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BIO 403

WILDLIFE CONSERVATION AND MANAGEMENT

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Course code: BIO 403

Course title: Wildlife Conservation and Management

Course credit load: 2 Units

Series 1: Principles of Wildlife Management

- **Part 1.1: General Principles and Glossary of Ecosystem Management**
  - Sub Part 1.1.1: Defining wildlife and wildlife management
  - Sub Part 1.1.2: Key concepts in ecosystem management
  - Sub Part 1.1.3: Glossary of essential wildlife management terms
- **Part 1.2: Principles of Wildlife Population Management**
  - Sub Part 1.2.1: Carrying capacity and population regulation
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- **Part 1.3: Biological Gardens and Ex-Situ Conservation**
  - Sub Part 1.3.1: Zoos, botanical gardens, and biological parks
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- **Part 1.4: Fire as a Tool in Terrestrial Wildlife Management**
  - Sub Part 1.4.1: Ecological role of fire in wildlife habitats
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  - Sub Part 1.4.3: Risks and considerations in fire management

Introduction

Wildlife management is the science and practice of maintaining wildlife populations and their habitats at levels that balance ecological sustainability with human needs, whether for conservation, recreation, or sustainable use. Effective wildlife management requires understanding the principles that govern population dynamics, habitat quality, and ecosystem function, as well as the practical tools available to managers to influence these processes in pursuit of defined management objectives.

This Series introduces the foundational principles and terminology of wildlife and ecosystem management; the population-level principles of carrying capacity, habitat management, and sustainable harvest; the role of biological gardens (zoos and botanical gardens) as ex-situ conservation tools, with particular reference to Nigeria; and the use of fire as a deliberate management tool in terrestrial wildlife habitats, establishing the conceptual foundation for the more specialised topics covered in the remainder of this course.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 1.1** define wildlife management and explain key concepts and terminology in ecosystem management,
- **SLO 1.2** explain carrying capacity, habitat management principles, and sustainable yield in wildlife population management,
- **SLO 1.3** describe the role of biological gardens in ex-situ conservation, with reference to Nigeria, and
- **SLO 1.4** explain the ecological role of fire and the practice and risks of prescribed burning in wildlife management.

1.1 General Principles and Glossary of Ecosystem Management

1.1.1 Defining wildlife and wildlife management

Wildlife is broadly defined as undomesticated animal species living in their natural habitat, though the term is sometimes extended to include wild plants and the ecosystems that support them; wildlife management is the application of ecological knowledge and practical techniques to manipulate wildlife populations and their habitats to achieve specific human-defined objectives, which may include conservation of biodiversity, sustainable production of game or fish for food or recreation, control of pest or overabundant species, and restoration of degraded ecosystems.

Modern wildlife management has evolved from an early focus primarily on game species for hunting toward a broader ecosystem-based approach that recognises the interconnectedness of species, habitats, and human communities; the discipline draws on population ecology, habitat ecology, genetics, veterinary science, and increasingly social science and economics, since the success of wildlife management interventions depends heavily on the cooperation and support of the human communities who share the landscape with wildlife.

Fill in the blank: Wildlife management is the application of ecological knowledge to manipulate wildlife populations and their habitats to achieve specific _____ -defined objectives such as conservation or sustainable use.

1.1.2 Key concepts in ecosystem management

Ecosystem management is an integrated approach to managing natural resources that considers the entire ecological system (including its physical, biological, and human components) rather than managing individual species or resources in isolation; key concepts include ecosystem services (the benefits humans derive from ecosystems, including provisioning services such as food and water, regulating services such as climate regulation, and cultural services such as recreation), ecological integrity (the capacity of an ecosystem to maintain its characteristic structure, composition, and function over time), and adaptive management (an iterative approach

in which management actions are treated as experiments, monitored, and adjusted based on the results).

Other essential concepts include the precautionary principle (taking protective action even when scientific certainty about a threat is incomplete, given the risk of irreversible harm), stakeholder participation (involving all parties with an interest in a resource, including local communities, government agencies, and conservation organisations, in management decisions), and the landscape-scale perspective (recognising that wildlife populations and ecological processes typically operate across spatial scales larger than any single protected area, requiring coordination across administrative and land-use boundaries).

Fill in the blank: _____ management is an iterative approach in which management actions are treated as experiments, with outcomes monitored and used to adjust future management decisions.

1.1.3 Glossary of essential wildlife management terms

Several foundational terms recur throughout wildlife management: a population is a group of individuals of the same species occupying a defined area and capable of interbreeding; a habitat is the specific environment, including its physical and biotic characteristics, that provides the resources and conditions necessary for a species survival and reproduction; carrying capacity is the maximum population size that a given habitat can sustainably support given available resources; and a keystone species is a species whose impact on its ecosystem is disproportionately large relative to its abundance, such that its loss would cause significant ecosystem change.

Further essential terms include biodiversity (the variety of life at genetic, species, and ecosystem levels within a given area); conservation (the protection, sustainable management, and restoration of natural resources and biodiversity); in-situ conservation (conservation of species within their natural habitat, such as in national parks); ex-situ conservation (conservation of species outside their natural habitat, such as in zoos, gene banks, or botanical gardens); and endangered species (a species at high risk of extinction throughout all or a significant portion of its range).

Fill in the blank: A _____ species is one whose impact on its ecosystem is disproportionately large relative to its abundance, such that its loss would cause significant ecosystem change.

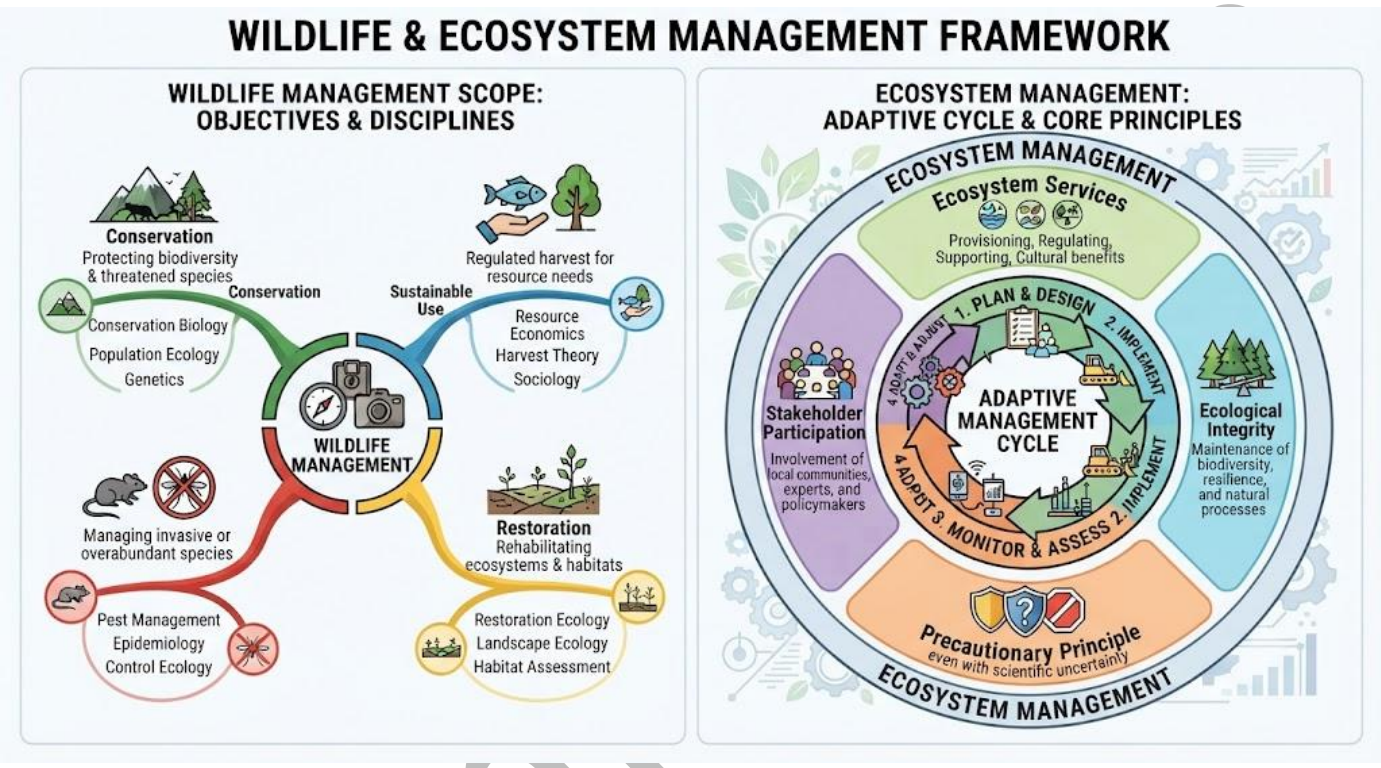

Figure 1.1: Wildlife management foundations and ecosystem concepts

Pilot questions 1.1

1. Define wildlife management and state two objectives it may pursue.
2. Explain what adaptive management is.
3. Define carrying capacity.
4. Distinguish between in-situ and ex-situ conservation.
5. Define keystone species and give one reason its loss matters for an ecosystem.

1.2 Principles of Wildlife Population Management

1.2.1 Carrying capacity and population regulation

Carrying capacity is the maximum population size of a species that a given habitat can sustain indefinitely given the available food, water, shelter, and space, without degrading the habitat resource base; populations below carrying capacity typically grow, while populations exceeding carrying capacity decline due to resource limitation, increased disease transmission, or starvation; carrying capacity is not a fixed number but varies with habitat condition, season, and the presence of competing or predatory species, and may itself decline if habitat quality is degraded by overgrazing, drought, or other pressures.

Density-dependent factors (those whose effect on population growth intensifies as population density increases, such as food competition, disease transmission, and predation) act as natural regulating mechanisms that tend to stabilise populations near carrying capacity; density-independent factors (such as severe weather events or fire) affect population size regardless of density and can cause populations to fluctuate independently of resource availability; wildlife managers use estimates of carrying capacity to set sustainable harvest quotas, determine appropriate stocking densities for protected areas, and assess whether a habitat can support reintroduction of a species.

Fill in the blank: _____ -dependent factors, such as food competition and disease transmission, intensify in effect as population density increases, acting as natural population regulating mechanisms.

1.2.2 Habitat management principles

Habitat management is the deliberate manipulation of vegetation, water, and other habitat features to improve conditions for target wildlife species; common habitat management techniques include controlled grazing or mowing (to maintain open grassland structure favoured by many grazing species), water management (creating or maintaining waterholes, dams, or wetlands to ensure year-round water availability), and vegetation management (selective

clearing, planting, or fire, depending on the successional stage and structure required by the target species).

Habitat heterogeneity (the presence of a diverse mosaic of habitat types and successional stages within a landscape) generally supports higher overall species diversity than uniform habitat, since different species require different habitat structures for feeding, breeding, and shelter; habitat connectivity (the degree to which a landscape facilitates or impedes the movement of organisms between habitat patches) is increasingly recognised as essential for maintaining viable wildlife populations in fragmented landscapes, and habitat corridors are a key tool for improving connectivity between otherwise isolated protected areas.

Fill in the blank: Habitat _____ , the presence of a diverse mosaic of habitat types within a landscape, generally supports higher overall species diversity than uniform habitat.

1.2.3 Sustainable yield and harvest management

Sustainable yield is the level of harvest (through regulated hunting, fishing, or other off-take) that a wildlife population can sustain indefinitely without causing long-term population decline; the concept of maximum sustainable yield (MSY) identifies the harvest level, typically near the population growth rate maximum (often around half of carrying capacity for populations following logistic growth), that produces the greatest sustainable harvest over time, though in practice many factors complicate the precise application of MSY, including uncertainty in population estimates and the risk of overestimating sustainable harvest levels.

Harvest management tools include setting quotas (maximum numbers that may be harvested in a season), establishing closed seasons (periods, typically coinciding with breeding, during which harvest is prohibited), size or sex restrictions (protecting breeding females or juveniles from harvest), and licensing systems (controlling who may harvest and how much, generating revenue that can fund conservation activities); effective harvest management requires reliable population monitoring data, since harvest quotas set without accurate population information risk unsustainable depletion.

Fill in the blank: Maximum sustainable yield (MSY) identifies the harvest level that produces the greatest sustainable harvest over time, typically occurring near _____ of carrying capacity for populations following logistic growth.

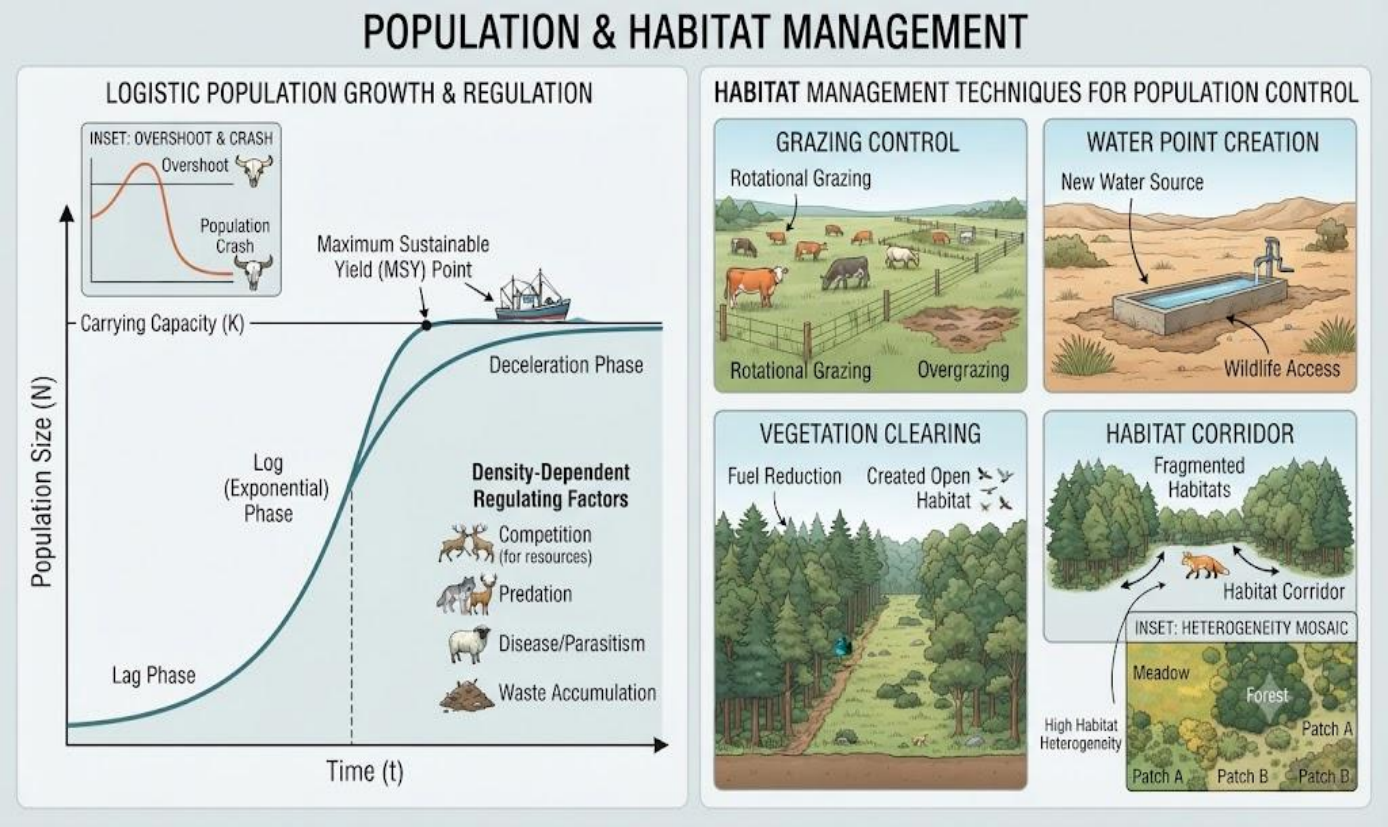

Figure 1.2: Population management principles

Pilot questions 1.2

1. Define carrying capacity and explain what happens to a population that exceeds it.
2. Distinguish between density-dependent and density-independent regulating factors.
3. Name three habitat management techniques.
4. Explain what habitat connectivity is and why it matters for wildlife populations.
5. Define maximum sustainable yield and name two harvest management tools.

1.3 Biological Gardens and Ex-Situ Conservation

1.3.1 Zoos, botanical gardens, and biological parks

Biological gardens (zoos, botanical gardens, and biological parks) are institutions that maintain living collections of animals or plants outside their natural habitats for purposes including public education, scientific research, recreation, and species conservation; modern zoos have evolved considerably from historical menageries focused primarily on display, increasingly emphasising naturalistic enclosures that meet animal welfare standards, conservation breeding programmes for threatened species, and conservation education aimed at building public support for biodiversity protection.

Botanical gardens similarly maintain living plant collections for taxonomic research, public education, and conservation, often including specialised facilities such as seed banks (long-term storage of seeds under controlled conditions to preserve genetic diversity for future use) and tissue culture laboratories (for propagating rare or difficult-to-grow species); biological parks combine elements of both zoological and botanical gardens, sometimes integrated with broader recreational or research facilities, and are an important category of institution in many African countries including Nigeria.

Fill in the blank: _____ banks are facilities for the long-term storage of plant seeds under controlled conditions, preserving genetic diversity for future conservation and research use.

1.3.2 Roles of biological gardens in conservation

Biological gardens contribute to conservation through several mechanisms: ex-situ breeding programmes (maintaining and breeding threatened species in captivity to build insurance populations against extinction in the wild, and in some cases producing individuals for reintroduction to restored habitats); genetic resource conservation (maintaining genetically diverse captive populations or seed banks that preserve genetic variation that might otherwise be lost from declining wild populations); research (providing controlled settings for studying reproductive biology, behaviour, nutrition, and veterinary care that inform both captive management and wild conservation efforts).

Public education and engagement is a further critical conservation role: biological gardens provide millions of visitors worldwide with direct encounters with wildlife and plants, building awareness and emotional connection to conservation issues that can translate into public support for conservation policy and funding; many successful reintroduction programmes (such as the California condor, Arabian oryx, and black-footed ferret) have relied on captive breeding in zoos as an essential step in species recovery, demonstrating the practical conservation value of well-managed ex-situ programmes when integrated with habitat protection and in-situ recovery efforts.

Fill in the blank: Ex-situ breeding programmes maintain and breed threatened species in captivity to build _____ populations against extinction in the wild, sometimes producing individuals for later reintroduction.

1.3.3 Biological gardens in Nigeria

Nigeria hosts several biological gardens and zoological parks that contribute to conservation, education, and recreation, including the University of Ibadan Zoological Garden (one of the oldest and most established, housing a range of Nigerian and African wildlife species and supporting university teaching and research), the National Zoological Garden in Jos, and various university and state-managed zoological and botanical gardens across the country; many of these institutions face significant resource constraints that limit their capacity to meet modern animal welfare and conservation breeding standards seen in well-funded zoos in other parts of the world.

Despite resource constraints, Nigerian biological gardens play important local roles, providing accessible wildlife education to school groups and the public who may never have the opportunity to see Nigerian wildlife in its natural habitat due to declining wild populations and limited access to remote protected areas; strengthening the conservation breeding and education capacity of Nigerian biological gardens, including improving enclosure standards, veterinary care, and staff training, represents an important opportunity to enhance their contribution to national wildlife conservation objectives.

Fill in the blank: The University of Ibadan Zoological Garden is one of the oldest established biological gardens in Nigeria, supporting university _____ and research alongside public education.

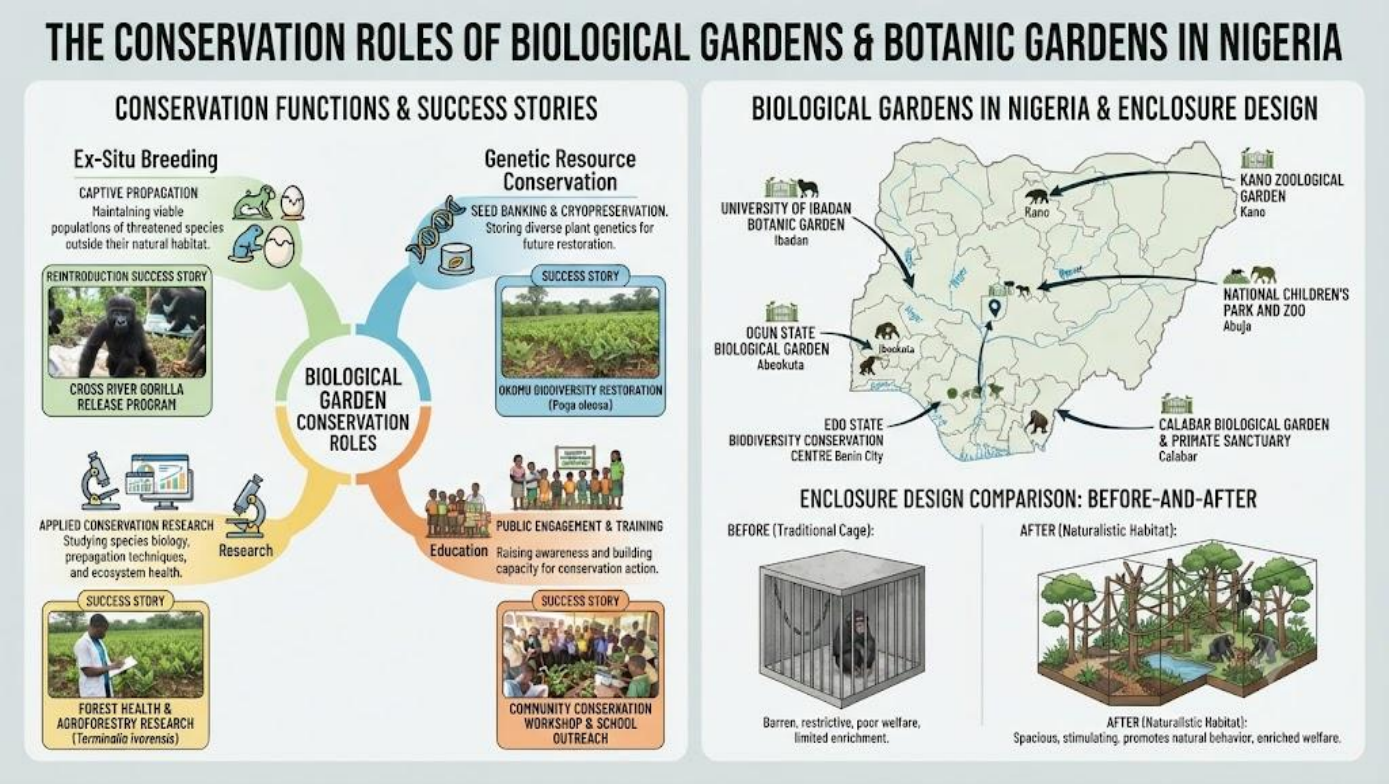

Figure 1.3: Biological gardens and ex-situ conservation

Pilot questions 1.3

1. Define biological garden and name two types of institution it includes.
2. Name three ways biological gardens contribute to conservation.
3. Explain what a seed bank is and its conservation value.
4. Name two Nigerian biological gardens.
5. Give one example of a species successfully recovered through zoo-based captive breeding.

1.4 Fire as a Tool in Terrestrial Wildlife Management

1.4.1 Ecological role of fire in wildlife habitats

Fire is a natural and recurring ecological process in many terrestrial ecosystems, particularly savannas, grasslands, and some forest types, where fire-adapted vegetation and wildlife communities have evolved over long periods with periodic burning; fire influences vegetation structure by removing woody encroachment and dead plant material, recycling nutrients tied up in standing biomass back into the soil, stimulating fresh grass and herbaceous growth that is highly attractive and nutritious for grazing wildlife, and maintaining the open habitat structure preferred by many savanna species.

In the absence of periodic fire, many savanna and grassland ecosystems undergo woody plant encroachment, gradually converting open grassland to denser bushland or woodland, with corresponding changes in the wildlife community as grassland specialist species decline and woodland or bushland species increase; understanding the natural fire regime (the frequency, intensity, seasonality, and extent of fire characteristic of a particular ecosystem before human modification) provides the ecological baseline against which deliberate fire management interventions are designed.

Fill in the blank: In the absence of periodic fire, many savanna ecosystems undergo woody plant _____ , gradually converting open grassland to denser bushland with corresponding changes in wildlife community composition.

1.4.2 Prescribed burning as a management tool

Prescribed burning (also called controlled burning) is the deliberate, planned application of fire to achieve specific management objectives under carefully controlled conditions, including weather, fuel moisture, and the presence of firebreaks to contain the burn within the intended area; early dry-season burning (conducted soon after the rains end, when fuel moisture is still relatively high) produces lower-intensity, patchy burns that create a habitat mosaic of burned and unburned patches, generally favoured in savanna wildlife management because it avoids the

more destructive, intense fires that occur later in the dry season when fuel loads and dryness are at their maximum.

Prescribed burning is used to achieve multiple management objectives: reducing fuel loads to prevent uncontrolled, high-intensity wildfires later in the season; stimulating nutritious new grass growth (green flush) that attracts grazing wildlife and can be used to draw animals into areas suitable for tourism viewing or away from areas requiring rest from grazing pressure; controlling woody plant encroachment to maintain open grassland habitat structure; and creating firebreaks (strips of burned or cleared vegetation) that limit the spread of subsequent unplanned fires.

Fill in the blank: _____ -season burning, conducted soon after the rains end when fuel moisture is still relatively high, produces lower-intensity, patchy burns that are generally favoured in savanna wildlife management.

1.4.3 Risks and considerations in fire management

Despite its value as a management tool, fire carries significant risks that must be carefully managed: uncontrolled escape of a prescribed burn beyond its intended boundary can cause unintended habitat damage, threaten human life and property, and in extreme cases cause direct wildlife mortality, particularly of slow-moving species, ground-nesting birds, and animals unable to escape rapidly; smoke from burning can affect air quality and visibility over wide areas, with implications for human health and aviation safety near protected areas.

