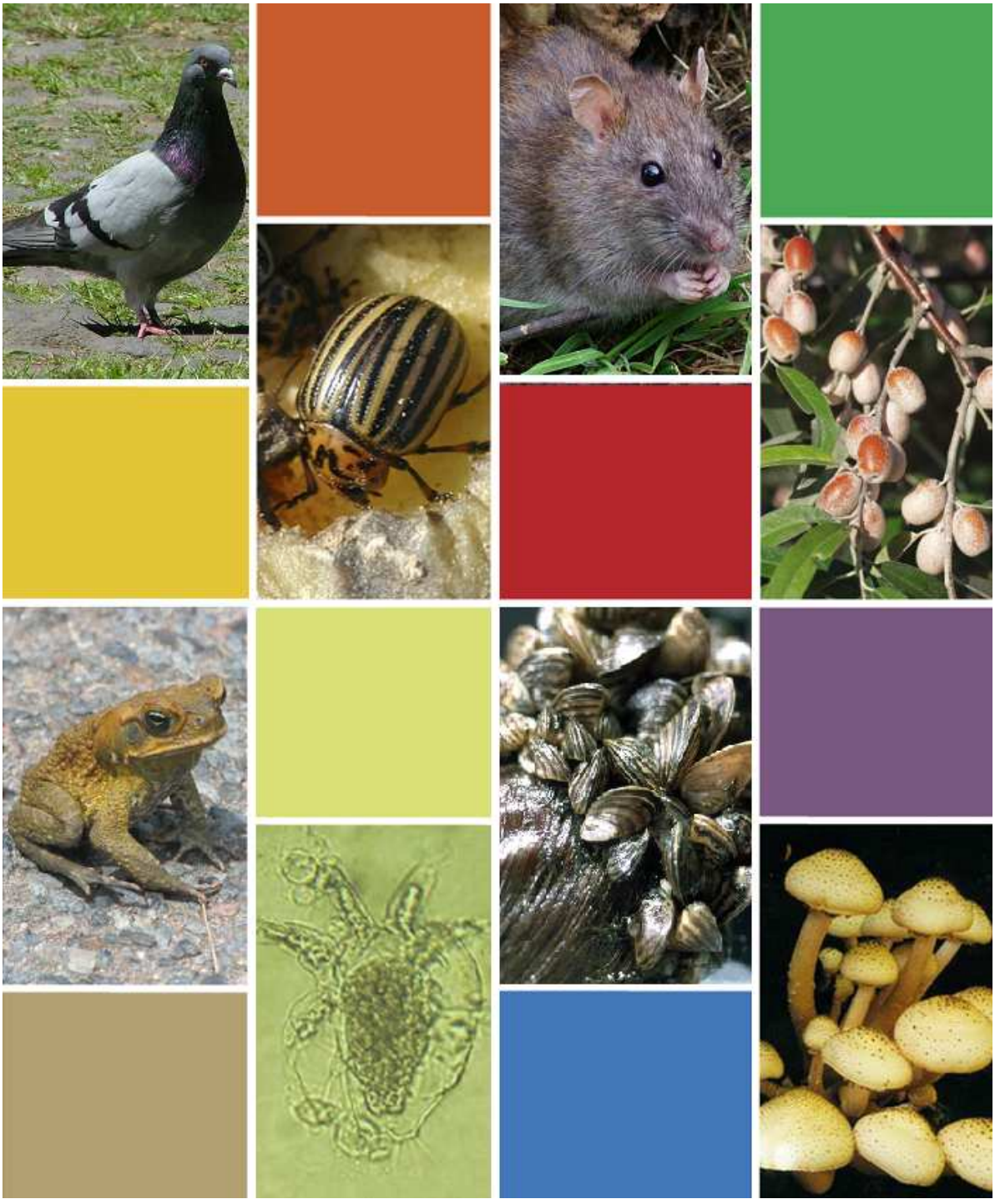
Living in an Ecosystem near You:

Invasive Alien Species



Convention on Biological Diversity

Glossary

All **bold** words in the book are found on this page. Be sure to check back when you want to know the meaning of a word in **bold**.

Biodiversity: the variety of life on Earth, at each of the genetic, species and ecosystem levels, and the relationships between them.
Cell: the basic building block of life. All organisms are made up of one or more cells.
Climate change: long-term major changes in the average weather pattern of a specific region or the Earth as a whole (e.g. more frequent storms or hotter or drier conditions, etc.).
Community: a group of organisms that share an environment.
Containment: a form of control that restricts the spread of IAS and keeps the population inside a specific geographic range
Control: a way to reduce the density and abundance of IAS to below an acceptable level. If IAS are kept below this level, then competing native species can get enough of an advantage to regain ground.
Direct driver: immediate cause of biodiversity loss
Ecosystem: all communities living and interacting with each other within a given area.
Ecosystem goods and services: benefits that people obtain from ecosystems.
Endangered species: a species threatened by extinction.
Environment: the set of conditions—land, organisms and climate—in which a group of organisms live.
Eradication: a form of control that eliminates IAS from a country or a specific region.
Evolution: the process by which inherited traits of a population change over generations.
Food chain: the sequence of who eats whom in a community.
Food web: many food chains that are related.
Fungus: organism that grows in the soil, dead matter or other fungus by decomposing organic matter and contributing nutrient recycling. The fruit of some fungi are mushrooms.
Gene: an important structure found in all cells that contains codes that make each individual unique.
Habitat loss: a process in which ecosystems are destroyed and thus unable to support the plants, animals and fungi that originally lived there.
Indirect driver: underlying cause of biodiversity loss that affects direct drivers.
Invasive alien species (IAS): biological species that spread outside their natural past or present distribution range and threaten biodiversity in these new areas.
Land use: human modification of the natural environment into a built environment..
Livelihood: way of supporting yourself, either through a paying job or by growing, producing and/or gathering everything you need to survive.
Microorganism: a creature too small to be seen with the naked eye; you need a magnifying glass or microscope to see it.
Mitigation: a form of control used if there are no other options; it focuses on minimizing the impacts of biodiversity and the economy.
Natural competitors: species that share the same environment and compete for resources such as water, food and shelter.
Niche: role and position of an organism or population within a community.
Nutrient cycling: the reusing of nitrogen, carbon and other nutrients in ecosystems.
Nutrient loading: an increase in chemical nutrients containing nitrogen and phosphorus that can lead to excessive plant growth and decay, lack of oxygen and poor water quality.
Organism: a living individual, such as a maize plant, a bird, a fish or a human.
Overexploitation: overuse or a species or ecosystem that can lead to habitat degradation or the inability of a natural area to renew itself.
Pathogen: scientific term for germ.
Pathway of invasion: any way that lets IAS enter or spread in a new territory.
Pollution: introduction of contaminants (e.g. chemicals, noise, heat or light) into ecosystem that causes harm.
Predation: an interaction in which a predator (or hunter) feeds on a prey, resulting in the death of the prey.
Prevention: a way to avoid introducing IAS into a region by regulating deliberate species introductions and minimizing accidental species introductions.
Renewable resource: resource that can be used more than once because it is replenished by natural processes at the rate it is used.
Resource: something that can be used to make something else. Farmers need natural resources, such as land, air, water and sunlight, to grow food.
Species: a group of organisms that can reproduce.
Variety: a grouping of plants having a common ancestor and the same characteristics.
Vector: any living or non-living thing that transports living organisms, either deliberately or accidentally.

