



Module 1.1 — Conservation Literacy

Section 5: Threats to Biodiversity

The Big Five Drivers, One Health, and Synergies.



**MPA Management
Training**

Learning Objectives

This section examines the critical threats facing global biodiversity, analyzing their drivers, health implications, and necessary conservation responses.



Analyze Drivers

Analyze the "Big Five" anthropogenic drivers of biodiversity loss and rank their impact across different biomes.



Evaluate One Health

Evaluate the link between habitat fragmentation, biodiversity loss, and the increased risk of zoonotic disease spillover.



Propose Responses

Propose evidence-based conservation responses to mitigate threats, emphasizing synergistic management strategies.

The Big Five Drivers — Overview

Drivers of Change

The IPBES Global Assessment identifies five direct anthropogenic drivers responsible for the rapid decline in nature. These threats do not act in isolation but often compound one another.

Understanding these drivers is critical for identifying appropriate conservation interventions and halting biodiversity loss.

i Rank ordered by global impact, Land/Sea Use Change remains the dominant driver, though Climate Change is the fastest growing threat.

Source: IPBES Global Assessment Report on Biodiversity and Ecosystem Services (2019)



Definition

The direct conversion, fragmentation, or degradation of natural habitats for human purposes. This includes deforestation for agriculture, urbanization, coastal reclamation, and dredging of marine environments. It is currently the single largest driver of biodiversity loss globally.



Ecological Impacts



Habitat Loss & Fragmentation

Large continuous habitats are broken into smaller, isolated patches, reducing the total livable area and preventing species migration.



Edge Effects

Changes in population or community structures that occur at the boundary of two or more habitats, often increasing vulnerability to predation and microclimate changes.



Genetic Isolation

Populations become separated, leading to reduced gene flow, inbreeding depression, and higher extinction risk for isolated groups.



Case Study: Haiti Deforestation

Stark Contrast: NASA satellite imagery reveals a sharp border between deforested Haiti (left) and forested Dominican Republic.

Critical Loss: Haiti retains <1% of its original primary forest (PNAS 2018), leading to severe soil erosion and landslide risks.

Coastal Impact: Widespread mangrove clearance for development and wetland drainage continues to degrade natural storm barriers.

Key Indicators

<1%
Primary Forest
Left

98%
Haiti Deforested

High
Erosion Risk

Sources: NASA, PNAS 2018, IPBES

Direct Exploitation of Organisms

Primary Driver #2

Definition

The unsustainable removal of animals and plants from the wild faster than they can reproduce. This includes overfishing, illegal wildlife trade, and unintentional bycatch. It disrupts food webs and can lead to rapid population collapses.



Caribbean Case Study: Reef Depletion



 90% of predatory fish are gone from Caribbean coral reefs due to historical overfishing.

 Queen Conch populations have declined by >50% across the region since the 1950s.

Ecological Cascades



Herbivore Loss & Algal Overgrowth

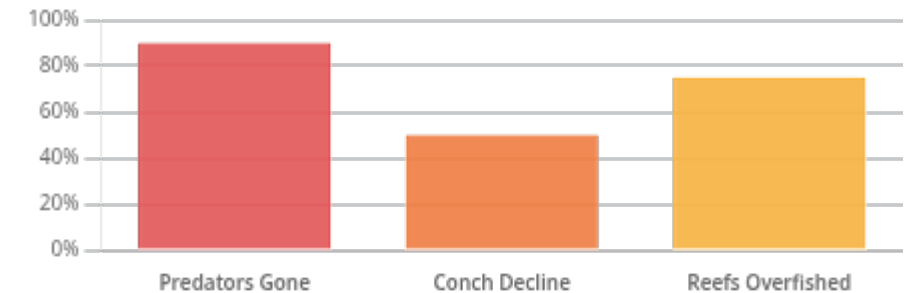
Overharvesting parrotfish and surgeonfish removes key grazers, allowing algae to smother corals (phase shift).



Predator Removal

Loss of sharks and groupers disrupts trophic balance, often leading to explosions of mesopredators or invasives.

Fishing Pressure Stats



Conservation Responses

Parrotfish
Bans

Managed
Access

No-Take
Zones

Definition

The fastest-growing threat, involving rising global temperatures, ocean acidification, sea-level rise, and more frequent extreme weather events. It acts as a "threat multiplier," exacerbating other stressors and pushing ecosystems beyond their tipping points.



