

Section 7

PREDATION

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Did my sheep die due to predation or scavenging?

- Given adequate time and opportunity to feed on the carcass, scavengers can make it virtually impossible to differentiate between predation and scavenging on an animal's carcass that died from some other cause.
- Predators often scavenge carcasses.
- Finding predator tracks, hair or droppings near a carcass may support the theory of predation, but these findings on their own do not automatically mean that predation has occurred.
- Signs of predation include one or more of the following:
 - Signs of a struggle.
 - Drag marks on the ground.
 - Broken vegetation.
 - Blood either at the point(s) of attack on the carcass or around the kill site.
- Another possible indicator of a predator attack is if the flock appears somewhat more nervous and vocal than normal.
- Being opportunistic predators, coyotes prefer lambs to adult sheep.
- Distinguishing a newborn lamb that has been killed by coyotes from a stillborn lamb that has been scavenged can be difficult. In order to do so, it must be determined whether the lamb breathed, drank or walked before it was eaten.
 - Did the lamb walk? The soft membrane covering the sole of the hoof wears off quickly when the lamb begins to walk. If the membrane is still intact odds are that the lamb was stillborn – or killed immediately at birth. Further investigation is required.
 - Did the newborn lamb breathe? If the animal has breathed the lungs will be pink and feel light and spongy and will float in water. The lungs of a stillborn lamb will be a dark purplish-red colour and will sink when placed in water.
 - Did the lamb nurse? The presence of milk in the stomach is also evidence of a live birth.



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What killed the sheep?

- Each species of predator has its own predatory habits and feeding characteristics.
- Prompt and thorough examination of the carcass, the site, and live animals associated with the attack will aid in determining whether the death was due to an accident, disease or predation.
- The most common predator in Canada is the coyote.
- Other predators of sheep include domestic dogs, wolves, bears, mountain lions, bobcats and occasionally birds of prey.
- It is important to note that not all predators (coyotes included) kill sheep.



The most common predator in Canada is the coyote.

- Here are some factors to help determine what type of predator killed the sheep:
 - Time of attack:
 - Coyotes normally hunt at night but most often kill sheep in the early morning.
 - Rainy days and late evenings are times when there is increased coyote predation on sheep.
 - Duration of attack:
 - Individual coyote attacks do not generally last very long as they are quick and competent killers, most often killing with suffocation by closing off the trachea.
 - The exception can be when the bitch is training young pups or when the lambs are very young and can be carried off without killing.
 - Dogs are inefficient predators so their attacks tend to be longer and more drawn out.
 - Temperament of flock:
 - The behaviour of the flock after an attack can be important in determining the species of predator.
 - Coyote attacks are usually quick and focused on a small number of sheep leaving the rest of the flock alone. Again, exception is when the bitch is training this year's pups.
 - Consequently, a flock witnessing a coyote kill will not normally appear as spooked, stressed or noisy as those suffering a dog attack.
 - After a dog attack the flock is more apt to be nervous and confused because the attack lasts longer, involves more chasing and harassing and usually involves several dogs attacking numerous sheep.
 - The only exception to this might be during the period from July to September when the female coyote is teaching young pups to hunt.
 - Extent of attack or kill:
 - Kills in excess of two or three animals may suggest that dogs were involved. An exception, however, is flocks lambing on pasture – when coyote predation occurs during the lambing period it is common to have multiple lambs killed.
 - Being relatively inexperienced killers, dogs tend to chase sheep extensively and, as a result, more sheep are attacked, injured or killed over a wider area than in coyote attacks.
 - Coyotes normally hunt alone and usually only one or two sheep will be killed with very few sheep injured.
 - Location of attack or carcasses:
 - If coyotes are responsible then the carcasses are likely to be found relatively close together.
 - Carcasses resulting from dog attacks tend to be scattered throughout the pasture as the sheep panic to escape.
 - Attacking behaviour:
 - To kill as quickly as possible, coyotes typically attack by biting adult sheep and larger lambs in the throat just behind the jaw and under the ears.

