Achieving Biodiversity Restoration

About Arup

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Achieving Biodiversity Restoration

Addressing the drivers of biodiversity loss

Contents:

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Biodiversity Crisis

Compromising our planet's life support systems

Biodiversity is the variety of life on earth in all its forms. It is the key resource upon which all communities and future generations depend, and it underpins the health of the planet. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) presents clear evidence that there is an ecological emergency, and the risks of climate change and accelerating catastrophic decline in biodiversity loss will result in very serious impacts on the livelihoods of billions of people worldwide.

Healthy ecosystems are the planet's life support system; the basis of societies, economies, food production and human health. The interrelationship between climate change, biodiversity loss and human well-being are indisputable. The climate emergency and biodiversity crisis are inseparable issues and neither will be successfully resolved unless both are tackled together. Resilient and diverse ecosystems provide us with the conditions and materials which enable our globally connected societies. Loss of biodiversity is directly linked to a decrease in the function of ecosystems and in turn the reduction of the life-sustaining services from nature. Ecological restoration and the focus on restoring functional and resilient ecosystems are the foundation to our recovery.

UN Sustainable Development Goals

Compromising our planet's life support systems

The UN Sustainable Development Goals (SDGs) were adopted by all 193 UN member states in 2015. They outline a shared ambition for peace and prosperity for all people and the world we live in. Whilst each goal focuses on resolving specific issues by 2030, they recognise that achieving sustainable development relies on strategies that tackle several issues at the same time. It is increasingly understood that biodiversity underpins human well-being and livelihoods, and is vital to the achievement of most SDGs. Biodiversity underlies sustainable development and provides essential benefits and services that support all aspects of society.

Progress towards achieving the SDGs is dependent on biodiversity loss and limiting climate change. This requires a coordinated and effective policy that address global challenges as a whole. To accomplish the 2030 agenda, there is an urgent requirement to halt both biodiversity loss and climate change for the benefit of the world's peoples, delivering a net zero, nature-positive, and equitable future for all.

Related SDGs are represented on the cards in this pack, using the following key:

SDG: 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17

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Global Biodiversity Framework - COP15

The UN Convention on Biological Diversity Kunming-Montreal Global Biodiversity Framework (GBF) has four long-term goals to achieve the 2050 Vision "Living in Harmony with Nature," and includes: enhancing the integrity of all ecosystems; valuing, maintaining or enhancing Nature's contributions to people; fair and equitable sharing of the benefits from genetic resources; and closing the finance gap, including other means of implementation to achieve the 2050 Vision. Crucially, each goal has corresponding milestones to assess progress in 2030.

The framework identifies 23 action-oriented targets to achieve within the decade to 2030, and organised into three categories:

- Reducing threats to biodiversity.
- Meeting people's needs through sustainable use and benefit-sharing.
- Developing tools and solutions for implementation and mainstreaming of biodiversity.

A Global Goal for Nature - Nature Positive

The GBF agreement provides a clear and defined pathway on the need to halt and reverse nature loss and also aligns with the Nature Positive Global Goal for Nature (Nature Positive). This 'parallel' initiative advocates for the adoption of a succinct Nature Positive Global Goal for Nature. The goal has three measurable objectives: Zero Net Loss of Nature from 2020, Net Positive by 2030, and Full Recovery by 2050.

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Land & Sea Use Change.

Land and sea use change is a major influence on natural habitats. It includes the conversion of natural habitats into anthropogenic landscapes and the degradation of the natural environment due to changes in the management of ecosystems or agroecosystems.

Biodiversity
Achieving Restoration


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Large-scale Agriculture

The global community needs to feed a steadily growing population on a planet with limited resources and under global change. Agricultural intensification has negative impacts on nutrient and water availability, water quality and drastically reduces the extent of ecosystems. A new agricultural evolution is necessary with the aim of modernising large-scale agriculture.

The growing demand for resources, such as fertilisers, water and land adversely impact natural ecosystems. Many countries still rely on labour-intensive and inefficient farming practices, rather than employing precision farming or smart farming techniques. Additionally, the extensive use of phosphate fertilisers has caused mineral phosphorous availability to plummet. According to a recent study, China, which produces 50% of the world's vegetables, and the USA will have exhausted their phosphorous reserves within the next 60 years.

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Application

Digitalising and Optimising Modern Farming

Emerging robotic technologies are capable of analysing crops to identify nutrient deficiencies. This could revolutionise farming techniques drastically by minimising the over-use of fertilisers. Similarly, wireless sensors can sense soil water content and allow efficient irrigation scheduling which reduces excess water use. Cutting-edge satellite imagery is accurate enough to distinguish features between 0.5-2.5cm in size, which can help farmers to identify crops that require early intervention before issues arise.