Ecological Impacts



Coral Bleaching & Acidification

Thermal stress causes corals to expel symbiotic algae (bleaching), while lower pH weakens calcium carbonate structures.



Range Shifts & Phenology Mismatch

Species migrate poleward to find cooler waters; timing of biological events (breeding/migration) desynchronizes with food availability.



Deoxygenation & Sea-Level Rise

Warmer water holds less oxygen (hypoxia), while rising seas drown coastal habitats like mangroves and nesting beaches.

Caribbean Examples

Mass Bleaching Events: Recurring severe bleaching in 2005, 2010, 2015, 2017, and the unprecedented heat stress of 2023.

Hurricane Intensification: Stronger storms (Category 4-5) causing physical destruction of reefs and coastal vegetation.

Sargassum Blooms: Warming waters fueling massive macroalgal influxes that smother coastlines.

Definition

The introduction of harmful contaminants into the environment, including agricultural runoff, plastics, microplastics, oil spills, and untreated wastewater. Pollution alters water chemistry and creates toxic conditions.



Roatan "Sea of Plastic" Event



Sargassum Influx (Releases H₂S)

Caribbean Hotspots

Roatan, Honduras: Viral images (2017) captured a "sea of plastic" washing in from Guatemalan rivers, creating massive floating garbage patches.

Sargassum Crisis: Decomposing macroalgae releases hydrogen sulfide and ammonia, causing respiratory issues and creating coastal dead zones.

Plastic Load: The wider Caribbean region receives approximately **14 million tons** of ocean plastic annually.

Pollution Indicators

14M

Tons Plastic/Yr

2011

Sargassum Start

High

H₂S Risk



Impact: Plastic debris smothers coral reefs and entangles marine life, while nutrient runoff fuels hypoxia.

Definition & Pathways



Non-native species introduced to new environments that outcompete, prey upon, or bring diseases to native species. Primary pathways include shipping ballast water, aquaculture escapes, and pet trade releases. They are a leading cause of extinction on islands.

Ecological Impacts



Native Extirpations

Direct predation and competition leads to rapid decline of native populations (e.g., 79% recruitment decline in native fish on reefs with lionfish).



Economic Losses

Significant damage to agriculture, fisheries, and tourism, costing the Caribbean region an estimated ~\$1 Billion annually in lost revenue and management.



Controls & Biosecurity

Management relies on prevention (biosecurity), rapid response protocols, targeted removal programs, and community culling derbies.

