Smithsonian
National Zoological Park
Conservation and Research Center

School Outreach Program

Teachers' Guide – 7th Grade Life Sciences

BOTTLENECK GENES

Black-Footed Ferret Ambassador Program

Third Edition (2006)
Revised by: Vanessa Neuerburg (2003)
Developed by: Susan R. Peachey (2000)

Jennifer L. Buff
CRC Education Program Manager
crceducation@si.edu

Smithsonian
National Zoological Park
Conservation and Research Center

BOTTLENECK GENES

Black Footed Ferret Ambassador Program for Virginia 7th Grade Life Sciences Students

TABLE OF CONTENTS

Construction of the black-footed ferret mobile display unit was funded by the National Fish and Wildlife Foundation and Black-footed ferret Recovery Foundation.

BOTTLENECK GENES
Black Footed Ferret Ambassador Program

Topic:
Genetic diversity, small population biology and endangered species.

Virginia Science Standards of Learning (SOLs) targeted:
Bold elements are highly emphasized in this program.
LS.5, LS.7, **LS.8, LS.9, LS.10,** LS.11, LS.12, LS.13, **LS.14**

Goal:
To acquire knowledge about small population biology, genetic diversity, and the impact of genetic bottlenecks on species conservation.

Objectives:

Through an interactive activity, students are introduced to the study of conservation genetics and population bottlenecks. They will discover how the loss of genetic diversity and genetic characteristics can affect that population's ability to respond to changes in its environment. Other topics covered include: (1) wildlife management issues, and (2) the role of science and technology in conservation.

Following this program, students will:

1. Understand concepts related to small population biology and genetic diversity as it pertains to conservation endangered species.
2. Discover how the loss of genetic diversity in a species can affect that population's ability to respond to changes in its environment.
3. Explain the role that science and technology can play conservation efforts.
4. Be familiar with one of the most endangered species in North America, the black-footed ferret.

Overview:

This module has two sections:

In section one, an overview/discussion will provide an introduction to the natural history of the black-footed ferret including: (1) a review of the black-footed ferrets' unique niche in the prairie ecosystem, (2) issues leading to its decline, and (3) current conservation initiatives (including programs at the Conservation & Research Center). Basic information on genetic diversity and the role genes play in natural selection and adaptation will also be discussed. Special emphasis will be placed on the effects of fragmentation on small population biology.

In section two, students will participate in an interactive genetic bottleneck activity. Student teams, representing black-footed ferret populations, will receive a random number of colored beads, literally through the neck of a bottle. These beads represent the genes found in their hypothetical population of black-footed ferrets, following a genetic bottleneck event. Student

teams will also receive a deck of numbered cards that correspond to a series of environmental situations. Student teams will select five cards from this deck.

Using the genes (beads) and environmental factors (numbered cards), student teams perform the following tasks:

1. Calculate the percent genetic diversity of their population.
2. Use a key found on the student worksheet to identify the genetic characteristics their population received as well as the genes lost after a genetic bottleneck event.
3. Write a prediction for the ferrets' survival over the next year, based the population's genetic make-up and environmental situations presented to the population. Students will document their thoughts on whether their hypothetical black footed ferret population has the genetic characteristics necessary for adapting to random changes in their environment.

Pre-Program Preparation:

This outreach program is meant to support the genetics instruction at the middle school level (7^{th} grade Virginia Life Sciences Standards). Students will receive a greater benefit from the program if they prepare by reviewing vocabulary terms and concepts provided in the appendices of this guide, prior to the scheduled program. Additionally, if the program includes a visit from the CRC Ambassador black-footed ferret, students should be reminded that in the presence of a living wild animal, they need to remain calm and quiet. Teachers are expected to remain on hand to assist the CRC facilitator with student supervision.

Classroom Procedure and Activities (est. time – 1 hour):

Activity One: Overview presentation and discussion

A powerpoint presentation introduces students to the history black-footed ferret and prairie ecosystem. Current conservation initiatives are described, and the role that genetics research plays in restoring threatened populations is explained.

At a break in the presentation, CRC educator will use a glass bottle with colored beads to explain the concept of a "bottleneck effect" or "genetic bottleneck."

