MANITOBA ENVIROTHON

ENVIRONMENTAL AWARENESS

REGIONAL THEME RESOURCE

ACKNOWLEDGEMENTS

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MANITOBA ENVIROTHON

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INTRODUCTION

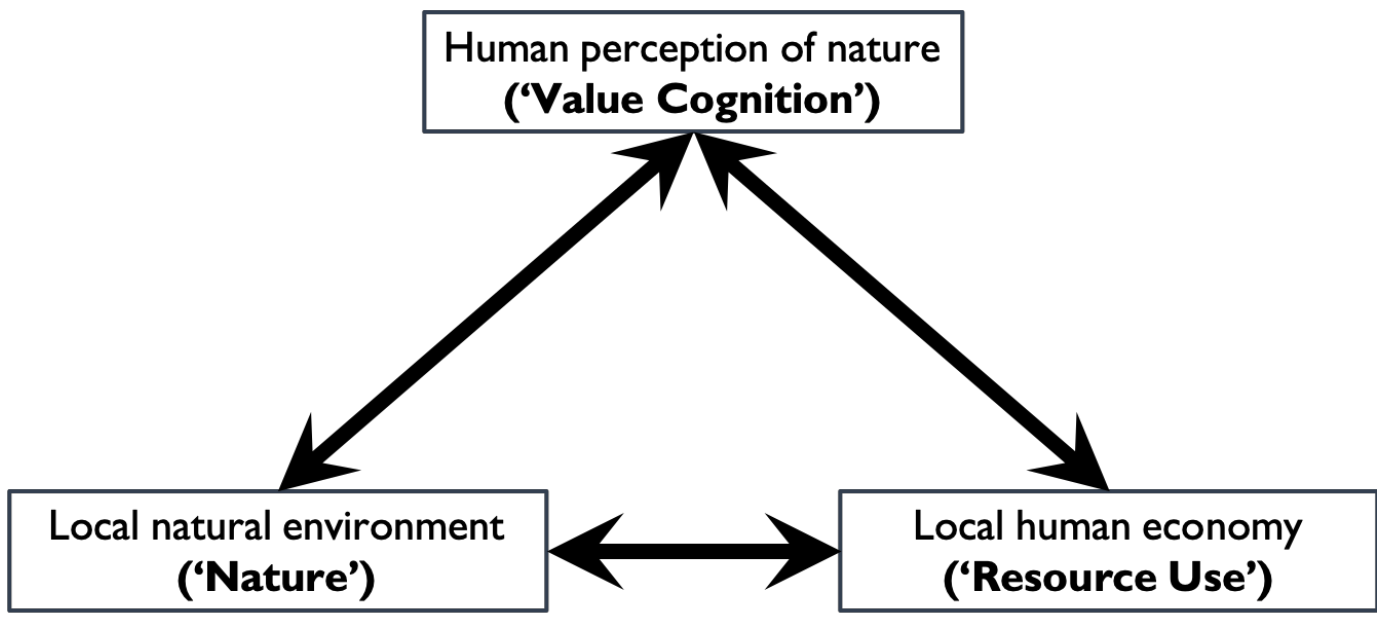
"We stand now where two roads diverge. But unlike the roads in Robert Frost's familiar poem, they are not equally fair. The road we have long been traveling is deceptively easy, a smooth superhighway on which we progress with great speed, but at its end lies disaster. The other fork of the road — the 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"

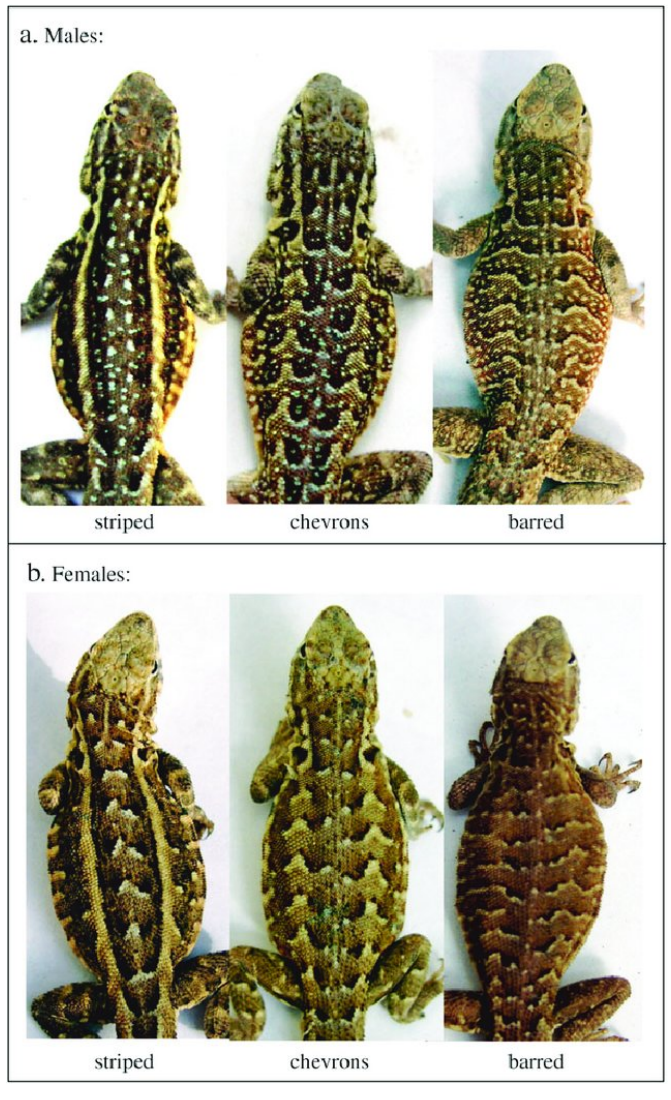
E.O. Wilson

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

© Lancaster *et al.* 2009, *Behavioural Ecology*

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.

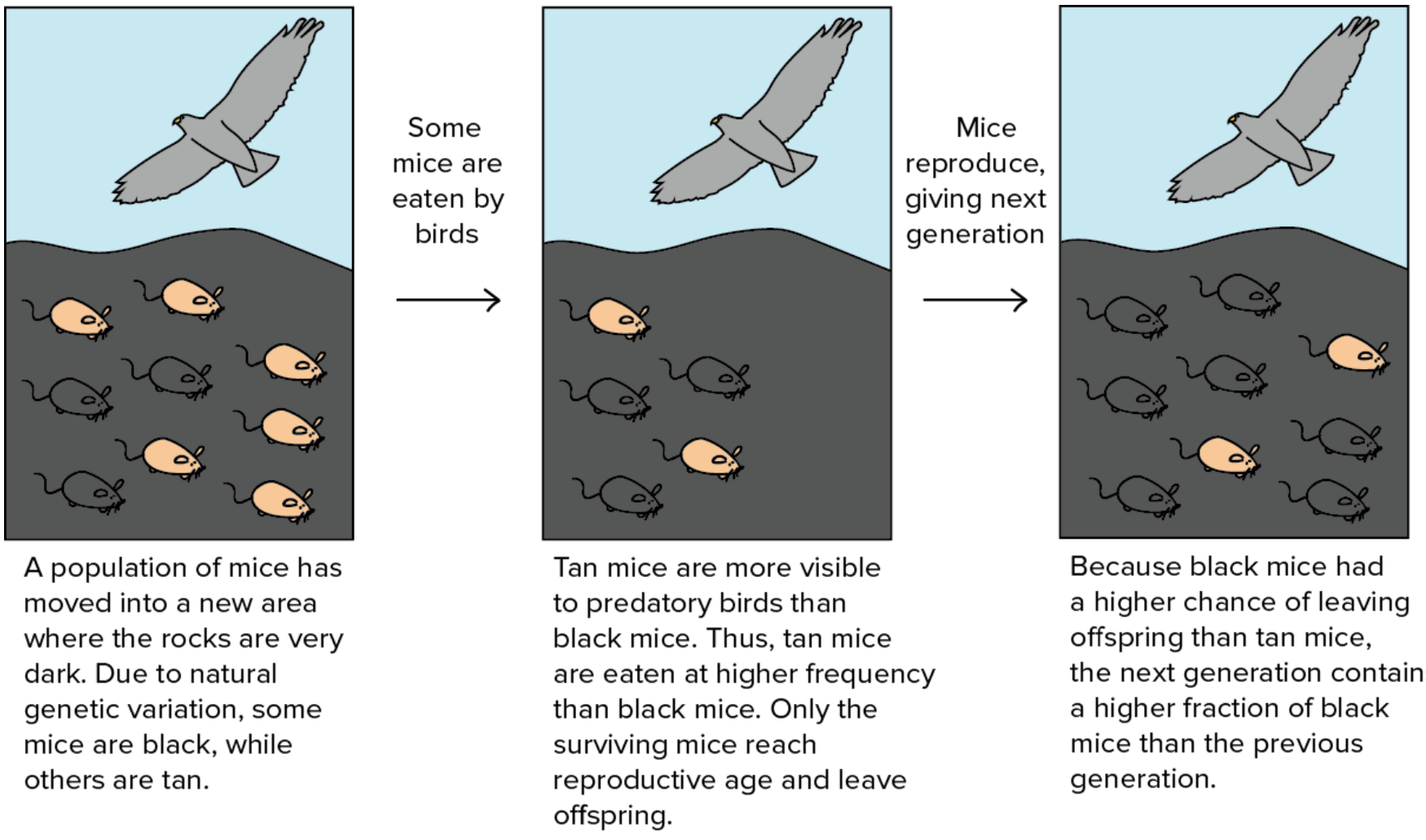
2. *Gene Flow* - the movement of genes from one population to another population. It is an important source of variation.

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?

