MANITOBA ENVIROTHON

ENVIRONMENTAL AWARENESS

PROVINCIAL THEME RESOURCE

ACKNOWLEDGEMENTS

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INTRODUCTION

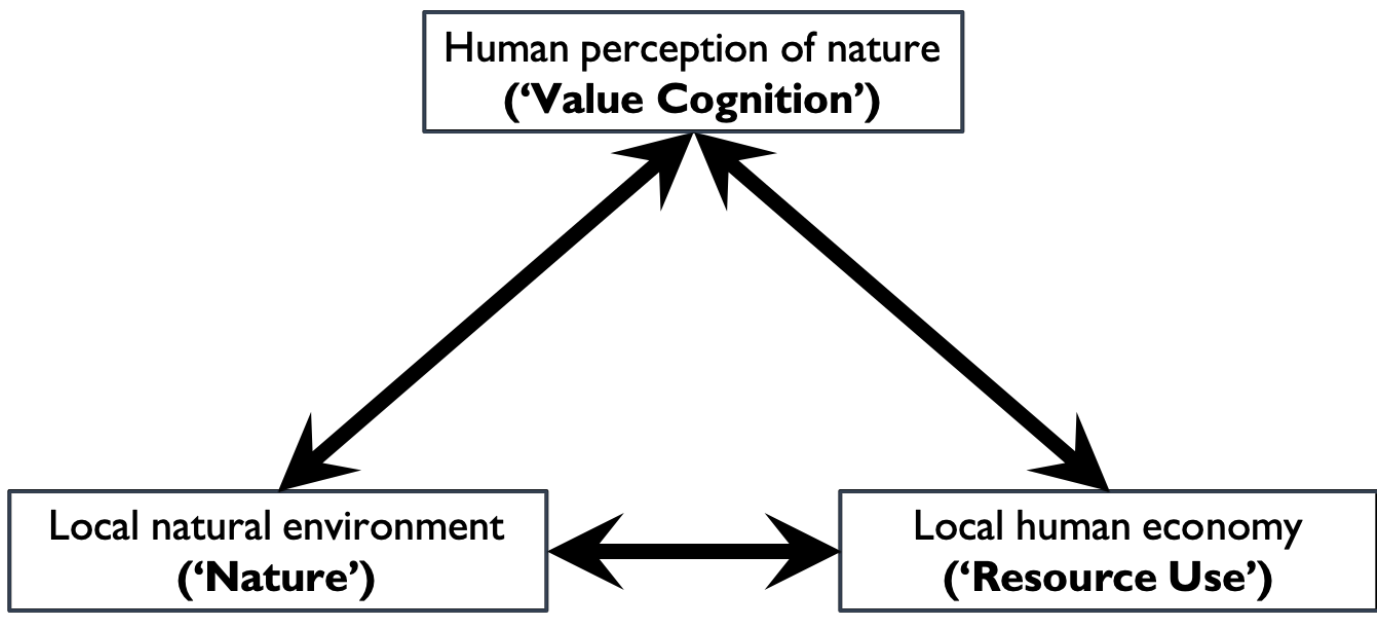
"We stand now where two roads diverge. But unlike the roads in Robert Frost's familiar poem, they are not equally fair. The road we have long been traveling is deceptively easy, a smooth superhighway on which we progress with great speed, but at its end lies disaster. The other fork of the road — the one less traveled by — offers our last, our only chance to reach a destination that assures the preservation of the earth."

Rachel Carson, *Silent Spring*

The study of the environment, sustainability, conservation, and biodiversity are crucial to understanding how humans and our development may impact, shape, and change the world around us. Since humans started to form groups and eventually civilizations, we began to change the world around us through the use of fire, building, harvesting, and other resource use.

Generally, there are two schools of thought on the value of biodiversity and conservation. Some view nature having an **instrumental** value**,** where species and ecosystems have value as goods or services or as information sources. Alternatively, some see nature having an **intrinsic** value, where species have value or good in their own right. This principle applies to individuals, although some conservation biologists may also apply it to species and ecosystems. If biodiversity can be said to have intrinsic value, then the onus switches to developers from biologists who must answer why it is permissible to destroy it. This is an important shift since otherwise only economic arguments are considered (favouring development).

The differences in the perception of the world around us impact how we treat, see, and use the natural world. In our modern perspective, there are three key elements in how we view the human environmental impact on nature:



Only when human perception begins to view nature as something of value in itself, or something to be sustained beyond immediate need for future generations, does "conservation" emerge as a consistent practice in the human community.

KEY TERMS

A few key terms are important to further understanding our environmental awareness.

Biodiversity is the sum of variation within and across all levels of biological organization.

Sustainability means meeting our own needs without compromising the ability of future generations to meet their own needs. This includes development seeking to blend environmental, social, and economic goals.

Conservation, in an ecological context, is the careful utilization of a natural resource in order to prevent depletion.

Advocacy is working to influence public policy in social, economic, political, and cultural spheres in order to bring about justice and positive change.

Environmental advocacy refers to a variety of activities, avocations, and careers. It can include work in environmental law and policy, carers with mainstream environmental groups (e.g., Sierra Club, Nature Conservancy, etc.), working with advocacy groups (e.g., ADD), and being part of local to international activist groups.

BIODIVERSITY

"We should preserve every scrap of biodiversity as priceless while we learn to use it and come to understand what it means to humanity"

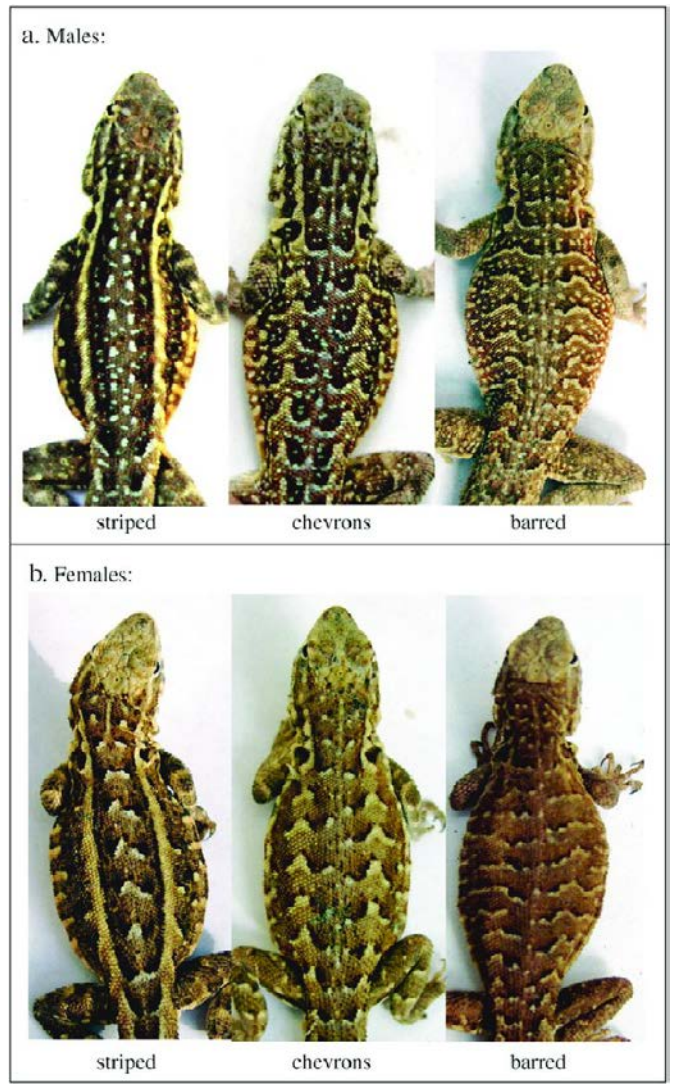
E.O. Wilson

Biological diversity, or biodiversity, is the sum of variation within and across the levels of biological organization. This biodiversity is driven by environmental variation that has led to changes in both genotypes (genetic variation) and phenotypes (physical or behavioural character, like hair colour or eye colour).

Environmental Variation

Phenotypes, or physical or behavioural character are influenced by variation in the environment of an animal (either before or after their natal period) and genetic variation. Though both can affect an individual's phenotype, genetic material is the only cause of diversity that can be passed on to new generations. Phenotypic diversity is often referred to as '**functional diversity**' because it represents the adaptive component of diversity.

A great example of how much phenotypes can vary can be observed within the plant *Brassica oleracea*. Different cultivars of this plant look very different to the observer. Each cultivar is genetically and phenotypically different, but more similar in genetic makeup than they would be to another species in the ***Brassica*** genus.



Phenotypic variation in common side-blotched lizard

Brussel Sprouts

Kohlrabi

Cauliflower

Broccoli

Collared Greens

Cabbage

Genetic variation is another form of variation that influences biodiversity. Differences in the genes of an organism leads to changes in their phenotype, leading to differences in natural selection (see below). Without genetic variation many of the basic mechanisms of evolutionary change cannot function. There are three main sources of genetic variation:

1. *Mutations* - changes in DNA, caused by many different forces. A singular mutation may have a large effect, but in many cases, organisms change through the addition of mutation on mutation.

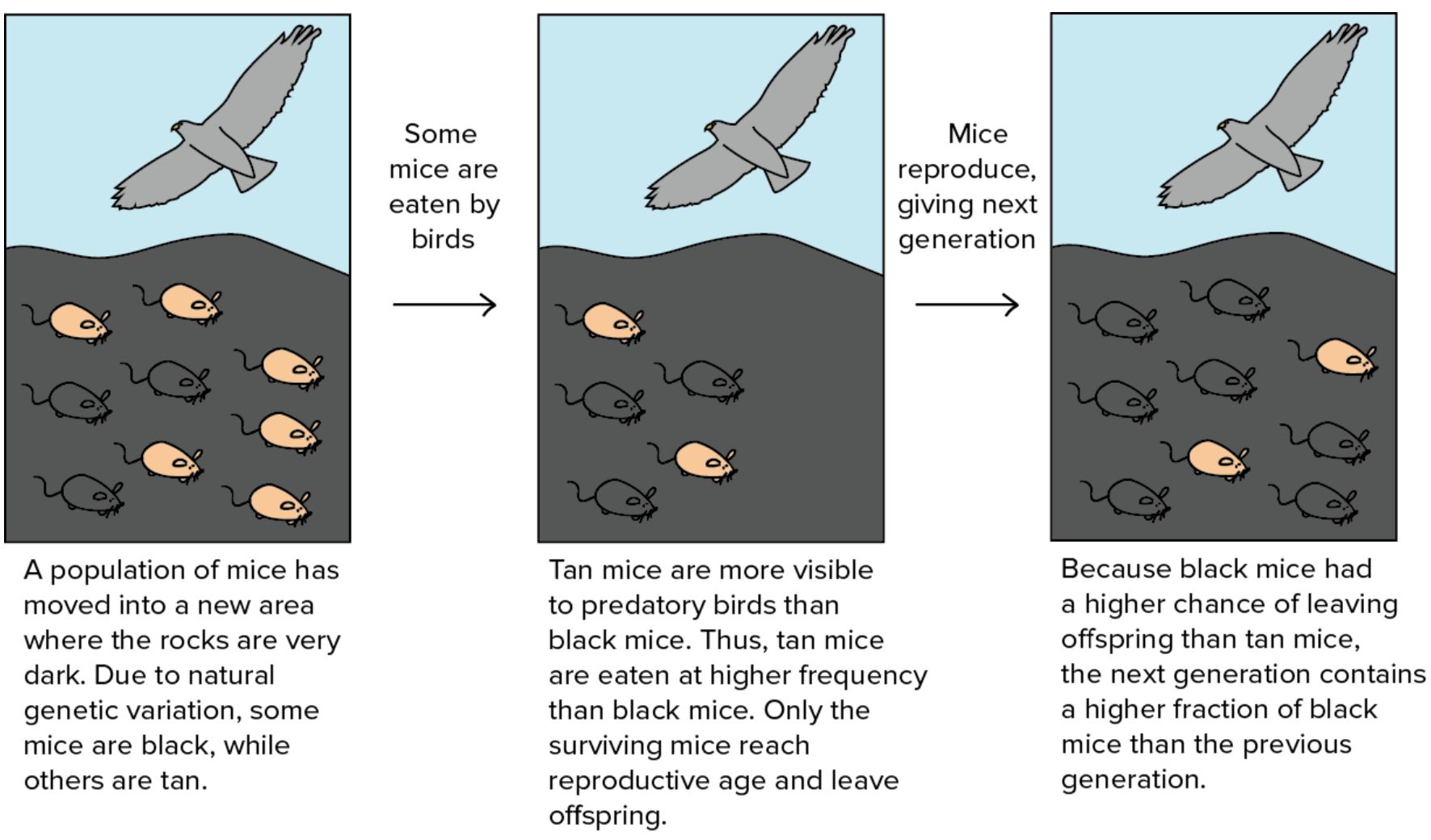
2. *Gene Flow* - the movement of genes from one population to another population. It is an important source of variation.

3. *Sexual Reproduction* - the mixing of genes creates new combinations into a population. This type of genetic shuffling is a very important source of genetic variation.

What evolutionary processes influence biodiversity?

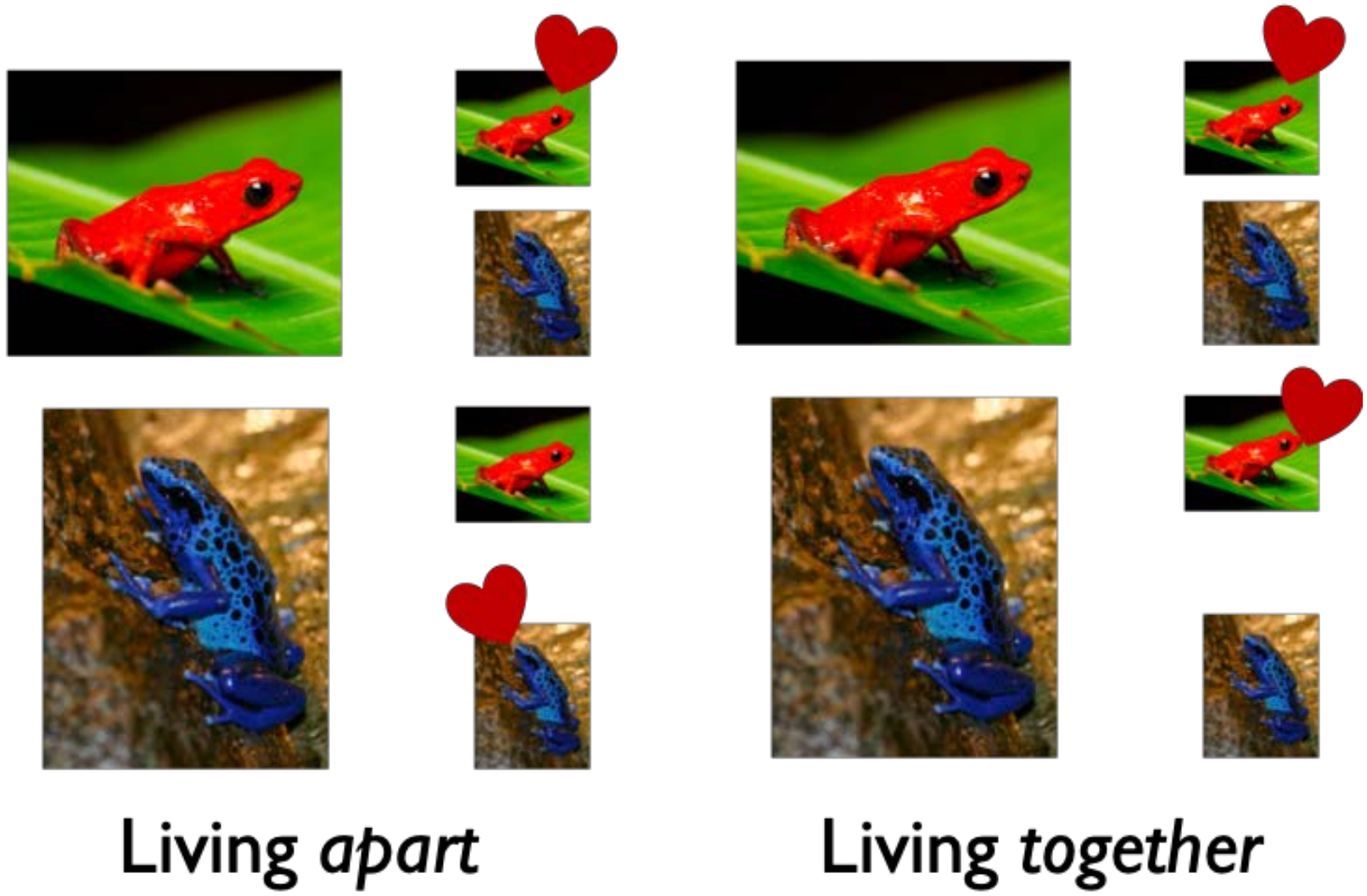
Both natural selection and drift influence what genes are passed onto the next generation and influence the biodiversity of all ecosystems.

Natural selection– the **differential survival and reproduction** of individuals in a population as a result of their having **heritable, adaptive traits**



Drift – when **chance** dictates which individuals **survive and reproduce**

Mate Choice can also impact biodiversity. As mentioned previously, sexual reproduction can influence how genes form new combinations into a population. Additionally, if an organism does not reproduce its genes will not be passed onto the next generation. In the case of poison dart frogs, red females prefer red males and blue females prefer blue males in areas where red and blue frogs live apart. However, when these two phenotypes, or colourations, live together both red and blue females prefer red males. The differences in mate choice will strongly influence the genes that are passed onto the next generation, like skin colour variation to the next generation.



Levels of Biodiversity

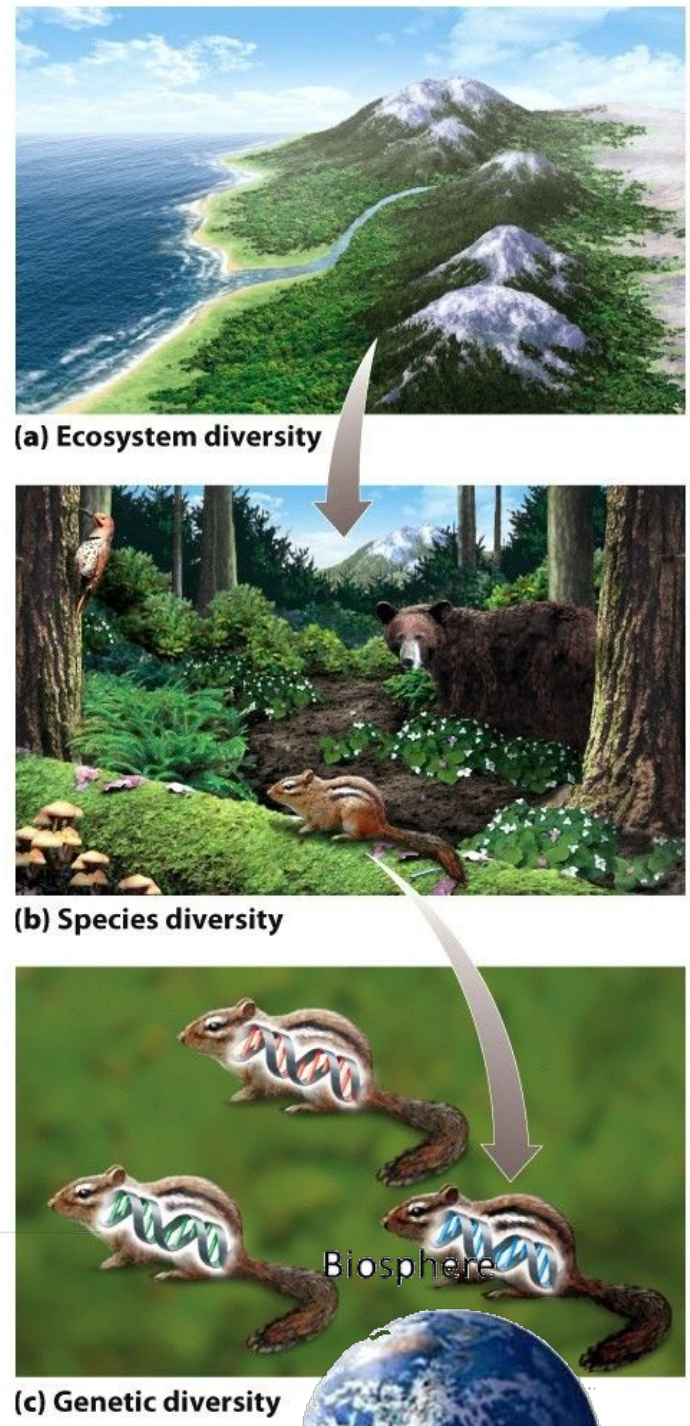
Biodiversity can be viewed at a variety of levels, through ecosystem diversity (big picture), species diversity, and genetic diversity (most specific).

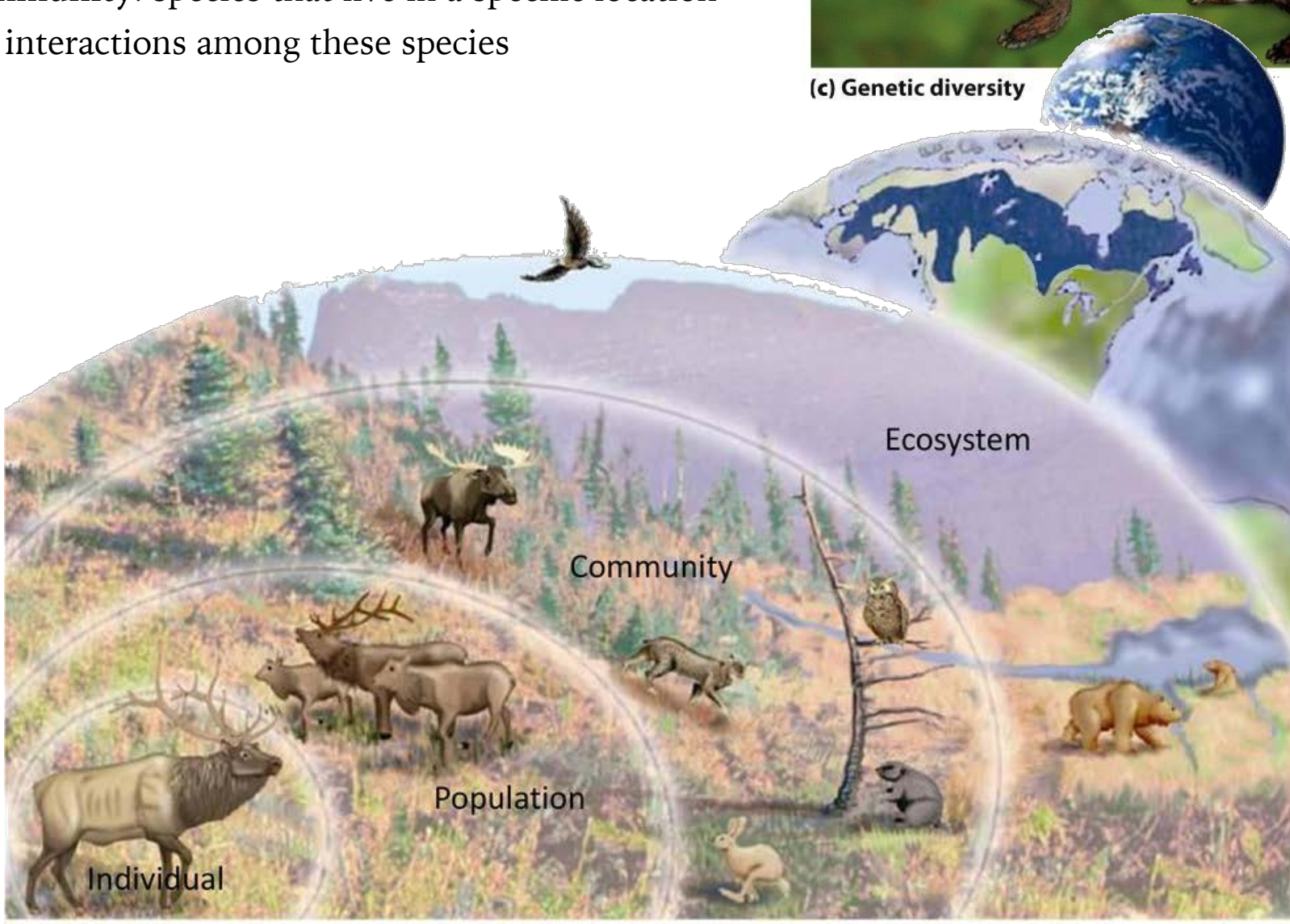
The ecoregion is the largest level of biodiversity, followed by ecosystems, communities, populations, and individuals.

Species:
Biological Species Concept **-** group of individuals that *do* or can *potentially* breed and produce viable offspring
Morphological Species Concept **-** group of individuals that differ in a morphological, physiological, or biochemical trait

Populations: group of individuals that *do* mate and produce offspring. Populations frequently differ genetically

Community: species that live in a specific location and interactions among these species



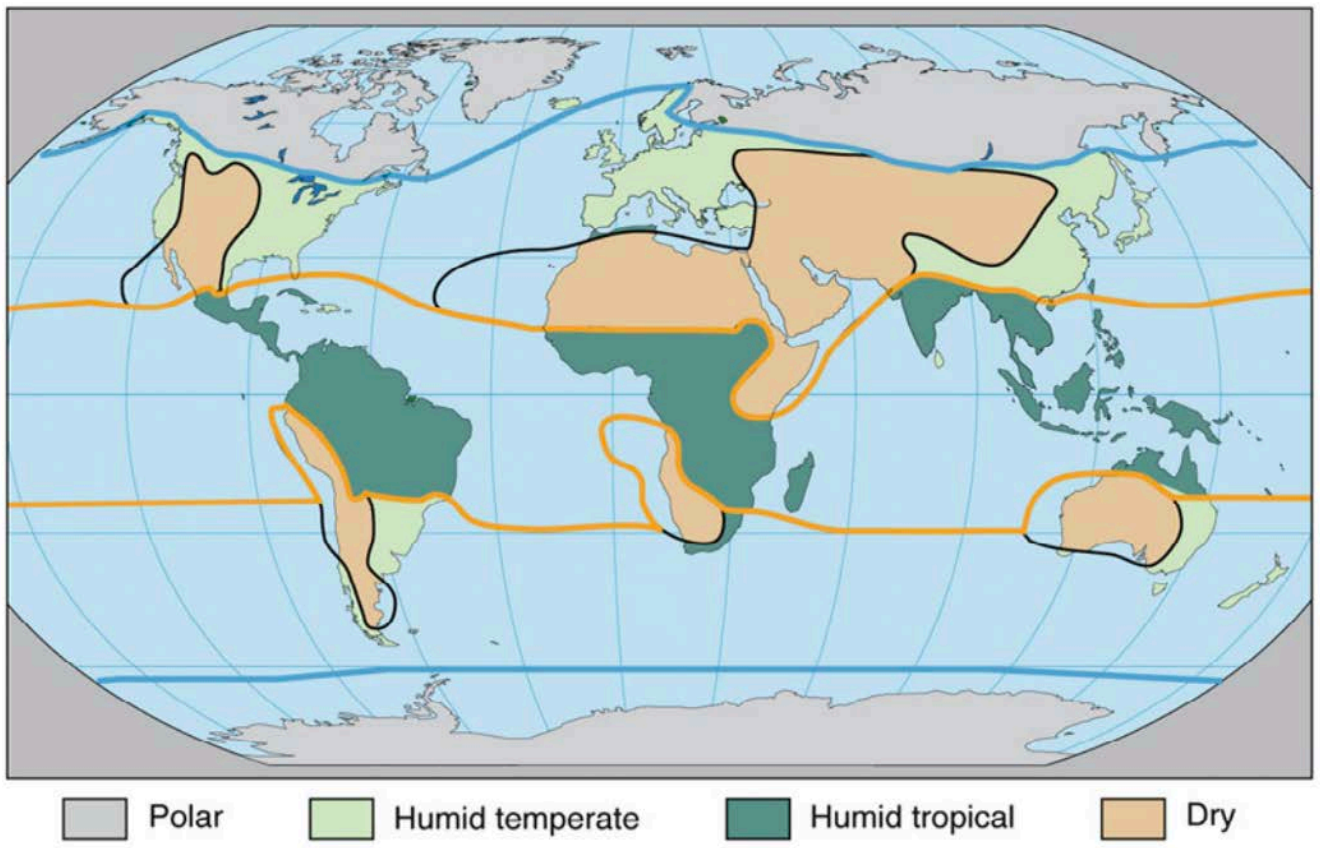


Communities will vary in **composition.** The *kind* of species that are present and the *abundances* of the species. The **composition** is influenced by predation, parasitism, competition, mutualism, dispersal, and other abiotic factors such as climate, history, and chance.