> Bottleneck effect: When a population experiences a severe change that kills off many individuals, then survivors represent only a portion of the original genetic diversity. The diversity of genes, and associated genetic characteristics or traits, is limited by the bottleneck event.

Activity Two: Genetic bottleneck demonstration

Review concepts of genetic diversity and population bottlenecks.

Class is divided into teams of two to three students each, and each team is given a copy of the student worksheet and bottleneck key.

Each team receives a small handful of colored beads from the bottle (colors represent genetic characteristics of the team's hypothetical black footed ferret population, after a genetic bottleneck event). Teams match colors to the key to document the genetic characteristics of their population's genetic characteristics.

Teams randomly select five cards From a deck of "environmental change" cards. Using the key, teams match the numbered cards selected with the environmental scenarios represented by each number.

On the student worksheet, teams:

1. Calculate their percent genetic diversity for their hypothetical black footed ferret population; based on the number of characteristics (colors of beads) they received through the bottleneck
2. Describe their population based on its current genetic makeup
3. Develop and write a scenario for their population for a one-year time frame, addressing the following:
    - How well is your population genetically equipped to survive in its environment?
    - How do random changes in the environment affect the population?
    - Does a high or low percent genetic diversity impact on your population's ability to survive changes in its environment?
4. Teams present results to the class for discussion and questions

Post-Visit Extensions:

Visit www.blackfootedferret.org for more information on the history of the black footed ferret and current conservation efforts; link to "saving a species" to monitor the progress of recent reintroduction efforts, and "ecosystem" to learn about other species in the prairie ecosystem.

Some scientists consider the prairie dog a keystone species of the prairie ecosystem. Research the prairie dog and the crucial role this species plays in its environment and how its survival impacts other species, such as the black footed ferret. Research other keystone species to investigate their relationships to the plants and animals in their habitats.

This activity has been adapted for use in the 2003 edition of Project Wild K-12 Curriculum and Activity Guide. Another activity in this guide pertaining to population biology is "Birds of Prey," in which students explore the relationship between ground squirrels and falcons.

Additional resources on the topic of conservation genetics are included in the appendices of this teacher guide, and include a vocabulary list, background information, additional web resources and a short list of scientific publications. These resources can assist teachers in creating lesson plans on genes and genetic diversity and incorporating this outreach program into school curriculum.

BLACK FOOTED FERRET
Genetic Bottleneck Scenario

Team member names:

Step 1: KEY TO GENETIC CHARACTERISTICS

Instructions: Using the color code key below (bead color = genetic characteristic), circle the genetic characteristics your hypothetical black footed ferret population received through the genetic bottleneck event. Then answer the questions related to genetic diversity, bottleneck events, and characteristics.

- ❒ **BLACK …** precise vision
- ❒ **ORANGE …** accurate smell
- ❒ **RED …** healthy reproduction
- ❒ **PINK …** strong claws / legs
- ❒ **WHITE …** immunity to canine distemper
- ❒ **PURPLE …** acute hearing
- ❒ **GREEN …** agility
- ❒ **YELLOW …** camouflage
- ❒ **DARK BLUE (B)* …** healthy jaw formation *(dominant gene)*
- ❒ **LIGHT BLUE (b)* …** jaw deformity *(recessive gene)*

* Guidelines for documenting the expression of dominant and recessive genes:

1. **BB** = dominant gene expressed
2. **Bb** = dominant gene expressed
3. **bb** = recessive gene expressed

Questions about genetic characteristics following a bottleneck event:

1. **Calculate the percent (%) genetic diversity of your hypothetical black footed ferret population.** 10 genes (colors) represent 100% genetic diversity in the original black footed ferret population.
   a. _____ genes (colors) received / 10 original genes in the population = _____ (decimal)
   b. Multiply this decimal amount by 100 = _____ %
2. **How was your population impacted by dominant and recessive genetic characteristics?**

Step 2: KEY TO ENVIRONMENTAL SITUATIONS

Instructions: Using the key to 16 environmental situations below (card number = environmental situation), circle the five situations that took place in the locality where your hypothetical black footed population lives. Some environmental situations may relate directly to your population's genetic characteristics, others may be random environmental events where your population's genetic characteristics allow adapt to changes.

