WETLAND ECOSYSTEMS III

EVOLUTION, DIVERSITY AND THE SUSTAINABILITY OF ECOSYSTEMS

EDUCATOR'S

GUIDE

HIGH SCHOOL SCI ENCE GRADES 9 to 12

PRESENTED BY Ducks Unlimited Canada

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info ZONE

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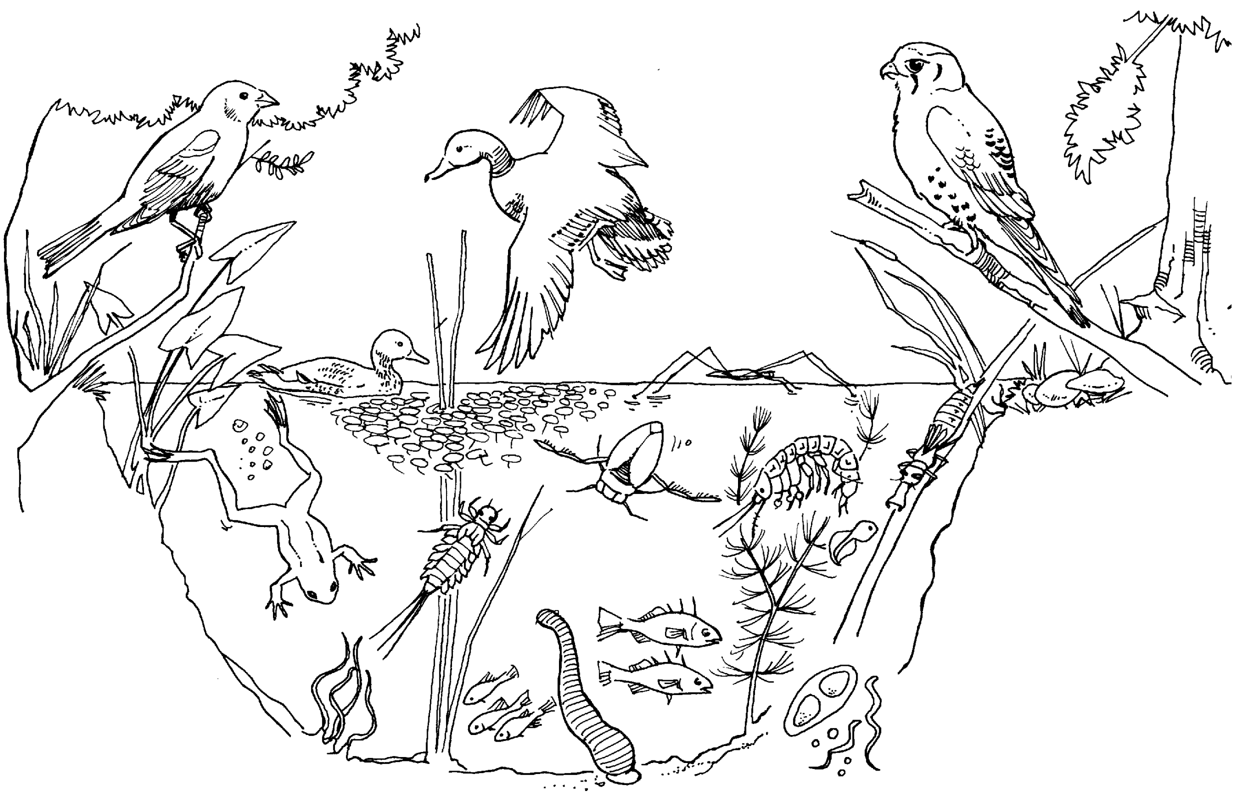
Introduction

In this unit, wetlands found close to most communities across North America are used to demonstrate a wide variety of ecological concepts. Through the activities and lessons provided, students can develop the foundation for literacy in the life sciences. You can help students enhance their understanding of the environmental, technological and social aspects of science and encourage them to work together to solve problems. At Ducks Unlimited, it is our hope that students in their senior years (grades 9 to 12) will develop an appreciation for science and a sense of wonder about wetlands.

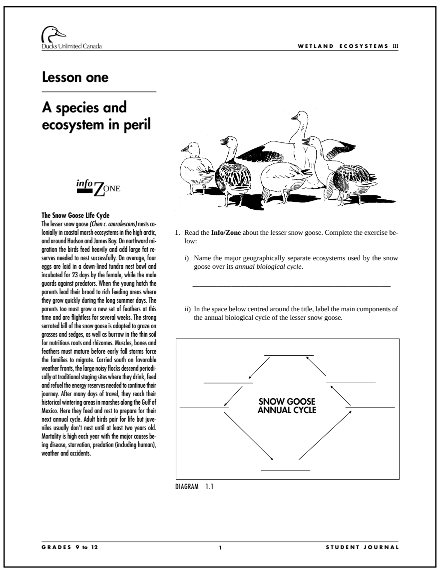
This unit combines a field trip to a wetland ecosystem with a variety of classroom activities. The field trip can be undertaken at any point in the unit but timing will depend most on season, weather conditions and opportunity. If a field trip is not possible, the classroom lessons and some of the activities may be used in a stand-alone format.



Lesson one

A species and ecosystem in peril

Estimated time: two to five hours


Ducks Unlimited Canada WETLAND ECOSYSTEMS III

Lesson one

A species and ecosystem in peril

info ZONE

The Snow Goose Life Cycle
The lesser snow goose *(Chen c. caerulescens)* nests colonially in coastal marsh ecosystems in the high arctic, and around Hudson and James Bay. On northward migration the birds feed heavily and add large fat reserves needed to nest successfully. On average, four eggs are laid in a down-lined tundra nest bowl and incubated for 23 days by the female, while the male guards against predators. When the young hatch the parents lead their brood to rich feeding areas where they grow quickly during the long summer days. The parents too must grow a new set of feathers at this time and are flightless for several weeks. The strong serrated bill of the snow goose is adapted to graze on grasses and sedges, as well as burrow in the thin soil for nutritious roots and rhizomes. Muscles, bones and feathers must mature before early fall storms force the families to migrate. Carried south on favorable weather fronts, the large noisy flocks descend periodically at traditional staging sites where they drink, feed and refuel the energy reserves needed to continue their journey. After many days of travel, they reach their historical wintering areas in marshes along the Gulf of Mexico. Here they feed and rest to prepare for their next annual cycle. Adult birds pair for life but juveniles usually don't nest until at least two years old. Mortality is high each year with the major causes being disease, starvation, predation (including human), weather and accidents.

1. Read the **Info/Zone** about the lesser snow goose. Complete the exercise below:

   i) Name the major geographically separate ecosystems used by the snow goose over its *annual biological cycle*.

   ii) In the space below centred around the title, label the main components of the annual biological cycle of the lesser snow goose.

SNOW GOOSE ANNUAL CYCLE

DIAGRAM 1.1

GRADES 9 to 12 1 STUDENT JOURNAL

STUDENT JOURNAL PAGE ONE

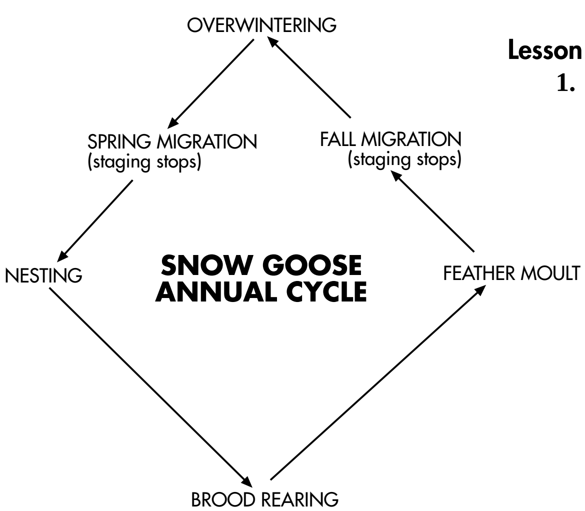


DIAGRAM 1.1

Curriculum alignment

Human actions, both intentional and unintentional, modify ecosystem diversity, carrying capacity and sustainability through direct and indirect changes to both biotic and abiotic factors. In this lesson, students will evaluate potential management solutions to environmental problems through discussion and democratic processes.

Vocabulary

Carrying capacity, interpolation, extrapolation, exponential growth, hyper-saline, anthropogenic, socio-political, hypothesis, annual biological cycle, adaptation, abiotic, biotic, staging area, harvest rate, biomass pyramid, species diversity, sustainability, desertification, referendum, public hearing.

