2023 NCF-ENVIROTHON NEW BRUNSWICK

WILDLIFE STUDY RESOURCES

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Wildlife Study Resources

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2. Identify common New Brunswick birds (without the use of a field guide) and describe their diet and habitat.
3. Identify wildlife skulls based on shape, size, and dentition.
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5. Describe how to age a white-tailed deer using the tooth replacement and wear technique.
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7. Explain the difference between generalist and specialist species and provide examples of each.

Study Resources

Resource Title	Source	Located on
Selected Mammals of New Brunswick	*Mammals and Birds of Nova Scotia- Province of Nova Scotia Department of Natural Resources and Renewables, 2022*	Pages 4-14
Selected Birds of New Brunswick	*Mammals and Birds of Nova Scotia- Province of Nova Scotia Department of Natural Resources and Renewables, 2022*	Pages 15- 22
Basics of Skull Identification	*Tkacyk, F, 2022*	Pages 23-28
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Aging a Deer by Examining Its Jawbone	*Pierce, R., J. Sumners, and E. Finn, 2022*	Pages 33-37
Territories and Home Range	*New Hampshire Fish and Game Department and New Hampshire PBS, 2022*	Pages 38-40
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Selected Mammals of New Brunswick

The term mammal comes from the Latin word *mamma* (breast) and is used because these animals feed their young with milk produced by the mammary glands, or breasts. They are warm-blooded, have bodies covered with hair, and have well-developed brains. They may be found in water or on land. Sixty-four mammal species occur in New Brunswick. Below are a selected grouping:

LITTLE BROWN BAT (*Myotis lucifugus*)

Bats are the only mammals to have mastered true flight. Their wings are thin, tough membranes that stretch from the sides and rear of the body and are supported by the arms, legs, and tail. Bats catch insects on the fly or off ground vegetation using their mouths or wings as nets. Each bat eats up to half its body weight in insects every night, the equivalent of 1,000 to 3,000 mosquitoes. Bats emit a rapid series of high-pitched cries when flying and use the echoes to navigate. When a flying insect is detected, they increase the frequency and pitch of their calls to home in on the echo from the insect's body.

Seven species of bats that breed most years in New Brunswick include the little brown, long-eared, silver-haired, red, hoary, big brown and tri-coloured. Some reside year-round, hibernating in caves through the winter, while others migrate south. Certain bat species seem more susceptible to the devastating white nose syndrome. These include the little brown, the northern long-eared and the tri-coloured bat. These are the species which overwinter in colonies in New Brunswick caves and abandoned mines. The Big Brown Bat (*Eptesicus fuscus*), a species also susceptible to WNS, overwinters in small numbers in buildings in southern New Brunswick. All others are migratory and do not overwinter here.

Size
7-9 g
(0.25-0.3 oz)

Young
1, May-July

Diet
worms, insects

Life Span
24 years

Activity Pattern nocturnal, hibernate in winter

The most common species throughout Canada is the little brown bat. These bats have long, silky brown hair. The hairs on the back are tipped with a shiny copper colour. The little brown bat usually weighs less than 10 g, is about 8 cm long, and has a wing-spread of 25 cm. These little bats zigzag over water, fields, and roads at dawn and dusk, feeding on insects. They are designated as "Endangered" by both the federal and provincial government

Little brown bats hibernate together in caves through winter, subsisting on body fat. Mating occurs in late autumn or during the dormant period. Males and females go their separate ways when they emerge in April and May. Males, either alone or in small groups, hang upside down by their hind feet under tree bark or behind house shutters. Females form nursery colonies in warm, dark barns and attics. The newborn clings to its mother constantly for the first few days, even when she flies. At three weeks, the young bat can fly.

SNOWSHOE HARE (*Lepus americanus*)

Snowshoe hares are common across Canada, including New Brunswick. This animal is also known as the varying hare because its colour changes from grayish brown in summer to white in winter to act as protective camouflage. It is also mistakenly called a rabbit. Rabbits have young that are born blind, hairless, and helpless in underground burrows. Young hares are born above ground, fully furred, with their eyes open, and are soon ready to run. Adult snowshoe hares are 33 cm to 46 cm long and weigh 1.5 kg to 2 kg. Their large hind feet have long toes and stiff hairs that act as snowshoes to support them on snow.

Snowshoe hares eat a variety of green vegetation, including vetches, dandelions, clovers, and daisies, as well as the leaves of aspens, birches, and willows. In winter, they feed on buds, twigs, bark, and needles of trees and shrubs. They usually feed at night, coming out from their rest sites under conifer boughs and logs, known as forms. Unlike deer, which break off twigs and leave ragged ends, hares neatly slice twigs with their sharp teeth and leave smooth ends.

Many predators feed upon snowshoe hares, including great horned and barred owls, lynx, bobcats, foxes, coyotes, minks, and humans. Hares have excellent hearing and may try to avoid detection by freezing and relying on their protective colouration, or by fleeing. They can travel with bounds up to 3 m long and speeds up to 17 km/h. They inhabit conifer thickets and alder swamps, and follow familiar runways between feeding and shelter areas.

Hare numbers can increase rapidly as females may have two or three litters of several young each year. Hare populations often appear to alternate between a period of abundance once every eight to ten years. These cycles seem to be more extreme in northern Canada than in the Maritimes.

Size
1.5-2 kg
(3-4 lb)

Young
2-4, April-July

Diet
plants

Life Span
4-5 years

Activity Pattern dawn-dusk, year round

BEAVER (*Castor canadensis*)

Size
18-25 kg
(40-55 lb)

Young
4, May-June

Diet
trees, aquatic plants

Life Span
12 years

Activity Pattern diurnal, year round

Beavers are New Brunswick's largest rodent. They are known for their habit of building dams and dome-shaped lodges from mud and sticks. Dams are built to form ponds 2 m to 3 m deep to allow swimming under thick winter ice. Beaver lodges have underwater entrances to a central chamber that is above water. In fall, beavers store branches in food piles outside the lodges so they can remain active all winter.

Beavers are well adapted for aquatic life. They have webbed hind feet that have comb-like claws for grooming waterproof oil through their coats. Lips meet behind the front teeth, allowing them to cut and peel branches underwater. Flaps in the nose and ears can be closed when diving. The flat, scaly tail serves as a rudder when swimming, a prop when standing or walking, and a lever when dragging logs.

Beavers come ashore to cut trees and grind vegetation. Their year-round diet consists of inner bark, leaves, buds, and twigs from aspen and other hardwood trees.

A beaver colony is socially centered around an adult female, and usually includes a mate, new kits, and young from the previous year. Young beavers leave the female's lodge by their second spring to establish new colonies. Beavers inhabit slow-flowing streams, lakes, rivers, marshes, and coastal wetlands across Canada, including all of New Brunswick. They usually live in forested areas, and aspens are their preferred food. Beavers are not easily predated but can be captured by bears, coyotes, fishers, bobcats, and lynx on land or when ice provides access to a lodge. Otters occasionally prey on young beavers, entering the lodge by the underwater tunnels.

PORCUPINE (*Erethizon dorsatum*)

Porcupines are the second largest rodent in Canada, next to the beaver, and can be up to 1 m in length. They are found in every province and territory except Newfoundland and Prince Edward Island. They are common across New Brunswick. Porcupines inhabit all forests types and have even adapted to living in prairie regions.

Porcupines are large, slow animals with three notable adaptations for their lifestyle. They have short, strong legs with powerful claws for climbing trees, and strong skulls and teeth for chewing bark and twigs from trees. Their best- known adaptation is one for defence from predators-about 30,000 stiff quills on the head, neck, back, and tail.

These quills can be raised by the porcupine when approached but cannot be thrown. Quills easily detach from the porcupine when touched and have backward projecting scales that make them difficult to remove. Porcupines grow back damaged or lost quills in 10 days to 6 months. Fishers kill porcupines by repeated biting the unprotected head, flipping them over to eat at the unquilled underside. Bobcats, foxes, and coyotes occasionally prey on porcupines.

Porcupines are usually active at night. They feed on twigs, buds, and the inner bark of trees for most of the year, and leaves when available. They are attracted to salt sources and chew sweat-stained wood such as canoe paddles and axe handles. Porcupines are usually solitary except when mating in late autumn. They spend most of their time feeding or sleeping in trees or rock dens.

Size
4-10 kg
(9-22 lb)

Young
1, May-June

Diet
trees

Life Span
10 years

Activity Pattern nocturnal, year round

EASTERN COYOTE (*Canis latrans*)

Size
13-16 kg
(29-35 lb)

Young
5-7, April-May

Diet
omnivore

Life Span
15 years (captive)

Activity
Pattern nocturnal, year round

Coyotes are members of the dog family. They are usually tawny gray with a black swath along the middle of the back from shoulder to tail. Blond, red, and black colour variations are also found in New Brunswick. Adult females average 13 kg and adult males average 16 kg. They are agile, usually travel with the tail low, can bound up to 5 m, and have maximum speeds of 55 km/h.

Historically a plains animal, the coyote expanded its range east and was first recorded in New Brunswick in 1953 although was not widespread across the province until the 1970's. During this period of range expansion and successful breeding with wolves, the eastern coyote gradually became a larger animal with coarser fur than the western form. Coyotes inhabit a wide range of habitats, from wooded areas to farmland, and even residential areas.

Coyotes are largely nocturnal, preferring to hunt either after dark or at dawn and dusk. In New Brunswick, their main prey are snowshoe hares and white-tailed deer. Meat is obtained from capture of live prey or by eating dead animals. However, they are adaptable omnivores and consume insects, blueberries, apples, small mammals, and a variety of other items. The basic social unit consists of a mated pair and their pups.

Coyotes may mate for life and defend their territory from other breeders. Both parents care for the young on a territory that averages 35 km2 to 40 km2. Coyotes often hunt in small packs of two to six individuals, especially in winter. They are suspicious of humans and avoid contact. Their howling calls are heard more often than they are seen.

AMERICAN MARTEN (*Martes americana*)

Size
0.6-1.3 kg
(1-3 lb)

Young
1-5, March-April

Diet
small mammals

Life Span
10 years

Activity
Pattern nocturnal, year round

Found throughout the boreal and Acadian forests of Canada, American martens are members of the weasel family. Martens are associated with mature softwood forests with abundant dead and downed trees for denning and hunting.

Martens vary in colour from yellowish to very dark brown, and have a pale, cream-coloured throat and chest. Females have a 49 cm to 60 cm long body and a 13 cm to 18 cm long tail. Males are 55 cm to 64 cm long in their body and have a 15 cm to 20 cm long tail. Females can weigh 0.6 kg to 0.8 kg, while males can be 0.7 kg to 1.3 kg.

Martens are mainly nocturnal and active all winter. They are agile tree and spend a lot of time hunting above the ground. They are solitary animals that den in logs, stumps, or trees. Martens feed on mice, squirrels, snowshoe hares, insects, fruit, and birds.

BLACK BEAR (*Ursus americanus*)

Black bears are the smallest and most common North American bear in Canada. They are the only bear species found outside the arctic and western regions of North America, and the only bear in New Brunswick. Scattered across the province, black bears inhabit the forest, preferring wooded areas and swamps. They use a variety of habitats and approach settled areas for easy food sources such as bee hives, agricultural crops, and garbage. They stand about 1 m high at the shoulder and can weigh up to 200 kg. Their coat colour varies from almost white to various shades of brown, but it is usually black, especially in the east.

Black bears shuffle when they walk, are good swimmers and climbers, and can sprint short distances at speeds up to 56 km/h. Most large and small mammals are too fast for bears to catch with any consistency. Their diet reflects the food available and includes plants and animals. They eat berries, apples, grasses, buds, leaves, fishes, mice, birds, eggs, frogs, insects, and larvae. The smell of decaying meat or garbage can be detected by their sensitive noses at distances over 1.5 km away.

Black bears have a variety of adaptations for their yearly cycles of denning and cub production. Each winter, as food becomes scarce, travel becomes difficult, and temperatures drop, they enter a new den under trees, rocks, or brush. In late fall they enter a period of dormancy called “torpor” where they are unconscious but will awaken if disturbed. Black bears undergo reduced metabolic rates and lower body temperature (typically not below 15 C). In comparison, a true hibernator (such as a Little Brown Bat) undergoes temperature reductions to 2-5 C and is much more difficult to arouse during this period. Denned bears do not eat, drink, or eliminate waste during this time.

Adults mate in early summer, but the fertilized eggs will not implant and begin to grow until fall. Cubs are born during the winter in the den, and females must nurse the cubs from the body reserves stored the previous year. Newborn cubs weigh only 0.2 kg to 0.3 kg, but may grow rapidly to 4 kg at six weeks, and 30 kg at nine months. Females and cubs leave their den in early spring and remain together for another year.

Size
45-200 kg
(100-440)

Young
1-3, January-February

Diet
omnivore

Life Span
12 years

Activity Pattern nocturnal, hibernate in winter

EASTERN COUGAR (*Felis concolor*)

Size
36-90 kg
(80-200 lb)

Young
3, March or July

Diet
deer

Life Span
12 years

Activity Pattern nocturnal, year round

The three members of the cat family found in Canada are the cougar, lynx, and bobcat. Cougars are also known as mountain lions and used to be found from the Yukon to Chile and east to Nova Scotia. They still occur regularly in British Columbia and the Rocky Mountains of Alberta. Just as they had done to wolves, settlers tried to kill any cougars found. By the 1900s, the population of these big cats was greatly reduced from central and eastern Canada. Sightings of eastern cougars are reported on occasion in New Brunswick. but there has been no tangible evidence to confirm a breeding population. All reported sightings are recorded and investigated by wildlife agencies.

Male cougars are much larger than females with a body length from 170 cm to 275 cm, tail length of 66 cm to 90 cm, and weight of 45 kg to 90 kg. Females range in body length from 150 cm to 230 cm, tail length of 53 cm to 81 cm, and weight of 36 kg to 63 kg. Their long tails are a distinctive feature. Coat colour varies from gray to yellow brown with a white belly. The back of the ears and the tip of the tail are black.

A variety of forested habitats are used by this solitary, nocturnal hunter. They capture their prey by stalking and leaping rather than chasing. Cougars feed mostly on large mammals, especially deer. Moose, porcupines, beavers, snowshoe hares, mice, and birds are also eaten.

LYNX (*Felis lynx*)

Size
8.5-10.5 kg
(19-23 lb)

Young
2, April-May

Diet
snowshoe hares

Life Span
12 years

Activity Pattern nocturnal, year round

The lynx is the most widely distributed of Canada's three cats. It is found throughout the boreal forest region. In New Brunswick, the lynx is most common in the mountainous region of the northwest but sighted occasionally in the remote areas of Albert county in the southeast. Adult males weigh about 10 kg, females average 8.5 kg in weight, and both sexes are 80 cm to 90 cm long from head to tail.

This is a long-legged cat with a short body and a stubby tail. The tail is black around the entire tip, compared to the bobcat tail that has narrow bands and black only on the top. The lynx has a ruff of fur around the face and long, black hairs come to a point on the ears. Coat hairs are long and silky and are replaced every spring and fall. The coat is grayish brown with light gray or white underparts.

Lynx are active year-round, moving mainly at night. They are agile climbers and can swim when necessary. They rest under trees or rock ledges. Like the bobcat and cougar, lynx hunt by sight and sound. Most of their prey are ambushed, with little energy spent on chasing. Lynx feed on mice, voles, squirrels, and grouse, and also scavenge on dead animals. They take fawns or moose calves on rare occasions. However, over 40 per cent of the summer diet and more than 60 per cent of the winter diet is made up of snowshoe hares.

An adult lynx usually eats two snowshoe hares every three days. Like hares, lynx have large, furry paws that act as snowshoes to help them travel in snow. They use the same young, dense softwood thickets and swamps where hares are typically found. Since lynx are so dependent on hares for food, their population levels rise and fall with the cycles in snowshoe hare numbers. This species is listed as "Endangered" by the province and the federal government.

BOBCAT (*Felis rufus*)

Bobcats occur through most of the United States, north-central Mexico, and parts of southern Canada. These cats were found throughout New Brunswick. Bobcat males average 88 cm in length, while females average 80 cm in length. Both sexes have inconspicuous black ear tufts and short tails (14 cm long) that are white below with a broad black band on the upper tip. Fur colour can range in shade between yellow, brown, gray, and reddish and is flecked with dark streaks and spots.

Adults are territorial and home ranges of males are usually two to five times larger than those of females. These cats are primarily nocturnal and solitary, except for the female with young. Kittens are weaned at two months of age but usually remain with the female into their first winter. Bobcats use various dens for daily resting spots, as well as birth sites. Beds of mosses and leaves may be made in rock crevices, hollow logs, or thickets.

Snowshoe hares are the most frequent prey of bobcats. Although bobcats occasionally catch live deer, carcasses are more frequently the source of deer meat. Small mammals, birds, and porcupines are also eaten. Bobcats use a variety of habitats, especially coniferous stands with dense understorey vegetation.

Size
7-13 kg
(15-29 lb)

Young
2, April-May

Diet
small mammals

Life Span
12 years

Activity Pattern nocturnal, year round

HARBOUR SEAL (*Phoca vitulina*)

Size
60-70 kg
(132-154 lb)

Young
1, May-June

Diet
fish

Life Span
17 years (captive)

Activity Pattern tidal, year round

Four seal species are found in the coastal waters of New Brunswick. They include the harp seal (*Phoca groenlandica*), hooded seal (*Cystophora cristata*), grey seal (*Halichoerus grypus*), and the harbour seal. The harbour seal is the most common species off the coast of New Brunswick. The harbour seal has a round, smooth head, while the grey has a long, straight head.

Harbour seals occur along the northern coasts of Europe, Asia, and North America. They inhabit coastal waters, including bays, harbours, and river estuaries. They are not confined to salt water and can range inland after fish. Their diet is primarily fish, along with squid, octopus, clams, and occasionally crayfish, crab, or shrimp.

Harbour seals average 1.5 m in length and 60 kg to 70 kg in weight. Their coat colour varies. The background can range from creamy white to dark brown, the back is usually light brown with irregular dark spots or patches, and the creamy white underside has scattered dark brown spots. Their coats are replaced each year between August and November.

Their activity pattern reflects the tides and weather. They haul out of the water at low tide to rest on sand bars and rocky shoals, forming loose groups of up to 500 individuals. With the incoming tide they remain in the water to feed. They can dive up to 100 m for short periods and can remain under water for 20 minutes. Harbour seals mate in shallow water or on sand bars.

Pups are born with their eyes open, measure 60 cm to 90 cm in length, and weigh 9 kg to 13 kg. After their first week, pups are strong enough to dive in shallow water and to drag themselves ashore. Young seals will double in weight by their first winter but are not sexually mature until five or six years of age.

WHITE-TAILED DEER (*Odocoileus virginianus*)

Size
25-150 kg
(55-330 lb)

Young
1-3, May-June

Diet
plants

Life Span
10 years

Activity Pattern dawn/dusk, year round

New Brunswick's white-tailed-deer is named for its distinctive flaglike tail that is up to 30 cm long, brown above and white underside. When disturbed, a white-tailed-deer will flash the white underside of its tail. Standing about 1 m high at the shoulder, females can weigh 25 kg to 100 kg. Males can weigh 35 kg to 150 kg and carry spiked antlers, which they shed each winter. The short summer coat is reddish brown, while the longer, warmer winter coat is grayish. Deer are very fast and agile, bounding up to 9 m in a leap and running as fast as 65 km/h.

Archaeological digs revealed evidence that deer were present in the region several thousand years ago, but likely disappeared due to changes in climate. Deer returned to this province late in the nineteenth century. They moved in from southern Maine.

White-tailed deer occur from South America to most of southern Canada. They are common across New Brunswick, using edge areas between forests and openings. Fields and cut overs are important feeding sites, especially when close to forest cover areas. Deer feed on a variety of vegetation. They eat grasses, herbs, leaves, clover, apples, mushrooms, and other plants from spring through to fall. In winter, they eat mostly hardwood twigs and buds, as well as lichens hanging from trees.