Effective fire management requires detailed planning including weather forecasting (burning only under suitable wind and humidity conditions), pre-established and maintained firebreaks, trained fire crews equipped with appropriate firefighting resources, and clear protocols for who has authority to ignite and to call off a burn; the timing, frequency, and extent of prescribed burning must also be calibrated to the specific ecological requirements of the management area, since burning too frequently, too rarely, or at the wrong season can each produce undesirable ecological outcomes rather than the intended habitat benefits.

Fill in the blank: Uncontrolled escape of a prescribed burn beyond its intended boundary can cause unintended habitat damage, threaten human life and property, and cause direct wildlife _____ , particularly of slow-moving or ground-nesting species.

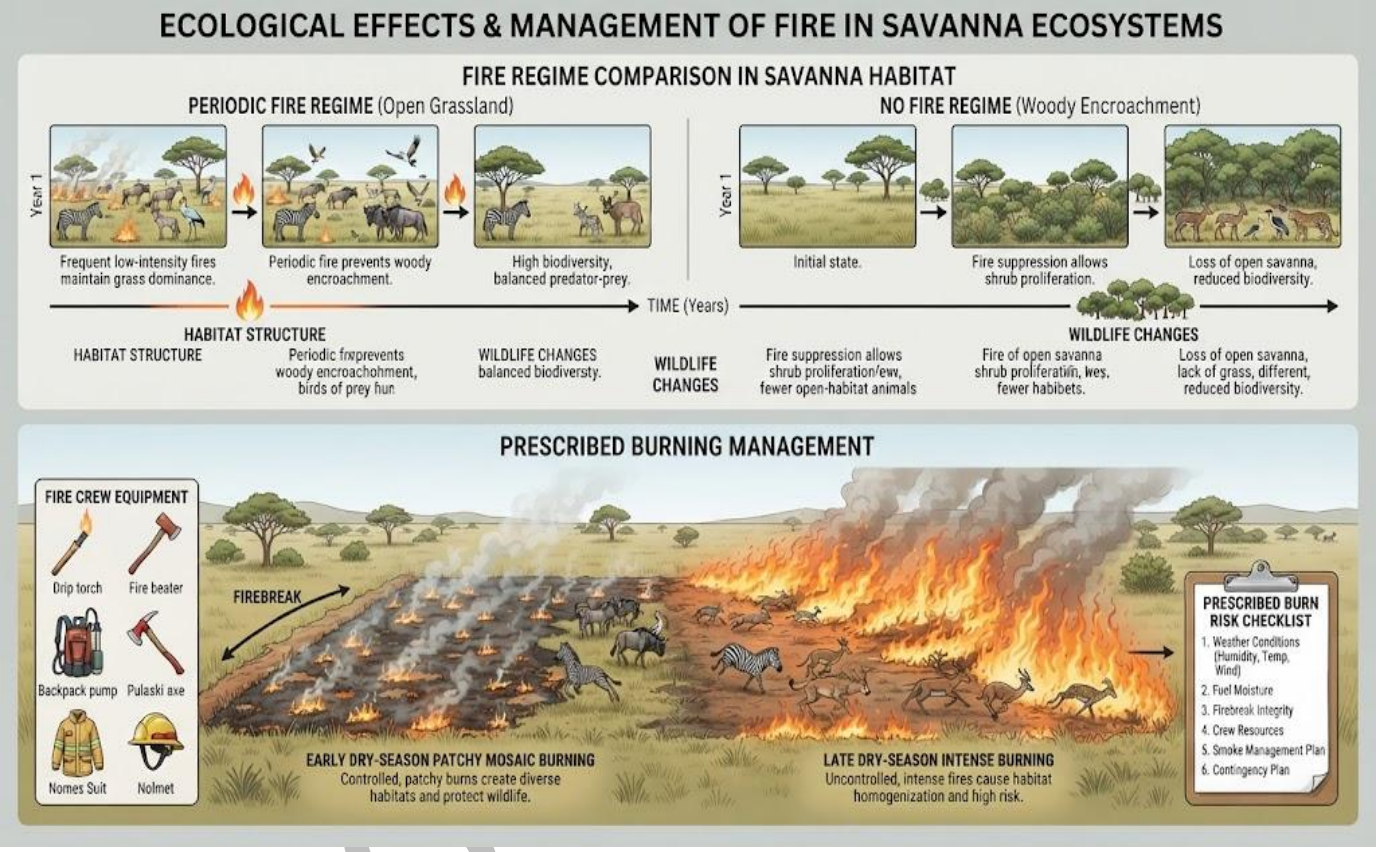

Figure 1.4: Fire as a wildlife management tool

Pilot questions 1.4

1. Explain the ecological role of fire in savanna ecosystems.
2. Explain what happens to savanna habitat structure in the absence of periodic fire.
3. Define prescribed burning and state why early dry-season burning is generally favoured.
4. Name three management objectives achieved through prescribed burning.
5. Name three risks associated with fire management and one precaution to address each.

Series Summary

This Series established the conceptual and practical foundations of wildlife management. Wildlife management applies ecological knowledge to manipulate populations and habitats toward defined objectives, drawing on key concepts such as carrying capacity, ecosystem services, and adaptive management. Population-level principles, including density-dependent regulation, habitat heterogeneity and connectivity, and sustainable yield, provide the tools managers use to maintain healthy wildlife populations while balancing conservation with sustainable use.

Biological gardens contribute a complementary ex-situ dimension to conservation, supporting breeding programmes, genetic resource preservation, research, and public education, with Nigerian institutions such as the University of Ibadan Zoological Garden playing important local roles despite resource constraints. Fire, properly understood as a natural ecological process in savanna systems, can be harnessed through prescribed burning as a deliberate management tool, though its use requires careful planning to balance habitat benefits against the real risks of uncontrolled spread and wildlife harm.

Glossary of Terms

- **Adaptive management:** an iterative management approach in which actions are treated as experiments, monitored, and adjusted based on outcomes over time.
- **Carrying capacity:** the maximum population size that a given habitat can sustainably support given available food, water, shelter, and space.
- **Density-dependent factor:** a population-regulating factor, such as food competition or disease, whose effect intensifies as population density increases.
- **Ex-situ conservation:** the conservation of species outside their natural habitat, such as in zoos, botanical gardens, or seed banks.
- **Habitat connectivity:** the degree to which a landscape facilitates the movement of organisms between separate habitat patches.

- **In-situ conservation:** the conservation of species within their natural habitat, such as in national parks and protected areas.
- **Keystone species:** a species whose ecological impact is disproportionately large relative to its abundance, such that its loss causes significant ecosystem change.
- **Maximum sustainable yield (MSY):** the harvest level that a population can sustain indefinitely while producing the greatest possible long-term yield.
- **Prescribed burning:** the deliberate, planned application of fire under controlled conditions to achieve specific habitat management objectives.
- **Seed bank:** a facility for the long-term storage of seeds under controlled conditions to preserve plant genetic diversity for future use.

Concept Check Questions [Series 1]

Objective Questions

1. Wildlife management applies ecological knowledge to manipulate populations and habitats to achieve specific human-defined _____ . (Linked to SLO 1.1)
2. Carrying capacity is the maximum population size a habitat can sustainably _____ given available resources. (Linked to SLO 1.2)
3. Ex-situ breeding programmes build _____ populations against extinction in the wild. (Linked to SLO 1.3)
4. In the absence of periodic fire, savanna ecosystems undergo woody plant _____ . (Linked to SLO 1.4)
5. _____ -season burning is generally favoured in savanna wildlife management because it produces lower-intensity, patchy burns. (Linked to SLO 1.4)

Short-Answer Questions

6. Distinguish between in-situ and ex-situ conservation. (Linked to SLO 1.1)
7. Distinguish between density-dependent and density-independent regulating factors. (Linked to SLO 1.2)
8. Name three ways biological gardens contribute to conservation. (Linked to SLO 1.3)
9. Explain the ecological role of fire in savanna ecosystems. (Linked to SLO 1.4)
10. Name two Nigerian biological gardens. (Linked to SLO 1.3)

Long-Answer Questions

11. Define wildlife management and explain key concepts in ecosystem management. (Linked to SLO 1.1)
12. Explain carrying capacity, habitat management, and sustainable yield in wildlife population management. (Linked to SLO 1.2)
13. Describe the role of biological gardens in conservation and explain the use of fire as a management tool. (Linked to SLOs 1.3, 1.4)

Answers to Concept Check Questions [Series 1]

Objective Questions

1. Objectives.
2. Support.
3. Insurance.
4. Encroachment.
5. Early dry.

Short-Answer Questions

6. In-situ conservation protects species within their natural habitat (e.g. national parks); ex-situ conservation protects species outside their natural habitat (e.g. zoos, seed banks).
7. Density-dependent factors (food competition, disease) intensify in effect as population density increases; density-independent factors (severe weather, fire) affect population size regardless of density.
8. Ex-situ breeding programmes, genetic resource conservation, and research (or public education and engagement).
9. Fire removes woody encroachment, recycles nutrients into soil, stimulates fresh grass growth attractive to grazers, and maintains open habitat structure favoured by savanna species.
10. University of Ibadan Zoological Garden and the National Zoological Garden, Jos.

Long-Answer Questions

11. Wildlife management applies ecological knowledge to manipulate populations and habitats for objectives including conservation, sustainable use, pest control, and restoration. Key ecosystem management concepts: ecosystem services, ecological integrity, adaptive management, precautionary principle, stakeholder participation, landscape-scale perspective.
12. Carrying capacity is the maximum sustainable population size; populations regulated by density-dependent factors near this level. Habitat management uses grazing control, water management, and vegetation management; heterogeneity and connectivity support diversity. Sustainable yield/MSY guides harvest quotas, closed seasons, and licensing to prevent population depletion.
13. Biological gardens (zoos, botanical gardens) support ex-situ breeding, genetic conservation, research, and education; Nigerian examples include University of Ibadan Zoological Garden. Fire

is a natural savanna process; prescribed burning (especially early dry-season) reduces fuel load, stimulates grass growth, and controls woody encroachment, but carries risks of uncontrolled spread requiring careful planning and firebreaks.

Answers to Pilot Questions [Series 1]

Part 1.1

1. Wildlife management is the application of ecological knowledge to manipulate wildlife populations and habitats for defined objectives; objectives include biodiversity conservation and sustainable use (or pest control, ecosystem restoration).
2. Adaptive management is an iterative approach in which management actions are treated as experiments, monitored, and adjusted based on outcomes over time.
3. Carrying capacity is the maximum population size a given habitat can sustainably support given available food, water, shelter, and space.
4. In-situ conservation protects species within their natural habitat; ex-situ conservation protects species outside their natural habitat, such as in zoos or seed banks.
5. A keystone species is one whose ecological impact is disproportionately large relative to its abundance; its loss can cause cascading changes throughout the ecosystem it once structured.

Part 1.2

1. Carrying capacity is the maximum sustainable population size for a habitat; populations exceeding it typically decline due to resource limitation, disease, or starvation.
2. Density-dependent factors intensify in effect as population density rises (food competition, disease); density-independent factors (severe weather, fire) affect population size regardless of density.
3. Controlled grazing/mowing, water management, and vegetation management (or fire).
4. Habitat connectivity is the degree to which a landscape facilitates movement between habitat patches; it matters because it allows gene flow, recolonisation, and access to resources across fragmented landscapes.
5. MSY is the harvest level that can be sustained indefinitely while producing the greatest yield; tools include quotas and closed seasons (or size/sex restrictions, licensing).

Part 1.3

1. A biological garden is an institution maintaining living animal or plant collections outside their natural habitat; types include zoos and botanical gardens.
2. Ex-situ breeding programmes, genetic resource conservation, and public education (or research).
3. A seed bank stores seeds long-term under controlled conditions, preserving plant genetic diversity that might otherwise be lost from declining wild populations.
4. University of Ibadan Zoological Garden and the National Zoological Garden, Jos.
5. The California condor (or Arabian oryx, black-footed ferret), recovered through zoo-based captive breeding and reintroduction.

Part 1.4

1. Fire removes woody encroachment and dead biomass, recycles nutrients into the soil, stimulates fresh nutritious grass growth, and maintains the open habitat structure preferred by many savanna species.
2. Savanna habitats undergo woody plant encroachment, gradually converting open grassland into denser bushland or woodland, with grassland specialist wildlife declining as bushland species increase.
3. Prescribed burning is the deliberate, planned application of fire under controlled conditions; early dry-season burning is favoured because fuel moisture is still relatively high, producing lower-intensity, patchy burns rather than destructive intense fires.
4. Reducing fuel loads, stimulating nutritious grass growth, and controlling woody encroachment (or creating firebreaks).
5. Uncontrolled fire spread (precaution: firebreaks and weather monitoring), wildlife mortality (precaution: appropriate timing and burn intensity), smoke/air quality impact (precaution: planning burns to avoid sensitive periods or areas).

References and Attribution

Textual References (Books and External Sources)

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- Bothma, J. du P., & Van Rooyen, N. (2005). Intensive wildlife production in Southern Africa. Van Schaik Publishers.
- National Open University of Nigeria (NOUN). (2023). Wildlife conservation and management course material. NOUN Press.

Figures, Plates, Tables, and Boxes

- Figure 1.1: Wildlife management foundations and ecosystem concepts Attribution: AI generated. Suggested OER search string: "wildlife management ecosystem management adaptive management ecosystem services carrying capacity biodiversity diagram OER".
- Figure 1.2: Population management principles Attribution: AI generated. Suggested OER search string: "carrying capacity logistic growth maximum sustainable yield habitat management corridor heterogeneity wildlife diagram OER".
- Figure 1.3: Biological gardens and ex-situ conservation Attribution: AI generated. Suggested OER search string: "biological gardens zoo ex-situ conservation Nigeria University Ibadan zoological garden seed bank captive breeding OER".
- Figure 1.4: Fire as a wildlife management tool Attribution: AI generated. Suggested OER search string: "fire ecology savanna prescribed burning wildlife management firebreaks fuel load woody encroachment diagram OER".

Course code: BIO 403

Course title: Wildlife Conservation and Management

Course credit load: 2 Units

Series 2: Wildlife Diseases

- **Part 2.1: Principles of Wildlife Disease**
    - Sub Part 2.1.1: Disease ecology in wildlife populations
    - Sub Part 2.1.2: Modes of disease transmission
    - Sub Part 2.1.3: Factors influencing disease emergence and spread
- **Part 2.2: Major Wildlife Diseases**
    - Sub Part 2.2.1: Viral diseases of wildlife
    - Sub Part 2.2.2: Bacterial and parasitic diseases of wildlife
    - Sub Part 2.2.3: Wildlife diseases of particular concern in Nigeria and Africa
- **Part 2.3: Zoonotic Diseases and the Wildlife-Human-Livestock Interface**
    - Sub Part 2.3.1: Zoonotic disease transmission
    - Sub Part 2.3.2: Wildlife-livestock disease interactions
    - Sub Part 2.3.3: The One Health approach
- **Part 2.4: Disease Surveillance and Management**
    - Sub Part 2.4.1: Disease surveillance and monitoring
    - Sub Part 2.4.2: Disease management strategies in wildlife populations
    - Sub Part 2.4.3: Disease considerations in translocation and reintroduction

Introduction

Disease is a natural component of wildlife population dynamics, but it can also pose serious threats to small or already-stressed populations, complicate conservation interventions, and create risks for human health and livestock production where wildlife, domestic animals, and people interact closely. Understanding the ecology of wildlife disease and the principles of disease surveillance and management is therefore essential for effective wildlife conservation and management practice.

This Series covers the ecological principles underlying wildlife disease transmission and emergence; the major viral, bacterial, and parasitic diseases affecting wildlife, with particular attention to diseases of concern in Nigeria and Africa; the zoonotic diseases that can pass between wildlife, livestock, and humans, and the One Health approach to managing this interface; and the practical tools of disease surveillance, management, and the disease considerations that must be addressed during wildlife translocation and reintroduction programmes.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 2.1** explain the principles of wildlife disease ecology, transmission modes, and factors influencing disease emergence,
- **SLO 2.2** describe major viral, bacterial, and parasitic wildlife diseases, including those of concern in Nigeria and Africa,
- **SLO 2.3** explain zoonotic disease transmission, wildlife-livestock interactions, and the One Health approach, and
- **SLO 2.4** describe disease surveillance and management strategies, including considerations for translocation and reintroduction.

2.1 Principles of Wildlife Disease

2.1.1 Disease ecology in wildlife populations

Wildlife disease ecology examines the interactions between pathogens, host wildlife populations, and the environment that determine whether and how disease spreads and persists in a population; the disease triangle (a classic conceptual model) identifies three interacting factors necessary for disease to occur: a susceptible host (an individual capable of being infected), a pathogen (the disease-causing organism, including viruses, bacteria, fungi, protozoa, and helminths), and an environment conducive to transmission (including factors such as population density, climate, and habitat condition).

The basic reproduction number (R0) is a key epidemiological concept representing the average number of new infections produced by a single infected individual in a fully susceptible population; if R0 is greater than 1, a disease outbreak will tend to spread through the population, while if R0 is less than 1, the outbreak will tend to die out; understanding R0 and the host density threshold below which a disease cannot persist (the threshold host density) helps wildlife managers predict and respond to disease outbreaks in populations of differing density and structure.

Fill in the blank: The disease triangle identifies three interacting factors necessary for disease to occur: a susceptible host, a pathogen, and an environment conducive to _____ .

2.1.2 Modes of disease transmission

Wildlife pathogens are transmitted through several major routes: direct transmission (requiring physical contact between infected and susceptible individuals, such as through mating, fighting, grooming, or mother-to-offspring contact); indirect transmission (via a contaminated environment, such as shared water sources, soil, or vegetation contaminated with pathogen-laden faeces, urine, or secretions, which a susceptible individual subsequently contacts); and vector-borne transmission (in which an intermediate organism, typically a blood-feeding arthropod such as a tick, mosquito, or tsetse fly, transmits the pathogen between hosts).

Airborne transmission (via aerosolised respiratory droplets, important for many respiratory pathogens in densely aggregated wildlife such as colonial seabirds or communally roosting bats) and vertical transmission (from mother to offspring, either in utero, during birth, or through milk) are additional important transmission routes for specific pathogens; understanding the dominant transmission route for a given pathogen is essential for designing effective disease control measures, since strategies effective against directly transmitted diseases (such as reducing contact rates) may be ineffective against vector-borne or environmentally persistent pathogens.

Fill in the blank: _____ transmission occurs when a blood-feeding arthropod such as a tick or mosquito transmits a pathogen between wildlife hosts.

2.1.3 Factors influencing disease emergence and spread

Several factors increase the risk of wildlife disease emergence and spread: high host population density (increasing contact rates and facilitating transmission, particularly for directly transmitted pathogens); habitat fragmentation and degradation (causing stress, nutritional deficiency, and aggregation of wildlife in remaining suitable habitat, all of which can increase susceptibility to and transmission of disease); climate change (altering the geographic range and seasonal activity of disease vectors such as ticks and mosquitoes, potentially introducing diseases to previously unaffected regions or populations); and increased contact between wildlife, livestock, and humans at expanding agricultural and settlement frontiers.

Emerging infectious diseases (newly recognised diseases or diseases increasing in incidence, geographic range, or host range) are of particular concern in wildlife conservation because naive populations (those with no prior exposure and therefore no acquired immunity) can experience catastrophic mortality when a novel pathogen is introduced; the introduction of novel pathogens through wildlife trade, translocation of infected animals, or contact with domestic animals carrying pathogens to which wildlife have no evolved resistance, represents a recurring and serious threat to wildlife populations worldwide, including in Nigeria.

Fill in the blank: _____ populations, those with no prior exposure and therefore no acquired immunity to a pathogen, can experience catastrophic mortality when a novel disease is introduced.

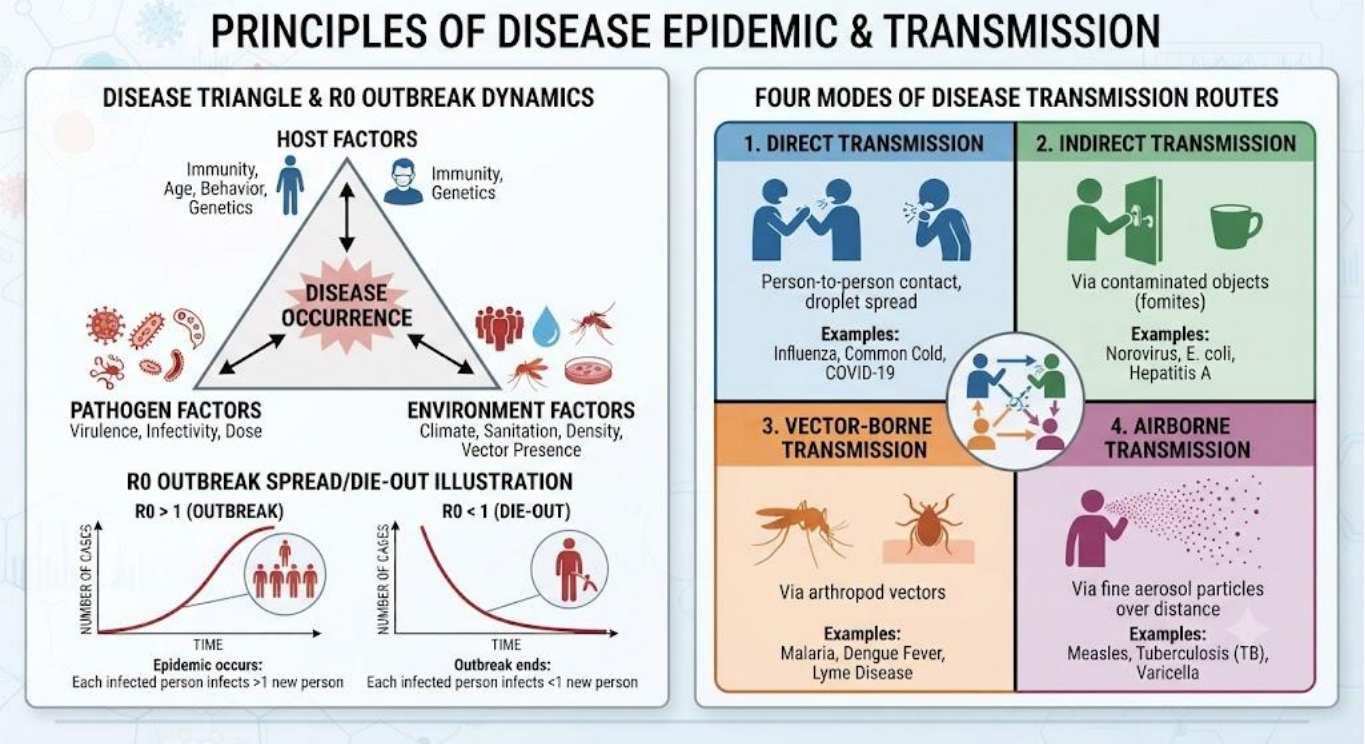

Figure 2.1: Wildlife disease ecology and transmission

Pilot questions 2.1

1. Describe the three factors of the disease triangle.
2. Explain what the basic reproduction number (R0) represents and its significance.
3. Distinguish between direct and indirect disease transmission.
4. Explain what vector-borne transmission is and give one example vector.
5. Name two factors that increase the risk of wildlife disease emergence.

2.2 Major Wildlife Diseases

2.2.1 Viral diseases of wildlife

Rabies (caused by a lyssavirus, transmitted primarily through the bite of an infected mammal) affects a wide range of wild and domestic mammals and is invariably fatal once clinical signs appear, making it one of the most significant wildlife and public health diseases globally; in Africa, wild canids (jackals, wild dogs) and bats serve as important reservoir hosts, and rabies control in wildlife populations typically focuses on oral vaccination campaigns and management of the domestic dog population, which is the primary source of human rabies exposure in most of Africa including Nigeria.

Avian influenza (caused by influenza A viruses, with wild waterfowl serving as natural reservoir hosts for low-pathogenicity strains) can cause severe outbreaks in domestic poultry and, in highly pathogenic forms such as H5N1, can also cause significant wild bird mortality and pose a zoonotic risk; foot-and-mouth disease (a highly contagious viral disease of cloven-hoofed animals, with African buffalo serving as an important wildlife reservoir in parts of Africa) creates ongoing management challenges at the interface between wildlife conservation areas and livestock farming, requiring buffer zones and fencing in some contexts to prevent transmission to cattle.

Fill in the blank: _____ is caused by a lyssavirus transmitted through the bite of an infected mammal and is invariably fatal once clinical signs appear, making it a critical wildlife and public health concern.

2.2.2 Bacterial and parasitic diseases of wildlife

Anthrax (caused by the spore-forming bacterium Bacillus anthracis, with spores persisting in soil for decades and causing periodic outbreaks particularly in herbivores during dry seasons when animals congregate at limited water and grazing resources) is a significant cause of wildlife mortality in some African savanna ecosystems and poses a serious zoonotic risk to people who handle or consume carcasses; bovine tuberculosis (caused by Mycobacterium bovis, affecting a wide range of wildlife and livestock species, with African buffalo serving as an important

wildlife reservoir) is a chronic, debilitating disease with significant implications for both wildlife conservation and livestock health.

Trypanosomiasis (caused by Trypanosoma protozoan parasites transmitted by tsetse flies, affecting both wildlife and livestock, with many African wild ungulates showing greater tolerance to infection than introduced cattle breeds) has historically shaped land use patterns across much of sub-Saharan Africa, since tsetse-infested areas have remained relatively free of cattle farming, inadvertently preserving wildlife habitat in some regions; gastrointestinal helminths (parasitic worms) and external parasites (ticks, mites, lice) are nearly universal in wild populations and typically cause subclinical effects, though heavy burdens can significantly affect body condition, reproduction, and survival, particularly in stressed or malnourished animals.

Fill in the blank: _____ , caused by spore-forming Bacillus bacteria persisting in soil for decades, causes periodic wildlife mortality outbreaks, particularly in herbivores during dry seasons.