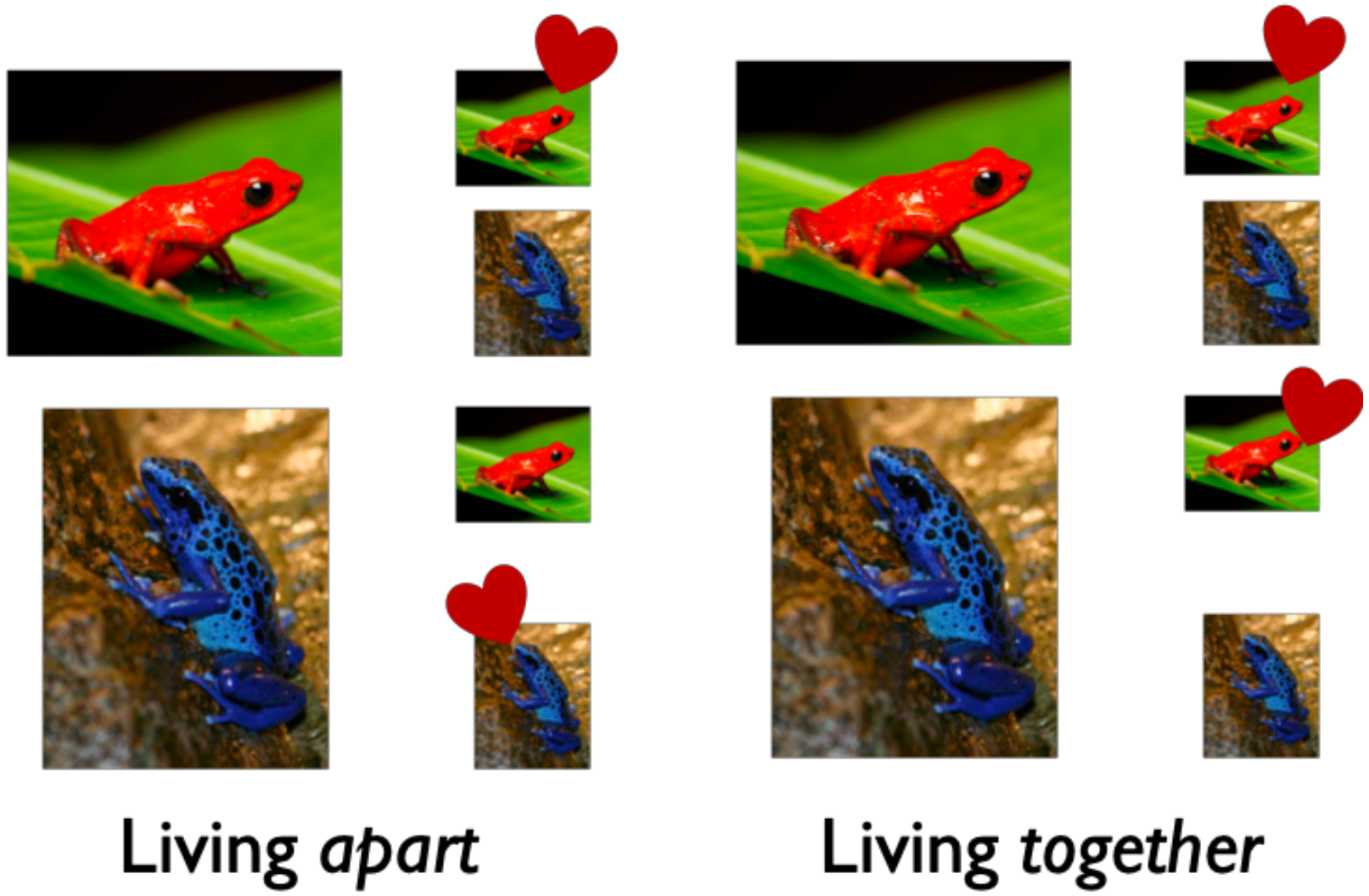
Both natural selection and drift influence what genes are passed onto the next generation and influence the biodiversity of all ecosystems.

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

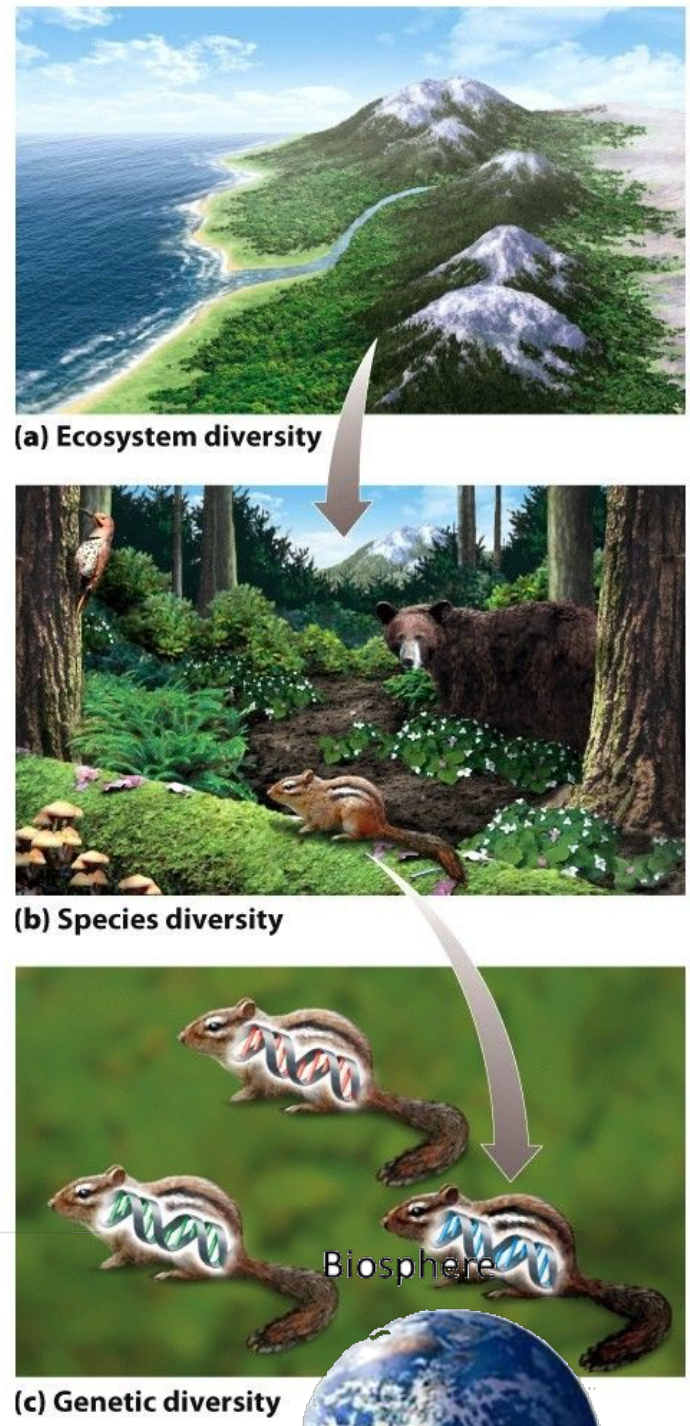
Biodiversity can be viewed at a variety of levels, through ecosystem diversity (big picture), species diversity, and genetic diversity (most specific).

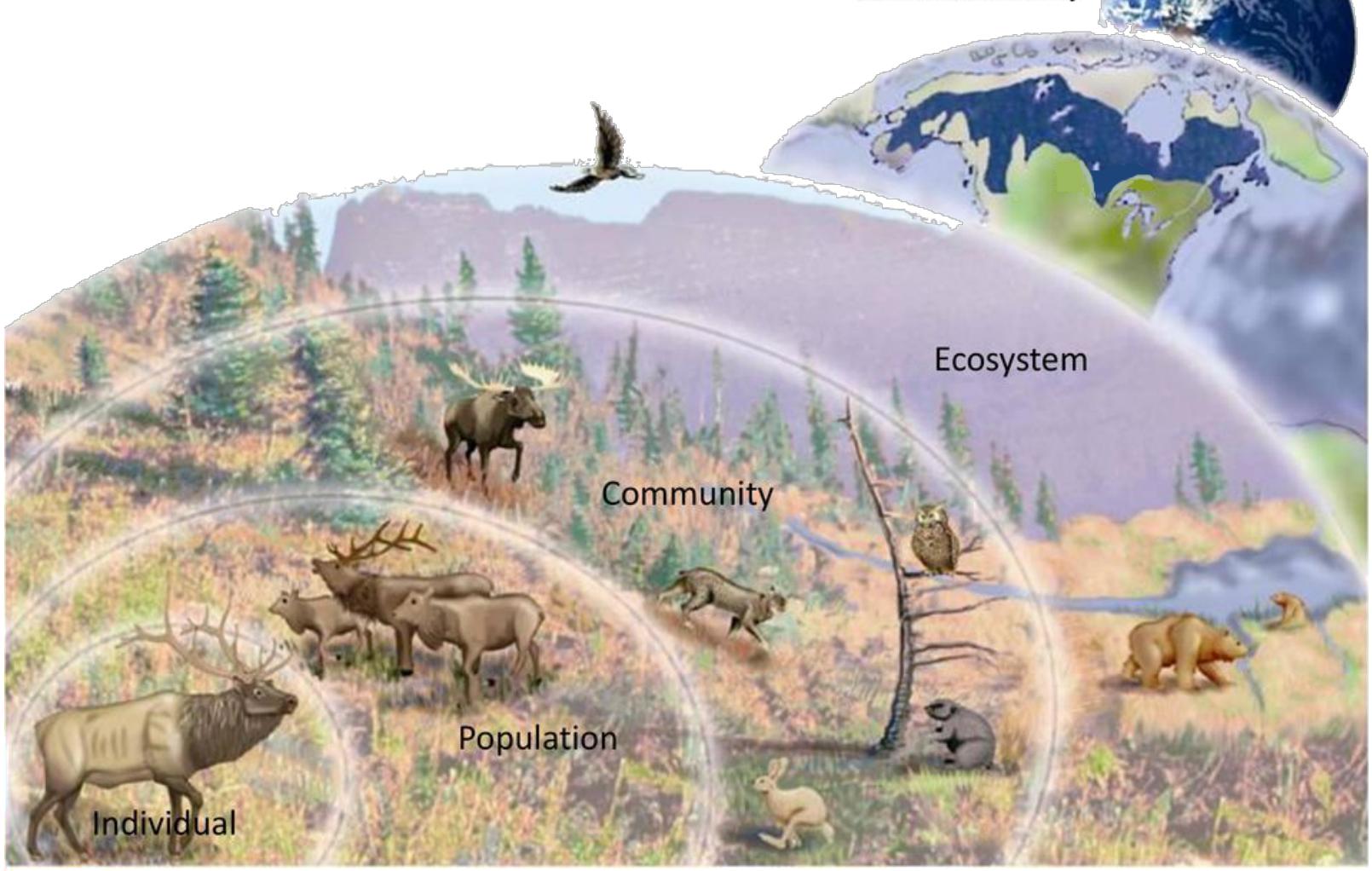
The ecoregion is the largest level of biodiversity, followed by ecosystems, communities, populations, and individuals.