Deer breed in the fall and, as a result males (bucks) often lose weight before entering the winter season. Deer restrict their movements in winter to save energy because of cold temperatures, difficult travel, and less abundant and nutritious food. They may gather ('yard up') in periods of deep snow in preferred wintering areas with dense softwoods for shelter from snow and wind. By late winter, they are often in poor body condition, and population numbers can decline from starvation and predators such as dogs, coyotes, and bobcats.

Females (does) give birth in late May or early June. The number of fawns reflects the condition of a doe, which is based on summer food and winter stress. Usually one or two fawns are born, and occasionally three or more may be born. Fawns are born with reddish brown coats with white spots. The spotted coat helps to camouflage them from predators such as bears and coyotes. The fawns are also protected because they give off almost no odour to attract predators. Fawns are hidden from predators until they are strong enough to keep up.

MOOSE (*Alces alces*)

Size
270-500 kg
(594-1100 lb)

Young
1-2, May-June

Diet
plants

Life Span
12 years

Activity Pattern dawn/dusk, year round

The moose is the largest member of the deer family and the larges land mammal in New Brunswick. These dark brown animals have long gray legs, humped shoulders, large ears, long heads and muzzles, and a skin flap or "bell" hanging from the throat. Males weigh more at 400 kg to 500 kg than females at 270 kg to 350 kg. Both sexes are 1.5 m to 2 m in height at the shoulder. Males, known as bulls, carry a new set of antlers on their head each year from spring to early winter.

Moose can be found from Alaska to Newfoundland, except in a few coastal, tundra, and urbanized areas. They inhabit young forests, including wet sites near lakes and swamps.

The name "moose," from the language of the Algonkians, means "eater of twigs." Moose browse in winter on twigs of trees and shrubs such as willows, aspens, and balsam fir. In summer this diet of twigs is complemented by leaves, herbs and grasses as well as aquatic plants such as the water lily. Moose are strong swimmers and will dive for submerged vegetation. They daily require about 2.2 kg of plant matter for every 50 kg of body weight.

Moose can be active at any time but are especially active at dawn and dusk. They are seen in small groups during the breeding season. Breeding bulls as well as females (cows) with calves are aggressive. Females usually breed for the first time at two and one-half years of age. Although mature, young bulls usually do not get the opportunity to breed until they are five or six years old as the older and larger bulls out compete them for mates. Females often give birth to twins, which are 1 m in length. After two weeks, the calves are moving about, following the cow. Weighing 10 kg to 16 kg at birth, they double their weight in three weeks. Black bears and coyotes are the only effective natural predators of moose in New Brunswick, taking mostly calves in spring and early summer.

Adapted from: Province of Nova Scotia. (2022, October 13). Mammals and Birds of Nova Scotia.https://novascotia.ca/natr/wildlife/wns/wns7f.asp.

Selected Birds of New Brunswick

Birds are warm-blooded, which means they burn energy to keep their body temperatures at the same level. Their front limbs are modified into wings to allow them to fly. Their bodies are covered with feathers and their feet have scales. There are over 220 different kinds of birds that breed every year in New Brunswick. According to the New Brunswick Bird Records Committee there have been over 430 species sighted within the province.

DOUBLE-CRESTED CORMORANT (*Phalacrocorax auritus)*

Size
60-75 cm
(23-29 in)

Diet
fish

Young
3-4, May-June

Life Span 17-23 years

Activity Pattern diurnal, migrate for winter

Cormorants are dark, large water birds with long bodies and thick necks. Bills are long and hooked at the tip, and tails are long, wide, and wedge-shaped. The legs are set back on the body, so the birds stand very upright. When perching, the birds often hold their wings out to dry. Cormorants are excellent swimmers, usually diving underwater for 20 to 30 seconds while catching fishes. They eat any fish they can catch in marine or fresh water, feeding on cod, hake, pollock, herring, gaspereau, sculpins, trout, suckers, and eels.

In the Atlantic region, there are great cormorants (*Phalacrocorax carbo*) and double-crested cormorants. Double-crested cormorants occur from Newfoundland to the interior of Alberta in both marine and freshwater areas. They are four times as numerous in the province as great cormorants. Double-crested cormorants migrate to New Brunswick in mid-April to late May and leave between mid-September and late October, heading south into the Gulf of Maine and beyond

Cormorants nest in colonies isolated from mammalian predators and close to a supply of fish. Numerous double-crested cormorant colonies are distributed along New Brunswicks's coastline, as well as several that are located on inland lakes. Nests are bulky structures of sticks, weed stalks, and seaweed. When trees are used for nest sites, they quickly die from the bird droppings

AMERICAN BLACK DUCK (*Anas rubripes)*

American black ducks are the most widespread and abundant species of duck in New Brunswick. They have dark brown bodies, light brown heads, olive yellow bills, and orange red legs. Their wings have purple patches on the top edge and white linings underneath that flash as they fly. An interesting feature of this duck is the side breast feathers. Males have U-shaped markings, while those of females are V-shaped.

Black ducks breed throughout the Maritimes. Nests are located on the ground under dense vegetation in woods, in fields, on islands, and along streams. After hatching, the young immediately on aquatic insects. Adult foods vary and include seeds, aquatic vegetation, and small aquatic animals like mosquito larvae. Black ducks are fond of grains, wild rice, and corn.

Black ducks are found in virtually any salt or fresh water from ocean to streams, including ponds and marshes. In coastal areas, they spend most of the daylight hours on mud flats and in salt water and then fly into grain fields and freshwater marshes for the night. Black ducks readily adjust to urban environments and can often be seen feeding and resting in town parks.

Size
50-63 cm
(20-25 in)

Diet
plants, insects

Young
6-12, May-June

Life Span 14-20 years

Activity
Pattern diurnal, some migrate for winter

COMMON MERGANSER (*Mergus merganser)*

There are three species of mergansers found in New Brunswick and the rest of Canada: the hooded merganser (*Lophodytes cucullatus*), the red-breasted merganser (*Mergus serrator*), and the common merganser. All three species are diving ducks with spikelike bills and saw-edged jaws for catching fish. They are long, slender-bodied birds that fly with their bill, head, body, and tail aligned in the same plane.

Male and female common mergansers have thin red bills and white breasts and wing patches. They differ in that males have smooth black to green heads and lots of white on the body, while females have cinnamon brown heads with ragged crests and gray bodies.

Common mergansers winter from Newfoundland to Florida, mostly in open fresh waters. They breed in the boreal regions of Asia, Europe, and North America, as well as mountainous areas further south. They frequent freshwater streams, rivers, and lakes across New Brunswick. Clear water is preferred for sight feeding on small fishes.

Hooded and common mergansers are more restricted to forested areas, as they both nest in tree cavities, unlike the ground-nesting red-breasted mergansers. Common mergansers have also been known to nest in buildings, holes in banks or cliffs, and under brush if suitable hollow trees or old woodpecker holes were not available. Ducklings are led to water immediately after hatching. Females with young often gradually move downstream to tidal waters.

Size
53-68 cm
(21-27 in)

Diet
fish

Young
8-12, May-July

Life Span unknown

Activity
Pattern diurnal, year round

OSPREY (*Pandion haliaetus)*

Size
53-62 cm
(21-24 in)

Diet
fish

Young
2-4, May-June

Life Span 18-21 years

Activity Pattern diurnal, migrate for winter

These large birds of prey are found near water on all continents except Antarctica. They are smaller than eagles, but larger than hawks, with bodies 53 cm to 62 cm long and wingspans of 135 cm to 183 cm. They can be recognized from a distance by their large size, white underparts, and long wings with black marks at the crooks in their wrists. Ospreys are summer migrants to New Brunswick, usually arriving in April. They are most common in coastal areas with shallow bays and estuaries but also frequent lakes with abundant fish.

Ospreys live almost exclusively on fish. Their feet have long, sharp talons, with flexible outer toes and horny spines that are adapted for catching and holding fish. Ospreys hunt over water, hovering in the air just before their spectacular feet-first dive, often fully submerging. They rise out of the water with their powerful wings, shake off the excess water, and carry off the fish in a streamlined head-first position. Along the coast they feed primarily on tomcod and flounder, and in fresh water they often catch suckers, perch, and gaspereau.

Nests are conspicuous, massive structures of sticks that are re-used from year to year. Nests are usually built close to water, but the birds will nest inland if necessary. Typically, nests are constructed in living or dead trees that are taller or somehow more obvious than surrounding trees. Ospreys will also nest on cliff tops or on the ground and use alternate nest sites such as power poles. Many ospreys have been successfully attracted to artificial nest platforms. In some areas, ospreys will nest in colonies and follow each other to supplies of fish.

Both parents feed fish to the young birds at the nest until they fledge in August. Ospreys from New Brunswick will migrate in the fall to the southern United States, Central and South America. Adults will return here to breed the next summer, but sub-adults (second-year birds) will remain on the wintering grounds. There are currently about 400 breeding pairs of adults osprey in the province.

RUFFED GROUSE (*Bonasa umbellus*)

Size
40-48 cm
(16-19 in)

Young
9-12, May - June

Diet
plants

Life Span 8-11 years

Activity Pattern diurnal, year-round

Ruffed grouse, often called partridge, are chicken like birds that are widespread, permanent residents throughout Canada and the United States. Ruffed grouse associate mostly with hardwood and mixed wood areas. They are often in or near edges of thick cover, streams, openings, alder patches, and orchards. They feed on various plant parts such as buds, leaves, flowers, berries, and apples.

Ruffed grouse vary from mottled grays and browns to chestnut reds on the back with white underneath. The fan-shape tail has several small wavy bands, and one large black band at the end. When courting or defending its young, the bird will usually fan out its tail and raise its black neck ruffs, for which it is named.

Ruffed grouse are best known for their "drumming" courtship and territorial display frequently heard in spring and occasionally in fall. Males stand on logs or rocks and beat their wings forward rapidly. They produce a muffled thumping that quickens into a whir, like the sound of a motor starting. One male may mate with several females, who nest and raise young on their own. Nests are slight hollows in the ground lined with leaves and feathers, usually under trees, logs, rocks, or brush piles. Chicks follow the female and begin feeding on insects and leaves within hours after hatching. They can fly short distances by five to six days of age.

Ruffed grouse show several adaptations for survival. They switch from a summer diet of green plant parts to a winter diet of tree buds and shrubs, ensuring a relatively constant food supply. They develop feathers and horny growths on their legs to help them keep warm and to grasp branches in winter. They also develop fleshy projections on their feet (called combs) for the winter months to help them walk easier on powdery snow (thing snowshoes). In very cold temperatures they will dive under powdery snow to conserve heat. When avoiding predators, they may run or freeze in position, their mottled colour helping to hide them, or they may burst into rapid flight with a startling flutter of wings.

PIPING PLOVER (Charadrius melodus)

Size
15-19 cm
(6-7.5 in)

Young
4, June

Diet
marine worms, insects

Life Span 8-11 years

Activity Pattern diurnal, migrate for winter

The piping plover is a small, stocky bird with upper parts the colour of dry sand and a white rump patch visible in flight. Breeding adults have an orange base to their stubby black bill, bright orange legs, a black bar across the forehead, and a black ring around the neck. Winter birds and juveniles show only black on the bill, dull orange legs, and no black bands on the head or neck. The semipalmated plover (*Charadrius semipalmatus*) is a more common relative that has mud-brown upper parts the colour of wet sand and lacks the white rump patch.

Piping plovers breed on the shores of both fresh and salt water in the prairie provinces. Great Lakes region, and all four Atlantic provinces. They winter along coasts from Texas to North Carolina. Their name comes from the call notes, a constant piping that sounds like "peep" or "peep-lo." Like other plovers, they run in short starts and stops. The pale feathers blend into the open sandy shores where the birds feed and nest. In New Brunswick, the majority of nests are found along the Northumberland shore.

Piping plovers return to their breeding grounds in late March or early April. A mated pair will form a depression in the sand above the high water mark, which may be lined with a few small stones or shell fragments. Both adults incubate the four eggs for about 25 days, and the young are mobile soon after hatching. All ages feed on marine worms, crustaceans, and insects that they pluck from the sand. Young birds can fly after about 30 days. Plovers often gather in groups on undisturbed beaches before they migrate south in August.

The population of piping plovers has declined drastically since the 1940's, and the species was declared a species-at-risk (Endangered)both federally and provincially since the late 1980's. Several factors are contributing to the population decline along the Atlantic Coast. Shoreline developments have reduced the amount of coastal nesting and feeding habitat. Increasing human use of beaches has led to destruction of nests and of young by foot or vehicular traffic. As well, increasing garbage levels attract predators such as raccoons, skunks, and foxes. Both the eggs and young of piping plovers are so well camouflaged that they are difficult to detect. With excessive disturbance when predators, pets or humans approach, adults may desert the nest or try to lead intruders away with a broken wing display. Unattended eggs or young are susceptible to heat, predators, starvation, and stress.

HERRING GULL (*Larus argentatus)*

There are four species of gulls that breed in New Brunswick; great black-backed gulls (*Larus marinus*), black-legged kittiwakes (*Rissa tridactyla*), ring-billed gulls *(Larus delawarensis*) and herring gulls. Several other species are seen in the fall and winter. Herring gulls are the most abundant, widespread, and familiar gull in North America. They are often called seagulls, despite the fact that herring gulls rarely travel far from the coast and often inhabit inland areas.

Adult herring gulls are large, with white heads and chests, pale gray backs, and black wing tips with conspicuous white spots. Two features that are different from similar gulls are the pink flesh-coloured legs and an orange spot on the thick yellow bill. Juvenile gulls are dark brown, gradually showing less brown and more gray over four years as they reach breeding age.

Herring gulls tend to nest in coastal colonies of 20 to 200 pairs, often amidst cormorants or terns. Nests are depressions in the ground lined with grass, moss, or seaweed. They often feed on the eggs and young of other bird species nesting the same area. They are omnivorous birds and also eat insects, berries, fish, crab, shellfish, sea urchins, mice, and dead animals. The herring gull is a scavenger adapted to feeding on anything available at landfill sites, sewer outlets, poultry processing plants, and freshly ploughed fields.

Size
58-66 cm
(23-26 in)

Young
3, May - June

Diet
omnivore

Life Span 15-18 years

Activity Pattern diurnal, year-round

ATLANTIC PUFFIN (*Fratercula arctica)*

Most people can immediately recognize a picture of a puffin. Fishermen call the puffin a "sea parrot" because of its large red, blue and yellow triangular bill. Both males and females have this distinctive bill. Other obvious features are the chunky black and white body, orange legs, and white face. Puffins are less conspicuous in their winter plumage with gray faces and darker, yellow-tipped bills and legs. The colourful outer bill sheath is shed each fall and grows back in the spring. A puffin's age can be estimated fairly accurately by the number of vertical grooves on the bill.

Atlantic puffins breed from Europe to Maine, with several million in Iceland. Most of the North American birds are in Newfoundland (270,000 pairs), with more than 850 pairs in New Brunswick (outer Bay of Fundy Islands), and only 70 pairs in Nova Scotia.

Puffins nest in island colonies, using ground burrows or rock crevices for protection from predators. Each mated pair only raises one young puffin. Adults feed the young at the burrows, where they remain until fledged, for safety from foxes, gulls, and other predators. Puffins have been linked to flying submarines, as they catch capelin and sand lance by underwater pursuit. They typically carry fish sideways in their bills and can hold as many as a dozen at a time.

Size
29-35 cm
(11-14 in)

Young
1, July

Diet
fish

Life Span 21 years

Activity Pattern diurnal, migrate for winter

HAIRY WOODPECKER (*Picoides villosus*)

Size
22-26 cm
(7-10 in)

Young
3-5, May - June

Diet
insects

Life Span 7-13 years

Activity Pattern diurnal, year-round

In New Brunswick, there are two common black-and-white woodpeckers with white backs. Both species have a black eye stripe and "moustache," with a white eyebrow and line under the eye. Males have a small red patch on the back of the head, females have no red marks, and juveniles have red on the crown of their heads. The medium size (24 cm), longer-billed hairy woodpecker is often confused with the similar, smaller (15 cm) downy woodpecker.

Hairy woodpeckers reside year-round and breed throughout the province. They inhabit a wide variety of habitats, from coniferous forests to hardwood swamps. They are more common in open woodlands than in dense forest or settled lands with few trees. Hairy woodpeckers are shyer than the downy and are seen less often near bird feeders and suburban areas.

The hairy's sharp "peek" calls draw attention, as do its loud drumming signals. Territories of this woodpecker species are around 8 ha, and individual birds may range more widely in a day. They forage mainly on trunks of trees and shrubs, feeding almost exclusively on insects.

Woodpeckers excavate their own nesting cavities in trees each spring. The hard outer bark helps protect nests from predators like raccoons. Hairy woodpeckers usually nest in live or dead aspens and birches within hardwood or mixed wood stands. Hairy woodpecker young are so noisy that their nests can usually be located by sound from a considerable distance. Cavities dug out by woodpeckers can later be used by other wildlife species such as flying squirrels and swallows.

BLACK-CAPPED CHICKADEE (*Parus atricapillus*)

Size
12-14 cm
(5-6 in)

Young
6-8, May - July

Diet
insects

Life Span 5-12.5 years

Activity Pattern diurnal, year-round

Black-capped chickadees range from the southern Yukon to Newfoundland. These active little birds are present year-round throughout New Brunswick. People can easily recognize their most distinctive call ("chicka-dee-dee-dee") and appearance (black cap and bib on a gray-and-white body). The song of the male chickadee is actually a whistled "fee-bee," with the first part stronger. They are the same size as the less common boreal chickadee (*Parus hudsonicus*), which has a brown cap.

Boreal and black-capped chickadees dig holes in the decaying tree stumps for nests. They will also use natural cavities, old woodpecker holes, and artificial nest boxes. The nest is formed inside the cavity with moss, hair, feathers, or vegetation. Black-capped chickadee females usually lay a first nest in late May and often again in June or July. Eggs are incubated for 13 days by the female, and then both adults feed the young at the nest for about 12 days.

Both species of chickadees are found across Canada. They inhabit virtually all forested regions, as well as urban areas. Black-capped chickadees live in hardwoods, mixed woods, and softwoods. Boreal chickadees tend to be in softwoods and mixed woods. Chickadees usually roam through woods checking branches for insects and insect eggs. Insects make up most of their diet, but they also eat seeds and small fruit.

Adapted from: Province of Nova Scotia. (2022, October 13). Mammals and Birds of Nova Scotia. https://novascotia.ca/natr/wildlife/wns/wns7f.asp.