2.2.3 Wildlife diseases of particular concern in Nigeria and Africa

African swine fever (a highly contagious and often fatal viral disease of domestic pigs and wild suid species, with warthogs and bushpigs able to harbour the virus with minimal clinical signs, serving as a wildlife reservoir maintained by argasid soft ticks) poses ongoing challenges for both wildlife management and the domestic pig farming industry in Nigeria and across Africa, with periodic outbreaks causing significant economic losses; Ebola virus disease (a highly lethal viral haemorrhagic fever with bats considered the likely natural reservoir, and great apes and other wildlife serving as amplifying hosts during outbreaks) has caused significant wildlife mortality in Central African great ape populations and represents an important example of a wildlife disease with severe human zoonotic spillover potential.

Newcastle disease (a highly contagious viral disease affecting domestic poultry and wild birds) and avian cholera (a bacterial disease causing periodic mass mortality events in wild waterbirds) are of ongoing concern for both wildlife populations and the substantial poultry farming sector in Nigeria; monitoring and managing these diseases requires coordination between wildlife agencies, veterinary services, and agricultural authorities, reflecting the broader principle that

effective wildlife disease management in Nigeria depends on strong institutional collaboration across sectors that have traditionally operated separately.

Fill in the blank: _____ are able to harbour the African swine fever virus with minimal clinical signs, serving as a wildlife reservoir maintained by argasid soft ticks in many parts of Africa.

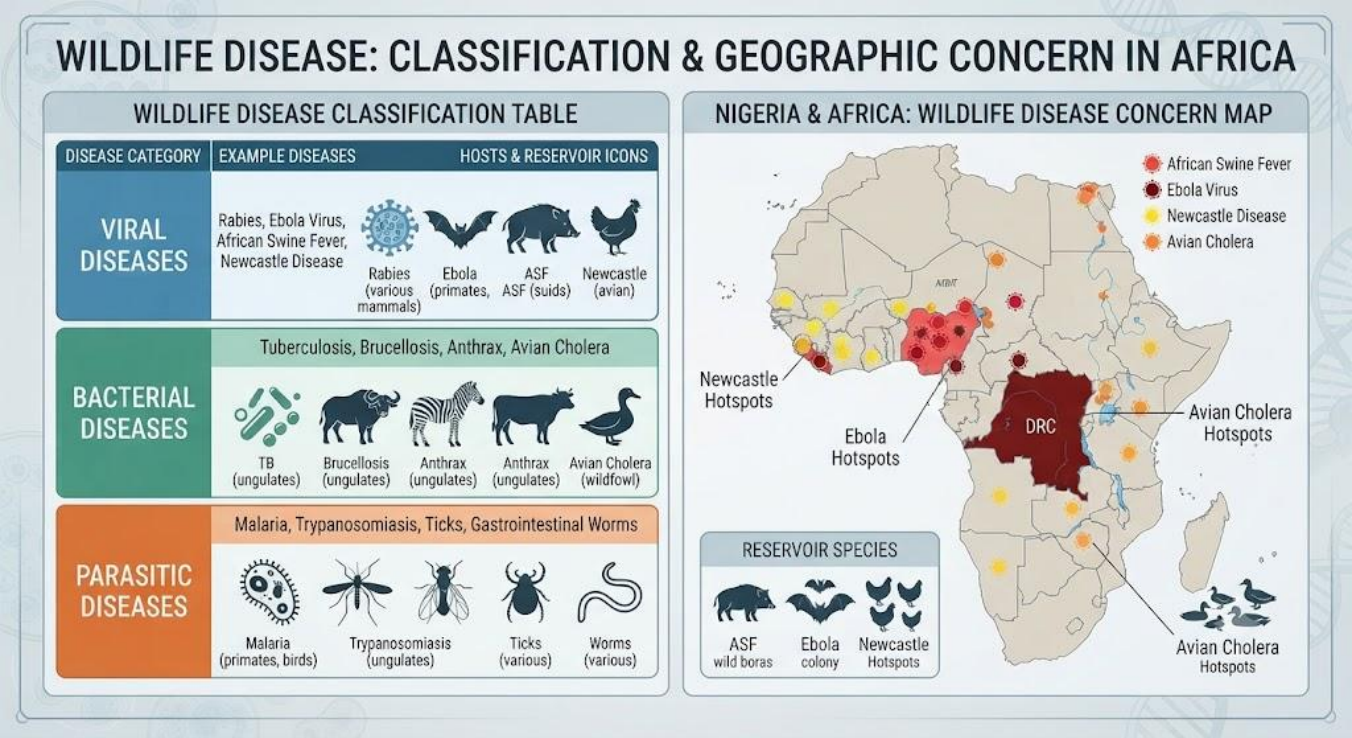

Figure 2.2: Major wildlife diseases

Pilot questions 2.2

1. Describe rabies and explain why it is significant for both wildlife and public health.
2. Explain the role of African buffalo as a wildlife reservoir for foot-and-mouth disease and bovine tuberculosis.
3. Describe anthrax and explain why outbreaks often occur during the dry season.
4. Explain how trypanosomiasis has historically influenced land use patterns in sub-Saharan Africa.
5. Name two wildlife diseases of particular concern in Nigeria and state their reservoir hosts.

2.3 Zoonotic Diseases and the Wildlife-Human-Livestock Interface

2.3.1 Zoonotic disease transmission

A zoonotic disease (zoonosis) is one that can be transmitted between animals and humans, either directly (through contact with infected animals, their tissues, or bodily fluids) or indirectly (through vectors, contaminated food or water, or environmental exposure); the majority of emerging infectious diseases affecting humans, including HIV/AIDS, Ebola virus disease, SARS, and most recently COVID-19, have wildlife origins, reflecting the close evolutionary relationship between humans and other animals and the increasing frequency of human contact with wildlife reservoirs.

Spillover events (the transmission of a pathogen from its natural wildlife reservoir to a new host species, including humans) are influenced by the frequency and intensity of contact between humans and wildlife reservoirs, which has increased substantially due to deforestation, agricultural expansion into wildlife habitat, bushmeat hunting and trade, and the wildlife pet trade; understanding the specific behaviours and contexts that increase spillover risk (such as the hunting and butchering of wildlife, or close contact with bat roosts) allows targeted public health interventions to reduce zoonotic disease emergence at its source.

Fill in the blank: A _____ event is the transmission of a pathogen from its natural wildlife reservoir to a new host species, including humans, and is influenced by the frequency of human-wildlife contact.

2.3.2 Wildlife-livestock disease interactions

Disease transmission at the wildlife-livestock interface operates in both directions: wildlife can transmit pathogens to livestock (as with foot-and-mouth disease from African buffalo, or trypanosomiasis from wild ungulates via tsetse flies to cattle), causing significant economic losses to farmers and creating conflict between conservation interests and agricultural communities; conversely, livestock can transmit pathogens to wildlife (as with rinderpest, historically devastating to African wild ungulate populations following its introduction with

imported cattle in the late nineteenth century, and more recent concerns about disease spillover from domestic dogs to wild canids such as African wild dogs and Ethiopian wolves).

Managing the wildlife-livestock disease interface requires a combination of approaches: physical separation (fencing protected areas to limit wildlife-livestock contact, though this can disrupt wildlife migration and gene flow), vaccination of livestock and, where feasible, wildlife against shared pathogens, buffer zones with reduced livestock density around protected areas, and surveillance systems that monitor disease status in both wildlife and livestock populations to detect emerging problems early; the appropriate balance of these approaches depends on the specific disease, ecosystem, and socioeconomic context.

Fill in the blank: _____ , historically devastating to African wild ungulate populations following its introduction with imported cattle in the late nineteenth century, illustrates how livestock can transmit pathogens to wildlife.

2.3.3 The One Health approach

The One Health approach is a collaborative, multi-sectoral framework that recognises the interconnection between human health, animal health (both wildlife and domestic), and environmental health, and promotes coordinated action across these traditionally separate sectors to address health challenges, including zoonotic and wildlife disease; One Health initiatives bring together veterinarians, physicians, ecologists, wildlife biologists, and public health professionals to share surveillance data, conduct joint outbreak investigations, and develop integrated disease prevention and response strategies.

In Nigeria and across Africa, One Health approaches are increasingly applied to address challenges including zoonotic disease surveillance at wildlife markets and bushmeat trade points, joint human-animal vaccination campaigns (such as integrated rabies control combining domestic dog vaccination with public health education), and early warning systems that monitor wildlife disease events as potential indicators of broader public health risk; strengthening One Health institutional capacity, including laboratory diagnostic infrastructure and cross-sectoral coordination mechanisms, remains an important priority for both wildlife conservation and public health in the region.

Fill in the blank: The One Health approach is a collaborative framework recognising the interconnection between human health, animal health, and _____ health, promoting coordinated cross-sectoral action.

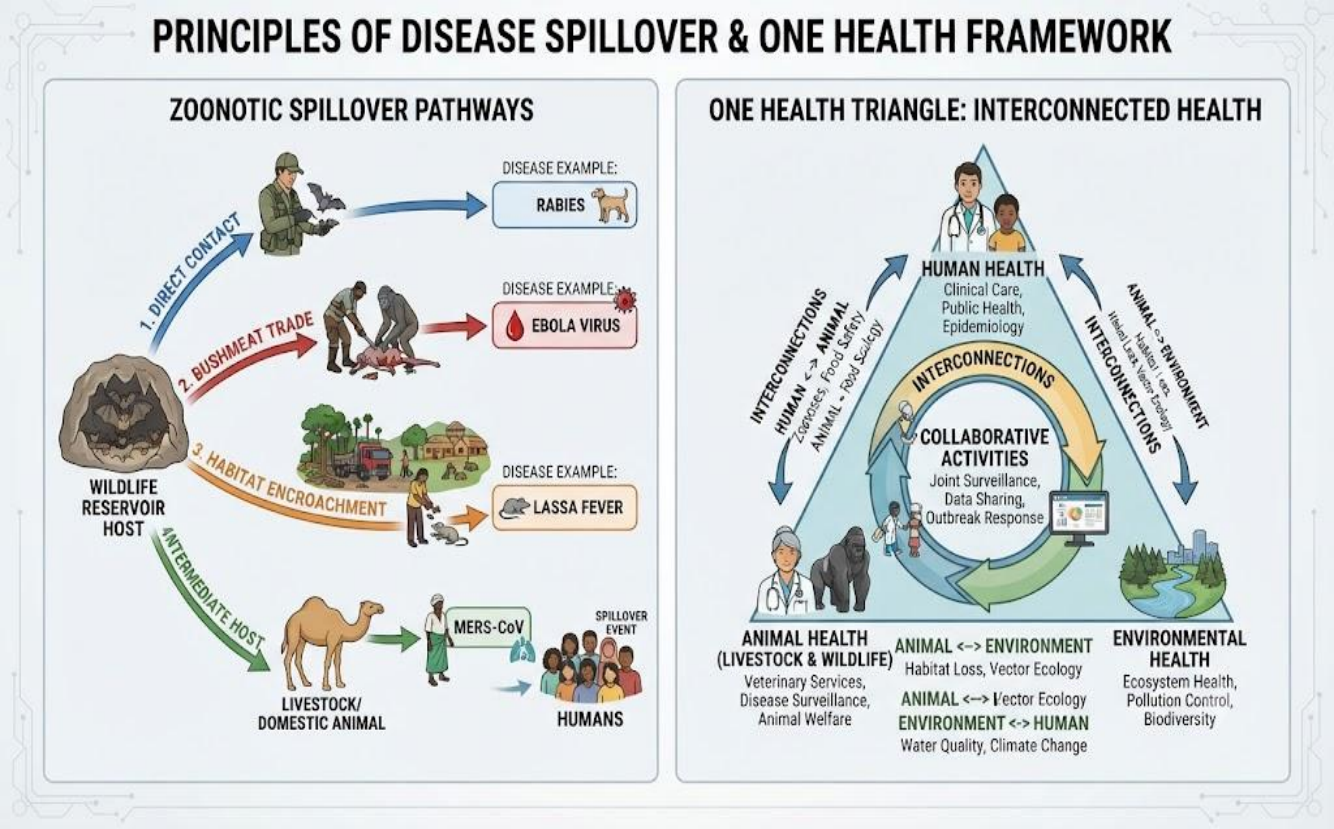

Figure 2.3: Zoonotic disease and the One Health interface

Pilot questions 2.3

1. Define zoonotic disease and give two examples with wildlife origins.
2. Explain what a spillover event is and name two factors that increase spillover risk.
3. Give one example each of wildlife-to-livestock and livestock-to-wildlife disease transmission.
4. Name three approaches used to manage the wildlife-livestock disease interface.
5. Define the One Health approach and explain why it is important for wildlife disease management.

2.4 Disease Surveillance and Management

2.4.1 Disease surveillance and monitoring

Wildlife disease surveillance is the systematic, ongoing collection and analysis of data on disease occurrence in wildlife populations to detect outbreaks early, monitor disease trends, and inform management responses; surveillance approaches include passive surveillance (relying on opportunistic reports of sick or dead animals from rangers, researchers, or the public) and active surveillance (systematic sampling of apparently healthy animals to detect subclinical infection, disease prevalence, or pathogen presence, often through capture and blood or tissue sampling, or through non-invasive sampling of faeces or environmental material).

Sentinel species (species particularly sensitive to certain pathogens, whose disease status can provide an early warning of broader ecosystem health problems) and mortality event investigation (the systematic post-mortem examination and laboratory testing of wildlife found dead, to determine cause of death and detect emerging disease threats) are important surveillance tools; effective surveillance requires standardised data recording, laboratory diagnostic capacity, and rapid reporting mechanisms that allow wildlife and public health authorities to respond quickly when unusual mortality patterns or new pathogens are detected.

Fill in the blank: _____ surveillance relies on opportunistic reports of sick or dead wildlife from rangers, researchers, or the public, while active surveillance systematically samples apparently healthy animals.

2.4.2 Disease management strategies in wildlife populations

Direct disease management interventions in wildlife populations include vaccination campaigns (used for diseases such as rabies in wildlife reservoirs, often delivered through oral bait vaccines distributed across the landscape rather than individual injection, which is impractical for free-ranging wildlife), selective culling or removal of infected individuals (used cautiously due to potential negative impacts on population structure and the difficulty of reliably identifying infected individuals before clinical signs appear), and habitat or population management to reduce stress and density-dependent disease transmission risk.

Indirect management approaches focus on reducing the underlying risk factors for disease emergence and spread: maintaining habitat quality and connectivity to reduce stress and crowding, managing the interface with domestic animals to reduce cross-species transmission opportunities, and quarantine protocols for any animals being moved between locations; given the practical and ethical challenges of directly treating wild animals at a population scale, prevention through risk factor management and early detection through surveillance are generally more cost-effective and sustainable than reactive treatment of established outbreaks.

Fill in the blank: Oral bait vaccines are often used for diseases such as rabies in wildlife reservoirs because they can be distributed across the landscape, unlike individual injection which is impractical for _____ -ranging wildlife.

2.4.3 Disease considerations in translocation and reintroduction

Wildlife translocation (moving animals from one location to another for conservation, management, or research purposes) and reintroduction (releasing captive-bred or translocated animals into habitat from which the species has been extirpated) carry significant disease risks that must be carefully managed: animals being moved may carry pathogens to which the recipient population has no immunity, potentially introducing novel disease into a previously unexposed population, or conversely may lack immunity to pathogens already present at the release site, making them vulnerable to disease upon arrival.

Standard disease risk management protocols for translocation and reintroduction include comprehensive pre-movement health screening (testing for the major pathogens of concern for the species and region), quarantine periods (isolating animals before movement to confirm health status and allow treatment of any detected infections), post-release monitoring (tracking the health status of released animals and their interactions with existing wildlife), and disease risk assessment conducted by veterinary and wildlife health specialists as an integral part of translocation planning, rather than an afterthought; failure to adequately manage disease risk has caused the failure of numerous historical reintroduction programmes worldwide.

Fill in the blank: _____ periods, isolating animals before movement to confirm health status, are a standard disease risk management protocol applied before wildlife translocation or reintroduction.

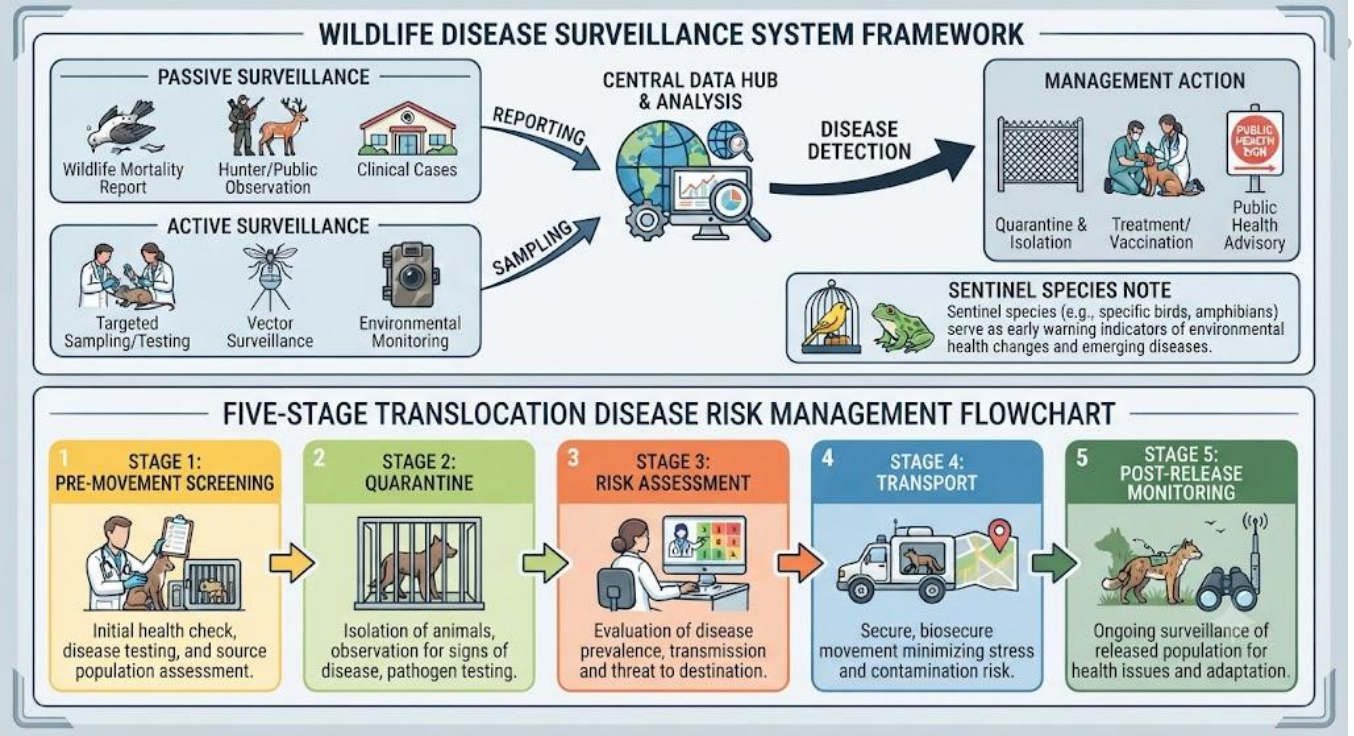

Figure 2.4: Disease surveillance and translocation risk management

Pilot questions 2.4

1. Distinguish between passive and active disease surveillance.
2. Explain what a sentinel species is and its value in disease surveillance.
3. Name two direct disease management interventions in wildlife populations.
4. Explain why oral bait vaccines are preferred over injection for managing rabies in wildlife.
5. Name four components of a disease risk management protocol for wildlife translocation.

Series Summary

This Series examined the ecology and management of disease in wildlife populations. The disease triangle of host, pathogen, and environment, together with transmission routes including direct, indirect, vector-borne, and airborne pathways, explains how and why diseases spread through wildlife communities. Major diseases such as rabies, anthrax, foot-and-mouth disease, trypanosomiasis, African swine fever, and Ebola virus disease each illustrate distinct transmission dynamics and reservoir relationships relevant to Nigeria and the wider African context.

Zoonotic spillover, the wildlife-livestock disease interface, and the One Health framework demonstrate that wildlife disease cannot be managed in isolation from human and livestock health, particularly given the wildlife origins of many emerging infectious diseases. Disease surveillance, combining passive and active approaches, sentinel species, and mortality investigation, underpins effective management, while comprehensive pre-movement screening, quarantine, and post-release monitoring are essential safeguards in translocation and reintroduction programmes that aim to support, rather than undermine, wildlife population recovery.

Glossary of Terms

- **Basic reproduction number (R0):** the average number of new infections produced by a single infected individual in a fully susceptible population, determining whether a disease will spread or decline.
- **Disease triangle:** the conceptual model identifying a susceptible host, a pathogen, and a conducive environment as the three factors necessary for disease to occur.
- **Emerging infectious disease:** a newly recognised disease, or a disease increasing in incidence, geographic range, or host range.
- **One Health:** a collaborative, multi-sectoral framework recognising the interconnection between human, animal, and environmental health.

- **Reservoir host:** a species that maintains a pathogen in nature and can transmit it to other species without necessarily showing severe disease itself.
- **Spillover event:** the transmission of a pathogen from its natural wildlife reservoir to a new host species, including humans.
- **Translocation:** the deliberate movement of wild animals from one location to another for conservation, management, or research purposes.
- **Vector-borne transmission:** disease transmission via an intermediate organism, typically a blood-feeding arthropod, that carries the pathogen between hosts.
- **Zoonotic disease (zoonosis):** a disease that can be transmitted between animals and humans, directly or indirectly.

Concept Check Questions [Series 2]

Objective Questions

1. The disease triangle identifies host, pathogen, and an environment conducive to _____ as necessary for disease to occur. (Linked to SLO 2.1)
2. _____ is invariably fatal once clinical signs appear and is transmitted through the bite of an infected mammal. (Linked to SLO 2.2)
3. A _____ event is the transmission of a pathogen from its natural wildlife reservoir to a new host species, including humans. (Linked to SLO 2.3)
4. The One Health approach recognises the interconnection between human, animal, and _____ health. (Linked to SLO 2.3)
5. _____ surveillance relies on opportunistic reports of sick or dead wildlife rather than systematic sampling. (Linked to SLO 2.4)

Short-Answer Questions

1. Describe the three factors of the disease triangle. (Linked to SLO 2.1)
2. Name two diseases of concern in Nigeria/Africa and their reservoir hosts. (Linked to SLO 2.2)
3. Explain what a spillover event is and name one factor that increases its risk. (Linked to SLO 2.3)
4. Distinguish between passive and active disease surveillance. (Linked to SLO 2.4)
5. Name four components of a disease risk management protocol for translocation. (Linked to SLO 2.4)

Long-Answer Questions

1. Explain the principles of wildlife disease ecology and transmission, and describe major wildlife diseases. (Linked to SLOs 2.1, 2.2)
2. Explain zoonotic disease transmission, the One Health approach, and disease surveillance and management strategies in wildlife. (Linked to SLOs 2.3, 2.4)

Answers to Concept Check Questions [Series 2]

Objective Questions

1. Transmission.
2. Rabies.
3. Spillover.
4. Environmental.
5. Passive.

Short-Answer Questions

1. A susceptible host capable of being infected, a pathogen capable of causing disease, and an environment conducive to transmission between them.
2. African swine fever (warthogs/bushpigs reservoir) and Ebola virus disease (bats considered the likely reservoir).
3. A spillover event is the transmission of a pathogen from its natural wildlife reservoir to a new host species, including humans; increased human-wildlife contact through deforestation or bushmeat hunting increases spillover risk.
4. Passive surveillance relies on opportunistic reports of sick or dead animals; active surveillance systematically samples apparently healthy animals to detect subclinical infection.
5. Pre-movement health screening, quarantine period, disease risk assessment, and post-release monitoring.

Long-Answer Questions

1. Disease ecology: disease triangle (host, pathogen, environment); R0 determines outbreak spread. Transmission: direct, indirect, vector-borne, airborne, vertical. Major diseases: rabies (lyssavirus, fatal), avian influenza (waterfowl reservoir), foot-and-mouth disease (buffalo reservoir), anthrax (soil-persisting spores), trypanosomiasis (tsetse-borne), African swine fever (warthog reservoir), Ebola (bat reservoir).
2. Zoonotic diseases transmit between animals and humans; spillover risk increases with human-wildlife contact (bushmeat, habitat encroachment). Wildlife-livestock interface requires fencing, vaccination, buffer zones, surveillance. One Health integrates human, animal, environmental health sectors. Surveillance combines passive and active approaches

with sentinel species; management uses vaccination, risk reduction, and careful translocation protocols (screening, quarantine, monitoring).

Answers to Pilot Questions [Series 2]

Part 2.1

1. A susceptible host (capable of infection), a pathogen (disease-causing organism), and an environment conducive to transmission between them.
2. R0 is the average number of new infections produced by one infected individual in a fully susceptible population; if R0 is greater than 1 the disease spreads, if less than 1 it dies out.
3. Direct transmission requires physical contact between infected and susceptible individuals; indirect transmission occurs via a contaminated environment that a susceptible individual subsequently contacts.
4. Vector-borne transmission occurs when a blood-feeding arthropod transmits a pathogen between hosts; example vectors include ticks, mosquitoes, and tsetse flies.
5. High host population density and habitat fragmentation/degradation (or climate change, increased wildlife-livestock-human contact).

Part 2.2

1. Rabies is caused by a lyssavirus transmitted through the bite of an infected mammal; it is significant because it is invariably fatal once clinical signs appear in both wildlife and humans.
2. African buffalo can carry foot-and-mouth disease virus and Mycobacterium bovis (bovine tuberculosis) with limited clinical impact, serving as a wildlife reservoir that can transmit these pathogens to cattle at the wildlife-livestock interface.
3. Anthrax is caused by spore-forming Bacillus anthracis bacteria; outbreaks often occur in the dry season because animals congregate at limited water and grazing resources, increasing exposure to soil-borne spores.
4. Tsetse-infested areas have remained relatively free of cattle farming because trypanosomiasis is highly lethal to introduced cattle breeds, inadvertently preserving wildlife habitat in those regions.