Population growth in developing countries is increasing the need for these technologies, significantly accelerating their availability and affordability. As a result, more producers are able to operate more sustainably/efficiently whilst mitigating the impacts of climate change.

Habitat Degradation

The way we live is having a drastic impact on our environment. Land use change, deforestation and urbanisation are the main drivers of habitat degradation at a global scale. Increased demand for food, unsustainable consumption and the need for space is adversely affecting natural ecosystems to a point where they are unable to support their full range of native species anymore. Habitat simplification, degradation and species loss frequently enhance a community's vulnerabilities to collapse, and social and economic decline.

It is estimated that over 50% of the world's land area has been converted from natural to human-dominated or degraded habitats. The resulting lack of habitat and species diversity not only weakens the resilience of natural communities, but also limits the benefits we receive from healthy ecosystems, such as clean water, flood regulation, sources of medicines or pollination for our crops.

Feature

Rethinking Land Management and Conservation

Globally, agricultural intensification has had detrimental impacts on the natural environment. New approaches to land management are required to ensure the long-term provision of ecosystem services. For example, the reintroduction of integrated management into farmland or river catchments can provide a wide range of benefits, such as improved food production and CO_2 sequestration.

Cultivating a mixture of crops and wildflowers in the same field creates habitats for a wide range of animal species, such as pollinators, and increases the resilience and productivity of crops. Similarly, rewilding approaches such as the reintroduction of beavers can increase the complexity and function of natural habitats and contribute to flood regulation.

Deforestation and Forest Degradation

Forests provide many ecosystem services, such as flood protection, food, local and global climate regulation, timber and non-timber forest products. Deforestation and degradation of woodlands already have massive impacts on these environmental services and continue to drastically reduce biodiversity in some of the world's most pristine regions.

Over 3.6 million hectares of pristine rainforest were cut down in 2018, driven by forest clearing for agriculture, palm oil plantations and illegal logging. While global trends in deforestation reduced in 2018, they are still the second-highest since records began in 2002. In 2019, catastrophic fires in the Amazon have reflected shortcomings of centralised policies in protecting forest resources against degradation and deforestation.

© Rainforest Action Network

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Application

Forest Conservation and Urban Forestry

Mitigating the degradation of forests is difficult to reconcile with economic pressures driving land use change. Overall, global forest cover has increased by 7% since 1982. However, these increases are mainly occurring in the northern hemisphere. Worldwide shifts in forestry management towards decentralised management of forests provide opportunities to increase global forest stocks.

Community-based forestry schemes in India and the Philippines have allowed governments to shift the responsibility for natural resource management towards communities. This will empower local stakeholders, giving them additional sources of income and promoting equitable access to this shared resource. Similarly, urban forestry is increasingly more relevant to city planning. Sustainable infrastructure, coupled with natural features, can improve air quality and health and well-being, increase biodiversity and reduce urban heat and runoff.


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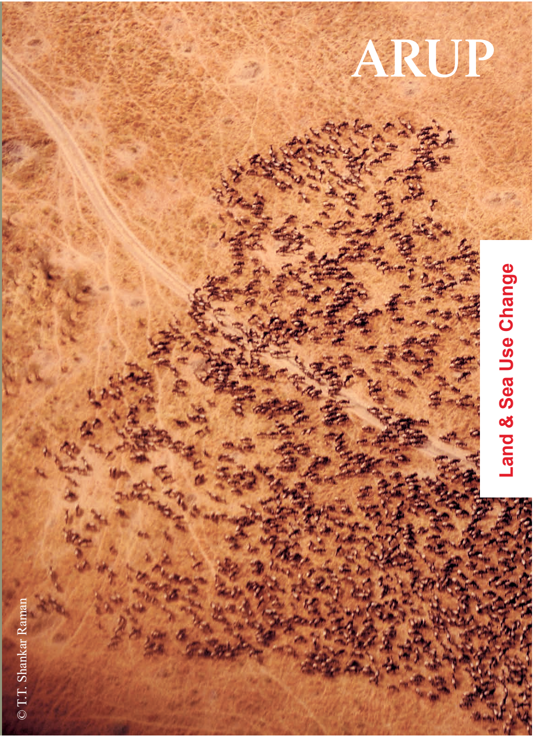
Species Dispersal and Migration

Climate change and shifts in temperature are driving a global redistribution of habitats at sea and on land. Studies have shown that the average species moves 20km per decade poleward, and over 10m per decade up in elevation. However, that is in response to past climate change; future climate change is expected to be faster. In addition, climate change and habitat degradation and fragmentation will compromise species’ ability to shift their habitat ranges as a response to global climate change.