1. A farmer tries to protect his wheat fields by exterminating resident prairie dogs.
2. The survival rate of this year's baby black footed ferrets is high, and as the babies grow into adulthood, they will disperse from your population into adjacent prairie dog towns to establish a new colony.
3. Humans building homes 10 miles away wiped out a prairie dog colony and the surviving black-footed ferrets from there invade your territory for food.
4. Female ferrets in your population can only produce one kit per year unless they have the gene for a healthy rate of reproduction.
5. Ranchers allow their dogs to run loose (hint: domestic dogs carry dog diseases).
6. A new generation of captive-born black-footed ferrets is released at a nearby reintroduction site.
7. Sylvatic plague strikes the resident prairie dog colony; there is an 80% prairie dog mortality rate.

8. A coyote prowls at night. A good sense of smell would allow you to avoid this crafty predator.
9. A black footed ferret will need healthy, strong jaws in order to hang on and win the fight as its aggressive prairie dog prey fights back in its dark, narrow, winding burrow system.
10. A great horned owl relies on its keen eyesight to spot potential prey in the dark. Can your black footed ferrets remain unseen?
11. A badger sneaks around the prairie dog town. Can your black footed ferrets hear it coming with enough time to flee?
12. A prairie dog colony is established on a nearby Native American reservation.
13. Severe rains flood the prairie dog burrows.
14. An interstate is built nearby.
15. Drought causes the prairie soil to compact and harden. Black footed ferrets will need strong legs in order to adapt the burrows stolen from their prairie dog prey to make their homes.
16. A golden eagle hunts for a meal. Good vision would help your ferrets avoid capture.

Step 3: POPULATION PREDICTIONS

Instructions: Using the table that that follows, predict your population's chances of survival for each of your environmental situations. Consider, specifically, how your population's genetic makeup impacts your population's ability to adapt to each situation.

Environmental Situation #	Survival Prediction (good/poor)	Reasons (explain your prediction by describing the characteristics that either help or hinder your population's survival)

Overall thoughts on the chances of your black footed ferret population:

Bottleneck Genes: Black Footed Ferret Ambassador Program
VOCABULARY LIST

adapted - the way in which living things have adjusted to their environment through biology or behavior, thereby improving their chances of survival

behavioral - anything an organism does that involves action or response

biological diversity - the richness and variety of living things in a given environment

bottleneck effect - when a population experiences a severe change that kills off many individuals, survivors represent only a portion of the original genetic diversity; the diversity of genes, and associated genetic characteristics or traits, is limited by the bottleneck event (aka, genetic bottleneck)

camouflage - the use of color or patterns by an animal to blend into its surroundings

carnivore - a flesh eating animal or predatory organism (such as a bird of prey or an insectivorous plant)

coloration - the arrangement of color and markings on a particular species; coloration often serves as a protective function.

community - the plants and animals within a certain habitat (see ecosystem)

conservation biology - investigates individuals and populations that have been affected by habitat loss, exploitation, and/or environmental change; This information is used to make informed decisions to ensure the survival of that species in the future.

conservation genetics - investigates the extent of diversity among the individuals in a population and designs effective management techniques for the survival of a species based upon this information

dominant gene - gene that always shows itself

ecosystem - a system made up of a community of animals, plants and bacteria interrelated together with its physical and chemical environment

endangerment - to expose a species to the threat of extinction

epidemic - a communicable disease affecting individuals within a species on a huge scale

eradication - to remove, do away with, or destroy

evolve - to develop gradually through genetic changes over the long term

extinction - the disappearance of a species from Earth

food chain - a chain of organisms that are linked together because each is food for the next in line; all of the food chains found in an ecosystem are called a food web.

founder effect - the impact of a loss of genetic diversity from the establishment of a new population from only a few individuals

gene - a piece of DNA that codes for a particular trait; the basic unit of heredity

gene pool - all the genes present in a population

generalist - a very adaptable species with a flexible diet, high birthrate, and widespread or nonspecific habitat need

genetic diversity - variation in the genetic composition of individuals within or among species; the heritable genetic variation within and among populations

genetic erosion - loss of genetic diversity between and within populations of the same species over time; or reduction of the genetic basis of a species due to human intervention, environmental changes, etc.