5. African swine fever (warthog/bushpig reservoir) and Ebola virus disease (bat reservoir).

Part 2.3

1. A zoonotic disease is one transmissible between animals and humans; examples with wildlife origins include HIV/AIDS and Ebola virus disease.
2. A spillover event is the transmission of a pathogen from its wildlife reservoir to a new host species; deforestation and bushmeat hunting/trade increase spillover risk.
3. Wildlife-to-livestock: foot-and-mouth disease from African buffalo to cattle. Livestock-to-wildlife: rinderpest from imported cattle to African wild ungulates.
4. Physical separation/fencing, vaccination, and buffer zones (or surveillance systems).
5. One Health is a collaborative framework recognising interconnection between human, animal, and environmental health; it is important because most emerging infectious diseases have wildlife origins, requiring cross-sectoral collaboration to manage effectively.

Part 2.4

1. Passive surveillance relies on opportunistic reports of sick or dead animals; active surveillance systematically samples apparently healthy animals to detect subclinical infection or pathogen presence.
2. A sentinel species is particularly sensitive to certain pathogens; monitoring its disease status provides early warning of broader ecosystem health problems before they affect other species.
3. Vaccination campaigns and selective culling/removal of infected individuals.
4. Individual injection is impractical for free-ranging wildlife that cannot be easily captured repeatedly; oral bait vaccines can be distributed across the landscape and consumed voluntarily.
5. Pre-movement health screening, quarantine period, disease risk assessment, and post-release monitoring.

References and Attribution

Textual References (Books and External Sources)

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Figures, Plates, Tables, and Boxes

- Figure 2.1: Wildlife disease ecology and transmission Attribution: AI generated. Suggested OER search string: "wildlife disease ecology transmission disease triangle R0 vector-borne zoonotic epidemiology diagram OER".
- Figure 2.2: Major wildlife diseases Attribution: AI generated. Suggested OER search string: "wildlife disease rabies anthrax trypanosomiasis African swine fever Ebola Nigeria Africa reservoir host diagram OER".
- Figure 2.3: Zoonotic disease and the One Health interface Attribution: AI generated. Suggested OER search string: "zoonotic disease spillover One Health wildlife livestock human health interface Ebola bushmeat trade diagram OER".
- Figure 2.4: Disease surveillance and translocation risk management Attribution: AI generated. Suggested OER search string: "wildlife disease surveillance translocation reintroduction quarantine health screening disease management diagram OER".

Course code: BIO 403

Course title: Wildlife Conservation and Management

Course credit load: 2 Units

Series 3: Wildlife Resources: Problems and Prospects

- **Part 3.1: Wildlife Resources of the World and Nigeria**
  - Sub Part 3.1.1: Global wildlife resources and biodiversity
  - Sub Part 3.1.2: Wildlife resources of Nigeria
  - Sub Part 3.1.3: Economic and ecological value of wildlife
- **Part 3.2: Problems Facing Wildlife Resources**
  - Sub Part 3.2.1: Habitat loss and fragmentation
  - Sub Part 3.2.2: Overexploitation, bushmeat, and wildlife trade
  - Sub Part 3.2.3: Human-wildlife conflict
- **Part 3.3: Prospects for Wildlife Conservation**
  - Sub Part 3.3.1: Protected areas and their management
  - Sub Part 3.3.2: Community-based conservation
  - Sub Part 3.3.3: Wildlife-based tourism and conservation financing
- **Part 3.4: Conflicts Related to Wildlife Resources**
  - Sub Part 3.4.1: Types and causes of wildlife-related conflict
  - Sub Part 3.4.2: Human-wildlife conflict mitigation methods
  - Sub Part 3.4.3: Conflict resolution and stakeholder engagement

Introduction

Wildlife resources represent an irreplaceable component of global and national natural heritage, providing ecological services, economic livelihoods, cultural values, and scientific knowledge of enormous importance. Yet wildlife populations worldwide and in Nigeria face an escalating array of threats driven by human population growth, habitat conversion, overexploitation, and climate change. Understanding both the problems confronting wildlife resources and the conservation approaches available to address them is central to wildlife conservation and management.

This Series surveys the wildlife resources of the world and Nigeria and their value; the major problems of habitat loss, overexploitation, and human-wildlife conflict; the conservation prospects offered by protected areas, community-based conservation, and wildlife tourism; and the nature of conflicts over wildlife resources and the methods available for mitigation and resolution. Together these topics frame the applied conservation challenge that drives the policies and laws discussed in the following Series.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 3.1** describe the wildlife resources of the world and Nigeria and explain their economic and ecological value,
- **SLO 3.2** describe the major problems facing wildlife resources, including habitat loss, overexploitation, and human-wildlife conflict,
- **SLO 3.3** describe protected areas, community-based conservation, and wildlife tourism as conservation prospects, and
- **SLO 3.4** explain the types and causes of wildlife-related conflict and describe methods of mitigation and stakeholder engagement.

3.1 Wildlife Resources of the World and Nigeria

3.1.1 Global wildlife resources and biodiversity

The Earth supports an extraordinary diversity of wildlife, currently estimated at approximately 8 to 10 million species of animals, plants, fungi, and microorganisms, of which fewer than 2 million have been formally described and named; this biodiversity is distributed unevenly across the planet, with tropical regions, particularly tropical rainforests and coral reefs, supporting disproportionately high species richness and endemism; seventeen megadiverse countries (including Brazil, Indonesia, Colombia, Mexico, and several African nations) are estimated to harbour more than 70 percent of the world total species diversity on less than 10 percent of the Earth land area.

Global wildlife resources include not only charismatic large mammals and birds but also the vast diversity of invertebrates, reptiles, amphibians, freshwater and marine fish, plants, and microorganisms that together constitute functional ecosystems; estimates of global extinction rates suggest that species are currently disappearing at 100 to 1000 times the natural background rate, primarily driven by habitat destruction, overexploitation, invasive species, pollution, and climate change, in what many scientists describe as the sixth mass extinction event in Earth history.

Fill in the blank: The Earth is estimated to support approximately 8 to 10 million species, though fewer than _____ million have been formally described and named.

3.1.2 Wildlife resources of Nigeria

Nigeria is one of Africa most biologically diverse countries, reflecting its position at the junction of the West African forest zone, the Sudano-Sahelian savanna, and the coastal mangrove and freshwater wetland ecosystems; Nigeria wildlife includes approximately 899 bird species, 274 mammal species, 154 reptile species, 54 amphibian species, and thousands of invertebrate and plant species, many of which are endemic or near-endemic to the West African region; key wildlife-rich areas include the Cross River National Park (home to Cross River gorillas, forest

elephants, and chimpanzees), Yankari Game Reserve (famous for its elephant population and Wikki Warm Springs), and Gashaka-Gumti National Park (the largest national park in Nigeria).

Nigeria freshwater resources, including the Niger and Benue River systems, Niger Delta mangroves, and Lake Chad basin, support outstanding aquatic biodiversity including hundreds of fish species, many endemic to specific river systems; the Niger Delta is of global significance for its biodiversity and ecological productivity, though it has been severely impacted by oil pollution and habitat conversion; Nigeria was once home to large populations of elephants, lions, leopards, cheetahs, and African wild dogs, but many large mammal species have been dramatically reduced in range and abundance due to habitat loss and hunting pressure.

Fill in the blank: _____ National Park, the largest national park in Nigeria, is located in the northeast and supports exceptional wildlife diversity including Cross River gorillas and forest elephants.

3.1.3 Economic and ecological value of wildlife

Wildlife provides economic value through direct use (bushmeat and fish providing protein for millions of rural Nigerians and supporting commercial markets; wildlife-based tourism generating revenue from safari and ecotourism activities; sale of live animals and wildlife products for trade); indirect use (ecosystem services provided by wildlife and the habitats they sustain, including pollination of crops, seed dispersal, water purification, flood regulation, and carbon storage in forest ecosystems maintained by wildlife); and option and existence values (the value society places on knowing wildlife exists and on preserving the option to use or benefit from it in future).

The ecological value of wildlife extends beyond economic metrics: wildlife species fulfil functional roles in ecosystems as herbivores regulating vegetation structure, predators controlling prey populations, seed dispersers and pollinators linking plant communities, and decomposers recycling nutrients; the loss of key wildlife species can trigger trophic cascades that destabilise entire ecosystems, as illustrated by the collapse of vegetation structure in areas where large browsers and grazers have been eliminated; recognising both economic and intrinsic ecological

values is essential for making a compelling case for wildlife conservation in policy and development contexts.

Fill in the blank: The indirect economic value of wildlife includes _____ services such as pollination, seed dispersal, water purification, and carbon storage in forest ecosystems.

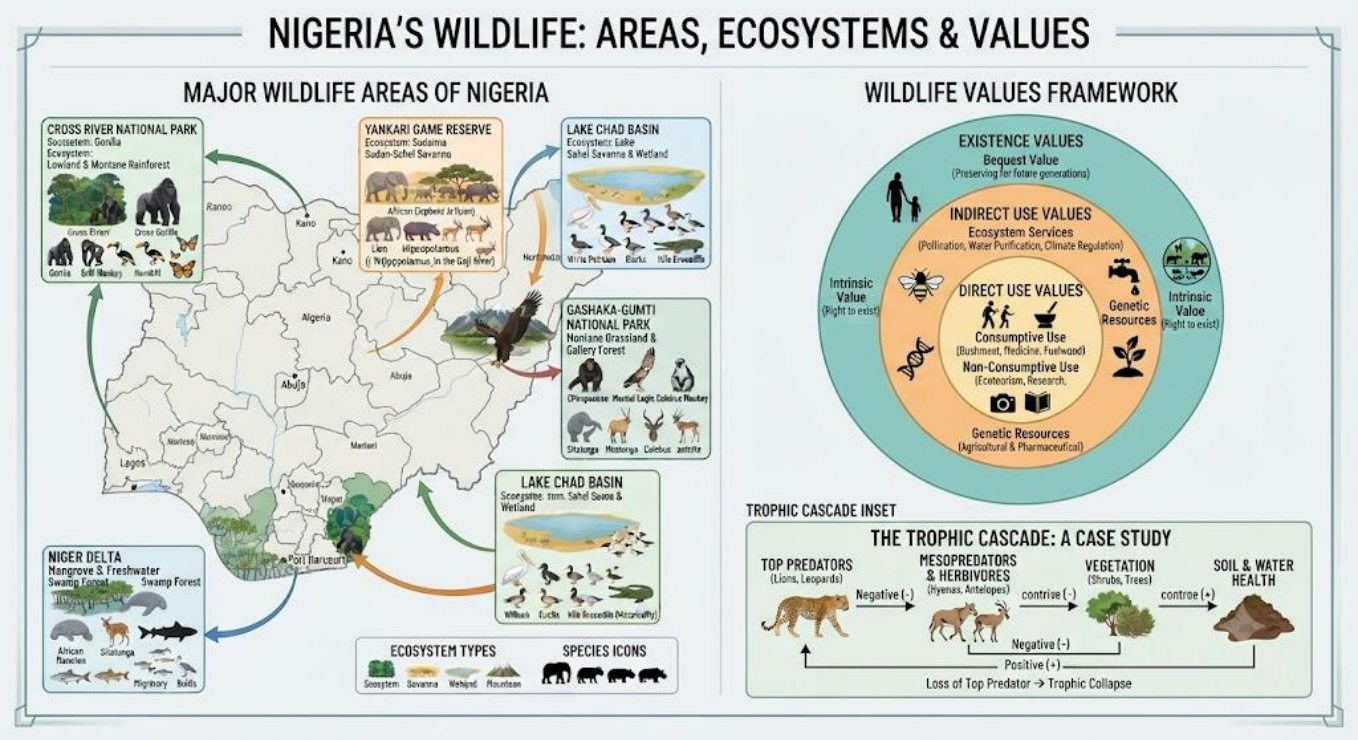

Figure 3.1: Wildlife resources of Nigeria and their value

Pilot questions 3.1

1. Name three major wildlife-rich areas in Nigeria and state one characteristic species for each.
2. State the approximate number of bird and mammal species found in Nigeria.
3. Distinguish between direct and indirect economic value of wildlife.
4. Explain what a trophic cascade is and give one example relevant to wildlife.
5. What is meant by the option and existence value of wildlife?

3.2 Problems Facing Wildlife Resources

3.2.1 Habitat loss and fragmentation

Habitat loss (the outright conversion of natural habitat to other land uses, primarily agriculture, urban development, and infrastructure) is widely recognised as the single most important driver of wildlife decline globally and in Nigeria; Nigeria has experienced among the highest rates of deforestation in Africa, with original forest cover reduced to less than 10 percent of its historical extent, driven by agricultural expansion (both smallholder subsistence farming and commercial plantations), logging, charcoal production, and urban and infrastructure development; this habitat loss has caused dramatic reductions in the ranges and population sizes of forest-dependent species.

Habitat fragmentation (the breaking apart of previously continuous habitat into smaller, isolated patches separated by unsuitable land) compounds the effects of habitat loss by reducing the size of individual patches below the minimum area required for viable populations of area-sensitive species, disrupting dispersal and gene flow between remaining populations, increasing edge effects (the disproportionate influence of the habitat boundary on conditions throughout the patch, particularly in small patches), and increasing the vulnerability of isolated populations to stochastic events such as disease outbreaks or drought.

Fill in the blank: Habitat _____ breaks previously continuous habitat into smaller, isolated patches, disrupting dispersal and gene flow and increasing vulnerability of populations to stochastic events.

3.2.2 Overexploitation, bushmeat, and wildlife trade

Overexploitation (the harvesting of wildlife at rates that exceed the population capacity to reproduce and replace harvested individuals) is the second major driver of wildlife decline, particularly for commercially valuable and large-bodied species with slow reproductive rates; bushmeat hunting (the hunting of wild animals for meat, both for subsistence consumption and for commercial sale in urban markets) is of particular significance in West and Central Africa, where it represents the primary protein source for millions of people and a major commercial

enterprise, placing intense pressure on forest wildlife including primates, ungulates, and large rodents.

The illegal international wildlife trade (encompassing live animals, skins, ivory, bushmeat, and other wildlife products) is estimated to be worth billions of dollars annually, representing one of the most lucrative forms of organised crime globally; key commodities traded from or through Nigeria and West Africa include elephant ivory, pangolin scales (pangolins are now the most heavily traded wild mammal globally), grey parrots, and various primate species; effective control requires international cooperation, improved law enforcement, demand reduction in consumer countries, and sustainable livelihood alternatives for communities dependent on wildlife resources.

Fill in the blank: _____ are now the most heavily traded wild mammal globally, with their scales trafficked from Africa through international wildlife trade networks despite full legal protection.

3.2.3 Human-wildlife conflict

Human-wildlife conflict (HWC) arises when wildlife causes damage to human livelihoods, property, or safety, or when human activities harm or kill wildlife in retaliation or through incidental impacts; common forms of HWC in Nigeria include crop raiding by elephants, primates (baboons and monkeys), and bush pigs; livestock predation by leopards, hyenas, and pythons; damage to fisheries by hippopotamuses, crocodiles, and otters; and occasionally direct threats to human safety from elephants, hippopotamuses, crocodiles, and venomous snakes.

HWC is intensifying across Nigeria and Africa as human populations expand into previously wildlife-dominated areas, as wildlife populations are compressed into smaller areas by habitat loss, and as natural prey or food sources for predators and crop raiders become scarcer; the socioeconomic impacts of HWC fall disproportionately on the poorest rural communities, who lose crops, livestock, or occasionally family members and receive little compensation, generating hostility toward wildlife and conservation efforts that severely undermines local support for protected area management.

Fill in the blank: Human-wildlife conflict is intensifying as human populations expand into wildlife areas and wildlife populations are compressed by _____ loss, reducing natural food sources for predators and crop raiders.

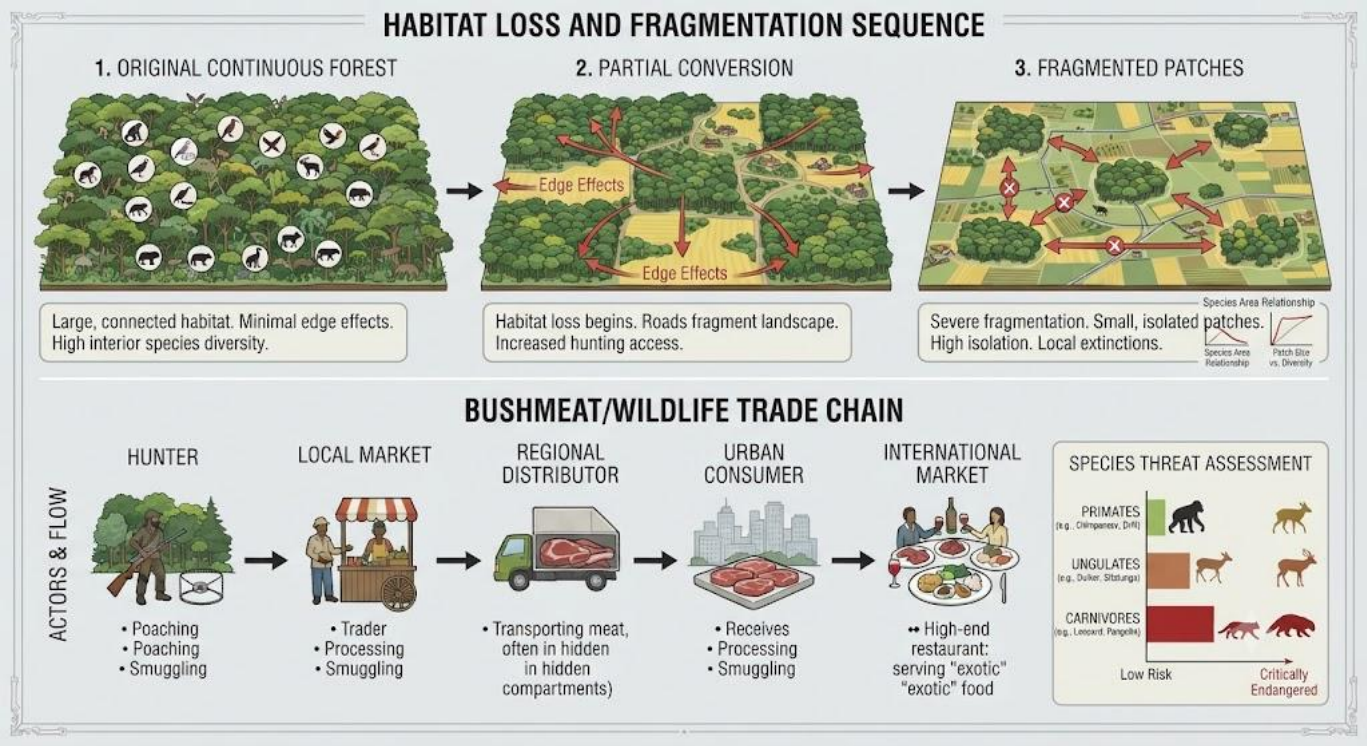

Figure 3.2: Problems facing wildlife resources

Pilot questions 3.2

1. Explain why habitat loss is considered the most important driver of wildlife decline.
2. Explain the concept of edge effects in fragmented habitats.
3. Define overexploitation and explain why large-bodied species with slow reproductive rates are especially vulnerable.
4. Name two wildlife species heavily traded illegally from or through Nigeria and explain the demand driving each.
5. Describe three forms of human-wildlife conflict common in Nigeria.

3.3 Prospects for Wildlife Conservation

3.3.1 Protected areas and their management

Protected areas (PAs) are geographically defined areas managed to achieve long-term nature conservation, and they remain the cornerstone of biodiversity conservation globally; Nigeria protected area network includes national parks (managed by the Nigerian National Parks Service), game reserves, strict nature reserves, and forest reserves managed by state governments and the Federal Department of Forestry; major national parks include Kainji Lake, Cross River, Chad Basin, Old Oyo, Gashaka-Gumti, and Yankari, covering a combined area that falls short of the internationally recommended minimum of 17 percent of national territory under formal protection.

Effective management of protected areas requires adequate staffing, equipment, and funding for anti-poaching patrols and law enforcement; management planning that identifies conservation objectives and the actions needed to achieve them; regular biological monitoring to assess whether wildlife populations are responding to management; community engagement and benefit-sharing with communities living in and around the protected area; and addressing encroachment and illegal resource use through a combination of law enforcement and alternative livelihood provision; many Nigerian protected areas suffer from insufficient government funding, inadequate ranger numbers, and significant encroachment that severely limits their conservation effectiveness.

Fill in the blank: Nigeria protected area network includes national parks managed by the Nigerian National _____ Service, game reserves, and forest reserves managed by state governments.

3.3.2 Community-based conservation

Community-based conservation (CBC) approaches recognise that wildlife conservation cannot succeed in the long term without the active participation and support of the local communities who live with wildlife and bear the costs of conservation in terms of crop damage, livestock losses, and restricted access to resources; CBC models range from community conservancies

(where local communities hold formal land rights and management authority over wildlife resources, as in many parts of southern and East Africa, where this approach has dramatically expanded wildlife habitat outside formal protected areas) to collaborative management arrangements between government agencies and local communities.

The rationale for CBC is that communities who directly benefit from wildlife (through wildlife-based tourism revenue, sustainable harvest rights, or employment) have an economic incentive to protect wildlife from poaching and habitat destruction, and their local ecological knowledge and community governance systems can complement formal government management; CBC has achieved notable successes in some contexts, including the recovery of rhinoceros, elephant, and lion populations on community conservancies in Namibia and Kenya, but requires genuine devolution of rights, equitable benefit sharing, and strong governance institutions to succeed.

Fill in the blank: Community _____ give local communities formal land rights and management authority over wildlife resources, creating economic incentives to protect wildlife from poaching and habitat destruction.

3.3.3 Wildlife-based tourism and conservation financing

Wildlife-based tourism (ecotourism and safari tourism) is one of the most economically significant land uses in many African countries, generating substantial foreign exchange earnings and providing employment and income at local and national levels; in countries such as Kenya, Tanzania, Botswana, and South Africa, wildlife tourism revenues run to billions of dollars annually and provide strong economic justification for maintaining wildlife habitat and populations; in Nigeria, wildlife tourism potential remains largely unrealised, with few international visitors to national parks despite the country outstanding biodiversity, partly due to infrastructure limitations and security concerns.

Conservation financing mechanisms beyond government budgets include payments for ecosystem services (compensating landowners or communities for maintaining habitats that provide water regulation, carbon storage, or biodiversity), conservation trust funds (endowed funds that generate investment income to finance protected area management in perpetuity), debt-for-nature swaps (where foreign debt is forgiven in exchange for national government

conservation commitments), and carbon credits (where forest protection generates certified carbon credits that can be sold on international markets); developing these alternative financing mechanisms is increasingly important in Nigeria given the chronic underfunding of the national parks system.

Fill in the blank: _____ for ecosystem services compensates landowners or communities for maintaining habitats that provide water regulation, carbon storage, or biodiversity to wider society.

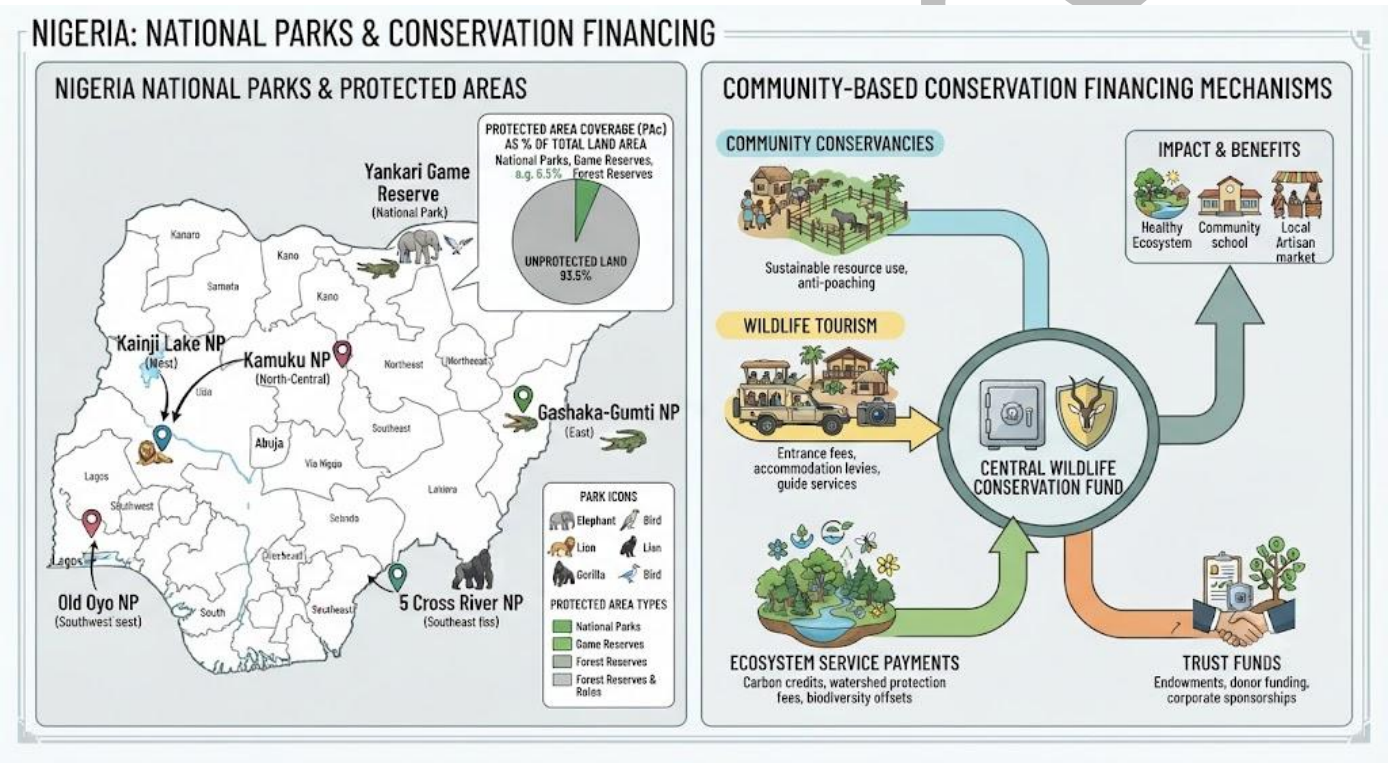

Figure 3.3: Conservation prospects for wildlife resources

Pilot questions 3.3

1. Name four national parks in Nigeria and state one characteristic feature of each.
2. Explain two challenges facing effective management of Nigerian protected areas.
3. Define community-based conservation and explain why it is important.
4. Explain what a payment for ecosystem services is and give one example.
5. Name two conservation financing mechanisms beyond government budgets.