Ecosystem: biological community together with abiotic environment. It is influenced by water cycles, nutrient availability, climate and energy capture

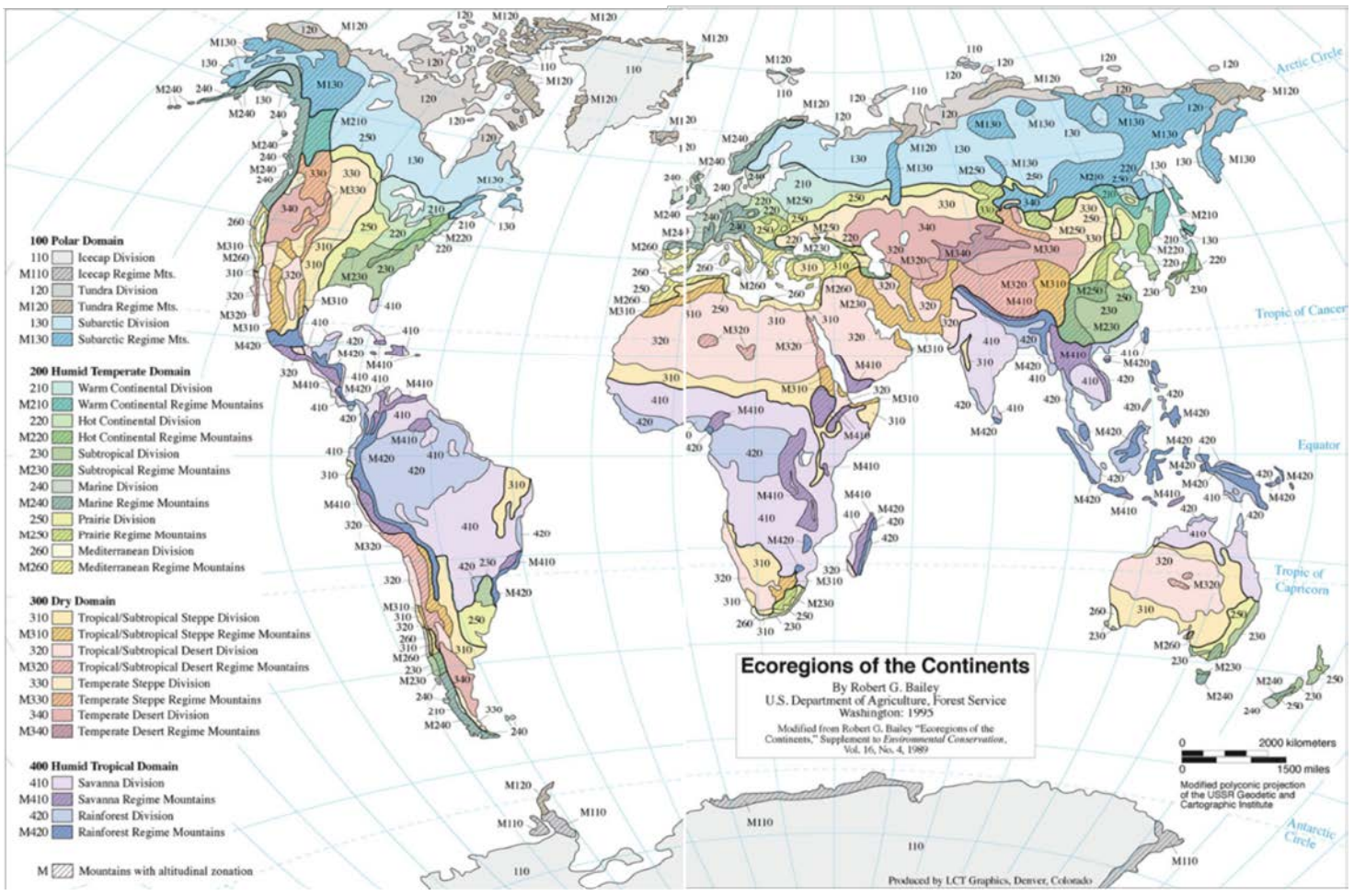
Canadian Ecosystems
© Biodivcanada

Ecoregion domains: area with a combination of predictable patterns of climate, which are influenced by latitude, global position, and altitude. Eco-regions were conceived as a more detailed measure of the world's biodiversity for conservation. Several organizations, including the U.S Forest Service, the World Wildlife Fund and the Nature Conservancy, have since adopted and incorporated the eco-region concept.



Global Ecoregions

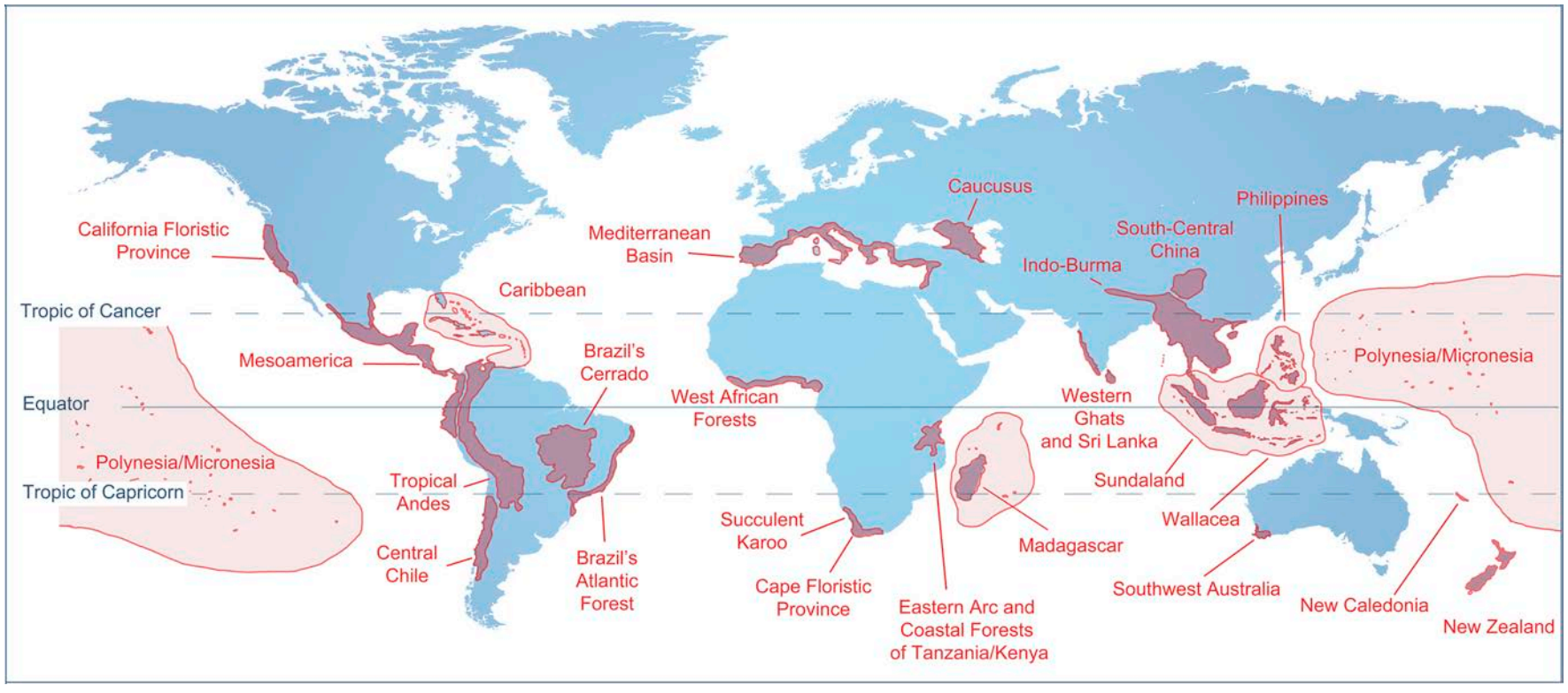
Ecoregion divisions: represents a single regional climate. Currently, 14 divisions are recognized (e.g., tundra, subarctic, subtropical, prairie, etc.). Manitoba is quite diverse, and includes Great Plains (Prairie, Humid Temperate), Northern Forests (Warm Continental, Humid Temperate), Hudson Plain (Subarctic, Polar), Taiga (Subarctic, Polar), and Tundra (Subarctic, Polar)



Global Ecoregions Divisons

Biodiversity hot spots

A biodiversity hotspot is a biogeographic region that is both a significant reservoir of biodiversity and is threatened with destruction.



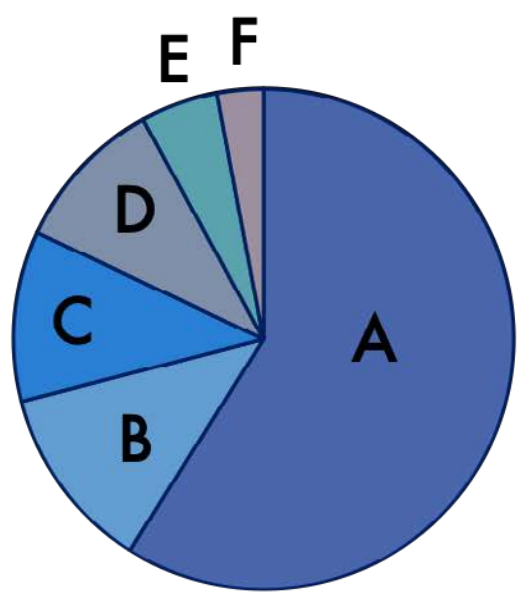
Global Biodiversity Hotspots
© Spicer 2017, *Plant Diversity*

Biodiversity hotspots are defined as areas that must have at least 1500 plant species and lost at least 70% of original habitat extent. In the past few years, 35 hotspots have been identified, where 75% of most threatened mammals, birds, and amphibians survive. Although they make up only 2.3% of the world's surface, many conservation groups use these areas as a focus to where they spend their money, as they are seen as a place where conservation money can get more 'bang for their buck'. Over 50% of all the world's plant species, ~43% of all terrestrial vertebrate animal species, and 29% of freshwater fish species are found in these regions.

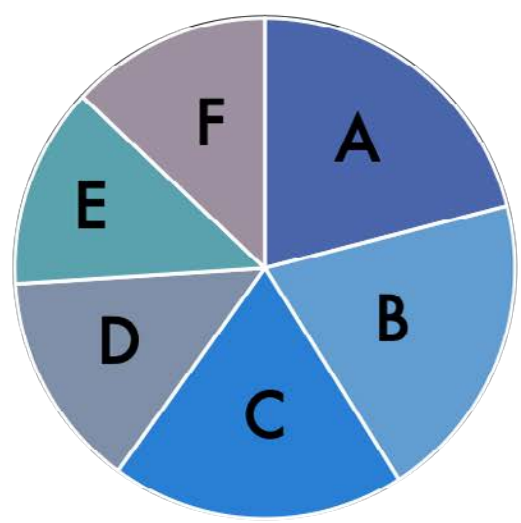
Measuring biodiversity

Four measures are commonly used to measure biodiversity. Richness and abundance are used to describe the number of species in an area (e.g., the higher the richness the more biodiverse), and the number of species of one kind within each community.

Richness (S) - number of groups of related individuals. In many surveys, richness is expressed as the number of species and is called *species richness (S)*

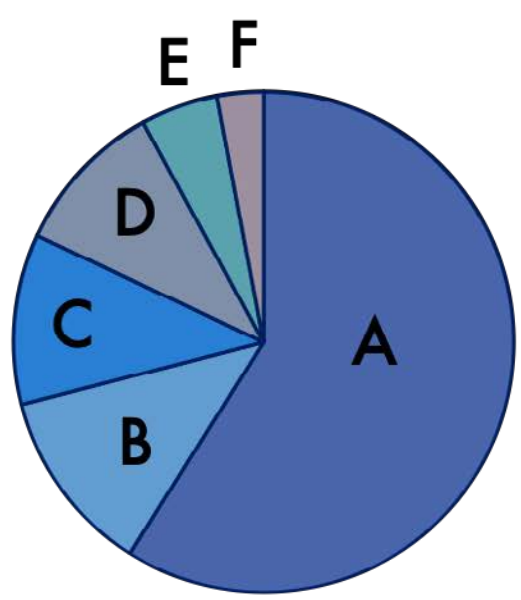


Community One
S = 6

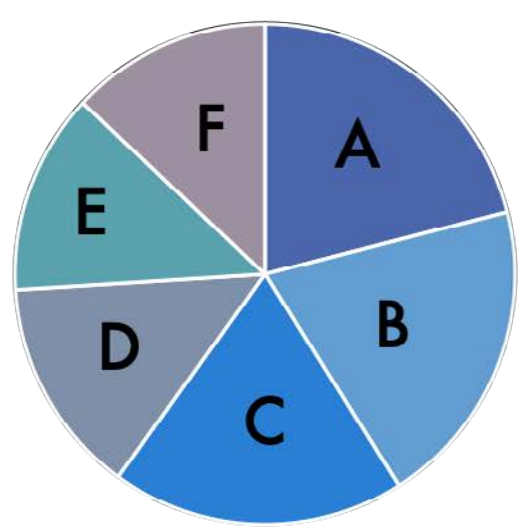


Community Two
S = 6

Abundance (A) - number of individuals per sample (e.g., community, population, etc.)



Community One –
Species A – A = 59/100



Community Two –
Species A – A =
21/100

Shannon-Weiner Index (H') – a diversity index that uses the number of species encountered to estimate the overall variation of organisms within a region. It is used to indicate both the variety and proportions of different species within a community.

Where:
H = the Shannon diversity index
P_i = fraction of the entire population made up of species i
S = numbers of species encountered
∑ = sum from species 1 to species S

$$H' = -\sum_{i=1}^{s} p_i \ln p_i$$

To calculate the index:

1. Divide the number of individuals of species #1 you found in your sample by the total number of individuals of all species. This is P_i
2. Multiply the fraction by its natural log (P_1 * ln P_1)
3. Repeat this for all of the different species that you have. The last species is species "s"

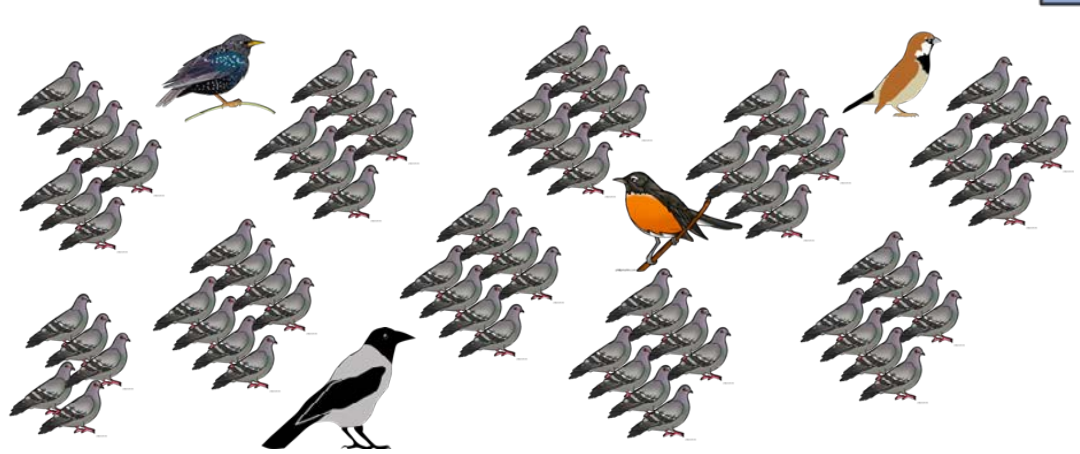
Sum all the - (P_i * ln P_i) products to get the value of H'

Example:

Community One

Birds	N_i	P_i	$\ln P_i$	$-(P_i * \ln P_i)$
Pigeon	96	0.96	-0.041	0.039
Robin	1	0.01	-4.61	0.046
Starling	1	0.01	-4.61	0.046
Crow	1	0.01	-4.61	0.046
House Sparrow	1	0.01	-4.61	0.046

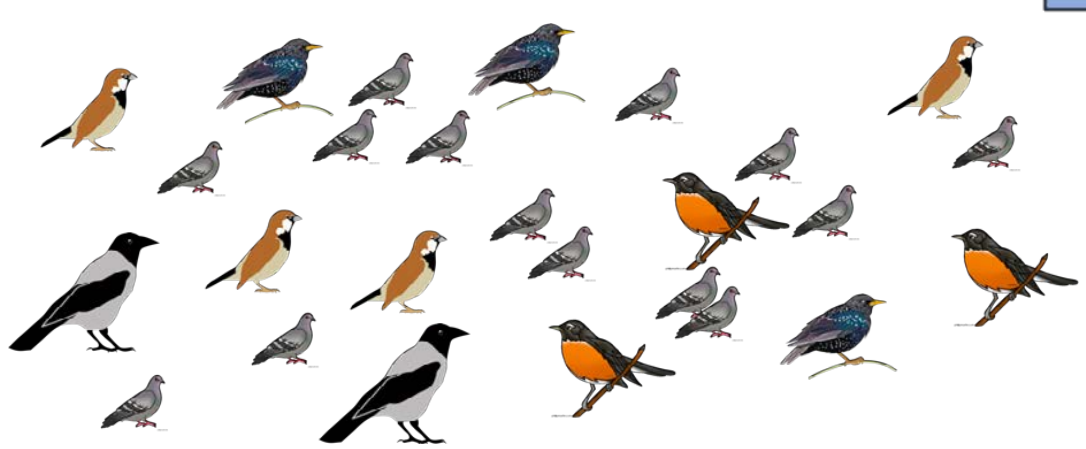
H'= 0.223



Community Two

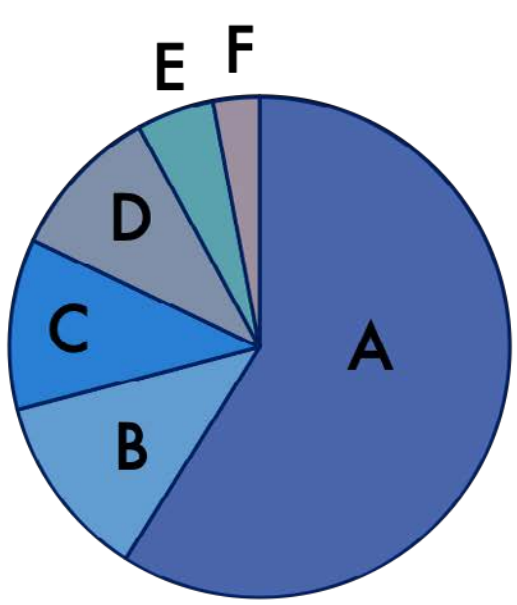
Birds	N_i	P_i	lnP_i	$-(P_i * lnP_i)$
Pigeon	14	14	14	14
Robin	0.54	0.54	0.54	0.54
Starling	-0.062	-0.062	-0.062	-0.062
Crow	0.033	0.033	0.033	0.033
House Sparrow	3	3	3	3

H'= 1.078

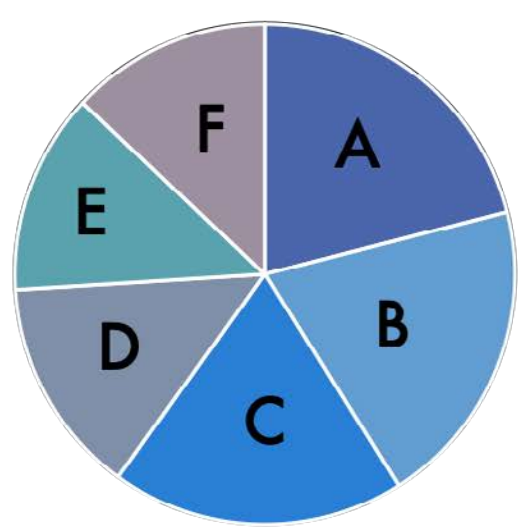


Based on the biodiversity index, community two has a higher *Shannon-Weiner Index (H')* and therefore is considered more biodiverse.

Evenness – the relative abundance of each species (*E*). It is calculated as *H'/lnS*, or the diversity index (H') divided by the natural log of species richness. The evenness is a measure that can be used to compare communities to each other.



Community One –
E = 1.29 / ln (6) = 0.72



Community Two –
E = 1.77 / ln (6) = 0.99

STATE OF THE PLANET

PROBLEMS AND CONSEQUENCES

Humans are the dominant ecological force on earth and changing the world around them at unprecedented levels. Over 98% of suitable agricultural land has been cultivated. This occupies over 25% of global land surface. Every year 0.1% of the total forest cover is lost. Many of the oceans are depleted of numerous fish species. Humans have substantially impacted and shaped the natural world around us.

CLIMATE CHANGE

Climate change, or the alteration and lasting change of the distribution of weather patterns over period of time, is something that the earth is now facing. Of all the ways in which human activity affects the distribution and abundance of wildlife on our planet, none is as pervasive and powerful as climate change. All species have a capability to adapt – at least to some degree – to natural stresses. Changes to climate and habitat have been occurring for eons, and with them have come changes to the diversity of species on earth. What makes current climate change unique is that, with the exception of cataclysmic events such as meteor strikes, the rate at which it is taking place is leaving species and ecosystems no time to adapt.

The direct impacts of human caused climate change have now been documented on every continent, in every ocean, and in most major taxonomic groups. The increase in storms and unpredictable weather patterns is also expected with climate change. These extreme weather events can devastate biotic populations as well as their habitat. This puts already vulnerable species further at risk of extinction.

POLLUTION

All forms of pollution are a large threat to biodiversity and conservation. Pollution is the introduction or presence of contaminants, whether they are chemicals or otherwise, into the natural environment that cause a negative change. It can be obvious, like the smoke stacks at a factory, or hidden, like the leaching of chemicals through the soil. Pollution can lead to the direct death of insect larvae, fish, amphibians and other animals. It can bioaccumulate or biomagnify in its environment. Diffuse pollution, like eutrophication, can cause long-term effects.

Eutrophication

Eutrophication is the alteration of the productivity (trophic status) of a waterbody through the accumulation of nutrients, including phosphorus and nitrogen. It may lead to algal bloom and ultimately the loss of oxygen and die offs. Eutrophication is largely a human-caused problem and remains the single-most widespread and serious pollution problem facing lakes across the globe. Worldwide, millions of lakes have been, and continue to be, eutrophied. Human activities can hugely increase the rate and extent of this process through both point-source (e.g., sewage treatment plants) and non-point source (e.g., agricultural runoff) additions of limiting nutrients (especially phosphorus) into aquatic ecosystems. Decreasing the amount of phosphorus that enters a lake is the best way to limit the problems associated with eutrophication. For example, in the 1970s phosphate was banned as an ingredient in detergents (laundry, dish soap, personal hygiene products, etc.) to reduce eutrophication of lakes (at the time it was in response to the eutrophication of Lake Erie). The increases in nutrients and eutrophication have led to biodiversity loss and ecosystem dysfunction.

Air pollution

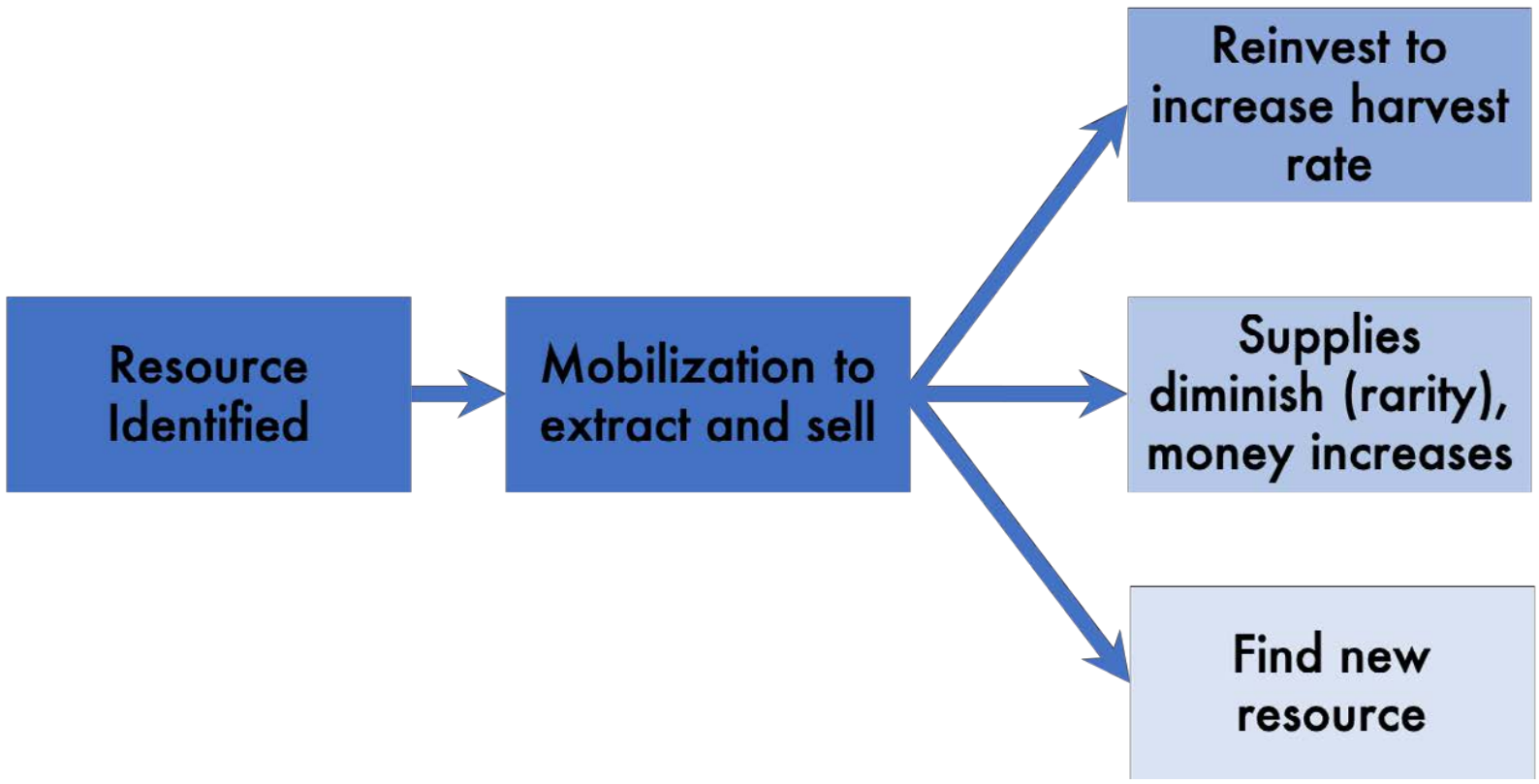
Ecosystems can be negatively impacted by air pollution, such as sulphur and nitrogen emissions as well as ground level ozone. Sulphur dioxide and nitrogen oxides emissions can deposit into water, vegetation, and soils as 'acid rains'. This will lead to an increase in acidity which can have strong negative impacts on plants and animals. Eventually, this decreases an ecosystems ability to provide *ecosystem services*.

OVEREXPLOITATION

Overexploitation is overharvesting, or the collection of a renewable resource to the point of diminishing returns. Sustained overharvesting can lead to extinction. Although harvesting natural resources is a part of our past, it is becoming more common and impacting more species. The rate at which we are overharvesting is increasing due to improved technology, increased road access to remote areas, need to feed growing urban populations, and increasing affluence (wealth) throughout the world.

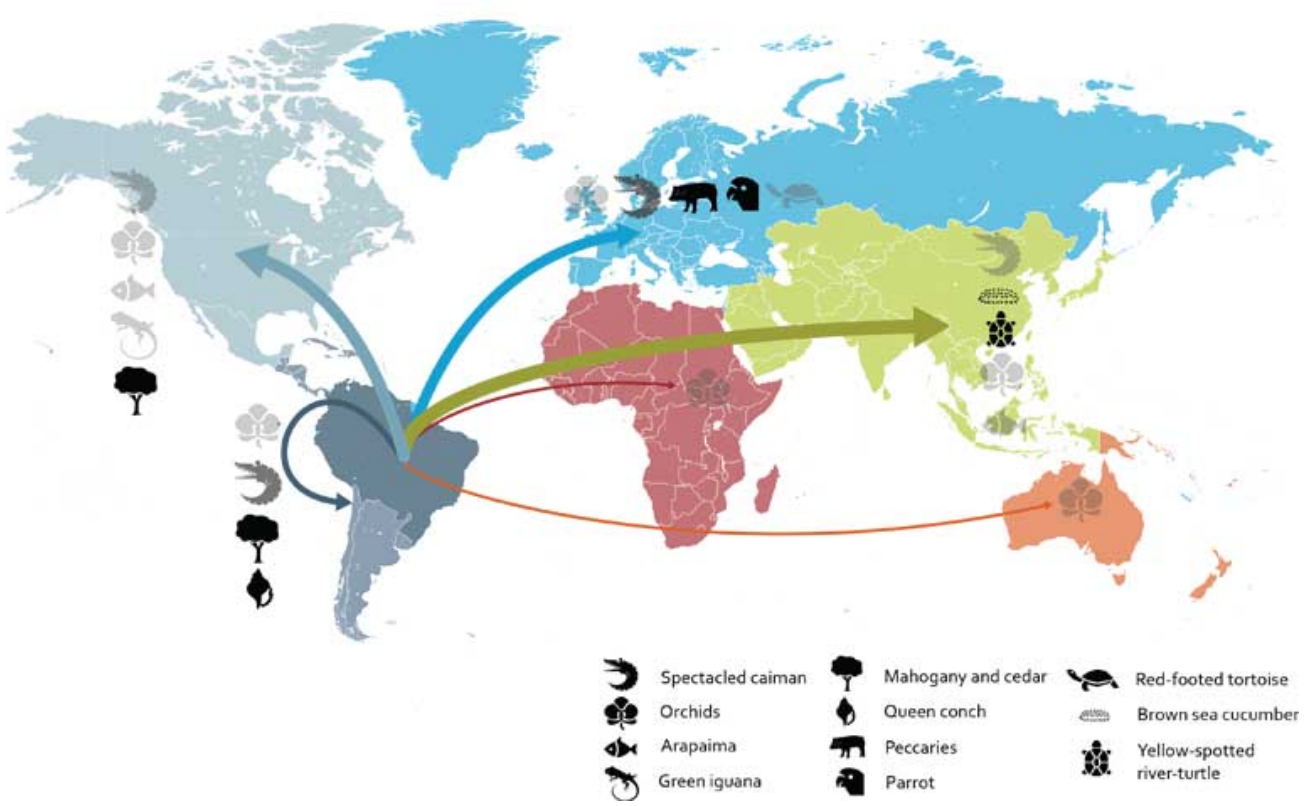
Exploitation is caused out of necessity (basic resources) and lack of restraint (finding a way to exploit resources).

