduelis chloris*)

This bird (14.5 cm in size) lives in open woodland, bushes, and gardens in Europe, Northern Africa, Asia Minor, Middle East, and Central Asia. Its diet consists of nuts and seeds, especially sunflower seeds and peanuts.

Classification:

HERBIVORE

4. Rose-ringed Parakeet
(*Psittacula krameri*)

This bird (41 cm in size) lives in woodlands and farmlands in Central Africa east to Uganda, India, Sri Lanka, and has been introduced to Middle and Far East, North America, England, Netherlands, Belgium, and West Germany. It eats grain or ripening fruit.

Classification:

HERBIVORE

3. Bicolored Wren
(*Campylorhynchus griseus*)

This bird (22 cm in size) lives in dry savanna, cactus scrub, and open woods in Colombia, Venezuela, Northern Brazil and Guyana. Its finds insects and insect eggs by peering and poking into crevices on the ground.

Classification:

CARNIVORE
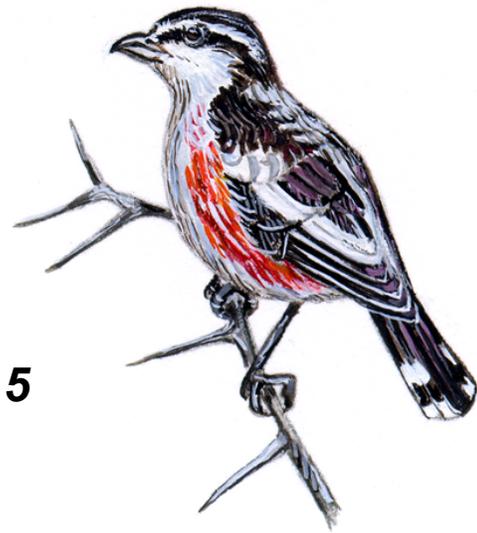
5

6

7

8

6. Clay Colored Robin
(*Turdus gray*i)

This bird (23-24 cm in size) lives in open woodland, woodland edge and clearings, usually near streams in Southeast Mexico, Central America, coastal Colombia. It eats insects, earthworms, slugs and lizards as well as fruit.

Classification:

OMNIVORE

5. Bru Bru Shrike
(*Nilaus afer*)

This bird (15 cm in size) lives in savanna woodland and sometimes the forest edge in tropical Africa. It eats insects and catches food on the wing.

Classification:

CARNIVORE

7. Pine Grosbeak
(*Pinicola enucleator*)

This bird (20 cm in size) lives in the coniferous and scrub forests of North and West North America, North Scandinavia and Siberia. It eats berries and buds on the ground or in treetops.

8. Eurasian Jay
(*Garrulus glandarius*)

This bird lives in oak woods, and open country in Western Europe, across Asia to Japan and Southeast Asia. It eats insects, beech nuts and acorns.

Classification:

HERBIVORE

Classification:

OMNIVORE

9

10

10. Hermit Thrush
(Catharus guttatus)

This bird (15-20 cm in size) lives in woodlands, forest edges and thickets in North and Central America. It eats insects, spiders, snails, earthworms and salamanders as well as fruits and seeds.

Classification:

OMNIVORE

9. Common Tree Creeper
(*Certhia familiaris*)

This bird (12.5 cm in size) lives in woodlands particularly coniferous woodlands in Western Europe and Japan. It eats insects and insect eggs gleaned from tree bark.

Classification:

CARNIVORE

Reference: *The Illustrated Encyclopedia of Birds: The Definitive Reference to Birds of the World.* Consultant-in Chief Dr. C. Perrins. New York: Prentice Hall Press, 1990.

Table Bio-BI-1: Bird Classification Validation Data Sheet

Bird ID	Bird Name	Classification
1	Western Greenfinch (*Carduelis chloris*)	Herbivore
2	European Starling (*Sturnus vulgaris*)	Omnivore
3	Bicolored Wren (*Campylorhynchus griseus*)	Carnivore
4	Rose-ringed Parakeet (*Psittacula krameri*)	Herbivore
5	Bru Bru Shrike (*Nilaus afer*)	Carnivore
6	Clay Colored Robin (*Turdus grayi*)	Omnivore
7	Pine Grosbeak (*Pinicola enucleator*)	Herbivore
8	Eurasian Jay (*Garrulus glandarius*)	Omnivore
9	Common Tree Creeper (*Certhia familiaris*)	Carnivore
10	Hermit Thrush (*Catharus guttatus*)	Omnivore

Bird Beak Accuracy Assessment
Student Activity Guide

Name: _____Date: _____

Overview
Scientists classify many features in our environment, such as species, land cover types and rock types. These classifications, or categories, help us to organize and understand the natural world. In order for these classifications to be useful to scientists, we need to know how accurate they are. A difference/error matrix is the basic tool used to measure the accuracy of a classification procedure. This difference/error matrix also shows us where there was confusion or difficulty classifying certain classes.

