LES 17

O B S E R V A T O R Y
SCIENCE AND TECHNOLOGY (ST)
ENVIRONMENTAL SCIENCE AND TECHNOLOGY (EST)
Teacher's Guide A
Second Year of Secondary Cycle Two

A PARK IN THE CITY

STUDENT LOG

PROCEDURE AND EVALUATION: SSC2 – SCIENCE

Observatory / Guide
11129-A

Name: _____ Group: _____ ST EST

The case study

FOR IMMEDIATE RELEASE

PRESS RELEASE

Growing a healthy city

Gardenville, February 18, 2009. The city council wishes to inform residents that at its last meeting, it adopted a resolution to create new green spaces in the city.

To make an informed decision about the best type of park to develop, we have commissioned a study from the Reforesters consulting firm. We have asked Reforesters to study the two types of parks we have in Gardenville—nature parks and landscaped parks—and to answer the following questions:

- Which type of green space offers the greater biodiversity?
- Which type of green space absorbs more carbon dioxide?
- Where should these green spaces be located—near homes, roads, factories, etc.?

The firm will present a report with its recommendations for the suitable type of park to develop. When we have received this report, we will hold a special meeting to inform residents of the study's conclusions and our decision. At that time, we will ask all residents with an interest in this project to work with us toward ensuring its success.

In this context, you will play the role of an expert from the consulting firm and study the two types of park. To carry out your study, you will need to either choose two local parks that meet the criteria on the following page or use the data provided by your teacher.

Once your study is complete, you will draft the mayor's speech explaining the role trees play in the carbon and nitrogen cycles and in promoting human health. You will include the firm's recommendations for the type of green space to develop in the city and the best locations for the future parks. You could also suggest improvements to these two types of park.

The case study (*continued*)

Characteristics of the two types of park

Nature park:

- natural vegetation with very few modifications except possibly a few trails or paths
- random plant reproduction with little or no human intervention

Landscaped park:

- often developed by a landscaping firm
- many different types of plants and trees as well as paths and picnic areas
- regular maintenance of plants and trees

Collecting data in the field

Sectioning off a sample area:

- Measure a randomly selected 20 m × 20 m quadrat in the park under study. Place stakes at the four corners of the quadrat.
- Connect the stakes with string to mark the boundaries of the quadrat and make it easier to count the trees.

Counting the trees:

- Measure and record the circumference of every tree with a circumference of 15 cm or more. Then identify the species and mark the tree with a piece of ribbon.
- If a tree is growing on the edge of the quadrat, include it in the count only if at least half of its trunk is inside the quadrat.

Measuring the circumference of trees:

- Pull the tape measure tightly around the tree, perpendicular to the trunk.
- Take the measurement 1.3 metres from the ground.
- If the tree trunk splits less than 1.3 metres from the ground, count each of the two trunks as a separate tree.

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Creating the context

I ask myself questions

1. What is biodiversity?

2. What is carbon dioxide?

3. What is the carbon cycle?

4. What is the nitrogen cycle?

5. Who are the main players in this case study?

6. What questions should guide you in your information gathering?

Name: _____ Group: _____ ST EST

Creating the context (*continued*)

I must

7. Reformulate the goal of the case study.

I think

8. What do you think would be the most appropriate type of park? Explain your answer.

What I know and what I must find out

9. Write the information you already know and the information you need to find out.

What I know	What I must find out

Name: _____ Group: _____ ST EST

Creating the context (*continued*)

I prepare my work

10. Where will you find the information you need to do your work?

11. Define the main steps of your case study in chronological order.

Reflection

	Yes	No
Do I fully understand what I have to do?	☐	☐

Name: _____ Group: _____ ST EST

Gathering information

I do research

1. In what forms is carbon found in living organisms?

2. What is the role of cellular respiration in the carbon cycle? Explain your answer and write the corresponding chemical equation.