Commercial Exploitative Pattern



Wildlife Trafficking

The wildlife trade is an issue at the heart of the tension between biodiversity conservation and human development. Wildlife is used for medicine, construction, food or culture, and has a fundamental role in regional, national, and international economies. A large proportion of trade and economy is entirely reliant upon wildlife products, including thousands of animal and plant species. It provides income for millions of producers, raw materials for businesses and local collectors, and goods for hundreds of millions of consumers.



Legal Wildlife Trade
© UNEP-WCMC

Yet, there is little recognition of this legal trade which has allowed it to be mismanaged and leaving room for an illegal trade to develop and prosper.

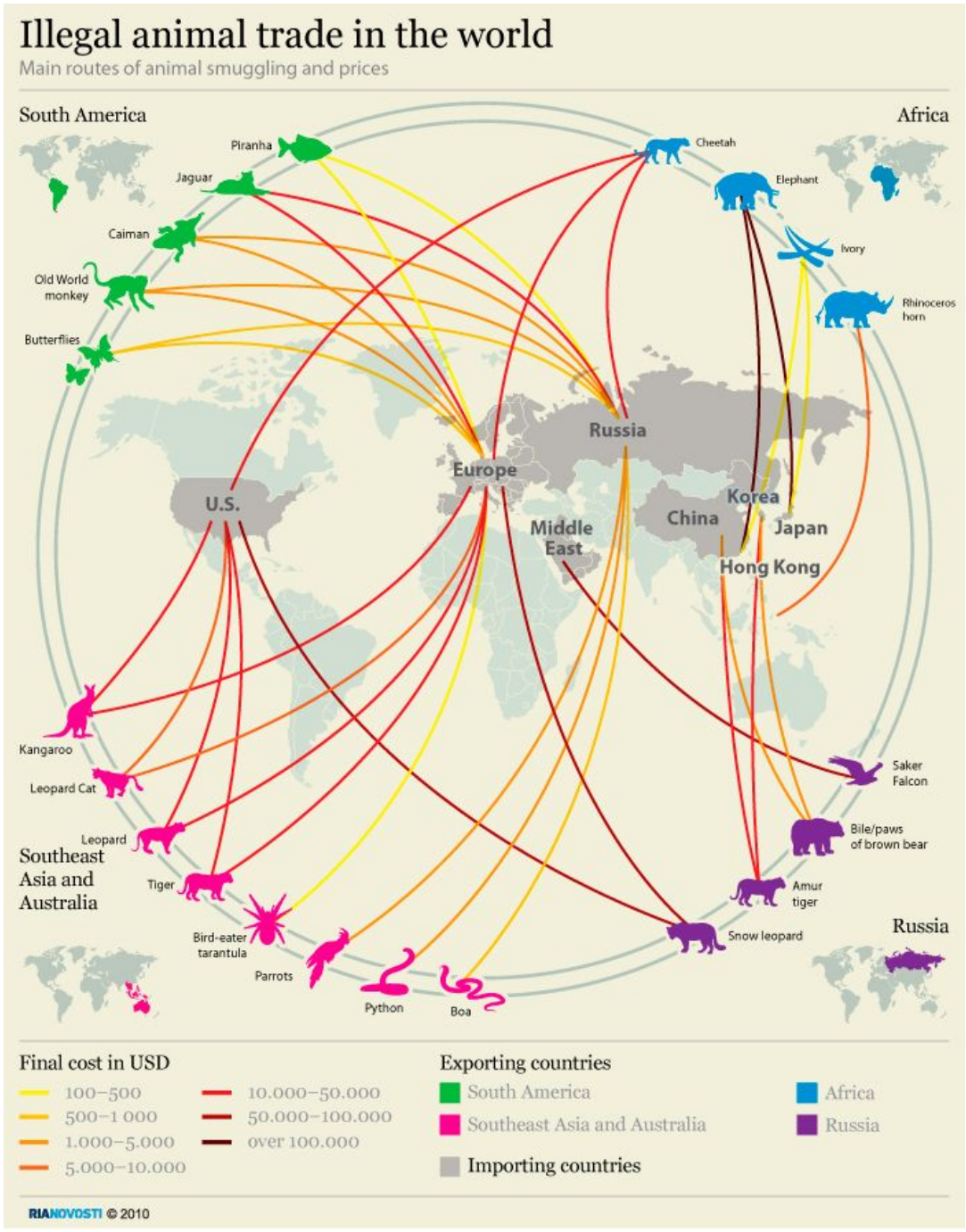
The illegal wildlife trade is due to a variety of factors including the pet trade, traditional medicine, and jewelry and trinkets.

Pet trade – illegal collection from the wild of animals or plants for personal collections, zoos, or research

Traditional medicine – illegal collection from the wild of animals or plants for 'medical' or 'cultural' reasons, including Asian and African traditional practices that have involved using shark fins for soup, bear gall bladder, tiger penises, and sea turtle eggs as aphrodisiacs.

Jewelry and Trinkets – harvest and sale of wildlife for jewelry is a threat to a number of species, including Queen conch, sea turtles, and ivory.

Wildlife crime is now big business throughout the world, with wildlife and other biological parts sold like illegal drugs and arms. The illegal wildlife trade is one of the main reasons that particular species are now endangered. One of the tools used in the wildlife trade is poaching, or the illegal killing of animals. Rhino poaching to fuel to demand for the illegal rhino horn trade (for ivory) reached an all-time high in 2011, with 448 rhinos poached in South Africa alone.



In order to combat the illegal wildlife trade, many countries have signed on to *CITES*, or the **C**onvention on **I**nternational **T**rade in **E**ndangered species of wild flora and fauna. This

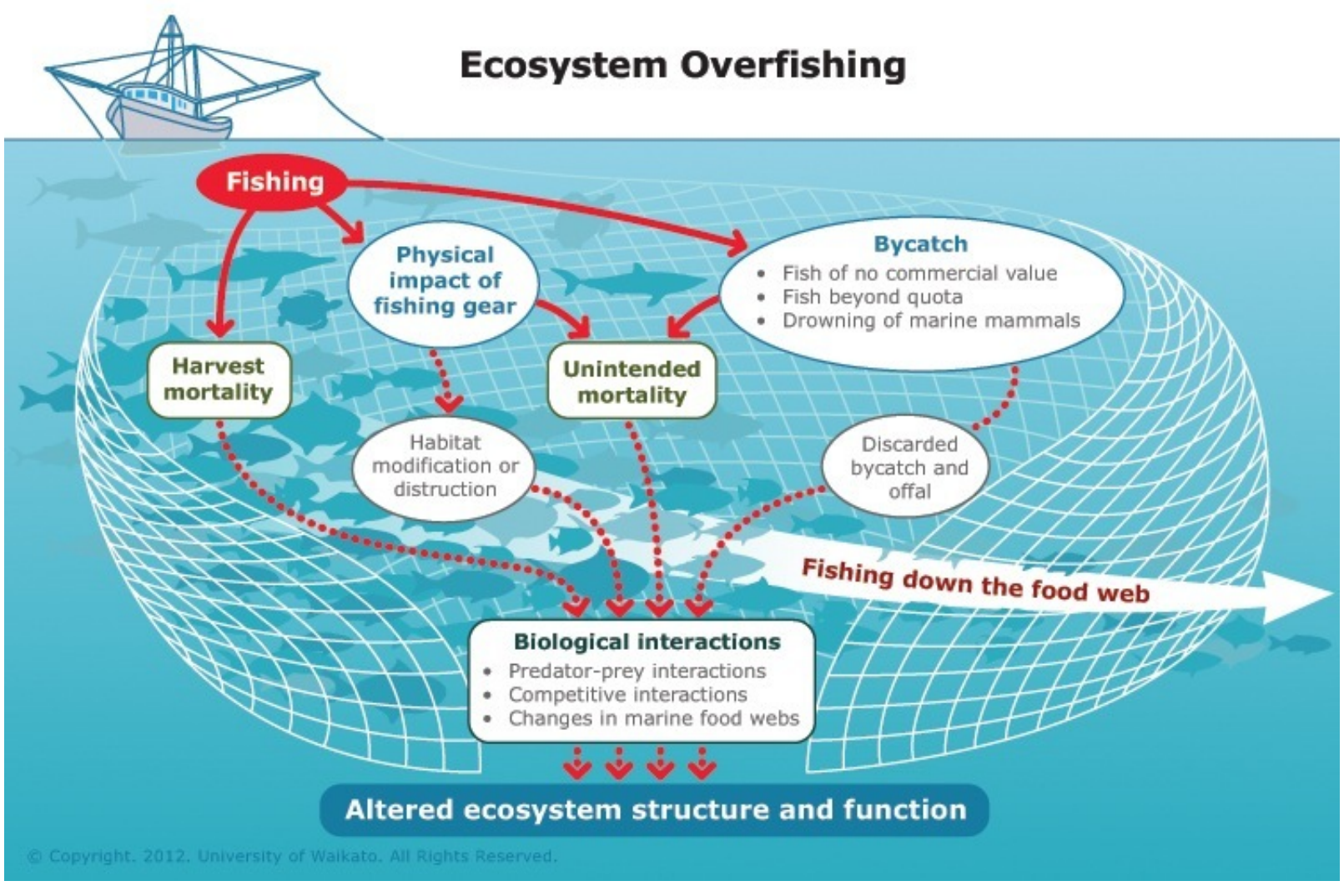
convention attempts to ensure that international trade in specimens of wild animals and plants does not threaten their survival. Over 35 000 species of plants and animals are regulated under this convention.

The wildlife trade monitoring network, or *TRAFFIC*, is a joint program of WWF and IUCN (International Union for Conservation of Nature). This has developed into a global network that is research-driven and action-oriented. It is governed by steering committee of parent groups WWF and IUCN. They provide analyses and recommend positions on wildlife trade issues to WWF and IUCN and to external audiences through advocacy and communications action.

Possible solutions to the illegal wildlife trade include removing and destroying (burning) ivory stalks and other animal products when seized. Changes in consumer choices, including buying certified products and educated buying, including not buying exotic pets, can assist ensuring that money does not flow into the illegal industry. Community enforcement against poaching and trafficking is also extremely important. Finally, lobbying large countries like China and the USA to enforce stricter laws can help.

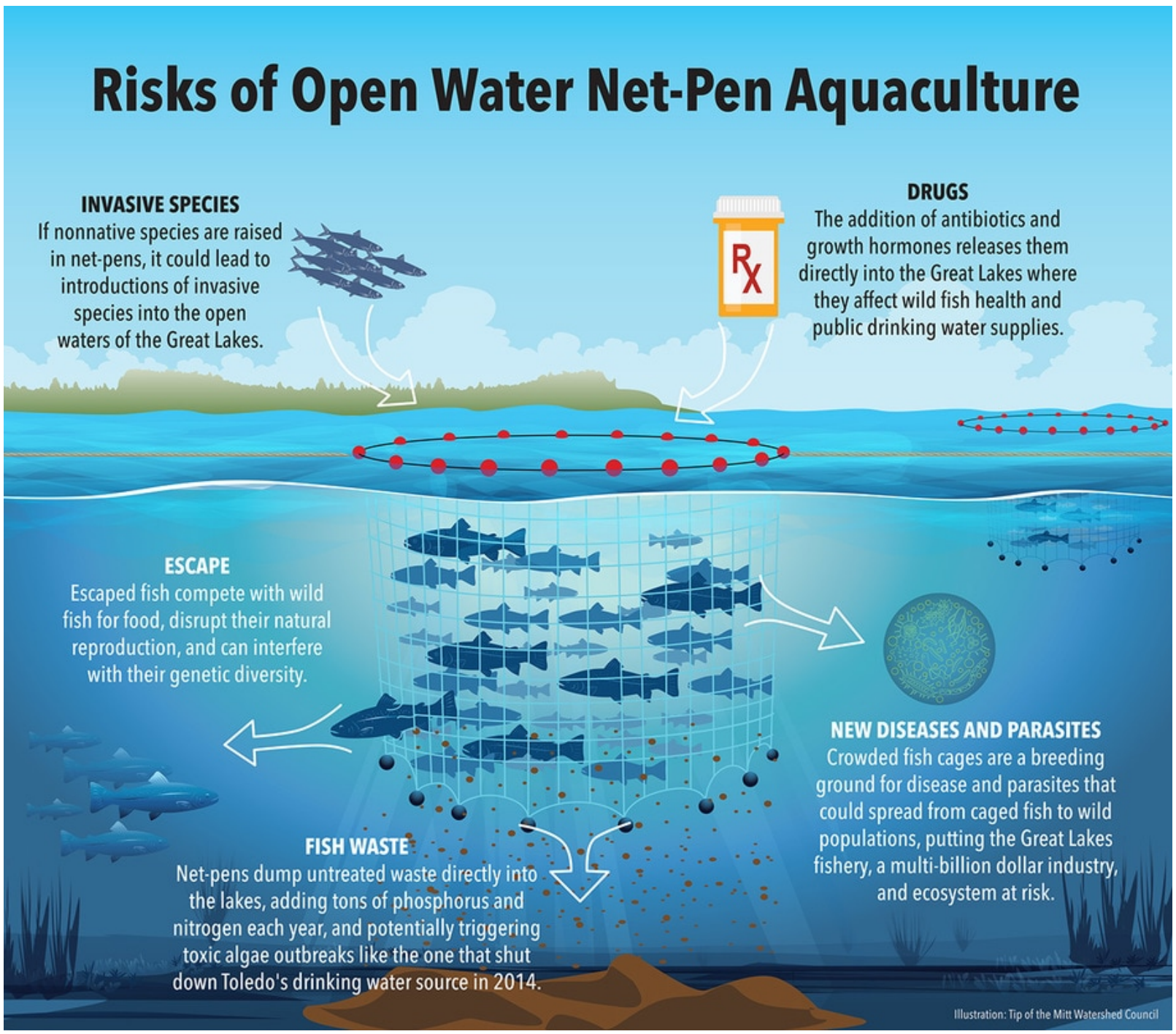
Overfishing

Overfishing has become a very large issue throughout the world.



Overfishing has a variety of issues. Fishing down the food web can lead to the reduction of large predatory fish (e.g., cod, swordfish, and tuna). Since the 1960's over 90% of these predatory fish have disappeared. Due to this problem, the fishing industry now attempts to fish lower on the food chain (smaller fish such as anchovies, menhaden, sardines, and herring). The physical impact of fishing gear and bycatch can lead to unintended mortality of other species such as dolphins, sharks, turtles, and other non-target species. The discard of bycatch and offal (food remains) can increase the nutrients in different regions. All of these impacts together may alter biological interactions, like predator-prey and competitive interactions and marine food webs.

As an alternative, fish farming, or aquaculture, has been proposed as an alternative to solve the problems of overfishing. However, this substitute has issues of its own. Aquaculture may lead to the introduction of invasive species if non-native species are being raised in new areas and individuals escape. The addition of drugs such as antibiotics or growth hormones may impact fish health, other wild animals, and public drinking supplies. Other issues with aquaculture are featured in the figure below.

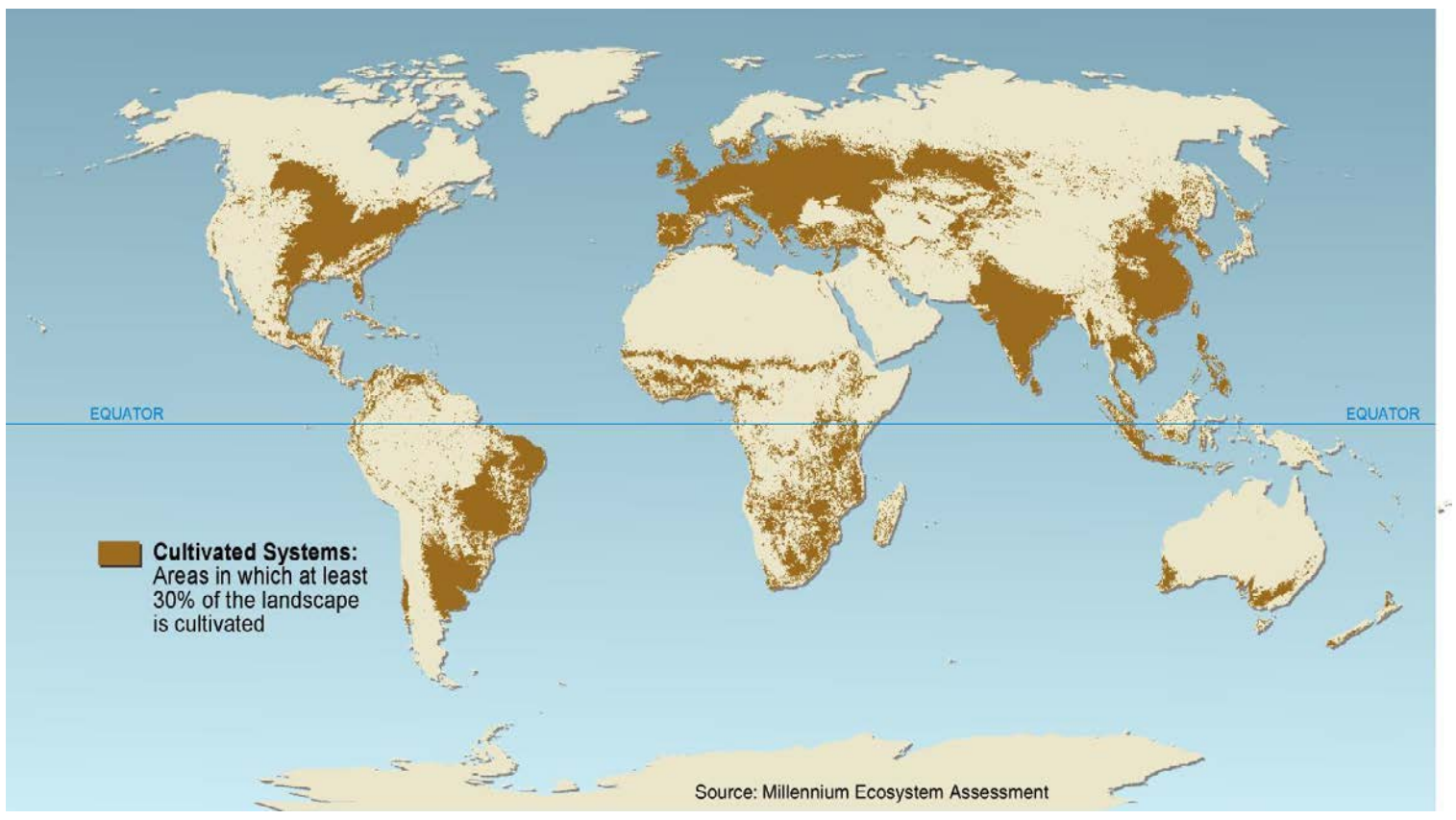


Commercial Overexploitation

The commercial extraction of resources, such as the mahogany from Central America, has led to certain plants and animals becoming endangered. In the case of mahogany (*Swietenia* spp.), its overharvest has led the tree to become endangered. Harvesters originally focused on one of the two species of mahogany (*S. mahagoni*) until it because so endangered that they had to switch to the second species (*S. macrophylla*). In the late 1990's it became so rare that its commercial harvest had to stop. It is now protected by *CITES* in certain countries. The main demand for this product has come from the USA, where it has been used to make expensive furniture. Importers have moved to new countries when local stocks are exhausted or new regulations prevent its harvest.

HABITAT DESTRUCTION AND DEGRADATION

Habitats have been destroyed and degraded around the world. Urban areas and islands are nearly completely altered. Areas that are considered developed, like Europe, China, Japan, eastern North America, and western Africa, often have more than 50% of their habitats altered. Only 15% of land in Europe remains unaltered. Germany and the United Kingdom have no regions that remain unaltered. Agriculture is estimated to be the proximate driver for around 80% of deforestation and loss of grasslands worldwide. While in the 19th century, hunting or fishing was the major threat to wildlife, in 21st century Canada, the loss of habitat is the major threat for many species.



© Philippe Rekacewicz, Emmanuelle Bournay, UNEP/GRID-Arendal

Types of Habitat Loss

In reference to ecosystems, degradation, destruction, and fragmentation indicate three different levels of disturbance on an ecosystem.

Destruction - Complete elimination of the habitat, damaged to a point where it cannot support the naturally occurring ecological communities

Degradation - reduces the quality of the environment making it difficult for biota to thrive, disruption of ecosystem processes. This can occur while the habitat still appears to be intact.

Fragmentation - large habitat areas split up into smaller sections or fragments that are often isolated from each other.

Deforestation

Deforestation, or the removal of forests, can be caused by a variety of factors. Fires, clear-cutting for agriculture, ranching and development, unsustainable logging, and degradation due to climate change can all lead to the loss of forests. It has been estimated that we are losing about 18.7 million acres of forests annually.

Deforestation can have substantial impacts on the environment. It can lead to the increased greenhouse gas emissions. Forests can act as carbon sinks when left intact, but they act as carbon sources when they are cut, burned, or otherwise removed. In Sumatra, for example, deep peatlands are being cleared, drained, and converted into pulp plantations. This action is contributing to global greenhouse gas emissions. Additionally, water cycles can be disrupted by the removal of forests. Trees play a key role in the water cycle, helping balance water between land and the atmosphere. Deforestation can also lead to increased soil erosion as tree roots play an important role anchoring fertile soil. Finally, deforestation disrupts the lives of both humans and other animals. Millions of people depend on the forests, using it for hunting, gathering, and medicine. But deforestation impacts all of these

peoples. Further, animals count on these areas as key habitat, providing them with space, food, and water.

Forests represent the most widespread and diverse types of vegetation in the world. As such, deforestation is one of the largest causes of habitat destruction, around the world with high rates of deforestation in Canada. There are a few fundamental causes of deforestation.

1. *Human population pressure* – human populations are increasing, particularly in the tropics, increasing the pressure to feed more people. This is leading to the conversion of forests into agricultural land. It has been estimated that 90% of deforestation of the tropical forest is due to agriculture. The form of agricultural pressure varies from region to region. In Africa, slash-and-burn farming by small groups or families is destroying forested regions. In South America, large scale agriculture drives the conversion for beef and soy exports. Finally, in south east Asia, the combination of palm oil, coffee, timber industries, and resettlement programs has led to deforestation in this area.

2. *Perverse Subsidies* – a perverse subsidy is a payment by a government to an individual or company which, instead, increases the divergence between private and social costs/ benefits. For example, the German government supports coal-mining by giving mining companies subsidies. The German government gives $6.7 billion a year to mining, or the equivalent of $82 000 per miner per year. It would be more economically efficient to close all the mines and pay each an annual salary for the rest of the year. This would benefit the environment through less pollution and global warming.

3. *Commercial Logging* (clear cutting and selective logging) – the annual global consumption of wood is 3 billion m^3, with 50% of that used as fuel. Southeast Asia dominates the timber industry with 63% of total.

4. *Weak Governance* - Countries in a lot debt and/or where demand is high for timber, lots of money can be made with little investment. If governance is weak in these countries, they may promote logging and clearing or not control this activity, due to corruption or the lack of resources to enforce laws and regulations.

Grassland Destruction

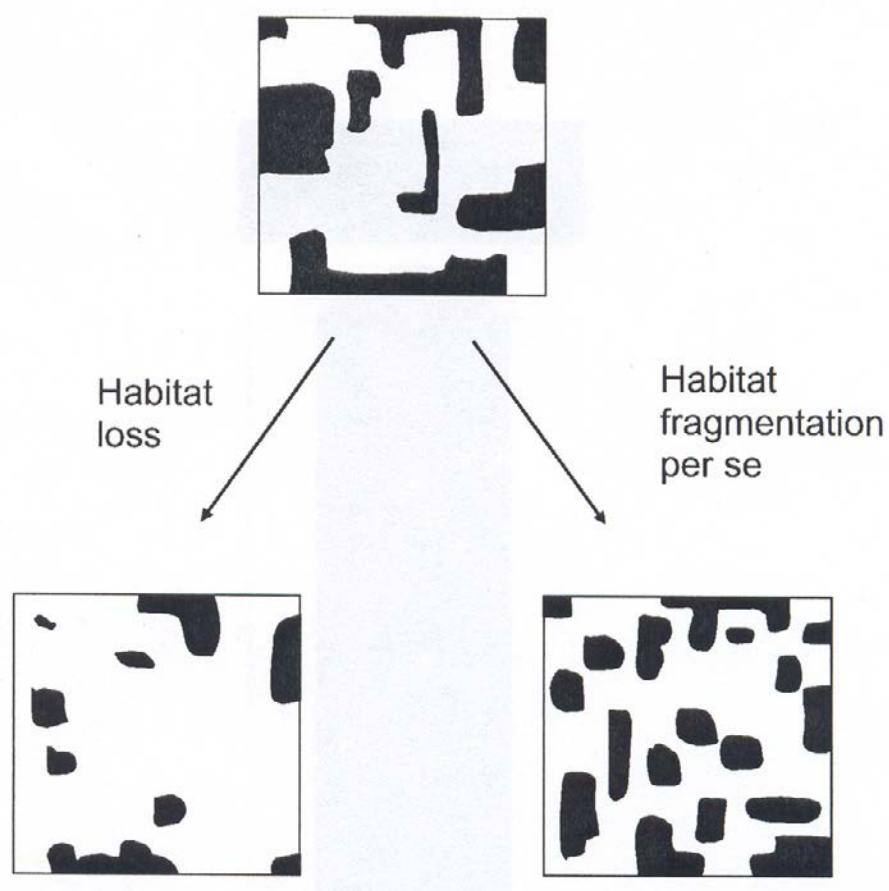
Grasslands are considered the most endangered ecosystems throughout the world, by the International Union for the Conservation of Nature. Recent research has shown that the Great Plains in North America are losing a higher proportion of grassland than the Amazon has lost tropical forests. Temperate grasslands are currently the least protected and most converted ecosystem. Within central Canada, only 5% of the remaining natural grasslands

are currently being protected. It has been estimated that 2.5 million acres of the Great Plains were ploughed between 2015-2016. Further, over half the species listed under *Manitoba's Endangered Species Act* are species that live in grasslands.

Like forests, grasslands are threatened by agricultural development. Over 50% of grasslands have been converted into crops and other land uses. Many are intensively grazed as rangelands, for cattle, goats, and sheep. Some are facing desertification or fragmentation due to urban development.

Habitat Fragmentation

Habitat fragmentation is the process by which a large piece of habitat is converted into a smaller number of patches with smaller areas that are isolated from each other. Habitat fragmentation can result in, (1) increase in the number of patches, (2) decrease in patch sizes, and (3) increase in isolation of patches. Habitat fragmentation can be different than habitat loss, as there may be the same amount of habitat available, just in a different location. Fragmentation can be caused by a variety of factors, including urbanization, agriculture, transportation, deforestation, resource extraction, flood control and hydroelectric, as well as oil and gas pipelines.