At the completion of this lesson students should be able to:

- graph and interpret wildlife population data, and extrapolate and develop hypotheses about the sustainability of population growth.
- understand the concept of the annual biological cycle and geographic components of habitat for a migratory species.
- understand adaptations of animals in relation to changing factors and discern between biotic and abiotic factors that have direct and indirect impacts, and which may be natural or human-induced.
- understand the concept of biomass/energy pyramid and its various trophic levels.
- understand and appreciate the many possible solutions to an environmental problem and how socio-political considerations may influence final decisions.
- appreciate the role that public hearings, referenda, scientific research and technology play in influencing political actions.

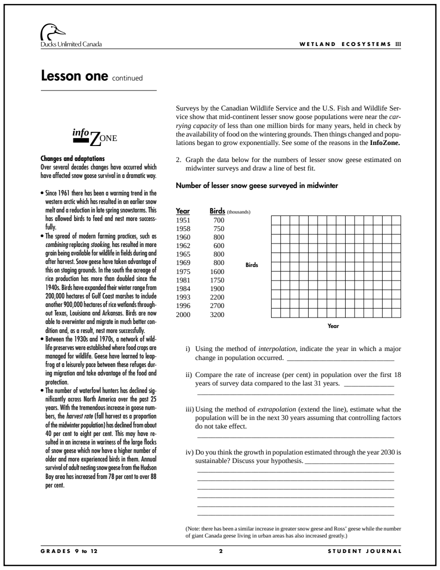
Resources

The video *Snow Goose in Peril* from the *Ducks Unlimited Natural History Series*, student journal, access to various Internet sites.

Lesson description

1. Begin this lesson by having the students read the short **InfoZone** piece about the lesser snow goose on page one of the student journal. Refer students to other library references (e.g. *The Birds of Canada* by W.G. Godfrey; *Ducks, Geese & Swans of North America* by F.C. Bellrose) and internet sites (e.g. **http://north.audubon.org/**). Discuss the concept of an annual cycle. For the snow goose this includes overwintering, spring migration, feeding or staging stops, nesting, egg incubation, brood rearing, feather moult and fall migration before a return to wintering. Note that each of these major functions has specific time and place characteristics and associated habitat requirements. Have students answer question 1i on page one. Have the students complete the diagram on page one of the student journal (diagram 1.1). The diagram should depict the lesser snow goose's annual cycle using words and arrows.

Lesson one continued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Lesson one continued

infoZONE

Changes and adaptations
Over several decades changes have occurred which have affected snow goose survival in a dramatic way.

- Since 1961 there has been a warming trend in the western arctic which has resulted in an earlier snow melt and a reduction in late spring snowstorms. This has allowed birds to feed and nest more successfully.
- The spread of modern farming practices, such as *combining* replacing *stooking*, has resulted in more grain being available for wildlife in fields during and after harvest. Snow geese have taken advantage of this on staging grounds. In the south the acreage of rice production has more than doubled since the 1940s. Birds have expanded their winter range from 200,000 hectares of Gulf Coast marshes to include another 900,000 hectares of rice wetlands throughout Texas, Louisiana and Arkansas. Birds are now able to overwinter and migrate in much better condition and, as a result, nest more successfully.
- Between the 1930s and 1970s, a network of wildlife preserves were established where food crops are managed for wildlife. Geese have learned to leapfrog at a leisurely pace between these refuges during migration and take advantage of the food and protection.
- The number of waterfowl hunters has declined significantly across North America over the past 25 years. With the tremendous increase in goose numbers, the *harvest rate* (fall harvest as a proportion of the midwinter population) has declined from about 40 per cent to eight per cent. This may have resulted in an increase in wariness of the large flocks of snow geese which now have a higher number of older and more experienced birds in them. Annual survival of adult nesting snow geese from the Hudson Bay area has increased from 78 per cent to over 88 per cent.

Surveys by the Canadian Wildlife Service and the U.S. Fish and Wildlife Service show that mid-continent lesser snow goose populations were near the *carrying capacity* of less than one million birds for many years, held in check by the availability of food on the wintering grounds. Then things changed and populations began to grow exponentially. See some of the reasons in the **InfoZone.**

2. Graph the data below for the numbers of lesser snow geese estimated on midwinter surveys and draw a line of best fit.

Number of lesser snow geese surveyed in midwinter

Year	Birds (thousands)
1951	700
1958	750
1960	800
1962	600
1965	800
1969	800
1975	1600
1981	1750
1984	1900
1993	2200
1996	2700
2000	3200

Birds
Year

i) Using the method of *interpolation*, indicate the year in which a major change in population occurred. ______________________

ii) Compare the rate of increase (per cent) in population over the first 18 years of survey data compared to the last 31 years. __________

iii) Using the method of *extrapolation* (extend the line), estimate what the population will be in the next 30 years assuming that controlling factors do not take effect.

iv) Do you think the growth in population estimated through the year 2030 is sustainable? Discuss your hypothesis. __________________

(Note: there has been a similar increase in greater snow geese and Ross' geese while the number of giant Canada geese living in urban areas has also increased greatly.)

GRADES 9 to 12 2 STUDENT JOURNAL

STUDENT JOURNAL PAGE TWO

2. Have the students graph (diagram 1.2) the midwinter population data provided on page two in their journal for the lesser snow goose. Explain that these surveys are most accurate in the winter when birds congregate in large flocks. Aerial surveys and photography are used to count the birds. Indicate that the survey is really just an index of the full population to show trends from year to year. Studies have shown that the index is multiplied by a correction factor to get a more accurate estimate of the full population (i.e. takes account of visibility factors while surveying).

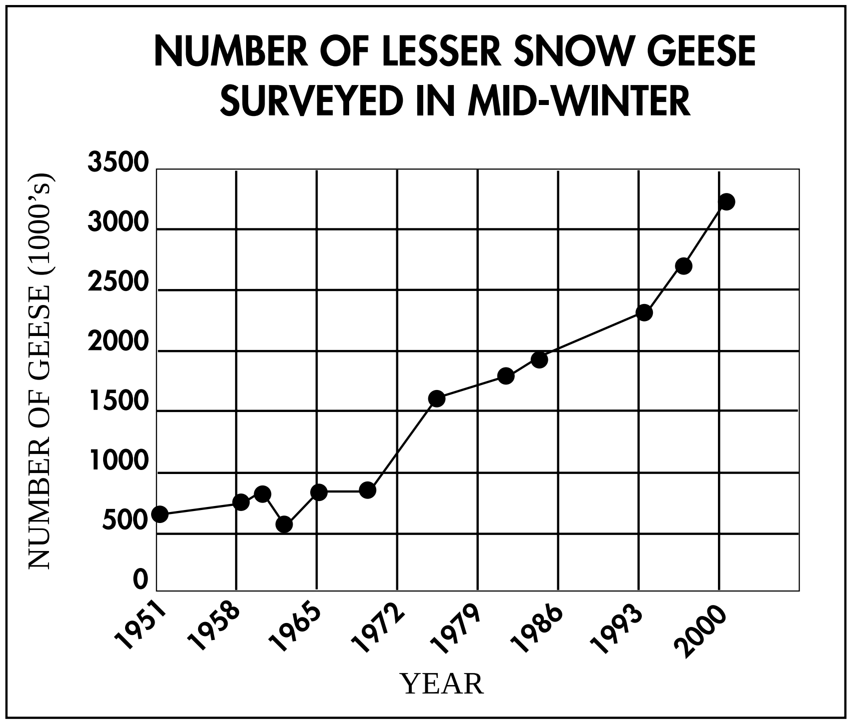


DIAGRAM 1.2

3. Ask students to consider the shape of the population graph and answer questions 2i to 2iii on page two of the student journal. Explain the concepts of interpolation (making conclusions about data between two known values) and extrapolation (making predictions about future trends beyond the scope of existing data).

4. Discuss the concept of carrying capacity (i.e. the number of individuals that the resources of a habitat can support). Also discuss the normal fluctuations of a population that is stable near its carrying capacity and how this differs from exponential growth that rises rapidly over an extended period of time. Have the students answer question 2iv in the student journal (page two) and discuss. It is not possible for exponential growth of a population to be maintained indefinitely. At some threshold limit, the population could slowly level off at a new higher carrying capacity or more likely *crash* and drop rapidly as controlling factors (starvation, disease, predation) catch up.

Lesson one continued

info ZONE

Along the Gulf of Mexico, widespread destruction of coastal salt marshes in Texas and Louisiana has forced snow geese and other species from their natural wintering habitat. Further inland, the concurrent conversion of millions of acres of bottomland hardwood forest and marshlands to rice and soybean fields has led to further negative impacts on many wetland dependent species. However, for the adaptable snow goose this has opened up a new food supply. Now snow geese spend more time on agricultural land than they do in their native coastal habitats.

