

Environmental Science, 15e

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9

Sustaining Biodiversity: Saving Ecosystems and Ecosystem Services

Core Case Study: Costa Rican Tropical Forests

- Despite natural capital degradation by ranchers, Costa Rica remains an oasis of biodiversity – home to an amazing variety of wildlife, especially birds
 - What two factors help protect Costa Rica's biodiversity?
 - What has the government done to improve the sustainability of forests?

9.1 What Are the Major Threats To Forest Ecosystems?

- Ecosystem services provided by forests go beyond the mere value of raw materials
- Forests are most threatened by:
 - Unsustainable cutting and burning of vegetation
 - The effects of climate change

Forests Vary in Age and Composition

- Categorized based on their age and structure
 - Old growth forests: uncut or regenerated forests not seriously disturbed by human activity or natural disasters for over 200 years
 - Second growth forests: result from secondary ecological succession – after the primary forests have been destroyed
- Tree plantations: managed farms growing only one or two species

Major Forest Types



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Forests Provide Important Economic and Ecosystem Services

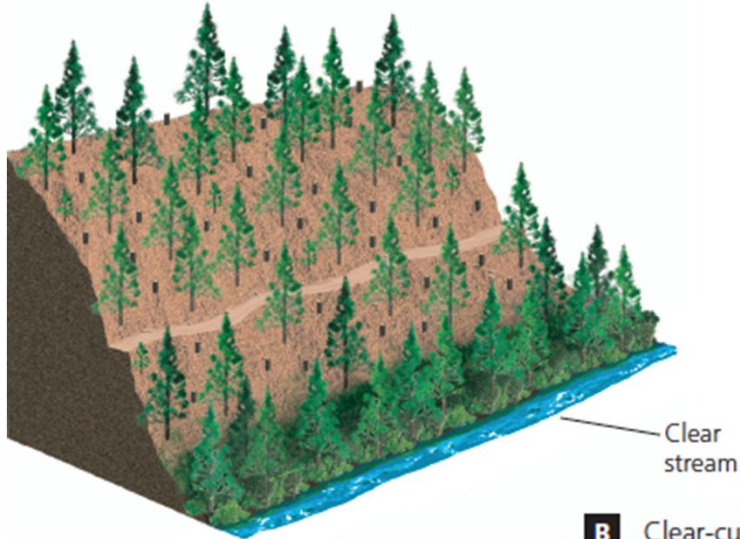
- Reduce atmospheric CO₂ through photosynthesis
- Provide habitat for about 2/3 of the earth's terrestrial species and are home to more than more than 300 million people
- Provide sustenance for many people who live in extreme poverty
- Provide health benefits – drugs are derived from forest plant species

There Are Several Ways To Harvest Trees

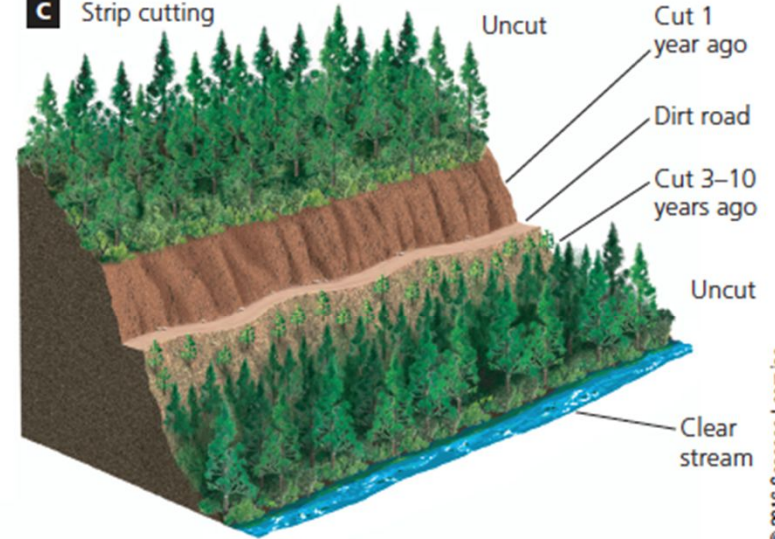
- Selective cutting: intermediate aged or mature trees are cut singly or in small groups
- Clear cutting: all trees are removed from a geographic area
 - Most efficient and least costly, but harms ecosystems
- Strip cutting: trees are removed in sections parallel to a feature, such as a road