3.4 Conflicts Related to Wildlife Resources

3.4.1 Types and causes of wildlife-related conflict

Conflicts related to wildlife resources arise from competing interests in how wildlife and their habitats should be managed and who should benefit from them; the major types of wildlife-related conflict include: human-wildlife conflict (the direct costs imposed on farming and pastoral communities by crop-raiding, livestock predation, and occasionally human injury or death caused by wildlife); conservation-community conflict (tensions between protected area authorities and neighbouring communities who feel excluded from resources, bear wildlife costs, and receive insufficient benefits from conservation); and resource access conflicts (disputes over who has the right to use wildlife resources, including between poachers and conservation authorities, between artisanal hunters and commercial operators, or between countries over shared migratory wildlife).

Underlying causes of wildlife-related conflict include the historical exclusion of local communities from decision-making in protected area establishment and management (which created a legacy of resentment toward conservation authorities in many parts of Nigeria and Africa); inequitable distribution of benefits from wildlife, where national government, tourism operators, and international conservation organisations capture most of the value while local communities bear the costs; and inadequate compensation mechanisms for wildlife-caused losses, leaving affected communities with no formal avenue for redress and little incentive to tolerate wildlife.

Fill in the blank: _____ -community conflict arises from tensions between protected area authorities and neighbouring communities who feel excluded from resources and receive insufficient benefits from conservation.

3.4.2 Human-wildlife conflict mitigation methods

Physical deterrents to human-wildlife conflict include: chilli pepper barriers (planting chilli around crop fields or burning chilli mixed with dung to deter elephants, effective and inexpensive for small-scale farmers); beehive fences (suspending beehives on a wire fence

around crop fields, exploiting elephant sensitivity to bee disturbance, used successfully in East Africa and increasingly in West Africa); predator-proof livestock enclosures (reinforced kraals or bomas that prevent nocturnal predation of livestock); and chain-link or electric fencing around high-value crops or around the boundaries of protected areas where intensive human-wildlife contact occurs.

Early warning systems (community-based alert networks that notify farmers in advance of approaching elephants or other crop raiders, allowing time to guard fields) and graduated deterrence responses (using non-lethal chasing methods before resorting to problem animal removal) are complementary approaches; crop insurance and compensation schemes (where farmers receive payment for verified wildlife-caused crop or livestock losses) can reduce the economic impact of HWC and improve community tolerance of wildlife, though schemes are costly and require accurate damage assessment and transparent payment mechanisms to be effective and trusted by affected communities.

Fill in the blank: _____ fences suspend beehives on wire fences around crop fields, exploiting elephant sensitivity to bee disturbance as a non-lethal deterrent to crop raiding.

3.4.3 Conflict resolution and stakeholder engagement

Effective long-term resolution of wildlife-related conflicts requires addressing the underlying inequities rather than simply mitigating the physical impacts; this means engaging all relevant stakeholders (including local communities, government agencies, conservation organisations, tourism operators, and researchers) in transparent dialogue about the costs and benefits of wildlife conservation and the rules and structures governing resource access and benefit distribution; conflict resolution processes that give communities a genuine voice and real decision-making authority over wildlife resources on their land are more likely to produce durable outcomes than top-down approaches.

Benefit-sharing mechanisms that direct tangible economic benefits from wildlife-based tourism, trophy hunting, or ecosystem service payments to affected communities are among the most effective tools for building community tolerance and active participation in conservation; establishing clear and accessible grievance and compensation mechanisms so that communities

with wildlife damage can seek redress without resorting to retaliatory killing; and building the capacity of community wildlife committees and local conservation governance institutions, ensures that communities have the institutional means to manage wildlife resources and conflicts over the long term.

Fill in the blank: _____ -sharing mechanisms that direct tangible economic benefits from wildlife-based activities to affected communities are among the most effective tools for building community tolerance of wildlife.

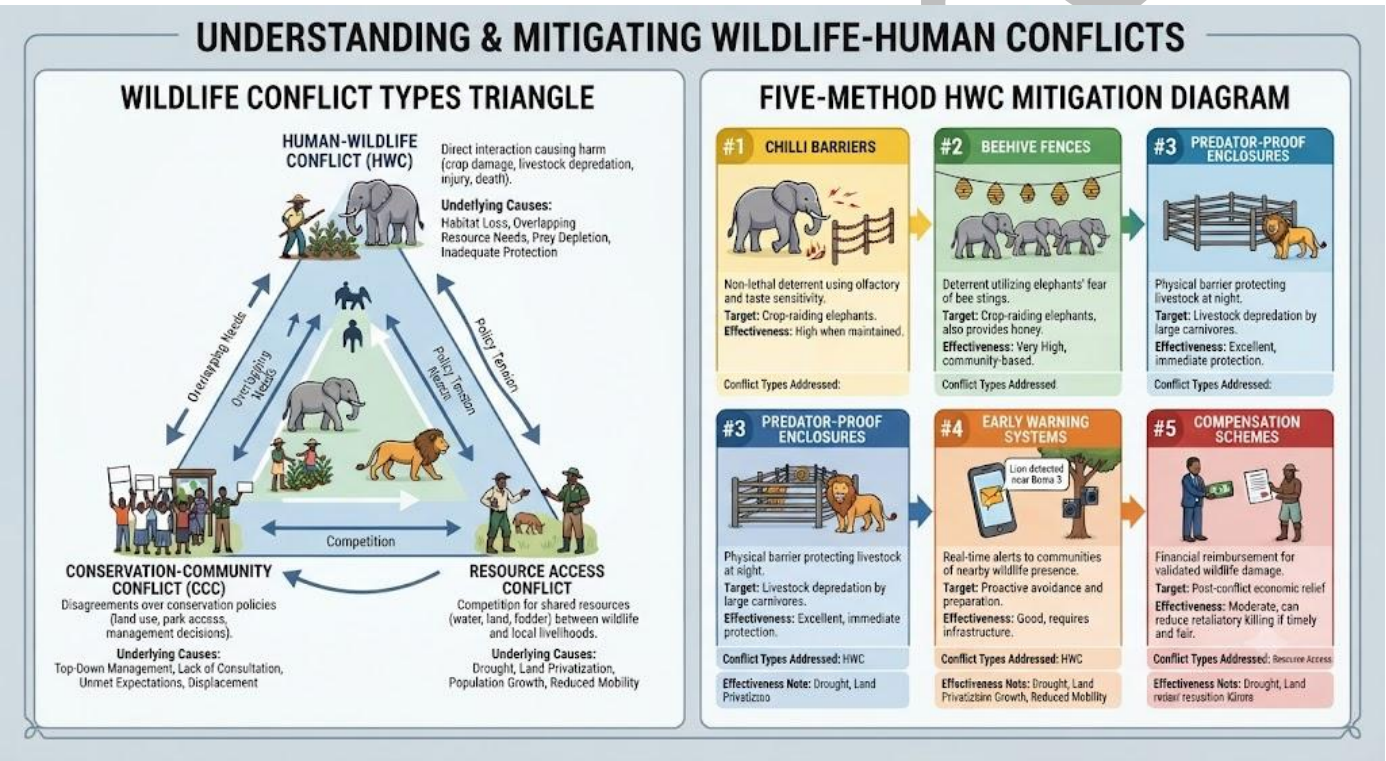

Figure 3.4: Wildlife-related conflicts and mitigation

Pilot questions 3.4

1. Name three types of wildlife-related conflict and give one cause for each.
2. Explain why local communities often resent protected areas in Nigeria.
3. Describe two physical methods used to deter elephant crop raiding.
4. Explain what a compensation scheme for wildlife damage is and one challenge in implementing it.
5. Explain what is required for effective long-term resolution of wildlife-related conflicts.

Series Summary

This Series surveyed the wildlife resources of the world and Nigeria, their value, and the serious problems they face. Nigeria outstanding biodiversity, including nearly 900 bird species and major protected areas such as Cross River National Park and Yankari Game Reserve, has direct and indirect economic value through bushmeat protein, ecosystem services, and unrealised wildlife tourism potential. Habitat loss and fragmentation, overexploitation including the illegal trade in pangolins and ivory, and intensifying human-wildlife conflict are the primary threats driving wildlife decline in Nigeria and across Africa.

Conservation prospects rest on adequately funded and managed protected areas, genuine community-based conservation that gives local communities rights and benefits, and diversified conservation financing mechanisms including wildlife tourism and ecosystem service payments. Wildlife-related conflicts, whether between people and animals or between communities and conservation authorities, are best addressed through equitable benefit-sharing, effective compensation schemes, physical deterrents for crop-raiding and predation, and inclusive stakeholder engagement that gives communities a real voice in wildlife governance.

Glossary of Terms

- **Bushmeat:** wild animal meat hunted for subsistence consumption or commercial sale, representing a major protein source in West and Central Africa and a significant driver of wildlife depletion.
- **Community-based conservation:** conservation approaches that involve local communities as active participants with genuine rights and benefits, based on the recognition that long-term conservation depends on community support.
- **Edge effect:** the disproportionate influence of the habitat boundary on conditions throughout a habitat patch, particularly pronounced in small, fragmented patches.
- **Habitat fragmentation:** the breaking apart of previously continuous habitat into smaller, isolated patches separated by unsuitable land.

- **Human-wildlife conflict:** situations in which wildlife causes damage to human livelihoods, property, or safety, generating negative attitudes and retaliatory killing.
- **Megadiverse country:** one of seventeen countries estimated to harbour more than 70 percent of global species diversity, each hosting exceptional numbers of endemic species.
- **Overexploitation:** harvesting of wildlife at rates that exceed the population capacity to reproduce and replace harvested individuals, leading to population decline.
- **Payment for ecosystem services:** a mechanism that compensates landowners or communities for maintaining habitats that provide water regulation, carbon storage, or biodiversity to wider society.
- **Protected area:** a geographically defined area managed to achieve long-term nature conservation goals.
- **Trophic cascade:** the indirect effects on lower trophic levels caused by the removal or addition of a predator or other key species, potentially restructuring entire ecosystems.

Concept Check Questions [Series 3]

Objective Questions

1. Nigeria approximately 899 bird species and 274 mammal species reflect its position at the junction of West African _____ , savanna, and coastal wetland ecosystems. (Linked to SLO 3.1)
2. Habitat _____ breaks previously continuous habitat into smaller, isolated patches, disrupting dispersal and gene flow. (Linked to SLO 3.2)
3. _____ are the most heavily traded wild mammal globally, with their scales trafficked through international networks. (Linked to SLO 3.2)
4. Nigeria national parks are managed by the Nigerian National _____ Service. (Linked to SLO 3.3)
5. _____ fences exploit elephant sensitivity to bee disturbance as a non-lethal deterrent to crop raiding. (Linked to SLO 3.4)

Short-Answer Questions

1. Name three major wildlife-rich areas in Nigeria and one characteristic species for each. (Linked to SLO 3.1)
2. Distinguish between direct and indirect economic value of wildlife. (Linked to SLO 3.1)
3. Explain two consequences of habitat fragmentation for wildlife populations. (Linked to SLO 3.2)
4. Define community-based conservation and explain why it is important. (Linked to SLO 3.3)
5. Name three types of wildlife-related conflict and one cause for each. (Linked to SLO 3.4)

Long-Answer Questions

1. Describe the wildlife resources of Nigeria and their value, and explain the major problems facing them. (Linked to SLOs 3.1, 3.2)
2. Describe the conservation prospects for wildlife and explain how wildlife-related conflicts arise and can be resolved. (Linked to SLOs 3.3, 3.4)

Answers to Concept Check Questions [Series 3]

Objective Questions

1. Forest.
2. Fragmentation.
3. Pangolins.
4. Parks.
5. Beehive.

Short-Answer Questions

1. Cross River National Park (Cross River gorilla), Yankari Game Reserve (African elephant), Gashaka-Gumti National Park (chimpanzee).
2. Direct value: bushmeat, wildlife tourism, live animal trade. Indirect value: ecosystem services such as pollination, seed dispersal, water purification, and carbon storage.
3. Disruption of dispersal and gene flow between isolated populations, and reduction of patch size below the minimum area required for viable populations of area-sensitive species.
4. Community-based conservation involves local communities as active participants with rights and benefits in wildlife management; it is important because long-term conservation depends on local community support and tolerance.
5. Human-wildlife conflict (crop raiding/livestock predation by wildlife); conservation-community conflict (exclusion of communities from protected areas/insufficient benefits); resource access conflict (competing claims between poachers and authorities or between user groups).

Long-Answer Questions

1. Nigeria wildlife: approximately 899 birds, 274 mammals; major areas include Cross River NP (gorilla), Yankari (elephant), Gashaka-Gumti (chimpanzee), Niger Delta (aquatic biodiversity). Value: direct (bushmeat, tourism, trade), indirect (ecosystem services), existence value. Problems: habitat loss (Nigeria has lost over 90% of original forest cover), fragmentation (edge effects, dispersal disruption), overexploitation (bushmeat trade, illegal ivory, pangolin trade), human-wildlife conflict (crop raiding, livestock predation).

2. Conservation prospects: protected areas (six national parks, need adequate funding and community engagement); community-based conservation (rights and benefits to communities, community conservancies); wildlife tourism (unrealised potential in Nigeria); financing (payments for ecosystem services, conservation trust funds, carbon credits). Conflicts arise from inequitable benefit distribution, historical exclusion, no compensation mechanisms. Resolution: benefit-sharing, transparent stakeholder engagement, compensation schemes, physical deterrents (chilli, beehive fences, predator-proof bomas), early warning systems.

Answers to Pilot Questions [Series 3]

Part 3.1

1. Cross River National Park (Cross River gorilla), Yankari Game Reserve (African elephant), Gashaka-Gumti National Park (chimpanzee, or any valid species for each).
2. Approximately 899 bird species and 274 mammal species.
3. Direct value: bushmeat, tourism, live trade (direct consumption or revenue). Indirect value: ecosystem services such as pollination, seed dispersal, and water purification that benefit humans without direct harvesting of wildlife.
4. A trophic cascade is the indirect effect on lower trophic levels caused by removal of a predator or key species; example: removal of large predators in a savanna leads to overpopulation of herbivores, which overgraze vegetation, causing habitat degradation.
5. Option value is the value society places on preserving the option to use wildlife in the future; existence value is the value people place on knowing wildlife exists, regardless of any direct use.

Part 3.2

1. Habitat loss converts natural habitat to agriculture and other uses, reducing total wildlife area and eliminating populations that cannot survive in the converted landscape; it removes not just individual species but entire communities and the ecosystem services they provide.
2. Edge effects are the disproportionate influence of the habitat boundary on interior conditions throughout a patch; in small fragmented patches, the interior is dominated by edge conditions

(increased light, dryness, wind, and predation), making them unsuitable for interior-specialist species.

3. Overexploitation is harvesting at rates exceeding the population reproductive capacity; large-bodied species with slow reproductive rates (low fecundity, late maturity) cannot replace individuals lost to harvesting quickly enough to prevent population decline.
4. Pangolins (scales traded for traditional medicine in Asia) and elephants (ivory traded for carvings and status symbols in Asia and elsewhere).
5. Crop raiding by elephants or monkeys, livestock predation by leopards or hyenas, and damage to fisheries by hippopotamuses (or direct threats to human safety from elephants or crocodiles).

Part 3.3

1. Kainji Lake (water-based wildlife and fishing), Cross River (Cross River gorilla), Chad Basin (migratory waterbirds), Old Oyo (savanna wildlife and archaeological heritage) (any four valid parks with features).
2. Insufficient government funding (inadequate ranger numbers and equipment) and significant encroachment reducing effective protected area size.
3. CBC involves local communities as active participants with rights and benefits in wildlife management; it is important because communities who benefit from wildlife have economic incentives to protect it from poaching and habitat destruction.
4. A payment for ecosystem services compensates landowners for maintaining habitats that provide services such as water regulation or carbon storage; example: paying forest communities to protect forest that regulates downstream water supply.
5. Conservation trust funds and payments for ecosystem services (or debt-for-nature swaps, carbon credits).

Part 3.4

1. Human-wildlife conflict (caused by crop raiding/predation), conservation-community conflict (caused by exclusion and inequitable benefit distribution), resource access conflict (caused by competing harvest rights between different user groups).
2. Many protected areas were established without consulting local communities, which were often forcibly excluded from resources they depended on, receiving little or no benefit from conservation while bearing all the costs of wildlife damage.

3. Chilli pepper barriers (planting chilli around fields or burning chilli-dung to deter elephants) and beehive fences (beehives on wire fence exploiting elephant sensitivity to bees).
4. A compensation scheme pays farmers for verified wildlife-caused crop or livestock losses; a key challenge is accurate damage assessment and transparent payment to prevent fraudulent claims and maintain community trust.
5. Effective long-term resolution requires genuine stakeholder engagement, equitable benefit-sharing, clear grievance and compensation mechanisms, and real community decision-making authority over wildlife resources on their land.

References and Attribution

Textual References (Books and External Sources)

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Figures, Plates, Tables, and Boxes

- Figure 3.1: Wildlife resources of Nigeria and their value Attribution: AI generated. Suggested OER search string: "wildlife resources Nigeria biodiversity national parks ecosystem services economic value trophic cascade OER".
- Figure 3.2: Problems facing wildlife resources Attribution: AI generated. Suggested OER search string: "habitat loss fragmentation bushmeat wildlife trade human wildlife conflict Nigeria Africa elephant pangolin OER".
- Figure 3.3: Conservation prospects for wildlife resources Attribution: AI generated. Suggested OER search string: "Nigeria national parks protected areas community conservation wildlife tourism ecosystem services conservation financing OER".
- Figure 3.4: Wildlife-related conflicts and mitigation Attribution: AI generated. Suggested OER search string: "human wildlife conflict mitigation beehive fence chilli pepper community conservation conflict resolution Nigeria Africa OER".

Course code: BIO 403

Course title: Wildlife Conservation and Management

Course credit load: 2 Units

Series 4: Conservation Policies and Laws

- **Part 4.1: Principles of Conservation Policy**
  - Sub Part 4.1.1: The basis and purpose of conservation policy
  - Sub Part 4.1.2: Key conservation policy concepts
  - Sub Part 4.1.3: Policy instruments for wildlife conservation
- **Part 4.2: International Conservation Laws and Agreements**
  - Sub Part 4.2.1: CITES and the regulation of international wildlife trade
  - Sub Part 4.2.2: The Convention on Biological Diversity
  - Sub Part 4.2.3: Other major international conservation agreements
- **Part 4.3: Wildlife Conservation Policies and Laws in Nigeria**
  - Sub Part 4.3.1: Federal wildlife legislation in Nigeria
  - Sub Part 4.3.2: National parks and protected area legislation
  - Sub Part 4.3.3: Challenges in wildlife law enforcement in Nigeria
- **Part 4.4: Conservation Policy in Practice**
  - Sub Part 4.4.1: Policy implementation and governance
  - Sub Part 4.4.2: The role of NGOs and international organisations
  - Sub Part 4.4.3: Linking policy to practice in Nigeria

Introduction

Conservation policies and laws provide the formal framework within which wildlife management operates, defining which species and habitats receive protection, regulating the harvest and trade of wildlife, establishing the system of protected areas, and setting out the obligations of governments and citizens in relation to biodiversity. Without an effective policy and legal framework, wildlife management lacks the authority and instruments needed to prevent overexploitation, habitat destruction, and illegal trade.

This Series covers the principles underlying conservation policy and the range of policy instruments available; the major international conservation agreements and laws, including CITES and the Convention on Biological Diversity; the principal wildlife legislation applicable in Nigeria at the federal level and in relation to protected areas; and the practical challenges of implementing and enforcing conservation law in Nigeria, the role of non-governmental organisations and international bodies, and the connection between policy frameworks and on-the-ground management practice.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 4.1** explain the basis and purpose of conservation policy and describe the key concepts and instruments of conservation policy,
- **SLO 4.2** describe CITES, the Convention on Biological Diversity, and other major international conservation agreements,
- **SLO 4.3** describe the principal wildlife legislation in Nigeria and the challenges of wildlife law enforcement, and
- **SLO 4.4** explain the roles of government, NGOs, and international organisations in conservation policy implementation.

4.1 Principles of Conservation Policy

4.1.1 The basis and purpose of conservation policy

Conservation policy is the set of deliberate decisions made by governments and other authorities to achieve defined objectives for the protection and sustainable management of natural resources and biodiversity; conservation policy is grounded in the recognition that market forces alone do not adequately protect wildlife and natural habitats, since many of the values that wildlife provides (particularly ecological services and existence values) are not captured in market prices and wildlife is therefore systematically undervalued and overexploited in the absence of regulatory intervention.

The purposes of conservation policy include: preventing the extinction of species and the loss of habitats; regulating the harvest and trade of wildlife to ensure sustainability; establishing and managing a system of protected areas; ensuring the equitable sharing of benefits from biodiversity; and fulfilling international obligations under treaties and conventions to which the government is a party; effective conservation policy requires a clear legal mandate (legislation that gives authorities the power to act), adequate institutional capacity (the staff, funding, and equipment to implement and enforce the law), and public support built through education and inclusive decision-making.

Fill in the blank: Conservation policy is grounded in the recognition that market forces alone do not adequately protect wildlife because many wildlife values, including _____ services and existence values, are not captured in market prices.

4.1.2 Key conservation policy concepts

Several foundational concepts underpin modern conservation policy: sustainable use (the use of biological resources in a way that allows their long-term renewal and does not lead to their decline, based on the principle that communities with sustainable livelihood interests in wildlife have the greatest incentive to protect it); the polluter pays principle (that the costs of environmental damage should be borne by those who cause it, rather than by society at large); intergenerational equity (the obligation to manage natural resources in a manner that preserves

the options of future generations, encoded in the Brundtland Commission definition of sustainable development as development that meets the needs of the present without compromising future generations).

The precautionary principle (taking protective action even when scientific certainty about a threat is incomplete, particularly for decisions with potentially irreversible consequences) is central to wildlife conservation policy because the extinction of species is irreversible; environmental impact assessment (EIA, a formal evaluation of the likely environmental consequences of a proposed development or policy before a decision is made to proceed) is a key procedural policy instrument applied to development projects that may affect wildlife or their habitats; biological diversity at genetic, species, and ecosystem levels is the principal object of conservation policy under the Convention on Biological Diversity framework.

Fill in the blank: The _____ principle requires taking protective action even when scientific certainty about a threat is incomplete, particularly when consequences may be irreversible, such as species extinction.

4.1.3 Policy instruments for wildlife conservation

Conservation policy is implemented through a range of instruments: regulatory instruments (laws and regulations that prohibit or restrict specific activities, such as banning the hunting of protected species, requiring permits for wildlife trade, or establishing protected areas in which extractive activities are prohibited or restricted); economic instruments (creating financial incentives or disincentives to guide behaviour toward conservation-compatible practices, such as subsidies for sustainable land use, taxes on extractive activities, payments for ecosystem services, or fines and penalties for environmental offences).

Voluntary and information-based instruments (such as environmental labelling and certification schemes that allow consumers to identify sustainably produced wildlife products, and public awareness campaigns that build understanding and support for conservation) complement regulatory and economic instruments; institutional instruments (establishing or strengthening the government agencies, courts, and community institutions responsible for conservation governance) are the foundation on which all other instruments depend; in Nigeria, the primary

policy instrument for wildlife conservation is regulatory legislation, with economic instruments and voluntary approaches playing a supplementary role.

Fill in the blank: _____ instruments create financial incentives for conservation-compatible behaviour, such as payments for ecosystem services or fines for environmental offences, complementing regulatory laws.