Changes in habitat types will have direct effects on humans dependent on ecosystem services for their income. Consequently, for many communities, particularly with traditional livelihoods, e.g. food cultivation, animal herding or hunting, there will be negative economic and social impacts. Outside of the world’s largest reserves, existing parks and smaller reserves are not large enough to accommodate shifts in species' native ranges.



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Feature

Climate Smart Connectivity

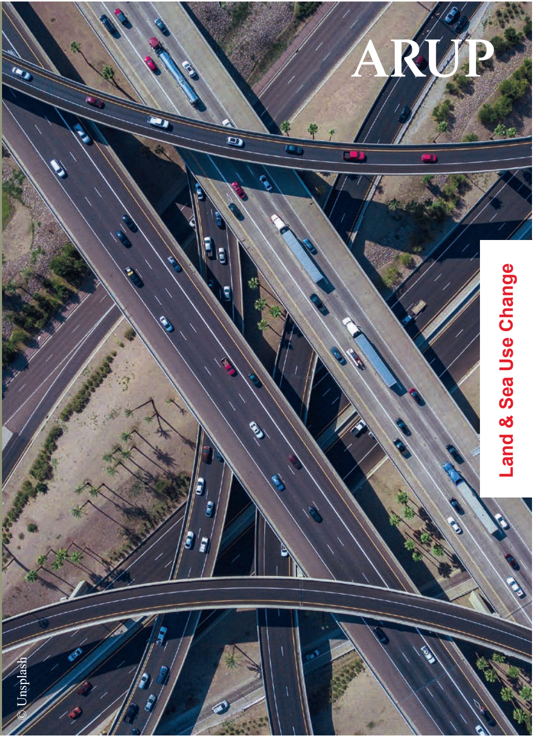
As climate change occurs, ecological corridors are the most frequently recommended conservation strategy to support species movement and dispersal. Climate change may also increase population variability and the likelihood of local extinction; however, corridors provide conduits for wildlife to recolonise habitats where populations have been lost. Since many species' response to climate change is still unpredictable, corridors can provide the necessary outlet for them to expand as needed throughout the landscape and ensure that fewer local populations become extinct.

The analysis of ecological models and data demonstrates that the implementation of corridors at broader scales may mitigate the effects of climate change and maintain the integrity of ecosystem processes. Climate-gradient corridors, which rely on the utilisation of time-ordered linkages between species ranges, also enable the tracking of species under global warming.

The Ecological Cost of Development

Population growth, increasing consumption and the focus on economic growth have devastating impacts on our planet. One way or another, unsustainable development is destroying biodiversity around 1,000 times faster than natural 'background' rates. This extinction crisis has widespread economic and societal impacts; for example, the economic value of biodiversity is illustrated by the threat to the UK's 1,500 pollinator species that deliver some £680m in products and ecosystem services.

Policy frameworks aimed at mitigating environmental impacts from human activities are currently not effective at halting biodiversity decline. While environmental impact assessments may provide suitable mitigation for identified development impacts, they often fail to adequately protect biodiversity. There is a clear need for new planning mechanisms in developing infrastructure; one which can deliver positive outcomes for biodiversity.



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Application

Biodiversity Net Gain

Biodiversity Net Gain is an approach to development that leaves biodiversity in a better state than before. It requires developers to have a measurable positive impact on nature. When a development has an impact on biodiversity it requires developers to provide an increase in appropriate natural habitat and ecological features over and above that being affected. This regenerative approach seeks to reverse the loss of biodiversity from development, whilst offering economically and environmentally sustainable solutions to business-related biodiversity loss and degradation.

A net gain in biodiversity requires action beyond offsetting ecological impacts. A technical understanding and appreciation of the ecological context, such as the restoration of ecological networks and success of offsets, is needed to deliver projects which have a measurable and genuine positive impact on the natural world.


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Agricultural Land Abandonment

In the period 2015-2030 about 11% (more than 20 million ha) of agricultural land in the EU is at high risk of abandonment due to factors related to biophysical land suitability, farm structure and agricultural viability.

The bulk of abandoned EU agricultural land (4.8 million ha) is likely to remain unused because of negligible re-cultivation of once-abandoned land. Less than 600,00 ha are projected to convert into forests and natural areas, while the conversion into built-up area will be minimal, just 18,000 ha. Land abandonment has substantial adverse social effects, including cultural losses such as heritage farming and landscapes, economic declines within rural communities, resulting in further agricultural contraction, and the movement of working populations from rural areas to cities, leaving behind an ageing rural population.

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Feature

Rewilding

Rewilding is generally large-scale conservation aimed at protecting and restoring natural processes and core wilderness areas, providing connectivity and reintroducing species that play unique roles in ecosystems. Rewilding is increasingly considered a suitable option for land use in cases of farmland abandonment when the social structure of farming communities has been eroded and low-intensity farming is no longer socially or economically viable.