- They maintain a grip until the animal suffocates or dies of internal bleeding. The external puncture wounds in the throat may be difficult to see.
- Coyotes seldom inflict injuries to other parts of the adult animal or carcass.
- Lambs will likely have bites to the head, neck and back causing extensive bone and tissue damage.
- In late summer or early fall when the female coyote is teaching pups to hunt, some unusual wounds may result from the pups' inexperienced hunting techniques. At this time, bites and rips to different body areas are common.
- Wounds to numerous live sheep on body areas other than the head or neck are signs of dog predation, or it may be coyote predation during pup training season (July to September).
- Dogs usually attack from the side or rear inflicting nonfatal wounds on various parts of the body.
- Frequently the skin and muscles in the flank, hindquarters and head will be ripped.
- Neck wounds will be superficial or severe lacerations.
- Lambs killed by dogs will have a slashed and ripped appearance.
- Clumps of wool lying spread around the attack area likely suggest an inefficient dog attack, or if feeding from the carcass has occurred, then evidence of more than one coyote involved in the attack.
- Note: A coyote's first-ever attack on a sheep might not be quite as typical as its subsequent attacks before he learns to suffocate the sheep to gain control on the prey. This is especially apparent with first-time adult sheep attacks. Once experienced, a coyote becomes quite efficient at killing large adult sheep.
- Feeding behaviour:
 - Reliable signs of coyote feeding include muscle tissue with ragged edges and splintered and chewed ribs.
 - They may start feeding in the abdominal cavity, eating the kidney, liver and lungs.
 - The stomach and intestines are usually pulled out, but are not normally eaten, other than the surrounding fatty tissues.
 - After the organs have been eaten, the coyote will feed on the muscle tissue of the rear quarters or the rib cage and shoulder.
 - Coyotes shy away from wool and the skin attached to the wool thus often the hide is not eaten and can remain intact in large patches. Feeding around the legs, shoulders and back will often show the hide being peeled back almost like it was skinned away from the meat.
 - Coyotes will often rub and roll in the carcass remains and may defecate after feeding.
 - Coyotes will often take smaller prey back to its den, especially during May and June when feeding its pups.
 - There are instances when coyotes may leave uneaten carcasses behind, this includes when guard animals are being used – coyotes may be chased off before having a chance to feed on the carcass. Also, in flocks where



Lambs killed by dogs will have a slashed and ripped appearance.

lambing occurs on pasture, multiple animals can be killed and only one or two are carried off.

- Tracks at site:
 - If the ground is sandy or soft from a recent rain, tracks can distinguish the presence of either coyotes or dogs.
 - It must be stressed, however, that tracks alone do not confirm that animal was the killer.
 - Coyote tracks are more oval shaped and the nail marks left are less prominent than those of dogs.
 - They are more uniform in size, with the hind track being slightly smaller than the front foot track, while dog tracks will vary in size according to size and weight of the dog species.
 - Coyote tracks tend to follow a straighter line and the rear tracks follow directly in line with or on top of front tracks.
 - A dog's rear tracks are normally slightly to one side of the front tracks.
- Droppings:
 - Droppings found near the site can also help to differentiate between coyotes and domestic dogs.
 - Hair and pieces of bone in the droppings would suggest either a coyote or feral dog.
 - Coyote droppings tend to be black, due largely to their consumption of blood.
 - In terms of dog droppings, they may be brown or black if their diet is primarily composed of meat, or if they have been on commercial dog food, then grain particles can be seen in the feces.
- Wolves:
 - Wolves can be found throughout Canada from the shores of the great lakes to the northern tip of Ellesmere Island.
 - Predation due to wolves usually occurs along forest-agriculture fringe.
 - When wolves attack they will bite the hind quarter, throat and head.
 - They will often kill adult sheep and consume or drag prey away.
 - Wolf kills show lots of tearing, bone crushing and consuming, and kills are somewhat messy like dog kills. Wolves do not necessarily kill their prey but feed on it while alive and the animal dies of trauma and blood loss.
- Bears
 - Bears often bite the sheep's head, neck and hind area.
 - There may also be claw marks on the back.
 - They may kill many sheep in one attack and consume or drag prey away.
- Cougars
 - With cougars there will be bite on the upper section of the neck and the rear of the skull along with claw marks on the back and neck.
 - They will drag their prey away prior to feeding and guard carcass remains, be careful when approaching kill area.
 - Carcass parts are sometimes found in trees.



Tracks alone do not confirm that animal was the killer.