Materials
A set of 10 bird pictures, *Sample Beak Types*, *Bird Accuracy Assessment Work Sheet*, *Bird Difference/Error Matrix Work Sheet*

What To Do and How To Do It
In the following activity you will be classifying types of birds as:

Symbol	Bird Classification	Description	Food Preference
C	Carnivores	meat eaters	fish, meat, insects, worms, small mammals
H	Herbivores	plant eaters	vegetation, seeds, nuts, and berries
O	Omnivores	plant and meat eaters	all of the above

The size and shape of the bird's beak will usually indicate its preferred food type. Many birds are opportunistic however, and will supplement their preferred diet with a variety of foods when a scarcity of food requires it.

Herbivore Beak Types

Finch Type: Heavy wedge shaped beaks are good for cracking nuts and seed

Parrot Type: Thick curved upper and lower beak are also for cracking nuts or tearing fruit apart. The upper beak as a sharp point and usually curves over the lower beak.

Carnivore Beak Types

Insect Eater Type: Long slender, slightly curved beaks are used to probe for insects and spiders in tree bark and soils

Meat Eater Type: Shorter than the insect eater, upper beak has a sharp curved overhanging tip and straight lower beak specialized for tearing meat.

Omnivore Beak Types

Jay Type: Wide, medium length beak is used for eating insects, fruit, seeds, and even carrion.

Thrush Type: Shorter and more slender than the Jay type, also for eating meat, plants, and insects.

Bird Beak Accuracy Assessment
Student Activity Guide-2

Name: _____ Date: _____

Procedure

1. Look at each of the birds on the cards (numbered 1-10) and classify it as a carnivore, herbivore, or omnivore. Record each answer in the "Student Classification" column.
2. Your teacher will provide the information to be recorded in the column labeled "Validation Data." Be sure to fill in this column accurately, these data will be needed to complete the *Bird Difference/Error Matrix*.
3. Look at all ten pairs and mark each matching pair with a "✓" and each different (incorrect) pair with an "✗" in the last columns.

Bird Accuracy Assessment Data

Bird ID Number	Student Classification	Validation Data	✓	✗
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

4. Fill in the Difference/Error Matrix using the Bird Accuracy Assessment Student Field Guide.

Bird Difference/Error Matrix

Validation Data

		Carnivore	Herbivore	Omnivore	Row Totals
Student Classification	Carnivore				
	Herbivore				
	Omnivore				
	Column Totals				

Be sure to check with your teacher when you have entered all your data pairs and summed the columns and rows.

Bird Beak Accuracy Assessment
Student Activity Guide-3

Name: _____ Date: _____

Note: The numbers in the outlined boxes (the major diagonal), with the exception of the lower right hand box, are classified correctly. Go through the other boxes in the matrix to find any incorrect classifications. The Bird Difference/Error Matrix indicates the most difficult classes to identify. The numbers off the major diagonal represent "incorrect" classifications.

Which difference/error box has the largest number?

   5. Calculate the overall accuracy as outlined in the *Bird Beak Accuracy Assessment Student Field Guide*.

Discussion

   1. Did you have difficulty correctly classifying a particular category? Why?

   2. How could you reduce the number of errors next time?

   3. What are some other ways you can classify birds?

   4. Do you have any suggestions for improving the classification criteria?

   5. How did other students' results vary? Compare your difference/error matrix to other students' difference/error matrices to see who had the largest number of accurate answers and to see if other students or groups made mistakes classifying the same categories. What caused the mistakes?

   6. What other measures can be used to evaluate data quality?

Further Investigations

   1. Combine all the class data to create a class difference/error matrix. Calculate the overall accuracy of the class. Which do you think is more accurate, your matrix or the combined class results? Why?

   2. Try to develop your own criteria for classifying a group of objects (for example, insects).

Bird Beak Accuracy Assessment
Student Field Guide

Task:

Assess the accuracy of your bird classification. You will create and analyze the data using a difference/error matrix.