The focus on restoring dynamic ecological processes, sometimes through an appropriate sequence of species reintroductions, attempts to move the ecosystem towards a more biodiverse and functional state. Crucially, with the re-establishment of functioning ecosystems there is an increase in quality and quantity of ecosystem services, e.g. carbon sequestration and recreation. However, as with agriculture, rewilding cannot be successfully implemented without intervention and correct management.

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Global Insect Decline

Insect biodiversity is threatened at a global scale. A multitude of scientific studies have reported declines in insect biomass, denoting rates of decline that could lead to the extinction of 40% of insect species over the next few decades. Major drivers appear to be intensification of agriculture, pesticides, habitat loss and climate change.

Up to 75% of our crop species are reliant on insect pollination to some degree. The nature and extent of these benefits can vary between crops, ranging from increasing the quantity and quality of fruit or seed produced to hastening crop development and increasing genetic diversity within crop species. Economically, the value of insect pollination services to crop agriculture has been estimated at £400m per annum within the UK and £153 billion per annum globally. Halting the collapse of insect biodiversity is integral to maintaining food security in an increasing global population.

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Application

Reforming Agriculture

The management of landscapes to promote insect life in both rural and urban environments is essential to support the recovery of insect populations. The establishment of hedgerows and wildflower strips in agricultural fields can increase both the biodiversity of agricultural land and reduce the need for pesticides.

Cultivating a variety of plants on farmland enhances the abundance of predators of many crop pests and promotes a wider variety of crop pollinator species. Growing nectar-producing plants around rice fields in Thailand, China and Vietnam have been proven to reduce the need for insecticides by 70%, while increasing yields by 5% and overall profits by 7.5%. By promoting and enhancing landscape and habitat variability, both crops and insects will benefit as we transition away from crop monocultures towards establishing diverse agricultural landscapes supported and inspired by nature.

© Agroscope, Matthias Tschumi

International Shipping

Shipping accounts for 80% of global merchandise trade, with over 10 billion tonnes of goods traded annually. Shipping routes between continents are concentrated on ‘marine roads’ which can have significant impacts on marine life. Collisions with vessels, noise and water pollution and fragmentation of marine habitats are a constant and growing threat to larger marine life, such as whales, dolphins and whale sharks.

Increasing international trade is driving the intensification of shipping. Ships will carry more than 75% of all goods moved by 2050. This in turn will have an increasingly detrimental effect on marine biodiversity. Noise pollution caused by shipping traffic has been shown to result in a 30% reduction in humpback whale feeding manoeuvres, culminating in overall reductions in foraging efficiency.

© Dan Heap

Application

Tracking Animals and Vessels

The global merchant fleet consists of roughly 53,000 vessels, many of which can be tracked in real-time. Technological advances in animal tracking allow the tracking of large marine species via satellites, or with transponders that can provide information on location and depth of animals. Tracking used in combination with ship Automatic Identification System data, make it possible to map both shipping routes and migratory patterns of large marine species.

These data streams can be utilised to redirect shipping routes and to establish temporary exclusion zones, similar to Marine Protected Areas. Enforcement of exclusion zones could be facilitated by deploying autonomous wind-powered vessels that patrol areas and report possible violations.


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Man-Made
Restrictions to Movement

Fences have long been used to define ownership, secure borders, control livestock and prevent vehicle collisions. Roads and tracks provide similar barriers to many animal species, obstructing or preventing species dispersal and seasonal migrations. Barriers cause isolation, fragmentation and reduced gene pool mixing between populations. Consequently, animal communities become susceptible and less resilient to other pressures such as hunting, diseases, poaching or environmental change.

Current trends in international politics suggest an increase in fencing around national borders in Europe and Northern America. Continuous fencing or the building of a border wall along the USA-Mexico border could disconnect more than 35% of US non-flying native terrestrial and freshwater animal species from over 50% of their natural range.

© Idobi

Application

Overcoming Barriers to Biodiversity

Green bridges and underpasses can mitigate habitat fragmentation arising from barriers. Several studies have shown that crossing structures over and under highways and extensive fencing allow sufficient movement of species to prevent genetic isolation in wildlife populations.

The control of livestock via fences may become obsolete through the establishment of digitalised herding technologies. Geo-tagging and virtual herding can be utilised to contain and move animal herds without relying on fences. This implementation of virtual fences will also facilitate the movement of wild animal populations through managed farmland, while also providing farmers with a reliable tool to control large herds of livestock. As such, virtual fencing may become an important tool for the management of national parks, game reserves and nature reserves, facilitating migratory movements of species.