- Eagles (Bald and Golden):
 - Tend to prey on newborn lambs during migration (early spring/late fall).
 - They will also scavenge on livestock carcasses.

Why are coyotes killing sheep on my farm?

- Coyotes will tend to kill, and eat (as adults) what they were taught to kill and eat as pups.
- Coyotes tend to kill animals that are easily caught – domestic livestock are easier to kill than wild ungulates. This is not to say these are the only type of livestock that coyotes kill.
- Many producers will quickly verify that losses are often some of their better ewes, of prime breeding age.
- Their home range will take them through many farms, some with livestock and differing livestock husbandry practices.
- Conditions that lead to coyotes killing livestock on one of those farms, puts all farms in their home range at risk of predation.
- Once predation starts, producers must be prepared to implement removal options to prevent further kills.
- Farms where predation has been a problem in previous years tend to have repeat occurrences of predation each year, particularly if no predator removal program has been implemented.
- See Coyotes subsection for more information.
http://www.cansheep.ca/User/Docs/PDF/T2-7_Coyotes.pdf



Once predation starts, producers must be prepared to implement removal options to prevent further kills.

Why is record keeping important?

- Knowing how many sheep you have in a particular pasture helps to quickly determine when losses begin.
- Keeping track of losses can be very beneficial in eventual control or removal of the problem predator.
- They can help identify loss patterns, or high-risk pastures.

Does the season and location of lambing affect predation?

- Highest predation typically occurs from late spring through September/October due to high feed requirements of raising pups.
- Lambs born on pasture are more likely to be at high risk to predation than older lambs or mature sheep.
- On the other hand, winter-born lambs that are raised indoors and hand fed may be as much at risk since they are not as alert or suspicious of humans or strange animals as lambs born on pasture.

What is the regional incidence of predation?

- Predation pressure varies throughout Canada.
- If you are in an area with heavy predation pressure, you should expect that predators will eventually test your preventative measures and you need to be prepared to deal with predation losses.
- In these areas, it is also important to know what preventative techniques producers in your area are using.
- Over time these techniques will become less effective as coyotes have time to figure out ways around them.



Predation pressure varies throughout Canada

Can my management practices influence predation?

- It is much easier to prevent predation than it is to stop it once it has begun.
- For managing predation, a variety of methods must be available as one method will not be effective for every producer.
- Most successful predator control programs use an integrated approach – combining good husbandry practices with effective control methods.
- One or more of the following can be used to minimize predation (some of these may be practical for small flocks and not practical for large flocks):
 - Lighted corrals.
 - Lambing in the barn.
 - Regular inspection of the sheep flock.
 - Prompt removal and disposal of dead stock.
 - Confinement at night.
 - Fencing.
 - Guard animals.
- **Additional tools to discourage coyotes:**
 - Bells on a number of sheep in the flock.
 - Aluminum pie plates hung around the perimeter of the pasture.
 - Playing the radio.
- Anything that causes an irregular sound or reflection can be effective. Each individual situation must be assessed as to what is most suitable.
- Pasture site selection is another management practice in preventing predation. For example, avoid pastures in brush areas for lambing, if possible.
- Although night confinement may be a practical option for small flocks, or flocks of dry ewes that lamb during the winter, it is not a feasible option for large, commercial flocks that have young lambs with them on pasture.
- Predator losses may be lower on farms where deadstock was promptly removed and disposed of, compared to farms that did not dispose of deadstock properly.
- Frequent checking of flocks may discourage predation before problems arise – particularly early morning and cool, rainy day surveillance.

- Periodically changing the time of day when the flock is checked may deter coyotes from attempting kills.
- When checking sheep take note of their behaviour. Are your sheep more nervous, alert or fearful than usual?
- Also take note of whether the sheep are more scattered or split into groups, or anything else that is uncharacteristic of your flock or breed of sheep.
- Prevention cannot be stressed enough, because once predators kill, they are more likely to return and kill again.
- If predators have started killing sheep, it is important to stop the killing as quickly as possible. This most often entails targeted removal of the problem predators.

What guard animals can I choose from?

