EarthDate

Mangrove Mayhem

If you've been on a boat, pretty much anywhere in the tropics, you've seen mangrove forests. There are at least 75 species of these small trees, evolved to live in harsh tidal conditions, their roots in sand, their trunks often submerged in saltwater.

There, they can form dense thickets that protect the coast from ravaging waves and storm surges. And that's just one of their benefits.

Mangroves' arching root networks trap and stabilize sediment to help build up the coast. In the process, they filter and clean coastal water.

Those same roots serve as nurseries, sheltering the young of many fish and crustacean species. While the forests provide timber for local human populations, and store carbon. But mangroves are in peril -- from coastal development, agriculture, and especially aquaculture. Shrimp farmers in Asia are responsible for a third of global mangrove destruction, as they clear forests to build their ponds.

Early efforts to replant the forests had failed. Until an innovative Florida ecologist realized that mangroves thrive best when their roots are wet only 30% of the time and dry the rest, as the tide comes and goes. He used a backhoe to regrade the coastline to encourage those conditions. Within three years, the resilient mangroves had returned.

His methods proved so successful, they've been adopted globally, in a preservation program that intends to bring 20% of mangrove coverage back within the decade.

I'm Scott Tinker.

Above the water, mangroves rise on graceful stilts and below, their roots form a thriving underwater world that creates vital coastal habitat now facing growing challenges to its survival.

Credit: By Thomas Peschak - International League of Conservation Photographers (iLCP), CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=79511271

Background: Mangrove Mayhem

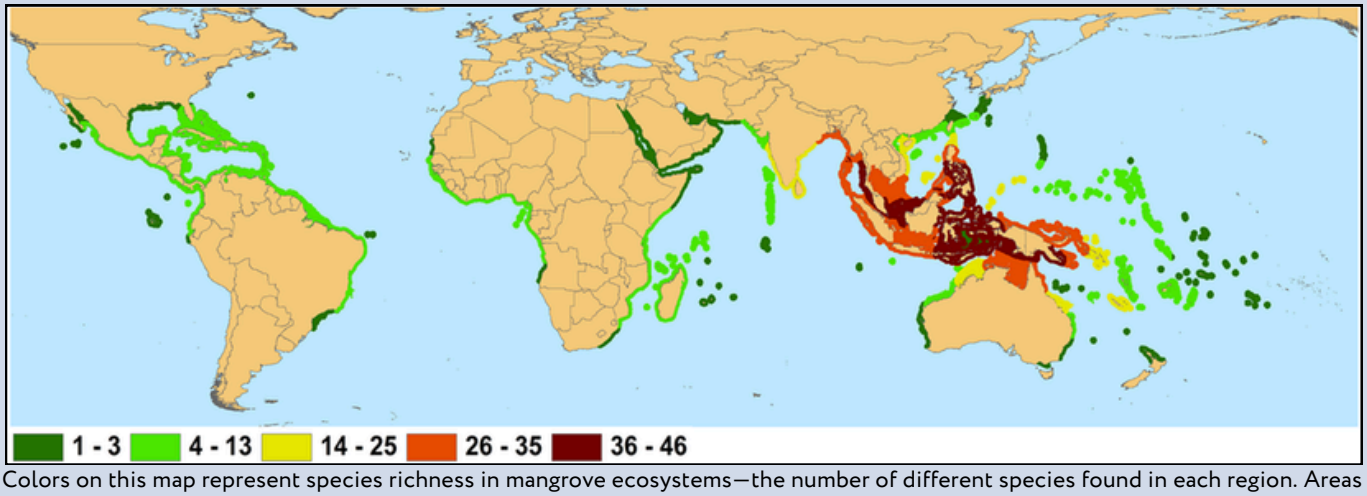
Synopsis: Mangroves act as natural seawalls and nurseries for countless species, but human development and climate variability are pushing them back from the shorelines they defend. Conservation alliances, community projects, and smarter restoration are beginning to turn the tide.

Phosphorus and Early Life

- Defining the term mangrove is not as simple as it might seem. Scientists still debate exactly which species qualify, since mangroves are not one closely related group but rather a collection of plants that evolved similar traits to survive in harsh coastal environments.
- Across the globe, there are about 76 recognized mangrove species, though some researchers place the number closer to 85. These species include both trees and shrubs, and despite their differences, any one of them can grow alone or form dense strands that become an entire forest.
- Uniting all mangroves is their remarkable ability to live where few plants can, along tropical and subtropical coastlines, rooted in salty, shifting, oxygen-poor waters.

Mangrove Characteristics

- Mangroves grow throughout intertidal zones in tropical and subtropical regions, generally between 25° north and south latitude. They thrive in these warm, stable climates and can be damaged by sudden cold snaps or unusually low temperatures. Their sensitively to cold limits how far they can extend toward the poles.
- The extreme conditions of the intertidal zones have driven mangroves to evolve a range of hardy characteristics.
- Because tides flood their habitat twice daily, mangrove roots must function both above and below water. Like all plants, mangroves require oxygen to support cellular respiration.
    - Pneumatophores act like snorkels, rising above water level to draw in air. They can range from 8 inches to nearly 10 feet tall. Their hydrophobic surfaces help prevent water from blocking oxygen flow.
    - Knee roots extend horizontally then bend sharply downward – like a bent knee - into the sediment. The horizontal portion stays above water long enough to absorb oxygen.