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Convention on Biological Diversity

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Introduction

Biodiversity is one the world's most precious **resources**. All life on Earth provides us with the food we eat, cleans the air we breathe, filters the water we drink, supplies the raw materials we use to construct our houses and buildings, is part of countless medicines and natural remedies, and many other things. It is also important to many cultural traditions and beliefs and to people's **livelihoods**.

Unfortunately, biodiversity and the benefits it provides are under threat. Scientists have identified five main threats to biodiversity. One of the main threats is the problem of **invasive alien species**, or IAS.

This book explores the nature of IAS. It is divided into six sections:

- What is biological diversity?
- What are IAS?
- How do IAS spread?
- How do IAS affect humans and other parts of biodiversity?
- What can you do?
- What is the Convention on Biological Diversity?

There are also several *special features* throughout the book:

- Words in **bold** are defined in the glossary on pages 2 and 3.
- The main text is dotted with *Did you know?* facts. They are a great way to learn all kinds of interesting and unusual things about invasive alien species in different parts of the world.
- Each section finishes with a game or puzzle to help you remember the important points.

Living in an ecosystem near you: Invasive alien species is a special project of the Secretariat of the Convention on Biological Diversity. The book's theme – invasive alien species – matches the 2009 theme for the International Day for Biological Diversity (IDB), celebrated worldwide on 22 May every year. The messages in this book, however, are important for every day of every year!

If you like what you read, want to share some comments or ask further questions about biodiversity, please visit cbd.int. Happy reading!

Sincerely, The CBD team

What is biological diversity?

Biodiversity (or biological diversity) means the variety of all life on Earth. It includes all the many species of animals and plants and other life forms and the variety that exists within each species. Biodiversity also includes the diversity present in **ecosystems** – or explained another way – the variation we see in the environment including landscapes, the vegetation and animals present in it, and the various ways in which these components interact with each other.

Genes are made of deoxyribonucleic acid, or DNA. If the total DNA in a person was laid in a straight line, it would stretch from the Earth to the sun and back over 30 times! A trip to the sun and back is almost 150 million kilometers.

Biodiversity is very complex and is often explained as the variety and variability of **genes**, **species** and **ecosystems**.

Genes are special codes or instructions found in all **cells**. These codes give **organisms** different characteristics that determine the way they look and behave. For example, the dog is a single species, but there are many different kinds of dogs due to genetic differences (e.g. big, small, black, brown, etc.). Genetic diversity occurs within a species and even with a **variety** of a given species. For example, in a single variety of tomato, the genes of one individual may cause it to flower earlier than others, while the genes of another individual may cause it to produce redder tomatoes than other plants. Genetic diversity is at the individual level and makes everyone unique. So in fact no two living things in nature are exactly the same.

A **species** is a group of organisms that can reproduce. Although we may not think about it, we see various species as we go about our daily life, such as humans, dogs and cats. Species diversity is the most obvious type of biodiversity. Our planet, Earth, supports millions of species, many of which are not yet

About 40 species of flightless birds exist today, including the ostrich, emu, cassowary, rhea, kiwi and penguin.

identified! At present, there are over 375,000 known species of plants that produce flowers and 15,000 known species of mammals and birds. There are billions of small organisms or **microorganisms** that scientists have yet to identify.

Ecosystems are what many people call "the environment" or "nature". They are made up of many different species. In the same way that humans live in **communities**, so, too, do animals, plants, and even microorganisms. Where communities of microorganisms, plants and animals co-exist, they form an ecosystem. There are many kinds of ecosystems on Earth. Ecosystems can be small like puddles, or large like deserts, forests, wetlands, mountains, lakes and rivers.

Not only does biodiversity exist, it also has a function or purpose. Ecosystems provide things that humans benefit from and depend on. These things are called **ecosystem goods and services**. Ecosystem goods and services include all the natural **resources** and processes that maintain the conditions for life on Earth. They provide direct benefits such as food, fibre (for example, for clothing and other materials) and medicines. They also provide us with indirect benefits such as climate regulation, water level regulation and nutrient recycling. These services keep our planet functioning. Biodiversity in ecosystems also protects us with "natural insurance" against future unknown conditions brought about by climate change or other events. Another important ecosystem service is the cultural value of natural landscapes to people's religious beliefs and leisure activities. Think about when you go for a walk in the words or along a river. Would it be as nice as if there was nothing but concrete buildings all around?

Biodiversity is what enables the ecosystems to continue to provide these benefits to people. As biodiversity is lost, we lose the benefits that ecosystems provide to people. This is why sustaining biodiversity is very much intimately related to sustainable human development.

Threats to biodiversity

Scientists warn that **biodiversity** is currently disappearing at an alarming rate. When we lose biodiversity, we lose unique **genes**, **species**, **ecosystem goods and services** and benefits to humans.

Species extinctions are part of life and **evolutionary processes**; in fact, 99.9% of all species that have ever existed are now extinct. (Remember the dinosaurs?) However, the biodiversity loss our world is now experiencing is especially problematic because the *rate* of species loss is higher than it has ever been. Scientists estimate that the extinction rate is up to 100 times higher than the background rate (the historical extinction rate without human intervention estimated from the fossil record) and that within the next century the extinction rate could rise as high as 1000 times the background rate!