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



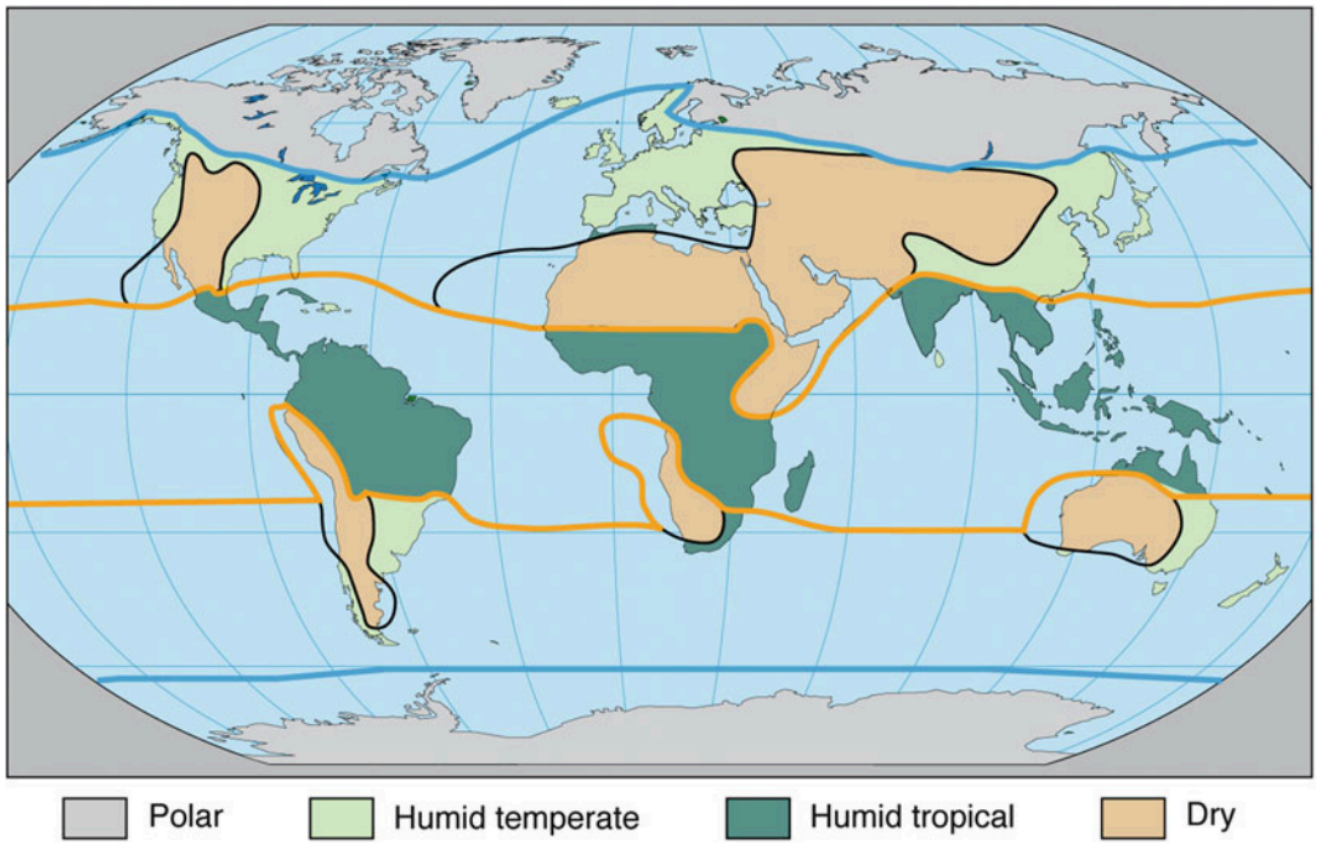


Communities will vary in **composition.** The *kind* of species that are present and the *abundances* of the species. The **composition** is influenced by predation, parasitism, competition, mutualism, dispersal, and other abiotic factors such as climate, history, and chance.