Colors on this map represent species richness in mangrove ecosystems—the number of different species found in each region. Areas with higher species richness indicate greater biodiversity. Most mangrove forests occur in tropical and subtropical climates, where warm temperatures and coastal conditions support a wide variety of species.

Credit: By Beth A. Polidoro, et al; https://commons.wikimedia.org/w/index.php?curid=110510213

Background: Mangrove Mayhem

  - Stilt or prop roots arch downward from the trunk, providing stability in soft, shifting sediments and lifting the plant above water.
- Mangroves have also developed adaptations to survive in the salty conditions of the intertidal zones. Different species manage salt in different ways.
  - Secretor species allow saltwater to enter their tissues but then push excess salt out through specialized pores in their leaves. As the water evaporates, salt crystals form on the leaf surface.
  - Non-secretor species prevent most salt from entering the plant at all. A specialized barrier in their roots limits the movement of salt into the plant's internal water, reducing dehydration that would otherwise occur through osmosis.

Benefits of Mangrove Forests

- Mangroves forests are coastal powerhouses that serve people, wildlife, and the planet in many overlapping ways. Some of their most important benefits include:

On this Black Mangrove (Avicennia germinans) leaf in Pará, Brazil, tiny salt crystals mark how the tree filters seawater and concentrates the salt at its surface, allowing the rest of the plant to thrive.

Credit: By Ulf Mehlig - Own work, CC BY-SA 2.5, https://commons.wikimedia.org/w/index.php?curid=1245764

- Coastal Protection and Resilience: Mangroves act as a natural barrier between land and sea. Their dense, tangled roots absorb and dissipate the energy of waves, storm surges and high tides, helping to shield inland areas from erosion, flooding, and the worst of storms.
  - By trapping and stabilizing sediment, mangroves build up shorelines over time, helping coastlines grow rather than shrink, and protecting communities, infrastructure, and habitats from gradual sea-level rise.
- Biodiversity Hotspots and Ecosystem Support: Mangrove forests form rich, complex habitats both above and below water, supporting a huge diversity of species. Fish, crustaceans, shellfish, birds, reptiles, mammals, plants, and microorganisms all find shelter, food, or breeding grounds among mangroves' roots, trunks, and canopy.
  - They serve as nurseries for juvenile fish and shellfish, many of which go on to become important for coral reefs or open-ocean fisheries. That makes mangroves vital not just locally but across entire marine food webs.
  - Because they stabilize sediments and filter water, mangroves help maintain water quality by trapping sediments, nutrients, and pollutants before they reach reefs or open seas.
- Carbon Sequestration and Climate Regulation: Mangroves are among the most efficient carbon-storing ecosystems on Earth. They capture CO_2 from the atmosphere and lock it deep into their soils and sediments.
  - Although mangroves take up a relatively small fraction of coast area, their carbon storage per hectare is high.
- Benefits for People and Coastal Communities: Local communities in tropical and subtropical regions often rely on mangroves for fisheries, food, and livelihoods. Because mangroves support diverse and abundant marine life, they underpin many coastal economies and food systems.

Background: Mangrove Mayhem

- They also provide wood, timber, and other natural resources, and in some regions non-timber products such as honey, plants, or materials for traditional uses.
- By shielding shorelines from storms and erosion, mangroves reduce property damage and loss, essentially acting as a low-cost, self-maintaining coast defense system that can save lives and livelihoods.

In the Sundarbans of coastal India, Bengal tigers share the mangroves with fish, birds, crustaceans, and countless other species, showing how rich and diverse these shifting islands can be.

Credit: By Prantik1987 - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=168479704

Mangroves in Peril

- Despite their importance, a global analysis published in 2025 found that between 1985 and 2020, mangrove area globally declined by 21.6%.
- There has been a net loss of 284,000 hectares between 2000 and 2020 with Asia accounting for over 60% of mangrove losses during that period.
  - Most of these declines are driven by direct human activities, such as coastal development, agricultural expansion, and overharvesting for timber or charcoal.
  - But climate-linked changes also play a role.
- One of the largest causes of mangrove loss is the expansion of aquaculture. Shrimp farming alone accounts for at least 35% of global mangrove destruction, as coastal forests are cleared and replaced by ponds.
  - These farms often operate for only a few years before disease and contamination force them to be abandoned, leaving polluted water and degraded habitat behind.
- Mangroves are also removed for tourist development, ports, housing, and agriculture, especially rice and palm oil farming.
  - In many regions, this has turned once continuous forests into fragmented patches, reducing their ability to protect coastlines and support marine life.
- Mangroves need space to move landward as sea levels rise. But in many places, coastal development now blocks this "natural retreat," creating a squeeze between rising water and human-built shorelines.
- Where sediment supply cannot keep pace with sea-level rise, forests can drown or erode, as seen in parts of the Sundarbans (eastern India), where some coastlines have retreated hundreds of meters each year.
- New satellite studies show that nearly half the world's mangroves are strongly affected by climate oscillations such as El Nino and La Nina. These cycles shift sea level and moisture patterns across the Pacific, creating a "see-saw" of growth and decline.