This biodiversity loss is affected by five main causes, or what scientists and politicians call **direct drivers** of change. **Habitat loss** takes away the homes of species and destroys **ecosystems**. **Climate change** can change habitats, migration patterns, or the timing of species reproduction, resulting in increased risks of extinction for certain species. **Invasive alien species** can out-compete native species and drive them to extinction. **Overexploitation** is when species and ecosystems are overused so that they cannot maintain healthy populations large enough to survive over many years. **Pollution** and **nutrient loading** (an increase in chemical nutrients containing nitrogen and phosphorus that can lead to excessive plant growth and decay in the ground, and, in water ecosystems, algal blooms followed by a lack of oxygen) both destroy habitats or make them unsuitable for species, forcing species to migrate or go extinct.

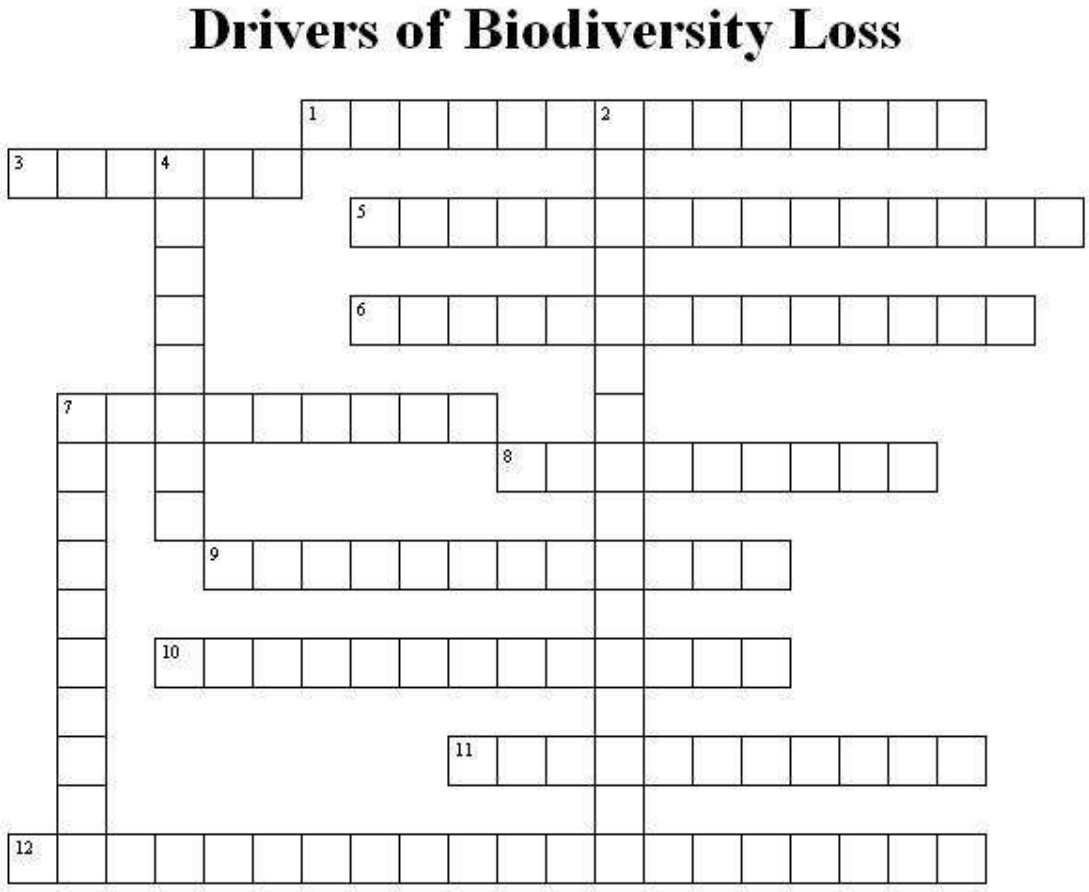
These five direct drivers of change are influenced by **indirect drivers** of change, or human causes that affect the direct drivers. Examples include population growth and the expansion of cities, economic trade and the movement of goods around the planet, and cultural beliefs that encourage people to want and buy more and more consumer goods.

It’s especially important for young people to learn about the drivers of biodiversity loss. Although each level of society is responsible for the environmental integrity of its community, young people have a special

interest in maintaining a healthy environment. Youth have more to lose if things go wrong because they are the ones who will have to deal with the consequences in the future.

Crossword Puzzle
Drivers of Biodiversity Loss

Use the clues below to complete the crossword puzzle. The preceding chapter and glossary will help you figure out each clue.



Across
1. historical rate of species extinctions (2 words)
3. a cause of biodiversity loss
5. changes the chemical balance in ecosystems (2 words)
6. term to describe the underlying causes of biodiversity loss (2 words)
7. natural process of species changing over time
8. causes biodiversity loss by making ecosystems inhospitable
9. term to describe the immediate causes of biodiversity loss (2 words)
10. global warming (2 words)
11. occurs when ecosystems are destroyed (2 words)
12. driver of biodiversity loss that lives outside its original distribution range (3 words)

Down
2. overuse
4. people responsible for reducing biodiversity loss
7. end-result of biodiversity loss

What are invasive alien species?

When biologists talk about **invasive alien species** (or IAS for short), they're not referring to Martians left behind by Unidentified Flying Objects (UFOs). Instead, the invasive alien species they study are actually biological species (such as plants, animals, **fungi** and bacteria) that spread outside their natural past or present distribution range and threaten **biodiversity** in these new areas.

Mallard ducks are genetic invaders. Mallards can cross-breed with 45 other waterfowl species, thus threatening their genetic integrity. Mallards and their hybrids compete with native birds for resources such as food, nesting sites and roosting sites.

The words that make up the term "invasive alien species" hint at some of the characteristics of IAS. First, they are living creatures or **organisms** (**species**). Second, they live outside of their native range and in places where they did not originate (alien). Third, they are very successful at spreading throughout their new habitat (invasive).

A species can be alien, without being invasive. In fact, some alien species are actually desirable in their new home. For example, some of the staple foods grown in Africa, including beans, cassava, groundnuts, maize, tomatoes and sweet potatoes, originated in the Americas and are alien to Africa!