3. What is the role of photosynthesis in the carbon cycle? Explain your answer and write the corresponding chemical equation.

4. What is the impact of human activity on the carbon cycle?

Name: _____ Group: _____ ST EST

Gathering information (*continued*)

5. What human activity has had the greatest impact on the carbon cycle?

6. How do trees affect the carbon cycle?

7. What role does nitrogen play in living organisms?

8. How do plants contribute to the nitrogen cycle?

9. How can you determine which type of park offers the greatest biodiversity?

Gathering information (*continued*)

10. What is species richness?

11. What is relative abundance?

12. What will you have to measure to be able to compare the species richness and relative abundance of each tree species in the parks?

13. a) What is population size?

b) What methods can be used to determine the size of a population?

c) What method would be the most appropriate for determining the population size of trees in a nature park or a landscaped park? Explain your answer.

Name: _____ Group: _____ ST EST

Gathering information (*continued*)

d) According to the chosen method, explain the steps you will take and the calculations you will do to determine the size of the tree populations.

14. a) What is population density?

b) How do you determine population density?

15. What are the various forms of population distribution?

Gathering information (*continued*)

16. How are the nitrogen cycle and the carbon cycle connected?

17. a) In the 20 m × 20 m quadrat in the landscaped park, measure and record the circumference of every tree with a circumference of 15 cm or more. Identify the trees by species and record the results in a table.

b) Classify and compile data for each tree species in the quadrat.

18. Record the area of the landscaped park you are studying.

19. Create a table to pool the results, listing the various tree species found in the landscaped park in alphabetical order. Then complete the table with the following information:

- the number of individuals of each species per quadrat
- the total number of individuals of each species
- the total number of individuals in each quadrat
- the total number of individuals in the study

20. a) In the 20 m × 20 m quadrat in the nature park, measure and record the circumference of every tree with a circumference of 15 cm or more. Identify the trees by species and record the results in a table.

b) Classify and compile data for each tree species in the quadrat.

21. Record the area of the nature park you are studying.

22. Create a table to pool the results, listing the various tree species found in the nature park in alphabetical order. Then complete the table with the following information:

- the number of individuals of each species per quadrat
- the total number of individuals of each species
- the total number of individuals in each quadrat
- the total number of individuals in the study

Name: _____ Group: _____ ST EST

Gathering information (*continued*)

I apply my research results

23. Calculate the species richness for each quadrat and for the entire landscaped park.

24. Do the following calculations for each tree species in the landscaped park. Record your results in a table.

a) total number of individuals
b) average number of individuals per quadrat
c) population size
d) population density

Species	Total number of individuals	Average number of individuals per quadrat	Population size	Population density (per ha)

Name: _____ Group: _____ ST EST

Gathering information (*continued*)

25. Calculate the species richness for each quadrat and for the entire nature park.

26. Do the same calculations as in question 24 for each tree species in the nature park. Record your results in a table.

Species	Total number of individuals	Average number of individuals per quadrat	Population size	Population density (per ha)

Name: _____ Group: _____ ST EST

Gathering information (*continued*)

27. Calculate the relative abundance of each tree species in the landscaped park. Then present your results in a bar graph, using a sheet of graph paper.

Species	Population size	Relative abundance (%)

28. What is the pattern of distribution of trees in the landscaped park? Explain your answer.

Name: _____ Group: _____ ST EST

Gathering information (*continued*)

29. Calculate the relative abundance of each tree species in the nature park. Then present your results in a bar graph, using a sheet of graph paper.

Species	Population size	Relative abundance (%)

30. What is the pattern of distribution of trees in the nature park? Explain your answer.

Name: _____ Group: _____ ST EST

Gathering information (*continued*)

31. What is the total density for each type of park?

32. Write any other relevant information that will help you formulate the consulting firm's recommendation and write the mayor's speech.