Forest Harvesting Methods

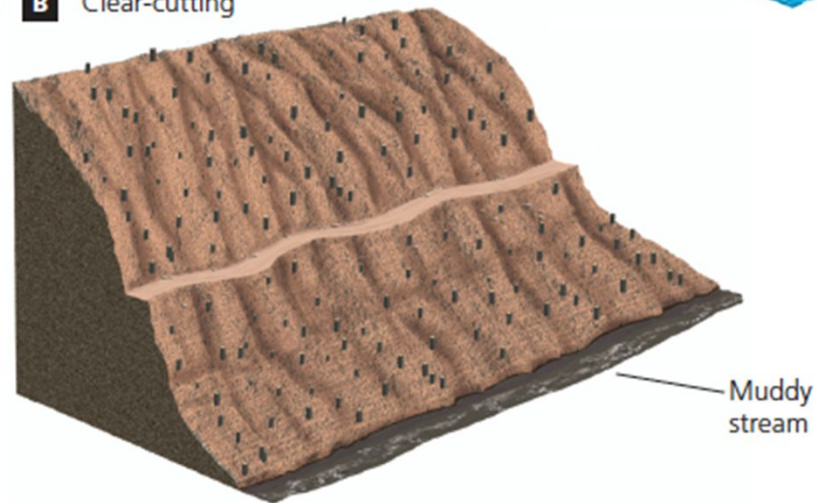
A Selective cutting



C Strip cutting



B Clear-cutting



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Tropical Forests Are Rapidly Disappearing

- At least $\frac{1}{2}$ of mature tropical forests (home to at least $\frac{1}{2}$ of the world's known species) have been lost since 1950
 - From 2000-2013, more than the equivalent of 50 soccer fields of tropical forest were lost every minute
- Rapid deforestation is taking place in Africa, Southeast Asia, and South America

Causes of Tropical Deforestation

- Pressures from population growth
- Government subsidies for large scale logging and ranching
- Direct causes vary according to geography
 - South America: cattle grazing and crop land
 - Indonesia/Southeast Asia: oil palm plantations
 - Africa forests: firewood and farming

9.2 How Should We Manage and Sustain Forests?

- Best accomplished by:
 - Emphasizing the economic value of ecosystem services
 - Removing government subsidies that favor deforestation
 - Protecting old growth forests by harvesting trees no faster than they can be re-grown
 - Planting new forests

We Can Manage Forests More Sustainably

- By certifying lumber/wood products as sustainable, full cost pricing for consumers
- Use more selective cutting in forests
- Phase out government subsidies and tax breaks that favor deforestation
- Create economic rewards for sustainable forestry
- Encourage tree planting programs and protect diverse forest areas

We Can Improve the Management of Forest Fires

- Strategies for reducing fire-related harm
 - Use controlled, prescribed burns to remove small trees and underbrush in high risk areas
 - Allow fires on public land to burn as long as they do not threaten human life or structures
 - Have thin trees/vegetation around buildings
 - Eliminate the use of wood shingles and siding in construction
 - Use solar powered micro-drones for early forest fire detection

We Can Reduce the Demand for Harvested Trees

- 60% of the wood consumed in the U.S. is wasted. How can this be reduced?
 - Use other non-tree fibers such as kenaf and hemp to yield more pulp per acre and require less pesticide use
 - Limit the use of throwaway paper products made from trees and use reusable products
 - Stop cutting fuel wood from forests and replace with production of biomass bricketts