Not all alien species become invasive alien species. To be a successful invader, a species must arrive, survive and thrive. It must out-compete native species for food and habitat, spread throughout its new

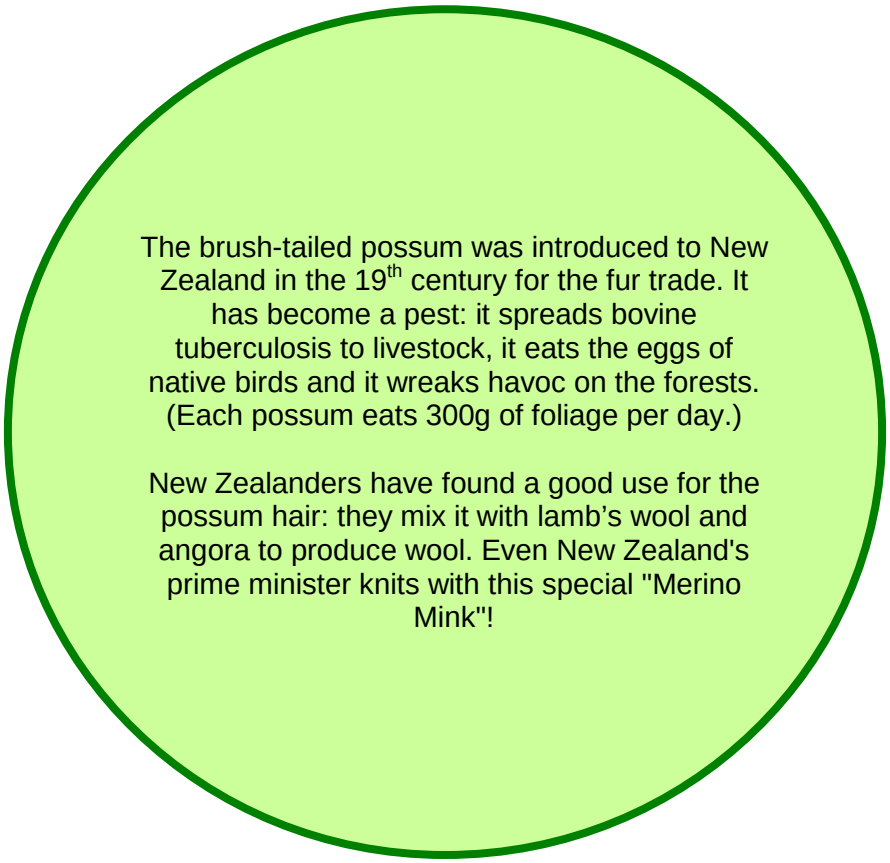
The mile-a-minute weed is a prolific grower: it spreads at 27mm per day. In a few months it can spread over 25m^2. That's enough space to park one car or six to twelve bikes. The mile-a-minute weed was introduced as a cover crop and ornamental plant in West Africa, Southeast Asia, Pacific Islands and the United States.

environment, increase its population size and disturb the **ecosystem** in its introduced range. These activities reduce the food and area available for local, native species making it harder for them to survive.

Species that become invasive usually share several characteristics. They grow and reproduce quickly. They are good at dispersing, or moving from one place to another. They can adapt physiologically to new conditions; in other words their bodies work whether it's hot or cold, dry or wet, windy or calm, or other conditions. They can eat a variety of food types.

IAS are not "bad species" per se, but they can have very harmful effects on biodiversity in their new environments.

You might be wondering what the big deal is about IAS. Species have been migrating and colonizing new territories for millennia. Species migration allows a species to survive when environmental conditions change. After a species colonizes a new territory, it will evolve over time. The descendents may eventually become so different from the original colonizer that they are considered a new species. So why are IAS such an issue now?



IAS are more of a problem now, than say 500 years ago, because humans and their technologies are making it easier for alien species to reach new territories and establish themselves very quickly. The major contributors to the problem are trade, transport, travel and tourism among nations and continents. Human inventions such as cargo, ships, ballast, airplanes, and other modes of transportation enable species to cross previously insurmountable geographic barriers. Each of these activities helps to

spread IAS. Currently, IAS are one of the main causes of biodiversity loss around the world. Not only do IAS wreak environmental havoc, but they also ruin cultural traditions and cost our economies hundreds of billions of dollars every year.

By the mid 20th century, native fish stocks in Lake Victoria, Africa, had plummeted due to overfishing. In 1954, the Nile perch (*Lates niloticus*) was introduced to restock the lake. Unfortunately, it had the opposite effect. The Nile perch contributed to the extinction of more than 200 endemic species by eating and out-competing them. It also caused other undesirable effects. Local men and women lost their traditional fishing and processing jobs, and many trees were felled to properly process the Nile perch's oily flesh; without the trees, there was lots of erosion and run-off, which made the lake susceptible to invasions by algae and water hyacinth. These invaders then depleted oxygen levels in the lake, causing more fish to die.

Matching Game

Where are the invaders?

Draw a line connecting an **alien invasive species** to both its native and invaded ranges. Hint: you'll have to do some research on some of these species, either in books or on the internet. The Global Invasive Species Database is a great place to start www.issg.org/database/welcome/).

Native Range	**Invasive Alien Species**	**Invaded Range**
a) Amazon basin of South America	Brown tree snake (*Boiga irregularis*)	1) 50+ countries on 5 continents
b) Asia (Russia, China, Japan, Korea)	Brushtail possum (*Trichosurus vulpecula*)	2) Canada, USA, Tasmania, Brazil, Panama, Madagascar, Myanmar, Pakistan, Australia, South Africa
c) Atlantic coast of Europe and North Africa	Comb jelly (*Mnemiopsis leidyi*)	3) England
d) Australia	Emerald ash borer	4) Europe, North America
e) Australia, Papua New Guinea, Melanesia	European green crab (*Carcinus maenas*)	5) European seas (Black Sea, Caspian Sea)
f) Caspian Sea, Black Sea	Golden apple snail (*Pomacea canaliculata*)	6) Guam, Hawaii,
g) Central and South America	Mallard duck (*Anas platyrhynchos*)	7) New Zealand
h) Nile River	Mile-a-minute weed (*Mikania micrantha*)	8) New Zealand, South Africa, Mexico, Zambia
i) North America	Nile perch (*Lates niloticus*)	9) North America (Canada, United States)
j) North America, Eurasia	North American gray squirrel (*Sciurus carolinensis)*	10) North America (Great Lakes), Western Europe
k) South America	Potato blight (*Phytophthora infestans*)	11) Southeast Asia
l) South America (Andes)	Water hyacinth (*Eichhornia crassipes*)	12) Southeast Asia, Pacific Islands, West Africa
m) Western Atlantic coast from USA to Argentina	Zebra mussel (*Dreissena polymorpha*)	13) Southern Africa (Lake Victoria)

How do invasive alien species spread?