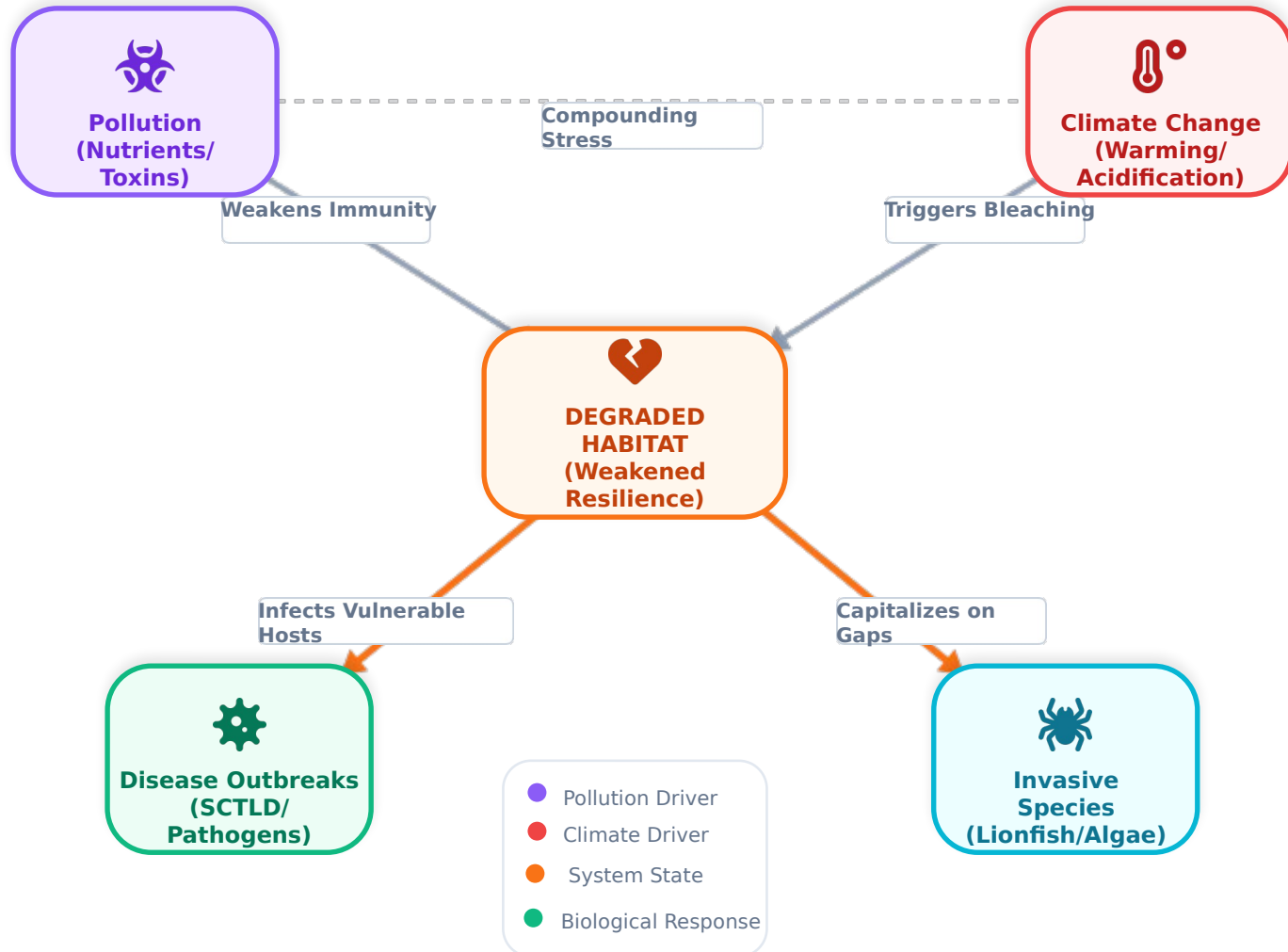
Caribbean Examples

Indo-Pacific Lionfish: Spreading since 1980s; a single female produces 2M eggs/year; no natural predators in Atlantic.

Green Iguana: Causing infrastructure damage and outcompeting native iguana species across islands.

Sargassum Blooms: Massive influxes of macroalgae smothering coastlines and disrupting tourism and nesting turtles.

Synergistic Effects of Multiple Threats



$$1 + 1 > 2$$

Compounded Risk Concept:
Multiple stressors acting together cause more damage than the sum of their individual effects.