Farming in the mid-continent and northern prairie areas in North America changed markedly after World War II with the widespread use of the combine. Before that, grain was cut by machine or by hand, gathered into sheaves, tied and then stooked in upright bundles to dry. The grain was removed by a hand flail or threshing machine before being winnowed to remove the seed from the chaff (see the following Internet site: http://waltonfeed.com/old/wheat.html). This process left almost no waste grain in the field for wildlife. The combine changed this. Now ripened grain in Canada is often mowed and dropped flat onto the ground in a loose windrow to dry. During this period which may last many days depending on weather conditions, birds and other wildlife can eat the grain. The combine picks up the windrows on a front-loading conveyor belt as it drives through the field. As the grain passes through, it is threshed and winnowed separating the clean grain into a storage bin. The waste chaff and stalks are thrown out the back as mulch or returned as windrows which are subsequently baled as straw. In this process some loose grain is lost onto the field and is available to wildlife.

There is now a trend to greater use of straight combining – cutting the grain and immediately threshing it without the intermediate step of drying in windrows on the field (common in the U.S.) – in Canada for winter cereals. This reduces the amount of waste grain available to wildlife. Conservation groups are promoting this method to farmers because it leads to less soil erosion, greater cover for field nesting birds and less likelihood of wildlife damage to harvested crops. An added benefit is the reduced food supply for expanding goose populations while they move through this area on fall and spring migration.

5. Have the students read the **InfoZone** on *Changes and adaptations* on page two of their journal. Have the students answer question 3i on page three. Discuss each of the four major changes that occurred and how geese have adapted. For example, geese have adapted to the establishment of refuges along their migration route by selecting these sites as safe resting and feeding areas where they can renew energy supplies and avoid hunters. Geese have adapted to the warming trend in the western arctic by arriving earlier, finding more food and nesting more successfully. See the **InfoZone** on this page for an overview of how changes in agriculture have influenced geese. See the following Internet sites for additional information and photos: **www.dennill.com/mf%20combines.htm**; **www.jwp.bc.ca/deepwater/photo2.htm.**

6. Have the students answer questions 3ii to 3iv on page three of their journal. The four factors that have changed for geese are all *human-induced-biotic* except the weather change. The weather change may be a reflection of global warming climate change resulting from human pollution and increased greenhouse gases. All of the factors are indirect except hunting pressure which has declined and lead directly to greater snow goose survival. Changes in the other factors have lead to greater food supplies for geese and indirectly to higher survival and production of offspring.

7. Have the students review the **InfoZone** on *Impacts on the ecosystem* (page three in their journal). Assign them to work in groups of four on exercise 4.i on page three of the student journal. They can develop their ideas using arrows and words to display the interrelated causes and effects operating with/on snow geese in the latter half of the 20th century. Once they are satisfied that they have identified most of the factors and responses, each team will transfer their findings to a poster board. Display all of the poster boards and discuss the results with the whole class. Develop a final version of the chart.

8. Discuss the biomass pyramid on page four of the student journal. Discuss the various trophic (feeding) levels in the snow goose's system. Explain how some organisms can appear on several levels if they eat both plant and animal foods. Discuss the concept of biomass and energy pyramids. Note that under present conditions the pyramid for the snow goose is likely narrower at the base (producer level) than the primary consumer (snow goose) level as vegetation has been destroyed and snow goose numbers have risen. Refer to the following Internet site for further background information and examples: **www.sturgeon.ab.ca/rw/Pyramids/ecopyra.html**. Have students answer question 4ii on page four of their journal.

9. Discuss species diversity in terms of the relative sustainability and stability of ecosystems. On the snow goose's arctic nesting grounds, it specializes by grazing for food on certain species of grasses and sedges. Therefore, as snow goose numbers have risen, the pressure on these few species of plants has increased proportionally. If the arctic ecosystem was able to support a wider variety of food species palatable to snow geese, their foraging would be distributed more widely and there would be less impact on any one species or feeding zone. The other wildlife species depending on these same plants for

Lesson one continued

info ZONE

With the removal of ground cover plants by grazing and grubbing snow geese, surface evaporation increases on mud flats and soil salinity is brought to the surface. High sub surface salinity (e.g. in marine marshes) results in hyper-saline conditions at the surface and restricted regrowth of any plants except a small number of salt tolerant species like Salicornia (known as glasswort). See the following Internet sites for more information about Salicornia: www.des.ucdavis.edu/wetlands/plants/sv.html; fisher.bio.umb.edu/pages/JFGenus/Jfgen19.htm.

This situation is common in southern Canada and around the world due to increased agriculture, particularly near wetlands or where irrigation is used. As farmers plough land closer and closer to wetlands to increase their income, the natural vegetation which creates a buffer zone is removed. Grasses, shrubs and sedges keep the water table below the surface and reduce surface evaporation. Where the adjacent wetlands or soils are alkaline, the salts are kept below the surface by these deep rooted plants. When natural cover is removed the salts are drawn up with evaporation and concentrate at the surface. Over time these salts wick up further into the field and impact plant growth. See the following Internet site for further information on this problem in Canada: www.agr.ca/search_e.phtml.

food or cover have also become directly affected by snow goose feeding. This impact could be permanent. Review some of the terms above and others in an excellent online ecological glossary at: **www.epa.gov/OCEPAterms/intro.htm.** Have students complete question 4iii on page four of their journal.

10. Have the students read the **InfoZone** on *Solutions?* (page five of their journal). Review the video *Snow Geese in Peril* available on loan or for purchase from Ducks Unlimited at 1-800-665-DUCK or by email (webfoot@ducks.ca). Review the following Internet sites for further background information:
www.cws-scf.ec.gc.ca/canbird/goose/lsmx.htm
www.npwrc.usgs.gov/resource/othrdata/snowprob/snowprob.htm
www.ducks.ca/conservator/184/tundra.htm

    Undertake exercise five on page five of the student journal. Divide the students into groups of four and assign them to one of the following groups or others. **Groups:** environmental research foundation, hunting guide business, non-special interest group, farmers co-op, bird watching society, habitat conservation group, hunting association, animal rights association, environmental activist group, aboriginal peoples' council, tour operator group, small business association, tax payers group, etc.

    Consistent with the group they belong to, each student group may select one or more of the solutions that their group will support (see the list of potential solutions on pages five through seven of the student journal). Based on the principles they believe are appropriate for their group, each group will prepare a brief paper (5 to 10 minutes) for public hearings to decide on the correct course of action to address this environmental issue. Each member of the group presents part of the paper to the rest of the class and answers questions from other students in defense of their stance. The teacher acts as chairperson for the public hearings.

    After all presentations are made, a referendum will be held to determine which solutions will be implemented and scientifically tested to see that they will solve the problem. Give each student a referendum form with all of the possible solutions listed (see appendix on page 20 of this guide). Students should vote based on their personal conclusions and not necessarily according to the position they were assigned. They should select no more than five solutions to support and must mark these on their ballot with numbers from one up to five, in order of priority. These are handed in to the teacher for review (you may elect to have students each sign their ballot). Compile and summarize the final results on the board or an overhead. The class will review and discuss the final results in an open forum. In particular discuss and make a list of some of the studies and hypotheses that will need to be developed by researchers to ensure that the solutions will actually solve the problem. As well, discuss the socio-political considerations which might affect some of the solutions. How important is public education as a precursor to holding a referendum?

Lesson one continued

Below is a summary of all of the listed solutions with some background information to consider. Attempt to have students consider these factors before holding the referendum:

i) **Genetic Engineering:** There has been some recent progress in genetically engineering some salt tolerant agricultural crop species. These crops would have considerable economic value once available. However, it would be an expensive process with little or no economic return to develop salt tolerant species of arctic grasses and sedges for reintroduction into damaged goose grazing sites. These plants would first have to satisfy the narrow nutritional requirements of snow goose goslings. Seeding or planting would be difficult and expensive, especially in the remote arctic environment. New technology would need to be developed for this non-agricultural zone. This solution might have merit over many decades but would depend on significant resources from the government and taxpayers.

ii) **Birth Control:** A lasting-effect medication would need to be developed and administered to at least 500,000 birds. The cost and logistics of this solution might preclude its adoption. There may be concern about non-target species and predators (including humans) being affected by such drugs.

iii) **Trap and Release:** A large trap and release program would be expensive and would need to continue indefinitely as snow goose populations increase to fill the void left by removed birds. This solution would likely only delay the inevitable crash in geese and spread the problem more quickly to ecosystems that are presently not affected. The release of species into new ecosystems could negatively impact species already present naturally (e.g. into northern Europe). Considerable research and monitoring would be required before this solution could be considered by the governments involved.

iv) **Subsistence Harvest:** Aboriginal people now have full access to hunt snow geese and collect their eggs for food. With implementation of education and marketing programs, the level of harvest by aboriginal people might increase slightly. It's unlikely that this initiative alone would solve the problem as most goose colonies are remote from aboriginal villages and the cost of transporting hunters would be high.

v) **Commercial Harvest:** If markets for snow goose meat could be developed this could be an effective and sustainable solution. However, public opposition might arise as it has in the past over other wildlife harvest issues (e.g. harp seal harvest). Laws have been developed over the last century that have restricted the commercial use of wild animals in North America. Education and marketing programs would be needed to convince the public that commercial harvest of snow geese was acceptable in this circumstance. In parts of Europe game animals are commonly available in food markets and seems culturally acceptable there.