Invasive alien species may be the world's greatest hitchhikers. They find ways to sneak across geographic borders and into new territories. Often, they receive lots of help from humans. Sometimes this help is deliberate, other times it is accidental.

The **pathway** and the **vector** that transports invasive alien species are important factors in enabling IAS to arrive and establish themselves in new territories. A **pathway** is any way that lets IAS enter or spread in a new territory. A **vector** is any living or non-living thing that transports living **organisms**, either deliberately or accidentally.

Let's look at a fictional case study to identify one pathway and vector in the spread of zebra mussels (*Dreissena polymorpha*), an invasive alien species in the Great Lakes of North America. Jacques and Marie go fishing in Lake Erie and a few zebra mussels attach onto the hull of their boat. At the end of the day, Marie and Jacques put their boat on a trailer. The next day, they drive to Lake Huron and launch their boat. The zebra mussels dislodge from the boat and fall into the lake. Now there are zebra mussels in Lake Huron. In this example, the pathway is transportation of the boat and the vectors are the boat with the zebra mussels and the people who drive the zebra mussels from Lake Erie to Lake Huron.

In the 1800s, ships used to carry dirt (solid ballast) instead of water to provide stability. Upon arrival, the dirt was dumped in "ballast heaps". Most of the worms, microbes, plant seeds and fungi in the solid ballast did not survive. Occasionally, some species would survive and thrive … becoming IAS!

There are many other pathways and vectors for invasive alien species. Here are some examples.

IAS can travel across oceans in the ballast water of ships (water that is carried in ships when they're not full of cargo; ballast helps provide stability and prevent the boat from capsizing). Ballast water can carry

aquatic organisms, microbes and diseases. At the end of a voyage, there can be hundreds of different species living in the ballast water!

When pet owners release their pets, they may be unknowingly contributing to the invasive alien species problem. Exotic reptiles, amphibians and aquarium fish and plants released into ponds or flushed down toilets easily find their way into the local water system. If they can establish themselves, they may out-compete native species for food and habitat.

If you find yourself in the Florida Everglades, watch out for Burmese pythons. Imported from their native rain forests in Southeast Asia, these snakes were sold as pets, and later dumped in the Florida Everglades. The Burmese python preys on endangered birds, and occasionally dines on alligators!

Species also hitchhike in or on timber, packaging, machinery and vehicles. Forests pests and diseases can travel from one region to another on unprocessed wood and wood products. Machinery and vehicles are rarely washed when they're moved from one place to another, so any organisms clinging on get a free ride to a new destination. Air transport provides species with lots of hiding places: the cabin – on passengers' clothing or in their luggage, the cargo bay, the wheel wells and other aircraft parts.

Shortly after World War II, the infamous brown tree snake arrived in Guam as a stowaway in a cargo ship. Since then, the snake has devastated the native bird population, caused thousands of power outages, and killed domestic birds and pets.

Your garden could be a source of invasive alien species. Many plant invaders were originally brought in by enthusiastic gardeners who sought intriguing plants for their gardens and parks. Some of these exotic plants adapted a bit too well to their new environment, spread and became invasive. In New Zealand, for example, more than seven out of ten invasive plants were first introduced as ornamental plants.

A large proportion of important crops and trees for agriculture and timber are grown outside their natural distribution. While they may contribute to local economies and food production, these alien species may become invasive if they start encroaching on nearby areas with native biodiversity.

Biological control is a pest control strategy that uses living natural enemies or competitors. Scientists often select alien species to control pests. In some cases, the species introduced to control an invasive species becomes an invasive species itself! For example, the leafy spurge is an invasive plant found throughout the world (but not in Australia). It shades out native vegetation, uses up the available water and nutrients, and leaches toxins into the soil that kill neighbouring plants. In some places, flea beetles were introduced to control leafy spurge. While they are effective at controlling leafy spurge populations, these flea beetles also attack beneficial agricultural crops such as mustard and canola. Like several other cases, these introduced biological control agents became invasive.

Tourism is an important pathway of invasion. In 2007, there were over 903 million international tourist arrivals. That's a lot of potential vectors for IAS! Tourists carry seeds and soil microbes in the dirt on their shoes. They bring back plants, plant parts or live animals as souvenirs. They travel with fruits and vegetables that may be contaminated with insects or microbes. All these species have the potential to become IAS. Tourists visiting islands and remote areas need to be especially careful not to transport alien species because these areas are the most vulnerable to IAS.

Word Search
Pathways of invasion

Hidden in this word search are examples of how **IAS** travel around the world. The leftover letters spell out a secret message. (Hint: it has three words.)

Y	R	E	N	I	H	C	A	M	P	R	O	T	E	C	T	N
B	I	O	L	O	G	I	C	A	L	C	O	N	T	R	O	L
A	T	I	A	V	E	B	N	I	O	D	I	V	E	R	P	H
S	I	T	Q	Y	Q	G	O	A	V	J	F	E	P	N	A	I
T	O	L	U	A	B	K	I	A	I	R	M	G	I	M	C	T
O	R	N	A	M	E	N	T	A	L	P	L	A	N	T	K	C
L	T	Q	C	T	A	L	A	T	N	E	D	I	C	C	A	H
U	Z	S	U	S	P	I	T	P	E	T	S	J	Z	Q	G	H
G	D	E	L	I	B	E	R	A	T	E	S	Y	T	V	I	I
G	D	O	T	R	O	Z	O	P	R	L	A	A	J	C	N	K
A	Y	H	U	U	R	C	P	M	L	W	U	X	L	C	G	E
G	U	S	R	O	D	E	S	E	H	A	M	O	L	L	V	R
E	J	R	E	T	E	B	N	T	K	T	N	H	U	M	A	N
N	B	O	A	T	R	Y	A	S	O	U	V	E	N	I	R	B
V	J	B	E	S	B	P	R	E	B	M	I	T	I	V	V	Y
A	G	R	I	C	U	L	T	U	R	E	V	E	C	T	O	R

accidental
agriculture
airplane
aquaculture
ballast
biological control
boat
border

deliberate
hitchhiker
human
luggage
machinery
ornamental plant
packaging
pathway

pets
shoes
souvenir
timber
tourist
transportation
vector

_ _ _ _ _ _ _   _ _ _ _ _ _ _ _   _ _ _ _ _ _ _ _ _ _ _ _

How do IAS affect humans and biodiversity?