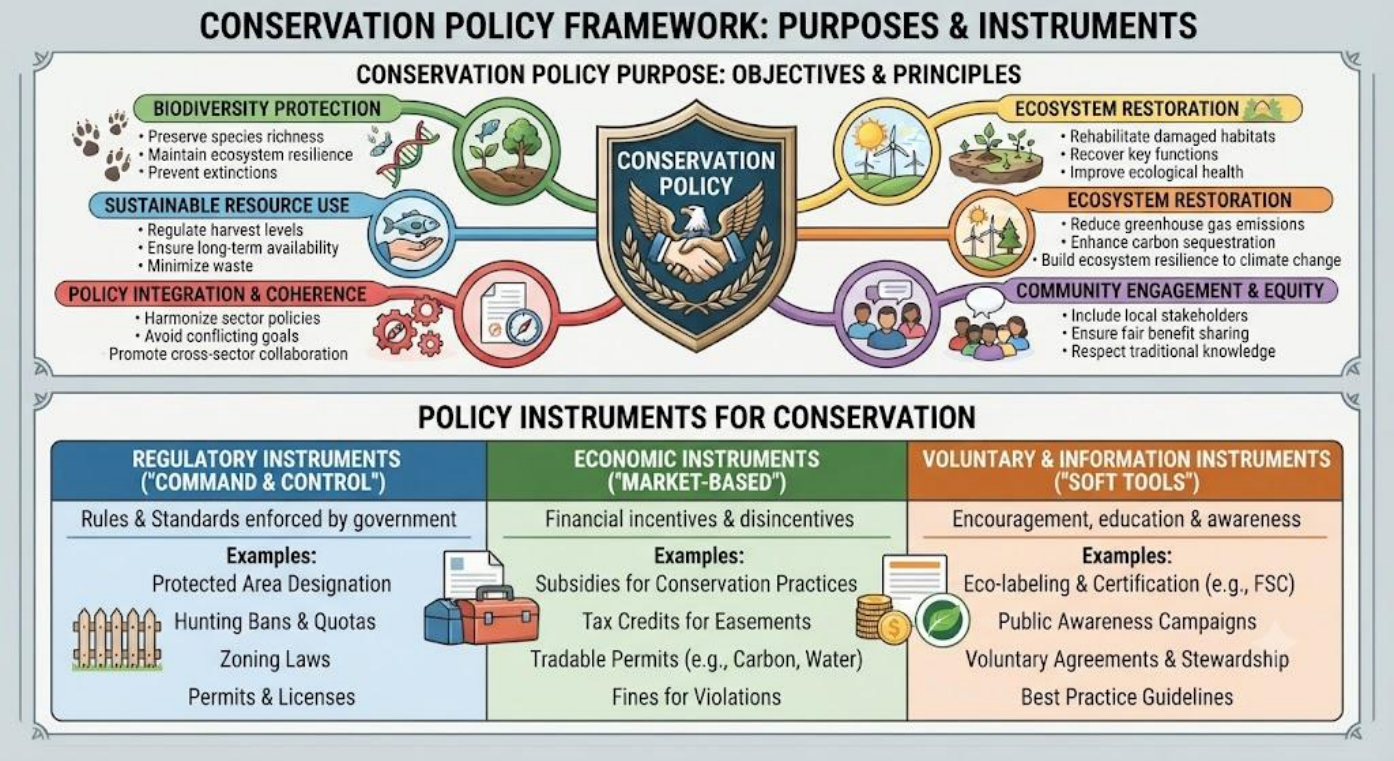

Figure 4.1: Conservation policy foundations

Pilot questions 4.1

1. Explain why market forces alone do not adequately protect wildlife.
2. Define sustainable use in the context of conservation policy.
3. Explain the precautionary principle and why it is particularly important for wildlife conservation.
4. Distinguish between regulatory and economic policy instruments.
5. What is an environmental impact assessment and when is it applied?

4.2 International Conservation Laws and Agreements

4.2.1 CITES and the regulation of international wildlife trade

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is an international agreement between governments, established in 1973 and currently with over 180 party countries including Nigeria, that regulates the international trade in wild animals and plants to ensure that such trade does not threaten the survival of species; CITES operates through a system of three appendices: Appendix I lists species threatened with extinction for which commercial international trade is generally prohibited (permits required only for exceptional non-commercial purposes); Appendix II lists species not currently threatened with extinction but which may become so if trade is not regulated, requiring export permits to confirm legal acquisition and sustainable harvest; Appendix III lists species protected in at least one country that has asked other CITES parties for assistance in controlling trade.

Nigeria is a significant transit and source country for illegal wildlife trade, and CITES obligations require Nigeria to maintain a Scientific Authority (to advise on sustainable trade levels) and a Management Authority (to issue and regulate CITES permits), to criminalise trade in CITES-listed species without appropriate permits, and to cooperate with other countries and INTERPOL in investigating and prosecuting wildlife trafficking; African species of particular concern under CITES include elephants (Appendix I for most populations), African grey parrots (Appendix I since 2017), pangolins (all species on Appendix I since 2017), and many great ape species.

Fill in the blank: CITES Appendix _____ lists species not currently threatened with extinction but which require export permits to confirm legal acquisition and sustainable harvest, to prevent trade from becoming a threat.

4.2.2 The Convention on Biological Diversity

The Convention on Biological Diversity (CBD), adopted at the Earth Summit in Rio de Janeiro in 1992 and entered into force in 1993, is the principal international treaty addressing biodiversity conservation; the CBD has three objectives: the conservation of biological diversity,

the sustainable use of its components, and the fair and equitable sharing of benefits arising from the utilisation of genetic resources; as a party to the CBD, Nigeria is obligated to develop and implement a National Biodiversity Strategy and Action Plan (NBSAP), establish a system of protected areas, integrate biodiversity conservation into sectoral plans, and report on the status of biodiversity and progress toward CBD targets.

The Kunming-Montreal Global Biodiversity Framework, adopted by CBD parties in 2022, sets the current global targets for biodiversity conservation to 2030, including the 30x30 target (protecting at least 30 percent of land and ocean areas by 2030) and commitments to restore degraded ecosystems and reduce pressures from overexploitation, pollution, invasive species, and climate change; the Nagoya Protocol (2010), a supplementary agreement to the CBD, establishes the legal framework for access and benefit-sharing from genetic resources, aiming to ensure that source countries and indigenous communities benefit equitably from commercial applications of their biodiversity.

Fill in the blank: The Convention on Biological Diversity has three objectives: conservation of biodiversity, sustainable use of its components, and the fair and equitable _____ of benefits from genetic resources.

4.2.3 Other major international conservation agreements

The Ramsar Convention on Wetlands (1971) is an intergovernmental treaty for the conservation and sustainable use of wetlands, requiring party countries to designate at least one wetland of international importance (Ramsar site) and to formulate and implement plans for their wise use and conservation; Nigeria has designated several Ramsar sites including Lake Chad (shared with Cameroon, Niger, and Chad) and parts of the Niger Delta; the Convention on Migratory Species (CMS, also known as the Bonn Convention, 1979) provides a global framework for the conservation of migratory animals and the habitats they depend upon across national boundaries.

The World Heritage Convention (1972, administered by UNESCO) provides for the designation and protection of sites of outstanding universal natural value as World Heritage Sites, with parties obligated to identify, protect, and conserve designated sites for future generations; the African Convention on the Conservation of Nature and Natural Resources (Algiers Convention,

1968, revised 2003) is a regional treaty that commits African Union member states, including Nigeria, to conservation of flora, fauna, soil, water, and the broader environment, and to integrate conservation into national development planning; awareness of these complementary international instruments is important for understanding the full scope of Nigeria international conservation obligations.

Fill in the blank: The Ramsar Convention requires party countries to designate at least one wetland of international importance as a _____ site and to formulate plans for its wise use and conservation.

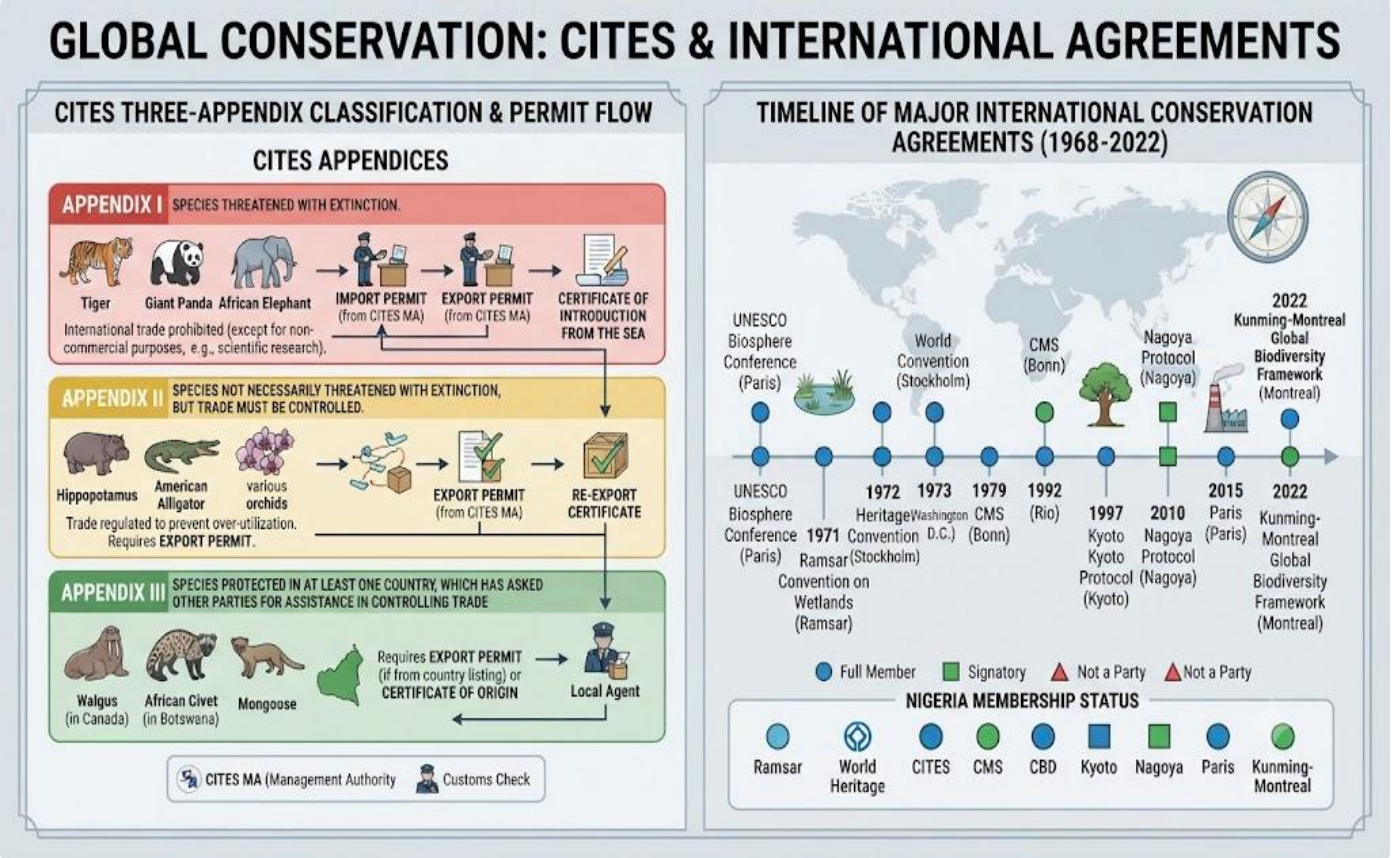

Figure 4.2: International conservation agreements

Pilot questions 4.2

1. Explain the three CITES appendices and the different levels of trade regulation each represents.
2. Name two African species currently listed on CITES Appendix I.

3. State the three objectives of the Convention on Biological Diversity.
4. Explain what the 30x30 target in the Kunming-Montreal Global Biodiversity Framework means.
5. State the purpose of the Ramsar Convention and give one Nigerian Ramsar site.

4.3 Wildlife Conservation Policies and Laws in Nigeria

4.3.1 Federal wildlife legislation in Nigeria

The principal federal legislation governing wildlife conservation in Nigeria includes the Endangered Species (Control of International Trade and Traffic) Act (Cap E9, Laws of the Federation of Nigeria 2004), which gives effect to Nigeria CITES obligations by prohibiting trade in listed endangered species without appropriate permits and establishing penalties for violations; the National Environmental Standards and Regulations Enforcement Agency (NESREA) Establishment Act (2007), which established NESREA as the federal agency responsible for enforcement of environmental laws and regulations, including those relating to wildlife; and sectoral legislation covering forestry, fisheries, and environmental impact assessment that is relevant to wildlife habitat protection.

The Forestry Act and its state-level equivalents regulate the use of forest reserves, which provide important habitat for wildlife outside formal national park boundaries; the Environmental Impact Assessment Act (1992) requires that proposed development projects with significant environmental consequences undergo formal EIA before approval, providing a mechanism for assessing and mitigating impacts on wildlife and their habitats; wildlife-related provisions also appear in state-level legislation, since land matters are partly within state jurisdiction in the Nigerian federal system, creating a complex multi-level legislative framework that requires coordination between federal and state authorities.

Fill in the blank: The Endangered Species (Control of International Trade and Traffic) Act gives effect to Nigeria _____ obligations by prohibiting trade in listed species without permits.

4.3.2 National parks and protected area legislation

The National Parks Service Act (Cap N65, Laws of the Federation of Nigeria 2004) establishes the Nigerian National Parks Service (NNPS) as the federal agency responsible for the management of national parks, and defines the legal framework for protected area designation, management planning, and the regulation of activities within park boundaries; activities prohibited in national parks include hunting, logging, mining, farming, and settlement, with penalties for violation; game reserves are typically established under state legislation and managed by state forestry or wildlife departments with varying levels of resource and institutional capacity.

Community forest reserves and private wildlife ranches represent additional categories of wildlife habitat with varying levels of legal protection under state and federal law; the designation of additional protected areas and the upgrading of game reserves to national park status are ongoing processes in Nigeria, driven partly by international obligations under the CBD and partly by the recognition that the current protected area estate is insufficient to maintain viable populations of Nigeria wide-ranging wildlife species; the legal framework for protected area management needs strengthening, particularly in relation to community rights, benefit sharing, and the legal recognition of community conservation areas.

Fill in the blank: The National Parks Service Act establishes the Nigerian National Parks _____ as the federal agency responsible for management planning and regulation of activities within national park boundaries.

4.3.3 Challenges in wildlife law enforcement in Nigeria

Despite the existence of reasonably comprehensive wildlife legislation at federal and state levels, enforcement is severely constrained by several factors: inadequate funding and staffing of the Nigerian National Parks Service and state wildlife agencies, resulting in insufficient ranger numbers and inadequate equipment for effective anti-poaching patrol of large, remote protected areas; corruption, which undermines prosecution of wildlife offenders and allows illegal wildlife trade to continue despite formal prohibitions; overlapping and sometimes conflicting

jurisdictions between federal and state agencies, creating uncertainty about which authority is responsible for enforcement in specific situations.

Weak judicial capacity and the low prioritisation of wildlife crime in the court system mean that prosecutions for wildlife offences are infrequent and penalties, even when imposed, are rarely proportionate to the commercial value of the illegal trade involved; inadequate penalties in older legislation (some of which has not been updated since the 1960s and 1970s) fail to deter professional wildlife traffickers for whom fines represent a trivial cost of business; addressing these enforcement challenges requires investment in ranger training and equipment, legislative reform to increase penalties and modernise offence provisions, anti-corruption measures, and capacity building for prosecutors and magistrates.

Fill in the blank: _____ undermines the prosecution of wildlife offenders in Nigeria and allows illegal wildlife trade to continue despite formal legal prohibitions.

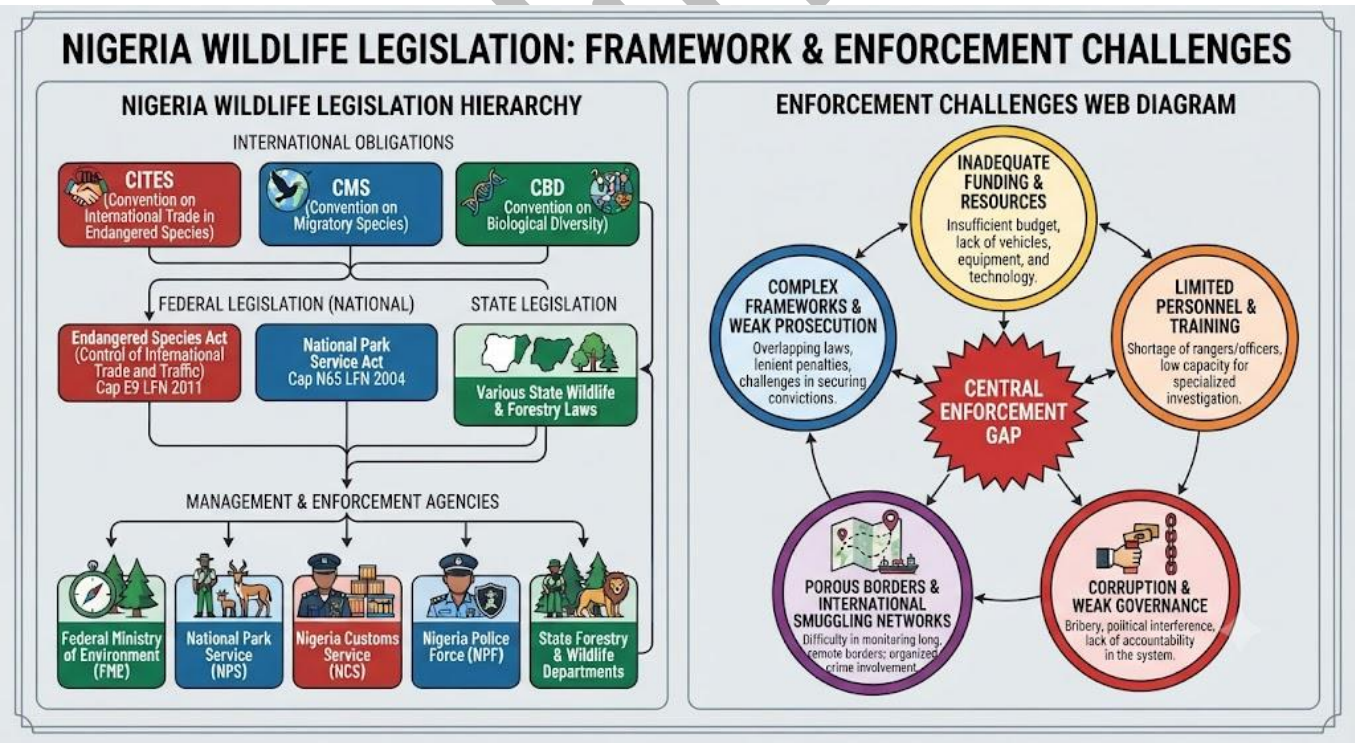

Figure 4.3: Nigeria wildlife legislation and enforcement challenges

Pilot questions 4.3

1. Name two pieces of federal legislation relevant to wildlife conservation in Nigeria.
2. What is the role of NESREA in wildlife conservation in Nigeria?
3. Describe the legal framework established by the National Parks Service Act.
4. Name three challenges facing wildlife law enforcement in Nigeria.
5. Explain why inadequate penalties undermine wildlife law enforcement.

4.4 Conservation Policy in Practice

4.4.1 Policy implementation and governance

Effective implementation of conservation policy requires more than the existence of laws and regulations; it requires functional governance institutions with clear mandates, sufficient resources, and accountability mechanisms; good conservation governance involves: legal authority (clear enabling legislation that gives relevant agencies the power to act and enforce), institutional capacity (adequately trained and resourced agencies with clear mandates and coordination mechanisms), transparency and accountability (reporting requirements, independent oversight, and accessible information so that stakeholders can assess whether conservation objectives are being achieved), and participation (inclusive decision-making processes that involve affected communities and civil society organisations).

Policy coherence, the alignment of conservation policy with policies in other sectors such as agriculture, land use, trade, and infrastructure development, is essential because conservation policies can be easily undermined by sector-specific policies that incentivise habitat conversion or overexploitation; in Nigeria, the frequent contradiction between conservation law and the agricultural expansion promoted in other government policies illustrates the challenge of policy coherence; adaptive governance (adjusting policies and institutions in response to monitoring data and changing conditions) is increasingly recognised as necessary given the rapid rate of environmental change and the associated uncertainty in conservation outcomes.

Fill in the blank: Policy _____ is the alignment of conservation policy with policies in other sectors such as agriculture and land use, essential because sector-specific policies can easily undermine conservation objectives.

4.4.2 The role of NGOs and international organisations

Non-governmental organisations (NGOs) play several important roles in wildlife conservation in Nigeria and across Africa: conducting biological monitoring and research that generates the data needed to inform policy; operating conservation programmes on the ground in and around protected areas, often filling gaps left by underfunded government agencies; advocacy and litigation to strengthen legislation and hold authorities accountable for environmental law enforcement; capacity building and training of rangers, community wildlife monitors, and conservation professionals; and fundraising from international donors to finance conservation activities that government budgets cannot cover.

Major international conservation organisations active in Nigeria include the Wildlife Conservation Society (WCS), World Wide Fund for Nature (WWF), the African Wildlife Foundation (AWF), and the International Union for Conservation of Nature (IUCN), the last of which maintains the IUCN Red List of Threatened Species (the global standard for species threat status assessment) and the World Database on Protected Areas; bilateral and multilateral development agencies (including the Global Environment Facility, which finances biodiversity and climate change projects in developing countries through grants to governments and NGOs) also play important conservation financing roles.

Fill in the blank: The IUCN maintains the _____ List of Threatened Species, the global standard for assessing the conservation status of species worldwide.

4.4.3 Linking policy to practice in Nigeria

Translating conservation policy into effective on-the-ground management in Nigeria requires bridging significant gaps between formal legislative frameworks and field-level reality; practical linkages between policy and practice include: improving the funding and resourcing of management agencies to bridge the gap between legal mandates and operational capacity;

strengthening the community engagement and benefit-sharing provisions of protected area management to build the local support that enforcement alone cannot achieve; and developing monitoring and evaluation systems that track whether management actions are achieving their conservation objectives and trigger adaptive management responses when they are not.

The growing engagement of Nigerian civil society organisations in conservation advocacy, the increasing participation of local communities in wildlife monitoring and governance through community-based conservation initiatives, and the development of wildlife-based enterprises including ecotourism that create economic incentives aligned with conservation represent encouraging signs of closer linkage between policy and practice; however, achieving genuinely effective wildlife conservation in Nigeria will require sustained political commitment, significant increases in conservation financing, and serious efforts to address the governance challenges, including corruption and elite capture, that currently undermine the implementation of Nigeria conservation policy framework.

Fill in the blank: Developing monitoring and _____ systems that track whether management actions are achieving conservation objectives is essential for triggering adaptive management when interventions are not working.

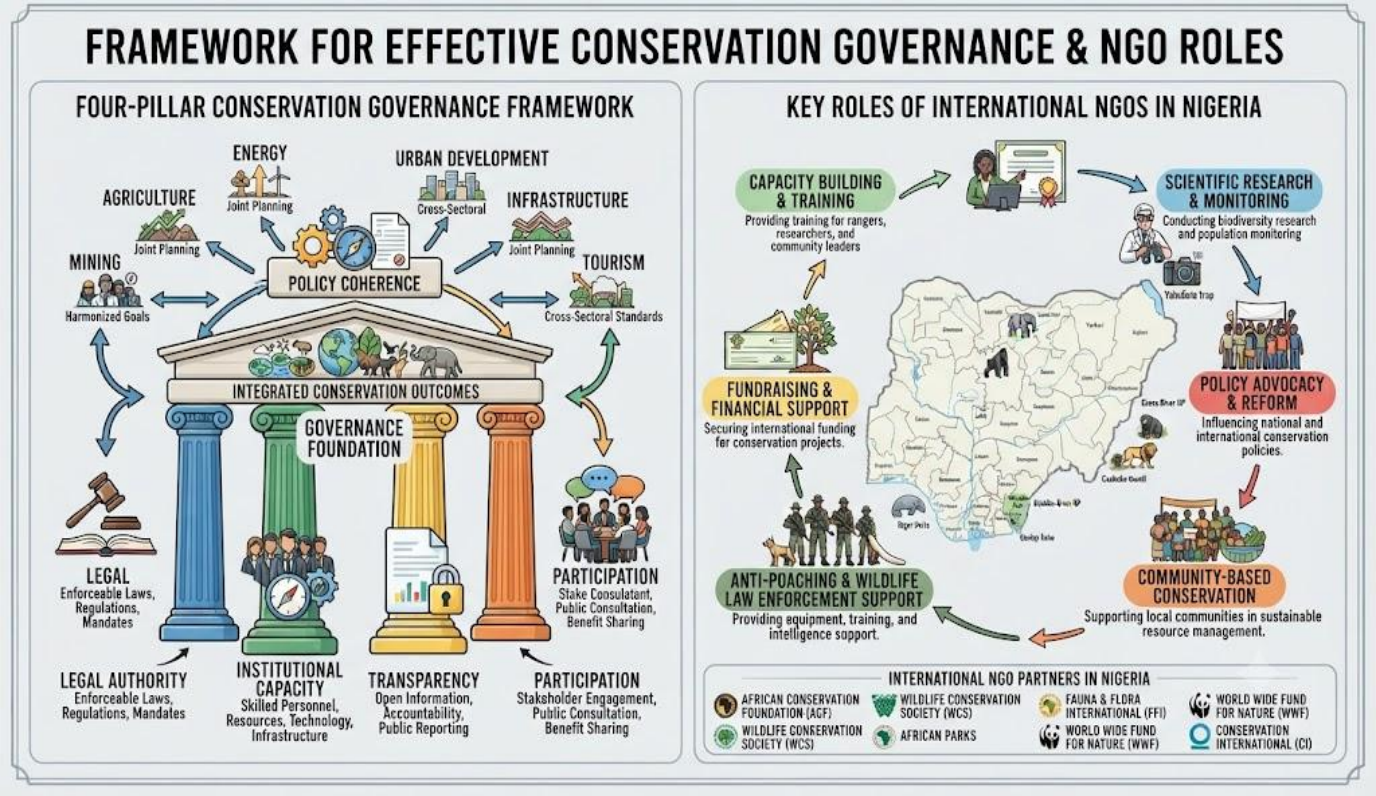

Figure 4.4: Conservation policy implementation and NGO roles

Pilot questions 4.4

1. Name four components of good conservation governance.
2. Explain what policy coherence means and why it matters for wildlife conservation.
3. Name three roles that NGOs play in wildlife conservation in Nigeria.
4. Name two major international conservation organisations active in Nigeria.
5. Name two practical steps that would help link conservation policy to management practice in Nigeria.

Series Summary

This Series examined the policy and legal framework that governs wildlife conservation in Nigeria and globally. Conservation policy addresses the systematic undervaluation of wildlife through regulatory, economic, and voluntary instruments, underpinned by principles such as sustainable use, the precautionary principle, intergenerational equity, and environmental impact assessment. Internationally, CITES regulates wildlife trade through its three-appendix system, the Convention on Biological Diversity sets global biodiversity targets including the 30x30 framework, and complementary agreements cover wetlands, migratory species, and world heritage sites.

In Nigeria, the Endangered Species Act, National Parks Service Act, and NESREA Establishment Act provide the federal legislative framework, though enforcement is severely constrained by inadequate funding, corruption, overlapping jurisdictions, and outdated penalties. NGOs including WWF, WCS, and IUCN fill important gaps in monitoring, advocacy, and capacity building. Linking formal policy to practical conservation outcomes demands stronger governance institutions, adequate resourcing, genuine community engagement, and robust monitoring systems, as well as the political will to address the governance failures that currently limit the effectiveness of Nigeria conservation policy framework.