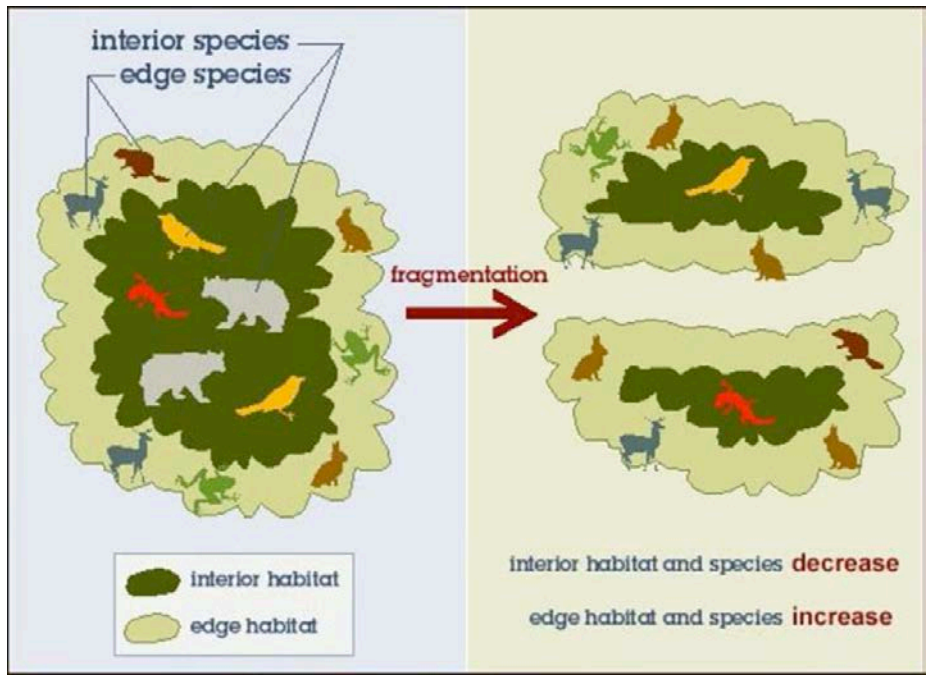
© Fahrig 2003, *Annual Review of Ecology and Systematics*

The consequences of fragmentation can vary,

1. *Population sizes are restricted* – smaller populations of individual species in fragmented areas may lead to genetic drift and inbreeding, and eventually lead to reduced reproductive success.

2. *Immigration is reduced* – isolated fragments may include species that either can not or will not cross barriers. This may include pollinators or seed dispersers which will then impact the growth and spread of plants. The isolation may lead to local extinction or extirpation.

3. *Edge effects* – the edge of a habitat has unique biotic and abiotic characteristics. Often this makes it a unique habitat for a group of species. However, in the case of habitat fragmentation, the process creates far more edge habitat compared to what was previously available, impacting the species that use this habitat as well as species who are unable to use these areas. Species adapted to the middle of an ecosystem, and not the edge, suddenly have far less area to use.



4. *Movement of exotic species* - Species that were previously limited in their ability to move deep into an area may now have access due to this disturbance.

5. *Loss of habitat variability* - the remaining fragments may not include all of the habitats present before. This may cause issues for many species, like birds who may need specific areas to nest and reproduce. For species like amphibians, this may cause issues if there is a lack of open water which is required for their survival.

6. *Habitat loss* - some species require large unbroken pieces of habitat to survive (e.g., bobcats and brown bears). Fragmentation results in these species no longer being able to survive within a region.

The degree of fragmentation impacts the severity of the consequences. Larger patches are commonly considered more important because they tend to include more viable populations of plants and animals and increased interior habitats. However, small patches may also be an important conservation area because they contain a unique or rare habitat type or species.

Reducing Habitat Loss and the Effects

In order to reduce habitat loss and its impacts, we can do a few things. For example, educate yourself and others, reduce pollution, protect significant areas like shorelines and wetlands, plant native vegetation, and prevent the spread of invasive species.

SPECIES INTRODUCTIONS AND INVASIVE SPECIES

Invasive species pose a serious threat to the stability of countless ecosystems. Invasive species have been shown to disrupt food webs, damage or destroy habitat, and contribute to the decline of many native species. In addition to their environmental impact, invasive species can have a significant impact on local economies.

Exotic species are species that occur outside of their natural range. Only ~1% of exotic species introductions lead to established populations capable of increasing and spreading. This process may take decades before they become invasive. An invasive species is an exotic species that establishes itself ***and*** increases in abundance at the expense of other species. Species include plants, seeds, eggs, spores, other propagules, and animals (e.g., mammals, reptiles, amphibians, fish, insects and other invertebrates).

An invasive species is an exotic (originating from another region of the world) species whose introduction causes or is likely to cause economic harm, environmental harm, and/or harm to native species (including human) health. This expansion is often due to human activities. Invasive species are more commonplace than one might think. Kentucky bluegrass, periwinkle, lily of the valley, and dandelion are all common plant species found in our lawns and gardens but are invasive species to this region. The domestic cat is thought to have originated in Africa. Some species have moved within the country into areas they have been previously absent. For example, the house finch, native to several western provinces, is now found in a number of eastern provinces.

Invasive species grow and reproduce rapidly, causing major disturbance to the areas in which they are present. These species can threaten an area's biodiversity by overwhelming native species, damaging habitat, disrupting food sources, and introducing parasites and disease. Most invasive species have little to no population control mechanisms in place to help control their population levels in the area of introduction and therefore often increase in numbers rapidly. Once invasive species are established in a region, they can be difficult, or impossible, to control and remove.

Invasive species often share characteristics that make them successful in their new region. Invasive species characteristics include:

Few natural enemies

Many invasive species do not have any natural enemies (e.g., predators, competitors, parasites, and pathogens) in the area they invade. A lack of predators and pathogens may allow the invasive species population to spiral out of control.

High reproductive rates

Invasive species frequently have rapid growth, very short life cycles, prolific young production (e.g., prolific seed production), and seed dormancy (in plants).

High survival

Invasive species often can tolerate a wide range of environmental conditions. Invasives often can use a variety of pollinators (e.g., insects (such as bees, wasps, butterflies, etc.) and birds) to complete their life cycle.

Good dispersal

Most invasive species can very effectively distribute themselves into new environments. A lack of natural barriers, predators, and intraspecific competition may allow them to spread quickly throughout the new region.

Aggressive competitors

Most invasive species are superior competitors to native species. They may be more effective at obtaining resources like food, water, and/or space, or be better specialized at obtaining one specific set of resources.

A combination of these characteristics allows invasive species to outcompete native species in a region and become established.

Invasive species can be added to a community either by natural range extensions or because of human activity. Humans have served as both unintentional and deliberate dispersal agents for millennia. In the last 200 to 500 years, the increase in human movement and trade has dramatically increased this dispersal. Human activities may include international, national, and regional trade and travel, horticulture, gardening and ornamentals, transportation and unity corridors, seed mixtures (re-vegetation, bird seed, wildflower), recreation, wildlife, livestock, humans, and pets (including the pet trade).

The global trade market can play a large role in the spread of invasive species. Shipping containers and packing materials are potential sources of accidental introduction of seeds, insects, pathogens, and other organisms. Cheat grass (*Bromus tectorum*) was introduced to North America in 1889 through shipments of grain seeds from Europe. Wooden packing material is often used to protect shipments of goods. These materials can often harbor invasive plant pathogens and insects. The Asian long horned beetle (*Anoplophora glabripennis*) has been intercepted in wood packing materials in the USA and the UK.

Humans tend to take favoured flora and fauna with us wherever we may travel. Some ornamental plants may escape from our landscaped areas to the native surroundings where

they can establish as invasive species. *Hiptage benghalensis*, a native plant in Asia, is a tropical ornamental that has established itself as an invasive species in Australian rainforests. Undesired pets are occasionally released by their owners, many of who do not realize the ecological significance of their release. The release of the Mississippian red-eared slider (*Trachemys scripta elegans*) has led to their invasion of wetlands and lakes in the Caribbean and Europe. Burmese pythons (*Python molurus bivittatus*) has been released and successfully established in the Florida Everglades National Park, creating devastating impacts. This introduction has led to a massive removal project, where over 15 000 snakes have been removed thus far.

When an invasive species enters an ecosystem, it can have an impact on the species that are present, on important habitats, or even on the ecosystem itself. Concern arises when an invasive species changes the system for the worse, by either reducing or eliminating populations of native species, or by otherwise changing the way the ecosystem works. These changes have made the invasion of alien species a major global problem. If organisms were not able to move beyond their normal ranges, each part of the world would have a unique array of plants, animals, and microorganisms. However, as species move from one area of the world to another, sometimes squeezing out the competition, different places in the world become more alike in their biology—a process called **biological homogenization**.

Responding to and controlling invasive species

Once an invasive species is detected, it is important to respond quickly and put in place control actions. It is much easier to eradicate invasive species if they are discovered quickly and the population levels are still low. A rapid response can help to lower the overall impact of an invasive species. While eradication may be the ultimate goal, this can be challenging and costly. If it proves impossible to completely remove an invasive species, early action can keep population sizes at low levels. For example, Giant African snails (*Achatina fulica*) were effectively eliminated from Florida.

Many strategies can be used to control invasive species once they have established themselves in a location. These include: biological, chemical, and mechanical. Each method can be used individually or in combination with each other to obtain the best results to control the invasive species. It is important to research and use the best management practices to select the correct approach for each invasive species and to understand the timing of control.

Biological control - The introduction of an enemy of an invasive species (e.g., parasite, predator, or competitor) can be used to reduce the population size of the invasive species. The biological control may consume the invasive species or cause it to become diseased and

die. Alternatively, the predators may go after other species within the community and cause more damage.

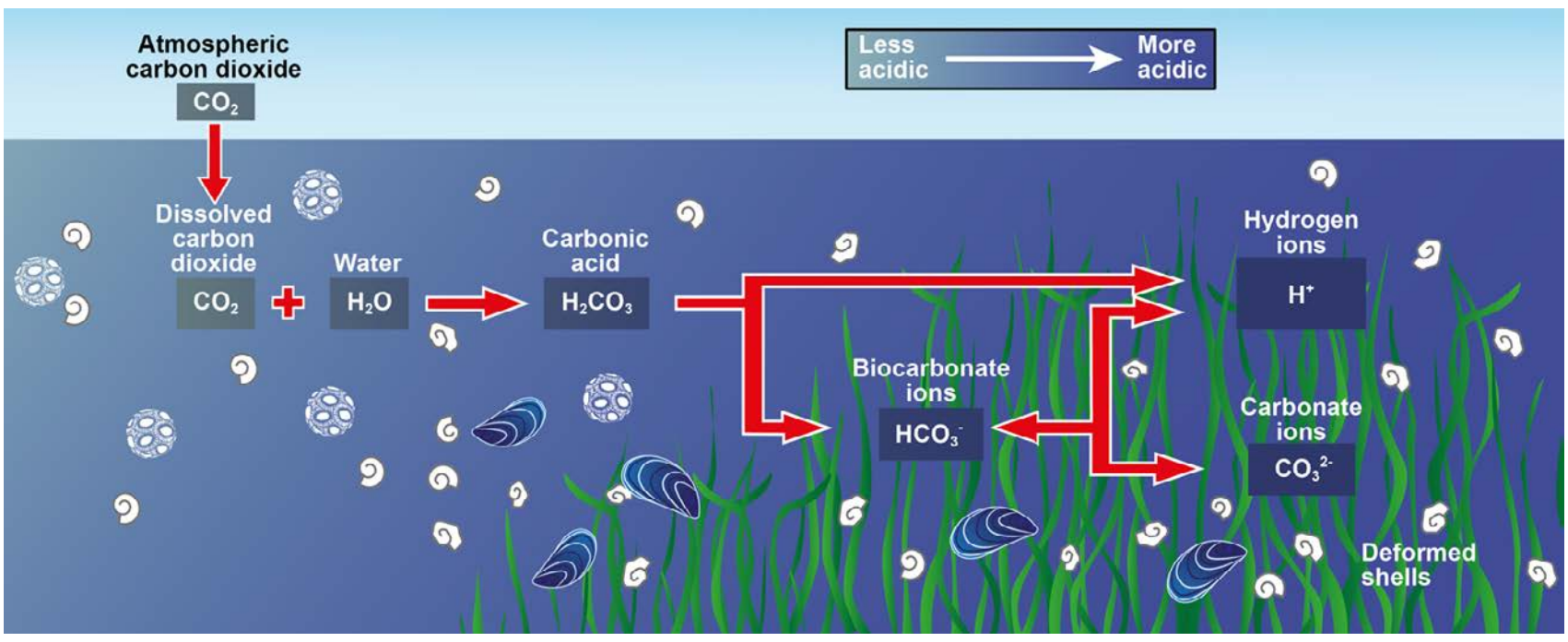
Chemical control - Chemicals may be used to kill invasive species, especially plants. Though chemicals can effectively control some species (e.g., water hyacinth in Florida) chemical control have some issues. Chemical controls can be expensive and may only be effective for a limited amount of time, as invasive species can evolve to be resistant to pesticides. Further, chemicals may affect non-target organisms.

Mechanical control - Mechanical control often involves machinery or human effort to remove the invasive species. This can involve actions such as using a saw to cut down invasive trees, pulling out invasive plants, removing nests, and trapping and hunting invasive animals. It can also include the creation of physical barriers to prevent the introduction or spread of invasive species (e.g. fishways, controlled burns). However, in this process you may not catch your target species and cause harm to other biota.

Overall, attempting to control invasive species once established is difficult, expensive and potentially harmful to ecosystems and the goal should be to prevent invasions.

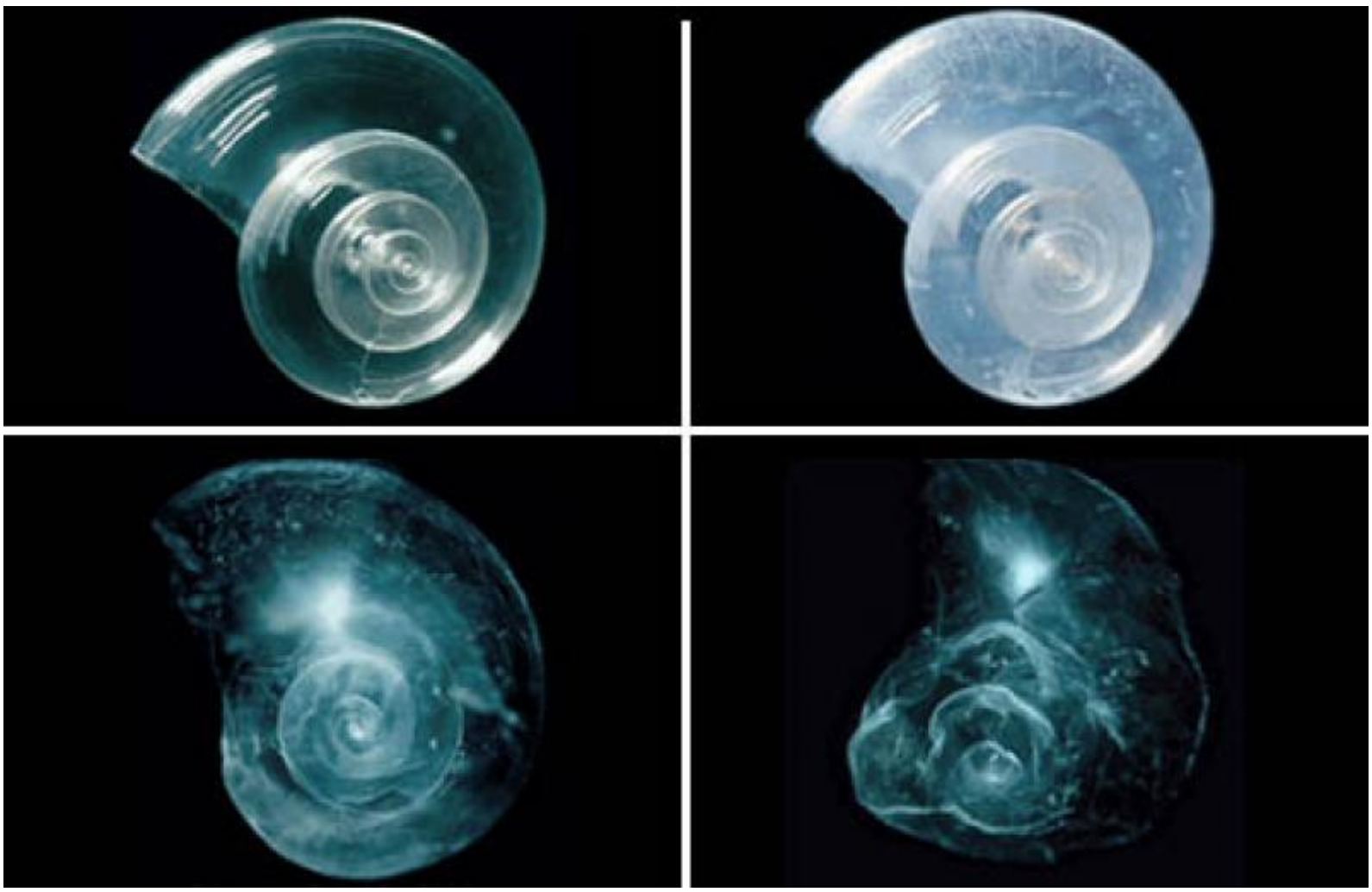
OCEAN ACIDIFICATION

The acidification of the oceans is of great concern for many of the species that live and rely on these ecosystems. As carbon dioxide (CO_2) is absorbed by sea water, chemical reactions take place that reduce the pH of the water, carbonate ion concentration, and the saturation rates of calcium carbonate minerals that are biologically important. This chemical reaction is known as *ocean acidification*.



© Plymouth Marine Laboratory

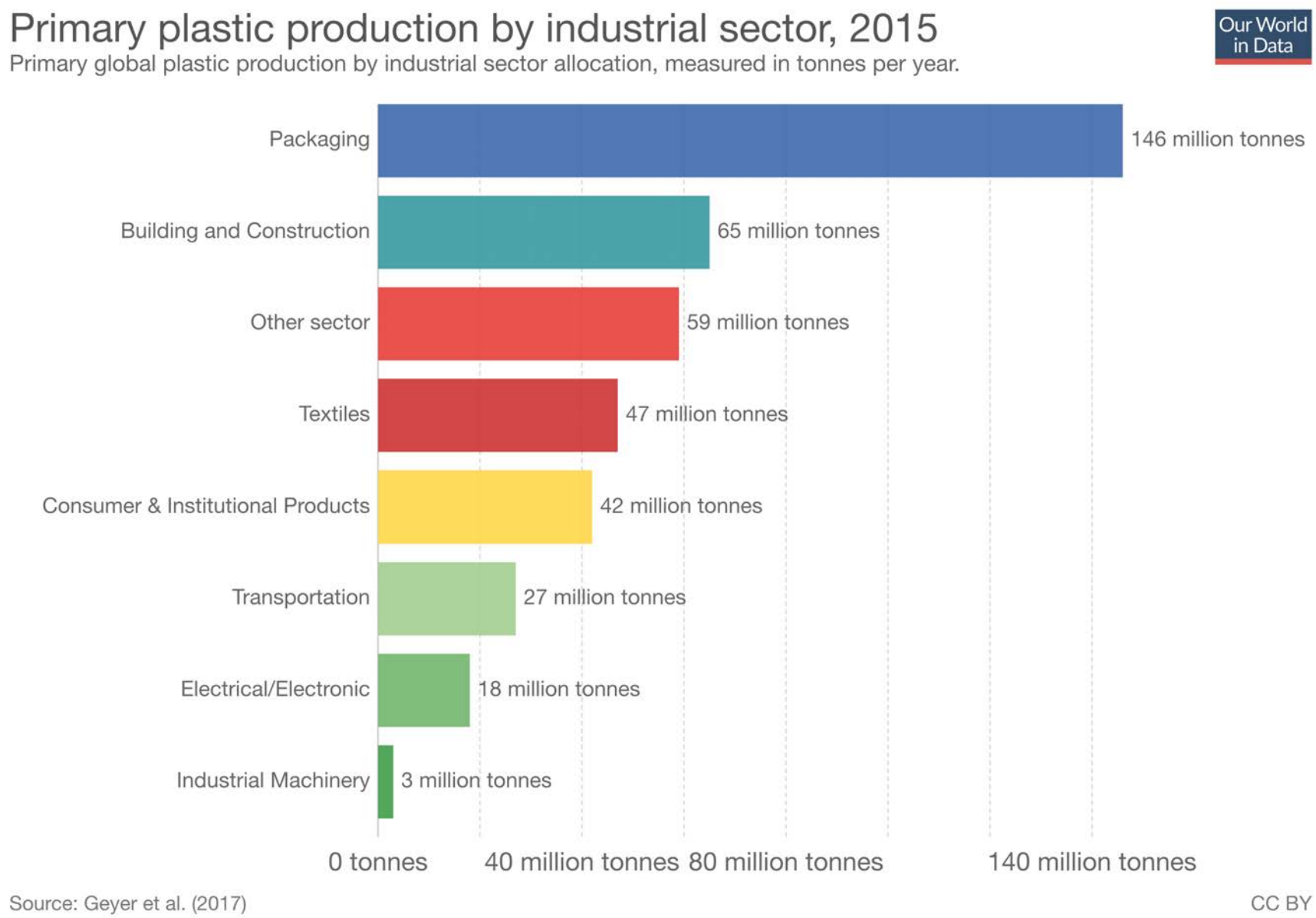
Ocean acidification is expected to impact a variety of ocean species by varying degrees. Algae and seagrasses that photosynthesize may benefit from this additional carbon dioxide. However, research has shown that the lower calcium carbonate saturation levels can impact species that require calcification, such as oysters, clams, sea urchins, corals, snails, and plankton. For example, pteropods, or *sea butterflies*, are a tiny animal that is a common food source for a variety of animals, ranging in size from krill to whales. Yet, pteropods shell dissolves when placed in sea water with pH and carbonate levels for the year 2100 (based on climate projections).



In a lab experiment, a pteropod shell was placed in seawater with increased acidity (based on estimates for 2100). It slowly dissolved over 45 days

PLASTICS

The world is facing a plastic problem and it is increasing exponentially. Plastics have become a part of global day to day life. In the past 69 years, the annual production of plastics has increased almost 200-fold to 381 million tonnes in 2015.



The production of plastics has varied amongst different sectors, with packaging representing the highest production of plastics.

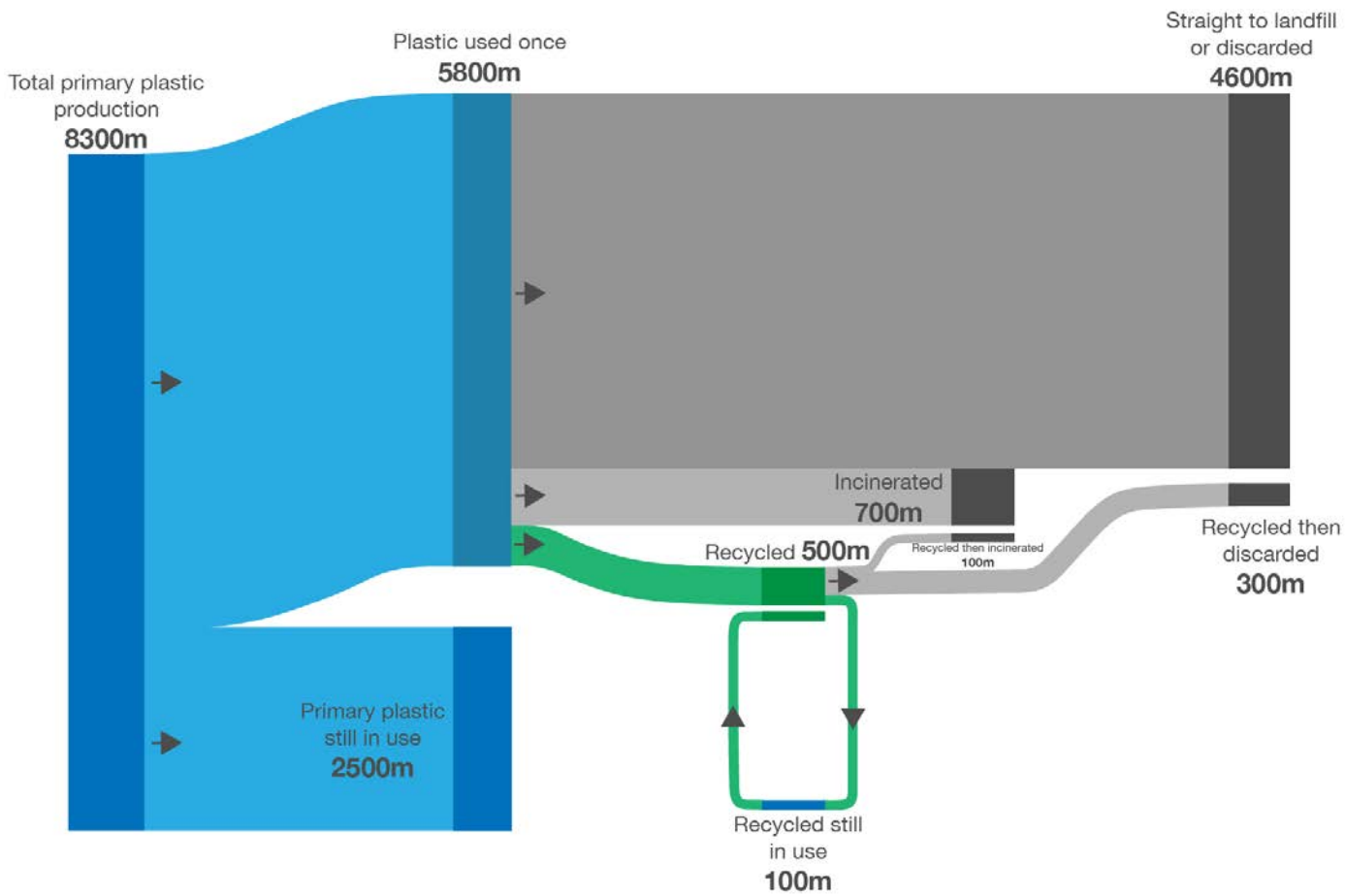
The figure represents the balance of plastic production and its fate over 65 years.

Global plastic production and its fate (1950-2015)

Our World in Data

Global production of polymer resins, synthetic fibres and additives, and its journey through to its ultimate fate (still in use, recycled, incinerated or discarded).
Figures below represent the cumulative mass of plastics over the period 1950-2015, measured in million tonnes.

Balance of plastic production and fate (m = million tonnes)
8300m produced → 4900m discarded + 800m incinerated + 2600m still in use (100m of recycled plastic)



Source: based on Geyer et al. (2017). Production, use, and fate of all plastics ever made.
This is a visualization from OurWorldinData.org, where you find data and research on how the world is changing. Licensed under CC-BY-SA by Hannah Ritchie and Max Roser (2018).

How much plastic enters the world's oceans?

Our World in Data

Estimates of global plastics entering the oceans in 2010 based on the pathway from primary production through to marine plastic inputs. Data is based on global estimates from Jambeck et al. (2015) based on plastic waste generation rates, coastal population sizes, and waste management practices by country.
Estimates of plastic pollution in surface waters are derived from Eriksen et al. (2014).

(1) Global primary plastic production.

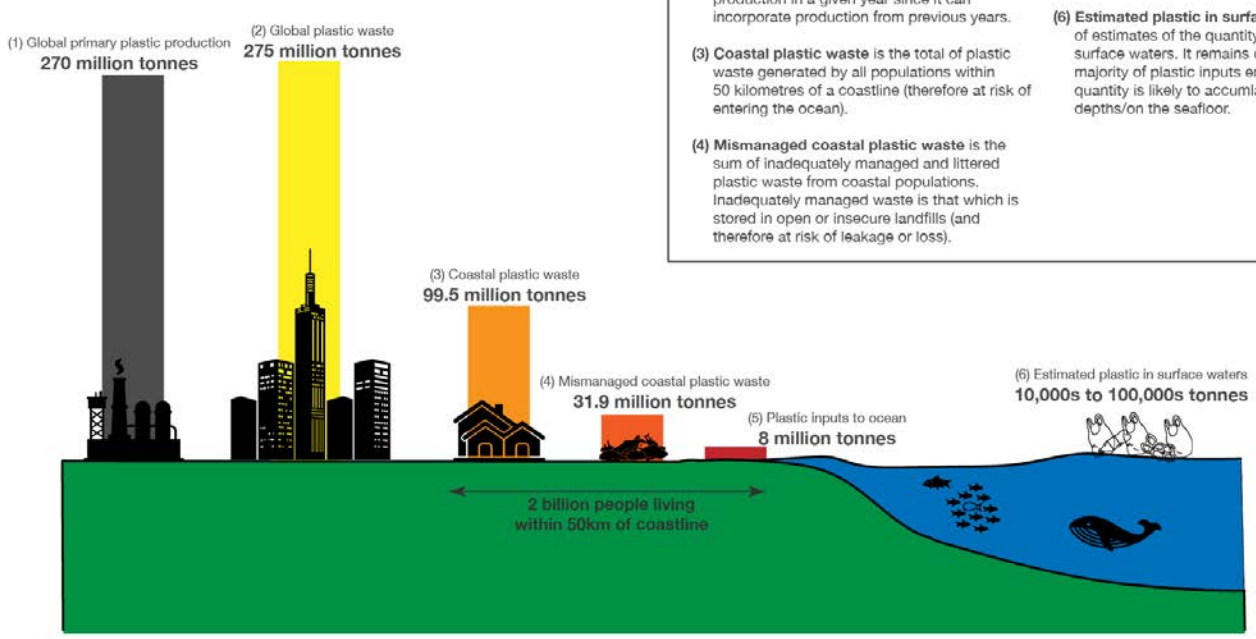
(2) Global plastic waste can exceed primary production in a given year since it can incorporate production from previous years.