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

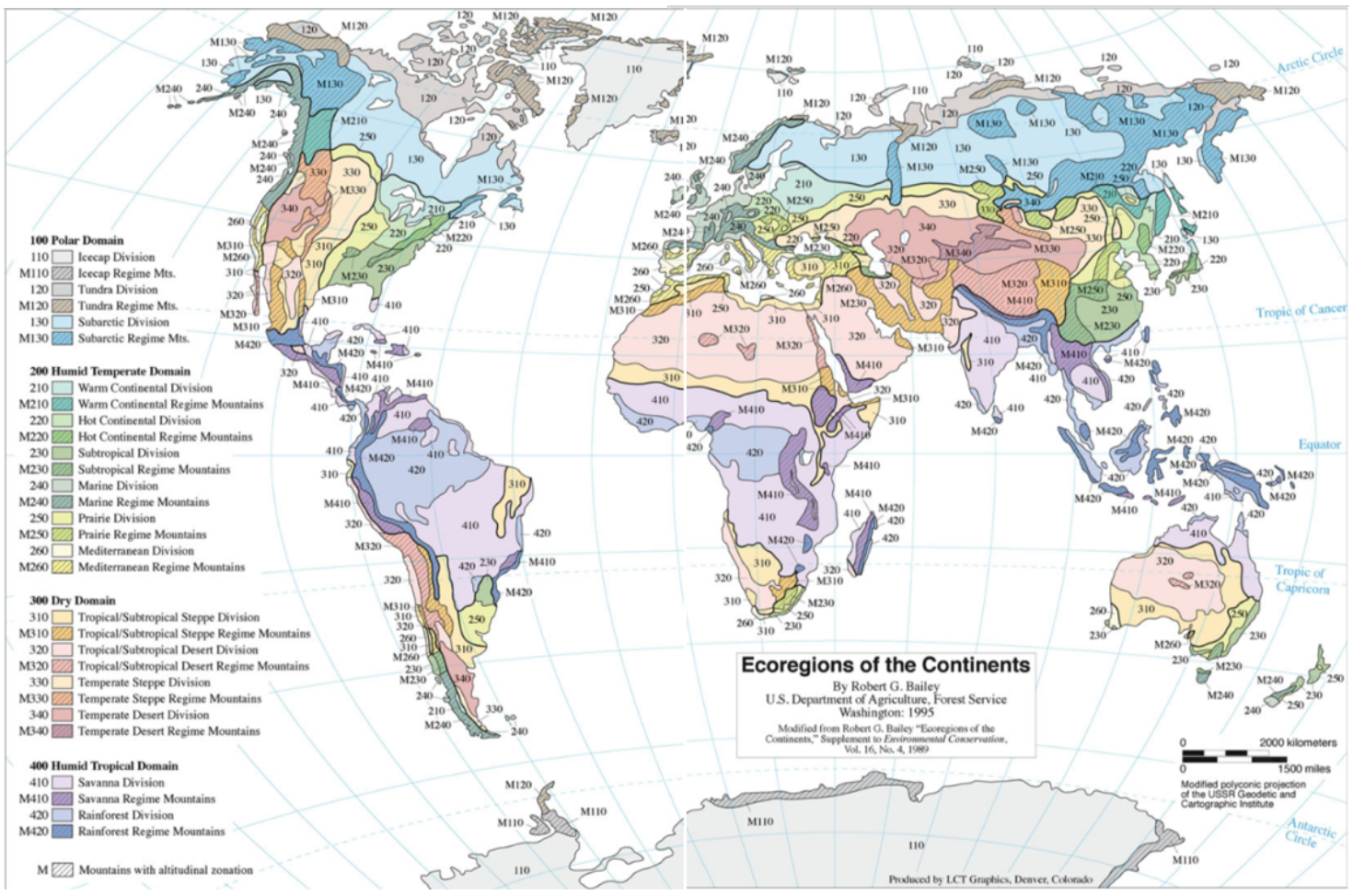
Canadian Ecosystems
© Biodivcanada

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

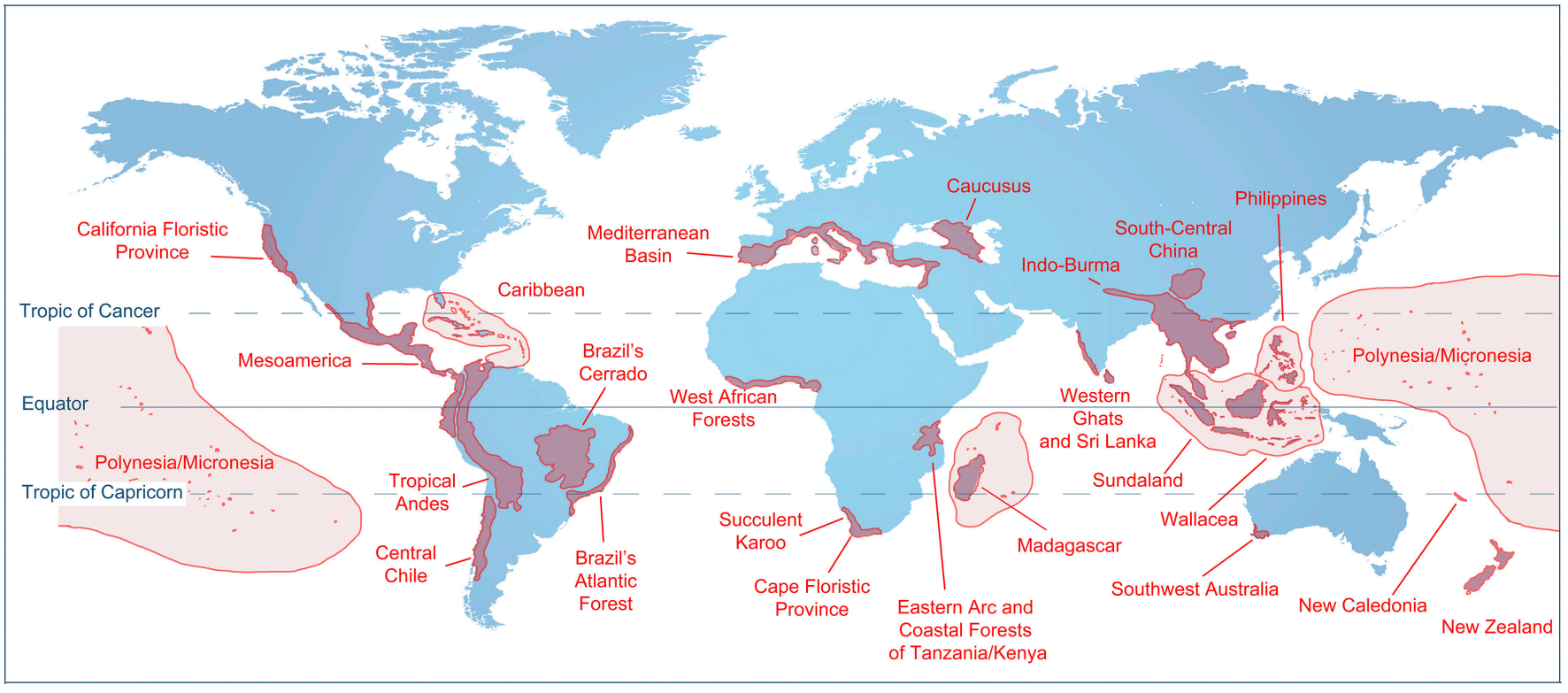
Ecoregion divisions: represents a single regional climate. Currently, 14 divisions are recognized (e.g., tundra, subarctic, subtropical, prairie, etc.). Manitoba is quite diverse, and includes Great Plains (Prairie, Humid Temperate), Northern Forests (Warm Continental, Humid Temperate), Hudson Plain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



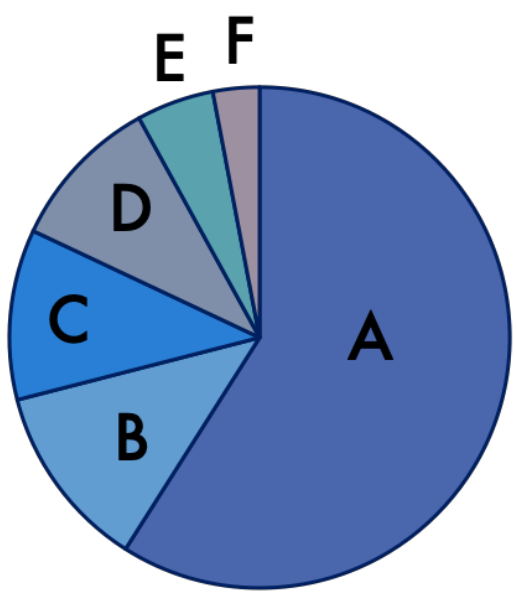
Global Biodiversity Hotspots
© Spicer 2017, *Plant Diversity*

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.

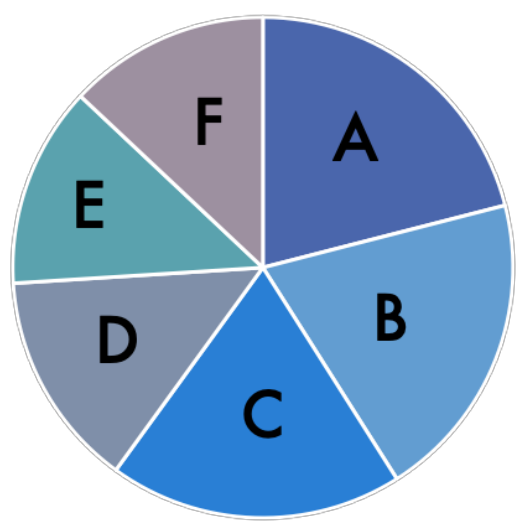
Measuring biodiversity

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)*

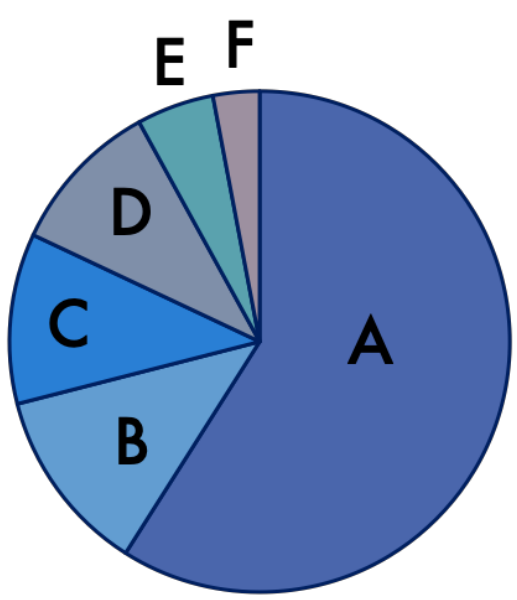


Community One
S = 6

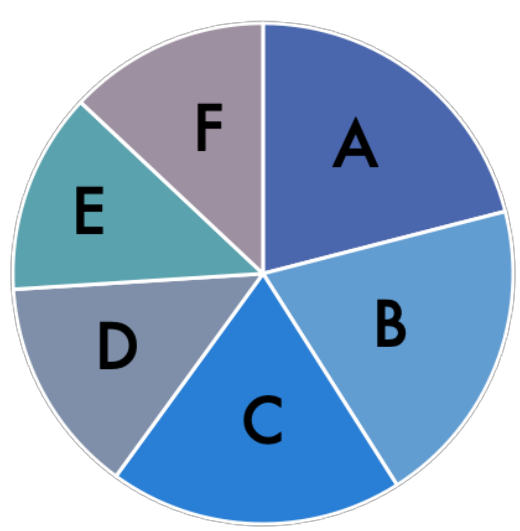


Community Two
S = 6

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

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

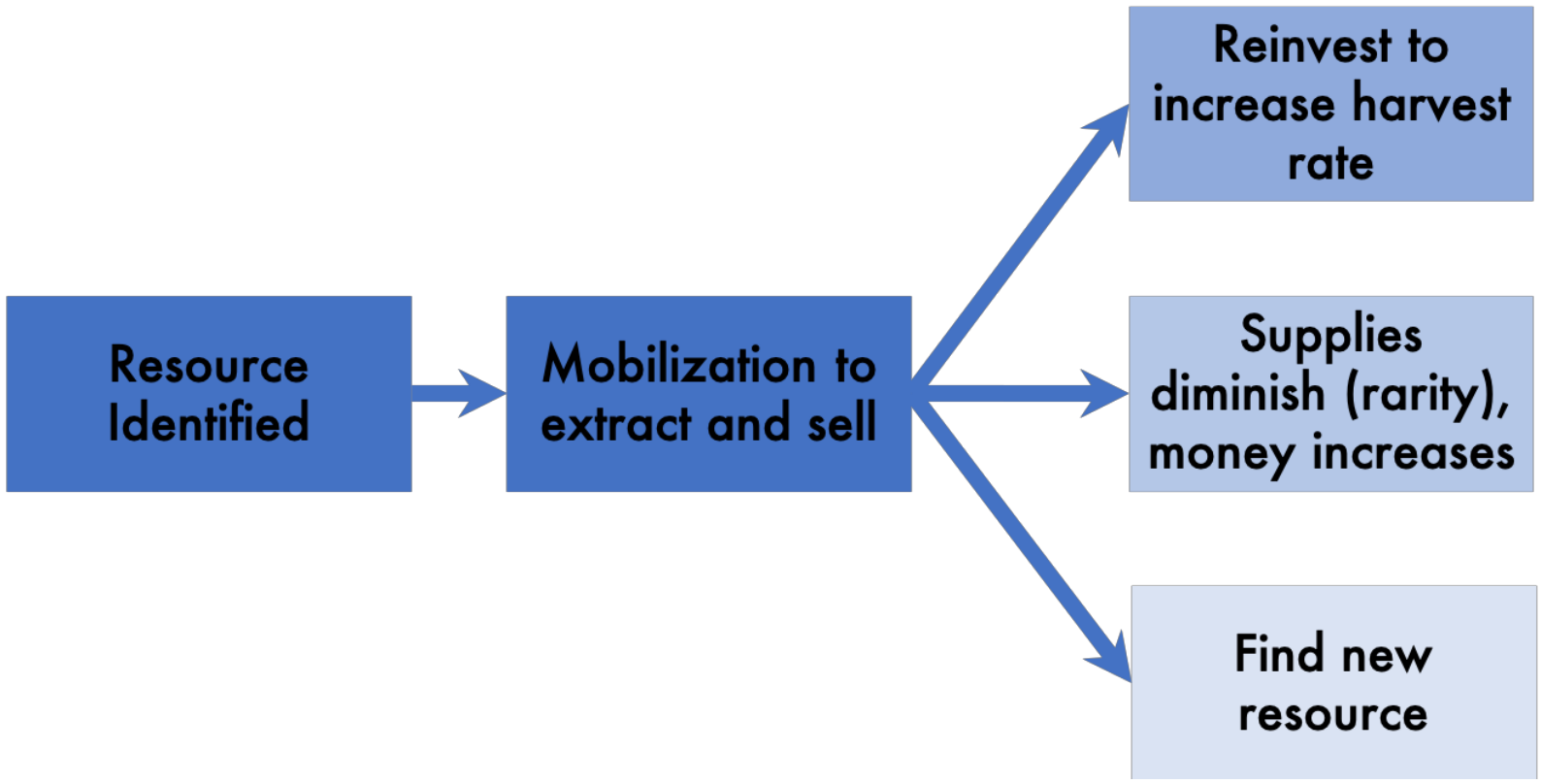
Ecosystems can be negatively impacted by air pollution, such as sulphur and nitrogen emissions as well as ground level ozone. Sulphur dioxide and nitrogen oxides emissions can deposit into water, vegetation, and soils as 'acid rains'. This will lead to an increase in acidity which can have strong negative 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.