Basics of Skull Identification

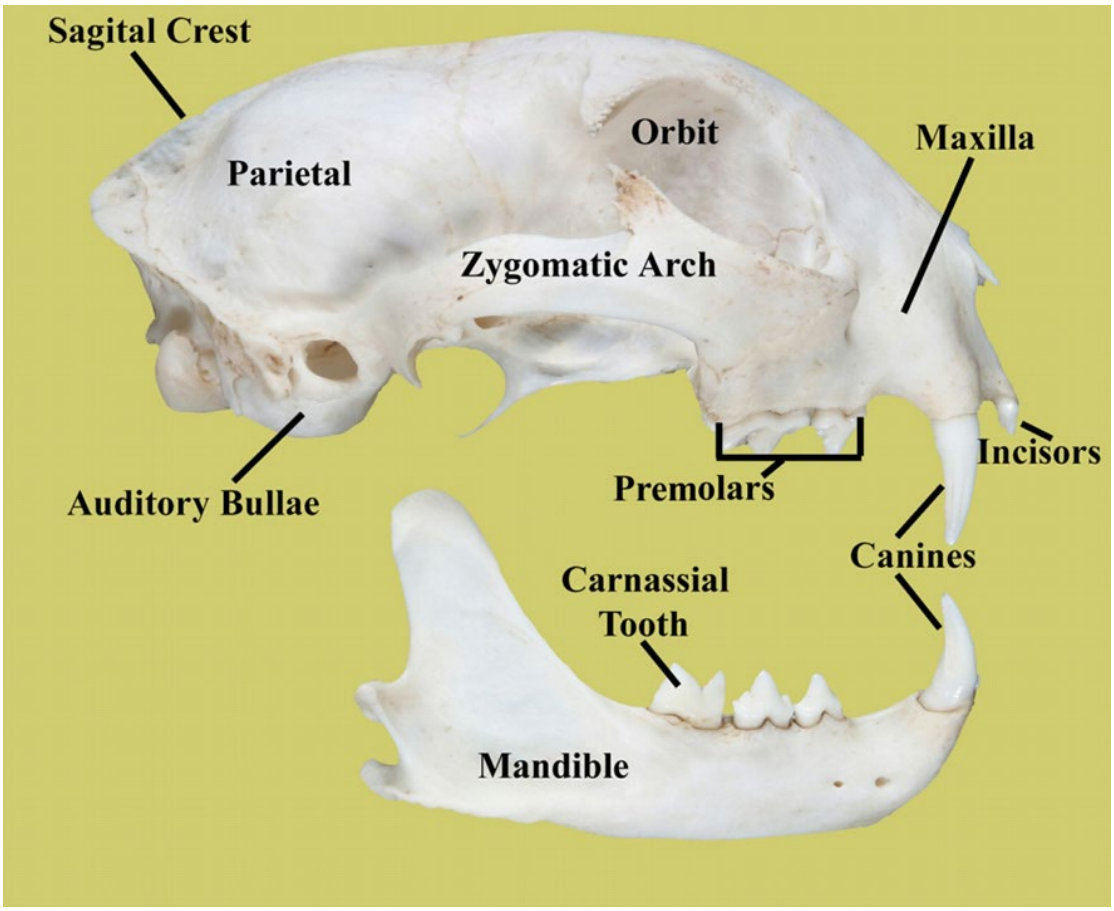
Skull Identification

The science of skull identification relies on the skills of close scrutiny and the study of physiology. Skulls hold a fascination for many people. For some they are symbols of death or fear, while for others physical representations of animals and the expressions of the stories of their lives. Skulls can tell us many things about an animal, including the species, its approximate age, size, health, what it ate, whether the animal was male or female and even how it died.

Skull Basics

Skull identification is best done by breaking down the skull into its parts. For the sake of simplicity, we will stick to mammal skulls here in this wildlife guide. There are four general regions to a mammal skull: the rostrum, zygomatic arches, braincase and mandibles.

The rostrum is the portion of the skull that contains the upper teeth, nose and palate. The zygomatic arches are the bones arching outward from the braincase and rostrum to form the cavities known as the "orbits." These cavities contain a space for the jaw muscles and for the eyes. The braincase is the part of the skull behind the rostrum, that includes the cavity where the brain is contained. The mandibles are the lower jaws, which contain all of the lower teeth.



Teeth as Identification Tools

The teeth found within a skull tell us several important things about the animal to which they belonged. First, what the animal ate. Next, what general group of animals it belongs to. Also, how much and what kind of wear they have had through use.

Rodents

Have a pair of chisel-like incisors at the very front of their rostrum and a pair at the very front of their mandibles. In most rodents, these have an orange enamel, as in the muskrat skull in the image above. Behind the incisors is a gap of no teeth, then a line of molars that all look very similar.

Rodent Incisors

Lagomorphs

Rabbits and hares - have similar skulls, only they have 2 pairs of incisors (one behind the other) in their upper jaws, molars that are squashed horizontally and a porous structure to their skulls called fenestrae. Look closely in front of the orbits to see the fenestrae in the skull of this snowshoe hare in the image below.

Lagomorph Skull (Hares & Rabbits)

Insectivores

Have many teeth, many with tall cusps (points). Shrews have specialized incisors that stick forward like a pair of forceps, and all their teeth have a brownish-orange tip. Their skulls are also tiny and lack zygomatic arches. These can be distinguished from moles (which are another type of insectivore) because mole skulls have zygomatic arches. In the image below, the shrew skull is on the left and the skull of a small mole is on the right.

L- Shrew R- Mole

Carnivores and omnivores

Have several types of teeth. At the very front of their skulls are a row of small, sharp incisors. Immediately behind these are the large, pointed canine teeth. Notice the incisors and canine teeth behind them in the image below of a coyote skull. Behind these are small premolars and finally molars at the very back of the mouth. The size, shape and orientation of all of these teeth vary great depending on the species. For instance, cats have relatively few teeth, proportionately large canine teeth and short rostrum; whereas wild dogs have more teeth, more premolars/molars, proportionately smaller canine teeth, and a long rostrum.

Carnivore/Omnivore Incisors

Ungulates

Have a largely herbivorous diet, and this is reflected in their teeth. They have a row of sharp incisors at the front of their skull. Deer, pronghorn, bighorn sheep, mountain goats, bison and musk ox all lack upper incisors. The only native North American deer that has canine teeth is the elk. Behind the incisors there is a significant gap lacking any teeth, then finally a row of similar looking molars for grinding vegetation. Notice the mandibles of a carnivore (the mandible at the top, from a raccoon) and that of an ungulate (the mandible at the bottom, from a deer). Look closely at how similar all of the teeth in the ungulate mandible appear to be when compared to a carnivore.

Top - Raccoon Jaw, Bottom – Ungulate Jaw

Other Distinct Skull Features

Here's a couple examples of distinct features to look for to help you with skull identification. In ungulates, look for the presence of antlers (for deer family) or horns (for pronghorn, bison, musk ox, mountain goats and wild sheep). Also look for the presence or absence of a thin ridge of bone running down the middle and across the top of the braincase, called a "sagittal crest." The presence, shape and size of this sagittal crest can help identify certain species of carnivores. The image below shows the skull of a striped skunk. Notice the thin sagittal crest running the length of the cranium.

Sagittal Crest of Striped Skunk

Tkaczyk, F. (2022, October 16). Skull Identification. https://www.wildernesscollege.com/skull-identification.html

Animal Adaptations

Summers in the far north can be a time of lush and lavish living for the animals—plenty of fresh new plant growth for the vegetarians, lots of insects and nectar for birds, berries and salmon for bears, and for wolves there's often an abundance of voles, mice, and snowshoe hares. The endless days of nonstop eating allow many animals the luxury of putting on fat.

But summers are fleeting and winters long—up to 8 months—and brutally cold. Temperatures can plunge to minus 70 degrees F. Gales make it feel even colder, and deep or drifted snow can make simply moving around an energy-draining ordeal.

Of course, if you can fly, one choice is to opt-out of winter all together.

Alaska's migratory birds do just that. Some birds, like loons whose summer lakes are frozen in winter, only go as far as the coasts of Alaska, Washington, and Oregon. Robins only need to reach places with frost-free ground, so they can hunt for worms and insects. Other birds go for the relative warmth of the southern US, and some take advantage of the tropics and subtropics—enjoying two summers.

Arctic terns take migration to the ultimate extreme—after a summer in the far north they spend their "winter" in Antarctic waters, so these amazing birds live most of their lives in perpetual daylight.

But what about the animals who stay?

Ptarmigan

Some birds, like ptarmigan, stick it out through the long and unimaginably tough northern winters. And most other animals—the walkers and crawlers and swimmers—simply don't have the option of leaving and have developed some ingenious and fascinating adaptations to extreme cold weather.

Taking it to Extremes

At the opposite extreme from the arctic terns that span the globe in pursuit of an endless summer, is an inconspicuous little amphibian called the wood frog. When leaves drift on the autumn wind, the wood frog finds a suitable place to spend a quiet winter, digs down into the forest duff, and as the surrounding temperature drops, he proceeds to freeze solid. No heart beat, no breathing, no signs of life—a tiny node of suspended existence, a perfectly inert frogsickle—buried under moss and snow for up to 8 months.

Wood Frog

Wood Frog scientists are studying this miraculous little creature, not only because it can freeze solid but perhaps especially because it thaws out and emerges completely unscathed in spring. We don't completely understand the wood frog's ability to survive the seemingly unsurvivable, but we do know that their livers produce a flush of glucose which protects the vital inner parts of their cells from freezing, which would cause lethal and irreversible damage.

In the spring, as the wood frog begins to thaw, its glazed frosty eyes transform to gold and ebony, its tiny heart spontaneously begins to beat, its throat pumps and its lungs take in the first breath of a resurrected life. Once the wood frog is fully warmed, it's ready for all that summer has to offer—hopping to a nearby pond to sing and mate and lay eggs, then moving back into the wet, mossy forest to feed on insects and enjoy the warmth of the endlessly circling sun.

Sleeping It Off

A little less extreme, but equally impressive, are animals that get through the winter by hibernating. The arctic ground squirrel, which huddles in an underground burrow for 7 to 8 months of the year, is a hibernator extraordinaire. When an animal truly hibernates, its body temperature drops and all metabolic functions slow way down. What's unique about arctic ground squirrels is that their body temperature falls below freezing—the only mammal on earth to do this and survive.

Researchers have measured arctic ground squirrel body temperatures as low as -4 degrees Celsius (26 degrees Fahrenheit). But it's not as simple as chilling down in autumn and warming again next spring. As the cold months pass, an arctic ground squirrel goes through cycles of deep cooling that last for about 24 days. Then it spontaneously begins to shiver, which raises its body temperature back to the normal 98 degrees. After about half-a-day, it slowly cools down into another long cycle of bone-cold torpor that lasts until the next brief rewarming.

We usually think of grizzly bears and black bears spending the winter months "hibernating in their dens", as if they were in a coma. Denning bears experience lowered body temperature, heart rate, and respiration, but they are not true hibernators. Their body temperatures don't drop as low as animals that hibernate, like the "super cooled" arctic ground

squirrel. A wintering black bear is in a deeply lethargic state (topor), not the deep sleep of a true hibernator; and a seriously disturbed bear can become active even in the middle of winter. Both arctic ground squirrels and bears live off their stored body fat in the winter.

Arctic Ground Squirrel

Eyes Wide Open

Some animals spend the winter fully awake and active, but they rarely venture out into the open air and sky. The key to their winter lifestyle is a cozy home and a very busy summer. During the fleeting time of endless daylight and lush growth, these animals store enough food to see them through 8 or 9 months of winter.

A Beaver is a highly successful northerner that could not survive the frigid outside temperatures for long —imagine coming out of the water, soaking wet, into sub-zero air! But beavers have a warm and lazy winter because they prepare well for it. All summer, they cut branches of willow, aspen, poplar, alder and birch and store them in their underwater feed pile near the den or lodge. When the pond or river freezes, they swim under the ice from their home to the stockpile, grab some food and head back, without ever being exposed to the lethally cold air.

The beaver labors all summer, even getting skinny from overexertion, making use of the endless arctic days to ensure enough food for the long winter ahead. So these animals exemplify one of the most important qualities for success in the far north—foresight.

The World's Warmest Fur

For animals that spend the winter outside, fully exposed to the deep cold and blizzards, sleeping through the whole thing is not an option and stockpiling enough food may be impossible.

The survival strategy for these animals has much to do with conserving body heat—which usually means having specialized fur…and lots of it.

Moose and caribou have very dense fur, and the outer or "guard" hairs are hollow, so each one traps a tiny pocket of air—adding up to millions of them on every animal—providing exceptional insulation. These animals also have soft, wooly underfur that fills the spaces between the guard hairs to add more warmth. Without its dense coat of beautifully designed fur, an animal could not survive exposed to the pervasive and often wind-driven cold of the far north.

The lush green growth of summer is a faint memory and many plants are buried under 1-2m (3-6 feet) of snow. Moose can live by browsing the twigs, branches, and bark of trees and shrubs; and they paw down through snow to find smaller plants. Caribou also dig through the snow for small dried plants, twigs and sticks, but they most prefer lichen, which they also find under the drifts. Sprawling areas of snow covered with small craters are a sure sign that caribou have been digging for food.

Moose and most caribou winter in the shelter of the boreal forest. Although temperatures are actually colder than on the open tundra or mountains, the trees offer protection from fierce winds and blizzards. Powdery snow can be very deep in the forest, however, and moose sometimes struggle to move around. Their long legs post-hole into the snow, just as a human sinks down without the benefit of snowshoes. During snowy winters, moose tend to stay in one area, restricted to their own compacted trails. Less movement helps to conserve energy, but at these times moose are highly vulnerable to predators like wolves or coyotes in New Brunswick.

Caribou are specially equipped for snow travel because they have wide, splaying hooves, which help them to stay on the upper layers of snow. Their hooves also make good snow shovels for digging around for lichen and other plants.

And what about the ptarmigan, one of the few birds that stays for the winter while most of the feathered ones high tail it southward? These uniquely adapted birds have feathers on their legs and feet, which not only helps to keep them warm but also gives them the advantage of built-in snowshoes for walking on top of the snow. When it's really cold, ptarmigan (and ruffed grouse) dive or tunnel down into the snow and make a snug cave where the temperature can be more than fifty degrees higher than the frigid air above. Fresh snow is a great insulator—typically it's 90 to 95 percent air, so it acts something like the caribou's hollow hairs. And dinner for ptarmigan? Seeds, twigs, buds of trees and whatever they can scratch out of the snow.

There's one other problem of winter…everything is covered in white. If you are a prey species, the last thing you want is to stand out like a bull's eye against a pure white background. So for ptarmigan, arctic fox, and snowshoe hares, the best strategy is to blend in by growing white fur for the winter.

Ptarmigan (winter plumage)

Whatever the means or method… animals that live through the extreme cold of far northern winters show us marvelous and fascinating examples of evolutionary adaptation. And for those who make it through the long, deep cold—the lush and lavish summer awaits.

McKenzie, L. (2017). Living North: Animal Adaptations. Encounters North.
https://www.encountersnorth.org/cold-summary/2017/8/2/living-north-animal-adaptations

Aging a Deer by Examining Its Jawbone

Successful deer management involves keeping accurate harvest records and manipulating several deer population parameters, including the sex and age ratio of the deer herd. Managing the age structure of the buck segment of the population is considered one of the most important factors for improving the quality of the deer herd within a particular area.

The age of a deer can be estimated from the dental characteristics of the lower jaw. A technique used to determine the age of deer from the jawbone is called tooth replacement and wear technique

Tooth replacement and wear technique

The majority of deer harvested are aged using the tooth replacement and wear technique. This technique simply requires determining which teeth are present in the jawbone and how worn those teeth are. Figure 1 depicts the general anatomy of the molars in a deer's lower jaw.

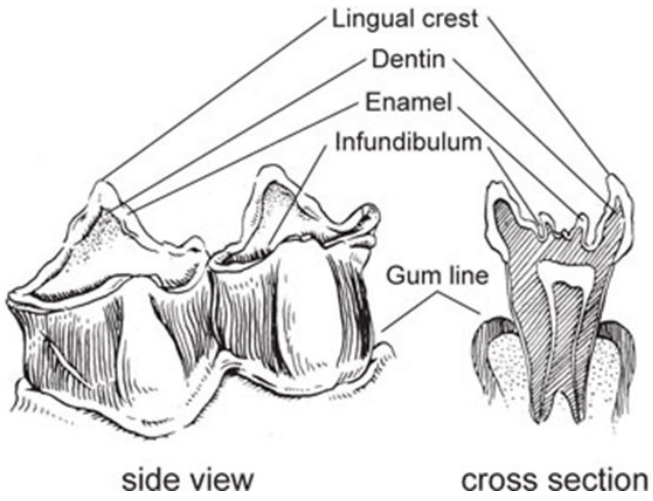


Figure 1. Anatomy of a deer molar.

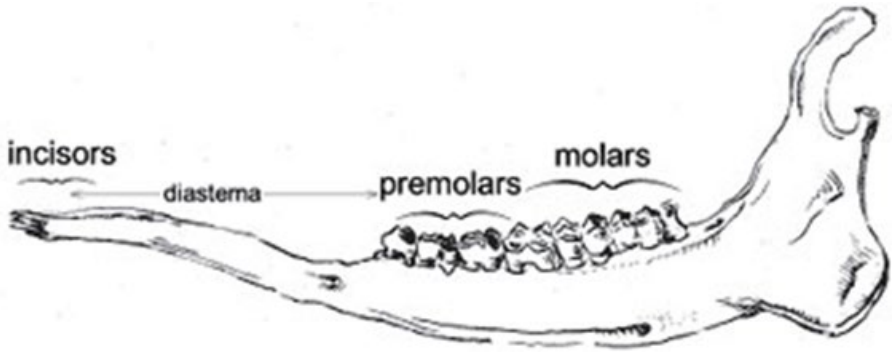


Figure 2. The deer jaw consists of incisors in the front, premolars and molars in the back, and a wide gap called the diastema in between.

Figure 2 depicts the jawbone of a healthy adult white-tailed deer. The incisors are the teeth in the front of a deer's mouth. Premolars and molars are located along the side of the jaw, separated from the incisors by a wide gap called the diastema. Deer do not have any top front teeth but only a rough palate. As a result, vegetation bitten off by deer appears to have been torn off and has a rough edge, whereas vegetation snipped off by rabbits or groundhogs is clean and smooth.

Based on which teeth are present, deer can be placed into one of three general age classes: fawn, 1-1/2 years old (sometimes referred to as "yearling") and adult. Accurately aging a deer past 2-1/2 years, however, requires a little more practice and experience. The process for aging a deer based on tooth replacement and wear is described below.

Fawn

Fawns typically have only three or four fully erupted teeth along each side of the jaw. The first three are temporary premolars (P1, P2 and P3) and are called "milk teeth" because deer are born with these teeth in place. The third premolar (P3) has three cusps, which is important to note. If a fourth tooth is present, it is the first molar (M1). A deer with only three or four fully erupted teeth along the jaw is a fawn (Figure 3).

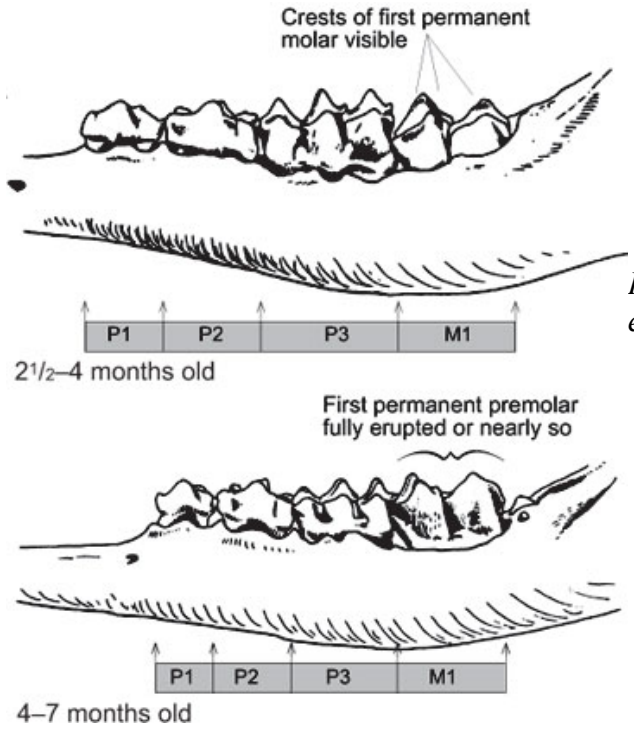


Figure 3. A fawn has only three or four fully erupted teeth along each side of its jaw.

Yearling

Yearlings generally have six fully erupted teeth along each side of the jaw. If the deer was born late or was killed early in the hunting season, the third molar (M3) may not be fully erupted. However, six teeth should be present along the jaw. Because the third premolar (P3) has not yet been replaced by a permanent P3, it still has three cusps. If the jawbone has six teeth along the side and P3 has three cusps, the deer is a yearling (1-1/2 years old). However, the third premolar will be replaced at 18 or 19 months, which will be obvious as P3 will have 2 cusps, will be white and unstained, showing virtually no wear, and may not be fully erupted (Figure 4).