Glossary of Terms

- **CITES:** the Convention on International Trade in Endangered Species of Wild Fauna and Flora, an international agreement regulating wildlife trade through a three-appendix permit system.
- **Convention on Biological Diversity (CBD):** the principal international treaty for biodiversity conservation, with objectives of conservation, sustainable use, and equitable benefit sharing from genetic resources.
- **Environmental impact assessment (EIA):** a formal evaluation of the likely environmental consequences of a proposed development before a decision to proceed is made.

- **Intergenerational equity:** the obligation to manage natural resources so that future generations have the same or better options as the present generation.
- **Kunming-Montreal Global Biodiversity Framework:** the 2022 global biodiversity targets including the 30x30 commitment to protect 30 percent of land and oceans by 2030.
- **NESREA:** the National Environmental Standards and Regulations Enforcement Agency, the Nigerian federal agency responsible for enforcing environmental laws including wildlife regulations.
- **Policy coherence:** the alignment of conservation policy with policies in other sectors to prevent cross-sectoral policies from undermining conservation objectives.
- **Precautionary principle:** the requirement to take protective action even when scientific certainty about a threat is incomplete, especially for potentially irreversible outcomes.
- **Ramsar Convention:** the 1971 intergovernmental treaty for the conservation and wise use of wetlands, requiring party countries to designate Ramsar sites.
- **Sustainable use:** the use of biological resources at levels that allow their long-term renewal without leading to population or ecosystem decline.

Concept Check Questions [Series 4]

Objective Questions

1. Conservation policy addresses the systematic undervaluation of wildlife because ecological services and _____ values are not captured in market prices. (Linked to SLO 4.1)
2. CITES Appendix _____ lists species threatened with extinction for which commercial international trade is generally prohibited. (Linked to SLO 4.2)
3. The CBD has three objectives: conservation, sustainable use, and fair and equitable _____ of benefits from genetic resources. (Linked to SLO 4.2)
4. The Endangered Species Act gives effect to Nigeria _____ obligations by prohibiting trade in listed species without permits. (Linked to SLO 4.3)
5. _____ undermines wildlife law enforcement in Nigeria and allows illegal trade to continue despite formal legal prohibitions. (Linked to SLO 4.3)

Short-Answer Questions

1. Explain why market forces alone do not adequately protect wildlife. (Linked to SLO 4.1)
2. Explain the three CITES appendices. (Linked to SLO 4.2)
3. Name two federal laws relevant to wildlife conservation in Nigeria. (Linked to SLO 4.3)
4. Name three challenges facing wildlife law enforcement in Nigeria. (Linked to SLO 4.3)
5. Name three roles NGOs play in wildlife conservation in Nigeria. (Linked to SLO 4.4)

Long-Answer Questions

1. Explain the principles of conservation policy and describe major international conservation agreements. (Linked to SLOs 4.1, 4.2)
2. Describe Nigeria wildlife legislation and enforcement challenges, and explain how conservation policy is put into practice. (Linked to SLOs 4.3, 4.4)

Answers to Concept Check Questions [Series 4]

Objective Questions

1. Existence.
2. I.
3. Sharing.
4. CITES.
5. Corruption.

Short-Answer Questions

1. Many wildlife values (ecological services, existence values) are not captured in market prices, so wildlife is systematically undervalued and overexploited in the absence of regulatory intervention.
2. Appendix I: commercial trade prohibited (most threatened species). Appendix II: trade permitted with export permits confirming legal and sustainable origin. Appendix III: species protected in one country requesting international assistance controlling trade.
3. Endangered Species (Control of International Trade and Traffic) Act and the National Parks Service Act.
4. Inadequate funding and staffing, corruption, and overlapping/conflicting jurisdictions between federal and state agencies (or weak judicial capacity, outdated penalties).
5. Biological monitoring and research, ground conservation programmes, and advocacy and litigation (or capacity building, fundraising, community engagement).

Long-Answer Questions

1. Conservation policy addresses wildlife undervaluation through regulatory, economic, and voluntary instruments. Key concepts: sustainable use, precautionary principle, intergenerational equity, EIA, policy coherence. International agreements: CITES (three-appendix trade regulation), CBD (conservation, sustainable use, benefit sharing; Kunming-Montreal 30x30 target; Nagoya Protocol), Ramsar (wetlands), CMS (migratory species), World Heritage Convention (natural heritage sites), Algiers Convention (Africa).
2. Nigeria legislation: Endangered Species Act (CITES implementation), National Parks Service Act (NNPS, national park management), NESREA Act (enforcement agency), EIA Act,

Forestry Act. Enforcement challenges: underfunding, corruption, overlapping jurisdictions, weak judicial capacity, outdated penalties. Practice links: NGOs (WCS, WWF, AWF, IUCN) fill monitoring, advocacy, capacity gaps; stronger governance requires policy coherence, adequate resourcing, community engagement, monitoring and evaluation systems.

Answers to Pilot Questions [Series 4]

Part 4.1

1. Many wildlife values, including ecological services and existence values, are not reflected in market prices; without regulatory intervention, wildlife is systematically undervalued and overexploited by market actors.
2. Sustainable use means using biological resources at rates and in ways that allow their long-term renewal, so that they remain available for present and future users without causing population or ecosystem decline.
3. The precautionary principle requires protective action even when scientific certainty is incomplete; it is particularly important in wildlife conservation because extinction is irreversible, making inaction under uncertainty especially dangerous.
4. Regulatory instruments prohibit or restrict activities by law (e.g. hunting bans, permit requirements); economic instruments create financial incentives or disincentives (e.g. payments for ecosystem services, fines for offences).
5. An EIA is a formal evaluation of the likely environmental consequences of a proposed development before approval; applied to projects with potentially significant wildlife or habitat impacts.

Part 4.2

1. Appendix I: trade prohibited, most threatened species. Appendix II: trade allowed with export permit confirming legal and sustainable origin. Appendix III: national protection with international trade control assistance requested.
2. African elephants (most populations) and African grey parrots (or any two valid Appendix I African species, e.g. mountain gorilla, chimpanzee, pangolins).

3. Conservation of biological diversity, sustainable use of its components, and the fair and equitable sharing of benefits arising from the utilisation of genetic resources.
4. The 30x30 target commits CBD parties to protect at least 30 percent of land and ocean areas under formal protection by 2030.
5. The Ramsar Convention promotes conservation and wise use of wetlands; Nigeria has designated Lake Chad and parts of the Niger Delta as Ramsar sites.

Part 4.3

1. The Endangered Species (Control of International Trade and Traffic) Act and the National Parks Service Act (or NESREA Establishment Act, EIA Act).
2. NESREA is the federal agency responsible for enforcing environmental laws and regulations in Nigeria, including those relating to wildlife conservation and illegal trade.
3. The National Parks Service Act establishes the NNPS as the federal agency for national park management, defines the legal framework for protected area designation and management planning, and prohibits extractive activities (hunting, logging, farming) within park boundaries.
4. Inadequate funding and staffing of wildlife agencies, corruption undermining prosecution, and overlapping jurisdictions between federal and state authorities (or weak judicial capacity, outdated and inadequate penalties).
5. Inadequate penalties, some dating from the 1960s, are trivial compared to the commercial value of illegal wildlife products; professional traffickers treat fines as an acceptable operating cost rather than a meaningful deterrent.

Part 4.4

1. Legal authority, institutional capacity, transparency and accountability, and participation.
2. Policy coherence is the alignment of conservation policy with other sectoral policies; it matters because agricultural expansion, land use, or infrastructure policies that incentivise habitat conversion can easily override the effects of conservation legislation.
3. Biological monitoring and research, ground conservation programmes, and advocacy and litigation (or capacity building, fundraising, community engagement).
4. Wildlife Conservation Society (WCS) and World Wide Fund for Nature (WWF) (or African Wildlife Foundation, IUCN).

5. Improving funding and resourcing of management agencies and strengthening community engagement and benefit-sharing provisions of protected area management (or developing monitoring and evaluation systems, legislative reform to increase penalties).

References and Attribution

Textual References (Books and External Sources)

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Figures, Plates, Tables, and Boxes

- Figure 4.1: Conservation policy foundations Attribution: AI generated. Suggested OER search string: "conservation policy wildlife law regulatory instruments precautionary principle sustainable use biodiversity OER".
- Figure 4.2: International conservation agreements Attribution: AI generated. Suggested OER search string: "CITES CBD Convention on Biological Diversity Ramsar Bonn Convention international wildlife law conservation agreements Nigeria OER".
- Figure 4.3: Nigeria wildlife legislation and enforcement challenges Attribution: AI generated. Suggested OER search string: "Nigeria wildlife law Endangered Species Act National Parks Service Act CITES enforcement challenges poaching OER".
- Figure 4.4: Conservation policy implementation and NGO roles Attribution: AI generated. Suggested OER search string: "conservation governance NGO IUCN WWF WCS Nigeria wildlife policy implementation community engagement monitoring OER".

Course code: BIO 403

Course title: Wildlife Conservation and Management

Course credit load: 2 Units

Series 5: Climate Change and Wildlife

- **Part 5.1: Climate Change: Mechanisms and Observed Trends**
  - Sub Part 5.1.1: The greenhouse effect and climate change drivers
  - Sub Part 5.1.2: Observed and projected climate trends
  - Sub Part 5.1.3: Climate change in Nigeria and West Africa
- **Part 5.2: Impacts of Climate Change on Wildlife**
  - Sub Part 5.2.1: Effects on species distribution and phenology
  - Sub Part 5.2.2: Effects on wildlife populations and ecosystems
  - Sub Part 5.2.3: Interactions between climate change and other threats
- **Part 5.3: Wildlife and Ecosystem Responses to Climate Change**
  - Sub Part 5.3.1: Behavioural and physiological responses
  - Sub Part 5.3.2: Evolutionary responses and adaptation
  - Sub Part 5.3.3: Ecosystem-level responses
- **Part 5.4: Climate Change Adaptation and Mitigation for Wildlife**
  - Sub Part 5.4.1: Climate-smart conservation planning
  - Sub Part 5.4.2: Wildlife corridors and assisted migration
  - Sub Part 5.4.3: The role of wildlife and ecosystems in climate mitigation

Introduction

Climate change is now widely recognised as one of the most serious long-term threats to biodiversity and wildlife conservation worldwide, acting alongside habitat loss, overexploitation, invasive species, and pollution to push many species toward extinction. Rising temperatures, shifting precipitation patterns, increasing frequency and severity of extreme weather events, and rising sea levels are already altering the distribution, abundance, and behaviour of wildlife across all ecosystems, and the pace of change is accelerating.

This Series covers the mechanisms and observed trends of climate change with particular reference to Nigeria and West Africa; the direct and indirect impacts of climate change on wildlife species, populations, and ecosystems; the behavioural, physiological, and evolutionary responses that species and ecosystems exhibit to changing conditions; and the practical conservation responses including climate-smart conservation planning, habitat connectivity for species movement, assisted migration, and the contributions of wildlife and natural ecosystems to climate mitigation through carbon storage and sequestration.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 5.1** explain the mechanisms of climate change and describe observed and projected climate trends in Nigeria and West Africa,
- **SLO 5.2** describe the impacts of climate change on wildlife species, populations, and ecosystems, including interactions with other threats,
- **SLO 5.3** describe the behavioural, physiological, evolutionary, and ecosystem-level responses of wildlife to climate change, and
- **SLO 5.4** explain climate-smart conservation planning, wildlife corridors, assisted migration, and the role of ecosystems in climate mitigation.

5.1 Climate Change: Mechanisms and Observed Trends

5.1.1 The greenhouse effect and climate change drivers

The greenhouse effect is the natural process by which certain gases in the atmosphere (primarily water vapour, carbon dioxide, methane, and nitrous oxide) absorb outgoing infrared radiation from the Earth surface and re-emit it in all directions, warming the lower atmosphere and surface; this natural greenhouse effect is essential for maintaining surface temperatures suitable for life, but human activities have substantially increased the concentrations of greenhouse gases in the atmosphere since the Industrial Revolution, intensifying the greenhouse effect and causing the additional warming now observed as anthropogenic climate change.

The primary human drivers of climate change include fossil fuel combustion (generating the majority of the additional carbon dioxide in the atmosphere), deforestation and land-use change (releasing stored carbon and reducing the capacity of terrestrial ecosystems to absorb carbon dioxide), agriculture (a major source of methane from livestock and rice cultivation, and nitrous oxide from fertiliser use), and industrial processes (including cement production and chemical manufacturing); the atmospheric concentration of carbon dioxide has risen from approximately 280 parts per million before industrialisation to over 420 parts per million today, a level not seen for at least the past 3 million years.

Fill in the blank: The natural _____ effect is intensified by human activities that increase atmospheric concentrations of carbon dioxide, methane, and other greenhouse gases, causing additional warming.

5.1.2 Observed and projected climate trends

Global average surface temperature has increased by approximately 1.1 to 1.2 degrees Celsius above pre-industrial levels as of the early 2020s, with the rate of warming accelerating; observed impacts include widespread retreat of glaciers and sea ice, rising sea levels (approximately 3 to 4 mm per year globally), shifts in precipitation patterns (with some regions experiencing increased rainfall and flooding while others experience intensified drought), increasing frequency and

intensity of extreme heat events, tropical cyclones, and heavy rainfall events, and shifts in the timing of seasonal events such as snowmelt and monsoons.

Under current national emissions reduction commitments, global warming is projected to reach 2.5 to 3 degrees Celsius above pre-industrial levels by 2100, well above the 1.5 degree and 2 degree thresholds identified in the Paris Agreement as the levels beyond which the risks of severe, widespread, and irreversible impacts on ecosystems and human society become substantially greater; achieving the Paris Agreement goals requires rapid and deep reductions in greenhouse gas emissions from all major emitting sectors, alongside the protection and restoration of natural carbon sinks including forests, wetlands, and other ecosystems.

Fill in the blank: Global average surface temperature has increased by approximately _____ degrees Celsius above pre-industrial levels as of the early 2020s, with the rate of warming accelerating.

5.1.3 Climate change in Nigeria and West Africa

Nigeria and West Africa are highly vulnerable to climate change impacts, with the region already experiencing significant warming (approximately 0.5 to 1.5 degrees Celsius over the twentieth century), increased frequency of extreme heat events, and shifts in rainfall patterns; the Sahel and far north of Nigeria are experiencing accelerating desertification and Lake Chad has shrunk to a fraction of its former extent due to a combination of reduced rainfall, increased evaporation, and increased irrigation abstraction, profoundly affecting the wildlife and millions of people who depended on its resources.

Projected future climate scenarios for Nigeria and West Africa suggest continued temperature increases (2 to 4 degrees Celsius by 2100 under high-emission scenarios), further intensification of drought in the north and increased rainfall variability across the country, rising sea levels threatening the Niger Delta and coastal mangrove ecosystems, and more frequent extreme rainfall events increasing flood risk in the middle-belt and southern zones; these changes will compound the existing pressures of deforestation, overexploitation, and habitat fragmentation on Nigeria wildlife, making climate change adaptation an essential component of the national conservation strategy.

Fill in the blank: Lake _____ has shrunk to a fraction of its former extent due to reduced rainfall, increased evaporation, and irrigation abstraction, affecting both wildlife and millions of people in the region.

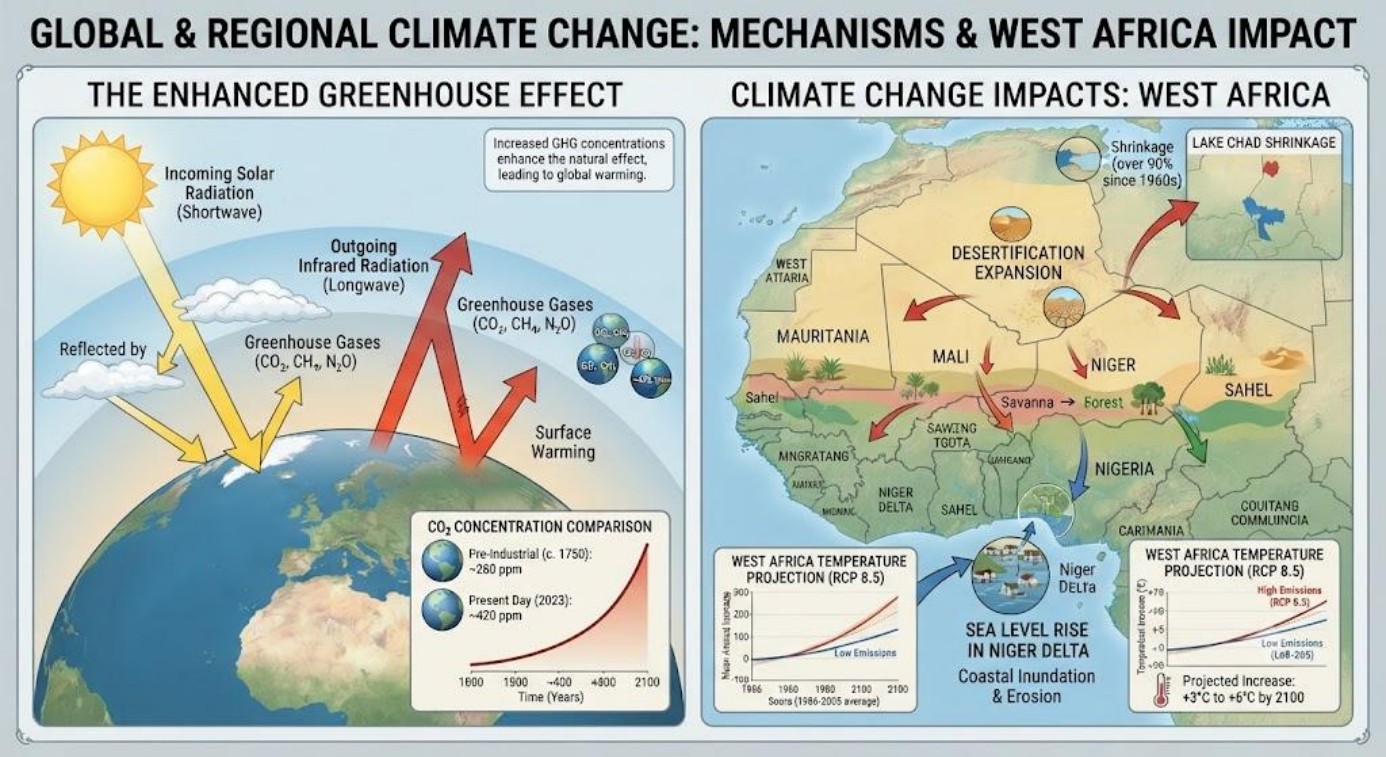

Figure 5.1: Climate change mechanisms and West Africa trends

Pilot questions 5.1

1. Explain the natural greenhouse effect and how human activities have intensified it.
2. Name three human activities that drive anthropogenic climate change.
3. State the observed global temperature increase above pre-industrial levels as of the early 2020s.
4. Describe two observed climate change impacts in Nigeria or West Africa.
5. Explain why Nigeria wildlife is particularly vulnerable to future climate change.

5.2 Impacts of Climate Change on Wildlife

5.2.1 Effects on species distribution and phenology

Climate change is already causing documented shifts in the geographic ranges of many species, as individuals and populations track the shifting location of their suitable climatic conditions; generally, species are moving poleward and to higher elevations as temperatures increase, following the movement of the climatic envelope in which they can survive and reproduce; in Africa including Nigeria, species are expected to shift southward (toward the equator) or to higher elevations in response to warming and aridification in northern areas, but many face significant barriers to movement including fragmented habitat, land use change, and urban development.

Phenology, the timing of seasonal biological events such as breeding, flowering, migration, and emergence, is being disrupted by climate change; many species in temperate regions have been documented breeding earlier in the spring, flowers opening earlier, and migratory birds arriving earlier, but in some cases different interacting species (such as insects and the birds that depend on them for chick-rearing food) are shifting their phenology at different rates, producing phenological mismatches in which important resources are no longer available at the time they are needed; in tropical systems such as Nigeria, phenological shifts are less well documented but are expected to affect seasonal timing of rainfall-dependent breeding and fruiting.

Fill in the blank: Phenological _____ occur when interacting species shift their seasonal timing at different rates, causing important resources to be unavailable when they are needed by a dependent species.

5.2.2 Effects on wildlife populations and ecosystems

Climate change affects wildlife populations through multiple pathways: direct thermal stress (temperatures exceeding the physiological tolerance limits of species, particularly during extreme heat events, causing heat stress, reproductive failure, and mortality); altered water availability (drought reducing the availability of drinking water and aquatic habitat, and affecting vegetation productivity that supports herbivore populations); habitat loss and degradation

through climate-driven vegetation change (such as the conversion of savanna to semi-arid scrub in the Sahel as rainfall declines, removing habitat for savanna-dependent wildlife species).

Marine and freshwater ecosystems are particularly sensitive to climate change: ocean warming and acidification (caused by the absorption of anthropogenic carbon dioxide) are bleaching coral reefs, disrupting marine fisheries, and threatening marine wildlife worldwide; freshwater temperature increases affect fish physiology and oxygen availability, while altered rainfall patterns cause unpredictable flood-drought cycles that disrupt aquatic community composition; in Nigeria, climate-driven declines in Lake Chad water levels and Niger Delta wetland productivity are already affecting waterbird, fish, and crocodilian populations that depend on these systems.

Fill in the blank: Ocean warming and _____ , caused by absorption of anthropogenic carbon dioxide, are bleaching coral reefs and disrupting marine wildlife worldwide.

5.2.3 Interactions between climate change and other threats

Climate change does not act alone; it interacts with and amplifies the other major threats to wildlife identified in the previous Series; habitat fragmentation reduces the ability of species to move in response to climate change by blocking dispersal pathways between suitable patches; overexploitation reduces population sizes to levels at which the genetic diversity and numerical resilience needed to adapt to new conditions are compromised; invasive species that are better adapted to warmer or drier conditions may expand their ranges into wildlife communities that are already stressed by climate change, displacing native species.

The compound or synergistic effects of multiple simultaneous threats are often more severe than the sum of individual effects; a species facing both climate change and habitat loss may go extinct at warming levels that would be tolerable if habitat were intact, because the combination eliminates both the habitat the species currently occupies and the pathways needed to reach alternative habitat; this interaction effect underscores the importance of addressing all major wildlife threats simultaneously rather than treating climate change adaptation as separate from conventional conservation of habitat and the control of hunting and trade.

Fill in the blank: Habitat _____ reduces the ability of species to move in response to climate change by blocking dispersal pathways, compounding the vulnerability of already-threatened populations.

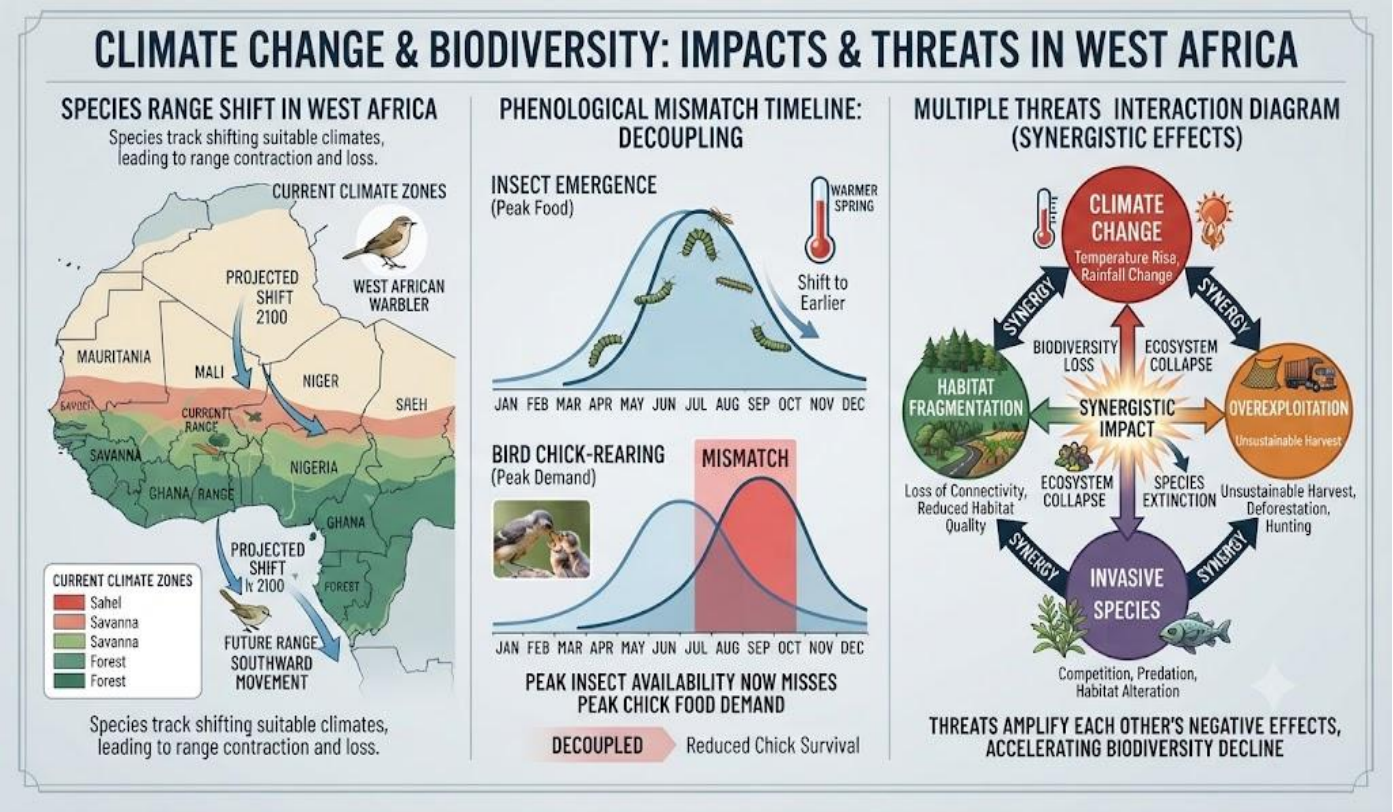

Figure 5.2: Climate change impacts on wildlife

Pilot questions 5.2

1. Explain what a phenological mismatch is and give one example.
2. Name three pathways through which climate change affects wildlife populations.
3. Explain how ocean acidification affects marine wildlife.
4. Explain how habitat fragmentation interacts with climate change to increase species extinction risk.
5. Explain why addressing climate change in isolation from other wildlife threats is insufficient.