(3) Coastal plastic waste is the total of plastic waste generated by all populations within 50 kilometres of a coastline (therefore at risk of entering the ocean).

(4) Mismanaged coastal plastic waste is the sum of inadequately managed and littered plastic waste from coastal populations. Inadequately managed waste is that which is stored in open or insecure landfills (and therefore at risk of leakage or loss).

(5) Plastic inputs to the ocean. Total annual inputs of plastic to the ocean environment (ranging from macro- to microplastic materials).

(6) Estimated plastic in surface waters. Range of estimates of the quantity of plastics in surface waters. It remains unclear where the majority of plastic inputs end up — a large quantity is likely to accumlate at greater depths/on the seafloor.



Source: data based on Jambeck et al. (2015) and Eriksen et al. (2014). Icon graphics from Noun Project.
This is a visualization from OurWorldinData.org, where find data and research on how the world is changing. Licensed under CC-BY-SA by Hannah Ritchie and Max Roser (2018).

Plastics have been found to have numerous impacts on ecosystems and wildlife. There are three main pathways by which plastic can impact wildlife and ecosystems:

1. *Entanglement* - Marine animals may become entrapped, encircled, or constricted by plastics. Research has mentioned whales, marine turtles, seals, fish, invertebrates and seabirds all being involved in this type of event. These events have involved plastic rope, netting, abandoned fishing gear, and packaging.

2. *Ingestion* - Plastic ingestion can occur intentionally, unintentionally, or indirectly through the ingestion of prey containing plastics. Ingestion has been documented in at least 233 marine species, including turtles, seals, whales, seabirds, invertebrates, and fish. The ingestion of plastics can be extremely detrimental to animal health. It can lead to reduced stomach capacity, leading to reduced appetite and incorrectly sensing satiation. Obstructions and perforations could also be caused by plastics, which can be deadly.

3. *Interaction* - Plastic debris can interact with animals, including collisions, obstructions, abrasions or being used as a substrate. For example, research has shown that fishing gear can cause abrasion and damage to coral reef ecosystems. Further, plastics could block light, organic matter availability, and oxygen exchange, which can negatively impact ecosystem structures.

Microplastics

Microplastics are particles of plastic smaller than 4.75mm in diameter. These pieces of plastic can be ingested causing a multitude of problems. Ingestion of microplastics rarely causes mortality, although it has been documented in a few cases where the concentration and exposure of microplastics far exceeded levels that would normally be encountered in the wild. However, microplastics have been shown to impact the consumption of prey, leading to energy depletion, fertility affects, and inhibited growth. Studies of the impacts of microplastics are starting in streams, lakes, and rivers within Manitoba.

WATER SCARCITY

Water scarcity may be the most underrated resource issue the world is facing today. Currently, 70% of world fresh water use is for irrigation and between 1950 and 2000, the world's irrigated area tripled to roughly 700 million acres. Today, more than 18 countries, containing half the world's people, are over pumping their aquifers, or sources of fresh water. Among these are the big three grain producers—China, India, and USA.

Yemen is facing a severe water crisis with some estimates suggesting the capital, Sanaa, could run dry in 10 years. With little being done to harness rainfall in the country, farmers are drilling deeper than ever for water - without any government regulation. Agriculture uses around 90% of the country's water resources - with around half of that being used to cultivate the herbal stimulant khat. At this moment, it is estimated that half of Yemen's population has no access to clean water.

Climate change is also hydrological change. Higher average global temperatures and more extreme, less predictable, weather conditions caused by climate change, are already having a measurable impact on this cycle, altering the amount, distribution, timing, and quality of available water. It is predicted these changes will also impact water quality. These changes will have wide-ranging consequences for human societies and ecosystems.

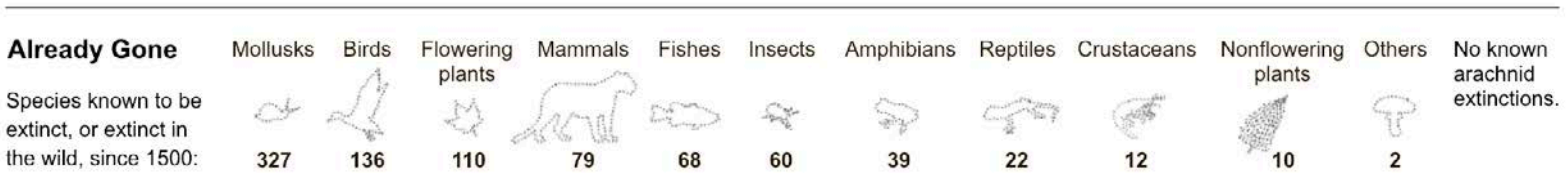
BIODIVERSITY CRISIS AND EXTINCTION

EXTINCTION RATES

Extinction is a normal process we see time and time again throughout the history of earth. So why are we currently concerned about extinction rates? If we compare prehistoric extinction rates to current rates we can see that historical rates are far lower (0.1 to 10 species per year) are much lower than our current rates. Extinctions are happening **1000 to 10 000 times faster** than the expected, natural rate of die-offs. This loss of animal and plant species is leading towards a mass extinction. We are creating the '6th extinction episode'.

Present-Day Extinctions

Based on our current estimates, these species are already gone:



Published: June 1, 2012

OPINION

Are We in the Midst Of a Sixth Mass Extinction?

A Tally of Life Under Threat

The International Union for Conservation of Nature has evaluated 52,205 species, depicted here, for their ability to survive. Related Article »

Each symbol represents 100 species assessed:

THREATENED

NOT THREATENED

BIRDS
99% of known species assessed
8,601 not threatened

1,253 threatened:
13%
of those assessed

MAMMALS
85% of known species assessed
3,448 not threatened

1,138 threatened:
25%
of those assessed

Stark Indicators Of Extinction Risks

Because most **known species** of birds, mammals and amphibians have been evaluated, scientists are confident about the percentage of each group that is threatened.

AMPHIBIANS
70% assessed
2,767 not threatened

1,917 threatened:
41%

Other Threatened Life: The Tip of a Vast Unknown

Only fractions of **known species** in these nine groups have been evaluated. Because assessments have focused on species likely to be in danger, the proportion of each group that is threatened may be overstated.

Meanwhile, the number of **unknown species** may be in the millions, or tens of millions — many times that of what has been discovered.

ARACHNIDS
0.02%
of known species assessed
5 not threatened; 19 threatened

INSECTS
0.3%
741 threatened
2,122 not threatened

OTHER
0.6%
277
489

CRUSTACEANS
3%
596
924

NONFLOWERING PLANTS
3%
629
716

FLOWERING PLANTS
5%
8,527
3,445

MOLLUSKS
5%
1,673

REPTILES
29%
of known species assessed
772 threatened
1,961 not threatened

FISHES
23%
2,028
5,346
1,946

Chart figures exclude 9,709 species evaluated but found to be too poorly known to assign to a threat category.

© Bill Marsh/*New York Times*

Fossil record for birds and mammals suggest prehistoric rate of 0.003 species lost pear year. Between 1900-2000 about 100 species have become extinct. The current rates of extinction are 333 times the prehistoric rate. Scientists conclude that current rates dwarf 'background' rates. We are already experiencing (or soon will) rates higher than the 5 previous mass extinctions. At this point of time, over 75% of all megafauna (large mammals) are extinct. Of our described species, 1.6% of mammals and 1.3% of mammals have gone extinct. Over 13% of birds, 25% of mammals, and 41% of amphibians are threatened with extinction.

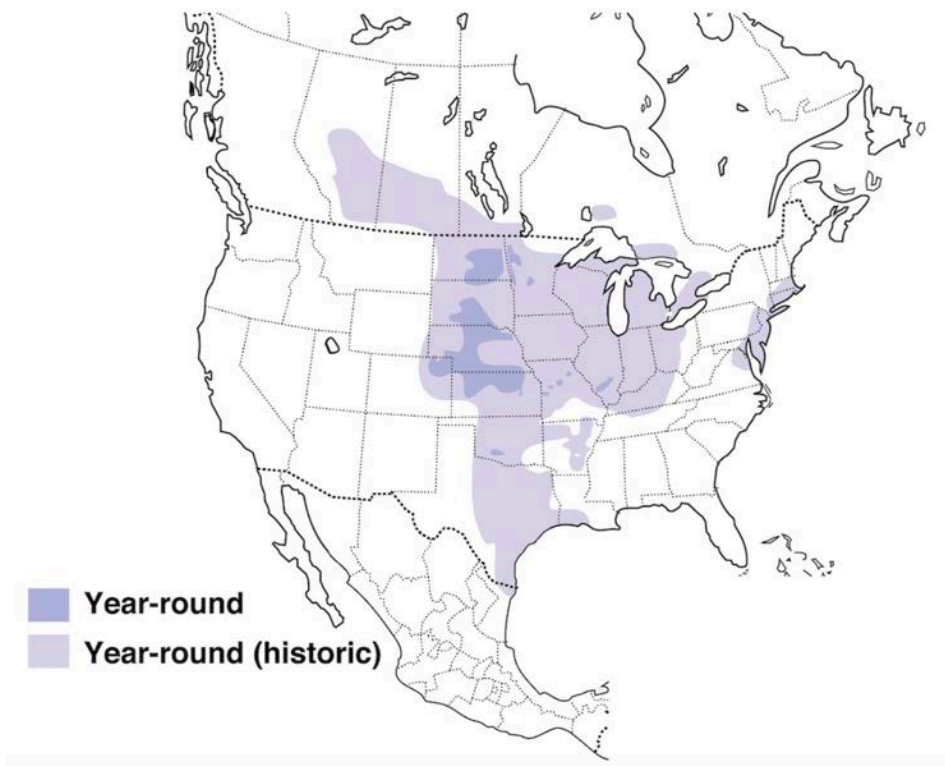
DRIVERS OF EXTINCTIONS IN CANADA

Habitat destruction and fragmentation, invasive species, overharvesting (unsustainable harvest), pollution, and climate change are the current drivers of extinctions in Canada. Currently, there are at least ten species that have gone extinct in Canada due to these main drivers. Some are extinct only in Canada (extirpated), like the Greater Prairie Chicken. However, some species like the Hadley Lake Sticklebacks are now globally extinct.

Habitat loss and fragmentation
Butterflies (2 spp.) – 1988, 1991
Greater Prairie Chicken – 1987
Banff longnose dance – 1986

Invasive Species
Hadley Lake Stickleback (catfish) – 1989
Banff long nose dace - 1986

Unsustainable Harvest
Greater prairie chicken – 1987
Striped bass – 1968



Historical and current distribution of the Greater Prairie Chicken
© The Cornell Lab of Ornithology Birds of North America

LOSS OF BIODIVERSITY

Natural communities provide food, help purify water, generate oxygen, and supply raw materials (building, clothing, paper, etc.), yet these communities are under threat from development, invasive species, climate change, and other factors.

Endangered Species and IUCN Red List

Various factors, including human activities and climatic changes, have led to the reduction and alteration in plant populations. In response, governments and public groups have groups which encourage and commission studies on rare and endangered plants or plants of unknown status. The International Union for Conservation of Nature (IUCN) tries to monitor and report on both plant and animal populations worldwide. The IUCN Red List of Threatened Species is a world-renowned database of information collected over the last four decades. The IUCN Red List assesses both plants and animals and provides taxonomic, conservation status, and distribution information. The IUCN Red List sorts each species into one of the following categories:

Extinct – a species or taxon is extinct when there is no reasonable doubt that the last individual of this group has died. Exhaustive surveys of known and expected habitat during appropriate times will have failed to record the presence of this species.

Extinct in the Wild – a species is considered to be extinct in the wild when they are only known to survive in cultivation (e.g. farming), in captivity (e.g. zoo), or as a naturalized population well outside their past range. As with extinct animals, exhaustive surveys of known and expected historical habitat during appropriate times will have failed to record the presence of this species.

Critically Endangered – a species is considered to be critically endangered when all evidence indicates that its population has either:

A. been seen to be reduced by 90% or more in last 10 years or three generations,
B. its geographic range has been reduced to less than 100 km^2 and severely fragmented or less than 10 km^2,
C. population less than 250 mature individuals and continuing to decline,
D. population size of less than 50 individuals, or
E. quantitative modelling suggests the probability of extinction at least 50% in the next 10 years. It is considered to be facing an extremely high risk of extinction in the wild.

Endangered – a species is endangered when the evidence indicates that its population has either:

A. been seen to be reduced by 70% or more in last 10 years or three generations,
B. its geographic range has been reduced to less than 5000 km^2 and severely fragmented or less than 500 km^2,
C. population less than 2500 mature individuals and continuing to decline,
D. population size of less than 250 individuals, or
E. quantitative modelling suggests the probability of extinction at least 20% in the next 10 years. It is considered to be facing a very high risk of extinction in the wild

Vulnerable – a species is considered vulnerable when its population meets any of the following criteria:

A. been seen to be reduced by 50% or more in last 10 years or three generations,
B. its geographic range has been reduced to less than 20 000 km^2 and severely fragmented or less than 2000 km^2,
C. population less than 10 000 mature individuals and continuing to decline,
D. population size of less than 1000 individuals, or
E. quantitative modeling suggests the probability of extinction at least 10% in the next 10 years. It is considered to be facing a high risk of extinction in the wild.

Near Threatened – a species that is near threatened is close to meeting the criteria for critically endangered, endangered or vulnerable in the near future.

Least Concern – a species is least concern when it does not meet any criteria to qualify for critically endangered, endangered, vulnerable, or near threatened. Species that are widespread or abundant are included in this category.

Canada has a national *Species At Risk Act,* the purpose of which is "to prevent wildlife species in Canada from disappearing, to provide for the recovery of wildlife species that are extirpated (no longer exist in the wild in Canada), endangered, or threatened as a result of human activity, and to manage species of special concern to prevent them from becoming endangered or threatened." In Manitoba, we currently have 25 endangered species (https://www.gov.mb.ca/sd/environment_and_biodiversity/species_ecosystems/index.html). They are protected under *The Endangered Species and Ecosystems Act*.

ANIMAL AND PLANT CHARACTERISTICS: WHAT MAKES AN ORGANISM GO EXTINCT?

Animals and plants go extinct for a variety of reasons, including loss of habitat, overexploitation (e.g., overhunted, overfishing, wildlife trade, etc.), and loss of food sources. In many cases, a species may have specific characteristics that make it more vulnerable to becoming extinct.

Rarity - If an animal, plant, or other organism is rare, having a limited range

Endemism - If an animal, plant, or other organism that is unique to a defined geographic region.

Other characteristics that impact the probability of an animal or plant going extinct include, ineffective dispersers, life-history traits (long generations, low fecundity, large body size, high survival), seasonal migration, little genetic diversity, specialized niche, require a pristine habitat, form groups, and/or have no prior contact with humans.

Sea Turtles are making a huge comeback, thanks to the Endangered Species Act

By Patrick J. Kiger January 29, 2019

Back in 1973, out of concern that many of America's native plants and animals were in danger of extinction, Congress passed the Endangered Species Act. The law enables regulators to designate species as either "endangered," meaning that they're at risk for becoming extinct throughout at least a significant portion of their range, or "threatened," meaning that they're likely to become endangered in the near future. Once plants and animals are on the list, they can't be harmed or harvested, and their habitats can't be modified or damaged in a way that kills, injuries or impairs their ability to breed, feed, take shelter or perform other functions necessary for existence.

While environmentalists have viewed the law as a milestone, mining and agribusiness interests long have considered it too restrictive. The Trump Administration recently has sought to change the way the law is applied to reduce what it considers burdensome protections for threatened species.

But the Act's defenders may get a boost from a study by Abel Valdivia, Shaye Wolf and Kieran Suckling of the Center for Biological Diversity in Tucson, Arizona, published

January 16 in the journal PLOS ONE. The researchers, who looked at 31 different populations of marine mammals and sea turtles, found that 78 percent of the mammals and 75 percent of the turtles increased their population size after receiving protection under the Act. Just 9 percent of marine mammal populations — and no sea turtle populations — decreased after receiving legal protection.

Sea turtles in particular benefited from the law, with their populations increasing by 980 percent. Even more impressive was the resurgence of Hawaiian humpback whales, which increased from just 800 animals in 1979 to more than 10,000 in 2005. The species recovered so much that regulators were able to remove it from the endangered list in 2016.

"The Endangered Species Act not only saved whales, sea turtles, sea otters and manatees from extinction, it dramatically increased their population numbers, putting them solidly on the road to full recovery," Wolf said in a press release. "We should celebrate the Act's track record of reducing harms from water pollution, overfishing, beach habitat destruction and killing. Humans often destroy marine ecosystems, but our study shows that with strong laws and careful stewardship, we can also restore them, causing wildlife numbers to surge."

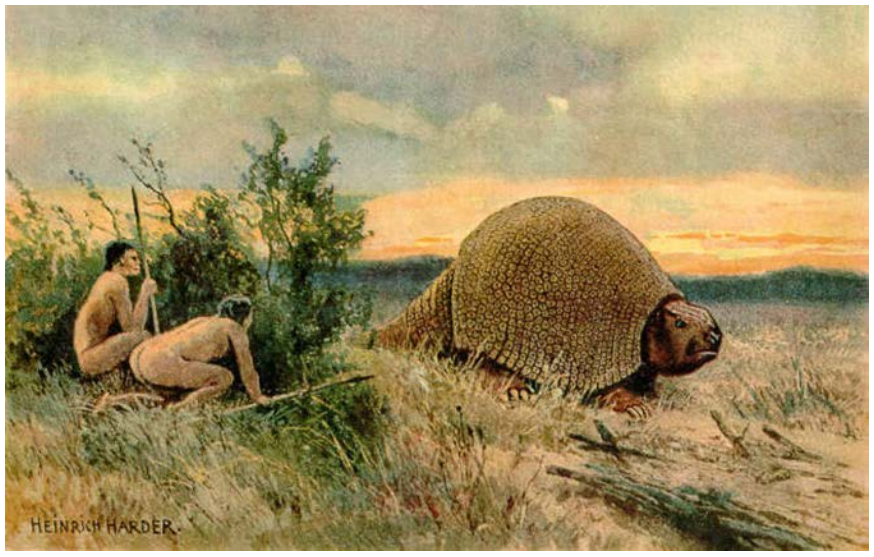
Source: https://animals.howstuffworks.com/endangered-species/sea-turtles-are-making-huge-comeback-thanks-to-endangered-species-act.htm

CONSERVATION AND SUSTAINABILITY

ORIGINS OF CONSERVATION BIOLOGY AND SUSTAINABILITY

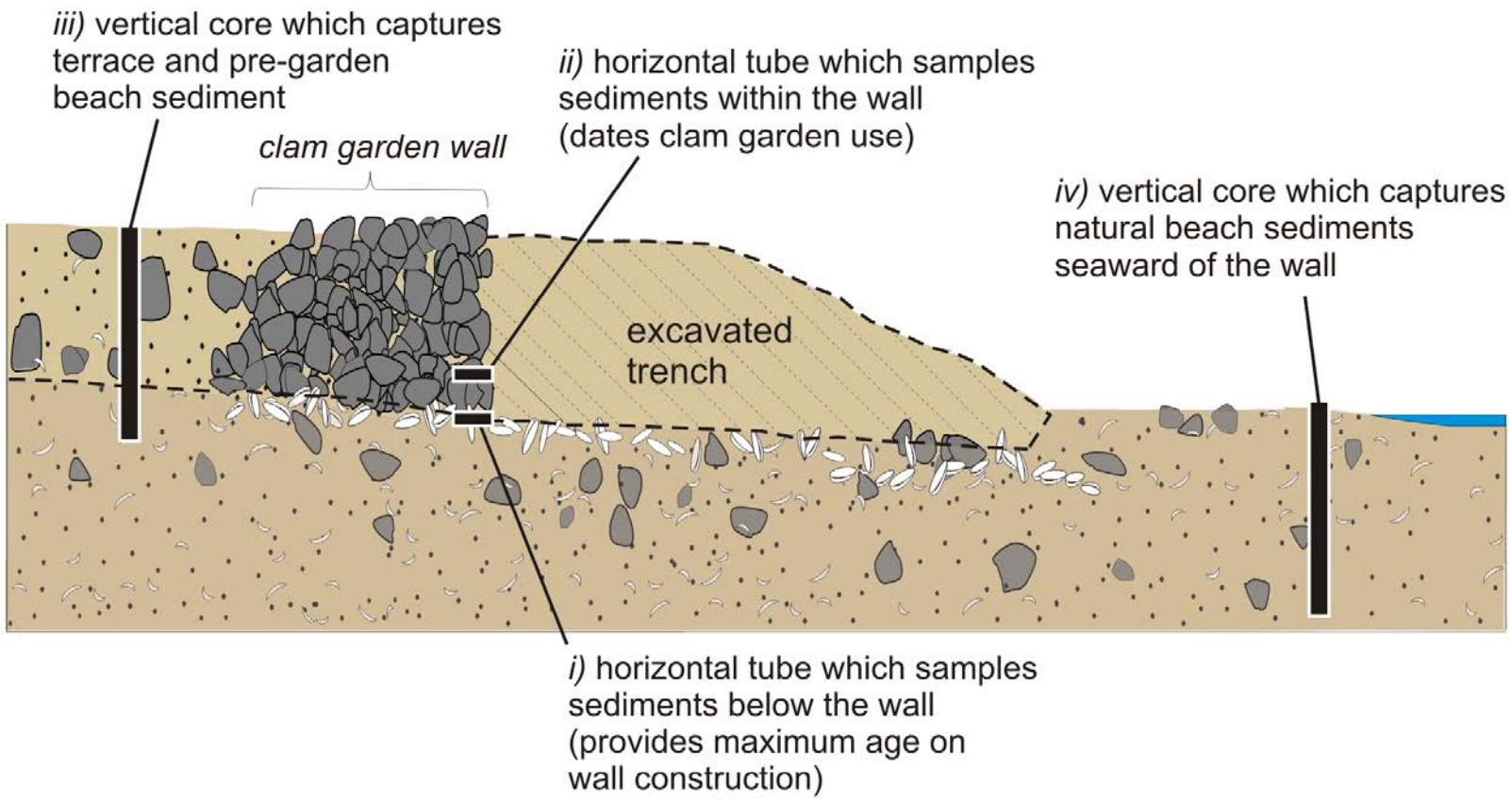
Historical Conservation

Early human societies have often been considered to have a light footprint and not have a substantial impact on the natural world around them. However, recent evidence has shown early humans are responsible for megafaunal extinctions in the Late Pleistocene era (~126 000 – 11 700 years ago). Known as the *overkill hypothesis*, this would be the first known example of humans being directly linked to the extinction of an animal. Recent research has now shown that this megafaunal extinctions due to **both** human presence and climate warming. Research has also shown that the influence of humans compared to climate on the extinctions of animals varied throughout the world, with humans playing a much larger role in the extinctions of animals in North America.



Throughout the world, early societies in Europe, Asia, Africa, Australia, and the Americas radically affected their physical environment and the species within it. They began to *manage* ecosystems even with little technological development, primarily through the use of fire. All early societies used fire and this single tool changed landscapes, exterminated species, and created areas that could be cultivated for crops. Amazonian peoples painstakingly created their own patches of fertile soil. They called these areas 'dark earths' that make up as much as 10% of the rainforest region.

First nations, including the Kwakwaka'wakw, created clam gardens in what is now present-day British Columbia. These first nations applied sophisticated management techniques to mimic ideal clam-growing conditions. They used stone terraces and sediments at appropriate elevations in the tidal column.



A conceptual diagram illustrating the structure of historical clam gardens
© Neudorf et al. 2017, *PLOS ONE*

The allocation of fishery resources among first nations in Alaska led to equitable sustainable use of salmon. Multiple species of salmon (*Oncorhynchus* spp.) are common to this region, but some are more prized than others. The Tlingit and Haida tribes, two groups of coastal native Alaskan peoples, placed a high value on the sockeye. Both tribes made rules limiting access to particular streams to an individual clan or house group. Streams were assigned by family leaders, as were limits on how many fish could be taken, and at what times. Tribes used knowledge and experience to protect this resource. They also had the power to enforce regulations and punish violators. Salmon populations were maintained under this method until Russia and the USA ignored this system, after which the salmon populations collapsed.

Early European settlers feared nature. They viewed nature as their *provider* and something to subdue, but most importantly **unlimited**. They spoke of nature as game or vermin. In this view, nature was prized for its uses. This attitude led to several species, including the passenger pigeon to become extinct.

Over time, through increasing prosperity and urbanization in western civilizations, nature became valued for recreation, or as a *playground*. As the landscape continued to be exploited, the view of the natural world shifted for many again as having an inherent value and therefore something to be saved.

Romantic-Transcendental Conservation Ethic

"Everybody needs beauty as well as bread, places to play in and pray in, where nature may heal and give strength to body and soul alike."
John Muir, *The Yosemite* (1912)

The romantic-transcendental conservation ethic suggests that nature offers spiritual connection or enlightenment. It believes that natural areas and species have intrinsic value and so they must be viewed as such. This conservation ethic is strongly opposed to harvesting resources and destroying nature. Conservationists with this ethic, such as John Muir, believed that the preservation of wild nature is a *morally superior* way to *use* natural resources. This conservation ethic led to the creation of the Sierra Club.

In Canada, this ethic led to the creation of our first national park, **Banff** in the late 1880's. It was believed that the best economic use of the space was to use it for tourism, although its creation also preserved wildlife and plants.

Current research has given further evidence to the importance of spending time in nature. Anecdotal, theoretical and empirical data now suggests that contact with nature promotes health and well-being.

"Nature experiences in urban green spaces may be having a considerable impact on population health, and that these benefits could be higher if more people were engaged in nature experiences."
Shanahan *et al.* 2016, *Scientific Reports*

Resource Conservation Ethic

The research conservation ethic views the natural world as having an *instrumental* value. They have five main views:

1. Use natural resources for human purposes in a manner that does not exceed nature's ability to produce them.
2. Recognize the ability of a system to continue
3. Maintain a production level or quality of life for future generations
4. Using better science and economics to get nature's resources flowing perpetually

5. Nature has no intrinsic value or there is no need to protect species that lacked direct human use

Gifford Pinchot was the first chief of the United States Forest Service (1905-1910) and followed the resource conservation ethic. This led to the subsequent reduction of the virgin forest throughout the USA.

In Canada, Algonquin National Park was created in 1893 to protect the area for sustainable timber harvest.

Evolutionary-Ecological Land Ethic

"The health of the land as a whole rather than the supply of its 'constituent resources,' is what needs conserving with land defined broadly to include soils, water, plants, animals, and people."

Aldo Leopold, 1946

The evolutionary-ecological land ethic took a broader all-encompassing approach to conservation. They have three main views:

1. Ecosystems are **equilibrial systems** of species interacting with the environment
2. Efficient functioning of systems (stable systems) required that **all parts be present**.
3. Processes and interactions within ecosystems are **complex and integrated**.

Aldo Leopold was an ecologist, forester, and environmentalist, who is partially responsible for developing this ethic. He is considered the 'father' of wildlife management in the USA, as well as influencing policy around the world.

Within this movement, Rachel Carson (Marine Biologist) wrote the book *Silent Spring* to raise awareness of the danger of backyard pesticides like DDT. During World War II, the

military developed DDT to stop the spread of typhus. After the war, the military began selling DDT and other pesticides commercially, to be applied to farms and gardens. However, DDT had not been tested for civilian use and many animals, other than target insects, were dying at high rates. The publication of this book led to the passage of the *Clean Air Act* (1963), *Wilderness Act* (1964), *National Environmental Act* (1969), and the establishment of the *Environmental Protection Agency* (1970) in the USA. Similar laws and acts were passed in Canada around the same period of time.

"It is an era dominated by industry, in which the right to make a dollar at whatever cost is seldom challenged...It is the public that is being asked to assume the risks that the insect controllers calculate. The public must decide whether it wished to continue on the present road, and it can do so only when in full possession of the facts"
Rachel Carson, *Silent Spring,* 1962

MODERN CONSERVATION BIOLOGY AND SUSTAINABILITY

Defining the field of Conservation Biology

The integrated field of conservation biology was developed in the 1970's as a '*crisis discipline*', by scientists like Michael Soulé, whose goal was to provide principals and tools for preserving biodiversity. The Society for Conservation Biology (SCB) was created in 1985, with the mission to advance the science and practice of conserving Earth's biological diversity.