Lesson one continued

vi) **Soup Kitchens:** A program of this type was recently implemented in Minneapolis to reduce the large urban Canada goose population. It appears that such a program can be effective and acceptable in some circumstances. Cost for this program would need to be borne by the taxpayer and could run as high as $40 per kilogram of ready-to-consume meat.

vii) **Do Nothing:** This is always an option and viewed by some as the most "natural" solution. Others view it as shirking responsibility since they feel the problem in this case was anthropogenic (human caused). It may be acceptable to have snow goose populations crash as a result of a do nothing response but many might view this as a cruel decision (i.e. starving geese). Many other species, as well as the arctic coastal marine ecosystem, may be permanently damaged.

viii) **Drastic Measures:** It's unlikely that public opinion and politicians would be tolerant of such practices even with the implementation of education programs. Many might view this as waste of a valuable natural resource. These actions might lead to significant impacts on other non-target species as well.

ix) **Agricultural Practices:** Turning back the clock on agricultural progress would likely be unacceptable to farmers and consumers who now enjoy low food prices. However, protecting the vestiges of salt marshes along the Gulf of Mexico, as well as interior wetlands and hardwood bottomlands should be a high priority. Development of more efficient machinery that would reduce grain spillage might be beneficial but other species benefiting from this new food source would also suffer. The wider adoption of straight combining vs. windrow combining (see **InfoZone** on page three) would be beneficial but some farmers would need to invest in new grain drying equipment.

x) **Increasing Hunting**

- **Increase Hunting Limits:** This alone may not be of great benefit as few hunters now achieve their limit. Geese are wary of hunters and quickly learn to avoid them. This solution would probably need to be combined with other hunting related solutions.

- **Spring Hunting:** Under the 1918 Migratory Bird Treaty signed between Canada and the U.S., waterfowl hunting is restricted to a 107 day period in the fall and winter. Normally spring hunting is not permitted, allowing birds to feed and nest without human disturbance. This concern does not presently exist for the snow goose. Consultation and consensus would be needed between Canadian and U.S. officials to allow spring hunting of snow geese but care would be needed to ensure that other species were not inadvertently disturbed. Northern aboriginal peoples are now permitted to hunt in the spring and a new spring hunt for non-aboriginals has recently been initiated in many states and provinces.

Lesson one continued

- **Reward Bands:** This technique is now used by researchers to learn about the biology of snow geese and other species with a maximum reward of $100. A $1 million reward band might lead to unethical and dangerous hunting practices and discard or waste of the hunted birds once they were inspected for the winning band.

- **Remove Hunting Restrictions:** Electronic calls (tape recordings) and baiting (with grain) of wildlife could greatly increase the vulnerability of snow geese to hunters. Presently, these practices are illegal. Studies would be needed to determine the value of such practices and if other non-target species might also be affected.

- **Hunter Education:** Hunters could act as a large unpaid workforce to help solve the snow goose problem. However, the snow goose is not a preferred quarry in some areas. Education programs to teach hunters how to hunt, prepare and cook snow geese might increase hunters' interest in this species.

- **Hunting in Refuges:** Establishment of refuges has been one of the factors leading to the snow goose problem. Management of these areas in ways that would increase snow goose mortality, both inside and outside of refuges, would be beneficial as long as other species were not affected.

xi) **Tillage:** Farmers must wait for their crops to ripen and dry before they can efficiently harvest them. More timely tillage after harvest might reduce the availability of spilled grain but a system to encourage or force farmers to do this is probably unrealistic. In fact, conservationists are encouraging farmers to reduce their tillage which results in many environmental benefits (e.g. less soil erosion, higher air and water quality, more cover for wildlife, reduced fuel use, etc.). One option might be to encourage greater use of fall seeded crops, such as winter wheat, which ripen earlier in the summer before snow goose migration and are more amenable to straight combining.

xii) **New Predators:** Releasing species into new environments may cause many unforeseen problems (see iii above).

xiii) **Sterilization:** See viii above.

Lesson two

Wetlands and environmental quality

Estimated time: 160 minutes

infoZONE

Canada holds over nine per cent of the world's reusable fresh water and much of this is in the form of wetlands. A wetland is an area of land where the water table is at or above the level of the surface for at least part of the year. Wetlands have characteristic soils and are inhabited by hydrophytic plants which have adapted to anaerobic soil conditions. These areas provide an important habitat for an incredible variety of wildlife. Many animals that live predominantly in other habitats make use of wetland areas for forage, many species of fish use the areas as spawning grounds, and migratory birds use these same wetlands as breeding areas or stopover points on their journey. In addition, wetlands slow the flow of surface water, which reduces erosion, and filter pollutants from runoff.

Wetlands are generally divided into four types – bogs, fens, swamps and marshes. The primary differences between each type are related to hydrology, soil subrates and biota.

Curriculum alignment

Human actions modify environments through direct changes to living things, water, air and land, and through indirect effects. Environmental quality refers to the ability of environments to be life supporting. A variety of biotic and abiotic factors are used as indicators of environmental quality.

Vocabulary

Wetlands, nutrient loading, biological oxygen demand, indicator species.

At the completion of this lesson students should be able to:

- describe examples of direct changes to environments that occur as a result of resource extraction, agricultural and/or human development.
- describe examples of changes to environments that occur as indirect consequences of human actions and lifestyles.
- identify abiotic factors in an environment that might affect the health and distribution of living things in that environment (e.g. available oxygen in water, presence of solids in air or water).
- interpret the quality of an environment in terms of the variety of life forms it supports (biodiversity).
- describe effects of removal of selected species on other species that live in an environment (e.g. effect of removal of soil fauna on the quality of soil)
- identify indicators of water quality (e.g. dissolved oxygen, presence of bacteria).
- identify indicators of soil quality (e.g. depth of soil, aeration/compaction, presence of minerals).
- identify indicators of air quality (e.g. presence of polluting gases, presence of particulates).

Resources

Student journal.

Activity description

1. Using the **InfoZones**, summarize the topic of wetlands for the students by listing some common types of wetlands. Discuss the diagram and depictions of wetland types below.

2. Ask students to copy the following diagram into their notebooks and consider the factors which relate to the diagram.

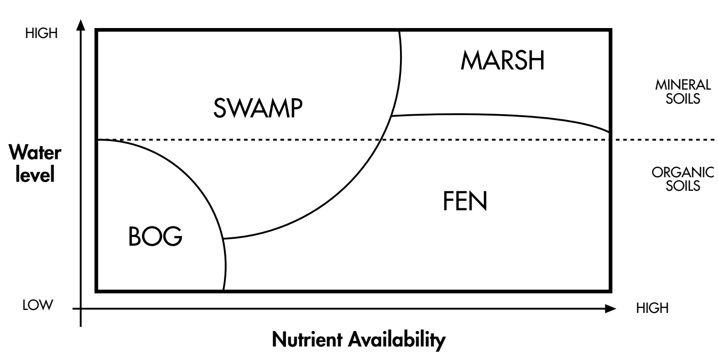


DIAGRAM 2.1

Lesson two continued

Types of wetlands

Bogs are peat dominated wetlands characterized by low nutrient levels. In some types of bogs all nutrients are supplied by precipitation (ambiotrophic). The water is low in calcium and magnesium, and strongly acidic (e.g. pH<4.8). Vegetation is primarily sphagnum mosses; trees, if present, are low and stunted (e.g. black spruce and tamarack).

Fens are peatlands with a high water table and slow internal drainage down very gradual slopes. Water is enriched in calcium and magnesium with a pH range of 5.5 to 7.0. Fens are generally dominated by grasses, sedges and reeds.

Swamps have standing or gently flowing water. Water levels may drop seasonally, have an almost neutral pH, and are moderately enriched in nutrients. Vegetation can be dense coniferous (e.g. cedar), deciduous forest (e.g. red maple) or tall shrub thickets (e.g. alder/willow).