genetics - the study of inheritance and the investigation of the genes responsible for inherited traits

habitat - a community or place where living things naturally grow and live

herbivore - an animal whose diet consists almost exclusively of plants

heredity - the passing of traits from one population to another

inbreeding - the breeding of related individuals within a species; This behavior limits the genetic combinations possible in offspring and reduces diversity. Over the long term it can lead to the demise of a species.

mustelid - family of fur-bearing meat eaters (carnivores) including the weasel, skunk, badger, wolverine, otter, fisher and ferret

niche - organism's role, or job, in its habitat

nocturnal - active during the night, rather than during daylight hours

omnivore - an animal that eats both plants and animals

population - the number of individuals representing a species in a given area

range - the geographic region in which a particular plant or animal is found (i.e. the southeastern US)

recessive gene - gene that is hidden when the dominant gene is present

reintroduction - to return a missing or extinct element of an ecosystem back where it belongs

reproduction - the natural process by which new individuals are generated and species is perpetuated

rodent - any of a very large order (Rodentia) of gnawing mammals, including prairie dogs, rats, squirrels, and beavers, characterized by constantly growing incisors adapted for gnawing or nibbling

specialist - a species that is primarily dependent on a single food source or habitat

survival - the process of ensuring that a species, or individual, will live to maturity and reproduce

Bottleneck Genes: Black Footed Ferret Ambassador Program
BACKGROUND INFORMATION

Native to the prairie ecosystem throughout the western Great Plains, the black-footed ferret is one of the most endangered mammals in North America. A specialist, the black-footed ferret eats prairie dogs and lives in their abandoned burrows.

In the early 1900s, settlers converted the large expanses of native grasslands into farmland, virtually destroying the prairie ecosystem and threatening many species, including the black-footed ferret and the prairie dog. In addition, prairie dogs are considered pests by farmers because of their natural burrowing behavior. In response to the concerns of the agriculture industry, the Federal government initiated a very effective eradication program which successfully killed thousands of prairie dogs.

Also contributing to the declining numbers of prairie dogs were diseases, like sylvatic plague. As the population of prairie dogs declined to only 2% of their original numbers, the black-footed ferret lost their only prey species and their populations crashed.

The black-footed ferret was listed as an endangered species in 1967 and was thought to be extinct in 1979. However, in 1981, a small population of black-footed ferrets was discovered on a ranch in Meeteetse, Wyoming. Scientists decided to allow this population to remain in the wild because of the lack of accurate information about the black-footed ferret. However, in 1985 the ferret population was nearly wiped out by outbreaks of canine distemper and sylvatic plague. Between 1985 and 1987, the remaining 18 ferrets were trapped and moved to a captive breeding facility in Wyoming, which is currently operated by the U.S. Fish and Wildlife Service (USFWS).

The Conservation and Research Center of the Smithsonian's National Zoo, located in Front Royal, Virginia, was the first program outside of Wyoming to receive black-footed ferrets for captive breeding. In addition, CRC contributes to the Black-Footed Ferret National Recovery Program by maintaining a genome resource bank (a repository of frozen semen) and by using assisted reproduction techniques, such as artificial insemination, to maintain genetic diversity and enhance reproductive efficiency.

Efforts are now being made to reintroduce captive-born ferrets back into their natural habitat. The goal for the black-footed ferret reintroduction program is to establish ten free-ranging ferret populations at ten different locations by the year 2010.

FACT SHEET (FEB 2004)

Black-Footed Ferret is the only ferret native to North America. It is ENDANGERED and once was considered the rarest mammal in North America.

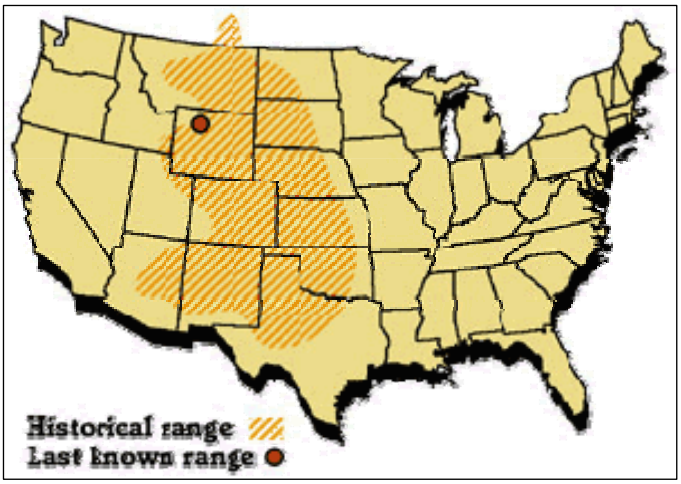
Phylogeny: Member of weasel family *Mustelidae* along with: the badger, skunk, fisher, marten, otter, mink, wolverine and weasel