Urbanisation and Encroachment

The global urban population has increased drastically over the past century, mostly due to population drift from rural areas into cities. Research has shown that as urbanisation increases, our exposure to and relationship with the natural environment drastically decreases. This is increasingly linked to a variety of public health issues, such as anxiety and depression.

As natural habitats are replaced by built structures, modified or remnant habitats may remain; however, these are unable to support many species and fail to provide a wider range of environmental benefits to urban populations. Today, 3.5 billion people, more than half of the world's population, live in urban areas, and this trend is set to continue over the next decades. According to the United Nations, nearly 70% of people will be living in urban environments by 2050.

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Application

Blue-Green Cities

By incorporating well-planned natural habitats into cities, we can provision and safeguard valuable ecosystem services for urban populations. Nature-based solutions for flood prevention, such as wetland and floodplain restoration have been utilised to provide catchment-based interventions and mitigate flood risk; the planting of woodland habitat mosaics reduces water runoff, improves urban air quality, provides sources for recreation and supports biodiversity.

Urban green infrastructure has a wide range of health benefits; greener neighbourhoods and town centres increase the time spent outdoors, improve social interactions in communities and promote healthier lifestyles. Recent research has demonstrated that green space is associated with reduced obesity; people living in greener residential areas spend more time outdoors and have a reduced risk of obesity, particularly in children.


© Camelia TWU

Palm Oil

In one way or another, much of the global population consumes or uses several products containing palm oil on a daily basis. Oil palms are the cheapest source of vegetable oil, and their mass cultivation has driven deforestation of tropical rainforests on a global scale. Habitat loss due to palm oil production has driven many species, such as orangutans, to the brink of extinction.

Oil palm monocultures are replacing high-diversity rainforests, significantly increasing carbon emissions and denying local communities access to forest resources. Approximately 30% (~5.8 million ha) of tropical forest loss in Indonesia since 2000 can be attributed to the growing demand for palm oil. In addition, trends suggest further expansion in global palm oil industries.

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Feature

Developing a New Generation of Biofuels

Advances in algal-based biofuel production will reduce the demand for oil palm plantations and other cash crops currently used to produce biofuel. These advances will decrease pressure for land use change and allow for restoration of degraded ecosystems such as rainforests in Indonesia, while reducing the need for crop monocultures in Europe, USA and Brazil and Asia.

There has been a specific focus on the use of algae as a biofuel product, and the use of algal oils as a substitute for palm oil in cosmetics and food. This may avoid the detrimental environmental effects associated with current palm oil production. However, there is yet to be further analysis on the environmental and social effects of management of algal-oil production vats.

Endangered Species

Research suggests that humans are driving animals and plants to extinction faster than new species can evolve, in what is termed the sixth mass extinction. Overconsumption is largely responsible for this crisis which threatens the survival of human civilisation.

Scientific research suggests that there are 8.7 million species of living organisms on our planet. However, human activities have also significantly increased global extinction rates; based on current estimates, each year up to 87,000 species are becoming extinct. A variety of specific pressures such as habitat degradation, illegal wildlife poaching for ingredients used in traditional medicines and unsustainable consumption of natural resources, are intensifying extinction rates for threatened or endangered species.

Feature

Effective Species Conservation

Global pressures on threatened species warrant the development of a consistent, fair and effective framework to allocate funds for conservation. Iconic species, such as giant pandas, often disproportionately benefit from conservation funding.

New research on the efficacy of protected areas in maintaining biodiversity is challenging this practice, as it is often ineffective in achieving conservation targets. Strategies supporting the conservation of umbrella species, i.e. conserving a single high-profile species which also benefits many other species, have wider benefits in determining the composition, structure and processes of ecosystems.

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Habitat Mapping

Mapping and surveying of habitats is expensive in terms of costs and labour and is often potentially dangerous. Mapping and surveying of remote or difficult-to-access areas, such as mountainous regions, coastal cliffs, forest canopies or derelict buildings, can pose serious challenges to ecologists.

Today, manual data collection and desk-based analysis of survey results is required to confidently assess environmental constraints of a location or project. Ecological surveys are limited if areas are difficult or dangerous to access and may potentially also cause disturbance to sensitive species. In the digital age, it is necessary to develop techniques to conduct high-confidence, low-disturbance, low-risk, and low-cost ecological surveys.

Application

Drones/UAV

The utilisation of Unmanned Autonomous Vehicles (UAV) can provide cost-efficient long-term surveillance of environmental impacts and reduce the time and cost involved in conventional mapping and surveying.

Drones are currently being utilised for habitat mapping, monitoring plant and animal populations and measuring carbon storage. The technology can provide new spatio-temporal understanding of threats faced by natural ecosystems. By pairing drone technology with other surveying techniques such as ground-based surveys, this can further increase the quality of data acquired. As an emerging technology the potential for the further application of Drones/UAV within the field of habitat mapping and surveying is vast.