"Species have value in themselves, a value neither conferred nor revocable, but springing from a species' long evolutionary heritage and potential or even from the mere fact of its existence."
Michael Soulé, What is Conservation Biology? 1985

The aim of conservation biology is to study problems and publish data and recommendations in scientific journals. However, this often brings them in conflict with different public groups and government policy makers. Conservation biology also became a field that was known for just putting out 'small fire' after 'small fire' but not addressing the big problems. For example, it often focused on saving individual species but not solving the larger issues that endangered the species in the first place. Further, presenting crisis after

crisis was not an effective way of presenting information and gaining support from the general public.

In order to become more effective, conservation biology recognized that it needed to turn conservation into more than just a practice for the privileged. Modern conservation biology attempts to incorporate human diversity, connect future generations to nature, transform businesses into allies, and have sustainable resources for people. The field has now blended ecology (study of interactions between species and their environment), ethics, and economics. It is now closely linked to sustainability, or development seeking to blend environmental, social, and economic goals.

Modern Conservation Biology

Modern conservation biology acknowledge that species and ecosystems are rarely in equilibrium, though component species may interact strongly at times. Events such as storms, wind, waves, floods, droughts, fires, etc. affect species and communities, and consistently reset the ecological succession clock. Dynamic systems respond to natural environmental change, and responses require maintenance of genetic diversity.

Modern conservation biology recognizes that humans will dictate the future of many or all ecosystems throughout the word and biodiversity should be protected where appropriate using scientific principles. However, it also includes affected people in *realistic development plans*. For example, it is important to provide people with a livelihood while maintaining biodiversity so one should sacrifice some lands for sustainable production while protecting and preserving others for biodiversity.

BIOINDICATORS AND BIOMONITORS

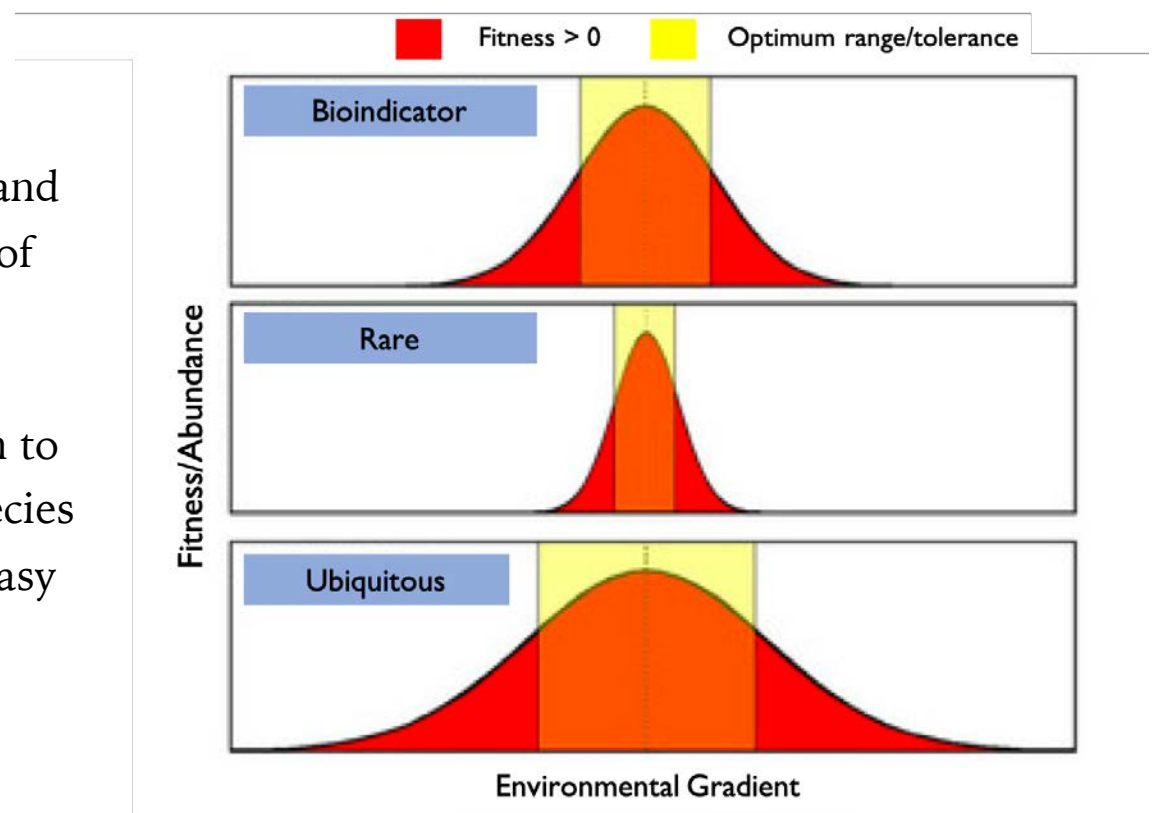
Bioindicators and biomonitors can be used to assess the health of an ecosystem. A ***bioindicator*** is an organism (or part of an organism, or a community of organisms) that contains information on the *quality* of the environment. A ***biomonitor*** is an organism (or part of an organism, or a community of organisms) that contains information on the *quantitative* aspects of the quality of the environment.

Organisms that respond to environmental changes by modifying their abundance, distribution, behavior, or physiology are often known as a bioindicators. By measuring the changes in biological indicators, we can measurer the changes in ecosystem function. Bioindicators function as a stand-in of ecosystem health.

In many cases, physical and chemical changes are instantaneous. Samples taken shortly after a physical or chemical change are only like snapshots that let us know what is happening at that specific moment. Bioindicators can act like videos and giving us a more complete picture of what is going on within a system. For example, pollution events can cause significant ecological impacts, but the location and cause of the impact may decay quickly, especially in flow-through aquatic ecosystems. A bioindicator can show this impact whereas a sample may miss the event.

Many different species can be used as bioindicators, such as canaries (e.g., coal mines), snails and other invertebrates. Acanthocephalans, a type of internal parasite found in fish, can also be used as a bioindicator and can often provide a better measure of recent pollution than bivalves (clams, etc.) or mollusks (snails, etc.). Lichens (blue-green algae symbionts with fungi) can be used as indicators of air pollution like sulfur dioxide, which is one of the ingredients in acid rain. The composition and biomass of algae can indicate the presence of excess nutrients in aquatic systems. Freshwater macroinvertebrates, like caddisfly nymphs, mayflies, and stoneflies can be used to detect changes in water quality, even if they are temporary or continuous.

A good bioindicator species must have a tight relationship between environmental quality and the distribution and abundance of the bioindicator. They must be abundant enough to be readily sampled and widespread enough to represent an ecosystem. The species may be well-studied as well as easy and cheap to study. It is also beneficial if the species is of economic and commercial importance.



A bioindicator species needs to be responsive to changes in the environmental gradient and so must have an optimum range/tolerance that is smaller than species who can live almost anywhere but larger than species that are rare (see image).

Bioindicators have their limitations. It may be difficult to identify good bioindicators as a direct link must be established between the bioindicator and environmental quality. They are also a qualitative (scientific method of observation to gather non-numerical data)

measure and cannot be used as a quantitative (empirical investigation of observable phenomena via statistical, mathematical, or computational techniques) measure. In a situation where a measurable quantitative change is desired, a biomonitor can be used. For example, reductions in the chlorophyll content of lichens or their diversity can indicate the severity of air pollution (biomonitor, quantitative). In contrast, the presence of a lichen species indicates poor air quality (bioindicator, qualitative).

Bioindicators are incorporated into a variety of conservation treaties. For example, countries that signed onto *Biodiversity Convention* (Rio, 1992) were supposed to define and monitor indicators of biodiversity. Birds, butterflies, and other conspicuous groups are now used to monitor changes in climate, air pollution, water quality. Biomonitoring is now incorporated in potentially damaging development projects to document the effects and minimize impacts.

SUSTAINABILITY SCIENCE

Sustainability cannot be achieved without conservation biology, but conservation will not take place unless sustainable solutions are used. Sustainability science is included in a multitude of traditional scientific disciplines, like biology, civil engineering, medicine, and social sciences. Sustainability science receives its greatest contribution from social sciences (~34%). Many parties are involved in this field, including anthropologists, educators, ecologist, lawyers, economists, biologists, sociologists, taxonomists, but particularly politicians and media.

ECOLOGICAL INTEGRITY

"Ecosystems have integrity when they have their native components intact including: abiotic components, biodiversity, and ecosystem processes"
Parks Canada

Ecosystem integrity is assessed using three main indicators:

1. Biodiversity
2. Ecosystem functions
3. Stressors

Poor ecological integrity share a variety of characteristics. They may include lack of biodiversity, pollution, over-use, invasive species, decrease in native species, decrease in keystone species, habitat loss, habitat fragmentation, loss of large carnivores, air pollution, pesticides, overharvesting of forest, or overuse of resources

CONSERVATION PLANNING AND PROTECTED AREAS

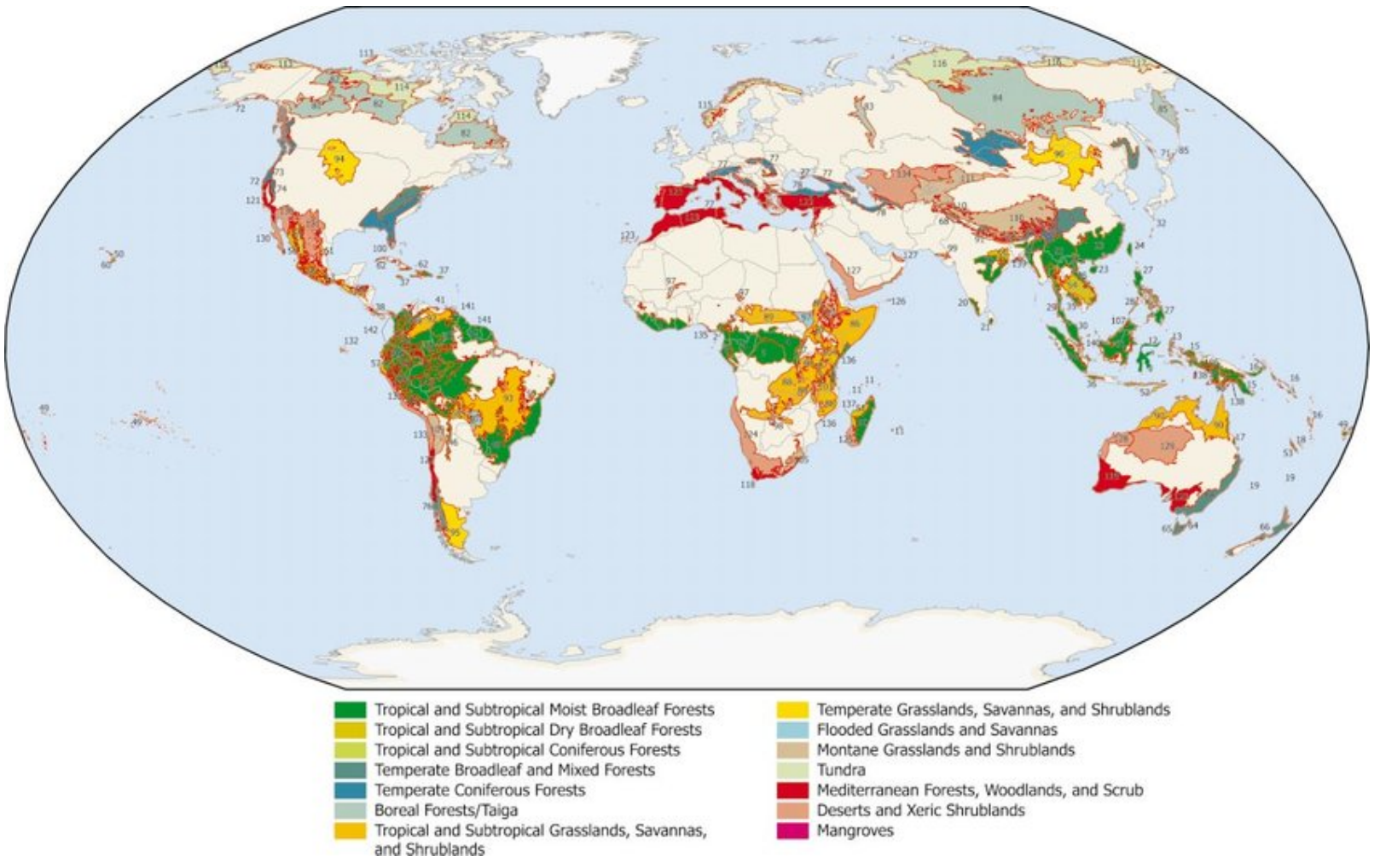
PRIORITIES FOR PROTECTING BIODIVERSITY

The priorities for protecting biodiversity include three measures:

1. *Distinctiveness* or *Irreplaceability* – rare, taxonomically distinct, or species with unusual genetic characteristics are prioritized.
2. *Endangerment* – how at risk is a specific area or species
3. *Utility* – if an ecosystem or species has value as food, or may be valuable, or has some value as a tourism location it is prioritized for preservation.

Global 200

The global 200 is identified by the World Wildlife Fund (WWF), as 238 ecoregions whose biodiversity and representation values are outstanding in a global perspective. It is based on the number of species in an area, urgency of threats to the region, and unique species found within the region.



Areas recognized as the 'Global 200'

CONSERVATION PLANNING

"Most conservation plans aim to protect what exists, which is actually much less than was originally there"
Elizabeth Kolbert, 2012, *New Yorker*

Conservation planning involves having a clear plan for the future, then working with governments and communities to implement these decisions. It can involve planning to deal with a number of issues, including susceptibility, lack of coping capacities, lack of adaptive capacities, and the exposure of populations to natural disasters. Using these indices, a *World Risk Index* (*Nature Conservancy*) can be developed to better assist conservation planning.

Conservation Targets

Conservation targets are identified through a variety of approaches.

1. *Species approaches* - choosing conservation targets based on focal, indicator, flagship, or umbrella species. These species are often selected based on life history characteristics that may reflect conservation concerns of other co-occurring species facing similar threats.

2. *Biodiversity indicators* - a measure or metric based on verifiable data that conveys information about more than itself. This could be a species that is a surrogate species when data on other taxa is deficient.

Conservation Goals

In order to better conserve an area, a group needs to set out goals to meet, which should then guide their decision-making process. It is more beneficial and effective to make specific goals than just stating you want to conserve an area.

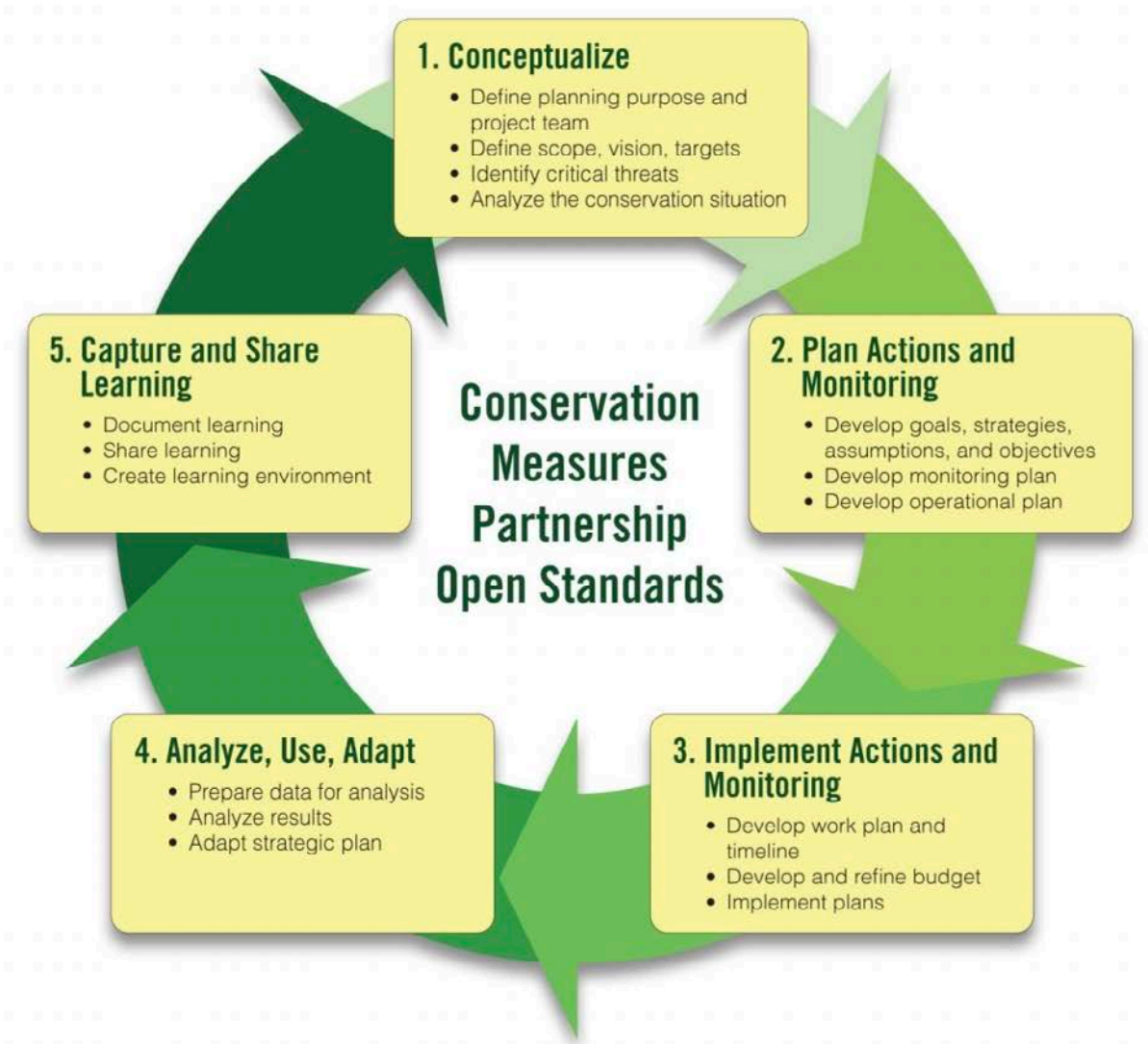
Goals need to be

1. Specific and attainable
2. Clear goals make it easier to define strategies and activities
3. Contain specific end-points and be able to demonstrate success
4. Based on scientific data/previous research

A conservation plan should also include guidelines on how to evaluate the success of each goal. It should also be flexible enough to adapt and anticipate change. The most effective

conservation is that which is willing to learn from its mistakes, make corrections, and then move forward.

Conservation Measurers Partnership has developed specific guidelines and open standards to assist conservation groups around the world as a road map to effective conservation planning.



© Conservation Measures Partnership

PROTECTED AREAS

A protected area is a geographic region that is a clearly defined space which has been recognized, dedicated, and managed, through legal or other means. This area has been protected to attain long term conservation of nature and its associated ecosystem services and cultural values (IUCN 2008).

Protected Areas Effectiveness

Most protected areas meet their goals, by reducing impacts on nature, creating disincentives that protect nature within the region. However, even when a protected area is not effectively

protected or degraded, it is more effective at protecting biodiversity than an unprotected area. Effectively planned areas incorporate considerations of habitat size, location, biodiversity, and risk of extinction into account.

IUCN seven types of protected areas

The IUCN (International Union for the Conservation of Nature) has developed seven different types of protected areas based on a specific set of characteristics.

1A. Protects biodiversity and geological/geomorphological (e.g., ecological reserves)

- Human visitation, use, and impacts are strictly controlled and limited. They are mainly managed for science or protection of natural processes and biodiversity.
- As of 2017, 495 places in Canada are characterized as this type of protected area with 23 located in Manitoba.

1B. Large unmodified or slightly modified areas without human habitation.

- They retain their natural character and influence. They are mostly protected and managed to protect their natural condition.
- As of 2017, 269 places in Canada have this distinction, with 8 located in Manitoba.

2. Large natural or near natural areas to protect large-scale ecological process, along with the complement of species and ecosystems characteristic of the area

- Provide a foundation for environmentally and culturally compatible spiritual, scientific, educational, recreational, and visitor opportunities.
- In Manitoba, Wapusk National Park is considered to be one of these areas
- As of 2017, 1739 places in Canada have this distinction, with 25 located in Manitoba.

3. Protect a specific natural monument

- It can be a landform, sea mount, submarine cavern, geological feature (e.g., cave, ancient grove). These areas are generally small and often have high visitor rates.
- In Manitoba, Birds Hill Provincial Park is one of these areas
- As of 2017, 577 places in Canada have this distinction

4. Protect particular species or habitats

- The management of these areas reflects the priority to preserve these species or animals. They may need regular and active interventions to serve the particular species or habitat requirements
- In Manitoba, Oak Hammock Marsh is one of these areas
- As of 2017, 2991 places in Canada have this distinction

5. Interaction of people and nature over time has produced an area of distinct character with significant ecological, biological, cultural and scenic value

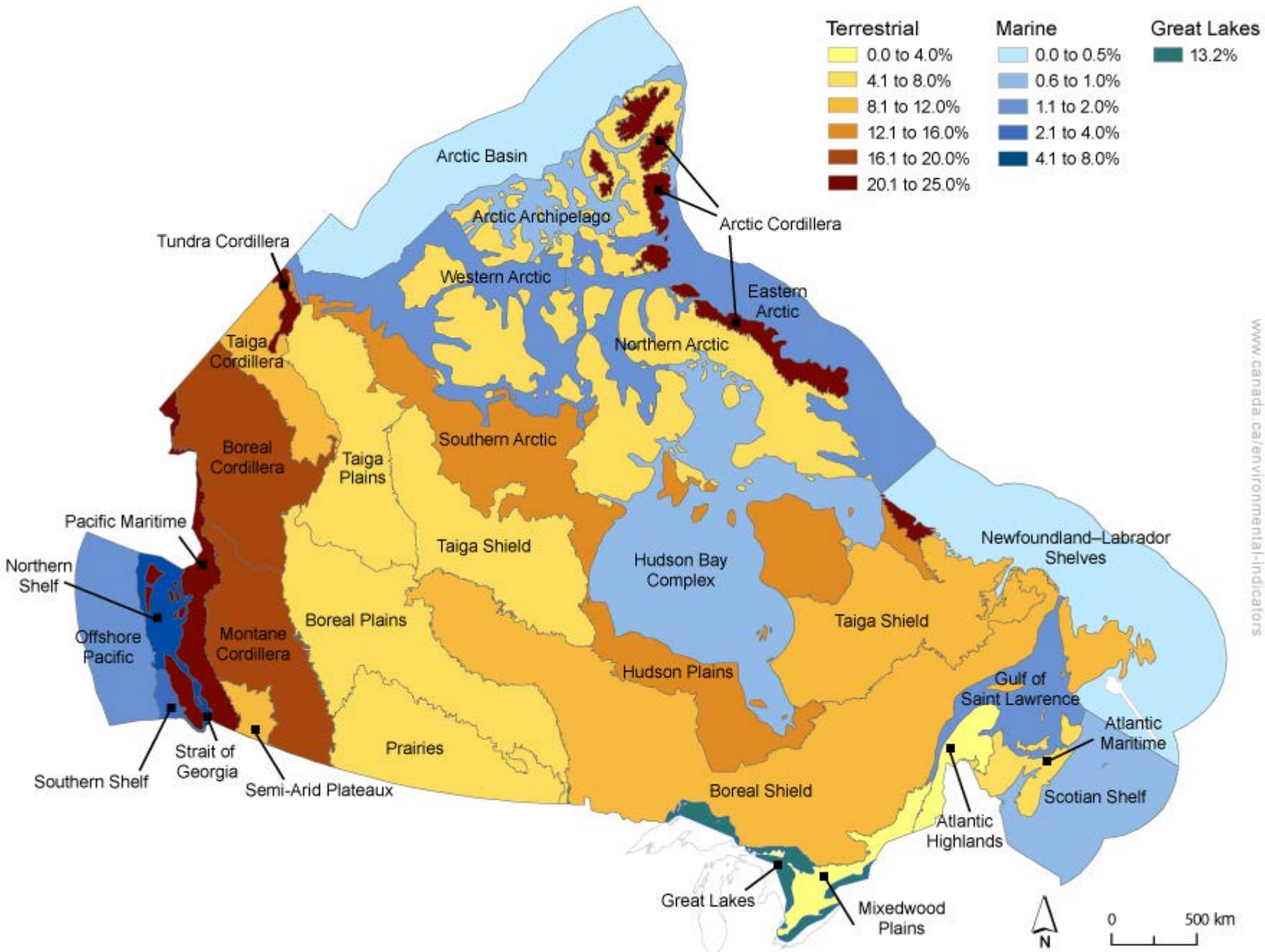
- Safeguarding the integrity of these interactions is vital to protecting and sustaining the area and its associated nature conservation.
- In Manitoba, Alaksen National Wildlife Area is one of these areas
- As of 2017, 160 places in Canada have this distinction

6. Conserve ecosystems and habitats, together with associated cultural values and traditional natural resource management systems

- Areas are generally large with most of the area in natural condition
- A proportion of this type of area is under sustainable natural resource management and where low-level non industrial use of natural resources is compatible with nature conservation
- In Manitoba, Narcisse Wildlife Management Area is one of these areas
- As of 2017, 1189 places in Canada have this distinction

Protected areas in Canada

The map shows the distribution and size of terrestrial (land and freshwater) protected areas and marine protected areas in 2015.



© Government of Canada

As of 2015 there are over 7100 terrestrial protected areas in Canada. A total of 2446 new terrestrial protected areas and 17 marine protected areas added to Canada's protected areas network since 2011.

The level of protection of lands varies between ecoregion. The map shows the percentage of each protected area, with the Pacific Maritime, Arctic Cordillera and Tundra Cordillera having the largest proportions of protected area. Yet less than 1% of the Arctic Basin, Hudson Bay complex, Newfoundland and Labrador Shelves and Scotian Shelf marine regions are protected.

Indigenous and community conserved areas

Indigenous and community conserved areas (ICCAs), or indigenous peoples' and community conserved territories and areas, are spaces managed by indigenous peoples or local communities with positive results for the conservation of biological and cultural diversity. Some ICCAs are situated in remote ecosystems that have had minimal human impact, while others encompass areas strongly affected modified by human occupation. ICCAs may or may not fit the IUCN definition of "protected area" but, when they do, they can fall into any IUCN protected area categories.

The following three characteristics are used to identify an ICCA:

- A strong relationship exists between an indigenous people or local community and specific sites (territory, ecosystem, species habitat). The relationship is often entrenched in the community's sense of identity and/or dependence for well-being and livelihood.

- The indigenous people or local community is the major player in decision-making and management. A local institution has the capacity to develop and enforce decisions.

- The community's management decisions and efforts lead to the conservation of habitats, species, genetic diversity, ecological services, and associated cultural values, even when the conscious objective of management is not conservation.

The IUCN World Parks Congress (2003) defined ICCA's as:

"natural and/or modified ecosystems containing significant biodiversity values and ecological services, voluntarily conserved by (sedentary and mobile) indigenous and local communities, through customary laws or other effective means"

The definition is recognized by the United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) and is expanded in the UNEP-WCMC ICCA Registry Handbook as "a type of Protected Area in which native peoples initiate the creation and/or are owners and managers".

Community-based management

Community-based conservation is a movement that started in the 1980's as the international movement to protect biodiversity increased. Previous conservation moments

had disregarded the interest of local inhabitants. The objective of this type of conservation is to incorporate local people when making decisions on conserving and creating national parks and wildlife refuges.

Community-based management (CBM) is a bottom up approach of organization that aims for local stakeholder participation in the planning, research, development, management and policy making for a community as a whole. This management technique enables local people to deal with the unique social, political and ecological problems their community might face and find their own solutions.

UNPROTECTED AREAS

Many species and communities occur outside of protected areas. Protected areas are not the only solution. Both protected and unprotected areas can contribute to a landscape for animals and plants to live and ecosystem services to be maintained. Selectively or long-rotation logging areas, agroforests, tree plantations, urban areas, military lands, and private reserves can all serve as habitat.

Unprotected areas can serve as buffer zones, stop-over areas for migrating species, habitat for generalist (non-picky) species, foraging areas for nearby species, educational opportunities, as well as *cheap* conservation opportunities.

SCIENCE AND VALUES

MOTIVATORS OF ENVIRONMENTAL BEHAVIOUR

Motivators of Environmental Behaviour

A variety of factors influence an individual's decisions, particularly in regard to environmental behaviour:

1. Perceived costs and benefits (including nonmonetary costs and benefits)
2. Moral and normative concerns (what you think you should be doing)
3. Emotion
4. Contextual factors (primarily available means)
5. Habits

In addition to these listed factors, the political orientation, age, gender, education, and other individual characteristics can influence environmental behaviour.

Perceived Costs and Benefits

Money, or saving money, can be a very powerful motivation. However, there are differences in the perception and importance of cost to an individual. Nonmonetary costs, such as comfort, time, and ease also can play a role in the amount of money a person is willing to spend. There often becomes a trade-off between attitude and cost. For example, doing something that makes you feel good but requires little cost, discomfort, convenience, or effort, such as recycling or composting, are more likely to be done. However, something that may take more time and may be more uncomfortable, such as taking rapid transit instead of driving, is not nearly as likely to be done.