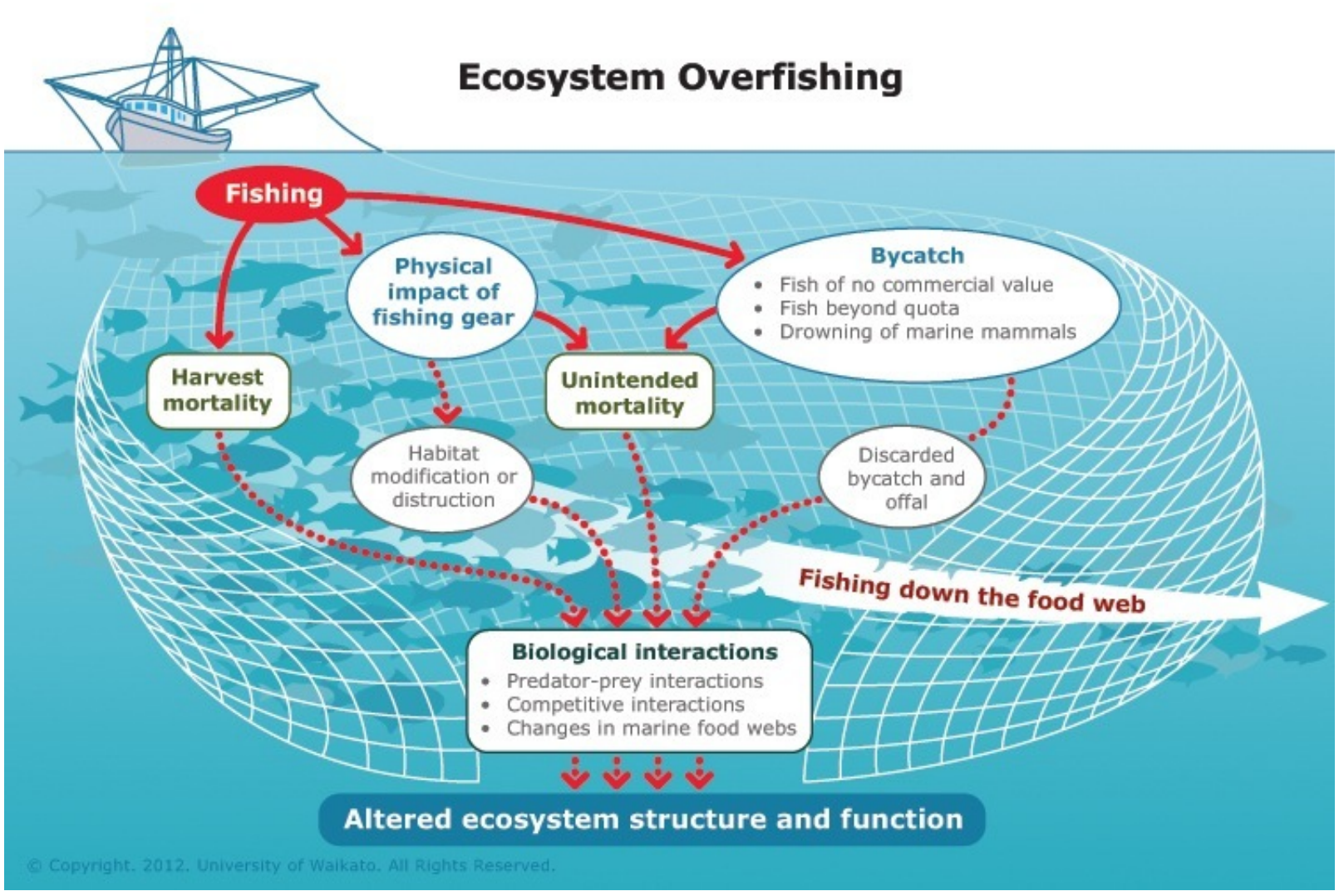
Exploitation is caused out of necessity (basic resources) and lack of restraint (finding a way to exploit resources).

Commercial Exploitative Pattern



Overfishing

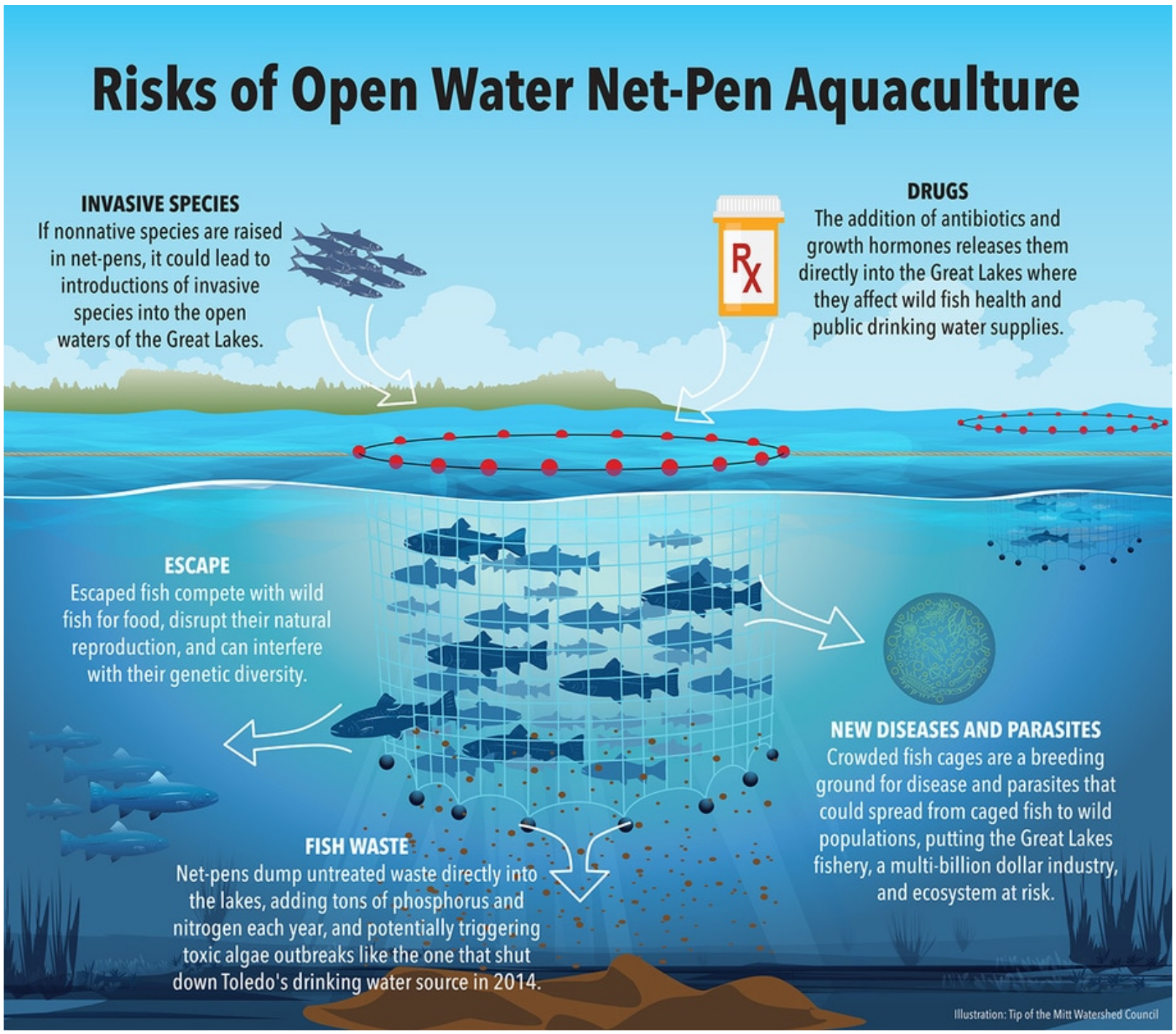
Overfishing has become a very large issue throughout the world.