There Are Several Ways To Reduce Tropical Deforestation

- Provide foreign aid or debt relief for sustainable forestry (developed countries)
- Crack down on illegal logging and create conservation reserves
- Subsidize tree planting (government)
- Buy only wood and wood products certified sustainable (consumers)
- Reduce poverty and slow population growth

9.3 How Should We Manage and Sustain Grasslands?

- Grassland productivity can be sustained and improved by:
 - Controlling the abundance and distribution of grazing livestock
 - Restoring degraded rangeland

Some Rangelands Are Overgrazed

- After forests, grasslands are the most widely used ecosystem
- Rangelands: unfenced, tropical/temperate grasslands that supply forage for grazing
 - Overgrazing harms grass roots, reduces grass cover, exposes top soil to erosion, compacts the soil, lowers its capacity to hold water, and encourages the invasion of rangeland species that cattle will not eat

How Can We Manage Rangelands More Sustainably?

- Control the number of grazing animals in an area and limit grazing time
 - Use rotational grazing
 - Fence off damaged, degraded areas
 - Use herbicides, mechanical removal, or controlled burning to suppress invader species
 - Permit short-term trampling by livestock that destroy the root systems of bioinvaders

9.4 How Should We Manage and Sustain Parks and Natural Reserves?

- More effective protection measures are needed for existing parks and natural reserves (and much of the earth's undisturbed land areas) to sustain their biodiversity

National Parks Face Many Environmental Threats

- Many are too small to maintain large animal species
- Many suffer from bioinvaders
- Some are so popular that the number of visitors degrades the very features that made them attractive in the first place
- Internationally, many are used illegally for firewood, hunting (poaching), logging, and mining

Nature Reserves Occupy Only a Small Part of Earth's Land

- At present, less than 13% of the earth's land is either strictly or partially protected and less than 6% is strictly protected from potentially harmful human activity
- Beneficial impacts to reserves can be increased by establishing buffer zones (strict protection of a reserve's inner core) to manage nature reserves

Protecting Wilderness Is an Important Way to Protect Biodiversity

- Undeveloped lands can be protected from exploitation by designating them as wilderness
 - To preserve biodiversity and keep these areas as centers of evolution
- Areas protected by the Wilderness Act (established in the mid 1960s) have grown nearly twelve-fold since the Act's inception

9.5 How Can Biodiversity Be Sustained in Terrestrial Ecosystems?

- By identifying and protecting biodiversity hotspots, employing restoration ecology and reconciliation ecology, we can help sustain terrestrial biodiversity and protect ecosystem services