ENVIRONMENTAL ECONOMICS

Some conservation biologists have placed greater emphasis on identifying and quantifying value of nature through *ecosystem services* and *environmental economics*.

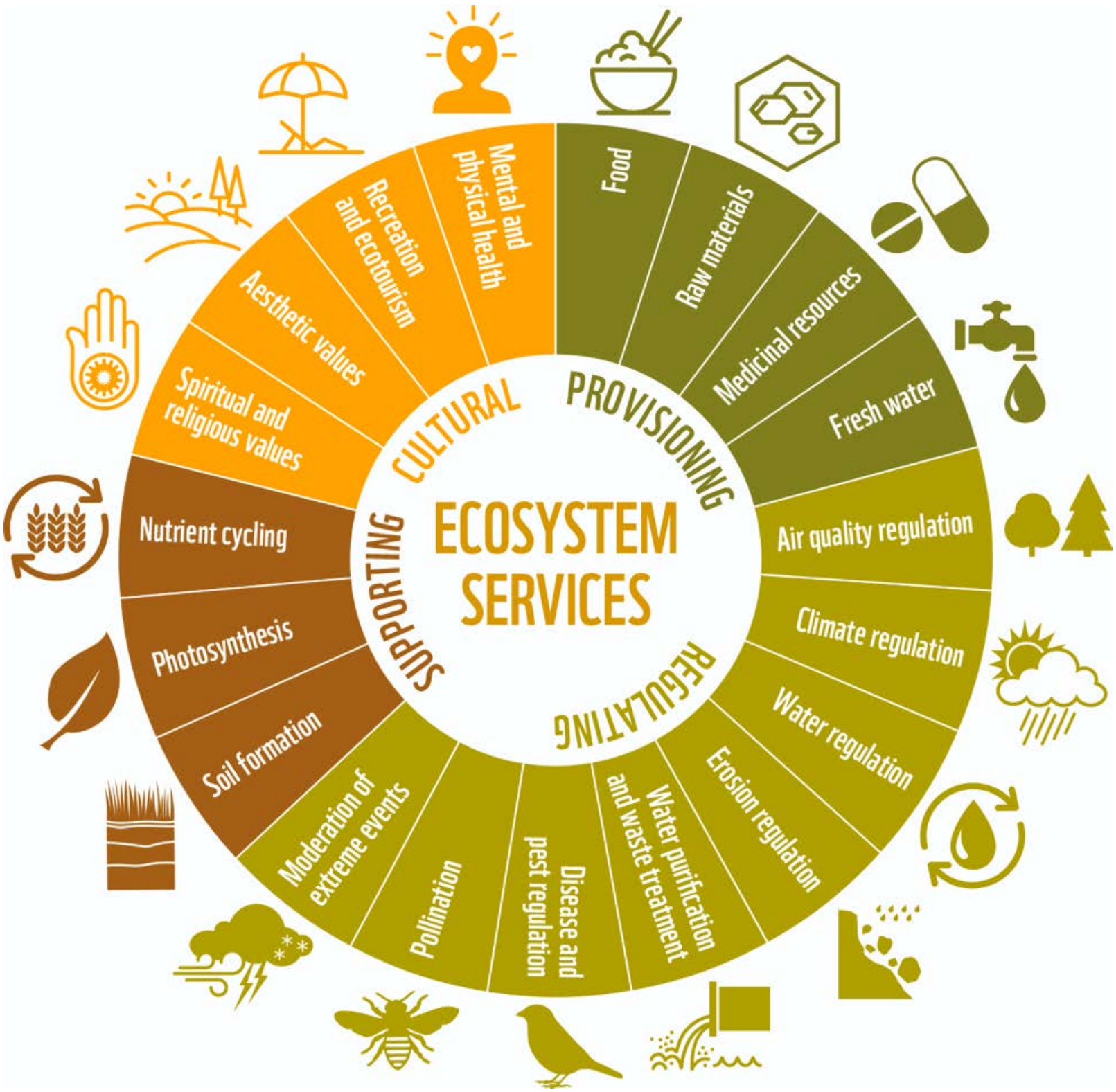
Ecosystem services

In order to evaluate the services that an ecosystem may provide,

1. Consider the services provided by nature
2. Calculate the economic benefits of the services
3. Create a plan that protects those services based on their *true* value

To prevent more biodiversity loss and habitat alteration, one needs to understand the causes of certain human behaviours. Decisions are often made by weighing the gain or loss of something, or a cost-benefit analysis.

Ecosystem services are those ecological characteristics, functions or processes that directly or indirectly contribute to human well-being.



The *UN's Millennium Ecosystem Assessment* uses four categories to define ecosystem services:

Provisioning: goods provided by nature that humans use (e.g., food and fiber)

Regulating: control nature in a way that aids humans (e.g., climate regulation and water)

Cultural: emotional and psychological benefits (e.g., spiritual and aesthetic)

Supporting: biogeochemical and ecological processes that support the other services (e.g., primary production, nutrient cycling, soil formation)

Stated-preference methods

People's statements can be one way to demonstrate value. Stated-preference methods can be evaluated through the willingness to pay (maximum price at or below at which a consumer will buy a unit of a product or service), and contingent valuation (collecting preference information from respondents using a survey).

For example, if you ask a region's residents how much they would be willing to pay to ensure long-term presence of wetlands, it is likely to be higher if they live closer to the effected space.

The issues with this method are:

1. It needs a large sample size
2. People can state any value but that does not necessarily match the reality of what they can pay or already pay.
3. An individual's valuation for an item may not remain stable over time – how we value objects or services are likely to change with shifts in our lives and values.
4. It may not be ethical to place value on a species or ecosystem.

Revealed-preference methods

People's actions can also demonstrate value. People can reveal the true value or preference for items through their buying power or preferences.

A. *Production function/equation for product sold commercially*

The value of an ecosystem can be obtained by the value of an item sold commercially. For example, boreal forests contain black and white spruce that produce mainly 2x4's but also wood chips for newsprint, wood shavings for pet and livestock bedding, and sawdust for particle board.

The issues with this method are, what happens to the value of a habitat when the USA adds duties to Canadian exports, or a building market collapses, or a dollar rises? Fluctuations in economics can dramatically shift how much an ecosystem is valued.

B. Travel cost method

The value of an area may be based on how much people are able to pay to see or do something. For example, people may pay a premium to see a beautiful beach or exotic forest, increasing their value as a tourism spot and decreasing the changes of it being destroyed.

For example, New Zealand is considered one of the most desirable vacation locations in the world and it brings in $12 billion dollars a year from tourism and the industry employs 7.4% of the workforce.

The issues with this method are remote locations, like the Arctic, deep sea vents, deserts may have low values due to difficulty getting there. Further, the ability of an ecosystem to attract tourists may not be its only value. Finally, the additional tourism may end up negatively impact biodiversity.

C. Hedonic pricing

Hedonic pricing is the premiums people will pay for proximity to nature or access to an ecosystem service.

For example, specific locations within cities like Winnipeg may be valued more due to their closeness to rivers, parks, and other natural areas.

Issues arise when people argue for protection for these high-priced locations. It may limit access based on socio-economic status and push out individuals who may have used these lands for long periods of time.

Replacement cost methods

Replacement cost methods are based on how much is society willing to pay for infrastructure or technology that would replace a natural service. For example, wetlands naturally filter water, among other functions. How much does it cost to preserve a wetland compared to the cost of building water filtration plants?

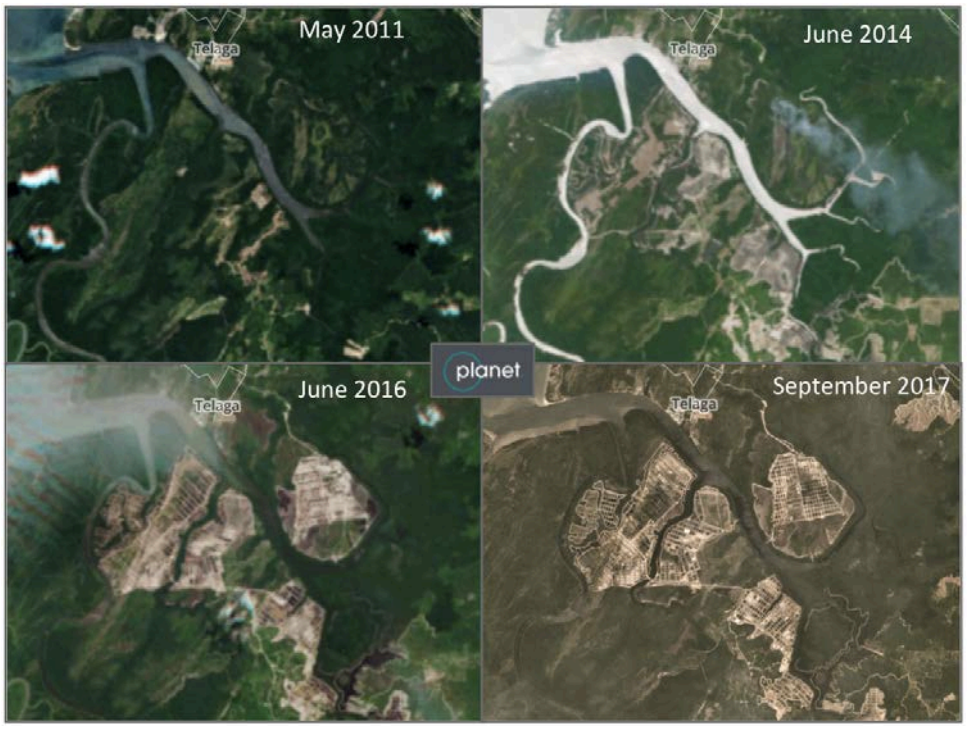
Issues arise with this method as future technology may become more efficient and economical at replacing a service provided by a natural area. If we were able to design a more efficient and cost-effective water filtration plant, the replacement costs of wetlands would decrease and encourage the development over these communities.

Issues with Cost-Benefit Analysis in Conservation

At the heart of cost-benefit analysis is the assumption that things can be substituted. The approach implies that more of one good thing can make up for the loss of another. For example, can more money immediately be a substitute for having polar bears in the future? Some evidence exists that losing a species may reduce the productivity of some particular ecosystems. For example, ocean fisheries recover faster from over fishing when there is higher biological diversity than when there is low biological diversity. Further, some ecosystems exhibit large changes when species are lost, like wolves regulate moose populations so that overgrazing on balsam fir trees are less likely. However, in some grassland habitats they produce as much biomass when species diversity is low compared to high species biological diversity and some extinctions have had no visible effects on the ecosystems where they previously lived, like the Golden Toad.

Keystone species
In some ecosystem one species may have a widespread impact on an ecosystem based on its presence and actions. These species are known as *keystone species*. For example, Arctic fox serve to regulate lemming and goose populations as well as influence nutrient distribution in the Arctic.

One final problem with cost-benefit analysis in conservation is there is no guarantee that the outcome of the analysis will favour conserving an area. For instance, some ecosystem services can be cost-effectively replaced by technology. The Zappo potato chip factory (Louisiana, USA) used a swamp for wastewater treatment. The cost of building a plant for treatment was $215 000 and so the wetland was valued at $89 000. However, after the factory expanded it outgrew the wetland, and so now that swamp is worth nothing and was replaced. Additionally, market fluctuations may lead ecosystem services to have a value lower than another activity. In many tropical areas, like Malaysia, large swaths of mangrove have been converted into shrimp farms. As the price of shrimp has increased so has the desire to farm and increasing deforestation.



Satellite images showing how shrimp farms have changed the mangroves
© Planet Labs/Mongabay

Environmental economists have recognized this problem and have developed a few strategies to incorporate both ethical and environmental issues into decision making processes. This includes environmental impact assessments, adding non-substitutability to any cost-benefit analysis, and paying for ecosystem services.

Payments for ecosystem services

Paying areas to preserve important biodiverse ecosystems is one idea that has been used to increase conservation. In Costa Rica, they developed a plan to pay farmers to preserve their lands instead of cultivating the areas for agriculture. The idea was to save the ecosystem services of a forest, such as carbon sequestration, watershed protection, biodiversity protection, and landscape beauty. Over 4000 farmers enrolled and promised to protect forests for 15-20 years, renegotiating payments every 5 years.

However, there are few issues with this plan. They payed larger payments for reforestation than conserving old growth forests. The payments were also not based on a quantitative assessment of land production (e.g., a lack of environmental impact surveys). Finally, it did not give a larger payment to forests near watersheds, which many would consider a higher importance.

LOOKING TO THE FUTURE

CONSERVATION SUCCESS STORIES

"Optimism is essential to achievement and it is also the foundation of courage and true progress."
Nicholas Murray Butler (1931)

Celebrating and learning from the successes in conservation in contrast to all the sad stories that are read daily.

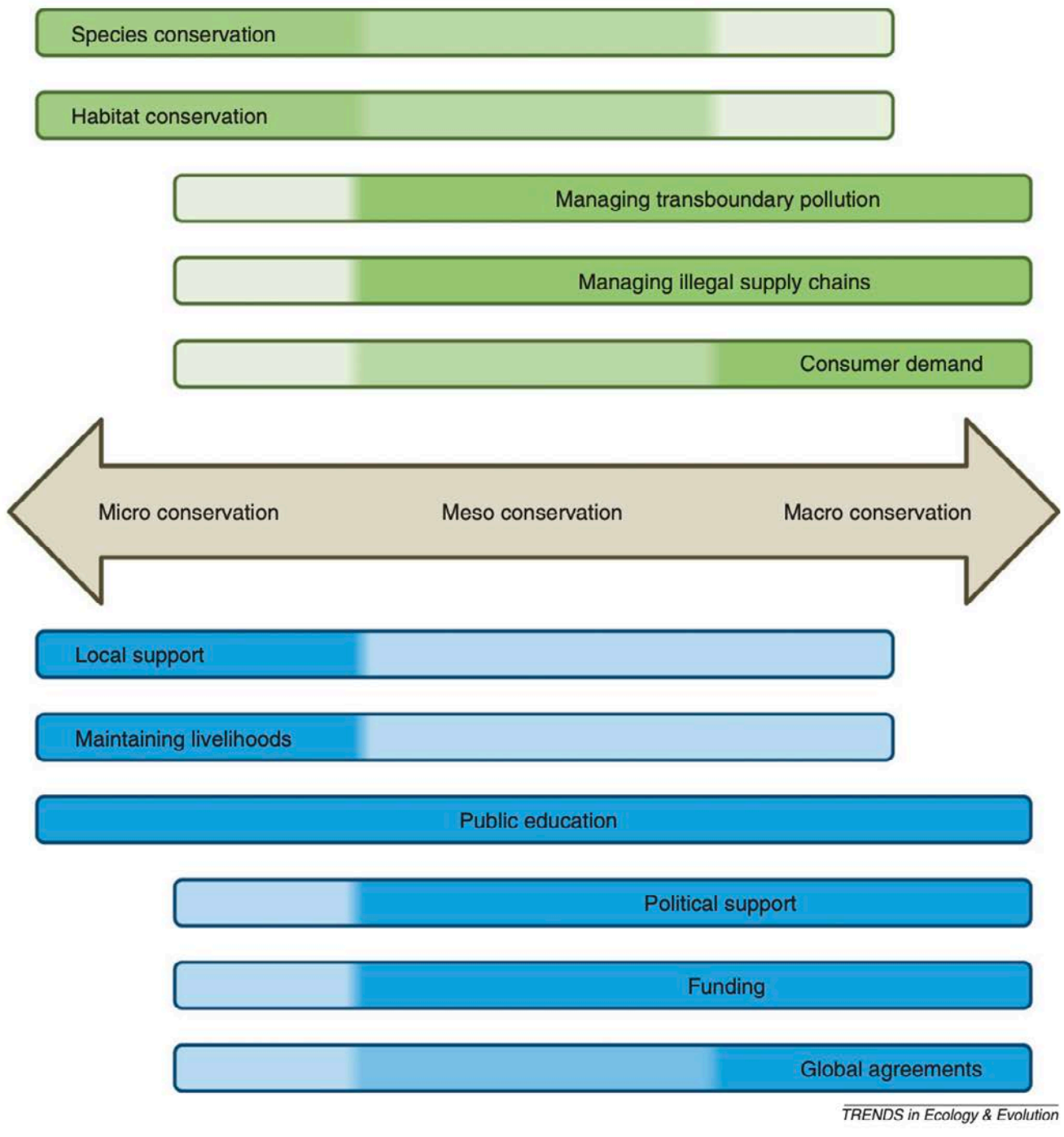
It can be important to examine success at different levels, from the small success to the large big picture. Conservation actions are likely to differ and overlap. Often conservation efforts may need to advance together at multiple scales.

Microscale – this conservation includes direct efforts to protect species or habitats. It includes creating protected areas and controlling illegal hunting.

Mesoscale – this conservation is at a more regional scale and includes transboundary agreements and the regulation of the international wildlife trade (e.g., CITES).

Macroscale – at this level, conservation is targeted at a global scale. It may include changing consumer demands and changing or creating legislation.

The following figure shows different conservation intervention scales. The green bars represent conservation actions and the blue bars show essential components of success. The darker shaded regions showing what scale at which each is important.



© Sodhi et al. 2011, *Trends in Ecology & Evolution*

Microscale Successes

Bardia National Park (Nepal)

The Bardia National Park has a Tiger Conservation Unit. It protects alluvial grasslands (silty, sand, clay soils from rivers) and subtropical deciduous forests. In 1976, this area was being

negatively impacted by human population growth, through land clearing and grazing. It became a national park in 1988, removing people from the park and banning livestock grazing. A study between 1998-200 found an increase in both predator and prey biodiversity. The densities of wild ungulates increased over four times in 22 years. They also found increased densities of endangered tiger and leopards.

Parrot Conservation

Parrots are the most highly threatened bird in the world. Currently, 31% species found in the tropical regions are at risk of going extinct. The conservation goal with this group of species is to reduce illegal hunting and harvesting. Nest poaching for the pet trade impacts 55% of threatened and endangered parrots. Research has demonstrated that nest poaching can be effectively reduced at protected locations. Nesting success is also three times higher in areas that are protecting.

Mesoscale Successes

Virunga Massif

The *Virguna Massif* is a transboundary region, between Democratic Republic of Congo, the Republic of Rwanda and the Republic of Uganda, that contains an extremely important habitat for mountain gorillas (*Gorilla beringei beringei*). The *Great Apes Survival Partnership* is an alliance in this area that aims to provide coordinated responses to address habitat loss and population declines. The area has witnessed an increase in count from of mountain gorillas from 480 in 2010 to 604 in 2016, which is the largest number ever recorded in this transboundary region.

Macroscale Successes

Overharvesting in Developing Tropical Nations

Multinational corporations are often the leaders in overharvesting of tropical forests. The largest commercial cattle herd in the world in Brazil. As of 2008, the industry was worth $6.9 billion, for meat and leather. Current enforcement was lacking in local laws and encouraged land grabs, squatters, and the burning of forests. Reports produced by the *World Bank*, the government of Brazil, and other research institutes have concluded that cattle ranching is found in around 80% of all the Amazonian deforested land. After these reports were released, Wal-mart, Carrefour, and Pao de Acucar paused their contracts with any suppliers that obtained beef from this region. They created the *Alianca da Terra* certification program. This guarantees to buyers that their beef is produced both sustainably and legally. They use ear tags and genetic testing to track the cattle.

SUSTAINABLE DEVELOPMENT

"Sustainable development is development that meets the needs of the present, without compromising the ability of future generations to meet their own needs."

The United Nations has developed sustainable development goals for 2030. It sets out a shared blueprint for peace and prosperity for people and the earth. There are 17 sustainable development goals (SDGs) involved in this project, that should be adopted by all countries, both developed and developing. They hope that these goals will help end poverty, improve health and education, reduce inequality, and increase economic growth, while also preserving and increasing the health of the earth.

SDG Video: https://youtu.be/0XTBYMfZyrM

Sustainable development is about finding better solutions and ways of doing things in our lives, both to improve our future and the present. It may involve changing how we work and live without reducing our quality of life. A sustainable development plan may give short to medium benefits. For example, sustainable development plans can save large sums of money for governments. Also, switching to cycling or walking can save an individual money, improve health, and can often be just as convenient and quick depending on the location.

Sustainable urbanization is key to successful development.

- As the world continues to urbanize, sustainable development depends increasingly on the successful management of urban growth, especially in low-income and lower-middle-income countries where the most rapid urbanization is expected between now and 2050. Integrated policies to improve the lives of both urban and rural dwellers are needed, strengthening the linkages between urban and rural areas and building on their existing economic, social and environmental ties.

- Urban growth is closely related to the three dimensions of sustainable development: economic, social and environmental. Well-managed urbanization, informed by an understanding of population trends over the long run, can help to maximize the benefits of agglomeration while minimizing environmental degradation and other potential adverse impacts of a growing number of city dwellers.

- To ensure that the benefits of urbanization are shared and that no one is left behind, policies to manage urban growth need to ensure access to infrastructure and social services for all, focusing on the needs of the urban poor and other vulnerable groups for housing, education, health care, decent work and a safe environment.

Business and the Environment

Businesses can have a huge impact on the environment and how natural resources are used. Companies may want to 'do the right thing' but several other motivators may be involved. Consumers want to support environmentally beneficial products, giving incentives to companies to reduce their environmental impact. Making sustainable decisions can also reduce the use of natural resources and save the company money. Companies may also be required to make environmentally friendly choices by government regulations or laws.

SOCIAL-ECOLOGICAL SUSTAINABILITY

The need to combine human well-being (socio-economic sustainability) and biodiversity conservation (ecological sustainability) has led to the development of social-ecological sustainability.

Snow Leopard Project

The Snow Leopard Conservancy has worked to conserve the endangered species throughout the Himalayan region. As part of this project, local communities attitudes toward Wildlife Conservation in the Hemis National Park was surveyed. Local communities were experiencing losses of income of around ~$128 a year (typical income - $200-500/year) due to predation on their livestock. Snow leopards were responsible for over 58% of the losses, compared to wolves (32%) and wild dogs, lynx, and fox were responsible fo the rest. It was expected that since the local communities were losing both food and income from the snow leopards protected in the park, they would also have a negative view of the park. As part of their conservation programs, the Ladakh Department of Wildlife Protection developed a compensation program, with claimants being paid up to 40% of the animal's worth. This compensation was using about 60% of the parks entire budget. They also had a number of unsettled claims that exceeded the park's budget and so compensation took a long period. However, the program did have many benefits. In collaboration with local communities and non-governmental organizations, the program promoted the coexistence between large predators and humans. It also reduced livestock losses and improved household incomes in an environmentally friendly, social responsible, and economically viable manner.

ECOSYSTEM STEWARDSHIP

"Ecosystem stewardship is an action-oriented framework intended to foster the social–ecological sustainability of a rapidly changing planet."
Stuart Chapin III et al. 2010, *Trends in Ecology & Evolution*

If you can assess and reduce the vulnerability to known stressors, like overgrazing, drought, pest outbreaks, climate change, and overfishing, you can react quickly and appropriately when situations change.

Ecosystem stewardship requires three components:

1. Reduce the *vulnerability* of a system to expected changes
    - For example, to reduce exposure to hazards and stress, build sea walls that can reduce the exposure to sea levels rises.
    - To reduce social-ecological sensitivities and adapt to adverse impacts, do not build in locations that are at a higher risk of natural disasters, such as along a vulnerable coastline.

2. Foster *resilience* to sustain desired conditions in the face of uncertainty and change
    - To maintain a higher biodiversity, prioritize conserving biodiversity hotspots or travel corridors, to allow species to adjust to a changing climate
    - Adapt governance to implement potential solutions, such as better coordination among non-governmental organizations (e.g., WWF, Conservation International, etc.), with similar goals

3. *Transform* from unwanted directions when other opportunities present themselves

Creating new models of sustainability incorporating ecosystem development and social dynamics is essential to conservation success.

LOCAL INITIATIVES AND CASE STUDIES

HOW CAN YOU HELP?

Legal and Institutional Instruments

A number of legal instruments have been used and continue to evolve as we better understand the world around us. Within Canada, the power to pass environmental legislation is divided between provincial and federal governments. The federal government has the power to pass laws in regards to fisheries, shipping, interprovincial trade and commerce, as well as criminal law.

In the early 20th century, governments began to create laws to regulate hunting and fishing to ensure a sustainable future. The Migratory Bird Treaty of 1916 between the US and Canada was the first international treaty for the protection of wildlife.

The federal government has already passed a variety of environmental laws, such as Canadian Environmental Protection Act, Canadian Environmental Assessment Act, Pest Control Products Act, Canada Shipping Act, Arctic Waters Pollution Prevention Act, Fisheries Act and Transportation of Dangerous Goods Act.

In contrast, the provincial government covers local nature and property. For example, the provincial government has the right to pass laws over agriculture, forestry, mining, and hydroelectric development. They also 'own' most natural resources. All provincial governments have passed laws regarding water and air pollution, as well as regulations on wildlife conservation and management.

As a concerned and active citizen, it is imperative for everyone to be in the political process and advocate for the world they desire. Environmental legislation has often been passed after political pressure from engaged citizens.

Policy

Conservation policy provides legal and political contexts for conservation research. It can be found at a variety of political levels, from municipal, provincial, federal, to international. They incorporate different aspects of environmental health, such as conservation, biodiversity, and ecosystem services. International efforts go beyond national borders, which require them to involve cooperation, treaties, and agreements.

UN Rio Earth Summit and the Convention on Biodiversity (1992)
One of the first global strategies on conservation was developed in 1992 when 100 nations came together in Rio. They developed an internationally recognized definition of sustainable development:

"Development that meets the needs of the current generation while ensuring that a healthy and viable world remains for future generations"

The convention was legally binding with the United Nations responsible for its enforcement. A global environment facility provides money to develop biodiversity protection and manage protected areas. The goals of the convention were to increase biodiversity conservation, sustainable use of components related to biodiversity, and the fair and equitable sharing of benefits from commercial and other use of genetic resources.

Species at Risk Act, SARA (2002)
The SARA act was passed by the federal government of Canada in response to the UN Rio Earth Summit. It passed in 2002, proclaimed in 2003, and implemented in 2004. It involves a four step process:

1. *Assessing status* - is a species at risk and what type of risk?
2. *Listing decision* - what are the socioeconomic costs of listing a species?
3. *Recovery plan* - how long is it expected for a species to recover and what goals need to be met in this process?
4. *Recovery action planning* - What steps will be taken to help a species?

If a species is listed on *SARA* it is illegal to kill, harm, harass, capture, or take an individual of a species that is listed as threatened, endangered, or extirpated. It is also illegal to damage or destroy their habitat or residence. There is an exception for harmful activities to continue if the activity is related to the conservation of a species, and the activity benefits the species or enhances its chance of survival.

Reduce, Reuse, and Recycling

Reducing the items you use, making smarter purchasing decisions, and choosing low impact and low waste products are all ways to increase world sustainability. *Reusing* items such as clothing furniture, and other suppliers is also important. *Recycling*, or the action or process of converting waste into reusable material, is also an option for decreasing an impact on the earth.

Reduce:

- Spend time thinking if you need to purchase an item, if you need the item, or if you could purchase the item second hand.
- Choose items that will have a long life (e.g., purchase long-lasting clothes)
- Consider the end life of an item before you purchase it - can it be composted?
- Avoid buying items that may become toxic waste.
- Choose items with less packaging

Reuse:

- Consider buying second hand items
- Donate items after they have been used to appropriate locations
- Consider other uses for items - Up-cycling!
- Lend out rarely used items!

Recycle and Compost:

- Recycle and compost whenever possible. Some compostable materials require industrial composting, so make sure you deposit into the correct locations.

More Recycling Won't Solve Plastic Pollution

It's a lie that wasteful consumers cause the problem and that changing our individual habits can fix it.

By Matt Wilkins July 6, 2018

The only thing worse than being lied to is not knowing you're being lied to. It's true that plastic pollution is a huge problem, of planetary proportions. And it's true we could all do more to reduce our plastic footprint. The lie is that blame for the plastic problem is wasteful consumers and that changing our individual habits will fix it.

Recycling plastic is to saving the Earth what hammering a nail is to halting a falling skyscraper. You struggle to find a place to do it and feel pleased when you succeed. But your effort is wholly inadequate and distracts from the real problem of why the building is collapsing in the first place. The real problem is that single-use plastic—the very idea of producing plastic items like grocery bags, which we use for an average of 12 minutes but can persist in the environment for half a millennium—is an incredibly reckless abuse of technology. Encouraging individuals to recycle more will never solve the problem of a massive production of single-use plastic that should have been avoided in the first place.

As an ecologist and evolutionary biologist, I have had a disturbing window into the accumulating literature on the hazards of plastic pollution. Scientists have long recognized that plastics biodegrade slowly, if at all, and pose multiple threats to wildlife through entanglement and consumption. More recent reports highlight dangers posed by absorption of toxic chemicals in the water and by plastic odors that mimic some species' natural food.