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Direct Exploitation

The human race has exploited wildlife throughout its history, causing biodiversity loss and species extinctions. In the past decades, the rates of loss have increased dramatically. Particularly vulnerable are marine fish, invertebrates, trees, and tropical vertebrates. The overexploitation of natural habitats is not only threatening biodiversity, but also communities that depend on nature.

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Water Scarcity and Groundwater Depletion

Water shortage is one of the major constraints to sustainable development and is increasingly exacerbated by climate change. Additionally, growth in agriculture, industry and urban environments has increased water scarcity, which has already led to significant reductions in groundwater supplies in many countries.

Desalinating seawater is often proposed as a measure to alleviate water scarcity; the heavily energy-intensive process extracts salt from seawater, transforming it into potable water. There are now nearly 16,000 desalination plants either active or under construction across the globe. However, new research has identified that desalination plants are discharging 50% more salt-laden brine than previously believed. The salt and chemical-rich effluent raises the level of salinity and poses a major risk to ocean life and marine ecosystems.

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Direct Exploitation

Application

Renewable and Sustainable Desalination

Typically, a desalination plant requires between 1.5 and 12kWh to desalinate $1m^3$ of saltwater. A shift from fossil fuels to renewable energy sources, such as solar heat, photovoltaics, geothermal and wind energy, would decrease the environmental impacts and costs of desalination.

Saline drainage water offers potential commercial, social and environmental gains. Scientists believe a large number of metals and salts in the effluent including uranium, strontium as well as sodium and magnesium have the potential to be recovered. Brine has now been successfully trialled for aquaculture use, with increases in fish biomass of 300% achieved. It has also been successfully used to cultivate the dietary supplement Spirulina.


© Generalitat de Catalunya

Demand for Sand

The global demand for sand and gravel used in construction is increasing steadily. Today, the global sand mining industry is worth US$70 billion and is extracting 68-85% of all materials mined annually. As the human population increases, so does the demand for sand.

Sand is an essential resource for many aspects of our lives, such as the manufacture of concrete, the reclamation of land and maintenance of beaches. Global demand for sand was at 9.5 billion tons per year in 2017; economic projections suggest that the market value for sand will increase almost five-fold within the 22nd century, from currently US$99.5 billion to US$481 billion due to increased demand and future shortages.

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Feature

Thresholds in Sand Extraction

In aquatic environments, sand excavation destroys aquatic habitats and can have direct effects on the movement of sediments and animals living within them. Shifts in species communities can lead to extinctions and the reduction of fish stocks, which damages local fisheries.

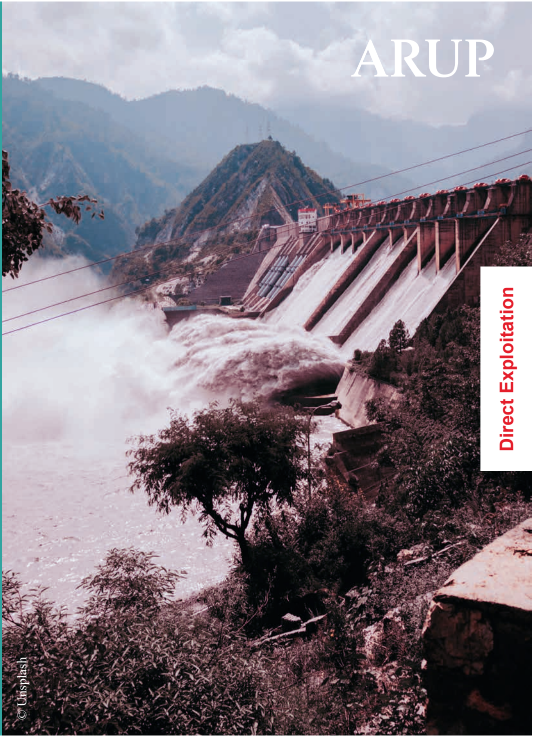
The detrimental impact of sand mining highlights the need to develop more sustainable mining practices. Innovative frameworks such as the Ecosystem Based Design rules calculate maximum sand yields and decrease direct environmental impacts in the early design phase of borrow pits. These rules can help maintain a good environmental status of local marine habitats which are subject to sand dredging.

© Unsplash

Hydroelectric Dams

Hydropower is currently the world's largest source of renewable electricity and a major driver of dam construction. Harnessing the power of water contributes to over 60% of global renewable energy generation and the trend is increasing; over 3,500 hydropower dams are currently being planned or are under construction globally, predominantly in South East Asia, South America, Africa and the Balkans.