Marshes are periodically flooded by standing or gently flowing water and are nutrient-rich. Water levels drop but the rooting zone is wet almost year-round, and the water is neutral to moderately alkaline. Dominant vegetation may include cattail, rushes, sedges and grasses as well as a wide variety of floating leaved and submerged species.

info ZONE

The biggest danger to the continued existence of wetlands comes from commercial development for urban, industrial and agricultural uses. Wetlands (particularly marshes and shallow open water) are easily drained and filled. Swamps are cleared of their harvestable timber and bogs are mined for their commercially valuable peats.

3. Ask students to complete the following diagram and discuss the factors and possible alternatives.

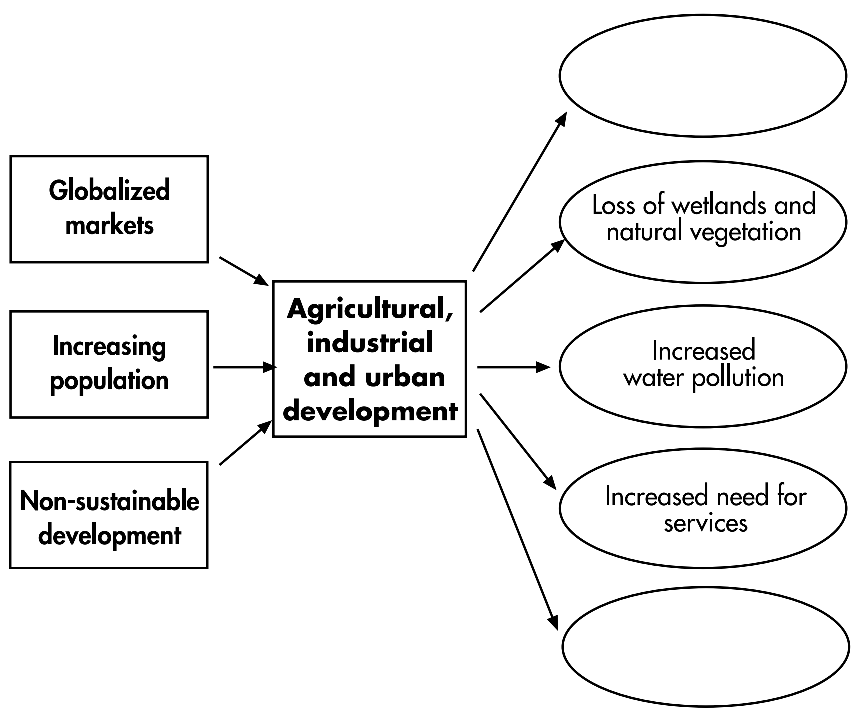


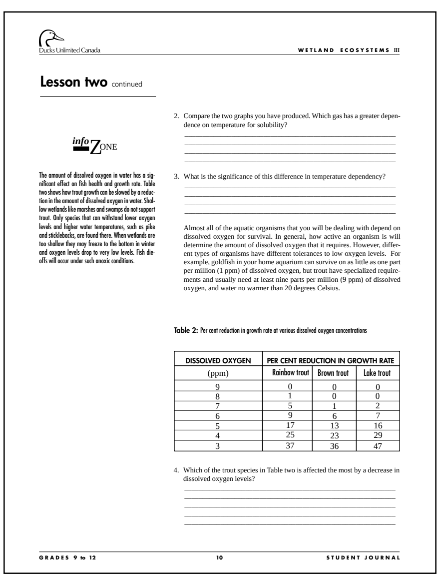
DIAGRAM 2.2

Lesson two continued

infoZONE

Environmental pollution is any discharge of material or energy into the environment that causes or may cause damage to the ecological balance. Pollutants may cause primary damage with a direct identifiable impact on the environment or secondary damage in the form of minor disturbances in the delicate balance of biological food webs that are detectable only over long time periods.

Some water-borne pollutants act as nutrients for water plants. Scientists sometimes refer to the dumping of this kind of pollutant as nutrient loading. In this case some aquatic plants suffer a population explosion and grow to cover the surface area of the water. This blocks the sunlight from photosynthetic organisms below the surface and results in an overall decrease in dissolved oxygen. Most organisms require dissolved oxygen to survive and are therefore not able to live in those areas. A decrease in species diversity results. Normally aerobic bacteria would decompose the dead aquatic plants as they sink to the bottom but when low oxygen conditions exist, anaerobic bacteria take over and methane and hydrogen sulfide are produced – hence the typical swampy, rotten egg smell.



Ducks Unlimited Canada
WETLAND ECOSYSTEMS III

Lesson two continued

2. Compare the two graphs you have produced. Which gas has a greater dependence on temperature for solubility?

3. What is the significance of this difference in temperature dependency?

infoZONE

The amount of dissolved oxygen in water has a significant effect on fish health and growth rate. Table two shows how trout growth can be slowed by a reduction in the amount of dissolved oxygen in water. Shallow wetlands like marshes and swamps do not support trout. Only species that can withstand lower oxygen levels and higher water temperatures, such as pike and sticklebacks, are found there. When wetlands are too shallow they may freeze to the bottom in winter and oxygen levels drop to very low levels. Fish die-offs will occur under such anoxic conditions.

Almost all of the aquatic organisms that you will be dealing with depend on dissolved oxygen for survival. In general, how active an organism is will determine the amount of dissolved oxygen that it requires. However, different types of organisms have different tolerances to low oxygen levels. For example, goldfish in your home aquarium can survive on as little as one part per million (1 ppm) of dissolved oxygen, but trout have specialized requirements and usually need at least nine parts per million (9 ppm) of dissolved oxygen, and water no warmer than 20 degrees Celsius.

Table 2: Per cent reduction in growth rate at various dissolved oxygen concentrations

DISSOLVED OXYGEN	PER CENT REDUCTION IN GROWTH RATE		
(ppm)	Rainbow trout	Brown trout	Lake trout
9	0	0	0
8	1	0	0
7	5	1	2
6	9	6	7
5	17	13	16
4	25	23	29
3	37	36	47

4. Which of the trout species in Table two is affected the most by a decrease in dissolved oxygen levels?

GRADES 9 to 12 10 STUDENT JOURNAL

STUDENT JOURNAL PAGE 10

4. Present students with a quick description of what a pollutant is and what it does. See **InfoZones** on pages 10 and 11.

5. Have the students read the section on water quality on page eight of their journal and complete activities one to three. Note that the x axis should be for the undependent variables and the y axis should be for the dependent variables.

6. Have the students read the **InfoZone**, view the data on trout on page 10 of their journal and complete activities four and five.

7. Have the students read about biochemical oxygen demand on page 12 of their journal and complete activities six to eight.

8. Review page 11 of this guide. Have the students read the **InfoZone** on page 13 of the student journal and complete activities 9 to 12.

9. Discuss the causes of urban development (e.g. economic growth, greater affluence, a desire to get further away from the urban core, etc.)

10. Discuss the other direct and indirect results arising from urban development (e.g. removal of agricultural land, increased cost for infrastructure like roads and schools).

11. Discuss some of the environmental consequences of urban development (loss of habitat for wildlife, greater potential for soil erosion and flooding, reduced areas for recreation and agriculture, reduced oxygen from natural ecosystems, reduced percolation of clean water into the ground water aquifiers, etc.)

12. Discuss some of the economic consequences of urban development (e.g. increased land costs and tax costs, potential decline of core neighbourhoods, short term increase in jobs and economic development, etc.)

Lesson two continued

info ZONE

Water can be polluted with silt, high nutrient loads from sewage, industrial effluent or fertilizers and/or high concentrations of heavy metals from manufacturing plants and mining operations.

Such polluted water running into a wetland, overland or in a river or stream, can be cleaned naturally. The abundance of organisms (bacteria, plants and animals) living in a wetland bind up or metabolize these pollutants, and silt loads settle to the bottom as the water flow slows down. Water percolating through bottom sediments into the ground becomes filtered and water flowing downstream out of the wetland in a stream or river is also much cleaner. See the following web sites for additional information about how natural or constructed wetlands can be used to cleanse polluted water.

www.enviromine.com/wetlands/
www.solaraquatics.com/sas.html
www.computan.on.ca/~ffg/ftgeo.htm

A number of small towns and large buildings use wetlands to provide tertiary treatment of effluent water, including the head office of Ducks Unlimited in Manitoba.