Plastics also accumulate up the food chain, and studies now show that we are likely ingesting it ourselves in seafood. If we consumers are to blame, how is it possible that we fail to react when a study reports that there will be more plastic than fish in the oceans by 2050? I would argue the simple answer is that it is hard. And the reason why it is hard has an interesting history.

Beginning in the 1950s, big beverage companies like Coca-Cola and Anheuser-Busch, along with Phillip Morris and others, formed a non-profit called Keep America Beautiful. Its mission is/was to educate and encourage environmental stewardship in the public. Joining forces with the Ad Council (the public service announcement geniuses behind Smokey the Bear and McGruff the Crime Dog), one of their first and most lasting impacts was bringing "litterbug" into the American lexiconthrough their marketing campaigns against thoughtless individuals.

Two decades later, their "Crying Indian" PSA, would become hugely influential for the U.S. environmental movement. In the ad, a Native American man canoes up to a highway, where a motorist tosses a bag of trash. The camera pans up to show a tear rolling down the man's cheek. By tapping into a shared national guilt for the history of mistreatment of Native Americans and the sins of a throwaway society, the PSA became a powerful symbol to motivate behavioral change. More recently, the Ad Council and Keep America Beautiful teams produced the "I Want to Be Recycled" campaign, which urges consumers to imagine the reincarnation of shampoo bottles and boxes, following the collection and processing of materials to the remolding of the next generation of products.

At face value, these efforts seem benevolent, but they obscure the real problem, which is the role that corporate polluters play in the plastic problem. This clever misdirection has led journalist and author Heather Rogers to describe Keep America Beautiful as the first corporate greenwashing front, as it has helped shift the public focus to consumer recycling behavior and actively thwarted legislation that would increase extended producer responsibility for waste management.

For example, back in 1953, Vermont passed a piece of legislation called the Beverage Container Law, which outlawed the sale of beverages in non-refillable containers. Single-use packaging was just being developed, and manufacturers were excited about the much higher profit margins associated with selling containers along with their products, rather than having to be in charge of recycling or cleaning and reusing them. Keep America Beautiful was founded that year and began working to thwart such legislation. Vermont lawmakers allowed the measure to lapse after four years, and the single-use container industry expanded, unfettered, for almost 20 years.

In 1971 Oregon reacted to a growing trash problem by becoming the first U.S. state to pass a "bottle bill," requiring a five-cent deposit on beverage containers that would be refunded upon the container's return. Bottle bills provide a strong incentive for container reuse and recycling, and the 10 states with bottle deposit laws have around 60 percent container recovery rates compared to 24 percent in states without them.

Yet Keep America Beautiful and other industrial lobbying groups have publicly opposed or marketed against bottle deposit legislation for decades, as it threatens their bottom line. Between 1989 and 1994 the beverage industry spent $14 million to defeat the National Bottle Bill.

In fact, the greatest success of Keep America Beautiful has been to shift the onus of environmental responsibility onto the public while simultaneously becoming a trusted name in the environmental movement. This psychological misdirect has built public support for a legal framework that punishes individual litterers with hefty fines or jail time, while imposing almost no responsibility on plastic manufacturers for the numerous environmental, economic and health hazards imposed by their products.

Because of a legal system that favors corporate generation of plastic, plus public acceptance of single-use items as part of the modern economy, consumers who want to reduce their plastic footprint are faced with a host of challenges. We should carry around reusable beverage and takeout containers. We should avoid bottled water or sodas at all costs. When we have to accept a single-use plastic container, we should inform ourselves about the complex nuances of which types of plastic are acceptable (No. 1–3, but not No. 5?), which forms are acceptable (bottles and jugs, but not bags?) and where they can be deposited (curbside or at a special location?).

In the case of most restaurants and gas stations, which almost never have customer-facing recycling facilities even where required by law, we should transport recyclables to another location that does recycle. Even then, we must live with the knowledge that plastics generally degrade with recycling, such that plastic bottles are more often turned into non-recyclable carpets and synthetic clothes than more bottles. Effectively, we have accepted individual responsibility for a problem we have little control over. We can swim against this plastic stream with all our might and fail to make much headway. At some point we need to address the source.

According to a 2016 Pew Research poll, 74 percent of Americans think the government should do “whatever it takes to protect the environment.” So what would swift, informed and effective governmental action to stop the pollution of our water, food and bodies look like?

Legislators could make laws that incentivize and facilitate recycling, like the national bottle deposit and bag tax bills that were proposed in 2009. These bills would have created a nationwide five-cent deposit on plastic bottles and other containers, and a nonrefundable five-cent charge on plastic bags at checkout. The U.K. launched a similar charge on all single-use grocery bags in 2015 and announced a nationwide

bottle deposit requirement in March of this year. Within six months of the plastic bag charge being in place, usage dropped over 80 percent. Similarly, in Germany, where a nationwide bottle bill was put in place in 2003, recycling rates have exceeded 98 percent. In the U.S. these actions would go a long way toward recovering the estimated $8 billion yearly economic opportunity cost of plastic waste.

Other actions could include a ban or "opt-in" policy on single-use items like plastic straws. That is, single-use plastic items would not be available or only upon request. A small tweak like this can lead to huge changes in consumer behavior, by making wastefulness an active choice rather than the status quo. Such measures were recently adopted by several U.S. cities, and are under consideration in California and the U.K.

And yet, some plastic producers continue to oppose legislation that would eat into their profit margins. Though California and Hawaii have banned the free distribution of plastic bags at checkout, a result of lobbying is that 10 U.S. states now have preemption laws preventing municipalities from regulating plastic at the local level. Plastic producers see their profits threatened and have taken a familiar tactic, forming the Save the Plastic Bag Coalition and the American Progressive Bag Alliance to fight bag bans under the guise of defending customers' finances and freedom to choose.

So what can we do to make responsible use of plastic a reality? First: reject the lie. Litterbugs are not responsible for the global ecological disaster of plastic. Humans can only function to the best of their abilities, given time, mental bandwidth and systemic constraints. Our huge problem with plastic is the result of a permissive legal framework that has allowed the uncontrolled rise of plastic pollution, despite clear evidence of the harm it causes to local communities and the world's oceans. Recycling is also too hard in most parts of the U.S. and lacks the proper incentives to make it work well.

Second: talk about our plastic problem loudly and often. Start conversations with your family members and friends. Call your local and federal representatives to support bottle bills, plastic bag taxes and increased producer responsibility for reuse and recycling. Stand up against preemptive bans on local plastic regulation. There are signs that corporations are listening to consumer opinions, too. After numerous petitions from customers and environmental organizations, McDonalds has pledged to use only sustainable packaging materials by 2025 and to phase out Styrofoam by the year's end.

Third: think bigger. There is now serious talk of zero waste. Instead of trying to reduce waste by a small fraction, some individuals and communities are shifting their lifestyles

to ensure that nearly everything is reused, recycled or composted. Non-recyclable straws and to-go cup lids do not fit into this system. Though inspiring, a zero waste lifestyle will be impractical or impossible for most of us within current economic systems.

A better alternative is the circular economy model, where waste is minimized by planning in advance how materials can be reused and recycled at a product's end of life rather than trying to figure that out after the fact. To make this happen, we can support groups like the Ellen MacArthur Foundation that are partnering with industry to incorporate "cradle-to-cradle" (i.e., circular economic) design into their products.

This could be our future—a future of clean cities, rivers and beaches but also simpler, more responsible choices for consumers. There are now too many humans and too much plastic on this pale blue dot to continue planning our industrial expansions on a quarterly basis. It's time to stop blaming consumers for our plastic crisis and demand a better system.

Source: Scientific American (https://blogs.scientificamerican.com/observations/more-recycling-wont-solve-plastic-pollution/)

Composting

Composting is the natural process by which organic materials, like food scraps and yard waste, break down into a nutrient-rich humus. This process takes place by decomposing animals (e.g., insects and nematodes) and soil microorganisms. Composting is one of the mechanisms by which waste can be diverted, reducing the production of green house gases. Further, the final product can be added to the environment to improve soil quality. Composting can easily be done at home, although other options are available in larger urban centres.

Green Action Centre (Winnipeg)
Community compost sites - if you are unable to compost at home but want to ensure your organic materials get recycled there are numerous locations in Winnipeg to compost your waste.
Compost Collection Service - Compost Winnipeg is a mid-scale composting service that caters to offices, multi-family residential buildings, and small restaurants and cafes to offer compost pickup. It operates throughout a variety of neighbourhoods throughout the city of Winnipeg.

Food Waste Is Becoming Serious Economic and Environmental Issue, Report Says

By Ron Nixon February 25, 2015

WASHINGTON — With millions of households across the country struggling to have enough to eat, and millions of tons of food being tossed in the garbage, food waste is increasingly being seen as a serious environmental and economic issue.

A report released Wednesday shows that about 60 million metric tons of food is wasted a year in the United States, with an estimated value of $162 billion. About 32 million metric tons of it end up in municipal landfills, at a cost of about $1.5 billion a year to local governments.

The problem is not limited to the United States.

The report estimates that a third of all the food produced in the world is never consumed, and the total cost of that food waste could be as high as $400 billion a year. Reducing food waste from 20 to 50 percent globally could save $120 billion to $300 billion a year by 2030, the report found.

"Food waste is a global issue, and tackling it is a priority," said Richard Swannell, director of sustainable food systems at the Waste and Resources Action Program, or Wrap, an antiwaste organization in Britain that compiled the new report. "The difficulty is often in knowing where to start and how to make the biggest economic and environmental savings."

The food discarded by retailers and consumers in the most developed countries would be more than enough to feed all of the world's 870 million hungry people, according to the Food and Agriculture Organization of the United Nations.

But it is not just those countries that have problems with food waste. The report showed that it is also an issue in African countries like South Africa.

The problem is expected to grow worse as the world's population increases, the report found. By 2030, when the global middle class expands, consumer food waste will cost

$600 billion a year, unless actions are taken to reduce the waste, according to the report.

Food waste is not only a social cost, but it contributes to growing environmental problems like climate change, experts say, with the production of food consuming vast quantities of water, fertilizer and land. The fuel that is burned to process, refrigerate and transport it also adds to the environmental cost.

Most food waste is thrown away in landfills, where it decomposes and emits methane, a potent greenhouse gas. Globally, it creates 3.3 billion metric tons of greenhouse gases annually, about 7 percent of the total emissions, according to the report.

The United Nations agency points out that methane gas from the world's landfills are surpassed in emissions by only China and the United States.

"Seven percent is not the largest contributor of greenhouse gasses, but it's not an insignificant amount," said Helen Mountford, the director of economics at the World Resources Institute. "But this is one area — reducing food waste — where we can make a difference."

Over the last several years, some cities and counties in the United States, including New York City, have started programs to tackle the issue. Hennepin County, Minn., the state's most populous county, provides grants from $10,000 to $50,000 to local business and nonprofits to help recycle food products or turn them into compost.

"There is still a lot in the waste stream," said Paul Kroening, supervising environmentalist at Hennepin County Environmental Services. "We are just scratching the surface."

A coalition of food industry trade groups, the Food Waste Reduction Alliance, has also increased effort to combat food waste. Meghan Stasz, the director of sustainability for the Grocery Manufacturers Association, a member of the alliance, said the group was working with supermarket chains to reduce waste by clarifying expiration dates and selling smaller portions of food.

Ms. Stasz said the group was also getting its members to donate more food and make changes in manufacturing processes to reduce the amount of wasted food. One member, the giant food company ConAgra, changed the way it placed dough in shell for its pot pies and saved 235 tons of dough in a year.

Mr. Swannell, of the antiwaste group Wrap, applauded those efforts, but said more still

needed to be done.

"Awareness of food waste has risen, but we need to do more to tie that awareness to actions on the ground," he said. "We need to find better ways to deal with food waste, but we need to prevent it in the first place."

Source: The New York Times (https://www.nytimes.com/2015/02/26/us/food-waste-is-becoming-serious-economic-and-environmental-issue-report-says.html)

Citizen Science

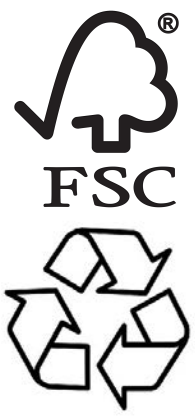
Citizen Science is the practice of public participation and collaboration in scientific research to help increase worldwide knowledge. Citizen science allows the public to share and contribute to monitoring and collection programs. Collaboration between researchers and the public, including volunteers, amateur scientists, students, and educators can help network and promote new ideas.

One of the oldest examples of citizen science is the *Christmas Bird Count*, that is sponsored by the National Audubon Society. Started in 1900, the bird count runs from December 14 - January 5 every year. An experienced birders leads a group of volunteers as they collect information about local birds. This bird census helps inform conservation efforts. Over 2000 groups participate annually throughout North America.

BioBlitz

One of the biggest concerns in protecting biodiversity is the recognition of what species exist and where they are found. A BioBlitz brings together taxonomic experts, citizen scientists and the general public to inventory all species (plants, animals, fungi, and more) in a particular area over a 24-hour period. Participants record all the organisms they find, and then experts verify their identity. Species records are compiled into a single data set; the species list, which provides a snapshot of the biodiversity in that location on that date.

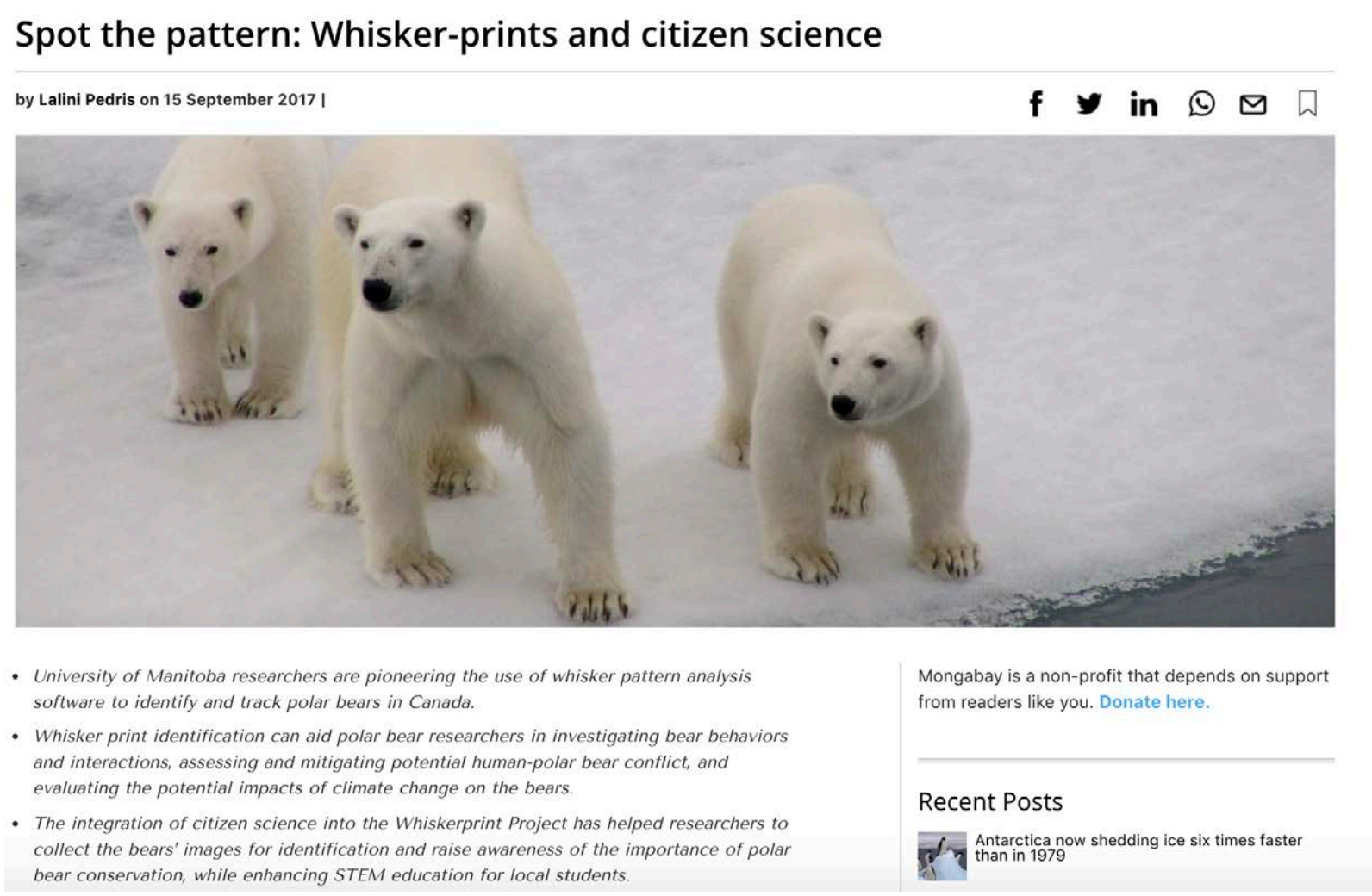
Smart Purchasing



Citizens can also invoke change through their purchasing power. For example, the use of the Forest Stewardship Council products (right), indicates that forest product comes from a sustainably managed forest. The presence of a recycling symbol or Mobius loop (right), indicates that a product is recyclable or contains recycled material.

Whisker-prints Project

The whisker print project is a citizen science initiative that allows researchers to track and identify polar bears through the use of digital photos. Polar bears have been historically difficult to track. Traditional mark and recapture methods, used to estimate populations, have not been very effective. Whisker printing is a non-invasive form of mark-recapture monitoring.



Spot the pattern: Whisker-prints and citizen science

by Lalini Pedris on 15 September 2017 |

- *University of Manitoba researchers are pioneering the use of whisker pattern analysis software to identify and track polar bears in Canada.*
- *Whisker print identification can aid polar bear researchers in investigating bear behaviors and interactions, assessing and mitigating potential human-polar bear conflict, and evaluating the potential impacts of climate change on the bears.*
- *The integration of citizen science into the Whiskerprint Project has helped researchers to collect the bears' images for identification and raise awareness of the importance of polar bear conservation, while enhancing STEM education for local students.*

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Recent Posts

Antarctica now shedding ice six times faster than in 1979

Each polar bear has a unique set of whisker prints, just as humans have unique sets of human fingerprints. A team, led by Dr. Jane Waterman (University of Manitoba) have designed and tested software to identify individuals based on their whiskers.

BEES IN URBAN AREAS

Bees are essential pollinators key to agriculture, food production, and the reproduction of thousands of plant species. As a keystone species, they play a vital role in ensuring ecosystem services are maintained. Beekeeping is an ancient practice, with cultures back to Ancient Rome keeping bees as part of their lives. As honeybee populations are in decline worldwide, increasing beekeeping can be beneficial for bees as well as all the plants and animals that depend on them.

Urban beekeeping has started to gain popularity around the world, including in Winnipeg. Bees do well in urban settings. They are often shielded from predators and pesticides. Large agricultural fields can often be dangerous for bees due to the chemicals used to control pests, like other insects, that attack crops. Urban areas also have a wide variety food sources available to honey bees. Large portions of rural settings, especially across southern Canada, have now been converted into agriculture. These areas now only contain one or two species, which create a 'feast or famine' situation for bees, as they may only flower for short periods. Finally, due to the additional warmth and wind protection that cities provide, the bee season can be longer.

The urban pollination project (https://beeproject.ca/services), hosted by *Beeproject Apiaries* in Winnipeg, allows the public to invest in honeybee protection, even if one knows very little about the process. This beekeeping service installs and maintains hives around the province and sells the local honey.

MANITOBA ECO-NETWORK

The Manitoba Eco-Network (https://mbeconetwork.org/) is a non-profit organization that promotes positive environmental action. Their mission is to connect Manitoba's and provide environmental information and education, through programs, projects, and activities. They provide a resource centre, networking and information services for their member groups. They also undertake projects to educate and increase public awareness on sustainable alternatives and to provide services to the environmental community. Some of their projects

include Organic Lawn Care, Water Caucus, Reel Green Film Festival, and Anne Lindsey Protecting Our Earth Awards. Currently they have 71 member groups, including Bike Winnipeg, Churchill Northern Studies Centre, Canadian Centre for Policy Alternatives (Manitoba), Green Action Centre, Lake Winnipeg Foundation, Oak Hammock Marsh, Oceans North Canada, Sierra Club Canada, and The Wildlife Society.

LOCALLY GROWN FOOD AND SUSTAINABLE AGRICULTURE

Generally, "locally grown" means food that "is grown (or raised) and harvested close to consumers' homes, then distributed over much shorter distances than is common in the conventional global industrial food system." Most people consider food to be locally grown if it comes from the same province or within a radius of about 160 km. It is very important to note that not all locally grown food is grown sustainably, so consumers must be prepared to ask questions if they want to know about the food they are purchasing.

Benefits of sustainable agriculture to farming communities

The economic benefits of local sustainable agriculture to farm communities include both revenue and employment. With fewer middlemen, farmers get a better return on their products, and have more income, making family farms more viable. Local businesses have more customers and more revenue, which creates jobs. And there are more job and entrepreneurship opportunities to manage farms, process and store food, manufacture equipment, and market and distribute food through food hubs, farmers markets and community supported agriculture farms (CSAs).

Communities benefit environmentally from sustainable agriculture in their region because their local ecosystems may be healthier. Air is cleaner because of reduced use of pesticides and fossil fuels. Water supplies are cleaner because of practices that protect soil as well as water. There is more wildlife and other biodiversity because marginal land is allowed to remain or return to its natural state.

There are a variety of social benefits of local sustainable agriculture. Communities have increased food security and access to fresher food because it travels less far. Some studies indicate that food raised using sustainable practices, picked closer to ripeness, and transported a shorter distance has higher concentrations of nutrients. Relationships between farmers and consumers are stronger. Farmers can get information about their food

to consumers easily, and consumers can target their purchases to local choices. Consumers become more connected to and knowledgeable about the food they eat. Developing local markets requires the cooperation of many community members and helps to build those communities so they thrive socially. As local agriculture becomes more sustainable, younger farmers and new immigrants are able to take the place of older farmers. The variety of owners of Manitoba's CSAs is evidence of this.

Local Food Programs

There is a wide variety of programs offering local food to consumers. Examples include *Farm to School* (http://www.farmtoschoolmanitoba.ca/), *Le Marche St Norbert Farmers' Market* (http://stnorbertfarmersmarket.ca/), *Harvest Moon Local Foods* (https://harvestmoon.localfoodmarketplace.com/), and *Direct Farm Manitoba* (https://www.directfarmmanitoba.ca/).

Direct Farm Manitoba is a cooperative that advances the interests of markets and farmers "by advocating on their behalf and connecting them to economic opportunities". *Harvest Moon Local Foods* connects consumers with local farmers and provides them options to purchase local food. *Le Marche St Norbert Farmers' Market* brings together local farmers and artisans to provide shopping opportunities to local residents. *Farm to School* is a fundraising program providing healthy local food to schools around Manitoba.

Marketing Food Locally

A number of organizations in Manitoba help farmers market locally grown food. Though not all of these organizations emphasize sustainability, they nonetheless provide a platform for farmers to advertise their sustainable practices. *Buy Manitoba* is an awareness project funded by the Government of Manitoba and the food industry, and run by the Manitoba Food Processers Association. Its goal is to help consumers identify Manitoba grown and processed food sold at a variety of outlets including major grocery stores, farmers' markets and specialty stores. *Peak of the Market* is a grower-owned vegetable supplier that prides itself on the quality of its produce and storage capabilities, and promotes Manitoba produce here and across North America. It offers some organic produce. *The Farmers' Markets Association of Manitoba* promotes farmers' markets as an important part of Manitoba's food system.

Farm to school programs can also act as marketing tools. They make parents aware of opportunities to purchase local produce and help to build a future customer base among students, as well as affect the current buying habits of their parents.

Effect of consumer interest and demand on local food supply

As is true for other goods, consumer food choices send strong messages to producers. Traditionally, consumers have been concerned primarily with the cost and nutritional quality of food. In recent years, more consumers are interested in knowing where their food comes from, and how it is grown and raised, whether sustainably or organically or humanely. The Internet has made it easier for consumers to learn about their food, and to choose food based on their values. Consumers are seeking direct connections with their farmers through farmers' market and CSAs and are also looking for local and sustainable food in supermarkets and restaurants.

All of this leads farmers and consumers to engage in more conversations and gives farmers more reasons and opportunities to produce food sustainably for local markets. Indeed, local food is accounting for an increasing share of total food sales. In 2012, sales at farmers' markets and through direct farm marketing accounted for 8% of the total retail grocery food sales in Manitoba.

Challenges to local farmers

In addition to the challenges most farmers face in implementing sustainable practices, smaller local farmers face a number of other challenges. Industry regulation may keep them from optimizing the use of their land. One Manitoba farmer says his family could make a good living by raising 3000 pasture chickens, but the quota system only allows him 1000.

He also notes that there are challenges in adding value to product. Government regulations require a commercial kitchen or a second kitchen in the farm house to produce jams and other preserves, something that is prohibitive for most small farmers. The recent controversy surrounding the cured meats produced at another Manitoba farm also highlights this difficulty.

Farmers may also have difficulty finding regulated and government inspected slaughter houses and processing facilities both close to their farms and willing to handle smaller amounts of food. Getting food to market during the growing season when the farm requires full time attention may be a problem.

In Manitoba, government and other organizations are working to overcome some of these challenges. In October, the Government of Manitoba announced new initiatives to promote food safety that include financial assistance for farmers to help them have the facilities for adding value. Older processing facilities are being repurposed for local needs. Food hubs and buying clubs are helping farmers deal with the challenge of getting food to market.

Programs and techniques for growing your own food

While growing your own food is not, strictly speaking, "agriculture," it can contribute to a sustainable local food system. These small plots with a variety of plants are less likely to need intensive pest control than large monocultures. Although backyard and balcony gardens do make use of available space for food production, they are usually very small, and thus can never fully compensate for the conversion of valuable agricultural land to residential development.

There are a number of programs to help those who have space to garden but difficulty using it, those who want to garden but do not have space, and those who need advice about growing food. Many communities in Manitoba have *community gardens* – areas along river banks, under power lines, on church lawns and at community centres where people can rent a plot of land for a season. *Food Matters Manitoba* sponsors an edible landscape competition to encourage people to grow produce in their yards and offers advice on what to plant. *Fort Whyte Farms*, a program of Fort Whyte Alive, offers opportunities for marginalized youth to learn about sustainable agriculture while developing life skills. *Sustainable South Osborne Community Co-op* in Winnipeg offers a variety of such programs.

Individual gardeners can maximize the sustainability of their gardens by using a variety of techniques, including:

> *Composting* allows gardeners to cycle nutrients in their yard by converting garden waste, food scraps, grass clippings, and leaves into compost that can be used to fertilize their garden and improve their soil.
>
> *Square foot gardening* allows gardeners to make optimal use of the space they have. Square foot gardens are 12" deep, 4' by 4' boxes on top of the ground that are filled with good quality soil and divided into 16 1' square areas. Each square is planted with one kind of plant. Because soil quality is good, and the bed is not compacted by walking, the plants are more productive.
>
> *Vertical gardening* takes advantage of vertical space. Where plants can grow in the ground, trellises encourage plants like beans, squash and tomatoes to spread upward instead of sideways, and increase the number of plants per area. Where there is no ground for plants to grow in, a frame with soil or a number of containers are placed on a wall, and the plants then grow on the wall.
>
> *Rainwater use* allows gardeners to conserve high quality drinking water. Water collected from roofs in rain barrels is perfectly fine for watering fruits and

vegetables. By collecting this water, gardeners may also reduce runoff from their property, along with any pollutants carried by that runoff.

Fruit Share is a program that allows people with more fruit in their yards than they can use to make that food available to others who will use it, including local food banks, and keeps that food out of the landfill.

Backyard poultry can add a significant source of protein to gardens, and also provide natural pest control and fertilizer. There is significant discussion about whether poultry have a place in urban settings, so many towns and cities are struggling with whether to allow this.

Aquaponics incorporates aquaculture and hydroponics in a system using fish waste as fertilizer for plants. The plants, which are often lettuce and other leafy vegetables and herbs, oxygenate the water and remove ammonia for the fish. The system can work on a household scale, and uses less water and nutrients than traditional agriculture, while being more productive than conventional hydroponics.

Contribution of local sustainable agriculture to regional and global sustainability

The regions around sustainable farming communities experience many of the same economic, environmental and social benefits as the communities themselves – a viable economy, a cleaner environment, and a rich social network. There are some other benefits to regional and global sustainability that go beyond the farming communities. Because food travels less distance to market, less fuel is used, and fewer greenhouse gases and other pollutants are produced in transporting it. It is important to note, however, that some of the fuel savings in transportation may be offset in cold climates – like Manitoba's – where more energy is needed to heat greenhouses than in warmer climates, and fresh food must be stored appropriately or processed to preserve it for later consumption. Because more food is sold directly to consumers, there is less packaging, and therefore less waste going to landfills. And because of the relationships between farmers and consumers, consumers have an interest in keeping farmland near their homes and can be an active voice for preservation of agricultural land.

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