- Livestock guard animals live with the flock, protecting the sheep from predation.
- It is important to remember that all types of guard animals should bond with the flock, not with humans.
- To be effective, they cannot be raised or treated like pets.
- Guard animals that can be used include: dogs, donkeys, llamas and horses.
- The choice depends on the livestock being protected, local terrain, acreage, predator threats, budget and personal preference.
- Whichever animal you choose, there will be feed, veterinary care and housing expenses.
- If you are following an aggressive rotational grazing program, with flocks in several paddocks at the same time, you may need at least one guard animal for each group.
- The major advantages of using guard animals include decreased predation, reduced labour to confine sheep at night and more efficient use of pastures for grazing.
- The following is an overview of the types of guard animals and their advantages/disadvantages:
 - Dogs:
 - There are several breeds that are proven guard dogs including: Great Pyrenees, Maremma, Akbash, Komondor and Anatolian Shepherd.
 - The dog chooses to remain with sheep because it has been reared with them since it was a puppy.
 - Its protective behaviour is largely instinctive, and there is relatively little formal training required other than timely correction of undesirable behaviours.
 - To form a bond between dog and sheep, a pup needs to be raised with sheep, preferably from birth but at least from weaning (six to eight weeks).
 - After the initial socialization period, when the pup is at least 16 weeks old, it and its companion sheep can be put into a larger area.
 - The dog should be encouraged to stay with the sheep and not be allowed to hang around the house, children or areas where sheep are not present.
 - The dog should be treated as a working animal, not a pet.



It is important to remember that all types of guard animals should bond with the flock, not with humans.

- Producers interested in procuring a guard dog should do the necessary research to determine the characteristics and temperament of each breed and decide which breed best suits the shepherd's expectations.
- Guard dogs work well in both fenced pasture and range operations.
- They are the most effective weapon in large flock, range-type operations or in heavily-treed pastures where more than one guard animal is required.
- An important thing to remember is that they are a full-time member of the flock; they are not a herding dog or a pet.
- In rare instances dogs may harass or injure sheep, or wander off and not stay with the sheep.
- Guard dogs have higher feed costs than guard donkeys or llamas.
- Dogs may not be an appropriate choice close to residential areas.
- Donkeys:
 - Donkeys are gaining popularity due to their relatively low cost, low maintenance requirements and natural herding instinct.
 - They do not like change in their surroundings, and will drive off a coyote or stray dog as much because it is an intruder as from any instinctive dislike of canines.
 - Donkeys will bray, bare teeth, and make running attacks, kicking and biting.
 - There is wide variation in how individual donkeys interact with sheep. Be aware that the donkey's behaviour and mood may be unpredictable during estrus, or when the ewes are lambing.
 - A jenny with a foal is seemingly the most effective at guarding a flock.
 - Adult intact male donkeys may be overly aggressive towards the sheep.
 - Two or more donkeys might stay together instead of being with the sheep.
 - Donkeys should have four to six weeks to bond with the sheep.
 - They are apparently most effective in small, open pastures or where sheep are cohesive and graze together.
 - Although donkeys do well on grass hay and pasture, they tend to become obese on high-quality diets and may develop laminitis (founder).
 - Donkeys' feet should be trimmed every three to four months.
 - Never allow a donkey access to a medicated lamb ration, as even trace amounts of certain medications (e.g. ionophores) can be toxic.
- Llamas:
 - The llama is very adaptable to many environments and bonds well with sheep and lambs.
 - They instinctively dislike canines, and are capable of protecting a flock from some predator attacks.
 - Typical responses of llamas to coyotes and dogs are being alert; alarm calling; walking to or running toward the predator; chasing, kicking, or pawing the predator; herding the sheep; or positioning themselves between the sheep and predator.
 - They will eat the same feed as sheep and are not prone to foot problems associated with high-quality feeds.



Donkeys are gaining popularity due to their relatively low cost, low maintenance requirements and natural herding instinct.

- Llamas need to be shorn periodically.
- Although females may be quite expensive, neutered males are reasonably priced and have developed an excellent reputation as a flock protector.
- It is a good idea to train the llama to halter and to come when called, otherwise considerable effort could be expended in a sheep and llama chase.
- In many areas, veterinarians have little experience with llamas.
- A male guard llama should always be gelded.
- Horses:
 - Although not widely recognized, several experienced producers have had excellent results in minimizing predator attacks by pasturing horse(s) with their sheep.
 - Apparently, draft horses are particularly effective, although the feed bill could be hard to justify if the horse were only used for predator control.

Can I use fencing to protect my flock?