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

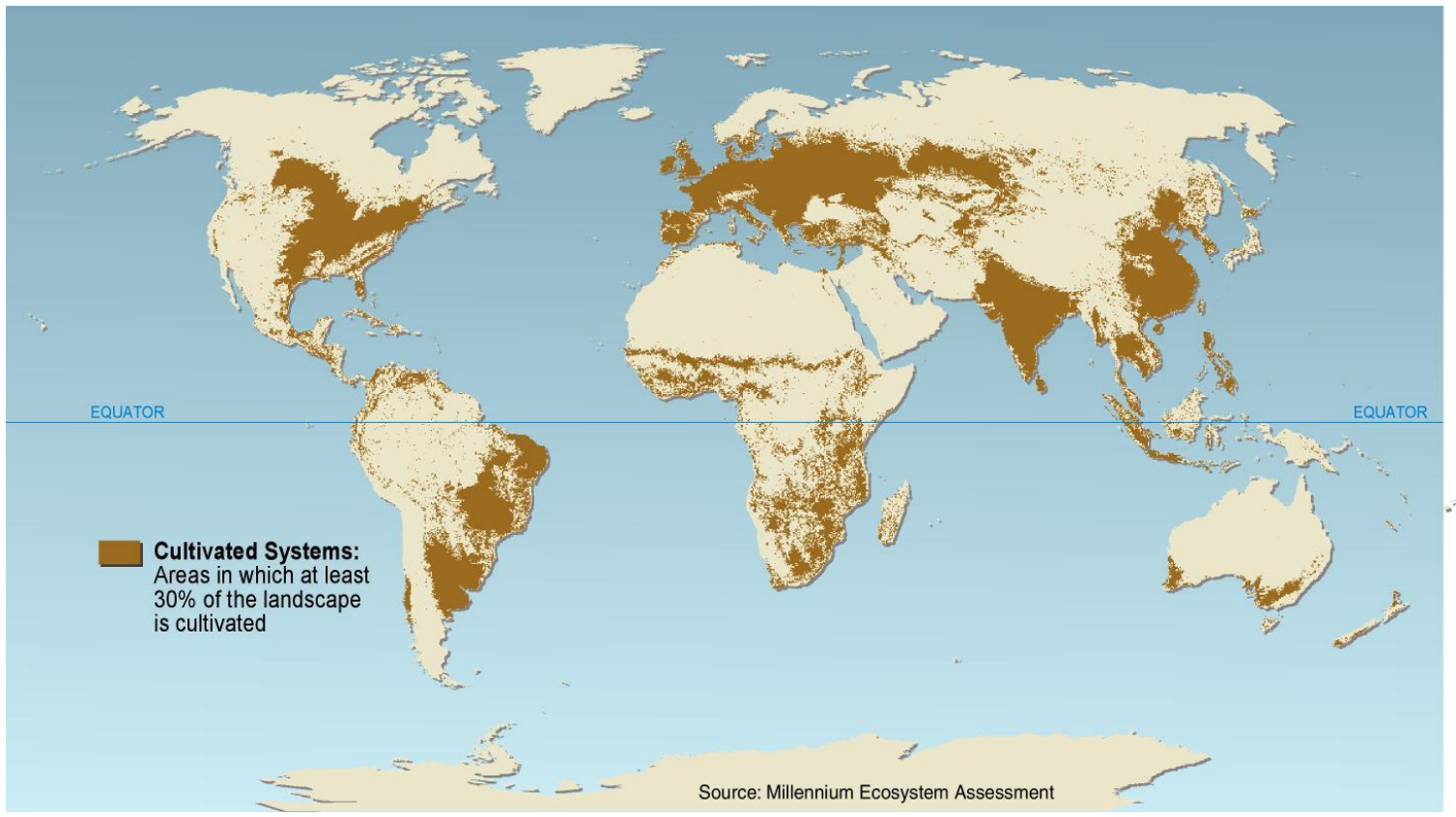
fish lower on the food chain (smaller fish such as anchovies, menhaden, sardines, and herring). The physical impact of fishing gear and bycatch can lead to unintended mortality of other species such as dolphins, sharks, turtles, and other non-target species. The discard of bycatch and offal (food remains) 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.



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

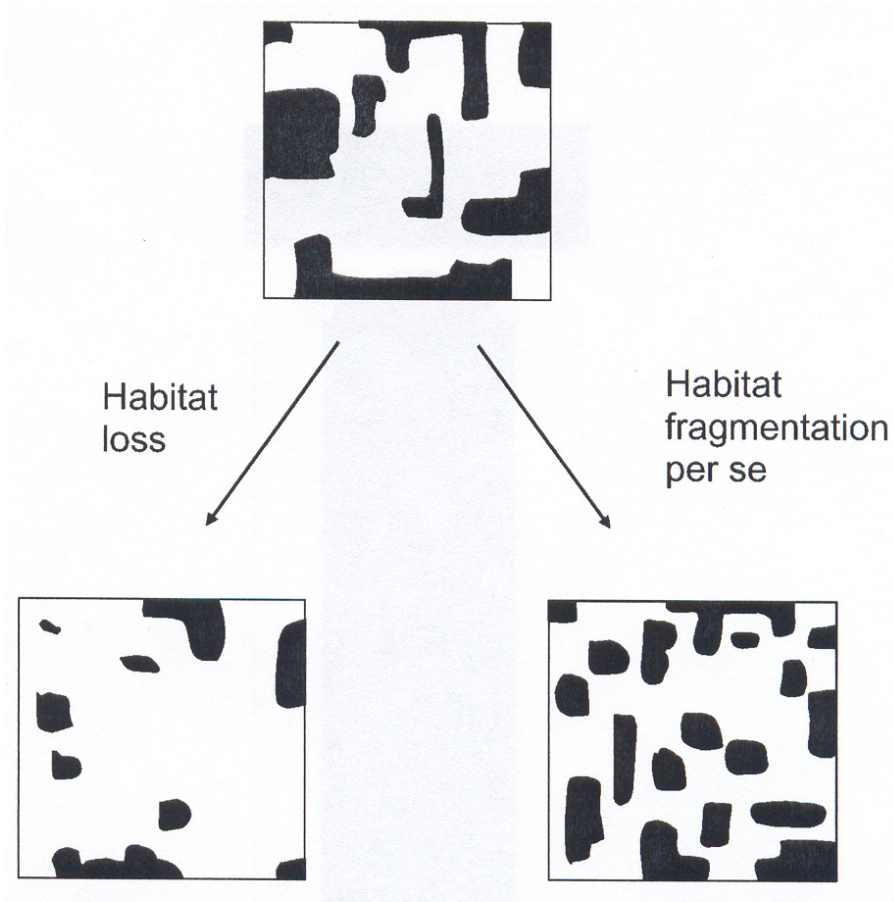
Grasslands are considered the most endangered ecosystems throughout the world, by the International Union for the Conservation of Nature. Recent research has shown that the Great Plains in North America are losing a higher proportion of grassland than the Amazon has lost tropical forests. Temperate grasslands 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.



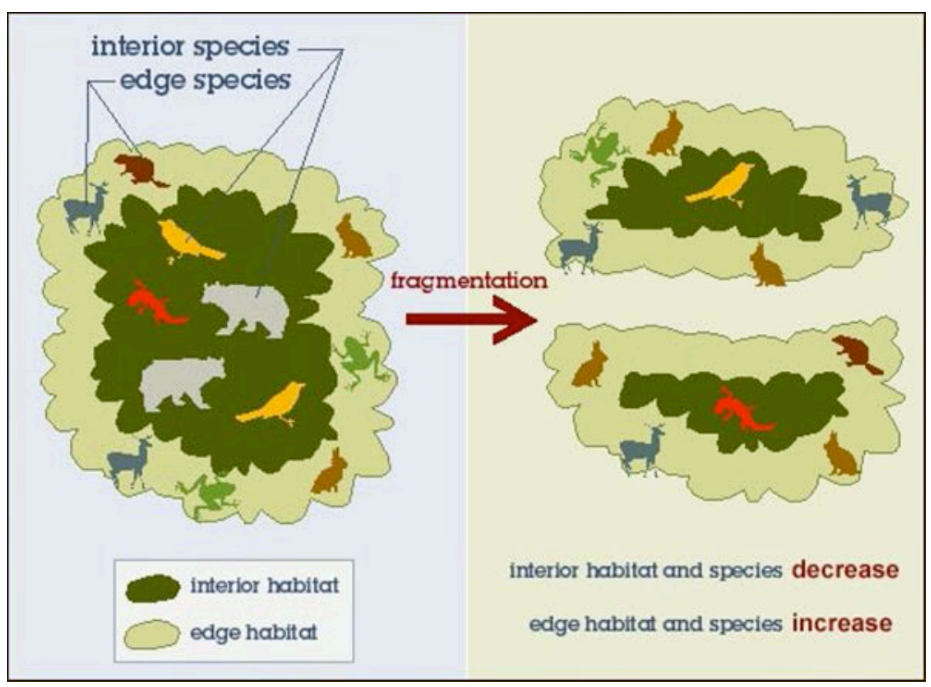
© Fahrig 2003, *Annual Review of Ecology and Systematics*

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 how severe 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.

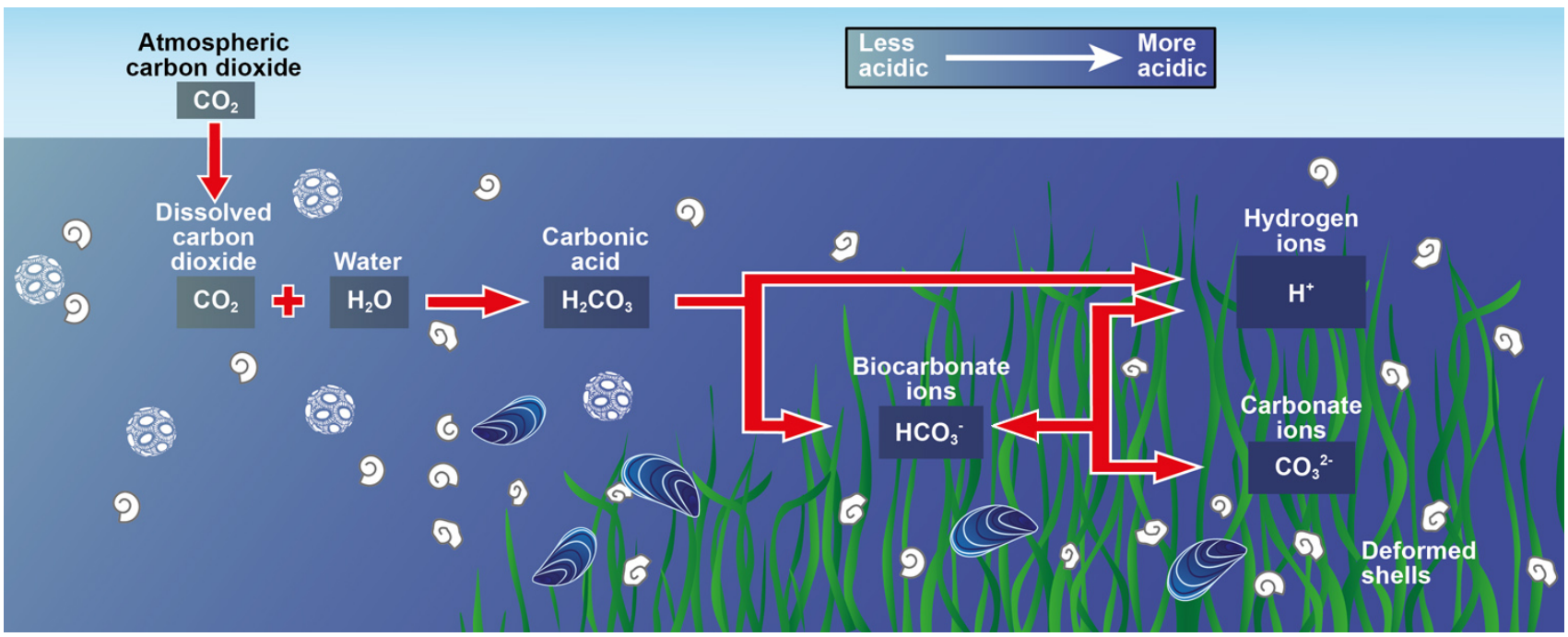
Mechanical control - Mechanical control often involves machinery or human effort to remove the invasive species. This can involve actions such as using a saw to cut down invasive trees, pulling out invasive plants, removing nests, and trapping and hunting invasive animals. It can also include the creation 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*.