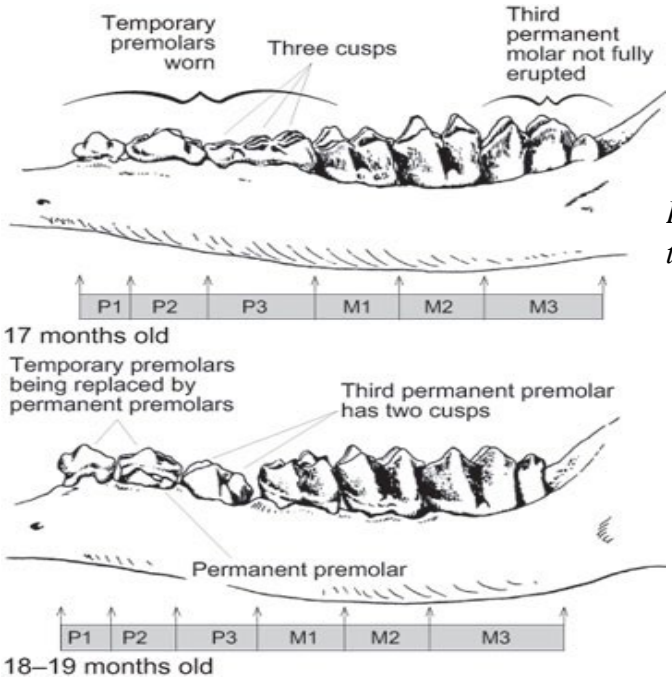


Figure 4. Yearlings have six fully erupted teeth on each side.

Adult

Adult deer (2-1/2 years and older) will have six fully erupted teeth along each side of the jaw: three permanent premolars and three permanent molars. Once again, note P3: It is now a permanent tooth and has only two cusps. In such cases, the deer is most likely an adult (Figure 5). However, as previously mentioned, a yearling could have a P3 with two cusps if it was an early-born fawn or was harvested late in the hunting season (into January).

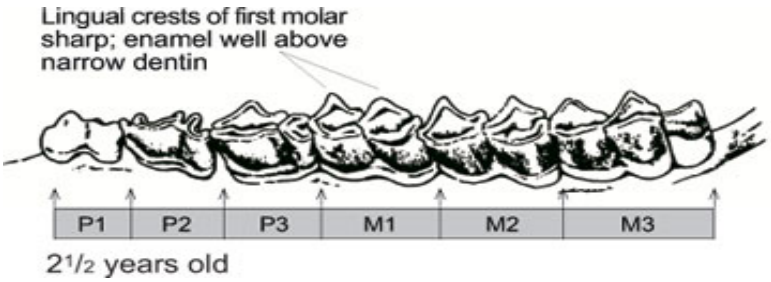


Figure 5. In an adult deer, P3 has only two crests

Aging of adult deer into older age classes requires evaluating the amount of wear on the teeth. Over time, teeth wear down, increasing the width of dentin (brown) exposed along each tooth's cusps. Specific age is estimated by comparing the width of dentin in relation to the width of enamel (white), while measuring overall wear (Figure 6). This deer-aging technique typically requires that the lower jawbone be extracted or the cheek cut away so that the teeth can be inspected closely.

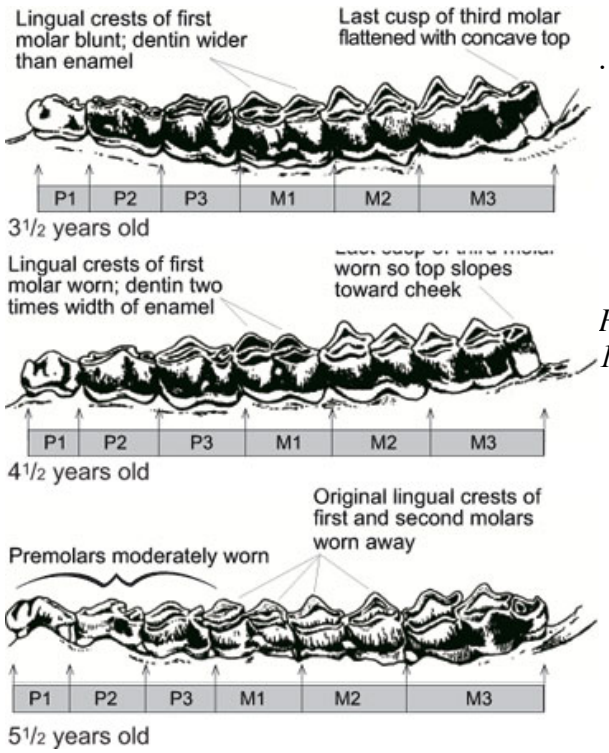


Figure 6. Accurately aging an adult deer past 2-1/2 years requires close attention to tooth wear.

Glossary of deer tooth terms

Cusps -The points or projections on the surface of a tooth.

Dentin -The softer inner core of a tooth, much darker in color than the enamel.

Enamel -The hard, white outer coat of a tooth.

Gum line- Point to which flesh of the gum covers a tooth.

Infundibulum- The funnel-shaped depression in the central crown of tooth between the crests; exterior surfaces will be stained dark.

Lingual crests- Tooth ridges running from front to back adjacent to the tongue.

Milk teeth- Temporary teeth in young animals, which are shed by 2 years of age.

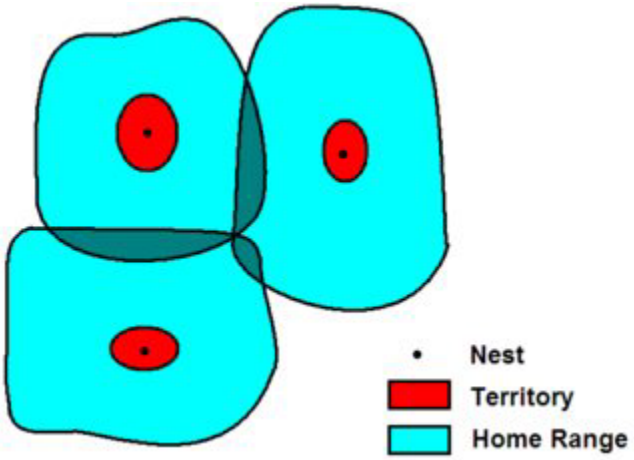
Molars- The large jaw teeth that grind food.

Territories and Home Range

A territory is a geographical area that an individual marks and defends.

A territory provides a safe place for young to be raised and usually contains a breeding / nesting site at its centre. Some organisms only have territories or defend them more vigorously during mating season. A territory can be marked out using movements (displays), sound (calling) or smell (scent). However, it costs time and ENERGY to defend a territory. For this reason, territories are relatively small, and some organisms will only defend their territory during mating season.

Territories and Home Range



This is the wider geographical area that an animal will seldom leave (unless they migrate in order to breed elsewhere). An animal's home range is usually much larger than its territory. Unlike territories, a home range is not actively defended and home ranges may overlap. The size of a home range will depend on:

- Density of resources (food)
- Population density
- Competition with other species
- Position in hierarchy of the individual or group

Home ranges may often be smaller than we think. Snapping turtles rarely leave their home range, which can be as small as 100m2 (except to breed, when they migrate elsewhere).

Home Range Examples

Room to Roam

Think about all the places you go during the week - to school, to the store, to the park - all of these places are important to you. They are your home range! Every animal species needs a certain amount of space to survive and thrive. The amount of space an animal uses on a regular basis is called its home range. Home ranges can stretch for many kilometers (0.6miles) or they can be only a meter (3.28 feet). The size of a home range often depends on the size of an animal. Large animals, like the moose, need more space to survive than smaller animals like the chipmunk!

Moving Around

Animals move around for a variety of reasons. They move for food, for shelter, to care for their young, to find a mate, and to escape predators. Some animals move seasonally from one location to another; this is migration. All animals move around within their habitat on a daily basis. The area an animal uses to meet its daily needs is its home range.

Having a home range is important for an animal's survival. They become familiar with their range. They know where the food and water is, where the danger is, and where the good hiding spots are. They also learn to identify when something has changed or invaded their home range. Many animals are as familiar with their home range as you are with your neighborhood! In fact, some animals are so attached to their home ranges that when they are removed from them, they will sometimes travel many kilometers (miles) to return! Some animals have one location in their home range, like a den or a nest, that is their home. They may move around their home range during the day or at night, but they always return to that one place to sleep! Other animals don't have a single place in their home range that is their home. They may rest wherever they can find a safe, comfortable spot! Other animals may have a few spots within their home range that they use to rest.

Back Off

Many animals, like the coyote, mark and defend some or all of their home range. When this happens, they have established **a territory**. When an animal establishes a territory, it usually only defends it against other members of its species. Many male animals will establish a territory and share it with more than one female but defend it against other males. This helps ensure that other males won't mate with the females in his home range.

Private Property

Bobcats are solitary animals, except during mating season. They mark their territory with urine, feces, scent markings, scratches and scrapes (piles of dirt and debris marked with scent). A

male's home range may overlap with the home range of a couple of females and often another male. Females' home ranges usually don't overlap. Home ranges can vary in size from less than 2.5 km square to 50km square (1 square mile to more than 20 miles), depending on the season of the year and the geographic location.

The fisher is usually nocturnal. A fisher's home range is usually about ten square miles and may overlap with the home ranges of a number of other fishers. It uses scent to mark its territory. A fisher moves around its home range frequently, following well-used trails. It travels both on the ground and through the trees. The fisher makes its den in crevices, under bushes, in logs, and in trees.

Source: Home Range (2022, October 16). https://nhpbs.org/wild/homerange.asp

What is the Difference Between Generalist and Specialist Animals?

A specialist animal, the koala only lives in and eats the leaves of eucalyptus trees.

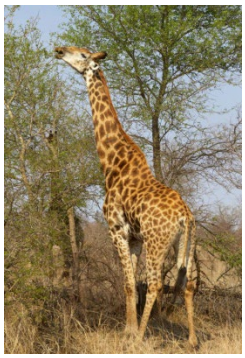
Generalist animals are those adapted to a wide range of environmental circumstances and food sources, while specialist animals are really good at one narrow thing they do. An example of a generalist would be mice, which can adapt to practically any environment and consume a variety of seeds, grains, and nuts. An example of a specialist would be the **koala**, which lives in eucalyptus trees and exclusively consumes eucalyptus leaves, one of the only animals capable of doing so.

The walrus, which uses layers of blubber to keep warm, is only adapted to arctic environments.

In general, generalist animals appear to be more successful than specialists, as they can take advantage of a wider range of circumstances. The downsides of generalism are stress and competition — because they compete in crowded biological niches, generalists have to elbow other generalists out of the way to survive on a fixed amount of nutrients. An example of this behavior is found in rats, which habitually kill mice. This behavior, known as muricide, is partially about eating the mouse for food, but only a portion of the mouse is usually consumed, signifying it may be more about eliminating competition. Being a generalist is tough work.

Rats are good examples of generalist animals.

Meanwhile, specialists can pretty much enjoy their narrow niche without much competition. Koalas, for instance, stay high up in the trees doing little but sleeping and eating, and they are too large for anything there to predate on them. Walruses are specialist animals that live in the far north, surviving the freezing cold with a layer of blubber several inches thick. They use their snouts and specialized mouths to dig molluscs out of the sea bed and suck them out of their shells. The giraffe would be another specialist, picking succulent leaves off the tallest trees using its extremely long neck.



Giraffes are specialist animals, picking leaves off the tallest trees.

Examining the adaptations used by both generalists and specialists can be informative from an evolutionary perspective. Specialists have evolved to adapt to thousands of unique niches, while generalists compete in huge numbers for the easy-to-get resources of central niches. Generalists tend to evolve somewhat more quickly than specialists, being put under greater evolutionary pressures. When a specialists' niche is disturbed — say through deforestation — it can suffer terribly and even go completely extinct, however. Without flexibility in its diet or mode of living, the specialist dies. Either immediately or in a few million years, some other animal may evolve to take over that empty niche.

Source: Anissimov, M. (2022, September 30). What is the Difference Between Generalist and Specialist Animals? https://www.allthingsnature.org/what-is-the-difference-between-generalist-and-specialist-animals.html

2023 NCF-Envirothon New Brunswick

Wildlife Study Resources

Key Topic #2: Wildlife Ecology

8. Identify the essential components of a habitat.
9. Describe the roles of producers, consumers, and decomposers in various ecosystems and identify their trophic levels.
10. Define limiting factors and carrying capacity with respect to wildlife populations.
11. Draw a food web and describe the flow of energy within it.
12. Explain the different types and levels of biodiversity, and how they apply to ecosystems.
13. Describe how changes in demographic, parameters (such as birth, mortality, reproduction rate, immigration, emigration, age structure, sex ratio, etc.) affect wildlife populations.
14. Describe different habitat characteristics that are important to wildlife (such as edges, ecotones, downed wood debris, riparian areas, early successional stages, etc.)
15. Familiarize yourself with management strategies for creation/ maintenance of deer wintering areas as well as productive wetlands for waterfowl.

Study Resources

Resource Title	Source	Located on
Habitat	*Rutledge, K., McDaniel, M., Teng, T., Hall, H., Ramroop, T., Sprout., Hunt, H. and D. Boudreau, 2022*	Pages 45-46
Limiting Factors to Population Growth	*National Geographic Resource Library, 2023*	Pages 47-48
Food Chains and Webs	*National Geographic Resource Library, 2022*	Pages 49-50
Levels of Biodiversity	*The Canadian Biodiversity Website, 2022*	Pages 51-52
Understanding Wildlife Biology: Population Dynamics 101	*Kramer,D., 2015*	Pages 53-54
What is Habitat Connectivity and Why is it Important for Conservation?	*M, K, 2018*	Pages 55

Study Resources begin on the next page! ➡

Habitat

A habitat is a place where an organism makes its home. A habitat meets all the environmental conditions an organism needs to survive. For an animal, that means everything it needs to find and gather food, select a mate, and successfully reproduce.

The main components of a habitat are shelter, water, food, and space. A habitat is said to have a suitable arrangement when it has the correct amount of all of these. Sometimes, a habitat can meet some components of a suitable arrangement, but not all.

Space

The amount of space an organism needs to thrive varies widely from species to species. For example, the common carpenter ant needs only a few square inches for an entire colony to develop tunnels, find food, and complete all the activities it needs to survive. In contrast, cougars are very solitary, territorial animals that need a large amount of space. Cougars can cover 455 square kilometers (175 square miles) of land to hunt and find a mate. A cougar could not survive in the same amount of space that a carpenter ant needs. Space is not the same as range; the range of an animal is the part of the world it inhabits. Grassland, for example, is the habitat of the giraffe, but the animal's range is central, eastern, and southern Africa.

Food

The availability of food is a crucial part of a habitat's suitable arrangement. For example, in the northern part of the U.S. state of Minnesota, black bears eat mostly plants, like clover, dandelions, and blueberries. If there were a drought, plants would become scarce. Even though the habitat would still have space (large forest), shelter (caves, forest floor), water (streams and lakes), and some food, it wouldn't have enough to eat.

Too much food can also disrupt a habitat. Algae is a microscopic aquatic organism that makes its own food through the process of photosynthesis. Nutrients like phosphorous contribute to the spread of algae. When a freshwater habitat has a sharp increase in phosphorous, algae "blooms," or reproduces quickly. Algae also dies very quickly, and the decaying algae produces an algal bloom. The algal bloom can discolor the water, turning it green, red, or brown. Algal blooms can also absorb oxygen from the water, destroying the habitat of organisms like fish and plants. Excess nutrients for algae can destroy the habitat's food chain. and plants.

Water

Water is essential to all forms of life. Every habitat must have some form of a water supply.

Some organisms need a lot of water, while others need very little. For example, dromedary camels are known for their ability to carry goods and people for long distances without needing much water. Dromedary camels, which have one hump, can travel 161 kilometers (100 miles) without a drink of water. Even with very little access to water in a hot, dry climate, dromedary camels have a suitable arrangement in northern Africa and the Arabian Peninsula.

Shelter

An organism's shelter protects it from predators and weather. Shelter also provides a space for eating, sleeping, hunting, and raising a family. Shelters come in many forms. A single tree, for example, can provide sheltered habitats for many different organisms. For a caterpillar, shelter might be the underside of a leaf. For a mushroom fungus, shelter might be the cool, damp area near tree roots. For a bald eagle, shelter may be a high perch to make a nest and watch for food.

Source: Rutledge, K., McDaniel, M., Teng, T., Hall, H., Ramroop, T., Sprout., Hunt, J. and D. Boudreau (2022, October 26) Habitat.
https://education.nationalgeographic.org/resource/habitat

Limiting Factors to Population Growth

A female cottontail rabbit (*Sylvilagus floridanus*) can give birth as often as seven times a year. A female American toad (*Anaxyrus americanus*) can lay thousands of eggs every spring. So why are the meadows and forests of the eastern United States not literally hopping with rabbits and toads? In nature, the size of a population and the rate of population growth are influenced by what ecologists call "limiting factors."

Think about all the different resources that two common animals need to stay alive. Cottontail rabbits need food to eat (grasses and other plants), water to drink, and a safe place to raise their young. American toads eat insects and, though they often live in forest habitat, need ponds or puddles to lay their eggs. Both toads and rabbits have to watch out for predators. But even if they avoid a hungry hawk or snake, they face other potentially deadly dangers, including diseases, forest fires, or drought.

Any of these factors—food, shelter, breeding sites, predators, and more—may serve to limit the growth of a rabbit or toad population. Often, the population is affected by several limiting factors that act together.

Limiting factors fall into two broad categories: density-dependent factors and density-independent factors. These names mean just what they say: Density-independent factors have an impact on the population, whether the population is large or small, growing or shrinking. For example, a wildfire that sweeps through a dense forest in the Everglades has a big impact on every population in the community, regardless of the density of any one population.

Wildfire is abiotic (nonliving), and most density-independent limiting factors fall in this category. Other density-independent factors include hurricanes, pollutants, and seasonal climate extremes.

Density-dependent limiting factors tend to be biotic—having to do with living organisms. Competition and predation are two important examples of density-dependent factors.

Mountain chickadees (*Parus gambeli*) compete for a special kind of nest site—tree holes. These little cavities are excavated and then abandoned by woodpeckers. Scientists who added new nest sites in one expanse of forest saw the chickadee nesting population increase significantly, suggesting that nest sites are a density-dependent limiting factor.

A small furry rodent found in eastern Greenland called the collared lemming (*Dicrostonyx groenlandicus*) is a good example of how predation can be a density-dependent limiting factor. The population goes through a boom-and-bust cycle every four years. The lemming population grows to as much as 1,000 times its initial size, then crashes. The cause is stoats (Mustela erminea), a type of weasel that hunts and eats lemmings almost exclusively. Stoats do not reproduce as fast as lemmings, so after a crash, when both stoat and lemming numbers are low, stoats do not have much impact on the lemming population. But by the fourth year, after the stoat population has had time to grow to greater numbers, the stoats—together with other predators—cause another lemming crash, and the cycle continues.

Carrying Capacity

If a population is small and resources are plentiful, a population may grow quickly. But over time, because of limiting factors, population growth tends to slow and then stop. The population has reached the “carrying capacity” of the ecosystem

National Geographic Resource Library (2023, February 1). Limiting Factors
https://education.nationalgeographic.org/resource/limiting-factors

Food Chains and Webs

A food web consists of all the food chains in a single ecosystem. Each living thing in an ecosystem is part of multiple food chains. Each food chain is one possible path that energy and nutrients may take as they move through the ecosystem. All of the interconnected and overlapping food chains in an ecosystem make up a food web.

Trophic Levels

Organisms in food webs are grouped into categories called trophic levels. Roughly speaking, these levels are divided into producers (first trophic level), consumers, and decomposers (last trophic level).

Producers

Producers make up the first trophic level. Producers, also known as autotrophs, make their own food and do not depend on any other organism for nutrition. Most autotrophs use a process called photosynthesis to create food (a nutrient called glucose) from sunlight, carbon dioxide, and water.