Feedback Loops

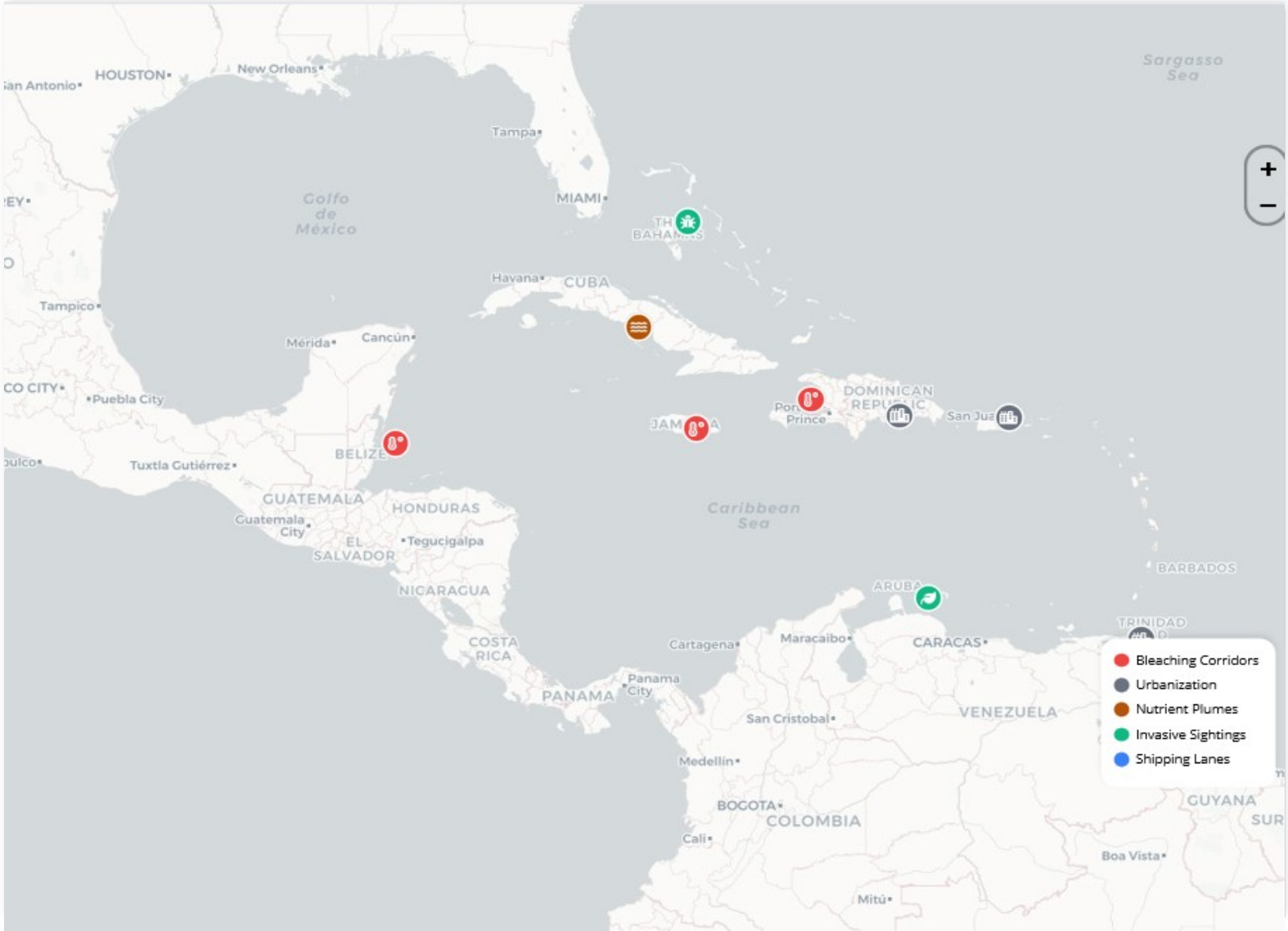
Threats rarely act in isolation. Pollution compromises coral immune systems, making them unable to recover from climate-induced bleaching events. This degraded state creates an opening for aggressive invasive species and fatal diseases.

Conservation Implication

Management cannot focus on just one driver. Reducing local stressors (pollution, fishing) is the only way to buy time for ecosystems to withstand global stressors (climate change).

Caribbean Threats Overview

Regional Hotspots & Drivers



Coral Bleaching Corridors

Location: Mesoamerican Reef, Jamaica, Haiti
Threat: Marine heatwaves & acidification

Coastal Urbanization

Location: Puerto Rico, Dominican Republic
Threat: Habitat loss, impervious surfaces

Sediment & Nutrient Plumes

Location: Orinoco Delta influence, Trinidad
Threat: Eutrophication, smothering reefs

Invasive Species (Lionfish)