5.3 Wildlife and Ecosystem Responses to Climate Change

5.3.1 Behavioural and physiological responses

Many wildlife species are already exhibiting behavioural responses to climate change: altered timing of migration (migratory birds departing and arriving earlier), changes in daily activity patterns (nocturnal or crepuscular activity increasing as daytime temperatures rise beyond the thermal comfort range), shifts in home range use (avoiding hotter, more exposed areas and concentrating in shaded or cooler microhabitats), and changes in diet or foraging behaviour (exploiting food resources that were previously unavailable or less abundant due to changed plant phenology or prey distribution).

Physiological responses include acclimatisation (reversible within-lifetime adjustments in physiological parameters such as metabolic rate, heat tolerance, and water balance in response to experienced temperatures) and changes in body size; Bergmann rule (the observation that individuals within a species tend to be larger in cooler climates) predicts that warming should lead to smaller body sizes within populations, and reductions in body size have been documented in multiple vertebrate species in response to warming; smaller body size may reduce reproductive output and competitive ability, with implications for population persistence.

Fill in the blank: _____ is the reversible within-lifetime adjustment of physiological parameters such as heat tolerance in response to experienced temperatures, distinct from genetic evolutionary change.

5.3.2 Evolutionary responses and adaptation

Evolutionary adaptation to climate change requires heritable genetic variation in the traits under selection, sufficiently rapid selection for favourable alleles, and population sizes large enough to maintain genetic diversity and avoid inbreeding depression; microevolution in response to climate change has been documented in several species, including shifts in the timing of breeding in birds and insects, changes in wing length or body coloration correlated with temperature, and tolerance of higher temperatures in some plant and animal populations; however, the rate of climate change is unprecedented in evolutionary terms, and many species

with slow generation times, small populations, or low genetic diversity may be unable to evolve fast enough to keep pace.

Phenotypic plasticity (the ability of individuals to change their phenotype in response to environmental conditions without genetic change, through developmental, behavioural, or physiological mechanisms) can buffer populations against climate change in the short term, buying time for evolutionary adaptation or migration to occur; the limits of plasticity are a critical determinant of vulnerability: species with high plasticity may be able to tolerate wider climatic variation than closely related species with lower plasticity, explaining some of the variation in climate vulnerability observed across taxonomic groups.

Fill in the blank: Phenotypic _____ is the ability of individuals to change their phenotype in response to environmental conditions without genetic change, potentially buffering populations against rapid climate change in the short term.

5.3.3 Ecosystem-level responses

At the ecosystem level, climate change is altering the composition, structure, and function of communities as species respond at different rates and through different mechanisms; biome boundary shifts (the movement of the boundaries between major vegetation types such as forest, savanna, and semi-arid scrub) driven by changing rainfall and temperature are already observable in parts of Africa including the Sahel, where the forest-savanna boundary is shifting; changes in community composition (as some species respond faster or more successfully than others, altering competitive relationships and trophic interactions) may produce novel communities with no historical analogue.

Ecosystem functions such as primary productivity, carbon cycling, water regulation, and decomposition rates are all sensitive to temperature and moisture changes; increases in drought frequency and severity are reducing vegetation productivity and increasing fire frequency in many savanna and grassland ecosystems, with cascading effects on herbivore biomass and predator populations; the loss of keystone species through climate-driven range contractions or local extinctions can trigger trophic cascades that restructure entire communities, potentially shifting ecosystems to alternative stable states from which recovery is difficult.

Fill in the blank: Biome _____ shifts, the movement of boundaries between major vegetation types driven by changing rainfall and temperature, are already observable in parts of Africa including the Sahel.

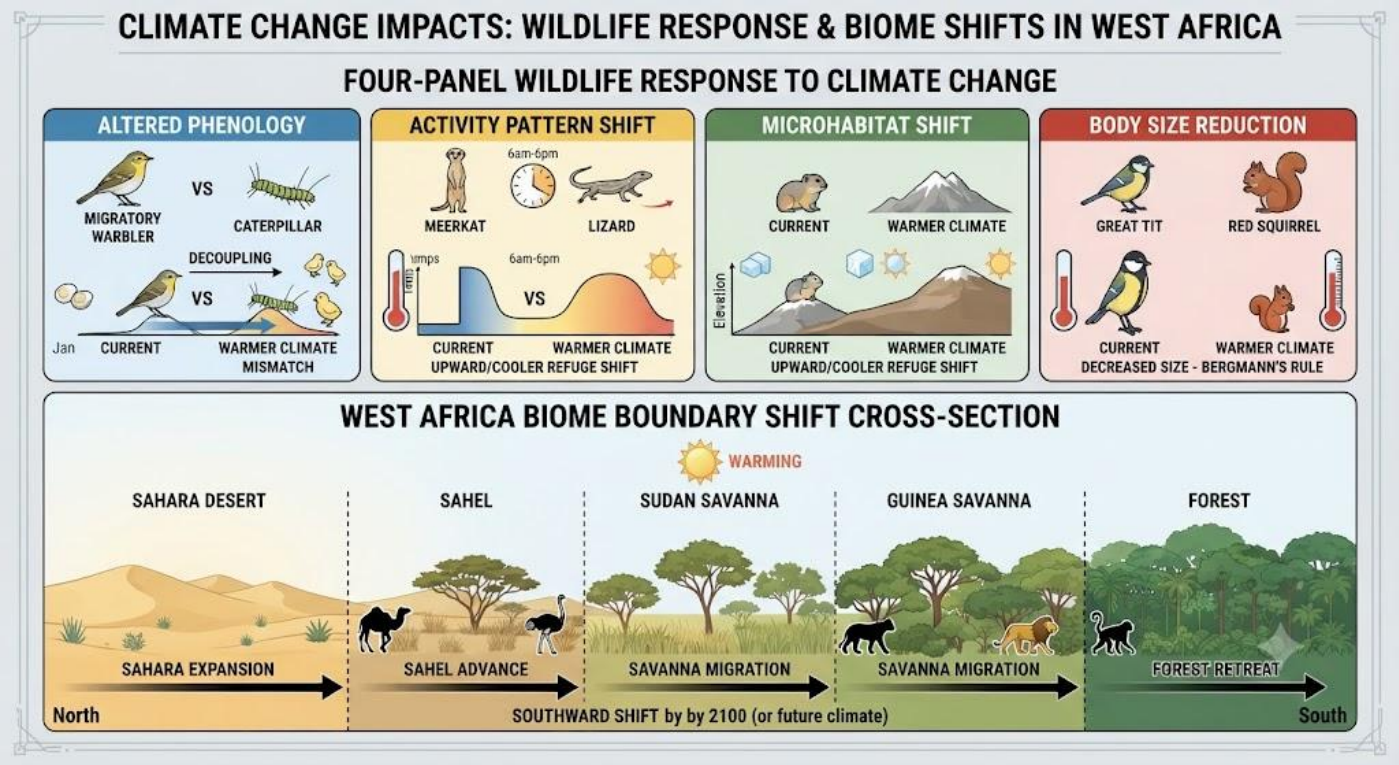

Figure 5.3: Wildlife responses to climate change

Pilot questions 5.3

1. Name three behavioural responses of wildlife to climate change.
2. Explain Bergmann rule and how climate change is expected to affect body size.
3. Distinguish between acclimatisation and evolutionary adaptation.
4. Explain what phenotypic plasticity is and why it matters for climate change vulnerability.
5. Explain what a biome boundary shift is and give an example from Africa.

5.4 Climate Change Adaptation and Mitigation for Wildlife

5.4.1 Climate-smart conservation planning

Climate-smart conservation planning integrates climate change projections into the design and management of protected area networks and conservation strategies, rather than treating current conditions as a fixed baseline; key approaches include: identifying climate refugia (areas projected to remain climatically suitable for biodiversity under future warming scenarios, due to topographic, coastal, or other features that buffer local temperatures and moisture levels) as priority areas for protection; protecting a range of elevational and latitudinal gradients within protected area networks to provide the spectrum of future climatic conditions across which species can move.

Species distribution models (projecting where species currently suitable climate space will be located under future scenarios) are an important tool in climate-smart conservation planning, allowing planners to identify where species ranges will contract, where new habitat may become suitable, and which areas are likely to become "climate change winners" versus "climate change losers"; adaptive management frameworks that schedule regular review of conservation strategies in light of new climate observations and projections allow conservation plans to be updated as understanding of climate change improves and as the conservation landscape evolves.

Fill in the blank: Climate _____ are areas projected to remain climatically suitable for biodiversity under future warming scenarios due to topographic or coastal features that buffer local conditions.

5.4.2 Wildlife corridors and assisted migration

Wildlife corridors (strips or networks of habitat connecting otherwise isolated protected areas or habitat patches) are one of the most important tools for enabling species to move in response to climate change, by providing pathways through the landscape matrix; corridor design for climate change adaptation should consider the direction and rate of projected range shifts, ensuring that corridors are oriented to facilitate movement in the direction of suitable future habitat rather than simply connecting existing patches; in Nigeria, identifying and establishing corridors between

the major national parks and forest reserves would significantly improve the capacity of wildlife populations to respond to climate-driven range shifts.

Assisted migration (the deliberate translocation of species or populations to locations outside their current range but within their projected future suitable habitat) is a more interventionist approach to climate change adaptation, appropriate for species with very restricted ranges, poor dispersal ability, or no available corridor, and for which the target location meets habitat suitability requirements; assisted migration requires careful risk assessment (to avoid introducing species that might become invasive or transmit disease to resident wildlife) and legal and regulatory frameworks that govern translocation, making it a measure of last resort for species that cannot respond through natural movement.

Fill in the blank: Assisted _____ is the deliberate translocation of species to locations within their projected future suitable habitat when natural movement through corridors is not possible.

5.4.3 The role of wildlife and ecosystems in climate mitigation

Natural ecosystems, including forests, wetlands, and grasslands, store enormous quantities of carbon in living biomass and soils, and their protection and restoration represents one of the most cost-effective strategies for reducing net greenhouse gas emissions (nature-based solutions to climate change); Nigeria forests, including the Cross River State rainforests and other remaining primary forests, store significant quantities of carbon that would be released if converted to agriculture or degraded by logging; the protection of these forests through effective wildlife conservation management therefore contributes directly to climate mitigation as well as biodiversity conservation.

Wildlife itself plays important roles in carbon cycling: large herbivores regulate vegetation structure and carbon storage in grasslands and savannas (with different grazing intensities producing different balances between grass and woody plant carbon stores); forest elephants are known to promote the growth of large hardwood trees (which store more carbon per tree than smaller-statured trees) through seed dispersal and the opening of canopy gaps; the concept of the carbon-biodiversity nexus recognises that protecting wildlife and its habitat simultaneously

addresses both the biodiversity crisis and the climate crisis, making wildlife conservation investments particularly high-value from a global environmental perspective.

Fill in the blank: Forest _____ promote the growth of large hardwood trees that store more carbon per tree through seed dispersal and canopy gap creation, illustrating the link between wildlife conservation and climate mitigation.

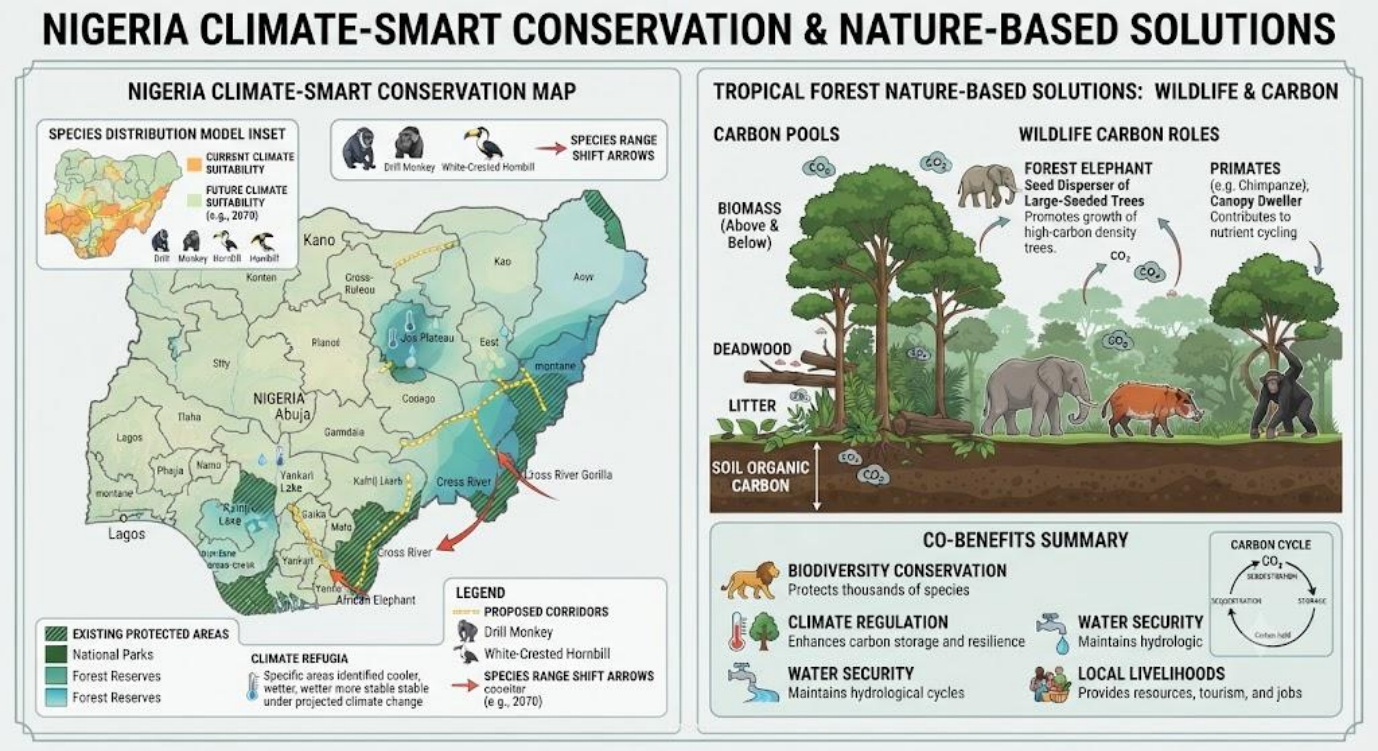

Figure 5.4: Climate-smart conservation and mitigation

Pilot questions 5.4

1. Define climate-smart conservation planning and give two of its key approaches.
2. Explain what a climate refugium is and why identifying them is important for conservation planning.
3. Explain how wildlife corridors can help species respond to climate change.
4. Define assisted migration and explain when it is appropriate.
5. Explain two ways in which wildlife contributes to carbon storage and climate mitigation.

Series Summary

This Series examined climate change as a major and accelerating threat to wildlife conservation in Nigeria and globally. The intensification of the greenhouse effect by human activities, particularly fossil fuel combustion and deforestation, has already warmed the global average temperature by over one degree Celsius, causing observable shifts in species ranges, phenological mismatches, habitat degradation, and ecosystem disruption. In Nigeria and West Africa, Lake Chad shrinkage, advancing desertification, rising sea levels threatening the Niger Delta, and increased rainfall variability compound the severe pressures already facing wildlife from habitat loss and overexploitation.

Wildlife responses to climate change range from short-term behavioural and physiological adjustments through phenotypic plasticity to longer-term evolutionary adaptation, though the unprecedented pace of current climate change exceeds the adaptive capacity of many species. Climate-smart conservation planning, using species distribution models to identify refugia and design corridor networks, and assisted migration for the most vulnerable species, are the primary conservation tools. The recognition that intact, wildlife-rich ecosystems are powerful carbon stores and nature-based climate solutions strengthens the case that wildlife conservation and climate mitigation are inseparable goals that must be pursued together.

Glossary of Terms

- **Acclimatisation:** a reversible within-lifetime physiological adjustment to changing environmental conditions, distinct from genetic evolutionary change.
- **Assisted migration:** the deliberate translocation of a species or population to locations outside its current range but within its projected future suitable habitat under climate change.
- **Biome boundary shift:** the movement of the boundary between major vegetation types (such as savanna and forest) driven by changing temperature and rainfall patterns.
- **Climate refugium:** an area projected to remain climatically suitable for biodiversity under future warming due to topographic, coastal, or other features that buffer local conditions.

- **Climate-smart conservation:** conservation planning that integrates climate change projections into the design and management of protected area networks and conservation strategies.
- **Greenhouse effect:** the warming of Earth lower atmosphere caused by the absorption and re-emission of infrared radiation by greenhouse gases.
- **Nature-based solutions:** conservation and restoration of natural ecosystems as strategies for addressing climate change and other environmental challenges.
- **Phenological mismatch:** the disruption of ecological relationships that occurs when interacting species shift their seasonal timing at different rates in response to climate change.
- **Phenotypic plasticity:** the ability of an individual organism to change its phenotype in response to environmental conditions without genetic change.
- **Species distribution model:** a model projecting the current and future geographic range of a species based on its climatic requirements.

Concept Check Questions [Series 5]

Objective Questions

1. The natural _____ effect is intensified by human activities, causing additional warming of Earth atmosphere. (Linked to SLO 5.1)
2. Global average surface temperature has increased by approximately 1.1 degrees Celsius above _____ -industrial levels as of the early 2020s. (Linked to SLO 5.1)
3. Phenological _____ occur when interacting species shift their seasonal timing at different rates, disrupting ecological relationships. (Linked to SLO 5.2)
4. _____ is the reversible within-lifetime adjustment of physiological parameters in response to experienced temperatures. (Linked to SLO 5.3)
5. Climate _____ are areas projected to remain suitable for biodiversity under future warming due to buffering features. (Linked to SLO 5.4)

Short-Answer Questions

1. Name three human activities driving anthropogenic climate change. (Linked to SLO 5.1)
2. Describe two observed climate change impacts in Nigeria or West Africa. (Linked to SLO 5.1)
3. Explain what a phenological mismatch is and give one example. (Linked to SLO 5.2)
4. Distinguish between acclimatisation and evolutionary adaptation to climate change. (Linked to SLO 5.3)
5. Explain two ways wildlife or ecosystems contribute to climate mitigation. (Linked to SLO 5.4)

Long-Answer Questions

1. Describe the mechanisms of climate change and its observed and projected impacts on wildlife. (Linked to SLOs 5.1, 5.2)
2. Describe wildlife responses to climate change and explain conservation adaptation and mitigation strategies. (Linked to SLOs 5.3, 5.4)

Answers to Concept Check Questions [Series 5]

Objective Questions

1. Greenhouse.
2. Pre.
3. Mismatches.
4. Acclimatisation.
5. Refugia.

Short-Answer Questions

1. Fossil fuel combustion, deforestation and land-use change, and agriculture (livestock/rice methane and fertiliser nitrous oxide).
2. Lake Chad shrinkage (due to reduced rainfall, increased evaporation, and irrigation abstraction) and advancing desertification in northern Nigeria (or rising sea levels threatening Niger Delta mangroves).
3. A phenological mismatch occurs when interacting species shift their seasonal timing at different rates; example: insects advancing their peak abundance earlier in spring while the migratory birds that depend on them for chick-rearing food do not advance as fast, creating a gap between food availability and peak demand.
4. Acclimatisation is a reversible within-lifetime physiological adjustment with no genetic change; evolutionary adaptation involves heritable genetic change in response to selection, persisting across generations.
5. Natural forest ecosystems store large quantities of carbon in biomass and soils, and their protection reduces net emissions; forest elephants promote growth of large hardwood trees through seed dispersal, increasing carbon storage per unit area.

Long-Answer Questions

1. Climate change mechanism: human activities (fossil fuels, deforestation, agriculture) intensify the greenhouse effect, raising atmospheric CO2 from 280 to over 420 ppm; global temperature up 1.1 degrees C. Nigeria impacts: Lake Chad shrinkage, desertification advance, rising sea levels, increased rainfall variability. Wildlife impacts: species range shifts (southward in West Africa), phenological mismatches, thermal stress, habitat loss through

vegetation change, ocean acidification affecting marine life, freshwater disruption. Interaction with fragmentation, overexploitation, and invasive species creates synergistic threats.

2. Responses: behavioural (altered migration timing, nocturnal activity shift, microhabitat retreat), physiological (acclimatisation, body size reduction), evolutionary (microevolution documented in some species, limited by generation time and genetic diversity), phenotypic plasticity (short-term buffer). Ecosystem: biome boundary shifts, novel communities, trophic cascades. Adaptation: climate-smart planning (refugia, gradient protection, SDMs), corridors (oriented to range shift direction), assisted migration (last resort for poor-dispersers). Mitigation: nature-based solutions (forest carbon storage), wildlife roles in carbon cycling (elephants, herbivores).

Answers to Pilot Questions [Series 5]

Part 5.1

1. Greenhouse gases in the atmosphere absorb and re-emit outgoing infrared radiation, warming the lower atmosphere; human activities have increased greenhouse gas concentrations, intensifying this warming effect beyond the natural level.
2. Fossil fuel combustion, deforestation and land-use change, and agriculture (livestock methane, rice cultivation, fertiliser nitrous oxide).
3. Approximately 1.1 to 1.2 degrees Celsius above pre-industrial levels as of the early 2020s.
4. Lake Chad has shrunk dramatically due to reduced rainfall, increased evaporation, and irrigation abstraction; the Sahel and far north of Nigeria are experiencing advancing desertification.
5. Nigeria wildlife already faces severe pressure from habitat loss, overexploitation, and fragmentation; climate change adds further stress through warming, desertification, sea level rise, and rainfall variability, and fragmented habitats block species from moving in response.

Part 5.2

1. A phenological mismatch occurs when two interacting species respond to climate change by shifting their seasonal timing at different rates; example: migratory birds breeding earlier but

insect prey abundance peaking even earlier, reducing food availability for chicks at the critical period.

2. Direct thermal stress exceeding physiological tolerance limits, altered water availability causing drought stress on vegetation and water-dependent wildlife, and climate-driven vegetation change reducing or eliminating habitat for savanna or forest-dependent species.
3. Ocean acidification (from absorbed CO2) reduces carbonate ion concentration, impairing the ability of marine organisms including corals, molluscs, and some plankton to form calcium carbonate shells and skeletons, causing coral bleaching and disrupting marine food webs.
4. Fragmentation blocks dispersal pathways, preventing species from moving to track shifting suitable climatic conditions; a species trapped in a small habitat patch by surrounding unsuitable land may go extinct at warming levels that would be survivable if it could move to cooler refugia.
5. Multiple interacting threats produce synergistic effects more severe than any single threat; addressing only climate change while habitat continues to be destroyed leaves species with nowhere to move to, and addressing only habitat while emissions continue means species will be exposed to increasingly unsuitable climatic conditions.

Part 5.3

1. Altered migration timing (departing or arriving earlier), changes in daily activity patterns (increased nocturnal/crepuscular activity), and shifts in home range use toward cooler or shaded microhabitats.
2. Bergmann rule observes that individuals within a species tend to be larger in cooler climates; climate warming is expected to select for smaller body sizes within populations, and reductions in body size have been documented in vertebrate species warming.
3. Acclimatisation is a reversible within-lifetime physiological adjustment with no heritable genetic change; evolutionary adaptation involves heritable genetic change across generations in response to natural selection.
4. Phenotypic plasticity is the ability to change phenotype in response to environmental conditions without genetic change; species with high plasticity can tolerate wider climatic variation, making them less vulnerable to climate change than closely related species with lower plasticity.
5. A biome boundary shift is the movement of the boundary between major vegetation types driven by climate change; example: the Sahel-savanna boundary in West Africa is shifting southward as northern areas become more arid under reduced and more variable rainfall.

Part 5.4

1. Climate-smart conservation planning integrates climate change projections into conservation strategy design; key approaches include identifying climate refugia as priority protection areas and protecting elevational and latitudinal gradients to provide future climatic space for species movement.
2. A climate refugium is an area projected to remain climatically suitable under future warming due to topographic or coastal buffering; identifying them focuses protection resources on areas most likely to support biodiversity under future conditions.
3. Corridors provide dispersal pathways through the landscape matrix, allowing species to move in the direction of suitable future habitat as their current climatic envelope shifts; corridors oriented in the direction of projected range shifts are most effective.
4. Assisted migration is the deliberate translocation of a species to its projected future suitable habitat outside its current range; appropriate when the species has poor dispersal ability, no available corridor, and a highly restricted range under climate threat.
5. Natural forest ecosystems store large quantities of carbon in biomass and soils, reducing atmospheric CO2 when protected; forest elephants promote growth of large hardwood trees with higher carbon stores per tree through seed dispersal and canopy gap creation.

References and Attribution

Textual References (Books and External Sources)

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Figures, Plates, Tables, and Boxes

- Figure 5.1: Climate change mechanisms and West Africa trends Attribution: AI generated. Suggested OER search string: "greenhouse effect climate change West Africa Nigeria Lake Chad desertification projected warming temperature OER".
- Figure 5.2: Climate change impacts on wildlife Attribution: AI generated. Suggested OER search string: "climate change wildlife range shift phenology mismatch habitat fragmentation synergistic threats biodiversity OER".
- Figure 5.3: Wildlife responses to climate change Attribution: AI generated. Suggested OER search string: "climate change wildlife responses phenology activity pattern body size biome shift West Africa savanna forest OER".
- Figure 5.4: Climate-smart conservation and mitigation Attribution: AI generated. Suggested OER search string: "climate smart conservation wildlife corridors assisted migration nature based solutions carbon storage forest elephant Nigeria OER".