Despite providing renewable energy, dams can drastically alter both the hydrology and ecological function of river and lake ecosystems. Additionally, by increasing deliberate flooding, for example to create reservoirs, newly inundated land such as tropical forests can become a source of emissions, rather than carbon sink. These changes can have severe consequences for the global climate; it is estimated that 1.3% of anthropogenic greenhouse gas emissions are a consequence of changes in terrestrial ecosystems due to dams.



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Feature

Understanding Trade-offs in Hydropower Generation

The development and operation of hydropower dams can have surprising impacts on greenhouse gas emissions. While the emissions of dams in upland areas of the Amazon are comparable with solar and wind energy (around 39kg CO_2eq per MWh), dams in lowland areas may emit more carbon than conventional fossil fuel power plants (over 133kg CO_2eq per MWh).

Achieving low-carbon hydropower will require flexible approaches towards planning future projects. Moreover, sustainable hydropower projects will require assessments that consider greenhouse gas emissions along with social and environmental impacts, and clearly reveal and evaluate the wider externalities and benefits of this key form of renewable energy generation.

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Illegal Fishing, Hunting and Poaching

Wildlife crime, including illegal hunting, poaching and trading is a global issue. It is the fourth largest illegal trade behind drugs, people smuggling and counterfeiting, and is estimated to yield £15 billion annually. Many vulnerable species already under threat of extinction are targeted by poachers. Efforts to combat the trade of illegal bushmeat and traditional medicine will require global policy developed with socio-economic and scientific input.

Similarly, illegal, unreported and unregulated fishing is one of the largest threats to sustainable fisheries worldwide, affecting both the high seas and small-scale fisheries. Global demand for seafood exceeds 143 million tons every year. However, unreported and illegal fishing may add a further 11 to 26 million tons of fish to this figure. The future of many terrestrial species and the integrity of global fish stocks are seriously threatened by these illegal practices.

© Dash Huang

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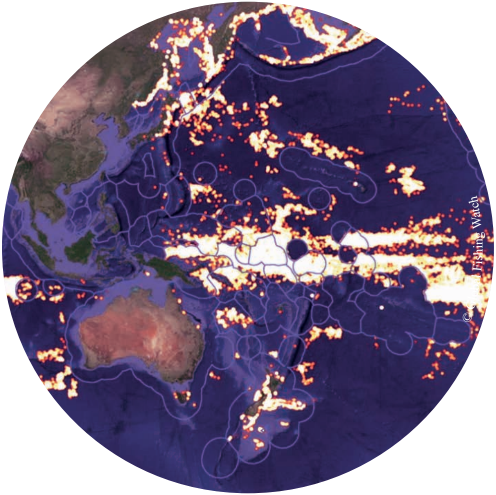
Application

Digital Tracking of Fishing Vessels

In order to maintain the financial viability of high-sea fishing, vessels are permitted to transfer their catch onto refrigerated cargo vessels, which return to port to offload the catch of multiple fishing vessels at once. This practice allows illegal fishing vessels to avoid control and sell illegal catch without repercussions.

Global Fishing Watch has developed a tool to track fishing vessels using vessel data. Machine learning algorithms are employed to identify vessels involved in illegal fishing practices. The use and success of this tool is growing rapidly, with support from partners like Google, the National Oceanic and Atmospheric Administration and the International Union for Conservation of Nature (IUCN). Geospatial analysis of illegal fishing practices has the potential to inform future policies promoting sustainable fisheries.



The Collapse of Biotic Systems

Biodiversity and habitat loss and unsustainable natural resource management have already led to significant disruptions in ecosystems. Humans strongly rely on services provided by nature for food security, health, well-being, safety and recreation. A collapse of biotic interactions will have significant impact on the ability of nature to provide economic and societal security.

Rapid and severe environmental change can have permanent effects on ecosystems. Regime shifts describe the transition of ecosystems past critical thresholds, where the services provided by and interactions within the system change drastically. For example, the collapse of the Canadian Newfoundland cod fishery in 1992 led to a yearly decline of over US$200 million in revenues and directly affected the livelihoods of 35,000 people. Collapsed ecosystems become unable to provide essential services, such as food or clean water, causing adverse effects from a local to global scale.

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Feature

Regime Shifts and their Consequences

There are over 300 peer-reviewed case studies of ecological regime shifts since the 20th century. Eutrophication resulting from agricultural intensification, lack of oxygen in rivers due to pollution, coral bleaching and desertification are just a few examples of regime shifts that can significantly affect already degraded ecosystems.

Research investigating ecological regime shifts in Chilika lagoon, India, demonstrated that the intensification of aquaculture, coupled with man-made changes in the lagoon's hydrology, has resulted in a drastic loss in aquatic biodiversity. This also led to the loss of access to fish and the livelihoods of fishermen, the breakdown of local institutions and cooperatives, and increases in conflicts.