Plants are the most familiar type of autotroph, but there are many other kinds. Algae, whose larger forms are known as seaweed, are autotrophic. Phytoplankton, tiny organisms that live in the ocean, are also autotrophs. Some types of bacteria are autotrophs. For example, bacteria living in active volcanoes use sulfur, not carbon dioxide, to produce their own food. This process is called chemosynthesis.

Consumers

The next trophic levels are made up of animals that eat producers. These organisms are called consumers. Consumers can be herbivores (animals that eat plants/producers), carnivores (animals that eat other animals) or omnivores (animals that eat both plants and animals). Omnivores, like people, consume many types of foods. People eat plants, such as vegetables and fruits. We also eat animals and animal products, such as meat, milk, and eggs. We eat fungi, such as mushrooms. We also eat algae, in edible seaweeds like nori (used to wrap sushi rolls) and sea lettuce (used in salads). Bears are omnivores, too. They eat berries and mushrooms, as well as animals such as salmon and deer.

Primary consumers are herbivores. Herbivores eat plants, algae, and other producers. They are at the second trophic level. In a grassland ecosystem, deer, mice, and even elephants are herbivores. They eat grasses, shrubs, and trees.

Secondary consumers eat herbivores. They are at the third trophic level. In a desert ecosystem, a secondary consumer may be a snake that eats a mouse. In the kelp forest, sea otters are secondary consumers that hunt sea urchins.

Tertiary consumers eat the secondary consumers. They are at the fourth trophic level. In the desert ecosystem, an owl or eagle may prey on a snake.

There may be more levels of consumers before a chain finally reaches its top predator. Top predators, also called apex predators, eat other consumers. They may be at the fourth or fifth trophic level. They have no natural enemies except humans. Lions are apex predators in the grassland ecosystem.

Detritivores and Decomposers

Detritivores and decomposers make up the last part of food chains. Detritivores are organisms that eat nonliving plant and animal remains. For example, scavengers such as vultures eat dead animals. Dung beetles eat animal feces. Decomposers, like fungi and bacteria, complete the food chain. Decomposers turn organic wastes, such as decaying plants, into inorganic materials, such as nutrient-rich soil. They complete the cycle of life, returning nutrients to the soil or oceans for use by autotrophs. This starts a whole new series of food chains.

Food Chains

Food webs connect many different food chains, and many different trophic levels. Food webs can support food chains that are long and complicated, or very short.

This short food chain is one part of the forest's food web. Another food chain in the same ecosystem might involve completely different organisms. A caterpillar may eat the leaves of a tree in the forest. A bird such as a sparrow may eat the caterpillar. A snake may then prey on the sparrow. An eagle, an apex predator, may prey on the snake. Yet another bird, a vulture, consumes the body of the dead eagle. Finally, bacteria in the soil decompose the remains.

Energy (Biomass)

Food webs are defined by their **biomass**. Biomass is the energy in living organisms. Autotrophs, the producers in a food web, convert the sun's energy into biomass. Biomass decreases with each trophic level. There is always more biomass in lower trophic levels than in higher ones.

Because biomass decreases with each trophic level, there are always more autotrophs than herbivores in a healthy food web. There are more herbivores than carnivores. An ecosystem cannot support a large number of omnivores without supporting an even larger number of herbivores, and an even larger number of autotrophs.

A healthy food web has an abundance of autotrophs, many herbivores, and relatively few carnivores and omnivores. This balance helps the ecosystem maintain and recycle biomass.

National Geographic Resource Library (2022, October 13). Food Web. https://education.nationalgeographic.org/resource/food-web.:

Levels of Biodiversity

Researchers generally accept three levels of biodiversity: genetic, species, and ecosystem. These levels are all interrelated yet distinct enough that they can be studied as three separate components. Some researchers believe that there are fewer or more levels than these, but the consensus is that three levels is a good number to work with. Most studies, either theoretical or experimental, focus on the species level, as it is the easiest to work on both conceptually and in practice. The following parts will cover all levels of diversity, though examples will generally use the species level.

1. Genetic Diversity

Genetic diversity is the variety present at the level of genes. Genes, made of DNA , are the building blocks that determine how an organism will develop and what its traits and abilities will be. This level of diversity can differ by alleles (different variants of the same gene, such as blue or brown eyes), by entire genes (which determine traits, such as the ability to metabolize a particular substance), or by units larger than genes such as chromosomal structure.

Genetic diversity can be measured at many different levels, including population, species, community, and biome. Which level is used depends upon what is being examined and why, but genetic diversity is important at each of these levels.

The amount of diversity at the genetic level is important because it represents the raw material for evolution and adaptation. More genetic diversity in a species or population means a greater ability for some of the individuals in it to adapt to changes in the environment. Less diversity leads to uniformity, which is a problem in the long term, as it is unlikely that any individual in the population would be able to adapt to changing conditions. As an example, modern agricultural practices use monocultures, which are large cultures of genetically identical plants. This is an advantage when it comes to growing and harvesting crops, but can be a problem when a disease or parasite attacks the field, as every plant in the field will be susceptible. Monocultures are also unable to deal well with changing conditions.

Within species, genetic diversity often increases with environmental variability, which can be expected. If the environment often changes, different genes will have an advantage at different times or places. In this situation genetic diversity remains high because many genes are in the population at any given time. If the environment didn't change, then the small number of genes that had an advantage in that unchanging environment would spread at the cost of the others, causing a drop in genetic diversity.

In communities, it can increase with the diversity of species. How much it increases depends not only on the number of species, but also on how closely related the species are. Species that are closely related (e.g. two species of maple) have similar genetic structures and makeup and therefore do not contribute much additional genetic diversity. These closely-related species will

contribute to genetic diversity in the community less than more remotely-related species (e.g. a maple and a pine) would.

An increase in species diversity can also affect the genetic diversity, and do so differently at different levels. If there are many species, the genetic diversity at that level will be larger than when there are fewer species. On the other hand, genetic diversity within each species can decrease. This can happen if the large number of species means so much competition that each species must be extremely specialized, such as only eating a single type of food. If they are so specialized, this specialization will lead to little genetic diversity within any of the species.

2. Species Diversity

Biodiversity studies typically focus on species. They do so not because species diversity is more important than the other two types, but because diversity is easier to work with. Species are relatively easy to identify by eye in the field, whereas genetic diversity (above) requires laboratories, time and resources to identify, and ecosystem diversity (see below) needs many complex measurements to be taken over a long period of time. Species are also easier to conceptualize and have been the basis of much of the evolutionary and ecological research that biodiversity draws on.

Species are well known and are distinct units of diversity. Each species can be considered to have a particular "role" in the ecosystem, so the addition or loss of single species may have consequences for the system as a whole. Conservation efforts often begin with the recognition that a species is endangered in some way, and a change in the number of species in an ecosystem is a readily obtainable and easily comprehensible measure of how healthy the ecosystem is.

3. Ecosystem Diversity

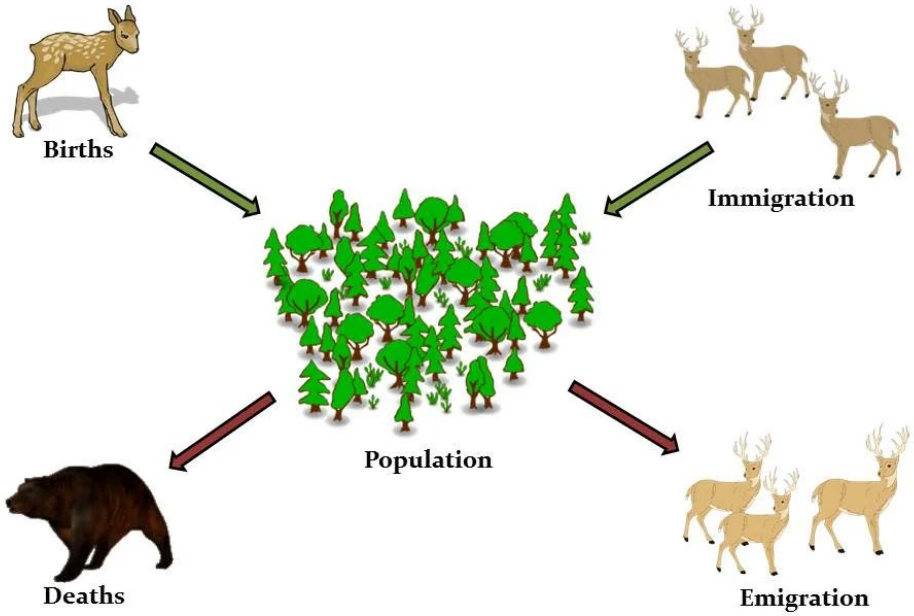
Ecosystem-level theory deals with species distributions and community patterns, the role and function of key species, and combines species' functions and interactions. The term "ecosystem" here represents all levels greater than species: associations, communities, ecosystems, and the like. Different names are used for this level, and it is sometimes divided into several different levels, such as community and ecosystem levels; all these levels are included in this overview. This is the least-understood level of the three described here due to the complexity of the interactions. Trying to understand all the species in an ecosystem and how they affect each other and their surroundings while at the same time being affected themselves, is extremely complex.

One of the difficulties in examining communities is that the transitions between them are usually not very sharp. A lake may have a very sharp boundary between it and the deciduous forest it is in, but the deciduous forest will shift much more gradually to grasslands or to a coniferous forest. This lack of sharp boundaries is known as "open communities" (as opposed to "closed communities," which would have sudden transitions) and makes studying ecosystems difficult, since even defining and delimiting them can be problematic.

Understanding Wildlife Biology: Population Dynamics 101

Populations of wild animals are constantly in a changing state. Over the course of a single year, a local population of deer (or elk, or squirrels, or even catfish) will experience periodic increases as young are born (or hatched) or new individuals travel in from another region. Within that same year, that population may experience decreases from death due to harvest or natural causes and individuals leaving the area in search of a new home.

This constant ebb and flow in the number of individuals, and the age structure of the local community, is known by wildlife biologists as population dynamics.



The processes that impact population dynamics can be broken down into four separate categories**:** births, deaths, immigration, and emigration. To better visualize these four processes, imagine a small rural town. In this instance, the small town represents a regional population. During one year in that small town, the neighbors down the street had a pair of twins (births), but unfortunately the man across street passed away (deaths). Your co-worker just received a promotion that required her to move to the next town over (emigration), but by the end of the year a new family moved into her old house from out of state (immigration). The population in the small town is constantly changing over time, sometimes hitting new highs when a new

factory opens and creates jobs or plummeting to new lows when that factory closes or lays off workers.

Wildlife biologists use a few additional terms to describe those four population processes. When discussing births, two terms are often used: fecundity and recruitment. Fecundity is the reproductive rate of an individual or the population as a whole. Fecundity is similar to a birth rate, but can vary with changing environmental conditions. In times of drought or low food resources, the fecundity of the population may decrease since a mother cannot acquire enough resources to create or care for young, and in times of resource surplus, fecundity may increase.

Recruitment refers to juveniles who survive into adulthood and become permanent members of the population. For example, a doe may have two fawns, but only one of the two fawns may survive through its first year. In this case the fecundity and recruitment of the population would be different.

In the example of the fawns, one of the fawns did not survive, representing a death in the population. Deaths do not only occur to juveniles; adults can also be removed from the population, whether it is by hunter harvest, predation, or other natural causes.

Immigration and emigration are not only key processes in population dynamics, they are essential for the long-term survival of a local population. Much like humans, individuals may enter or leave a population when pursuing better resources. For people, that may mean a nicer house or a better job, while with animals that may mean better access to mates, less competition for resources, a decrease in predators, or a number of other things. What is important about immigration and emigration is that as individuals move between populations they increase gene flow. Gene flow is the transfer of genes from one population to another. As gene flow increases, so does the genetic diversity of the population, and genetically diverse populations are more capable of withstanding environmental change (drought, for example).

The main take-away from this little lesson is that wildlife populations are ever changing, and those changes can be subtle (just a few individuals) or obvious (population collapse). It is important to remember a number of processes impact the size of the population, and a population needs all four of the factors—births, deaths, immigration, and emigration—to maintain long-term viability. By recording harvests, counting juveniles, identifying new individuals, and noticing when familiar faces (and antler configurations) disappear, a sportsman can get a better grasp on the current state of wildlife populations.

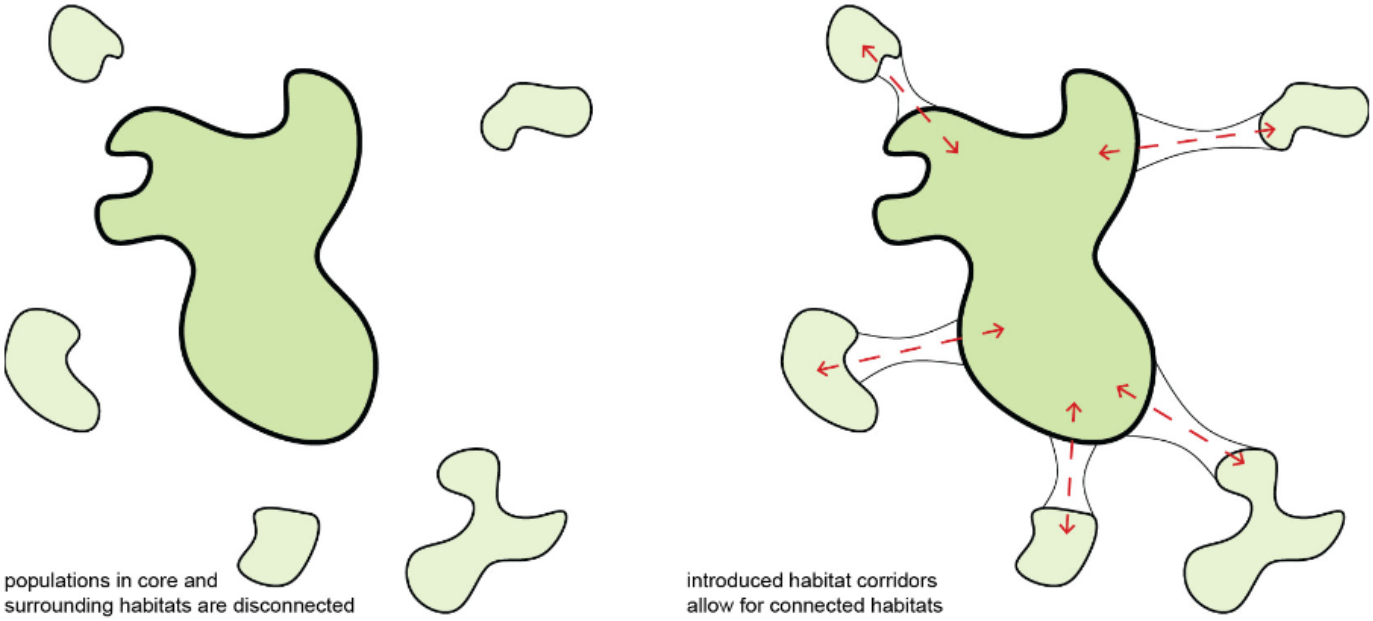
Kramer, D. (2015) Understanding Wildlife Biology: Population Dynamics 101. Outdoor Life. *https://www.outdoorlife.com/blogs/game-changers/understanding-wildlife-biology-population-dynamics-101/*

What is Habitat Connectivity and Why is it Important for Conservation?

Wildlife habitat connectivity is the degree to which separate patches of habitat are connected. Greater habitat connectivity means animals are able to travel between these patches.

It is important because this connectivity enables gene exchange and other crucial exchanges.

Wildlife corridors can be used to connect patches of habitat, increasing connectivity. In the image below, the habitat on the left has less connectivity than the habitat on the right, which has corridors connecting different patches. These corridors facilitate animal migration and movement.



M, K (2018, January 17). What is habitat connectivity and why is it important for conservation? https://socratic.org/questions/what-is-habitat-connectivity-and-why-is-it-important-for-conservation

Edges and Wildlife Corridors

Edge

An edge is the zone where two successional stages or vegetative conditions meet and where the wildlife species of each cover type mingle. This mingling increases the number and variety of wildlife species present. The resulting richness is known as "edge effect".

Edge conditions relate to the age difference between adjacent stands or cover types. Wildlife benefits are optimized by putting clearcuts next to pole-size stands.

Wildlife Corridors

Uncut strips of forest crossing a clearcut create edges and supply "wildlife corridors" from one habitat to another. Where possible these wildlife corridors should be designed to provide concealment and protection from wind and deep snow. They should pass through, or as close as possible to, the center of a clearcut.

The best place to put a wildlife corridor is along a stream flowing through the area to be clearcut. Such a corridor will also protect the stream. Corridors are a good place to leave snags and overmature trees that have cavities or the potential to become cavity trees.

Uncut immature stands or inoperable sites may also provide cover and travel lanes for wildlife.

From a fire management standpoint, hardwood corridors make excellent firebreaks.

Habitat Characteristics - Early Successional Habitat

So many wildlife habitat management projects refer to "early successional habitat" as their goal. But what is this "early successional habitat"? Why does it require work and maintenance?

Simply put, early successional habitat refers to the plants (and the animal that rely on them) that develop in an area shortly after a disturbance. Succession is the process by which plant communities change in a certain area over time from an early stage of development until they reach a final mature form or "climax community." For much of Virginia this final stage is some form of mature forest. The trick is that those changes mean the early stages of succession are temporary. During each stage of succession, the plant community alters the soil and microclimate, paving the way for the establishment of the next group of plant species.

Early successional plants are generally herbaceous annuals and perennials—grasses and wildflowers. One example is a farm field that lies fallow and gets overgrown, creating an area of early successional habitat that provides food and shelter for a wide variety of wildlife species, such as pollinator insects like butterflies and bees, snakes, turtles, songbirds, skunks, opossums, rabbits, turkey, quail, and white-tailed deer.

Each stage of succession supports a variety of wildlife species and provides valuable habitat. Early successional habitat, while rich and vibrant, is temporary. Left undisturbed, it sees the growth of tree species such as pine, oak, and hickory. As the tree canopy develops, the early successional plant species don't receive enough sunlight and fade away. The habitat becomes mature forest, and no longer supports the same species. Because these changes occur relatively quickly, quality early successional habitat is increasingly rare in Virginia.

So, what are the "disturbances" that help create and maintain early successional habitat? Essentially, they are events that set back the clock, preventing the growth of mature trees. Natural disturbances may include extreme weather events like hurricanes or tornados, wildfires, or even insects and disease. Techniques that manually create disturbances in habitat include timbering, bush-hogging, or discing, application of herbicide, and prescribed fire are all tools in the habitat manager's toolbox. Manipulating the habitat by these methods keeps the "succession" of the habitat from progressing to mature forests, creating a loop of early successional habitat welcoming to wildlife.

What is Early Successional Habitat? (2022, October 13). https://dwr.virginia.gov/blog/what-is-early-successional-habitat/

Habitat Features - Snags, Course Woody Debris, and Riparian Buffers

Snags

In intensively managed forests, poor forest planning can lead to a lack of suitable numbers and types of large decaying or preferred nesting trees , which often limits species that need cavities. Forests can be best managed for cavity nesting species of birds by selection harvesting techniques. After commercial timber is removed during the first intervention, the best management option for cavity nesters is to leave a minimum of 10- 12 snags (defined as standing dead trees, preferably greater than 20 cm dbh (7.9" diameter breast height)) per hectare for feeding, plus 12-15 live, or partially dead, mature Aspen or Beech (in the absence of Aspen or Beech, Maple and Yellow Birch may be substituted) with minimum dbh of 25 cm (10") to be used for nesting.

