Viewer discretion advised: This film contains images of roadkill, which some viewers may find disturbing.

FOCUS QUESTIONS

- How has the Atlantic Forest of Brazil changed over the last few centuries and what effects have these changes had on the natural functions of the forest ecosystem?
- What is habitat fragmentation and what effects does it have on wildlife?
- In what ways can we reconnect landscapes that have been fragmented by roads and highways?

OVERVIEW

"Eu acho que essa é a maior alegria do trabalho é ver uma mãe e o filhote seguindo ela por uma passagem de fauna, os filhotes já estão aprendendo que as passagens de fauna são uma rota segura de travessia. Essa experiência vai ser passada de geração em geração."

"I think the greatest joy of the work is to see a mother and her calf using a wildlife crossing. The cubs are learning a safe route to cross. This experience will be passed on from generation to generation." - Fernanda Abra, Biologist, Smithsonian's National Zoo and Conservation Biology Institute

In ***Road Warriors*** we learn that Brazil has the fourth largest road network on the planet and new roads and highways are expanding into remote areas like the Amazon. Road and highway expansion has led to habitat fragmentation and has created barriers to movement for animals, including endangered species, in search of food, water, and mates. Fortunately, biologist Fernadra Abra and her team have been working across Brazil to help design, install, and study different types of wildlife crossing structures like tunnels and canopy bridges that provide safe passage for animals throughout their now patchy landscape.

KEY CONCEPTS

- Habitat loss and fragmentation: Over the last three centuries a combination of logging, clearing for agriculture, and urbanization has reduced the Brazilian Atlantic Forest to 26% of its original area and 35% of the remaining forest area is composed of small, isolated fragments of forest habitat. Recent road and highway building has made it increasingly dangerous for animals to move among the fragments as they search for food, mates, and other resources.
- Ecosystem ecology: Understanding how living organisms interact with each other and their physical environment within a specific natural system is essential for reversing and restoring the Earth's degraded habitats and the essential functions they provide for wildlife.
- Corridor ecology: Wildlife have many reasons for needing to travel across large swaths of land but human activity has removed that ability by fragmenting large contiguous ecosystems into small isolated island habitats while also bisecting the fragments with roads and highways which create dangerous barriers to animal movement. Corridor ecology studies how and why animals move throughout the Earth's landscapes and how we can restore this essential ecosystem process.
- Biodiversity: Habitat fragmentation has created barriers to the movement of wildlife across landscapes which reduces the genetic diversity and health of isolated populations. Many species that find themselves in small isolated patches are unable to maintain large enough populations and species with more fragmentation are at greater risk of extinction.
- Conservation biology: The practice of conservation biology recognizes the intrinsic value of the Earth's natural diversity of organisms. Conservation biology works to understand how the natural world operates, how humans affect nature, and how we can use collective scientific and cultural knowledge to conserve Earth's biological diversity. Building wildlife crossing structures like overpasses, underpasses, and canopy bridges can restore some of the natural migration patterns of animals. The ability to move safely among fragments can ensure access to resources as well as maintain gene flow among populations.

BACKGROUND

The growing expansion of roads and highways has led to significant habitat fragmentation, threatening the survival of countless wildlife species. Studies show that vehicle collisions with animals cause millions of wildlife deaths each year and pose serious risks to human safety, costing billions in damages annually. Wildlife crossing structures, such as overpasses and underpasses, have been scientifically tested and can be impactful solutions that reconnect fragmented habitats. For example, the Banff Wildlife Crossings Project in Canada that was completed in 1997 has reduced wildlife-vehicle collisions by over 80% compared to data from before the project was implemented. In Colorado (US) vehicle-wildlife collisions cost an average of $80 million in property damage per year, including $66.3 million annually in medical expenses. With 97% reduction in crashes in some locations, where there might have been an average of 100 crashes in a year, there are now only three. Given their proven success in saving lives, preserving biodiversity, and reducing long-term costs, wildlife crossing structures should be a global priority for sustainable infrastructure development.

Beyond promoting both ecological and public safety, wildlife crossings play a crucial role in maintaining genetic diversity within animal populations. Fragmented habitats often isolate groups, leading to inbreeding and weakened species resilience. For example, highways across western Canada and the northern United States have been shown to be genetically isolating black and grizzly bear populations but the installment of wildlife crossing structures have promoted the movement of individual bears necessary to maintain genetically healthy populations.