There's a lot of concern about **IAS** because of their negative impacts on humans and **biodiversity**. IAS can have environmental, social and economic consequences.

A **food chain** is a sequence of who eats whom. The usual order of a food chain is sunlight, plants, herbivore, omnivore and/or carnivore. Food chains that are related in an **ecosystem** form a **food web**.

Biodiversity is threatened by IAS because IAS can out-compete native **species** and interrupt **food webs**, and cause species to go extinct. IAS can be especially devastating to birds; they contributed to the extinction of at least 65 species in recent history. **Predation** (an interaction in which a predator or hunter feeds on a prey, resulting in the death of the prey) by invasive rats and cats, and diseases caused by introduced germs (called **pathogens** by scientists) are the main causes of these extinctions. Predation by dogs, pigs and mongooses and habitat destruction by sheep, rabbits and goats are also factors.

IAS also affect biodiversity through their impact on **ecosystems**. They can change **land-use** and natural disturbance patterns (e.g. fires, insect outbreaks, diseases). Land-use is when humans change the natural environment into fields, settlements and other built environments. They can have an on impact **ecosystem services** such as nutrient cycling.

Plant and animal species on islands are isolated from all other species and so have developed in a very "safe" environment. They don't have the ability to defend themselves against invasive, partly because they lack the **natural competitors** and predators that usually control populations of invasive alien species in their native ecosystems. (Natural competitors are species that share the same environment and compete for resources such as water, food and shelter.) These factors make biodiversity on islands particularly vulnerable to IAS.

IAS also impact human health, food security and **livelihoods**. Many diseases affecting humans, plants and animals are carried by IAS. These diseases can ruin local food and livestock production, thereby causing hunger and famine. There are several historical examples. The bubonic plague spread from central Asia through North Africa, Europe and China using a flea vector on an invasive species of rat. The Irish potato famine in the 1840s was caused by a **fungus** introduced from North America, with devastating impacts on the health of local people. European explorers and colonizers brought viruses carrying smallpox and measles into the Western Hemisphere. The low resistance of indigenous peoples to these parasites played a part in bringing down the mighty Inca and Aztec empires. Rinderpest, a viral disease, was introduced into Africa in the 1890s via infected cattle and soon spread to both domestic and wild herds of bovids (animals related to cows such as water buffalo, antelopes, gazelles, goats) throughout the African savannah, which changed the mammalian composition in the continent. Almost one quarter of African pastoralists (pastoralists are people who raise and herd livestock for a living) died from starvation in the early 20th century because rinderpest killed their cattle.

Invasive alien species cost our economies a lot of money. Each year, IAS cause over US$100 billion in environmental damage to plants (mainly in agriculture and forestry) in the United States, United Kingdom, Australia, South Africa, India and Brazil!

Some invasive alien species have environment, social and economic consequences. The water hyacinth (*Eichhornia crassipes*) blocks waterways, destroying aquatic wildlife and livelihoods of local people. With their tendency to latch onto boats and fishing gear and clog pipes and waterways, zebra mussels (*Dreissena polymorpha*) affect fisheries, mollusk diversity and electrical power generation.

How will climate change affect IAS?

Climate change and **IAS** are two of the greatest threats to **biodiversity**. Scientists predict that climate change will promote IAS and amplify their impact on **ecosystems**. Some of the characteristics of IAS give them an advantage under climate change: they can tolerate a variety of climates, they can rapidly shift distribution ranges, and they rarely need other species to reproduce successfully (i.e. they don't need organisms to pollinate their flowers or disperse their seeds).

Climate change can create conditions that make it easier for IAS to arrive, survive and thrive. Native species can become stressed under new climatic conditions and therefore less able to resist and out-compete invaders. Climate change is expected to bring more frequent and more extreme climatic events such as droughts, storms, fires or freezing that disturb ecosystems, and make them vulnerable to invasion. Under these new conditions some non-invasive alien species may become invasive.

Climate change will affect different types of **organisms** in different ways. For example, higher carbon dioxide (CO_2) levels in the atmosphere can stimulate photosynthesis in plants, and especially in IAS. Photosynthesis is a process in which green plants use sunlight (light energy) to convert CO_2 into sugar (chemical energy). Climate change may dramatically reorganize plant **communities** around the world.

Oceans will also be affected by IAS. Warmer and less salty oceans could stress marine species, cause mass mortalities, and open up **niches** (roles and positions of an organism or population within a community) for IAS to colonize. The end result could be greater homogenization of global marine biodiversity. In other words, the differences in the ecosystems and species found in different parts of the oceans will disappear. If this scenario plays out, then the species you see snorkeling or SCUBA diving in Australia's Great Barrier Reef may be no different from those you see in the Caribbean or even the North Atlantic Ocean!

Insects are strongly influenced by temperature; many species are limited by summer heat and/or extreme temperatures for growth, reproduction and survival. So climate change could enlarge or shrink the area or range where certain insect species live. Species that eat a variety of food, have a broad distribution range and can adapt physiologically to new conditions are most likely to become IAS. Physiological adaptations enable an

organism to do both special functions (e.g. making venom or slime) and general functions (e.g. regulating body temperature and growing). Some of these insect species can spread diseases including West Nile virus and dengue fever.

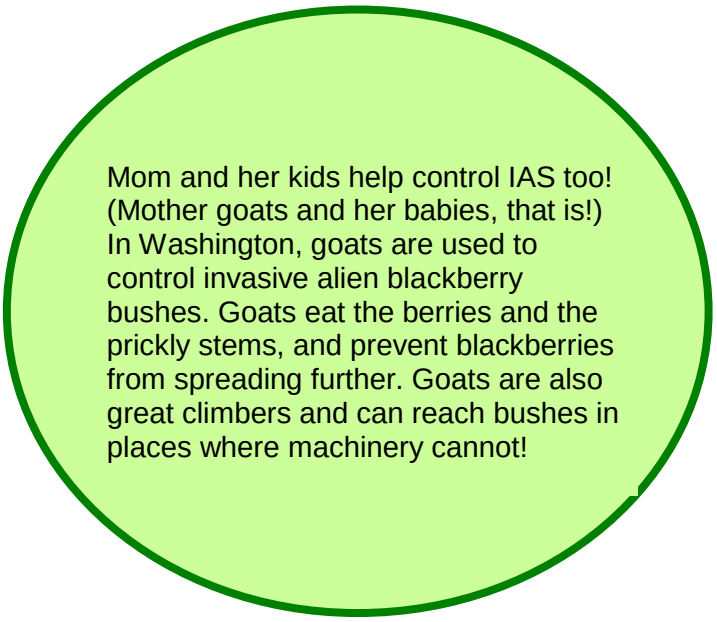
Game
Create an invader

Identify which of the following characteristics are likely to be exhibited by **invasive alien species**. Invent and draw an IAS that has these characteristics.