Location: Bahamas, widespread Caribbean
Threat: Predation on native juveniles

75%

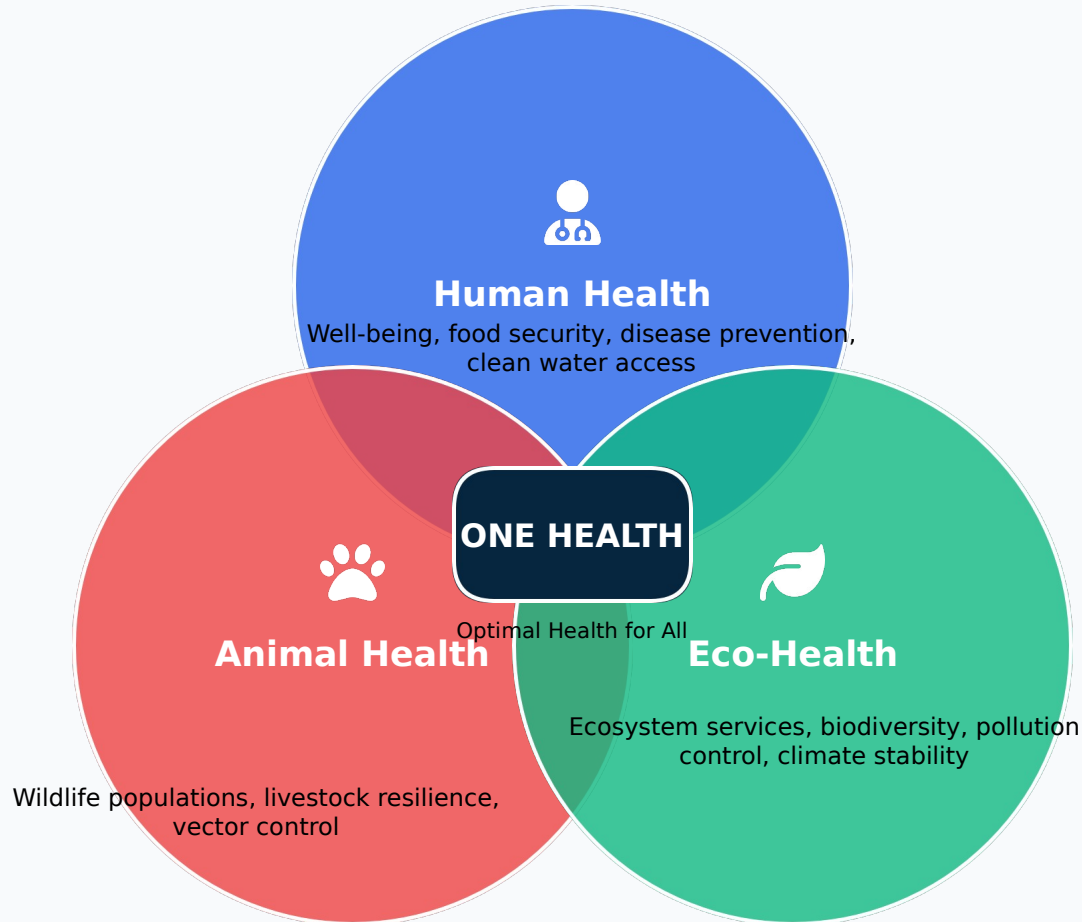
Reefs Threatened

High

Bleaching Risk

20+

Invasive Species



Concept Definition

One Health is an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals, and ecosystems. It recognizes that the health of humans is closely connected to the health of animals and our shared environment.

Drivers of Risk



LAND USE
CHANGE



WILDLIFE
TRADE



CLIMATE
SHIFTS

"Pandemic prevention is estimated to cost 100 times less than pandemic response. Protecting nature protects ourselves."

— IPBES Workshop on Biodiversity and Pandemics



Intact Ecosystem

High biodiversity creates a natural buffer. Pathogens circulate within wild hosts but are contained ("dilution effect").



Disturbance & Encroachment

Deforestation and land-use change create "edge effects," pushing humans and livestock into wildlife habitats.

Risk Modifier

Loss of biodiversity removes buffer species, leaving only high-risk reservoirs (e.g., rats).



Contact Interface

Increased interaction via hunting, wildlife markets, or livestock farming facilitates pathogen jump (spillover).

Alternative Route

 Wildlife Trade / Wet Markets allow direct transmission.



Spillover & Spread

Pathogen adapts to human host. Without containment, local outbreak becomes an epidemic or global pandemic.

Primary Drivers

- **Habitat Destruction:** Converts natural buffers into high-contact zones.
- **Wildlife Trade:** Brings diverse pathogens directly into urban centers.
- **Intensive Livestock:** Acts as an amplification bridge for viruses.

Preventive Interventions

- ✓ **Habitat Protection:** Keep wild spaces intact to maintain natural barriers.
- ✓ **Surveillance:** Monitor wildlife and livestock interfaces for early detection.
- ✓ **Safe Value Chains:** Regulate markets and ensure biosecurity in farming.

High Biodiversity

"Dilution Effect" in Action

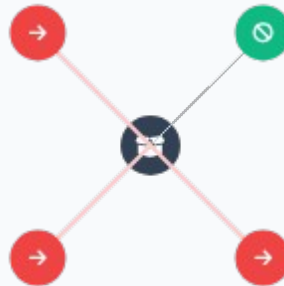


Reduced Disease Risk

Pathogens end up in "dead-end" hosts, breaking the transmission chain.

Low Biodiversity

"Amplification Effect"



Increased Outbreak Risk

Resilient "competent" hosts dominate, amplifying pathogen spread.

How It Works

In diverse ecosystems, many species are "poor hosts" (incompetent reservoirs) for pathogens. When a vector (like a tick or mosquito) bites a poor host, the pathogen fails to reproduce. This "wasted bite" dilutes the overall prevalence of the disease in the vector population.