In Pekalongan, Central Java, new shrimp ponds are built within mangrove areas, illustrating how expanding aquaculture continues to replace these coastal forests.

Credit: By Stephen Kennedy - https://www.flickr.com/photos/shkizzle/6774585654/in/photostream, CC BY 2.0, https://commons.wikimedia.org/w/index.php?curid=19041568

Background: Mangrove Mayhem

- During certain El Nino warmer-water events, sea levels in northern Australia drop dramatically, exposing mangrove roots and contributing to large die-back. One area that sustained a massive loss was in the Gulf of Carpentaria along the northern coast of Australia. From 2015-2016, forty-million mangroves trees died because of unusually low sea-level due to El Nino Southern Oscillation.
- La Nina colder-water years can bring the opposite pattern.
- These short-term swings can produce abrupt and severe stress that mangroves cannot always tolerate, especially where human disturbance is already present.

- Some mangrove regions are also threatened by invasive plants and animals.
  - Species such as Spartina alterniflora have out-competed native mangroves in parts of China. Introduced mammals, including feral cats and rats, impact mangrove-dependent birds such as the critically endangered mangrove finch in the Galapagos.

Mangrove roots and trunks in the Dominican Republic are exposed during drought conditions linked to El Niño, which can raise salinity and stress the trees. Although many associate El Niño only with the Pacific, its climate effects are felt around the world, including the Caribbean.

Credit: By Anton Bielousov - Own work: Dominican Republic trip, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=18865413

  - Even mangroves themselves can become invasive when introduced outside their native range, changing habitat structure and affecting native wildlife.
- In many places, the most serious threats occur where multiple stressors overlap including clearing for aquaculture, blocked landward migration, pollution, invasive species, and climate-linked fluctuations in sea level. These pressures make It harder for mangroves to recover, even though they are naturally resilient.

Solutions for Mangrove Destruction

- Mangrove forests are under pressure, but they are ecosystems of resiliency.
  - Where people change how they manage coasts, mangroves can recover surprisingly fast.
- A World Bank mangrove restoration project in the Philippines planted nearly three million seedlings in the 1980s and early 1990s. Fewer than one in five survived more than a few years.
  - Many projects treated mangrove restoration like terrestrial forests: raise seedlings in nurseries, plant them in bare mudflats, and watch them grow. Unfortunately, this practice often fails.
- Florida ecologist Robin Lewis knew there had to be a better way and mimicking nature was the trick. He noticed that mangroves grow best when roots are wet about 30% of the time and dry for the other 70% of time. This varied slightly for different species but was generally true.
  - Lewis was tasked with restoring 1300 acres of mangroves near Ft. Lauderdale, Florida and he managed to do so without planting a single tree.
  - Instead, he mapped the water movement and then moved dirt with backhoes and bulldozers, adjusting the slope so the tide would generate the 30/70 ratio of wet-to-dry.

Background: Mangrove Mayhem

  - Just three years later, the shore was covered with mangrove seedlings as diversity expanded over the next few years. Learning to "fix the tides" allowed nature to recover.
  - The world took notice and now Lewis' method has been used in countries across the globe, leading other successful rehabilitation efforts.
- The Global Mangrove Alliance, a private and government partnership has set a goal to increase mangrove cover by roughly 20% by 2030.
  - Many countries are expanding marine and coastal protected areas that explicitly include mangrove forests, such as new or strengthened reserves in Indonesia, Liberia, and Pakistan.
  - "Mikoko Pamoja" (Mangroves Together) is a program in Kenya's Gasi Bay that has stopped local logging and funded conservation efforts.
  - Residents in a village in Papua New Guinea pushed their government to establish replanting programs to protect their homes from flooding.
  - Indigenous and local government groups in India's Karnataka state designed a mangrove conservation plan with protection zones, tourism limits, and replanting.
  - Women's groups in Cambodia are leading mangrove projects and creating floating gardens.
  - The "One Child, One Tree" program in the Philippines links school-based education with coastal cleanup and mangrove restoration.
  - Training both teachers and students from Jamaica and the Bahamas is a three-phase program that provides professional development, classroom lessons, and hands-on restoration projects.
- The geographic reach of these projects highlights the global importance of the mangrove ecosystems to people everywhere. Taken together, these efforts offer a path out of the dilemma.

Coastal Chaos to Mangrove Recovery

- When coastlines are planned to leave room for mangroves, when restoration follows the topography and tides rather than fighting them, and when local communities share in the benefits, mangroves can return
- Mangroves once seemed expendable, cleared for shrimp ponds and development. Today, their true value is recognized and the need to protect them is evident.
- If they are given even a modest chance to recover, their roots can quickly re-weave the edge between land and sea.

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