Coarse Woody Debris

There is considerable research to show the importance of both standing and down coarse woody debris (CWD) for maintenance of biodiversity. Such material is important for denning sites, decomposition (nutrient cycling), feeding areas, and thermal and drought refuges, among other values. It is important that forest management leave any surplus coarse woody debris on site and not remove it during harvest. Tree limbs and tops should be left on site after harvest. A more difficult problem is to specify the amounts of the larger classes of coarse woody debris, including whole trees and large tree boles. It is known that this type of debris is important. For most species of cavity-dependent wildlife, other components of "forest maturity" are required for successful occupancy, especially those which address food and cover. Most species of wildlife dependent on tree cavities have different food, cover, and spatial requirements. A lone dead Maple tree in a clear-cut might be used for nesting by a Northern Flicker, Tree Swallow or American Kestrel, and is quickly labelled as a "wildlife tree."

Riparian Buffer

Buffer have generally been proposed based on their value as; 1. **filters** - the ability of a band of shoreline vegetation to absorb nutrients before they enter a waterway; 2. **shelters** - the amount of canopy needed to keep water temperature from surpassing the tolerances of fish species requiring cool water; 3. **stabilizers** - preventing erosion on steep slopes and the siltation of waterways, and; 4. **detritus suppliers** - provide input of coarse woody debris. At a landscape level, the creation of a relatively uncut, older-aged buffer system network also has value in that it creates corridors that are important for wildlife movement. In New Brunswick, these buffer guidelines are set under the Watercourse Buffer Zone Guidelines for Crown Land Forestry Activities and the Clean Water Act. The Clean Water Act requires a minimum 30m (98') buffer zone on all watercourses.

Creation of Deer Wintering Areas on Private Land

The white-tailed deer (*Odocoileus virginianus*) is one of the most widely distributed and often studied wildlife species in North America. A key factor in their life strategy is to congregate, or yard, in large, high density groups during winter. Deer yards tend to occur frequently in fertile riparian areas or on south-facing slopes which provide shelter from the prevailing wind and offer maximum exposure to the sun. Yards can generally be described as irregular in shape, mature or mixed softwood stands which offer cover as well as access to acceptable browse. Deer exhibit fidelity to both their winter and summer ranges and is thought to be a learned social behavior transmitted from does to fawns over successive generations. Although there is evidence that deer are able to alter their migration patterns, elimination of a traditional yard may have serious detrimental effects on deer accustomed to migrating to a particular area. In New Brunswick, deer primarily migrate to wintering areas and begin to yard in response to snow depths greater than 19 cm (7.5”), and at depths of 50 cm (19.7”) become severely restricted in their movements. Wintering deer tend to seek out sites with large overstory trees, abundant understory growth, proximity to high softwood canopy and absence of a second story beneath the main canopy, and show an avoidance of north-facing slopes. The following forest management practices should be taken into consideration in New Brunswick regions where wintering areas are necessary due to high snow loads and / or very low winter temperatures:

1. Current wintering areas should be mapped within a Geographic Information System (GIS) and planners must integrate deer habitat requirements into their immediate and long-term harvest planning Within deer wintering areas, selective cutting is preferable to clearcutting.
2. Deer wintering areas are dynamic and should not be managed as though they are fixed in time and space. Like any forested area, a myriad of factors (such as temperature, precipitation, and winter severity) can change from year to year within a deer yard, and affect the composition and distribution of the resident flora and fauna, as well as the physical environment itself (e.g. blowdown).
3. In scheduling forest harvesting, forest planners must not only consider the normal winter conditions experienced within the region of the deer wintering area, but account for the unpredictable nature of snow conditions in parts of New Brunswick:
    a. In areas which experience harsh winters (i.e. where deer select habitat based primarily on the proportion of cover rather than the availability of browse), at least 50% of existing conifer cover within the yard should be retained and be at least 10ha (32.8’). in area. Conifer height in each patch should be 10 m or higher and have crown closure between 60% and 80%
    b. In areas which experience mild winters (i.e. where deer select habitat based primarily on the availability of browse rather than the proportion of cover), at least 30% of existing conifer cover should be retained, be at least 5 ha. Conifer height in each patch should be 10 meters (32.8’) or higher and crown closure should be at least 30%.

4. Shelter patches should not be isolated but linked to other uncut areas by corridors with a minimum width of 30m (98') and a crown closure of at least 50%. Corridors should follow watercourses (when present) or established travel routes.
5. Light harvesting to maximize browse quality and availability in the yard should be employed where possible, while maintaining the necessary levels of crown closure. Cutting should be scheduled for the fall or early winter to provide large amounts of easily accessible browse for deer.

Nova Scotia Department of Natural Resources (2012). Special Management Practices for White-tailed Deer Wintering Areas.
https://novascotia.ca/natr/wildlife/habitats/terrestrial/pdf/SMP_White-tailed_Deer.pdf

Managing Small Wetlands for Waterfowl

Wetlands provide important habitat for a wide variety of plant and animal species and are excellent places to observe wildlife. Many small wetlands involve private land. Some of these areas are very productive and diverse in wildlife species while others can be made more so by applying a few proven management techniques.

Ducks Unlimited Canada has been actively creating and managing larger wetlands throughout the Maritimes since the mid 1960's. With the publication of this booklet, Ducks Unlimited Canada hopes to assist individuals in managing the thousands of small privately owned marshes.

Wetland Types

A Wetland can be defined as " an area of land which is covered by water for part or all of the year". They may be associated with rivers, lakes, streams or coastal habitats. The types of wetlands usually described are marshes (fresh or salt water, bogs, fens, swamps, and ponds).

One of the most productive wetland types is the freshwater marsh with water less than one metre (3.3’) deep. These marshes usually contain aquatic vegetation which provide escape cover, food and nest sites for wildlife.

This section provides a few instructions on how to improve small freshwater marshes and ponds. Salt marshes are naturally productive, while bogs, fens and swamps are usually nutrient poor or are not easily improved.

Important Considerations

A great deal of research has been carried out in recent years on marsh management as it applies to waterfowl habitat. This research has identified three important characteristics which make marshes attractive to waterfowl.

1. A hemi-marsh exists where there is approximately half open water and half vegetation which is dispersed throughout the water. This creates edge within the marsh. Edge is that point where two different habitat types meet, thus creating ideal feeding and escape opportunities. See Figure 1.

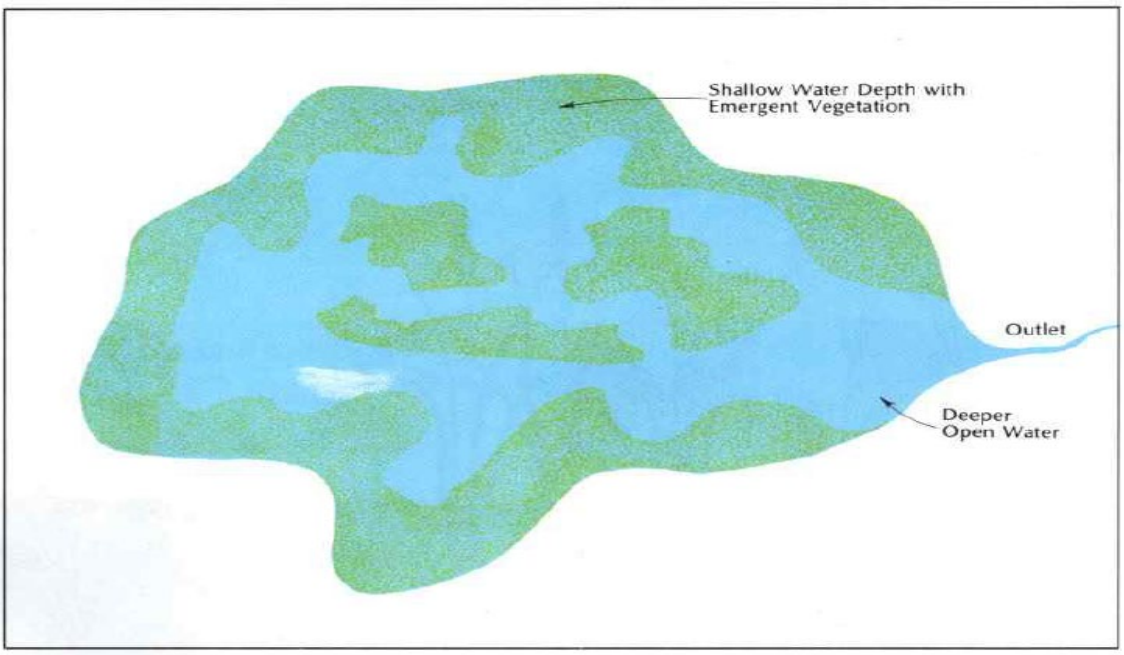


Figure 1
HEMIMARSH
50 percent Open Water

2. A ready supply of nutrients (mainly phosphorous and nitrogen) through natural fertility, recycling (see Figure 3A) or artificial sources will result in the availability of plant and animal food for waterfowl.

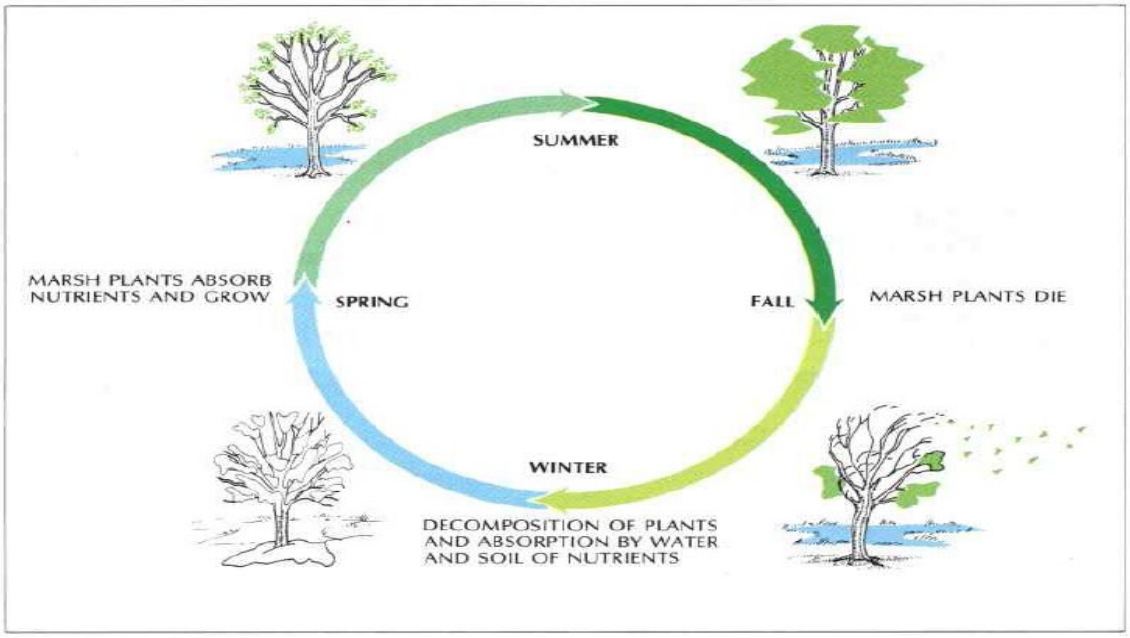


Figure 3A
SEASONAL NUTRIENT CYCLE

3. A suitable water depth, usually less than 1 metre (3.3'), is important to establish vegetation in the marsh.

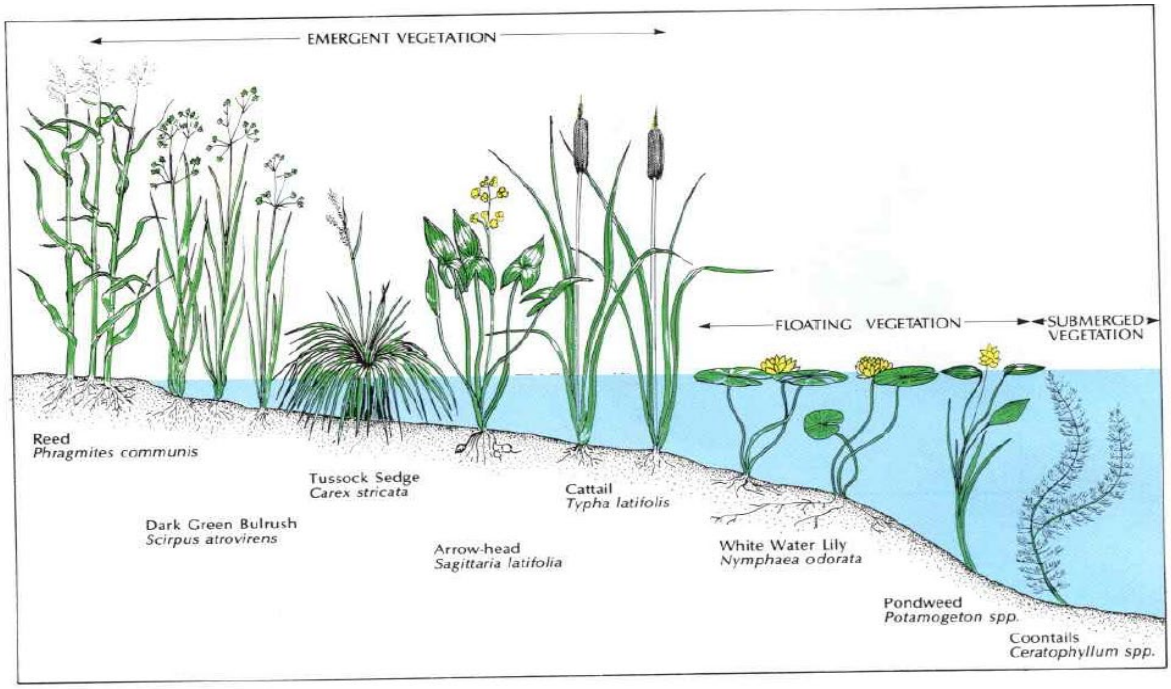


Figure 2
WATER DEPTH AFFECTS PLANT GROWTH

When managing for waterfowl it must be remembered that a particular marsh may provide one or more needs. For example, in the early spring, hens and drakes usually seek out small, isolated ponds which act as pairing territories. The hen may select a nest site near another wetland which she will use as brood rearing habitat, while the flying young and post breeding adults may group together on yet another wetland - perhaps a salt- marsh. In some cases, on larger marshes, all these requirements are met in one place.

When considering what improvements may be carried out on a particular wetland, the life cycle of waterfowl must be considered. Ask what the wetland will most likely be used for...pairing, brood rearing, staging and migration stops are all important.

To enhance a wetland, management should be directed toward creating a hemi-marsh situation and to have some method to control water levels

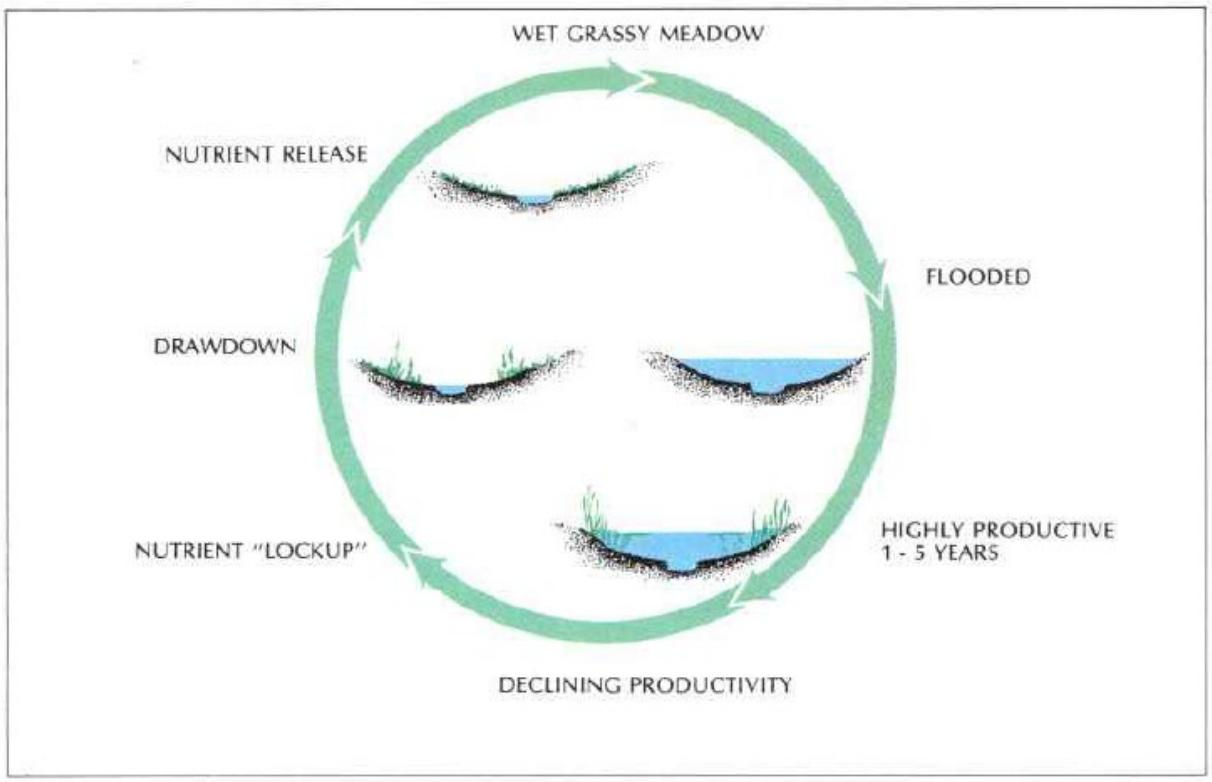


Figure 3B
LONG TERM PRODUCTIVITY CYCLE

Major factors Which Limit Waterfowl Use

1. Too much water (an old beaver pond or lake) usually characterized by insufficient emergent vegetation.
2. Too little water flooded in early spring and dry by early summer, before young ducks can fly.
3. Insufficient levels of nutrients (usually phosphorous and nitrogen), which will translate into a lack of food for waterfowl further up the food chain.
4. Too much disturbance around the wetland or lack of upland cover.

Coping With Limiting Factors

If you are lucky enough to have a beaver pond or a shallow natural lake on your property then you already have a marsh, courtesy of nature. If it contains sufficient nutrients to support plant growth and invertebrate populations, then chances are ducks will already be using your marsh. Initially you may only have to manage the upland to enhance it.

However, in many cases, marshes can be somewhat improved. Figure 3A illustrates how marsh productivity is cyclical. Management involves trying to maximize the time in the cycle which is productive.

1- Too Much Water

Excessive water depth will result in an open water marsh with emergent vegetation confined to the shallower water. Coloured water, typical in many Maritime wetlands, prevents light penetration which is necessary for plant growth.

Lowering the water level to an average depth of 45 to 60 cm (18-24")is a way to make an area more attractive to ducks. Dabbling ducks which feed by tipping up will have access to the food supply on the marsh bottom if the water is shallow.

2- Too Little Water

Building a Dam - Many natural marshes are flooded temporarily in the spring and dry out in the summer. Marshes associated with river floodplains, high saltmarshes, and abandoned beaver ponds are typical examples. Most of Ducks Unlimited Canada's efforts in the Maritimes have involved building dykes, dams and water control structures on larger marshes to retain some water throughout the summer. This same technique can be applied on a smaller scale by a property owner to enhance a natural wetland which goes dry in summer.

The building of a small dam to retain water is an idea that requires careful planning and design. Such development requires the approval of your Provincial Department of the Environment and Fisheries and Oceans Canada. These regulatory agencies must be assured that the project can be constructed in an environmentally safe manner and that there is minimal impact, to other properties or to the wildlife habitat. The potential for siltation of stream and fish habitat is of prime concern. Dams might also be barriers for passage to fish spawning habitat.

The design and construction require some basic engineering skills and construction expertise. If your dam is to exceed a certain height (1 to 1.5 metres/ 3.3-5') drawings prepared by a licensed professional engineer may be required before government approval is granted. The risk of a washout will dramatically increase with a higher dam and larger watershed. Only a properly engineered and built water control structure will prevent this from happening.

Dam construction is not as simple as it might appear. Shortcuts on the design to save money or time will increase the likelihood of failure and there are many testimonies to this fact including ruined fish habitat, damaged property, and financial loss.