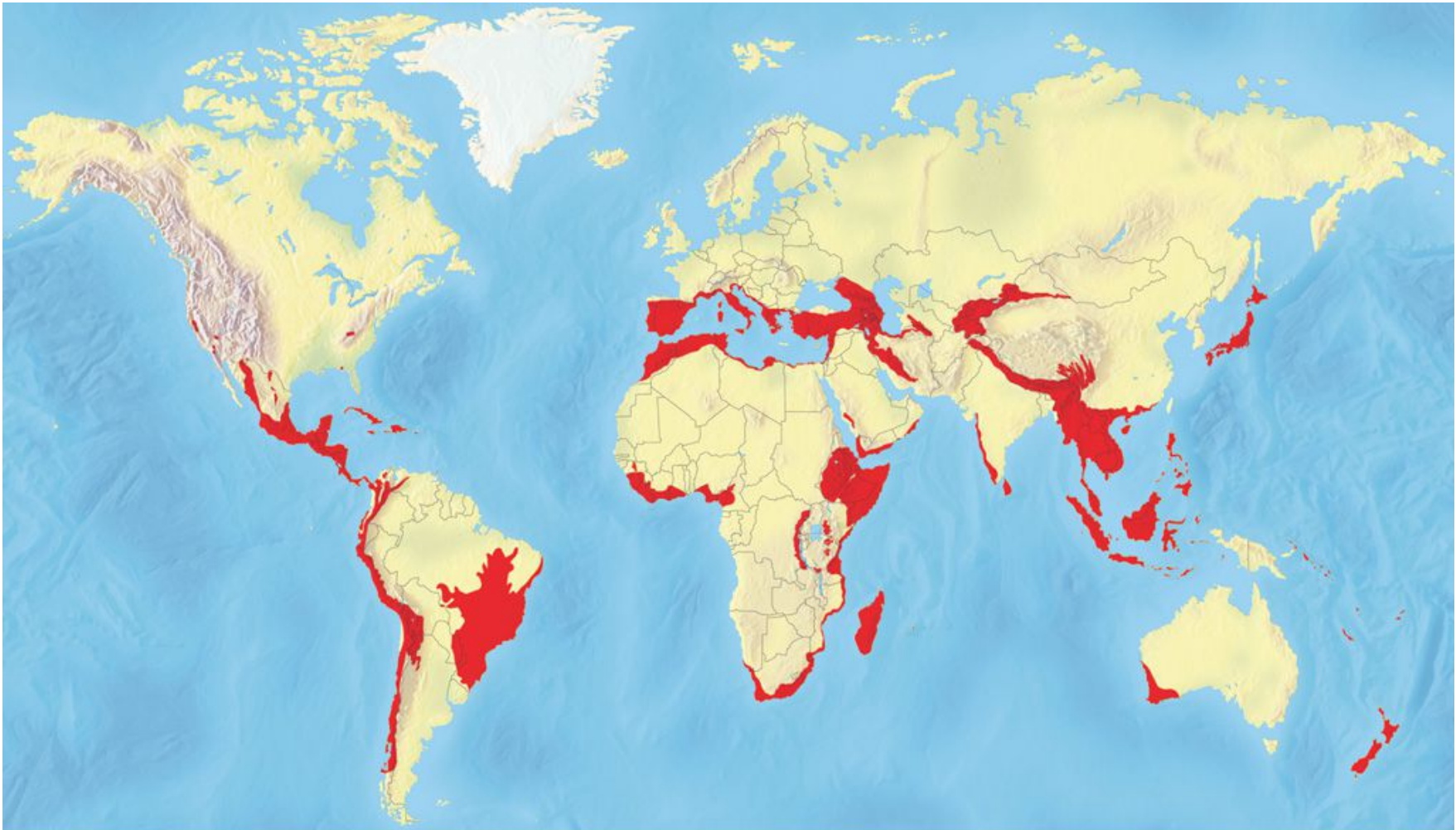
The Ecosystem Approach: Strategies For Sustaining Terrestrial Biodiversity

- Inventory all of the species found in terrestrial ecosystems along with the ecosystem services they provide
- Identify threatened terrestrial ecosystems with potential for recovery
- Restore degraded ecosystems
- Make development biodiversity friendly – provide financial incentives and tax breaks to protect endangered ecosystems

Protecting Global Biodiversity Hotspots Is an Urgent Priority

- Take emergency measures to rapidly protect terrestrial biodiversity hotspots
 - These areas cover little more than 2% of the earth's surface, but are estimated to contain most of the world's flowering plants and terrestrial vertebrates
 - Only about 5% of hotspot areas are currently protected with government funding and law enforcement

Endangered Natural Capital: Map of Biodiversity Hotspots



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Protecting Ecosystem Services Is Another Urgent Priority

- The 2005 UN Millennium Ecosystem Assessment outlined how to sustain vital ecological and ecosystem services
 - By protecting reserves/biodiversity hotspots
- Residents, public officials and conservation scientists need to work together in developing win-win protection strategies for ecosystem services

We Can Rehabilitate and Partially Restore Ecosystems That We Have Damaged

- Repair ecosystem damage and enhance ecological succession by:
 - Ecological restoration – returning degraded habitats and ecosystems as close as possible to their natural state
 - Rehabilitating ecosystems without trying to restore their original condition
 - Replacing degraded ecosystems, like forests, with productive pastureland
 - Creating artificial ecosystems (reef balls)