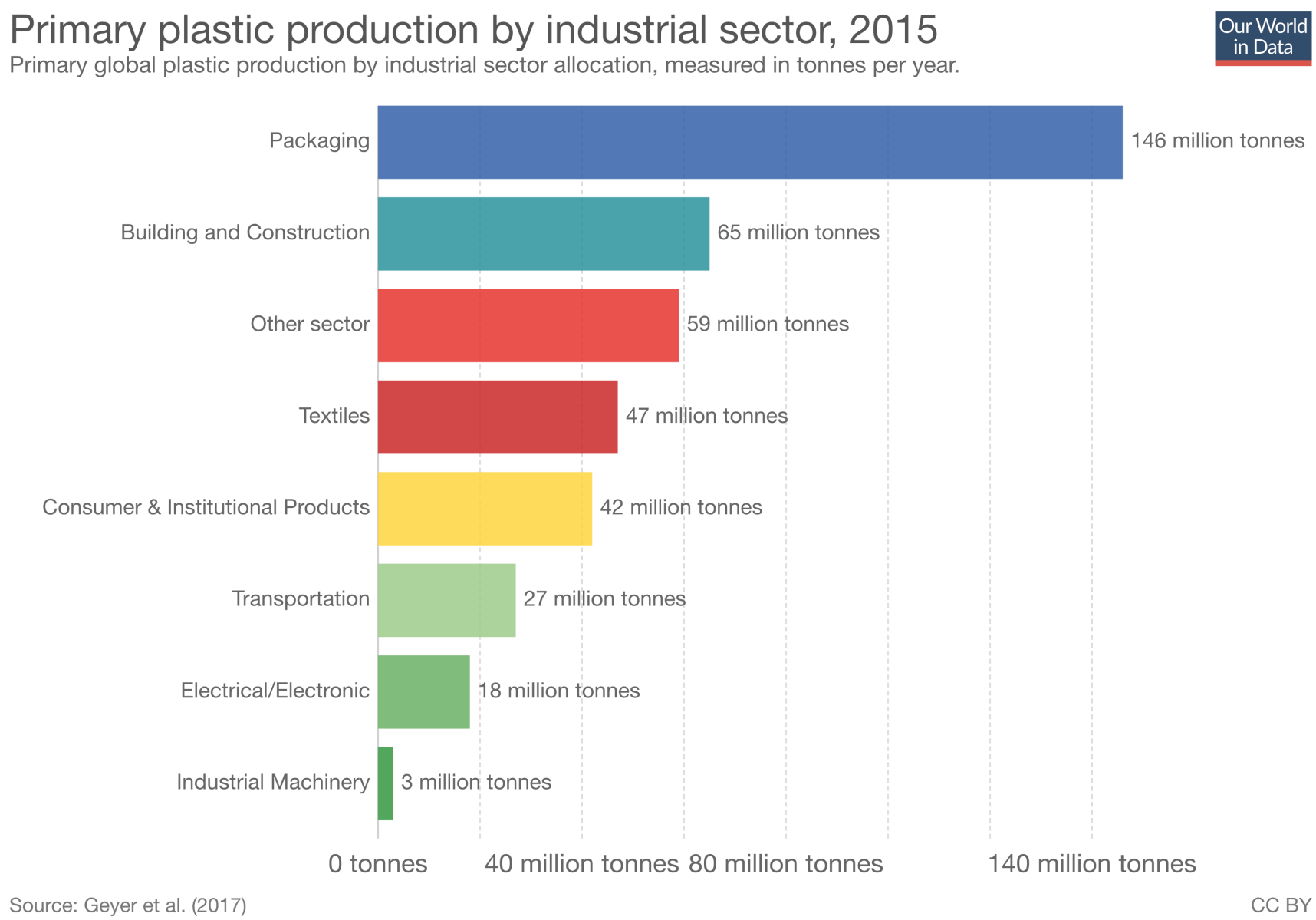


© Plymouth Marine Laboratory

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.

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.

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

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.

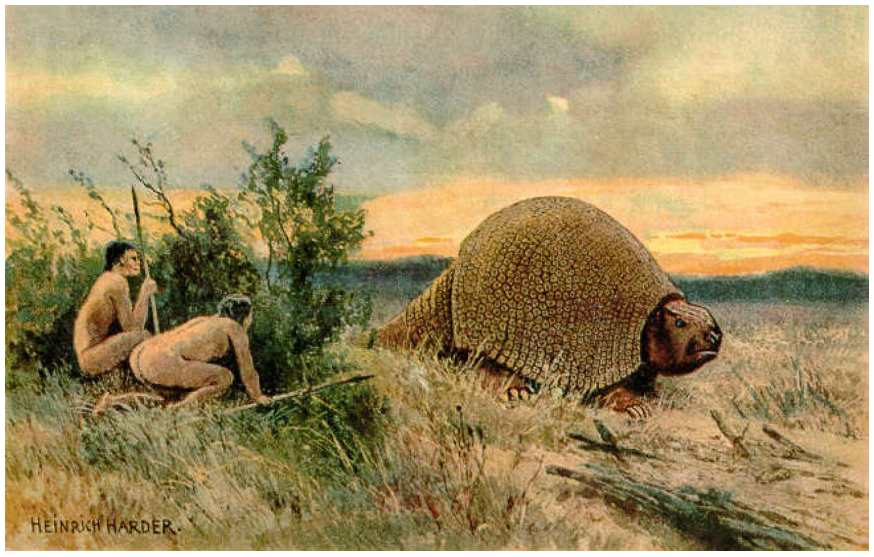
Canada has a national *Species At Risk Act,* the purpose of which is "to prevent wildlife species in Canada from disappearing, to provide for the recovery of wildlife species that are extirpated (no longer exist in the wild in Canada), endangered, or threatened as a result of human activity, and to manage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

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.

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.

HISTORY OF CONSERVATION IN NORTH AMERICA

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.

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

CONSERVATION PLANNING

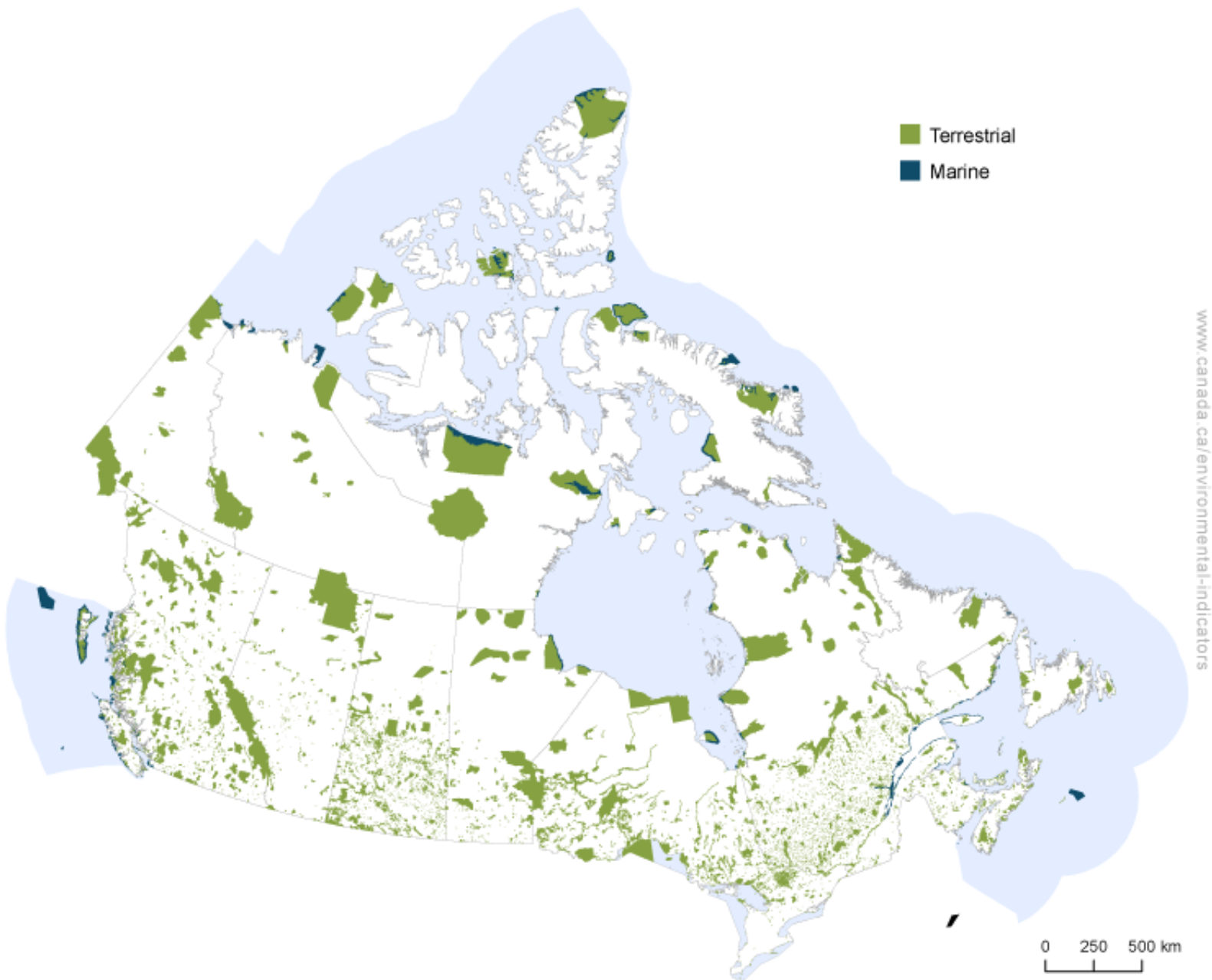
"Most conservation plans aim to protect what exists, which is actually much less than was originally there"
Elizabeth Kolbert, 2012, *New Yorker*