Key Examples

Lyme Disease: Forests with diverse mammals (opossums, squirrels) have fewer infected ticks than fragmented forests dominated by white-footed mice (highly competent hosts).

West Nile Virus: Areas with high bird diversity show lower human infection rates as mosquitoes bite non-competent bird species.

Conservation Implication

Caveat: Context-dependent; applies mostly to vector-borne generalist pathogens.

Takeaway: Conserving intact, diverse ecosystems is a direct public health strategy to prevent future zoonotic outbreaks.

Economic Risk of Biodiversity Loss



Annual Loss Cost

\$10 Trillion

Global economic impact of biodiversity loss annually including healthcare costs

Source: World Health Organization (WHO)



Prevention Value

< 5% Cost

Prevention costs (\$20B) are less than 5% of estimated pandemic response costs

Source: Harvard C-CHANGE



Degradation Loss

\$2.7 Trillion

Potential annual global GDP loss from collapse of select ecosystem services

Source: World Bank



Nature Dependency

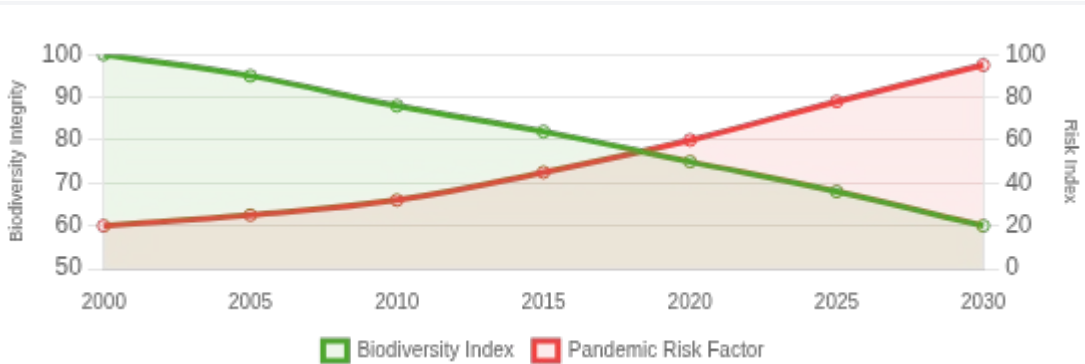
55% of GDP

Percentage of global GDP moderately or highly dependent on nature (~\$44T)

Source: World Economic Forum (WEF)



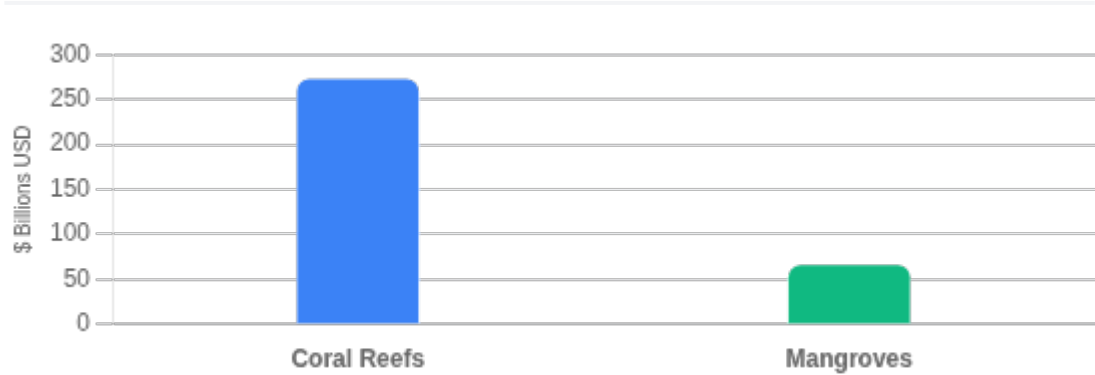
Pandemic Risk vs. Biodiversity Loss



Projected correlation between biodiversity decline and zoonotic spillover risk



Coastal Protection Value (Reefs/Mangroves)



Annual avoided damages from storms and flooding

Case Study: Caribbean Lionfish Invasion

 **High Impact Invader**

Species Profile

Origin Story

Aquarium trade escape (Florida, 1980s)

Biological Traits

-  **Venomous Spines**
-  **2 Million+ Eggs/Year**
-  **Generalist Predator**

- 1985**
First sighting off Dania Beach, Florida
- 2000s**
Rapid spread through Bahamas & Caribbean
- 2010s**
Colonization of Gulf of Mexico & South America
- 2026**
Established across entire Western Atlantic

Ecological Impacts

-79%

Recruitment Decline

Research shows a single lionfish on a patch reef can reduce recruitment of native reef fish by nearly 80% in just 5 weeks.