Scientific Strategies For Ecological Restoration and Rehabilitation

- Identify the causes of degradation (pollution, overgrazing, mining, invasive species, etc.)
- Stop degradation by eliminating or reducing the factors above
- Reintroduce keystone species to restore natural ecological processes
- Protect degraded areas to encourage natural recovery

Reconciliation Ecology: Sharing Our World With Other Species

- How can we reconcile biodiversity conservation and human development?
 - Use sustainable forms of ecotourism to protect local wildlife and ecosystems
 - Teach local populations need to protect local wildlife and ecosystems, and to manage ecotourism to provide win-win sustainability

9.6 How Can We Help To Sustain Aquatic Biodiversity?

- Establishing protected sanctuaries, managing coastal development, reducing water pollution, and preventing overfishing can help sustain aquatic biodiversity and increase beneficial human environmental impacts

Human Activities Are Destroying and Degrading Aquatic Biodiversity

- Coastal habitats are disappearing 2-10 times faster than those being lost from tropical forests
 - Bottom trawling may be the largest human-caused disturbance to the entire biosphere
 - Coral reefs absorb heat from the warming atmosphere, are subject to pollution, and are susceptible to ocean acidification

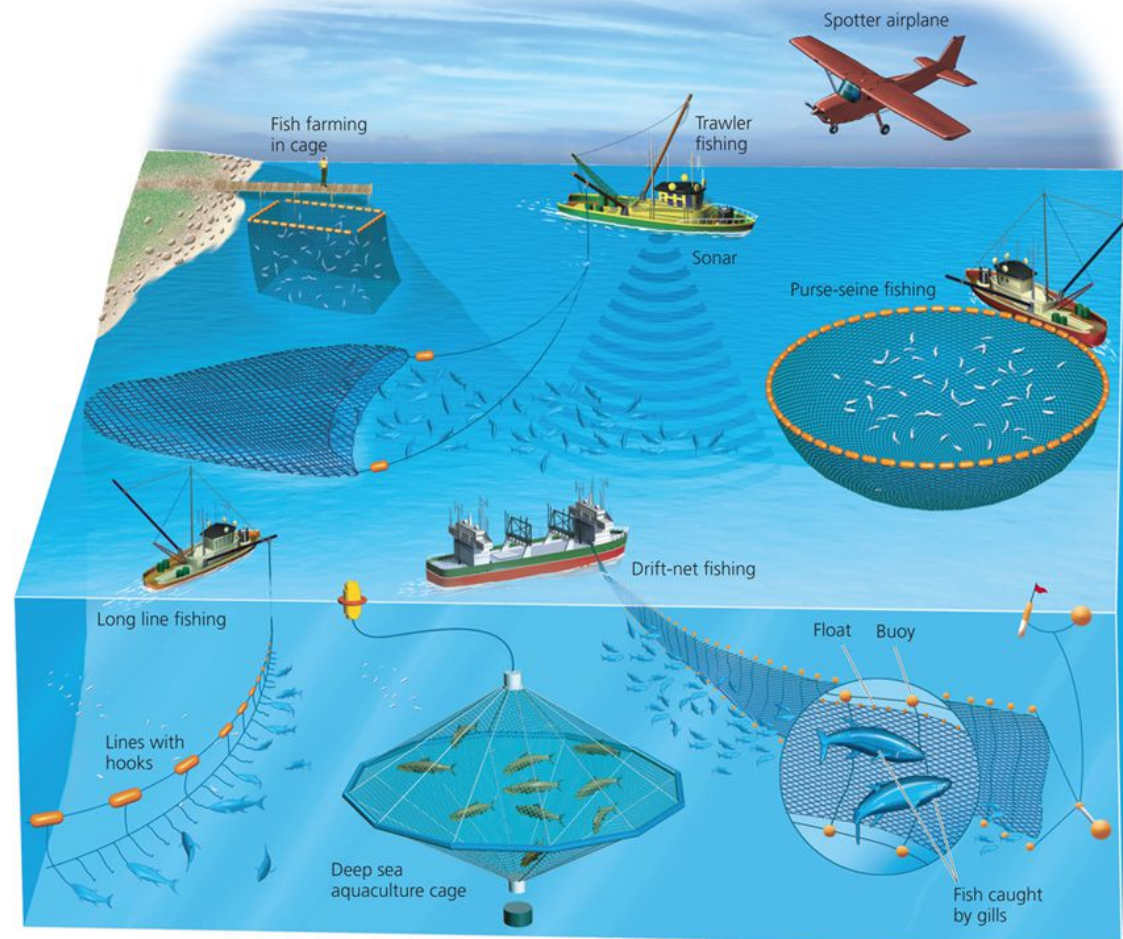
Problems That Threaten Aquatic Biodiversity