Reflection

	Yes	No
Do I fully understand the concepts covered in this situation?	☐	☐

Name: _____ Group: _____ ST EST

Completing the case study

1. According to your results, which type of park would absorb more carbon dioxide? Explain your answer.

2. Which type of park contains greater biodiversity? Explain your answer.

3. Which type of park do you recommend? Suggest a few places where this type of park should be located.

4. Write the mayor's speech explaining the role of trees in the carbon and nitrogen cycles and presenting the recommendations of the consulting firm.

Name: _____ Group: _____ ST EST

Completing the case study (*continued*)

Reflection

	Yes	No
Have I considered other approaches?	☐	☐

Name: _____ Group: _____ ST EST

Validating the case study

I justify my approach

1. What are the advantages of your recommendation?

2. What are the disadvantages of your recommendation?

3. Do you have any improvements to suggest for the development of future parks? Explain your answer.

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Validating the case study (*continued*)

4. What are the advantages of the method you used to determine the size of each tree population?

5. What are the disadvantages of the method you used to determine the size of each tree population?

6. If you had to redo this study, what improvements would you make to your work?

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My evaluation

Use the evaluation grid on the following page to evaluate yourself. Write A, B, C, D or E in the "Me" column of the chart below.

SSC2—Makes the most of his/her knowledge of science and technology				
Criteria*	**Observable indicators**	**Me**	**Teacher**	**Comments**
1	**Creating the context** Definition of the goal and formulation of the steps to achieve it		☐ With help	
2	**Gathering information** Compilation of data; calculations to determine the biodiversity and population density		☐ With help	
3	**Completing the case study** Determination of the biodiversity of the park types and formulation of the recommendation		☐ With help	
4	**Validating the case study** Justification of the recommendation		☐ With help	

***Evaluation criteria**

1 Formulation of appropriate questions
2 Appropriate use of scientific and technological concepts, laws, models and theories
3 Relevant explanations or solutions
4 Suitable justification of explanations, solutions, decisions or opinions

Name: _____ Group: _____

ST EST

Evaluation grid

SSC2 Makes the most of his/her knowledge of science and technology

Criteria*	Observable indicators	A	B	C	D	E
1	**Creating the context** Definition of the goal and formulation of the steps to achieve it	The goal of the case study is very clearly formulated, and all the steps to achieve it are relevant.	The goal of the case study is clearly formulated, and most of the steps to achieve it are relevant.	The goal of the case study is not very clearly formulated, OR only some steps to achieve it are relevant.	The goal of the case study is not very clearly formulated, AND only some steps to achieve it are relevant.	The work must be done again.
2	**Gathering information** Compilation of data; calculations to determine the biodiversity and population density	The data is properly compiled to facilitate analysis. All the calculations are correct.	Most of the data is properly compiled to facilitate analysis. Most of the calculations are correct.	The data is not properly compiled, OR many calculations are incorrect.	The data is not properly compiled, AND many calculations are incorrect.	The work must be done again.
3	**Completing the case study** Determination of the biodiversity of the park types and formulation of the recommendation	The recommendation is highly relevant: it takes into account the results obtained. The mayor's speech explains the role of trees in the carbon and nitrogen cycles very clearly.	The recommendation is relevant: it takes into account some of the results obtained. The mayor's speech explains the role of trees in the carbon and nitrogen cycles clearly.	The recommendation is not very relevant, OR the mayor's speech does not explain the role of trees in the carbon and nitrogen cycles very clearly.	The recommendation is not very relevant, AND the mayor's speech explains the role of trees in the carbon and nitrogen cycles poorly.	The work must be done again.
4	**Validating the case study** Justification of the recommendation	The advantages and disadvantages of the recommendation are relevant and very clearly explained.	The advantages and disadvantages of the recommendation are relevant and clearly explained.	The advantages and disadvantages of the recommendation are not very relevant.	The advantages and disadvantages of the recommendation are irrelevant.	The work must be done again.