What You Need:

❏ **Completed Accuracy Assessment Data Work Sheet**

Bird ID Number	Student Classification	Validation Data	✓	✗
1	O	H		✗
2	O	O	✓	
3	O	C	✓	
4	H	H	✓	
5	C	C	✓	
6	C	O		✗
7	H	H	✓	
8	O	O	✓	
9	H	C		✗
10	H	O		✗

❏ Graph paper or blank paper

❏ Pencil or Pen

❏ Calculator

❏ Ruler/Straight Edge

1. Build an empty difference/error matrix.
   a. There should be a column and row in the matrix for every type of bird class that occurs on your *Accuracy Assessment Data Work Sheet*.
   b. Add two extra rows and two extra columns for the titles and totals.

Note: The example difference/error matrix is shaded to help show the titles, totals, and data in agreement. There is no need to shade your matrix.

2. Label Your Difference/Error Matrix with Titles and Bird Classes.
   a. Label the top, "*Validation Data*."
   b. Label the left side, "*Student Classification*."
   c. Label the columns and rows of the difference/error matrix with the bird classes from the *Accuracy Assessment Data Work Sheet* (C, H, O). Put the classes in the same order from the upper left-hand corner going down (row titles) and across (column titles).
   d. Label the last row "*Column Totals*."
   e. Label the last column, "*Row Totals*."

Validation Data

	C	H	O	Row Totals
C				
H				
O				
Column Totals				

Student Classification

3. Tally each row of data from the completed *Accuracy Assessment Data Work Sheet*.

a. Find the row in your matrix matching the Student Classification.
E.g., In the first row of the completed *Accuracy Assessment Data Work Sheet*, the Student Classification is "O" (Omnivore).

		Validation Data			
		C	H	O	Row Totals
Student Classification	C				
	H				
	O				
	Column Totals				

b. Find the column in your matrix matching the Validation Data.
E.g., In the first row of the completed *Accuracy Assessment Data Work Sheet*, the Validation Data is "H" (Herbivore).

		Validation Data			
		C	H	O	Row Totals
Student Classification	C				
	H				
	O				
	Column Totals				

c. Put a tally mark (*I*) in the box where the row and column overlap

		Validation Data			
		C	H	O	Row Totals
Student Classification	C				
	H				
	O		I		
	Column Totals				

d. Finish tallying for all the rows of data in your *Accuracy Assessment Data Work Sheet*.

		Validation Data			
		C	H	O	Row Totals
Student Classification	C	II		I	
	H	I	II	I	
	O		I	II	
	Column Totals				

4. Calculate Totals

a. **Calculate Row Totals** – For each row, add up all tally marks in the row and put that value in the *Row Total* box for that row.

Validation Data

Student Classification	C	H	O	Row Totals
C	II		I	3
H	I	II	I	
O		I	II	
Column Totals				

b. **Calculate Column Totals** – For each column, add up all tally marks in the column and put that value in the *Column Total* box for that column.

Validation Data

Student Classification	C	H	O	Row Totals
C	II		I	3
H	I	II	I	4
O		I	II	3
Column Totals	3			

c. **Total Data Samples**

Add up the *Row Totals* boxes. 3 + 4 + 3 = 10
Add up the *Column Totals* boxes. 3 + 3 + 4 = 10

The sum of the column totals should equal the sum of the row totals. This should be equal to the total number of data samples (rows) on your *Accuracy Assessment Data Work Sheet*.

Put this number in the bottom right box (where *Row Totals* and *Column Totals* overlap).

If the sum of the row totals does not equal the sum of the column totals, recheck your math and tallies.

Validation Data

Student Classification	C	H	O	Row Totals
C	II		I	3
H	I	II	I	4
O		I	II	3
Column Totals	3	3	4	10

5. Calculate the Overall Accuracy

$$\text{Overall Accuracy} = \frac{\text{sum of major diagonal tallies}}{\text{total number of samples}} \times 100$$

Add the tallies in all the boxes on the major diagonal of your matrix except the lower right-hand Total box. Divide this sum by the total number of samples (the value in the lower right-hand Total box). Multiply by 100 to convert it to a percentage.

Validation Data

Student Classification	C	H	O	Row Totals
C	II		I	**3**
H	I	II	I	**4**
O		I	II	**3**
Column Totals	**3**	**3**	**4**	**10**

$$\text{Overall Accuracy} = \frac{(2 + 2 + 2)}{10} \times 100 = 60\%$$