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.

PROTECTED AREAS

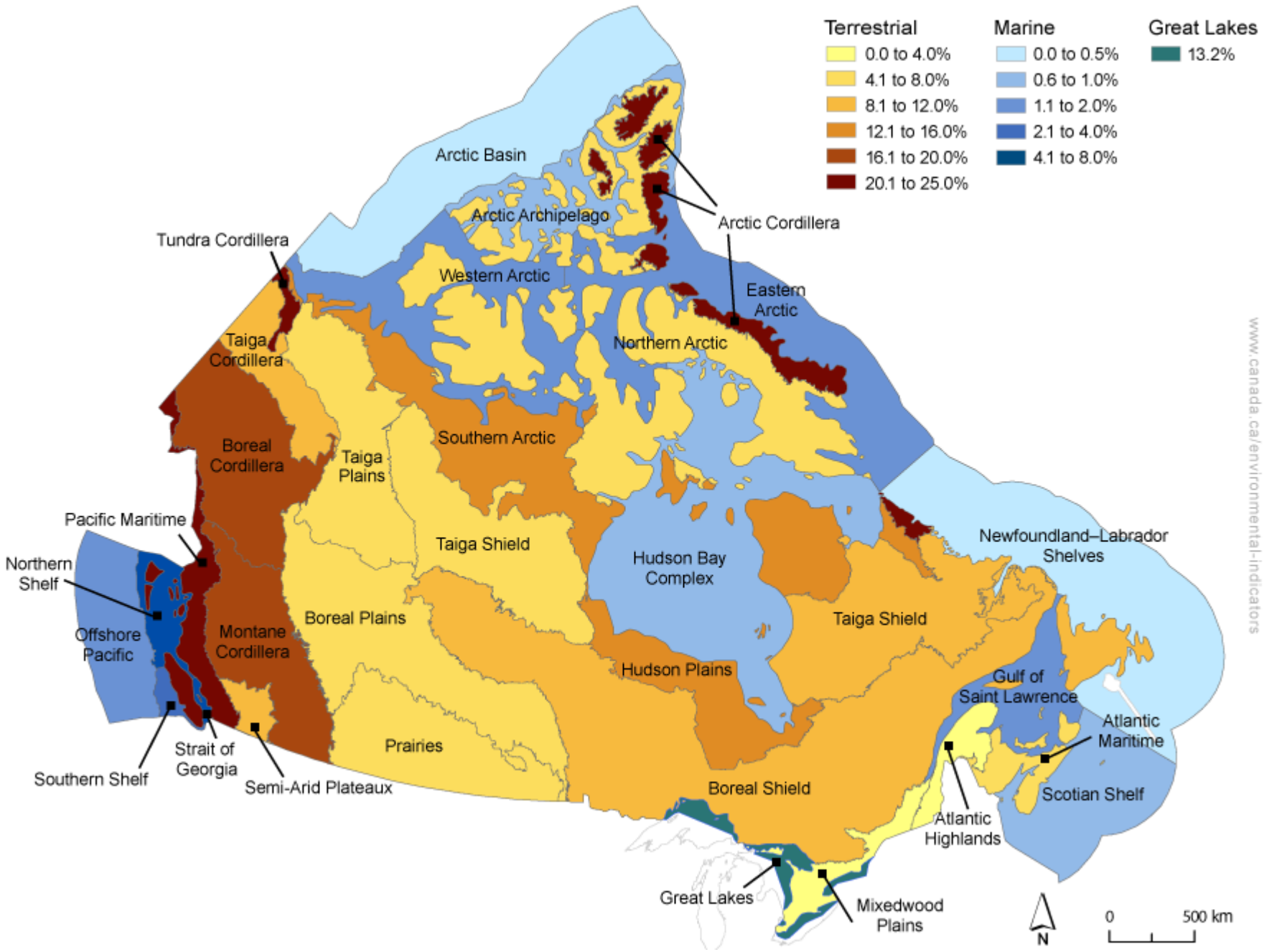
A protected area is a geographic region that is a clearly defined space which has been recognized, dedicated, and managed, through legal or other means. This area has been protected to attain long term conservation of nature and its associated ecosystem services and cultural values (IUCN 2008).

Protected areas in Canada



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



© Government of Canada

Hudson Bay complex, Newfoundland and Labrador Shelves and Scotian Shelf marine regions are protected.

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.

ENVIRONMENTAL ECONOMICS

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

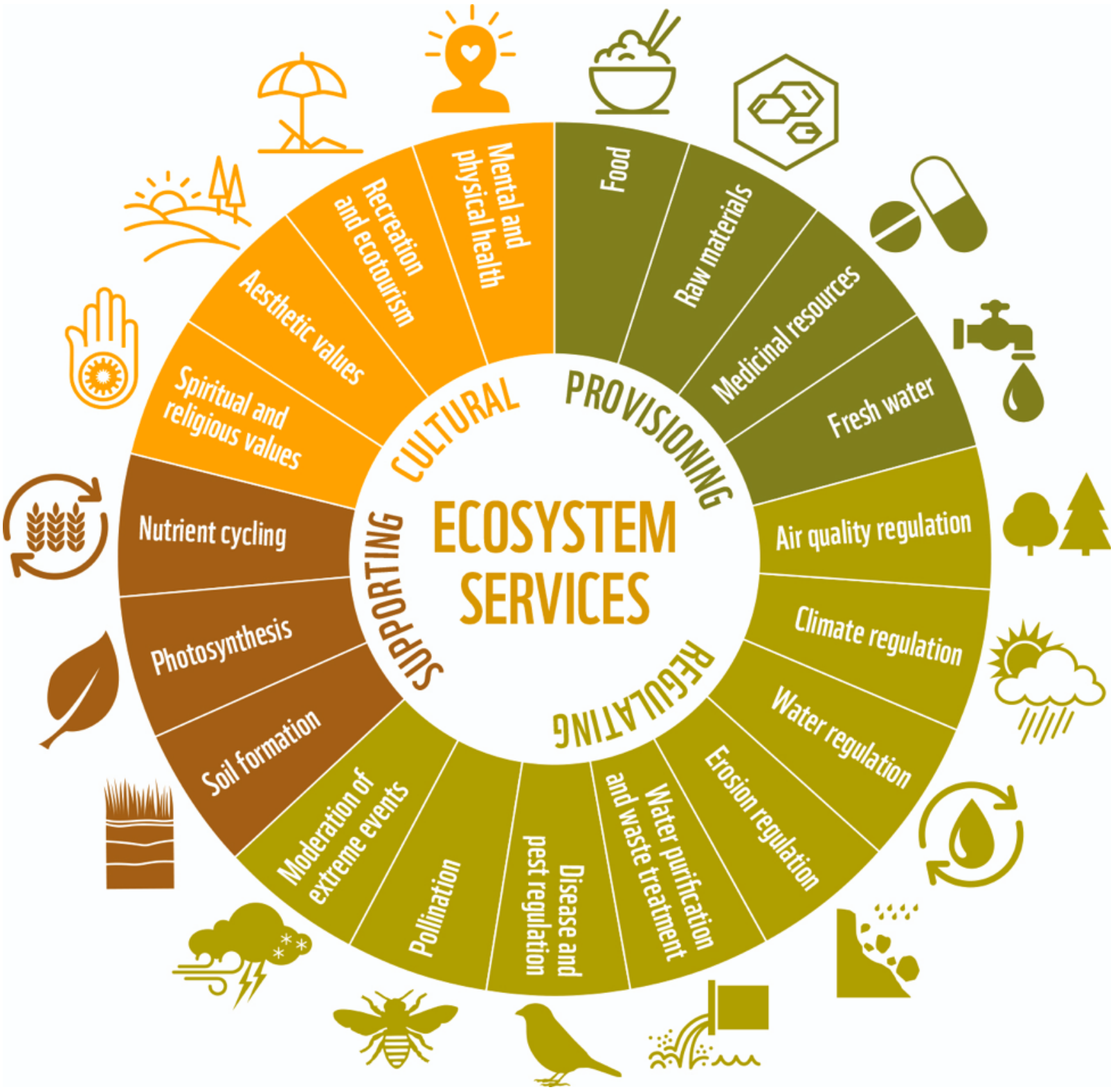
Ecosystem services

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)

LOOKING TO THE FUTURE

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.

LOCAL INITIATIVES AND CASE STUDIES

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.

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.

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.

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/)

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

BioBlitz Canada 150

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.

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.

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