*Evaluation criteria

1 Formulation of appropriate questions

2 Appropriate use of scientific and technological concepts, laws, models and theories

3 Relevant explanations or solutions

4 Suitable justification of explanations, solutions, decisions or opinions

Information documents

The forest: a green lung?

Highway operators like to remind us that vegetation growing along major roadways tends to thrive. And there is a reason for this: the carbon dioxide (CO_2) emitted by exhaust pipes is the raw material plants use for photosynthesis. In this process, small holes (or pores) on the surface of leaves, called *stomata*, open in the presence of light. The plant absorbs CO_2 through these pores, collecting the carbon to build the sugars necessary for its growth. Throughout the night, part of the CO_2 absorbed during the day is slowly released through the cuticle (or skin) of the leaves and other plant organs through a process called *cellular respiration*. The net result of this exchange—the tree absorbs more carbon than it releases—gives the tree its reputation as a *carbon sink*. CO_2 thus stimulates the growth of trees. In fact, according to research conducted in greenhouses by the French Institut national de la Recherche agronomique (INRA) [National Institute for Agricultural Research], doubling the amount of CO_2 available leads to a 40-percent increase in tree growth. This effect varies depending on the forest species: deciduous trees, such as beech, are more sensitive to variations in CO_2 than conifers, such as firs.

You might think that in a perfect carbon cycle, anthropogenic (human) emissions (created primarily by fossil fuel combustion) would be offset by photosynthesis sustained, and even stimulated, by the additional CO_2 emissions. A balance would be achieved between CO_2 emissions from human activity and CO_2 absorption by plants.

But this idea fails to account for the fact that trees store CO_2 only when they are growing. When they die (and rot), they release it. Other mechanisms also contribute to the production of CO_2, such as the respiration of plants, animals and microorganisms. Every autumn, the leaves fall to the ground. Some of this organic matter is decomposed by microorganisms (bacteria, fungi) living underground or in the forest litter (dead leaves, bark and twigs). The CO_2 released by this decomposition leads to concentrations in forestland that may be 25 times higher than atmospheric concentrations. By gradually releasing this CO_2 into the atmosphere, the soil generates 50 to 70 percent of the flow of carbon between the forest ecosystem and the atmosphere. . . .

Source: Anaïs Joseph and Éric Dufrêne, "Les forêts: soldats de bois contre effet de serre" [online article], *Banque des savoirs*, Conseil général de l'Essonne, France, June 5, 2006 (accessed February 24, 2009). *[Translation]*

Information documents (*continued*)

What is carbon fixation?

The Earth's climate has always changed, and it will continue to do so. What is different about the climate warming we are now observing is its attribution, according to a broad scientific consensus, to human causes. It can be explained by the greenhouse effect, which is the ability of the atmosphere to retain the heat of the sun's rays reflected by the Earth. This process is essential to life on Earth because it ensures a stable temperate climate. The heat is retained by greenhouse gases (GHG), the best-known and most widespread of which is carbon dioxide (CO_2). The climate is warming now because the proportion of these gases in the atmosphere is higher than in past centuries and has been increasing steadily since the beginning of the industrial era, in the mid-18th century. Climate change represents a serious danger for all living organisms, including humans, because natural systems cannot adapt fast enough to keep pace with probable changes. Climate warming will certainly have an impact in the coming decades, but the process has not yet reached a point of no return. That is why we must act quickly to minimize the damage. The use of fossil fuels—particularly for transportation—is the greatest source of GHG emissions. Every time we drive our cars, the gas we burn produces GHG that enter the atmosphere and immediately contribute to climate warming. In 2004, road transportation accounted for 33 percent of GHG emissions in Québec, including 22.6 percent for passenger vehicles (see Figure 1). Transportation is thus the principal source of GHG emissions in the province.