Three species of ferrets: Black-footed ferret (*Mustela nigripes*), (2) European polecat (*Mustela putorius*) and (3) Siberian polecat (*Mustela eversmanni*). The black-footed ferret is a different species than the domestic ferret; the domestic ferret (*Mustela putorius furo)* is a descendant of the European polecat.

Description:

- 20 to 24 inches long
- Black mask, feet and tipped tail
- Males weigh ~1 kg (2.2 lbs); females are smaller,weighing ~800 grams (0.8 kg; 1.8 lbs)

Habitat:
- North American Great Plains extending from southern Saskatchewan, Canada to northern Mexico
- Grasslands ecosystem
- Must have prairie dog colonies/towns to survive



Lifespan:
- In captivity, live 5 to 7 years
- In wild, live 2 to 3 years

Breeding:
- Solitary except mother with her babies (called 'kits')
- Seasonal breeders; breed March-June
- Females come into estrus (heat) only once a year!!!!! (similar to giant pandas)
- Use vaginal washes and PAP stain (to detect cornified superficial cells) to determine peak estrus
- Females produce offspring for first four years; fertility declines after 4 years of age
- Males produce sperm from maturity until death
- Both are able to breed and produce offspring at 1 year of age
- Average litter size: 2 to 4 kits

Diet:
- Nocturnal carnivore; depends on prairie dogs for food and shelter
- Considered a "specialist carnivore": 90% of diet is prairie dog
- Will kill and eat prairie dog and then live in prairie dog burrows

Prairie dogs:
Prairie dogs play an important role in the prairie ecosystem. They are the "landscapers" of the prairie. Prairie dogs aerate the prairie with the digging of their burrows. Their constant clipping of the annual grasses encourages growth.
- Prairie dogs are large ground squirrels
- Five species:
  - black-tailed
  - white-tailed
  - Gunnison
  - Mexican
  - Utah
- Omnivorous animals that eat grasses and forbs
- Seen as competitors with livestock for grasses; considered pests

Predators:
- Coyotes, swift fox
- Badgers (shown here)
- Birds of prey (owls and eagles)
- Snakes

Events leading to the endangerment of the black footed ferret:
- Encroachment of west: agriculture, industry
- Habitat lost due to agriculture and urban development
- Eradication of prairie dogs by government
- US government-sponsored prairie dog poisoning programs (photo caption: "1,601 prairie dogs poisoned in one day on one acre of land in 1919 in Arizona")

- Disease: (1) **Sylvatic plague (*Yersinia pestis*; same as Bubonic Plague)**: transmitted by fleas; infects prairie dogs; and (2) **Canine distemper virus**-dogs and other canids are carriers; black-footed ferrets are susceptible

20th Century Black Footed Ferret Crisis:

- 1965, a small population of black-footed ferrets was discovered in Mellette County, South Dakota. This population was studied by U.S. Fish and Wildlife Service from 1964 to 1974. Results: Ferrets were observed on 20 of the 151 prairie dog colonies. It became evident the black-footed ferrets were dependent on large colonies of prairie dogs.
- In 1966, the Endangered Species Preservation Act was passed. **The black-footed ferret was listed as an endangered species in 1967.**
- In 1971, six ferrets were bought to the U.S. Fish and Wildlife Service Research Center in Patuxent, Maryland to begin a captive breeding program. The first attempts at captive breeding proved unsuccessful and the **last captive black-footed ferret died in January 1979**.
- By the **mid-70's**, the remaining wild population being studied in South Dakota died out and the Black-Footed Ferret was thought to be **extinct.**

A Second Chance:

- After the crisis in the mid-1970s, the black-footed ferret was thought to be extinct. However, in 1981, a ranch dog, named Shep, killed an unusual creature on a ranch in **Meeteetse, WY.** The dog's owner took the unknown carcass to a taxidermist, who immediately recognized the species…black-footed ferret!
- This led to the discovery of the last known wild population of black-footed ferrets, existing on a neighboring ranch. Population peaked at ~130 animals in 1984, but by 1985, the population declined because of outbreaks of canine distemper and sylvatic plague.
- Concern about the ability of the few remaining animals to sustain this population, led to an ambitious approach to a last ditch recovery effort. From 1985 to 1987, the **last 18 black-footed ferrets** were brought into a captive breeding facility near Laramie, WY (now known as the **National Black-Footed Ferret Conservation Center, managed by the U.S. Fish and Wildlife Service**)
- The 1988 Black-Footed Ferret Recovery Plan emphasized natural breeding, multi-institutional propagation programs and the development of assisted reproductive techniques (such as artificial insemination). It also called for establishing at least 1,500 breeding adults in ten populations by 2010.

Other facilities that participate in Black-Footed Ferret captive breeding and recovery program:

- Conservation and Research Center of the Smithsonian's National Zoo (first facility outside Wyoming to receive black footed ferrets for captive breeding in 1988)
- Henry Doorly Zoo (Omaha, Nebraska)-Recently (2001) has left the program
- Toronto Zoo (Toronto, Canada)
- Phoenix Zoo (Phoenix, Arizona)
- Louisville Zoo (Louisville, Kentucky)
- Cheyenne Mountain Zoo (Colorado Springs, Colorado)

Recovery Goals

- The overall goal of the black-footed ferret captive-breeding program is to provide sufficient animals to allow recovery of this species in their natural habitat, while maintaining a self-sustaining captive population.
- Between 1987 and 2003, 4300 kits have been born in the 'Species Survival Plan' (SSP) captive-breeding program. Currently in 2004, there are 275 (101 males.174 females) black-footed ferrets in the SSP captive-breeding program.

Reintroduction:

Recovery of the black-footed ferret has been successful at producing a high number of animals in the captive-breeding program for reintroduction to the Great Plains. Over 1800 ferrets have been released in the wild since 1991. About 1200 black-footed ferrets have been born in the wild. Currently, 500 ferrets are surviving in the wild. Reintroduction sites are located at: Shirley Basin, WY; Charles M. Russel National Wildlife Refuge, MT; Fort Belknap Indian Reservation, MT; Badlands National Park/Buffalo Gap National Grasslands, SD; Conata Basin, SD; Cheyenne River Sioux Tribe, SD; Aubrey Valley, AZ; Coyote Basin, UT ; Northwest Colorado; Bureau of Land Management, MT ; Janos, Mexico ; Rosebud Tribal land, SD

Number of Black-Footed Ferrets released at reintroduction sites:

- 228 ferrets have been released in **Wyoming** since 1991
- 746 ferrets released in **South Dakota** since 1994. **There is no sylvatic plague in South Dakota!!**
- 350 black-footed ferrets have been released in **Montana** since 1994
- 150 ferrets have been released in **Arizona** since 1996
- 139 ferrets have been released in **Utah/Colorado** since 1999/2001
- ~200 ferrets have been released in **Mexico** since 2001

Conservation efforts at the Conservation and Research Center of the Smithsonian's National Zoo

- Located in Front Royal, VA, CRC has one of the world's most extensive programs in conservation biology research, training and education.
- CRC is not normally open to the public (except for the Autumn Conservation Festival in October), and has unique facilities and space for black-footed ferret recovery.
- In 1988, the first black-footed ferrets arrived at CRC. **Since then, over 161 kits have been born from natural breeding at CRC.**

Pre-Conditioning Prior to Reintroduction

- CRC has outdoor pens for preconditioning (training prior to release) the kits before reintroduction.
- Prairie dogs dig a burrow system inside the pens, after which they are removed and ferrets move in. Mothers and kits live in actual burrows, and the kits grow up in a more natural setting.
- Pens allow the kits to grow up in burrows, which increases their chance of survival in the wild.
- CRC is the only facility outside of Wyoming that can breed, pre-condition and release directly into the wild.
- Since 1999, **90 kits** from CRC have been released into CO, UT, SD, MX, AZ, WY and MT.