Source: Albins & Hixon (2008), Marine Ecology Progress Series

The Trophic Cascade Effect



Management Response



Culling Derbies

Organized spearfishing competitions to remove thousands of lionfish in single events.



"Eat 'Em to Beat 'Em"

Developing commercial markets (sea-to-plate) to create economic incentive for removal.



Gear Innovation

specialized traps and containment units designed to capture lionfish without bycatch.



Citizen Science

Training recreational divers to safely remove and report sightings via mobile apps.

Success Metric:



Populations controlled at local scale (MPAs)

Global & Caribbean Threat Matrix

Relative impact intensity of direct drivers across key ecosystems

	 Land/Sea Use Change	 Direct Exploitation	 Climate Change	 Pollution	 Invasive Species
 Coral Reefs	Medium	High	Critical	High	High
 Mangroves	Critical	Medium	High	Medium	Low
 Seagrasses	High	Low	High	Critical	Medium
 Tropical Moist Forests	Critical	High	Medium	Low	Medium
 Tropical Dry Forests	Critical	High	High	Low	Medium

 **Caribbean Context:** In the Caribbean, *Invasive Species* threat is elevated to **High/Critical** for reefs due to the Lionfish invasion, diverging from the global average.

Threat Intensity: ● Critical ● High ● Medium ● Low

Data Sources: IPBES Global Assessment Report (2019), IUCN Red List Analysis, WRI Reefs at Risk Caribbean.

Conservation Responses to Threats



1. Threat Assessment

Identify primary drivers & intensity



2. Intervention Selection

Match strategy to threat context



3. Monitoring KPIs

Track impact & adapt management



Protect

Area-Based Conservation

- ✓ Establish PAs & OECMs
- ✓ Recognize ICCAs & rights
- ✓ Enforce no-take zones

Targets : **Land Use** **Exploitation**



Restore

Ecological Recovery

- ✓ Mangrove/coral replanting
- ✓ Invasive species removal
- ✓ Reintroduce keystone spp.

Targets : **Land Use** **Invasives**



Regulate

Policy & Enforcement

- ✓ Set harvest quotas/limits
- ✓ Pollution control laws
- ✓ Biosecurity protocols

Targets : **Exploitation** **Pollution**



Incentivize

Sustainable Finance

- ✓ Blue bonds & carbon credits
- ✓ PES schemes for locals
- ✓ Eco-certification programs

Targets : **Land Use** **Exploitation**



Engage

Community Action

- ✓ Co-management agreements
- ✓ Citizen science monitoring
- ✓ Livelihood diversification

Targets : **Exploitation** **Invasives**



Future-Proof

Climate Adaptation

- ✓ Ecological corridors
- ✓ Assisted gene flow
- ✓ Climate-smart planning

Targets : **Climate** **Land Use**

Summary & Further Reading

💡 Key Takeaways



Synergistic Threats: The Big Five drivers rarely act alone; their combined impact ($1+1>2$) accelerates degradation, requiring integrated management.



One Health Nexus: Biodiversity loss directly increases pandemic risk through zoonotic spillover; healthy ecosystems are our primary defense.



Climate Acceleration: Climate change acts as a force multiplier, intensifying existing pressures like pollution and invasive species.



Effective Strategy: Multi-threat management strategies that address root causes simultaneously are most effective for long-term resilience.

Call to Action



Implement co-managed, adaptive approaches that address multiple stressors simultaneously to build true ecosystem resilience.

📖 Resources & Frameworks



Global Assessments

IPBES Global Assessment Report on Biodiversity
IPBES Invasive Alien Species Assessment Report
WEF Nature Risk Rising Report



Marine & Pollution

UNEP Marine Pollution Reports
NOAA/NASA Coral Bleaching Resources
WRI Reefs at Risk in the Caribbean



One Health

WHO One Health Framework
CDC Zoonotic Disease Resources



Caribbean Focus

CRFM Regional Lionfish Strategy
Caribbean Challenge Initiative Reports