We can fight climate warming in many ways, the first step being to reduce our use of fossil fuels. Other sure methods of reduction include energy efficiency, the use of "green energy," and carbon sinks. The principle behind carbon sinks is to prevent CO_2 from entering the atmosphere by sequestering it in growing trees. Since vegetable fibre is composed largely of carbon, trees need to absorb large amounts of carbon to ensure their growth. Carbon is captured through the process of photosynthesis, in which trees use chlorophyll and sunlight to capture CO_2, release oxygen (O_2) and transform the carbon into organic compounds. . . .

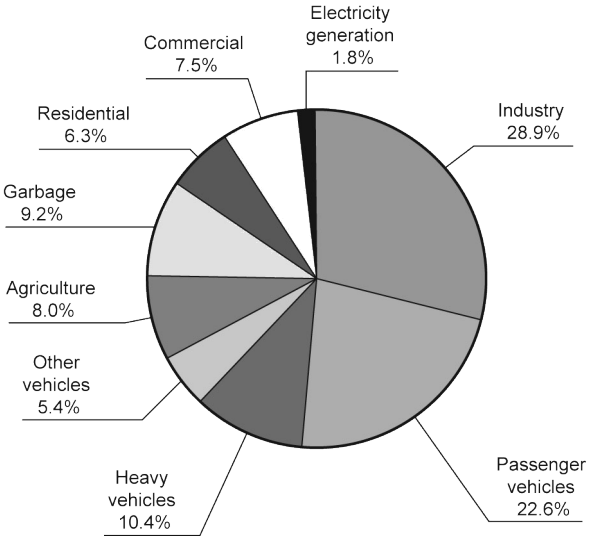


Figure 1: Principal sources of greenhouse gases in Québec in 2004

Information documents (*continued*)

What is carbon fixation? *(continued)*

One cubic metre of wood stores about a tonne of carbon dioxide, and in Canada, a single tree converts an average of 225 kg. . . . An activity described as "carbon neutral" is not necessarily without impact on the climate, especially if, like driving, it generates pollutants or harmful residues other than CO_2. The most effective way to fight climate change and air pollution is therefore to reduce road transportation and adopt more environmentally friendly habits of consumption.

How will carbon be fixed?

The carbon produced by fossil fuel combustion will be sequestered in growing trees. The biomass added every year to the structure of the tree is composed largely of carbon. When the tree reaches maturity and stops growing, its carbon capture rate will become marginal and is thus no longer calculated. The absorption rate of trees varies greatly depending on their species, their geographic locations and their growing conditions. In 1995, Freedman and Keith of Tree Canada calculated an average carbon capture rate for all trees in Canada over an 80-year period at 200 kg in urban areas and 225 kg in rural areas. . . .

Source: La Fondation Cowboys Fringants, "Roulez au neutre! Réduction des émissions de CO_2" [online article] (accessed November 19, 2008). *[Translation]*

Information documents (*continued*)

Identification key for the main tree species growing naturally in Québec

Deciduous trees

COMPOUND LEAVES

entire leaves
- fruit: one-winged samara ..... **Ash** *Fraxinus sp.*
- fruit: nut ..... **Walnut** *Juglans sp.* or **Hickory** *Carya sp.*

lobed leaves
- fruit: two-winged samara ..... **Manitoba maple** *Acer negundo*

SIMPLE LEAVES

entire leaves

LEAVES WITH ASYMMETRIC BASE
- thick, rough leaves ..... **American elm** *Ulmus americana*
- broad, cordate (heart-shaped) leaves ..... **American basswood** *Tilia americana*