A good indicator of polluted waters is a relatively low level of dissolved oxygen and a higher level of dissolved carbon dioxide than normal. Biochemical oxygen demand (B.O.D.) is the generally accepted method for measuring water quality. In this method a suspect water sample is taken and diluted with a known volume of distilled water which has already been thoroughly shaken to ensure it is saturated with oxygen. Half of the sample is tested immediately for the amount of dissolved oxygen, while the other half is sealed into a container in the dark at 20 ˚C for five days. After that time the sample is opened and tested for the amount of dissolved oxygen present. The difference between the oxygen levels in the two samples is a measure of how much oxygen is needed by the organisms within. The standards vary from province to province and country to country, but a B.O.D. of four parts per million (ppm) is considered to be from water of poor quality whereas one ppm is considered very clean. Highly polluted water may have a B.O.D. in the hundreds or even thousands.

Certain species are more tolerant of poor quality water and are often associated with polluted areas. One such species is the sludge worm or Tubifex, a segmented worm of the Tubificidae family. It is easily identified by its bright red colour. When feeding, its tail sticks up out of the mud and waves back and forth in a spiral motion. The bloodworm is another creature tolerant of low oxygen conditions and is easily identified by its blood red colour. It, however, is not really a worm but the larvae of the midgefly. Because these organisms are associated with low quality water sources they are considered to be indicator species of polluted water. Species like the stonefly and dragonfly nymph which require high oxygen levels are indicator species of unpolluted water. The leech is an intermediate species.

Lesson three

Specialization and natural selection

Estimated time: four hours

info ZONE

The expression *survival of the fittest* is intended by evolutionary biologists to be a general description of the mechanism behind the theory of *natural selection.* This theory holds that the following principles are true:

a) an individual's physical traits tend to be inherited from its parents.
b) there are noticeable variations in physical traits among individuals in a species; some of those traits will allow the individuals who possess them to be more successful at fulfilling basic needs.
c) of all the individuals born in every generation, a large proportion of those that survive to reproduce will have those advantageous traits.
d) over time there will be a gradual shift in the physical traits of a species to those traits which have conferred some advantage in fulfilling the basic needs – a process called *speciation.*

Over time, individuals of a species tend to become adapted to the environment in that their physical appearance and behaviour become specific to that environment. For example, all birds have feathers and hollow bones – an adaptation making flight possible – but diving birds also have webbed feet allowing them to propel themselves underwater. Webbed feet would make wading difficult for shore birds.

Evolution is genetically based change from generation to generation. Natural selection is the pathway by which evolution takes place. Natural selection means that those individual organisms which thrive under a particular set of environmental factors (both biotic and

Curriculum alignment

- Individual living things can be categorized into groups that share common features.

- The concept of natural selection provides a basis for interpreting the evolution, adaptation and extinction of species.

Vocabulary

Fitness, survival of the fittest, natural selection, specialization, speciation, habitat, ecological niche.

At the completion of this lesson students should be able to:

- identify general features of major groups of living things (e.g. skeletons and exoskeletons, specialized organs, limbs).

- identify and describe life cycles of various species.

- identify and describe examples of specialization within related groups of organisms (e.g. specialization for particular food sources, specialization for protection, etc.)

- identify evidence that has led to the concept of natural selection.

- describe the role of natural selection in evolutionary theory.

Resources

Materials collected by students.

Activity description

1. Write the name of the following three animals onto the blackboard: shark, dolphin and salmon. Ask the students to suggest ways in which these creatures are the same (e.g. streamlined appearance, fins for propulsion). Have them suggest reasons why these creatures would look the same even though biologists consider them to be only distantly related. Summarize the discussion by suggesting that *form follows function* (i.e. they look the same because they do similar things).

2. Have the students complete the exercise *Specialization and natural selection* from their student journal on pages 16 to 18.

3. To allow the students to demonstrate their understanding of natural selection and adaptation, as well as allow them a chance to demonstrate their creativity, have them do the *Design an alien* exercise from their student journal on page 19.

Lesson three continued

info ZONE

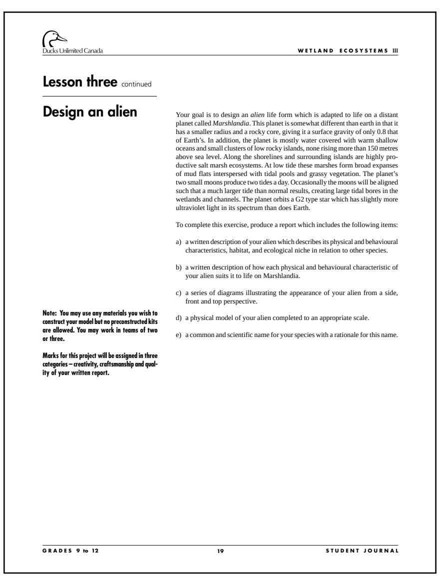
(continued on next page)
(continued from previous page)

abiotic) will pass these traits to their offspring who, over time, will be more successful and numerous than the offspring of organisms that did not thrive under these conditions. Each generation is similar to the one before but still different in small ways. It is these differences which are molded by natural selection over millions of years and lead to the evolution of genetic traits which are expressed in specialized physical and behavioural characteristics.

Organisms that look or act similarly to other organisms are probably more closely related. However, in the case of the dragonfly, bat and swallow which are distantly related, similarities are due to adaption to a simlar niche. The fossil record, experimentation and the study of natural history provides evidence for these theories.

See the following excellent background resource site for educators about evolution:

www.nap.edu/readingroom/books/evolution98/



Ducks Unlimited Canada
WETLAND ECOSYSTEMS III

Lesson three continued

Design an alien

Your goal is to design an *alien* life form which is adapted to life on a distant planet called *Marshlandia*. This planet is somewhat different than earth in that it has a smaller radius and a rocky core, giving it a surface gravity of only 0.8 that of Earth's. In addition, the planet is mostly water covered with warm shallow oceans and small clusters of low rocky islands, none rising more than 150 metres above sea level. Along the shorelines and surrounding islands are highly productive salt marsh ecosystems. At low tide these marshes form broad expanses of mud flats interspersed with tidal pools and grassy vegetation. The planet's two small moons produce two tides a day. Occasionally the moons will be aligned such that a much larger tide than normal results, creating large tidal bores in the wetlands and channels. The planet orbits a G2 type star which has slightly more ultraviolet light in its spectrum than does Earth.

To complete this exercise, produce a report which includes the following items:

a) a written description of your alien which describes its physical and behavioural characteristics, habitat, and ecological niche in relation to other species.

b) a written description of how each physical and behavioural characteristic of your alien suits it to life on Marshlandia.

c) a series of diagrams illustrating the appearance of your alien from a side, front and top perspective.

d) a physical model of your alien completed to an appropriate scale.

e) a common and scientific name for your species with a rationale for this name.

Note: You may use any materials you wish to construct your model but no preconstructed kits are allowed. You may work in teams of two or three.

Marks for this project will be assigned in three categories – creativity, craftsmanship and quality of your written report.

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STUDENT JOURNAL PAGE 19

4. The *Design an alien* exercise will require several class periods where the students can work in small groups of two to three students. Initially the groups should brainstorm ideas for the characteristics of their alien creature. The task can be divided up among the group members but at least one class period should be set aside so the groups can complete construction of their physical models. It will be necessary for each group to collect materials previous to this class.

5. The students success with this exercise can be judged using the following criteria:
   a. Overall creativity of the model and sketches on a scale of one to five.
   b. Craftsmanship of the model on a scale of one to five.
   c. Quality of their written report on a scale of 1 to 10.
   d. One point for each physical adaptation which is supported by an acceptable rationale.
   e. One point for each behavioural adaptation which is supported by an acceptable rationale.
   f. Rationale for naming their species on a scale of one to five.

Lesson four

Who am I?

Estimated time: two hours

info ZONE

The purpose of grouping or classifying things, referred to as *taxonomy*, is to impose some sort of order onto a highly variable and chaotic world, and improve our understanding and ability to communicate with others.

We group organisms by their similarities – either functional (purpose) or structural (appearance). In taxonomy we divide living things into categories and then proceed to redivide those categories. As we proceed from larger to smaller categories, the organisms in each grouping have more and more traits in common until they are so alike that they can interbreed to produce viable offspring. This last grouping is called a *species*.

Our modern system of classification is based on structural similarities and was originated by Karl von Linne, whose name was later latinized to Carolus Linnaeus. Latin is used as the base of this system because it is a *dead* language and is not subject to regional changes.

When grouping organisms we consider four things. From general to specific they are: structural/behavioural similarity, cellular organization, biochemical similarity and genetic similarity.

The genotype of an organism refers to the characteristics of the genes in its cells, whereas the phenotype refers to the physical and behavioural expression of the genotype in an organism which we can see and observe.

Curriculum alignment

Classification of living things is based on similarities and differences among organisms.

Vocabulary

Taxonomy, species, taxa, dichotomous key, genotype, phenotype, nomenclature.