Seek professional engineering expertise if you are unable to perform any of the essential steps. Hire experienced contractors that have built dams before and be sure to have all regulatory approvals before you start work.

Excavating and Level Ditching

In many situations it may be impossible to construct a dam to impound an area that lacks open water. Here the property owner can excavate shallow ponds or better yet, level ditches. Level ditching consists of excavating meandering channels 6 metres (19.7') wide and less than 1 metre (3.3') deep through the wetland. Refer to Figure 10. The ditch must not join a stream or drainage channel in order to remain full of water throughout the summer months. Level ditching is more cost effective than excavating a large pond and can most easily be completed by a tracked excavator.

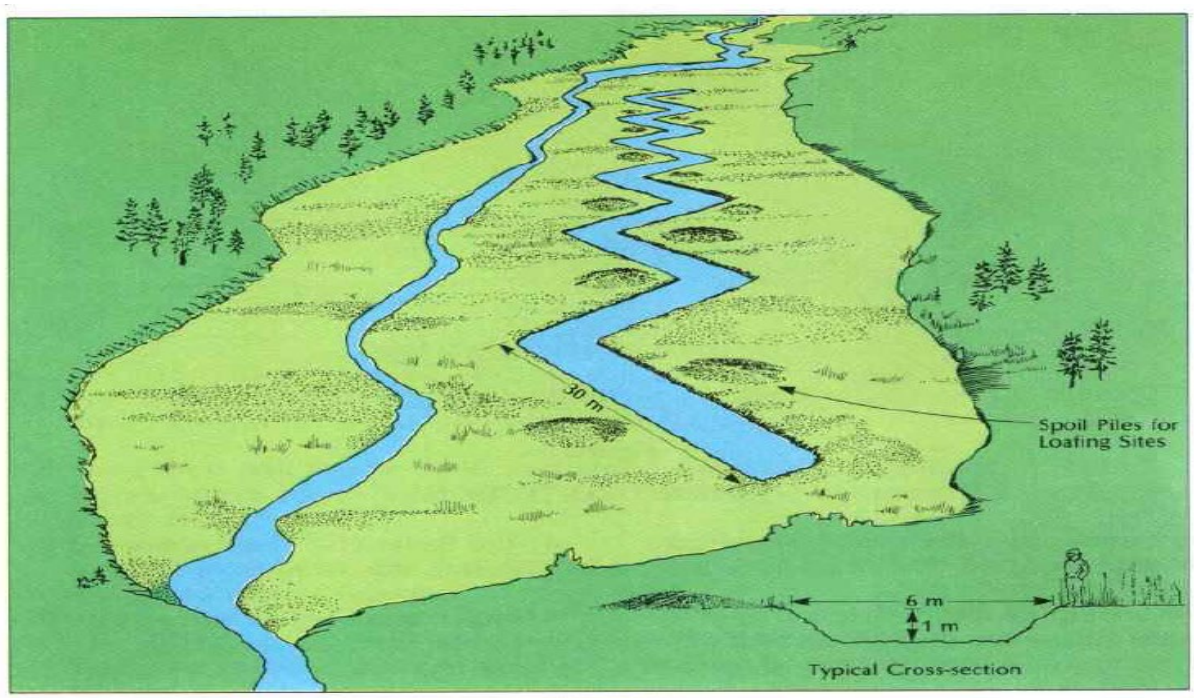


Figure 10
LEVEL DITCHING
Creating Open Water in an Overgrown Marsh

In order to create level ditching or ponds, the wetland must be relatively flat and contain a clay or mineral soil base. Excavated channels in peat or pure sand may not remain full of water and will have a poor nutrient content. Level ditches and ponds located adjacent to larger wetlands will be more effective than those in an isolated situation.

An example of where a series of small ponds or level ditching might be used is on low flat land with no defined stream, but with a high water table. This might even be a wooded swamp, in which case some trees may have to be removed first. The earth material may be piled close to the excavated channel creating denning sites for muskrats and loafing sites for waterfowl.

As with dam construction, extreme caution must be taken near a stream to avoid damage to fish habitat through siltation.

Obtain a permit from your Provincial Department of the Environment before attempting any excavation.

3- Low Nutrient Levels

Many wetlands in the Atlantic region have low productivity because of a lack of available nutrients. The more productive wetlands lie in the fertile soil zones or receive nutrients from outside sources such as agriculture.

In the more sterile areas, one potential enhancement technique to increase productivity is to artificially fertilize the wetland. The technique is not yet fully perfected, so little information is available to the public. Ongoing studies will soon tell us if fertilization is a viable option.

Another problem that will limit productivity on a marsh is caused by prolonged flooding. The nutrients become trapped in the partially decomposed plant material and in the marsh sediments. Removing the water from the marsh periodically stimulates decomposition of plant litter causing nutrients to be released back into the food chain upon reflooding. The length and duration of the temporary drawdowns may vary. In nature, beaver ponds may last 5 to 10 years before the beavers abandon thus creating a drawdown which may last a year or more until a new colony is established.

Many natural wetlands undergo a seasonal partial drawdown due to evaporation and transpiration. Nutrient recycling may occur here every year.

Drawdowns have a dramatic effect on marsh wildlife. A drawdown from August 15 to October 15 every few years may have the least negative impact on non-waterfowl species such as muskrat, while reducing the risk of a vegetative overgrowth which can happen by leaving the marsh dry all year. Proper nutrient levels will result in the availability of both animal and plant foods, which is possibly the most important attraction for waterfowl.

4- Disturbance

As some waterfowl species are very susceptible to disturbance, the surrounding upland can be as important as the marsh itself. Fencing is a way to keep livestock away from the marsh edge. With good escape cover in and around the marsh, waterfowl can tolerate moderate amounts of disturbance. See Figure 11.

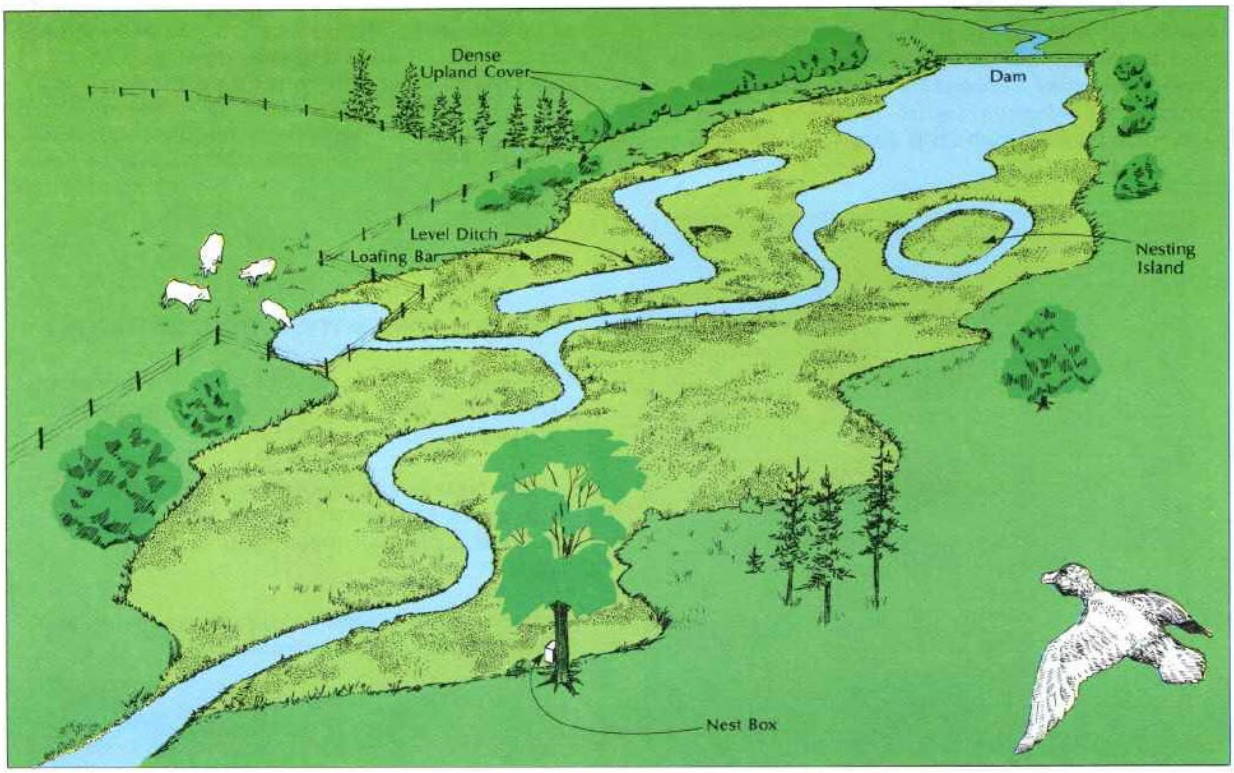


Figure 11
INTENSIVE MANAGEMENT

Additional Improvement Ideas

Marsh characteristics are continually changing. One problem managers have is to maintain the right combination of water, food and cover.

A marsh may eventually become overgrown with vegetation. In the case of cattail overgrowth, open water can be created by cutting the plants off below the waterline in late July or August. Again, keep in mind that the hemi-marsh is the ideal situation to create, so don't remove all the vegetation.

Muskrats are usually attracted to properly managed waterfowl marshes. They are beneficial in that they create open water by cutting plant growth to build houses, which in turn are used as loafing sites for duck s.

Food production can be enhanced by introducing plants such as wild rice. Spreading straw on the pond bottom, to be decomposed by bacteria, will result in increased invertebrate population s further up the food chain. Invertebrates are a high protein food preferred by ducklings. Do not use insecticides on uplands draining into the marsh.

Escape and nesting cover is essential around the marsh and it can be provided in numerous ways. Nest boxes compensate for a lack of natural tree cavities and may be used by wood ducks, mergansers or goldeneye. Dense cover around the marsh can be achieved by fencing out livestock and not mowing to the waters edge. Island construction, installation of loafing logs or placement of large round hay bales provide secure nesting and resting places within the marsh. Prohibiting spring burning on the uplands will protect nesting females.

What to Expect

Waterfowl use different wetland habitats during different times of the year.

While numbers of ducks using a particular small wetland may be relatively low, collectively these small areas are very important to the overall waterfowl population. Without a tremendous food supply, ducks usually do not use ponds much smaller than 1 hectare for brood rearing except when it is associated with a larger wetland complex. Like most wildlife, ducks are creatures of habit and they return to areas where they were successful in obtaining their survival requirements. By following the guidelines in this publication, you will increase your chances of attracting waterfowl to your property and having them return each year.

Ducks Unlimited Canada (1997) Managing Small Wetlands for Waterfowl

2023 NCF-Envirothon New Brunswick

Wildlife Study Resources

Key Topic #3: Wildlife, Conservation and Society

16. Describe the role and history of hunting in wildlife management.
17. Define invasive species and describe their characteristics.
18. Identify invasive species in New Brunswick, describe how they are spread, and explain their impact on local ecosystems.
19. Describe how Canadian wildlife species are affected by climate change.
20. Describe the use of technology such as remote sensing, GPS, and GIS in wildlife management.

Study Resources

Resource Title	Source	Located on
The Role of Hunting in Wildlife Conservation, Explained	*Moore, A.,2021*	Pages 72-73
Common New Brunswick Invasive Species and their Impacts	*New Brunswick Invasive Species Council, 2022.*	Pages 74-77
A Warming Planet- Can Wildlife Keep up with the Changes?	*Gahbauer, 2022.*	Pages 78-80
Remote Sensors Bring Wildlife Tracking to New Level	*Tibbits, J., 2017.*	Pages 81-84

Study Resources begin on the next page! ➡

The Role of Hunting in Wildlife Conservation, Explained

While some deem hunting to be a cruel, unnecessary and unethical practice, it remains the "backbone" of wildlife conservation in the United States, according to one NC State professor.

"Hunters do more to help wildlife than any other group in America," said Chris DePerno, a professor of fisheries, wildlife and conservation biology at the College of Natural Resources. "They not only provide financial support for state wildlife agencies, but they also play an important role in wildlife management activities."

The connection between hunting and conservation in the U.S. can be traced back to the late 19th century, according to DePerno. During this time period, unregulated killing and habitat destruction pushed many species, including bison, white-tailed deer and wild turkeys, to the edge of extinction.

By the early 20th century, sportsmen worked with Congress to pass a number of laws designed to provide long-term protection for wildlife and wilderness areas. That included the Lacy Act, which outlaws the interstate shipment of any wild animals killed in violation of state laws, and the Migratory Bird Treaty Act, which prohibits the killing, capturing, selling, trading and transport of nearly 1,100 species of migratory birds.

Paying for conservation

As state fish and wildlife agencies formed across the country to enforce laws and regulations, sportsmen groups recognized the need for a strong and stable source of funding for conservation. Working with the firearms industry and state agencies, they successfully lobbied Congress to pass two key pieces of legislation: the Migratory Bird Hunting Stamp Act and the Federal Aid in Wildlife Restoration Act.

Passed in 1934, the Migratory Bird Hunting Stamp Act, or the Duck Stamp Act, requires all hunters 16 years or older to purchase a federally issued stamp prior to hunting for ducks, geese and other migratory waterfowl species. The revenue generated from stamp sales is used to buy or lease waterfowl habitat. To date, the Duck Stamp Act has generated more than $1.1 billion for the preservation of over 6 million acres of waterfowl habitat.

Meanwhile, the Federal Aid in Wildlife Restoration Act, or the Pittman-Robertson Act, enacts an 11% excise tax on firearms, ammunition and archery equipment. The revenue generated from this tax is distributed to state fish and wildlife agencies each year to support the management and conservation of wildlife populations. Since it was passed by Congress in 1937, the Pittman-Robertson Act has generated more than $12 billion for state conservation initiatives.

Following the success of the Duck Stamp Act and Pittman-Robertson Act, Congress passed several other laws to bolster conservation funding, including the Dingell-Johnson Sport Fish Restoration Act of 1950, which created an excise tax on fishing equipment.

Today, state fish and wildlife agencies continue to rely on the Duck Stamp Act, Pittman-Robertson Act and the Dingell-Johnson Act to support conservation initiatives, according to DePerno. However, they also rely heavily on hunting license sales. In 2017, the last year data is available, more than 15 million Americans purchased a hunting license, generating over $500 million in revenue for conservation. “A lot of people think state wildlife agencies and programs are funded by taxpayers. But in reality, they’re mostly funded by hunters,” DePerno said. Hunters also raise millions of dollars and contribute thousands of volunteer hours to wildlife conservation through their memberships in organizations such as the National Wild Turkey Federation, Rocky Mountain Elk Foundation, Whitetails Unlimited, Pheasants Forever and Ducks Unlimited. Many of these organizations play a vital role in habitat creation and protection.

Supporting wildlife management

In addition to providing funds for conservation, hunters play an important role in helping state wildlife biologists manage the size of certain animal populations, according to Nils Peterson, a professor of forestry and environmental resources at the College of Natural Resources.

Some prey animals such as elk or deer can become overabundant in their habitat, mostly due to a lack of predators or landscape changes. This overabundance can threaten the well-being of other species, and, in some instances, impact human health and safety. When deer become overpopulated in urban and residential areas, for example, it can lead to an increase in vehicle collisions. Regulated hunting is one of the most effective tools that state wildlife agencies can use to address the overpopulation of a species, Peterson said. “It removes the excess number of animals.” DePerno added that the ultimate goal of wildlife management is to monitor populations “under an adaptive resource management process while using sound research principles.”

Wildlife managers typically model population growth and set management regulations, which may include season length or harvest quotas, based on field research and harvest data. Once these regulations are implemented, wildlife managers monitor the population while continually conducting research and adapting future management decisions based on the resulting data. If a population of white-tailed deer is too large, for example, wildlife managers might increase the season length or allow hunters to harvest one or more female deer to reduce the number of fawns born. On the other hand, if wildlife managers want the population to increase, they might implement a regulation restricting hunters to harvest adult males only, allowing all the females to produce fawns.

Many state and federal wildlife agencies also ask hunters to report the number of animals they harvested in a season and where the animals were harvested, according to DePerno. This allows biologists to evaluate long-term wildlife population and distribution changes.

“Ultimately, managers want to maximize the harvest without putting the population at risk of extinction,” DePerno said. “They want populations to remain healthy for people to enjoy in the future

Common New Brunswick Invasive Species and Their Impacts

Invasive species: an organism (plant, animal, disease, or parasite) that has been accidentally or deliberately introduced into ecosystems beyond their native range and whose introduction or spread negatively impacts the environment, economy, and/or society including human health.

Characteristics of invasive species:

1. Species that is non-native to an area/ecosystem
2. Reproduces/spreads rapidly (making them difficult to manage)
3. Negatively impacts the environment, economy, and/or society including human health

There are many "pathways of invasion" for invasive species, which are ways that an invasive species can be introduced to a new ecosystem naturally or through human activity, including:

- Spreading by wind, floating downstream, and animal dispersal (ex: birds eating seeds and dropping them elsewhere)
- Seeds and plant fragments stuck to hiking boot, tire treads (bikes, ATVs), pets (dogs, horses), recreational equipment, camping gear, and gardening equipment.
- Hitching rides on watercraft (boats, canoes, kayaks, paddleboards) and boat trailers
- Transportation in the ballast water of watercraft
- Movement of firewood, commercial wood imports, and inter-provincial and international shipping
- Introduction as a food source or a game species
- Introduction to get rid of another invasive species
- Release of unwanted pets (ex: rabbits, goldfish, red-eared sliders)
- Dumping of aquarium plants
- Pet and zoo escapees
- Being planted in gardens
- Relocation of infested soil and landscaping materials (ex: gravel)

Impacts of Invasive Species on Ecosystems

The arrival and spread invasive species to an area outside of their native range can cause negative impacts on the natural environment by out-competing native biodiversity and altering ecosystem functioning. Some examples of negative impacts to the environment include the increased predation of native species (alteration of predator/prey dynamics), reduction of resources and space for native species, the arrival of new diseases, and the reduced resiliency of affected ecosystems to withstand extreme climatic events resulting from climate change.

Invasive Species and Climate Change

When it comes to invasive species, climate change will help to facilitate the introduction of new invasives as well as their spread across the landscape, which combined will reduce the resiliency of natural areas and urban areas as well as negatively impact biodiversity (International Union

for Conservation of Nature, 2021). As the climate warms, invasive species that previously were not able to establish in new areas due to survival limitations based on the climate may now succeed and outcompete native species. These climatic changes can also bring the earlier arrival of spring, which can be advantageous to invasive species as they are able to sprout and establish earlier in comparison to native species, allowing them to outcompete native species and form monocultures. (North American Invasive Species Management Association, 2021). Climate change can also increase the frequency and intensity of extreme climatic events such as hurricanes and floods, which can help to transport invasive species to new areas that have been disturbed by these events. These introductions not only leave ecosystems vulnerable to future invasive species invasions, but they also reduce the ability for these areas to withstand the impacts of climate change overtime and the ecosystem services that they provide (ex: alteration of wetlands and floodplains by invasive species can reduce their ability to uptake water, which can increase flood levels during hurricanes).

Examples of invasive species in Atlantic Canada:

Emerald Ash Borer

The emerald ash borer (*Agrilus planipennis*) is a small emerald-colored wood-boring beetle that has caused the deaths of millions of ash trees across Canada and the United States since it was first detected in 2002. Originating from Eastern Asia, this forest pest exclusively targets ash trees, including the three species found in New Brunswick: black, white, and green ash. The emerald ash borer (EAB) causes the most damage during the larval stage, when the hatched eggs have become larvae and chew through the cambium layer of the tree that is responsible for transporting water and nutrients. Unfortunately, ash trees have a 99% mortality rate 8-10 years after they have become infested with EAB.

Adult emerald ash borer. Photo by Debbie Miller, USDA Forest Service, Bugwood.org.