LEAVES WITH SYMMETRIC BASE

single-toothed leaves
- pointed teeth
  - lance-shaped leaves
    - flowers in clusters called *catkins* ..... **Willow** *Salix sp.*
    - white flowers, fruit: cherries ..... **Cherry** *Prunus sp.*
  - oval leaves, one tooth per vein, smooth bark ..... **American beech** *Fagus grandifolia*
- rounded teeth
  - roundish leaves with small teeth ..... **Quaking aspen** *Populus tremuloides*
  - roundish leaves with large, wide teeth ..... **Large-toothed aspen** *Populus grandidentata*
  - triangular leaves with large teeth ..... **Eastern cottonwood** *Populus deltoides*

doubly toothed leaves ..... **Birch** *Betula sp.*
- triangular leaves ..... **Grey birch** *Betula populifolia*
- oval leaves ..... **Yellow birch** *Betula alleghaniensis*
- oval leaves with bark that peels off easily in horizontal strips ..... **Paper birch** *Betula papyrifera*

Information documents (*continued*)

Identification key for the main tree species growing naturally in Québec (*continued*)

lobed leaves

LEAVES WITH PALMATE VEINS

leaves with acute, pointed sinuses

- leaves: 3 to 5 wide lobes, shallow sinuses ..... **Red maple** *Acer rubrum*
- leaves: 5 narrow lobes, deep sinuses ..... **Silver maple** *Acer saccharinum*

leaves with rounded sinuses

- leaves with 5 lobes, sparsely toothed ..... **Sugar maple** *Acer saccharum*
- leaves with 3 lobes, finely toothed ..... **Striped maple** *Acer pensylvanicum*

LEAVES WITH PINNATE VEINS, fruit: acorn ..... **Oak** *Quercus sp.*

- leaves with pointed lobes ..... **Red oak** *Quercus rubra*
- leaves with rounded lobes
  - shallow sinuses ..... **Swamp white oak** *Quercus bicolor*
  - deep U-shaped sinuses ..... **White oak** *Quercus alba*
  - deep sinuses in the middle of the leaf reaching almost to the central vein (midrib) ..... **Bur oak** *Quercus macrocarpa*

Information documents (*continued*)

Identification key for the main tree species growing naturally in Québec (*continued*)

Conifers *(needle- or scale-shaped leaves; fruit: cones)*

NEEDLE-LIKE LEAVES

NEEDLES IN BUNDLES

bundles of more than 5 needles (that fall from the tree in the autumn) ..... **Tamarack larch** *Larix laricina*

bundles of 5 needles or fewer

- 5 needles ..... **Eastern white pine** *Pinus strobus*
- 3 needles ..... **Pitch pine** *Pinus rigida*
- 2 2- to 4-cm twisted needles ..... **Jack pine** *Pinus divaricata*
- 2 10- to 15-cm needles ..... **Red pine** *Pinus resinosa*

NEEDLES ATTACHED SINGLY TO BRANCHES

flat needles (will not roll between the fingers**)**

- needles in two rows, on each side of twig ..... **Balsam fir** *Abies basalmea*
- small needles (1 cm), rounded tips ..... **Canadian hemlock** *Tsuga canadensis*

four-sided needles (will roll between the fingers)

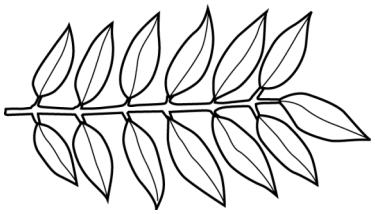
- hairless twigs, cylindrical cones ..... **White spruce** *Picea glauca*
- hairy twigs, round cones ..... **Black spruce** *Picea mariana*

SCALE-LIKE LEAVES, fruit: small cones with 8 to 17 scales ..... **Eastern arborvitae (white cedar)** *Thuja occidentalis*

Information documents (*continued*)