At the completion of this lesson students should be able to:

- describe the Linnaean classification system.
- identify advantages of using the Linnaean classification system as the basis for scientific classification (as opposed to the use of common names).
- identify the taxonomic levels used in scientific classification.
- define the term species and identify problems in its interpretation.
- observe the relationship of species based on their scientific classification.
- describe the contribution of research in expanding the number of known species and scientific knowledge of those species.
- recognize that growth in scientific knowledge has led to the development of classification systems based on more than two kingdoms.

Resources

Access to the school library or Internet for research purposes, poster paper, coloured markers, rulers, etc.

Class set of 10 envelopes, each containing 1 of each of the following items:

- pencil
- paper clip
- rubber band
- glass slide
- thumb tack
- straight pin
- pen
- penny
- nickel
- test tube
- plastic twist tie
- staple

Look for the following, or similar, resources in the library:

An Illustrated Flora of the Northern United States and Canada by N.L. Britton and A. Braun, 1970, Dover Books, Volume One to Three.

Common Marsh, Underwater and Floating-leaved Plants of the United States and Canda by N. Hotchkiss, 1972, Dover Books.

Native Trees of Canada by R.G. Hosie, 1973, Information Canada.

The How To Know Series including *Aquatic Plants* by G.W. Prescott, *The Insects* by H.E. Jacques and *The Freshwater Fishes* by S. Eddy.

The Field Guide Series including *The Birds* by R.T. Peterson, *The Mammals* by W.H. Burt and R.P. Grossenheider, *The Wildflowers* by R.T. Pterson and M. McKenny, *The Reptiles and Amphibians* by R. Conaut and *The Trees and Shrubs* by G.A. Petrides.

Lesson four continued

info ZONE

The idea of *kingdom* has changed with the increase in our technological sophistication. Originally there were only two kingdoms – plant and animal. The microscope allowed us to identify the kingdoms *protista* and *monera*, and biochemical analysis, the *fungi*. Kingdoms are supposed to allow us to trace all members of that kingdom to a common evolutionary ancestor.

Kingdom	**General**
Phylum	↓
Class	
Order	
Family	
Genus	
Species	**Specific**

Taxanomic Keys to the Common Animals of the North Central States by S. Eddy and A.C. Hodson, 1961, Burgess Publishing Co.

The Mammals of Canada by A.W.F. Banfield, 1974, University of Toronto Press.

The Birds of Canada by W.E. Godfrey, 1986, National Museums of Canada.

Ducks, Geese and Swans of North America by F.C. Bellrose, 1976, Stackpole Books.

Activity description

1. Begin by grouping the students into groups of three. Give each group an envelope containing the twelve items listed on the previous page under *Resources*. Have the students open the envelope and divide the items found within into two groups. Each group is then to be subdivided into two smaller groups. Have the students repeat the process of dividing groups until they have produced the smallest groups possible.

2. On a blank page have the students prepare a flow chart listing the items that are found within the original group and each successively smaller grouping. Have the students provide a descriptive name for each of their groupings. When finished, have one student from each group come up to the blackboard and sketch out their flow chart including the names given.

3. Have the students inspect each of the flow charts and identify the similarities found between the charts. Lead a discussion in which the students evaluate each of the criteria for its ability to distinguish between groups of items.

4. Show students the grouping of the same organisms (see below) and have them identify the criteria used for placing organisms into each group. Discuss the validity of each criteria.

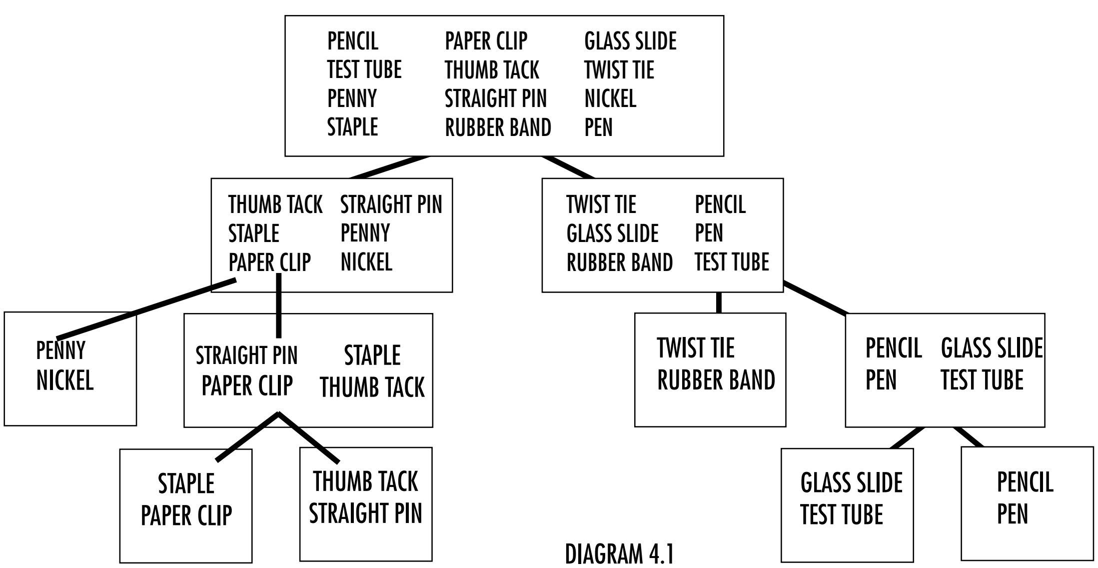


DIAGRAM 4.1

Lesson four continued

5. Outline for students the basics of taxonomy (see **InfoZone** on page 14).

   Note: The students should eventually agree that it is the structural similarity which is being used most often in deciding on a specific grouping.

6. Introduce the students to the idea of a dichotomous key using the student exercise *Who Am I?* on page 20 of their journal. Check the answers to the exercise with the students. Discuss any difficulties.

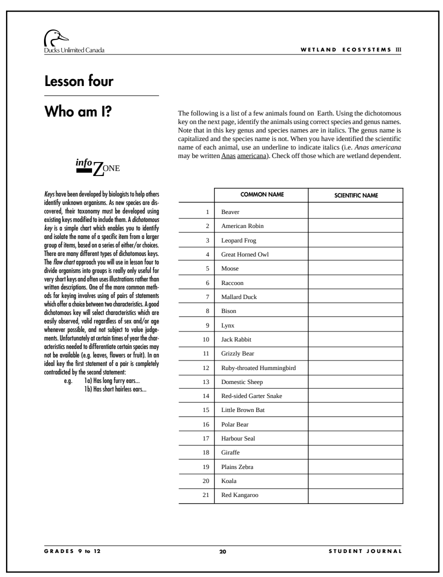
7. To emphasize the need for a dichotomous key to be clear and concise, have the students complete the student exercise on pages 23 and 24 of their journal. Before beginning, have the whole class agree on scientific names for each *species* and fill these in on page 23 of their journal. Emphasize that the goal is to construct a dichotomous key that will allow another user to clearly distinguish one organism from another within that group of organisms in as few steps as possible. Challenge them to produce a key that has less than eight pairs of statements.

8. Have the students work in groups of three and, when finished their dichotomous key, transcribe their key on a blackboard or chart paper. Have the class check the validity of each key produced and note any similarities and/or differences. Have each team present and defend their key.

info ZONE

The categories *(taxa)* used in taxonomy are placed in order from general to specific. A *dichotomous key* is designed to allow you to identify the scientific name (genus and species) by looking at the specific traits of an organism. Each key is specific to a particular level of organization. At the kingdom level such a key will necessarily focus on structural traits, whereas at a species level a dichotomous key is much more likely to focus on genetic traits. There are many types of dichotomous keys in use. This lesson will focus on two of the more popular types.

The scientific name given to an organism allows you to trace its relationship to other organisms and to make it absolutely clear which organism you are describing. Using a *common* name is not a good idea since *common* names usually aren't common – they vary from region to region and person to person. For example walleye *(Stizostedion vitreum)*, an important commercial fish of the perch family, are frequently referred to as pickerel *(Esox niger)*, even though the actual pickerel is a member of the pike family. The American Wigeon *(Anas americana)* is also known as the baldpate duck and the wigeon in some parts of its range.



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Lesson four

Who am I?