Assisted Reproductive Technology and Laparoscopic Artificial Insemination

- The 1988 Black-Footed Ferret Recovery Plan recognized the benefits of assisted reproductive technology, especially artificial insemination (AI).
- Scientists from CRC started studying the basic biology of the domestic ferret and the Siberian polecat to develop techniques that could be applied to the black-footed ferret. In 1995, it was discovered that more than 50% of the black-footed ferret males had failed to sire offspring due to a combination of behavioral and physiological factors, but sperm quality was not compromised. In 1996, SNZP/CRC began using artificial insemination (AI) in black-footed ferrets (a technique developed by Dr. JoGayle Howard) to maintain genetic diversity
- Laparoscopy is used to visualize the reproductive tract; then sperm is deposited directly into the uterus.
- For AI, semen can be collected from a male or frozen/thawed semen stored in the **Black-Footed Ferret Genome Resource Bank** (repository of cryopreserved sperm) can be used.
- **From 1996 to 2003, 121 kits have been born from artificial insemination at CRC.**

Visit www.blackfootedferret.org for more in-depth information on the history of the black-footed ferret and current conservation efforts.

Bottleneck Genes: Black Footed Ferret Ambassador Program ADDITIONAL INFORMATION

Visit these websites for more in-depth information:

www.blackfootedferret.org
This website was created by the Black-footed Ferret Recovery Implementation Team (BFFRIT). The BFFRIT was established in 1996 to more effectively integrate the expertise and resources of various parties contributing to the recovery of the black-footed ferret. It is a multi-agency/ conservation organization effort, led by the U.S. Fish and Wildlife Service, which includes representatives from federal and state governments, zoos, and nonprofit organizations. The team was created pursuant to Section 4(f)(2) of the amended Endangered Species Act which authorizes the Secretary of the Interior to procure the services of appropriate public and private agencies, institutions, and other qualified persons to help implement endangered species recovery plans. Although the role of the BFFRIT is strictly advisory in nature, the team assists in the development of national guidance, provides recommendations to the U.S. Fish and Wildlife Service regarding the appropriate conduct, methods, and priorities for ferret recovery efforts, and reviews any future revision or update of the black-footed ferret recovery plan.

www.science.mcmaster.ca/Biology/4FF3/consgen/
This website is the result of a biology course at McMaster University (located in Hamilton, Ontario), taught approximately once a year. The course entitled, "Biology Inquiry: Genetics in Conservation", is an independent study seminar course for fourth year university students. The themes of the course are the role of genetic individuality as the basis of biodiversity, and the use of contemporary molecular genetics methods and population genetics concepts in conservation biology. Each year, students prepare essays and seminar materials that are added to the website, edited by course instructor Dr. David Galbraith. Topics on the Web site to date include the genetics of small populations of plants and animals, inbreeding, population bottlenecks, extinction vortices and the declining population problem. Techniques examined have included DNA fingerprinting, DNA sequencing, minisatellite markers and RAPDs. Case studies ranging from cheetahs and lions to rattlesnakes and beavers have also been included. The Web site is an on-going project and is updated once or twice per year. Please contact David Galbraith (dgalbraith@rbg.ca) for more information.

www.dnr.state.mn.us/ecological_services/sna
The Minnesota Department of Natural Resources has put together a beautiful publication on prairie reconstruction, called *Going Native: A Prairie Restoration Handbook for Minnesota Landowners*. Although intended for individuals who are returning their property to a natural state, the book is very easy to read and has wonderful photographs, quotations, and resources on general prairie information. The book can be downloaded from this website with Adobe Acrobat Reader, or it can also be requested directly from the Minnesota DNR.

Scientific Publications on conservation genetics and small population biology

Ballou, J. D., and T. J. Foose. 1994. Demographic and genetic management of captive populations. *Wild Mammals in Captivity*. University of Chicago Press, Chicago, IL, 263-283.

Frankham, R. and K. Ralls. 1998. Conservation biology: inbreeding leads to extinction. *Nature* 392, 441-442.

O'Brien, Stephen J. 1994. *Annu. Rev. Genet.* 28, 467-489.

O'Brien, Stephen J. 1994. *Proc. Natl. Acd. Sci. USA 91*, 5748-5755.