- Can out-compete its competitors
- Can physiologically adapt to new conditions
- Can reproduce and spread quickly
- Can survive in a range of environmental conditions
- Can't easily fight against competitors
- Can't tolerate extreme temperatures
- Doesn't easily adapt to new conditions
- Eats a specialized diet
- Eats many different types of foods
- Harms biodiversity
- Has a broad distribution range
- Has few or no natural predators
- Interrupts food webs
- Likely to survive and spread as climate change occurs
- Lives outside its historical distribution range
- May go extinct with climate change
- Restricted to a narrow distribution range

What can you do?

All around the world people are working to prevent **invasive alien species** from impacting native **biodiversity** and to minimize their impact if they have already established themselves.



Existing strategies

Prevention is the first line of defense against IAS. It is also the cheapest (in the long run) and most practical. Prevention involves regulating deliberate **species** introductions and minimizing accidental species introductions by identifying high-risk species and **pathways**.

Governments use various tools to limit the entry of IAS into a country. They use risk assessments, which evaluate the likelihood of an IAS entering and establishing itself and its possible environmental and economic consequences. Governments also require people to get special permits and licenses when they want to move species within or between countries. If a person gets caught moving species without the appropriate authorization, he or she faces stiff penalties, fines or even jail time! At the border (or airport), government officials conduct custom checks and inspect shipments. If a species cannot be properly identified, it may be quarantined.

Controlling the entry of accidental and illegal species introductions is even more difficult. Governments try to manage pathways and **vectors** to screen out as many potential IAS as possible. They also do routine treatments of imports to remove hitchhiker species. For example, imported fruits and vegetables are checked regularly and treated for potentially invasive insects, bacteria and viruses. Raising awareness through education is another tool governments use.

Once an IAS has entered a country, prevention is no longer an option. The remaining options for dealing with IAS are **eradication**, **containment**, **control** and **mitigation**.

Eradication is eliminating an IAS from a country or a zone. The longer an IAS is left to establish itself, the harder and more expensive it is to eradicate, so early action is very important. Removing an IAS from an area is often enough to allow native flora and fauna to return.

Gorillo ogo, a species of alien algae invading the waters of Hawaii, is literally being sucked up. A special barge called the "Super Sucker" has a pump that sucks water and algae from the ocean and dumps it onto the boat's deck. The water runs back into the ocean and the algae stays on deck. The Super Sucker can remove 363 kilograms of algae per hour! Over the course of a day, the Super Sucker can remove the equivalent of one male and one female African elephant!

Containment of IAS is a special form of control that restricts the spread of an IAS and keeps the population inside a specific geographic range. Containment works best if the IAS is detected early and if there are barriers preventing the spread of the IAS.

The aim of **control** is to reduce the density and abundance of IAS below an acceptable level. If the IAS is kept below this level, then competing native species can get enough of an advantage to regain ground against the invasive species.

If eradication, containment and control are not options or haven't worked, the last option available is **mitigation**. The goal of mitigation is to "live with" the IAS and minimize impacts on biodiversity and the economy. In mitigation strategies, the focus is on helping native and endangered species, perhaps by moving them to another area without any IAS.

While governments, international environmental agreements (also called multilateral environmental agreements) and non-governmental organizations (NGOs) are working at their level to deal with IAS, there are lots of things you can do.

- If you buy a pet, make sure it’s from a reputable seller. Non-native pets should be properly labeled, legally imported and free from foreign pests and diseases that could spread to wildlife.
- Don’t release any unwanted pets or aquarium fish or plants into the wild. Instead, give it to a friend or return it to your local pet shop.
- After hiking, wash your shoes. Invasive weed seeds and fungus spores are common hitchhikers.
- Leave natural items in their natural habitats. Don’t bring back seeds or animals from your travels.
- Clean your boat before putting it in the water. Remove all aquatic plants and animals from the hull, propellers, intakes, trailers and other gear, and dispose of them in a place where they can’t wash back into the water.
- After going out in your boat, wash it with hot, high pressure tap water. Let it dry for five days before putting it into a new body of water.
- Don’t release live fish, including bait, into a body of water.
- Plant native species in your garden that provide food, cover and nesting sites for local wildlife, especially birds and butterflies.
- Drain containers where invasive mosquitoes breed.
- Volunteer to help with your local invasive plant eradication or control project. Parks and nature reserves are often looking for young people to help out. Plus, it’s great exercise and a fun way to explore your local environment.
- Tell others about IAS.

Game
Stopping an invader

Here's the story of how a fictional **invasive alien species** called "IAS grass" goes from its native country "Endemic" and eventually ends up becoming a pest in country "Invaded". In each of the bubbles, write how the IAS could have been stopped.

1. IAS grass is growing along a mountain path in Endemic.
2. Rosa and Miguel are on vacation. They decide to go hiking along the mountain path.
3. It's just rained so the path is muddy. Rosa's boots get covered in mud. There are IAS grass seeds mixed in with the mud.
4. Miguel picks a few IAS grasses to bring home as a souvenir.
5. After they finish hiking, Rosa and Miguel drive back into town. On the way they stop for a picnic.
6. At the picnic site, Rosa walks through the gardens. Some of the mud falls off her boots.
7. At then end of their vacation, Miguel and Rosa drive to the airport.
8. They board an airplane and fly back to Invaded.
9. At the airport in Invaded, Miguel and Rosa go through customs.
10. Miguel plants the IAS seeds in his garden at home.
11. Rosa goes hiking around a lake. Some mud falls off her boots and lands on the trail.
12. The next year, there are IAS grasses growing at the picnic site in Endemic.
13. The next year, there are IAS grasses growing all over Miguel's neighbourhood in Invaded.
14. The next year, there are IAS grasses growing along the trail next to the lake in Invaded.