Visual glossary

Deciduous trees



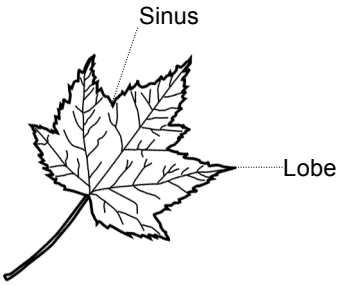
1. Compound leaf: several leaflets

or

Simple leaf

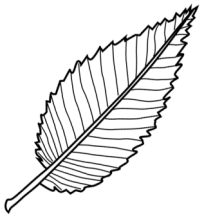
2. Entire leaf: without lobe

or



Lobed leaf

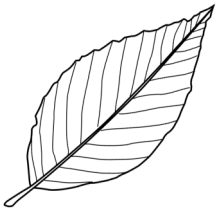
3. Other characteristics



Leaf with asymmetric base

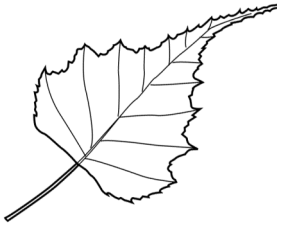
Leaf with symmetric base

Leaf with palmate veins (arranged like the fingers of a hand)

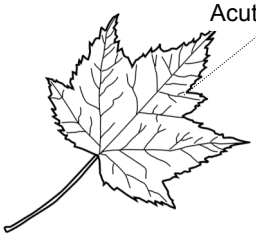


Leaf with pinnate veins (arranged like the barbs of a feather)

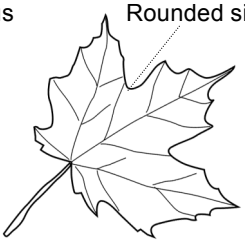
Single-toothed leaf



Doubly toothed leaf



Leaf with acute, pointed sinuses



Leaf with rounded sinuses

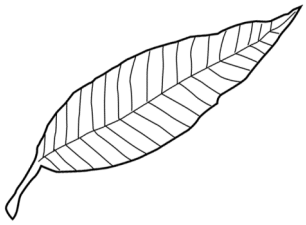
Name: _____ Group: _____ ST EST

Information documents (*continued*)

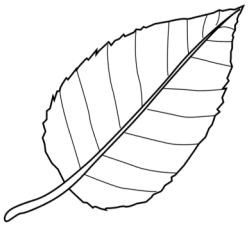
Visual glossary (*continued*)

Cordate leaf
(heart-shaped)

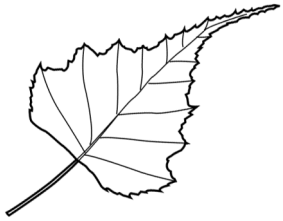
Round leaf



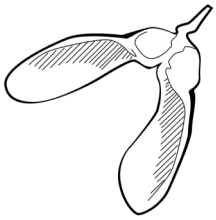
Lance-shaped leaf



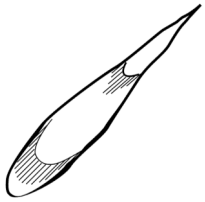
Oval leaf



Triangular leaf

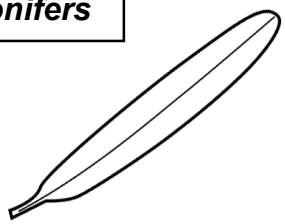


Two-winged samara



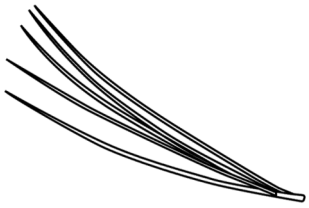
One-winged samara

Conifers

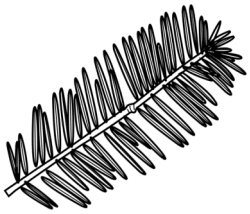


1. Needle-like leaf **or**

Scale-like leaf

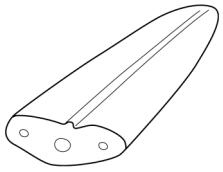


2. Needles in bundles **or**

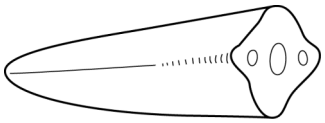


Single needles

3. Other characteristics



Flat needle



Four-sided needle