- Success in terms of fencing to keep coyotes out is variable and dependent on many different factors, including the predator's past experience, the availability of food, the predator population, the season of the year and the design and quality of the fence.
- Careful planning and proper fence line preparation are important first steps in the construction of an effective fence for predator control.
- Select the most level ground to run the fence.
- Do not cross creeks, sloughs, ravines or other unstable and difficult areas if at all possible.
- Keep the fence line as straight as possible.
- Clear trees, shrubs and debris from the fence line.
- Make the fence line wide enough to both prevent trees from falling on the fence and to permit a vehicle to be driven beside it for fence construction, inspection and maintenance.
- Coyotes usually penetrate mesh or nine wire fences by digging or crawling under the bottom wire, so it is extremely important to level the fence line properly.
- If the fence is to be electric, the fence line must be even enough to run a charged wire within 7.5 to 10 cm off the ground. The distance from the bottom wire to ground level may vary a good deal if fence lines are not levelled.
- After completion of the fence, the fence line should be reseeded to grass to prevent erosion and weed growth.
- Select a low-growing grass species that will minimize the risk of vegetation grounding the bottom-charged wire.
- Some of the most effective fences can be simple in design when combined with other deterrents, such as guard animals.
- Types of fencing:
 - Electric fence
 - They are a tool for protecting sheep from predators and are easily adapted to most livestock operations.



Coyotes usually penetrate mesh or nine wire fences by digging or crawling under the bottom wire, so it is extremely important to level the fence line properly.

- They require frequent inspection and maintenance to ensure proper operation and protection capability.
- Snow and frozen ground in winter can greatly reduce the effectiveness of electric fences for predation control.
- Additionally, heavy vegetative load can be a power drain. This can occur when the electric fence is being used as a perimeter fence and the outside area is not grazed or cropped.
- An effective electric fence for predator control can be constructed with either a multiple of single-strand wires or a combination of wire mesh and single-strand wires.
- A meshwire fence is more expensive to build than a fence made from single-strand wire.
- A meshwire (pagewire) fence can be made more coyote deterring by adding two or more electric offset wires to it. It presents a greater physical barrier to predators and requires less maintenance and fewer electrified wires than a fence using only single-strand wires.
- Ninewire fence
 - An electric fence made with nine single strands of 12.5 gauge, hightensile smooth wire provides an effective barrier to predators.
 - The overall height of this fence design is 1.37 m.
 - Wires are alternating, charged and grounded, beginning with the bottom wire as a charged wire.
- Meshwire fence
 - Galvanized, hightensile mesh wire can be used for predator control.
 - This wire is more versatile and longer lasting and can be stretched tighter than standard farm mesh wire.
 - The hightensile mesh wire is reasonably priced and available from fencing suppliers in various heights.
 - Galvanized mesh at least 1.2 m high with predator-proof spacings (smaller spacings on the bottom section of the mesh than at the top section) is recommended.
 - The spacing in the mesh wire must be no larger than 15 cm by 15 cm, as coyotes, foxes and small domestic dogs may crawl through larger spaces.
 - To build a new fence, place the mesh wire on the inside of the pasture posts. Pull the mesh taut, position the bottom of the mesh tight to the ground and staple the mesh securely to the posts. The fence wire must be tight to the ground to reduce the chances of a coyote digging underneath.
 - An existing sheep fence made from mesh and barbed wire can be electrified by adding several electrified offset wires.
 - The fence must be in good condition, and the wire must be free of rust, undamaged and taut.
 - Fence posts must be sturdy and, to prevent predators from jumping over, tall enough to support a fence of at least 137 cm.
 - If the posts are not tall enough to support the top wires, add extensions to increase fence height to at least 137 cm.



Some of the most effective fences can be simple in design when combined with other deterrents, such as guard animals.

- To stop predators from digging under the fence, place a charged 12.5 gauge hightensile wire 10 to 15 cm above ground level and 10 to 20 cm out from the mesh.
- If the fence posts are 10 cm or more in diameter and the mesh is attached to the inside of the posts, insulators and the charged wire can be attached directly to the outside of the posts.
- If the fence posts are less than 10 cm in diameter or the mesh is on the outside of the posts, offset brackets will be needed.

Are there any other ways to control predators?