Road Warriors highlights how these needs are being addressed in remote areas like the Amazon where road and highway construction is increasing. In the film we meet biologist Fernadra Abra who has coordinated more than 50 projects on wildlife road mortality and makes recommendations for mitigation measures to reduce deaths of animals on highways and railways throughout Brazil. Fernanda and her team have been working across Brazil to help design, install, and study different types of wildlife crossing structures like tunnels and canopy bridges that provide safe passage for animals throughout their now patchy landscape. To date, the team has documented over 40,000 safe wildlife crossings, and has spared the lives of countless endangered species.

BIODIVERSITY THREATS

The major threats to the Earth's biodiversity can be grouped into seven categories that spell the easily recalled acronym H.I.P.P.O.: **H**abitat destruction and fragmentation, **I**ntroduced species, **P**ollution, **P**opulation growth, and **O**verharvesting. Many species are threatened by a combination of these factors, but habitat loss is the greatest threat to biodiversity. In ***Road Warriors*** we learn that Brazil has the fourth largest road network on the planet and new roads and highways are expanding into remote areas like the Amazon. Road and highway expansion has led to habitat fragmentation and has created barriers to movement for animals, including endangered species, in search of food, water, and mates.

DISCUSSION QUESTIONS

- [Before showing the film] Have students list all the different types of wildlife they have seen crossing roads and highways and brainstorm what structures they know about or could construct that could make it easier and safer for wildlife to move across a landscape that is crisscrossed by roads.
- After showing the film, have students identify where in their local area they think there might be high wildlife crossing traffic and discuss what kind of crossing might work best for that location.
- In the film we learn that Fernanda Abra and her team collect tissue samples from wildlife, like pumas, killed on roadways. Ask students how collecting genetic data might help researchers understand the effect of habitat fragmentation and roads on the genetic diversity of isolated populations. Consider giving students hints of the evolutionary mechanisms of gene flow and genetic drift.

- As an extension activity for interested students, suggest going online and searching for local, state, or federal/country guidelines on building wildlife crossing structures. For example, in the United States the search term “wildlife crossing structures guidelines” will bring up the U.S. Department of Transportation Federal Highway Administration’s publication “Wildlife Crossing Structure Handbook: Design and Evaluation in North America.” Here, interested students can learn more about the overall wildlife-vehicle collision problem in the U.S., the needs that must be addressed, and the numerous creative solutions to plan, design, construct, monitor, and maintain effective animal crossings in places where roads are dangerous barriers.

Curriculum Connections

NGSS

HS-LS2 Ecosystems: Interactions, Energy, and Dynamics

- LS2.A: Interdependent Relationships in Ecosystems
- LS2.C: Ecosystem Dynamics, Functioning, and Resilience
- LS2.D: Social Interactions and Group Behavior
- LS4.D: Biodiversity and Humans

HS-LS3 Heredity: Inheritance and Variation of Traits

- LS3.B: Variation of Traits

HS-LS4 Biological Evolution: Unity and Diversity

- LS4.C: Adaptation

ETS1.B: Developing Possible Solutions

AP Biology (2021)

Enduring Understandings

- Evolution (EVO)
  - EVO-1: Evolution is characterized by a change in the genetic makeup of a population over time and is supported by multiple lines of evidence.
- Energetics (ENE)
  - ENE-4: Communities and ecosystems change on the basis of interactions among populations and disruptions to the environment.
- Information Storage and Transmission (IST)
  - IST-1: Heritable information provides for continuity of life.
- Systems Interactions (SYI)
  - SYI-3: Naturally occurring diversity among and between components within biological systems affects interactions with the environment.

IB Biology (First Exam May 2025)

A. Unity and Diversity: Common ancestry has given living organisms many shared features while evolution has resulted in the rich biodiversity of life on Earth.

- A3.1 Diversity of organisms
- A4.1 Evolution and speciation
- A4.2 Conservation of biodiversity

B. Form and Function: Adaptations are forms that correspond to function. These adaptations persist from generation to generation because they increase the chances of survival.

- B4.1 Adaptation to environment
- B4.2 Ecological niches

C. Interaction and Interdependence: Systems are based on interactions, interdependence and integration of components. Systems result in emergence of new properties at each level of biological organization.

- C4.1 Populations and communities

D. Continuity and Change: Living things have mechanisms for maintaining equilibrium and for bringing about transformation. Environmental change is a driver of evolution by natural selection.

- D3.1 Reproduction
- D3.2 Inheritance
- D4.1 Natural selection
- D4.2 Stability and change

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CREDIT

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