- Dam building and overuse for irrigation damage freshwater aquatic zones
- Deliberate/accidental introduction of troublesome invasive species
 - Responsible for almost 2/3 of U.S. fish extinctions
 - Where invasive species are dominating coral reefs (Bahamas), unchecked algal growth is overwhelming and destroys reefs

Overfishing: Gone Fishing, Fish Gone

- Industrial fishing fleets supply the growing global demand for seafood by using GPS equipment, fish-finding devices, huge nets, long fishing lines, spotter planes, and refrigerated factory ships that process and freeze their enormous catch
 - Severely reduces marine biodiversity
 - Degrades important marine ecosystem services

Harvesting Methods Used By the Commercial Fishing Industry



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Fish Prints: Similar in Nature to Ecological Footprints

- Defined as the area of the ocean needed to sustain the fish consumption of an average person, the nation, or the world
- Overfishing has led to the collapse of some of the world's major fisheries
 - Rapidly reproducing invasive species take over and disrupt ocean food webs when predator species dwindle

Can We Protect and Help Sustain Marine Biodiversity?

- Protection is possible but difficult because:
 - Fish prints and ecological footprints are expanding exponentially
 - Ocean damage is not highly visible to humans
 - People incorrectly view the ocean as an inexhaustible resource
 - Most of the world's ocean area lies outside the legal jurisdiction of any country, leading to overexploitation – a classic example of the tragedy of the commons

Taking an Ecosystem Approach to Sustaining Aquatic Biodiversity

- Some proposals:
 - Complete the mapping of the world's aquatic biodiversity
 - Identify and preserve the world's aquatic biodiversity hotspots
 - Create large/fully protected marine reserves to promote marine ecosystem recovery
 - Initiate global ecological restoration projects
 - Reduce poverty in areas near protected lands and waters

Additional Case Study: Restoring the Channel Islands Ecosystem

- The Channel Islands off California are an example of a biodiversity hotspot
 - A unique and diverse array of plants and animals, more than 60 of which are endemic to the islands
 - During the mid 19th century, pigs and sheep (nonnative species) were introduced to the island
 - many of which became feral over time

Additional Case Study: Restoring the Channel Islands Ecosystem

- These bioinvaders (especially the pigs) played a pivotal roll in the destruction of the island fox
 - The pigs competed with the foxes for food, and became a food source for the golden eagle (which replaced the bald eagle in the ecosystem)
 - Golden eagles preyed not only on the pigs, but on the island foxes – driving the foxes almost to extinction

Additional Case Study: Restoring the Channel Islands Ecosystem

- To save the foxes and other island species, the National Park Service and The Nature Conservancy ran a multi-year program to restore Santa Cruz Island
 - How did the Santa Cruz Island environment become unsustainable?
 - Using the food web, can you link the loss of the bald eagles to the endangerment of the island foxes?
 - What was the result of this program?

Restoring the Channel Islands Ecosystem and the Three Big Ideas

- The value of the Channel Islands goes beyond their economic value
- By restoring the Santa Cruz Island's terrestrial ecosystem, humans have worked to restore and sustain the island's biodiversity and ecosystem services
- The National Park Service also works to manage the island's coastline and protect the surrounding marine environment