- If you are not successful with livestock management and non-lethal control measures, removal of predators may be necessary.
- Legal or appropriate methods of removal vary from province to province.
- Producers are encouraged to contact their provincial Agriculture Ministry for more information on methods of removal:
 - **British Columbia** – Ministry of Environment
http://www.env.gov.bc.ca/cos/info/wildlife_human_interaction/docs/wolves.html
 - **Alberta** – Alberta Agriculture and Rural Development
[http://www1.agric.gov.ab.ca/\\$department/deptdocs.nsf/all/agdex43](http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex43)
 - **Saskatchewan** – Ministry of Agriculture
<http://www.agriculture.gov.sk.ca/Default.aspx?DN=06f049b3-ea6a-4c95-9929-f67e6e7880c3>
 - **Manitoba** – Manitoba Conservation
<http://www.gov.mb.ca/conservation/wildlife/about/who.html>
 - **Ontario** – Ontario Ministry of Agriculture, Food and Rural Affairs
<http://www.omafra.gov.on.ca/english/livestock/sheep/predator.html>
 - **New Brunswick** – Natural Resources
<http://www.gnb.ca/0078/fw/nw/coyote-e.asp>
 - **Nova Scotia** – Department of Natural Resources
<http://www.gov.ns.ca/natr/wildlife/nuisance/coyotes.htm>



Producers are encouraged to contact their provincial Agriculture Ministry for more information on methods of removal.

Is compensation available in my province?

- Compensation varies by province. Producers are encouraged to contact their provincial Agricultural Ministries or visit:
 - British Columbia
http://www.bcac.bc.ca/Council_CapsuleDetail.asp?ID=71&Page=0
 - Alberta
<http://www.nawmp.ab.ca/wildlifedamage.pdf>
 - Saskatchewan Predation Program
<http://www.sksheep.com/predation.htm>

- Manitoba
<http://www.gov.mb.ca/agriculture/livestock/beef/pdf/baa15s00.pdf>
- Ontario
<http://www.omafra.gov.on.ca/english/livestock/sheep/facts/lvstcomp.htm>
- Nova Scotia
<http://www.gov.ns.ca/agri/ci/reports/wildlife%20brochure.pdf>

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<http://ablamb.ca/documents/factsheets/PredatorControl.pdf>

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American Sheep Industry Association, 2004

http://www.sheepusa.org/index.phtml?page=site/newsandevents&nav_id=601e0a31bbf6a0ef56f1f0591aa0dc78&volume=Volume%2019,%202004%20-Special%20Edition:%20Predation

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Tracy Hagedorn, Alberta Agriculture and Rural Development, 2008

[http://www1.agric.gov.ab.ca/\\$department/deptdocs.nsf/all/sg9009](http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/sg9009)

When Coyotes Become a Nuisance

Ross Hall, Nova Scotia Department of Natural Resources, 2006

<http://www.gov.ns.ca/natr/wildlife/Nuisance/coyotes.asp>

Introduction to Sheep Production in Ontario

Ontario Sheep Marketing Agency

<http://www.ontariosheep.org/Intro%20to%20Sheep%20Production/Intro%20to%20Sheep%20Production.htm>

Guard Llamas

Iowa State University

<http://www.extension.iastate.edu/Publications/PM1527.pdf>

Predators – Preventing Predation

Doug Johnston, Ontario Sheep Marketing Agency

<http://www.ontariosheep.org/PREDBROC.HTML>

Sheep Predator Control

Manitoba Sheep Industry Initiative, Manitoba Agriculture, Food and Rural Initiatives

<http://www.gov.mb.ca/agriculture/livestock/sheep/bsa01s31.html>

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Anita O'Brien, Ontario Ministry of Agriculture, Food and Rural Affairs, 1997

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Parks Canada, 2009

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Brian Tapscott, Ontario Ministry of Agriculture, Food and Rural Affairs, 1997

<http://www.omafra.gov.on.ca/english/livestock/sheep/facts/coydog2.htm>

Coyote

Connecticut Department of Environmental Protection, 2009

http://www.ct.gov/Dep/cwp/view.asp?a=2723&q=325992&depNav_GID=1655

Additional resources

Coyotes

Information on different types of coyotes.

http://www.cansheep.ca/User/Docs/PDF/T2-7_Coyotes.pdf