The loss of ash trees from forest and riparian ecosystems changes the forest structure and functioning, which leads to a loss of habitat for native wildlife, increased ground temperature due to reduced forest canopy cover, and can allow other invasive species to establish. In urban environments, ash trees serve as windbreaks and regulate temperature by providing shelter and shade, and their root structures and leaves can mitigate water runoff and intercept urban pollution. Ash trees are also a culturally significant species for many Indigenous peoples across Canada that are use them to make traditional baskets and snowshoes. The loss of ash trees can also have a significant economic impact; as of 2012, the Canadian Food Inspection Agency has already spent over $30 million to manage the invasion of EAB (Ontario Ministry of Natural Resources, 2012). Although the adults move naturally by flying up to a few kilometers each year, they are commonly spread to new areas through the movement of infested firewood and wood products.

Hemlock Woolly Adelgid

The hemlock woolly adelgid (*Adelges tsugae*) is a small aphid-like insect that was first detected and eradicated in Canada in 2012, and more recently was discovered in southwestern Nova Scotia in 2017. Outside of its native range of Japan, HWA attacks and kills hemlock and some spruce tree species, including the eastern hemlock (Tsuga canadensis) that is found throughout the Maritime provinces. The insects feed on hemlock trees by inserting their mouthparts at the base of needles on hemlock twigs to extract nutrients and sap, which leads to the death of a tree in as little as 4 years. In infested tree stands, the “woolly” egg sacs can be easily spotted along the new growth twigs of the trees along with premature shoot and needle dieback, thinning tree crown, and discoloration of the foliage. The loss of hemlock trees can have significant negative impacts, including altering the forest structure, reducing habitat and food sources for wildlife, reducing shading of streams in riparian areas which can impact fish habitat, increasing erosion and sedimentation along riverbanks, and increasing presence of invasive species in the newly disturbed areas. Hemlock woolly adelgid can be spread to new areas through the movement of infested firewood and wood products.

Hemlock woolly adelgid on tree. Photo by Steven Katovich, Bugwood.org.

Jumping Worms

The name “jumping worms” is a catch-all term for 16 species of pheretimoid (“jumping”) worms recorded in North America, including the three most invasive species of jumping worms which are: A*myntha agrestis*, *Amyntha tokioensis*, and *Metaphire hilgenforfi*. Originally from east and southeast Asia, they were first found in North America in the 1900s and have spread across Canada through the movement of adults or eggs resulting from human activities including the transportation of cargo or goods, movement of potting soil or plants, and being used as fishing bait. They were first discovered in New Brunswick in 2021, and since then they have also been found in the soil of a houseplant in Nova Scotia. The name “jumping worm” comes from their aggressive thrashing and wiggling, as they “flick” their tail and move quickly through soil and break up material, causing a coffee-grind like appearance in impacted soils. While New Brunswick is home to other non-native earthworm species, jumping worms have a greater negative impact on the environment by changing the structure and nutrient composition of the soil as they consume the top layer of organic material, which reduces plant growth and forest productivity, altering foods web and the species composition in forest environments, and creating disturbed areas that increase opportunities for other invasive species introductions.

A jumping worm. Photo by NBISC

New Brunswick Invasive Species Council (2022, October 26).
https://static1.squarespace.com/static/6144adb9289b694822c3db7b/t/6357df20884ceb52a00d5ffe/1666703137304/NB+Envirothon+Study+Resources+-+Invasive+Species.pdf

A Warming Planet – Can Wildlife Keep up with the Changes?

It is undeniable that climate change is one of the greatest problems that we are facing around the world. It is redrawing the boundaries of where plants, animals and living organisms can survive. The problem is that not only is the climate changing but that it is changing so fast. Nature always adapts, but can it do so quickly enough? The fast global warming creates a whole host of problems affecting birds, mammals, amphibians, reptiles, aquatic creatures, insects and plants in different ways. Roughly half of all animal species are on the move. The average range of poleward shift for land-based species has been pegged at between six and 17 km per decade. Marine species are moving more than four times as fast.

The indirect impacts of shifting of species ranges are just as profound. Climate change is altering the distribution of malaria-transmitting mosquitoes, of insects that transmit the dengue and Zika viruses, and of various ticks. It also affects the determination of sex for animal offspring whose sex is determined by temperature. For Green Sea Turtles it is the temperature outside the egg that influences the sex of the growing embryo. This endangers their sex-balanced future in a warmer world. Some sea turtle populations are already so skewed by heat that the young reptiles are almost entirely female.

Caribou were once one of Canada's widespread animals, but today their numbers are dropping dramatically. Boreal caribou rely on the boreal forest and wetland ecosystems for survival. In northeastern Alberta, industrial activity has resulted in the destruction and fragmentation of boreal caribou habitat, which also increases wolf predation on caribou. Seven out of 12 boreal caribou herds in Alberta are already in decline.

If we want to keep this threatened species from continuing down the road to extinction, we need to protect its habitat and shield caribou from the effects of human industrial activities, as well as from the consequences of climate change. Global warming increases rainfall that freezes on the ground and blocks the growth of plants and lichen on which caribou feed. It also means more insect harassment, which interrupts feeding and drains caribou energies. Inadequate industrial development planning affects migratory habits and caribou calving grounds, leading to reduced birthrate and lower survival of the calves. Where migratory caribou herds live, the environment is changing fast.

There is no doubt that climate change is having a serious impact on wildlife. Will some species be able to change their habitat? Which animals might we find in our own backyard that we never expected? Just how dire will the future look for our beloved species?

One way for species to adapt is to shift or expand their range. There are many examples of species that are already on the move in response to climate change, or at least partially due to climate change. For instance, there are now Triggerfish (a tropical fish species) in Atlantic Canada waters, Giant Swallowtail Butterflies (once restricted to extreme southwestern Ontario)

are now spreading northward in the province, and Blacklegged Ticks (deer ticks) are increasing their range in North America.

As temperatures warm it also brings other issues for many species. Gray Jays, for instance, don't migrate and therefore stash food in the fall to help them through the winter. Warmer autumns are causing a lot of their stored food to decay before it freezes.

Arctic areas are warming quicker than other areas and sea ice melting along with glaciers and ice caps has far-reaching impacts. There is more at risk from a warming Arctic than just Polar Bears – there are also the Atlantic Walrus, Ringed Seals, Black Guillemots and many more that are affected.

Atlantic Walrus' like to climb out on ice or islands. With climate change, many areas are now ice-free and with rising sea levels some islands are no longer above water. Climate change also brings with it another threat for this species – increased shipping and people – definite threats to this sensitive and easily disturbed animal.

Polar Bear and Cub in Churchill Manitoba. Photo by Charmaine Paquette.

Ringed Seals typically give birth in early April in areas that are dug in snowdrifts. But with warmer springs, these birth lairs can collapse, exposing the pups to predators, like Polar Bears.

Black Guillemots are birds of the northern seas. Arctic Cod was the preferred food for the parents to feed the chicks, but with Arctic Cod becoming scarce due to an increase in sea surface temperatures, chicks are now fed sculpin which doesn't offer near the same amount of nourishment.

Not all species are able to move north and it seems that for many of them, even for those that can, climate change is happening too quickly for them to keep up. Even if they are able to expand their range, it doesn't happen without consequences. Entering new territories could mean more competition for food and interactions with new species. Some species are already at their northern limit. Where would they go?

While some animals are able to respond to these changes, many species won't be able to move fast enough, which may result in die-offs if they are not able to adapt in other ways. Even some birds and butterflies – mobile species – are not able to expand their ranges fast enough to keep up with the speed of climate change, and for some there may be nowhere else to go.

Northern Leopard Frog. Photo Elena Kreuzbert

A warming planet changes the spread of invasive species (both animals and plants) and habitat loss threatens Canada's ecologically significant species. Time is running out for the Northern Leopard Frog in the prairies and the Rocky Mountains; there are many more species of flora and fauna that are affected by global warming. We cannot continue to simply ignore climate change. Land degradation, biodiversity loss and climate change are three different faces of the same central challenge: the increasingly dangerous impact of our choices on the health of our natural environment. While global warming has happened in the past, it is – this time — hastened by human activities. It is up to us to slow it down and mitigate its impact. Wild species are worth protecting. Let's remember that we have a responsibility to other creatures and to the planet. Let us all do our part.

Gahbauer, S. (2022, October 26). A Warming Planet – Can Wildlife Keep up with the Changes? https://naturecanada.ca/news/blog/a-warming-planet-can-wildlife-keep-up-with-the-changes/

Remote Sensors Bring Wildlife Tracking to New Level

JOHN H. TIBBETTS

Trove of data yields fresh insights—and challenges.

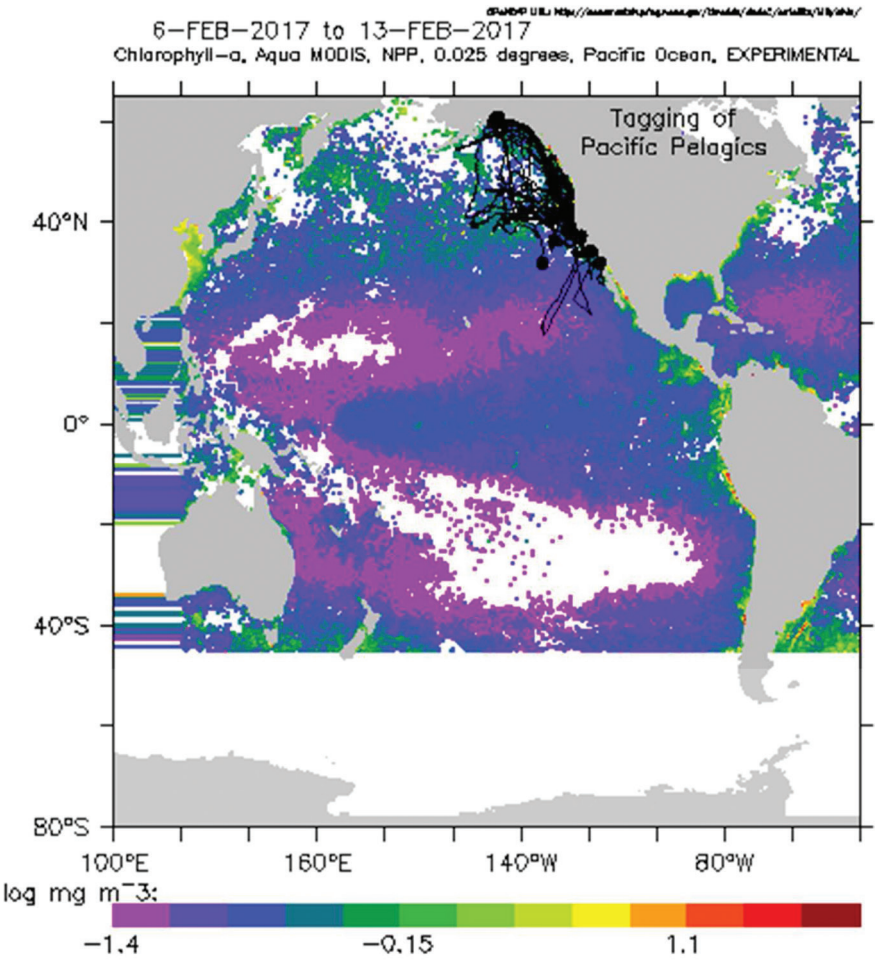
Sharper images of Earth from space—and other improved technologies—are transforming how scientists study the behaviors of wild species during seasonal and longer-term changes.

Around the world, scientists are outfitting animals with telemetry devices, linked to satellites and other space-based instruments, that record and transmit animal migrations and other movements across oceans, forests, deserts, and mountainous terrain. Researchers are tracking birds, bats, ungulates, and carnivores in thousands of studies across hundreds of taxa. Animal-tracking devices have become smaller, lighter, sturdier, cheaper, and more accurate, and they can store and transmit more data.

Over the past decade, many remote-sensing data sets from satellites that were once unavailable or expensive have become free of charge from NASA and other agencies.

Scientists are now combining animal-tracking and remote-sensing data to create models showing how individuals, animal groups, and species respond to seasonal or climatic changes. Researchers are also building models to forecast how these animals might fare as climate change accelerates.

Animal-movement data and remote-sensing images have become easier to combine and study. "If you know where an animal was in space



The black lines in this graphic show telemetry tracks of tagged pelagic fish in the northeastern Pacific Ocean. Small patches of green and yellow along coastlines are derived from satellite data indicating higher chlorophyll concentrations, which means that greater food resources are available at all trophic levels. Image: Florence Fetterer, Kenneth Knowles, Walt Meier, and Matthew Savoie. 2016, updated daily. Sea Ice Index, version 2. Boulder, Colorado, United States. National Snow and Ice Data Center. **http://dx.doi.org/10.7265/N5736NV7**

and time, then you can load remote-sensing data of the same space and time into a model," says Roland Kays, a zoologist at North Carolina State University and the North Carolina Museum of Natural Sciences.

"Combining remote sensing with animal tracking, we've learned that certain places are really special [in biological productivity] for just a moment in time. Bird migrants from Europe that cross the Sahara use parts of the Sahel nondesert zone as stopover sites for just a little while and then move on. You could visit that place on an average day and not see anything special, yet it could still be a critical habitat over a short time for species and may need conservation protection."

Some long-distance African migrants "surf the green wave," as it is known, of blooming plants during the time of their most nutritious growth. Thrush nightingales (*Luscinia luscinia*) and red-backed shrikes (*Lanius collurio*) closely follow the progressive green-up of fresh vegetation across the African landscape after monsoon rains.

The average monthly normalized difference vegetation index (NDVI), which draws on data from NASA satellites, is frequently used to track the amount and productivity of plant life in specific places. A satellite sensor sends pulses of infrared light to the Earth's surface, which reflect back to the sensor. Brighter reflections from the surface mean that vegetation is more abundant and growing more vigorously. This tool allows scientists to view greening and browning pattern changes in spaces over time at various scales. Some scientists have also combined NDVI with satellite data of wind direction and wind speed in models to understand how birds time their migrations to reach nutritious food resources at particular times.

The data challenge

A new journal, *Remote Sensing in Ecology and Conservation*, focuses on collaborations among ecologists and remote-sensing scientists. Ecologists, though, often struggle to understand how best to use these tools. "Remote-sensing technologies are great eyes on the Earth, but conservation scientists need to know the limitations and challenges of these technologies to use them effectively," says Ilaria Palumbo, a European forest ecologist and remote-sensing specialist. She is cochair of the Remote Sensing Conservation network, a 500-member global effort to help ecologists, conservationists, and nonprofit members broaden their skills in applied remote sensing and to locate, process, integrate, and analyze data.

"A major challenge is correctly linking the animal-position data in space and time to the environmental data in space and time," says Wiebke Neumann, an ecologist at the Swedish University of Agricultural Sciences in Uppsala. "Environmental data vary in source, format, and projection system, and that can make it difficult, if not impossible, for anyone other than remote-sensing experts to make use of [raw data] directly."

But training for conservation scientists is often focused on "pure" remote-sensing principles—such as working with raw satellite data and processing—without sufficient concrete examples of conservation applications where they can be or have been applied, says Palumbo.

To download and explore remotely sensed data, scientists need access to advanced computer systems with high storage and processing capacity. The next problem is locating and extracting a small fraction of available remote-sensing data that can be matched up in time and space with animal-tracking data.

Cara Wilson, a research oceanographer, leads a 3-day class each year to help marine scientists combine remote sensing with animal-tagging studies at the Environmental Research Division's Data Access Program (ERDDAP) of the National Oceanic and Atmospheric Administration's (NOAA's) Southwest Fisheries Science Center, in La Jolla, California.

Wilson and the rest of the NOAA team have developed codes written in Matlab and R, which are programming languages and software for statistical computing and graphics, that allow a scientist to extract specific environmental data—sea surface temperatures, for instance—for a given animal track with a comma-separated values (CSV) file of latitude, longitude, and date. With these aids, the researcher can download only the remote-sensing data that he or she needs to match up with specific tracking data points. The codes work with the ERDDAP server, managed by Wilson's lab, which can draw on more than 1000 remote-sensing data sets.

"Scientists in our classes usually already have some system to analyze their tracking data," says Wilson, "but they don't have coding experience to extract the environmental data." Still, scientists rarely get everything they hoped for. "The time series don't go back as far as they would like, or scientists have issues with cloud cover that blocks satellite images. I hear a lot of, 'Damn cloud cover.'"

Mule deer, mountain lions, and plants

Mule deer (*Odocoileus hemionus*) migrate to higher elevations to forage on new vegetation as spring arrives and mountain ice packs melt in the US Southwest. Months later, when mountain snow returns, mule deer migrate to lower elevations searching for food. Mountain lions (*Puma concolor*) also follow these changes in vegetation, according to an unpublished study led by David Stoner, a wildlife ecologist at Utah State University, in Logan. He presented the study's findings at the fall 2016 American Geophysical Union meeting.

According to Stoner, this is the first study to use remotely sensed data to describe links between climate and ecosystems across three trophic levels—primary producer, herbivore, and predator—over such a large geographic space.

Stoner is studying relationships among mule deer and mountain lion populations and greenery in Utah,

Nevada, and Arizona—a vast, arid, drought-prone region with extreme variations in terrain and vegetation. Mule deer are the primary food resource for mountain lions in the West.

To track mule deer movements, Stoner deployed global positioning system (GPS) collars on 30 individuals. He combined these tracking data with NDVI imagery of the region downloaded from the Moderate Resolution Imaging Spectroradiometer, which is flown on NASA's Terra and Aqua satellites. The data confirmed what the researchers assumed: that mule deer closely follow seasonal changes in plants as shown in the NDVI images. Greener vegetation supported higher densities of mule deer on average.

"It's a very strong correlation," says Stoner. "You have a greater abundance of deer when there is more vegetation because there's simply more food."

To understand mountain lion movements, Stoner used more than 15 years of records collected from 50 tracked individuals across the region and combined those data with NDVI images.

"Mountain lions are not directly tracking the phenological stages of plants," says Stoner. "They are following ungulates through space. Although mountain lions are carnivorous, their abundance follows closely with changes in vegetation productivity"—because their most important prey respond to those changes.

"If you had to choose one prey species that could give you predictive power in depicting mountain lion abundance," says Stoner, "it would be the mule deer. NDVI did a very good job of predicting population abundance of both species" across spatial gradients in vegetation productivity. Game managers could use this model, he says, to provide more accurate and inexpensive population-density estimates of mule deer and mountain lions.

The southwestern United States is expected to face more intense and longer-lasting droughts with climate change. To study future climate impacts on mule deer and mountain lions, Stoner and his colleagues modeled their populations using measurements of vegetation stressed by severe drought in 2002, when precipitation declined by 30 percent. Their model predicted a 22 percent decrease in deer density but a 43 percent decline in mountain lion

In the arid US Southwest, mule deer (*Odocoileus hemionus*) with telemetry collars closely follow seasonal changes in plants as shown by satellite imagery of primary productivity. Photograph: Ryan Moehring, US Fish and ildlife Service.

Mountain lion (*Puma concolor*) populations in the US Southwest are affected indirectly but powerfully by seasonal changes in vegetation. Their primary prey, mule deer (*Odocoileus hemionus*), respond sensitively to seasonal changes in plant life, and mountain lions track them closely through space. Photograph: David Stoner, Quinney College of Natural Resources, Utah State University.

density if the drought conditions that prevailed in 2002 became the climatic norm in the region. The carnivores were more sensitive to changes in vegetation than were their herbivorous prey.

By tracking plant phenology, researchers can gain insight into animal populations—their abundance, migrations, and reproduction—says Joseph Sexton, coleader of the study and senior scientist at the University of Maryland's Global Land Cover Facility. Sexton managed remote-sensing data and devised algorithms for the study's image analysis. "What we've learned," says Sexton, "is just how much of the variability of animal abundances and behavior in a water-dependent environment [is] driven by changes in plants."

Tibbits, J. (2017) Remote Sensors Bring Wildlife Tracking To A New Level.
https://academic.oup.com/bioscience/article/67/5/411/3737270