The following is a list of a few animals found on Earth. Using the dichotomous key on the next page, identify the animals using correct species and genus names. Note that in this key genus and species names are in italics. The genus name is capitalized and the species name is not. When you have identified the scientific name of each animal, use an underline to indicate italics (i.e. *Anas americana* may be written Anas americana). Check off those which are wetland dependent.

info ZONE

Keys have been developed by biologists to help others identify unknown organisms. As new species are discovered, their taxonomy must be developed using existing keys modified to include them. A *dichotomous key* is a simple chart which enables you to identify and isolate the name of a specific item from a larger group of items, based on a series of either/or choices. There are many different types of dichotomous keys. The *flow chart* approach you will use in lesson four to divide organisms into groups is really only useful for very short keys and often uses illustrations rather than written descriptions. One of the more common methods for keying involves using of pairs of statements which offer a choice between two characteristics. A good dichotomous key will select characteristics which are easily observed, valid regardless of sex and/or age whenever possible, and not subject to value judgements. Unfortunately at certain times of year the characteristics needed to differentiate certain species may not be available (e.g. leaves, flowers or fruit). In an ideal key the first statement of a pair is completely contradicted by the second statement:

e.g. 1a) Has long furry ears...
1b) Has short hairless ears...

	COMMON NAME	SCIENTIFIC NAME
1	Beaver	
2	American Robin	
3	Leopard Frog	
4	Great Horned Owl	
5	Moose	
6	Raccoon	
7	Mallard Duck	
8	Bison	
9	Lynx	
10	Jack Rabbit	
11	Grizzly Bear	
12	Ruby-throated Hummingbird	
13	Domestic Sheep	
14	Red-sided Garter Snake	
15	Little Brown Bat	
16	Polar Bear	
17	Harbour Seal	
18	Giraffe	
19	Plains Zebra	
20	Koala	
21	Red Kangaroo	

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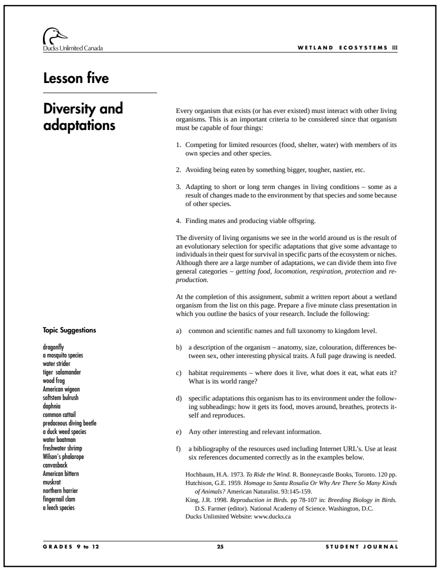
Lesson five

Diversity and adaptations

Estimated time: 160 minutes



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Curriculum alignment

Living things show a diversity of structural and behavioural adaptations.

At the completion of this lesson, students should be able to:

- demonstrate awareness of the diversity of forms of life.
- observe and identify examples of variation in the structure of living things.
- identify structures that play a role in locomotion, securing food and avoiding predators.
- identify structures that serve needs for obtaining and distributing nutrients, reproduction and protection.
- infer environmental conditions for which particular structures are adaptive.
- identify and describe examples of mimicry.
- identify and describe examples of adaptation to a single food source or to a narrow range of food sources.

Resources

Student journal, reference books, access to the Internet.

Activity description

1. Have the students turn to the *Diversity and adaptations* activity. Divide the students into groups of two or three, in order to cover a majority of the organisms listed.

2. Have the students use the library, Internet and other resources to complete the exercise.

3. Have written summaries of each group's research copied for all class members. Encourage the class to show appropriate public speaking, questioning and listening behaviours. The following guide may help students to develop their presentations and you may have students use this outline in evaluating the presentations of their classmates.

Comments

Class Presentation Evaluation	VERY GOOD	SATISFACTORY	POOR
1. Gave an interesting introduction			
2. Presented a clear explanation of topic.			
3. Presented information in an acceptable order.			
4. Communicated effectively (spoke clearly, etc.)			
5. Maintained a good rapport with audience (eye contact, acceptable posture, body language)			
6. Used visual/audio aids well.			
7. Maintained the interest of the class.			
8. Handled questions and comments acceptably.			

Lesson six

Wetland field trip

Estimated time: full day

infoZONE

Special water testing kits are available to measure pH and oxygen content. However, some high schools do not have the required chemicals or the necessary disposal facilities to use this type of kit. An aquarium water testing kit is a low-tech alternative.

Curriculum alignment

Living things show a diversity of structural and behavioural adaptations.

At the completion of this lesson, students should be able to:

- work in field teams in a safe manner.
- draw field maps.
- set out study plots.
- collect animal samples.
- measure water clarity.
- measure and calculate water flow.
- identify and measure plant and animal specimens.
- identify adaptations of animals to their environment.
- identify wetland impacts

Resources

Maps and/or aerial photographs of a wetland ecosystem, field guides for major animals and plants, dichotomous keys for the major invertebrates and plants, pH and water quality kits if available (see **InfoZone**).

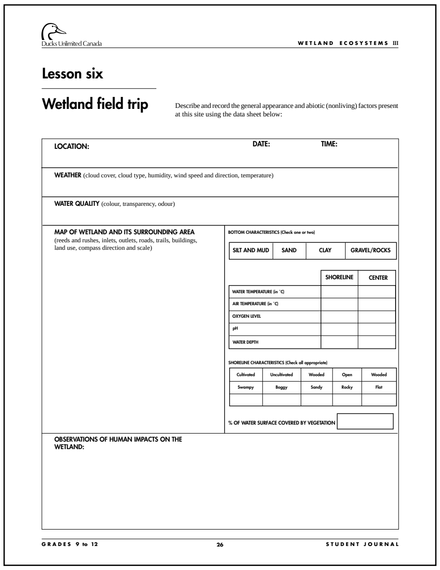
Activity description

1. Introduce the students to the area in which you expect to be working. Provide them with maps and/or aerial survey pictures of the area. Remind them of any hazards they should be careful around and the necessity for appropriate behaviour and clothing. Secure landowner permission to use the area in advance.

2. Divide the class into groups and provide them with the following list of materials.

- white plastic ice cube trays and/or pails
- dip net
- rake and shovel
- guide books
- eye-dropper
- sieves
- thermometer
- turkey baster (for sucking up organisms)
- measuring tape
- hand lenses and petri dishes
- pH kit for testing acidity
- containers for bringing materials back to lab (glass jars)
- plastic ruler
- one $metre^2$ wire
- magnifying lens
- O_2 meter/kit
- stop watch
- compass

Lesson six continued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Lesson six

Wetland field trip

Describe and record the general appearance and abiotic (nonliving) factors present at this site using the data sheet below:

LOCATION: DATE: TIME:

WEATHER (cloud cover, cloud type, humidity, wind speed and direction, temperature)

WATER QUALITY (colour, transparency, odour)

MAP OF WETLAND AND ITS SURROUNDING AREA (reeds and rushes, inlets, outlets, roads, trails, buildings, land use, compass direction and scale)

BOTTOM CHARACTERISTICS (Check one or two)

SILT AND MUD	SAND	CLAY	GRAVEL/ROCKS

	SHORELINE	CENTER
WATER TEMPERATURE (in °C)		
AIR TEMPERATURE (in °C)		
OXYGEN LEVEL		
pH		
WATER DEPTH		

SHORELINE CHARACTERISTICS (Check all appropriate)

Cultivated	Uncultivated	Wooded	Open	Weeded
Swampy	Boggy	Sandy	Rocky	Flat

% OF WATER SURFACE COVERED BY VEGETATION:

OBSERVATIONS OF HUMAN IMPACTS ON THE WETLAND:

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Personal equipment required

- clothing suitable for field work
- rubber or waterproof boots (if possible)
- notebook and pencils for labelling and drawing, clipboard
- snacks and lunch, including drinks

3. Have students turn to the *Wetland field trip* activity on page 26 of their journal.

4. Have the students list the types of organisms, both plant and animal, they would expect to find at the chosen site. Before departing for the field, review the activities which will be undertaken and the questions they will be required to answer.

5. Have the students complete the exercises on page 31 of the student journal.

6. Discuss water quality, biodiversity and other biochemical characteristics of the wetland in relation to inflow/outflow, surrounding land use, soil characteristics, water depth, shoreline slope, etc. Discuss which human induced factors have resulted in negative impacts on the wetland and what changes are required to address these.

Referendum form

Choose five solutions and number them in order of priority. Your choices should be based on your personal conclusions and not necessarity on the position you were assigned.

- ☐ Genetic Engineering
- ☐ Birth Control
- ☐ Trap and Release
- ☐ Subsistence Harvest
- ☐ Commercial Harvest
- ☐ Soup Kitchens
- ☐ Do Nothing
- ☐ Drastic Measures
- ☐ Agricultural Practices
- ☐ Increase hunting limits
- ☐ Spring hunting
- ☐ Reward bands
- ☐ Remove hunting restrictions
- ☐ Hunter education
- ☐ Hunting in refuges
- ☐ Tillage
- ☐ New Predators
- ☐ Sterilization