What is the Convention on Biological Diversity?

In 1992, governments, indigenous groups and non-governmental organizations (NGOs) from around the world gathered in Rio de Janeiro, Brazil, to talk about the **environment**. The Rio Earth Summit was the largest international environmental meeting ever. At the meeting, world leaders agreed that it was important to protect the environment for all people, including future generations. That's you! The leaders decided to adopt three conventions to achieve this goal.

Three conventions emerged from the Rio Earth Summit:

- The Convention on Biological Diversity (CBD)
- The United Nations Framework Convention on Climate Change (UNFCCC)
- The United Nations Convention to Combat Desertification (UNCCD)

A convention is an agreement or contract. The Convention on Biological Diversity (CBD) is an agreement between countries based on protecting biological resources. The CBD has three main goals: to protect **biodiversity**; to use biodiversity without destroying it; and, to share any benefits from genetic diversity equally.

How does the CBD work?

One hundred and ninety (190) countries and the European Community, making 191 Parties (the governments of the countries), have joined the CBD. That means 191 Parties across the planet have promised to achieve the goals of the Convention. The Convention is like a textbook that explains how parties should turn those goals into action. It suggests ways for Parties to help each other by sharing **resources** and technology so that all **biodiversity** benefits. Individually and collectively we can all make a difference by helping to preserve and protect the natural and biological resources of our precious planet.

The Convention on Biological Diversity's office is known as the Secretariat. It is located in Montreal, Canada. The head of the Secretariat is called the Executive Secretary. The Executive Secretary is an Assistant Secretary-General in the United Nations system – a very high position. The Executive Secretary, along with a staff of scientists, economists, lawyers, programme assistants and administrative staff, assist countries in carrying out their biodiversity work. The Secretariat also runs a web portal. To learn more about biological diversity around the world, visit the children and youth portal at cbd.int/youth and our main web portal at cbd.int.

Game
The CBD Secretariat, unscrambled

A	B	C	D	E	F	G	H	I	J	K	L	M
26	25	24	23	22	21	20	19	18	17	16	15	14
N	O	P	Q	R	S	T	U	V	W	X	Y	Z
13	12	11	10	9	8	7	6	5	4	3	2	1

Here are two facts about the CBD Secretariat that not too many people know. To find out what they are, replace each number with the corresponding letter.

26	25	12	6	7		22	13	20	19	7	2	
11	22	12	11	15	22		4	12	9	16		26
7		7	19	22		8	22	24	9	22	7	26
9	18	26	7	;		7	19	22	2		8	11
22	26	16		26	15	15		7	19	22		12
21	21	18	24	18	26	15		6	13		15	26
13	20	6	26	20	22	8		26	13	23		14
12	9	22	!									

20	22	13	22	5	26	,	8	4	18	7	1	22
9	15	26	13	23		4	26	8		7	19	22
	21	18	9	8	7		19	12	14	22		12
21		7	19	22		8	22	24	9	22	7	26
9	18	26	7	,	25	22	21	12	9	22		18
7		14	12	5	22	23		7	12		14	12
13	7	9	22	26	15	,	24	26	13	26	23	26
	18	13		17	6	15	2		1996	.		

Answer key

Drivers of biodiversity loss:

threat / a cause of biodiversity loss
extinction / end-result of biodiversity loss
evolution / natural process of species changing over time
habitat loss / occurs when ecosystems are destroyed
climate change / global warming
invasive alien species / driver of biodiversity loss that lives outside its original distribution range
overexploitation /overuse
pollution / causes biodiversity loss by making ecosystems inhospitable
nutrient loading / changes the chemical balance in ecosystems
direct driver / term to describe the immediate causes of biodiversity loss
indirect driver / term to describe the underlying causes of biodiversity loss
everyone / people responsible for reducing biodiversity loss
background rate / historical rate of species extinctions

Where are the invaders?

Native Range	**Invasive Alien Species**	**Invaded Range**
Central and South America	Mile-a-minute weed (*Mikania micrantha*)	Southeast Asia, Pacific Islands, West Africa
North America, Eurasia	Mallard duck (*Anas platyrhynchos*)	New Zealand, South Africa, Mexico, Zambia
Caspian Sea, Black Sea	Zebra mussel (*Dreissena polymorpha*)	North America (Great Lakes), Western Europe
South America (Andes)	Potato blight (*Phytophthora infestans*)	Europe, North America
Australia	Brushtail possum (*Trichosurus vulpecula*)	New Zealand
Nile River	Nile perch (*Lates niloticus*)	Southern Africa (Lake Victoria)
Amazon basin of South America	Water hyacinth (*Eichhornia crassipes*)	50+ countries on 5 continents
Australia, Papua New Guinea, Melanesia	Brown tree snake (*Boiga irregularis*)	Guam, Hawaii,
South America	Golden apple snail (*Pomacea canaliculata*)	Southeast Asia
Western Atlantic coast from USA to Argentina	Comb jelly (*Mnemiopsis leidyi*)	European seas (Black Sea, Caspian Sea)
Asia (Russia, China, Japan, Korea)	Emerald ash borer	North America (Canada, United States)
North America	North American gray squirrel (*Sciurus carolinensis)*	England
Atlantic coast of Europe and North Africa	European green crab (*Carcinus maenas*)	Canada, USA, Tasmania, Brazil, Panama, Madagascar, Myanmar, Pakistan, Australia, South Africa

Create an invader:
The following characteristics are more likely to be found in IAS than in non-IAS.

- Can survive in a range of environmental conditions
- Eats many different types of foods
- Can reproduce and spread quickly
- Can out-compete its competitors
- Likely to survive and spread as climate change occurs
- Has a broad distribution range
- Can physiologically adapt to new conditions
- Interrupts food webs
- Has few or no natural predators
- Harms biodiversity
- Lives outside its historical distribution range

Stopping an invader:
Various answers possible

The CBD Secretariat, unscrambled:

1. About 80 people work at the Secretariat; they speak all the official UN languages and more!
2. Geneva, Switzerland was the first home of the Secretariat, before it moved its office to Montreal, Canada in July 1996.

Web pages to visit:
cbd.int/youth and cbd.int
unep.org/tunza
cyberschoolbus.un.org
ecoliteracy.org

Convention on Biological Diversity