© Rita Willaert

Pest Resistance

Large-scale monocultures have resulted in the loss of genetic diversity between and within crops, the use of a small range of crop protection products, and the loss of semi-natural habitats, such as hedgerows and woodlands. Reduced crop diversity, coupled with pesticide and herbicide resistance, has driven a complete dependence on ever-increasing artificial interventions, effectively creating an unsustainable arms race.

The loss of natural habitats has also decreased the abundance of natural enemies of pests and unwanted weeds. Recent studies have shown that cabbage stem beetle, a major pest on oilseed rape, has become resistant to pesticide treatments. With decreasing efficacy of pesticides and the loss of natural predators, it is necessary to pursue novel and environmentally friendly approaches to crop protection.

© Niv Singer

Application

Smart Crop Protection

Research into invasive species and weed management suggests several ways of carrying out sustainable pest management. Technological approaches include crop surveillance via smart sensors, genetic modification of crops or the manipulation of pheromone chemical processes in insects, weeds and pathogens. On the other hand, eco-centric approaches, such as the cultivation of different crops in one field to strengthen pest resilience, are increasingly being trialled.

Understanding ecological interactions within crops and between pests and crops is crucial in the development of smart crop protection. Additionally, technocentric approaches, such as the Internet of Things smart sensor technologies or genome editing may play a significant role in shaping the future of crop protection.

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The Unreported Battleground

The rise in murder, violence and the intimidation of frontline environmental workers and indigenous people is now widespread across the world. Killings of official conservation staff and environmental campaigners have doubled over the past 15 years to reach levels usually associated with war zones. The death rate is now four a week, which is attributed to rising environmental stress as the global demand for resources pushes mining, farming and other extractive industries into ever more remote regions.

While the ongoing conflict associated with African wildlife poaching is well known, wildlife rangers across the world are facing an increasing threat when dealing with environmental crimes. For example, in Europe two Romanian forest rangers were murdered in the fight against illegal logging in 2019. In Spain there were two murders and more than 30 serious assaults on wildlife rangers between 2017 and 2019.

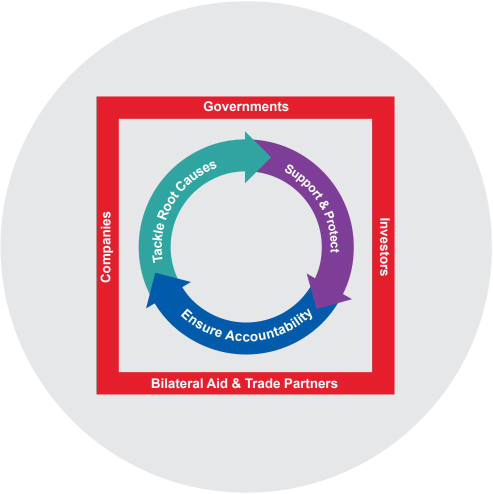
© Nabin Baral

Feature

Consumer Power

Illegal trafficking of wildlife and timber, along with that of drugs, people, and weapons, sustains an enormous underground criminal community. The UN has estimated that illegal logging raises about $100 billion and poaching of animals $20 billion per year in illicit funds. Much of the violence against environmental workers results from corruption, irresponsible business practices, organised crime, and disputes in land tenure and ownership.

Many organisations are working on the frontline to tackle the root causes of violence; including the support of environmental campaigners and workers and to ensure accountability. There is a necessity for government regulation and responsible business. Crucially, consumers can drive change by demanding standards or certifications demonstrating that products are sourced ethically and violence-free.



Soil Degradation

It is estimated that half of the topsoil on the planet has been lost in the last 150 years. Generating 3cm of topsoil takes 1,000 years, and if current rates of degradation continue all the world's topsoil could be diminished within 60 years. The soil beneath our feet is fundamental to the functioning of natural ecosystems and agriculture which economies and societies depend upon.

Soil also plays a crucial role in the cycling of nutrients, such as carbon and nitrogen and in the water cycle through regulating run-off. It also acts as a sink for many contaminants, protecting both the water and air environments from pollution. The principal causes of soil degradation are overgrazing and poor agricultural management, desertification and deforestation. The impacts of these actions include loss of soil biodiversity, compaction, loss of soil structure, nutrient degradation, soil salinity, infertility and erosion. For these reasons the sustainable management of soil is crucial.

© Brian Boucheron

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Application

Sustainable Agriculture and Land Management

Addressing soil degradation requires long-term management, as soil fertility and soil carbon take decades to build. To achieve this, it will be necessary to reduce soil loss, improve soil health, use salt-tolerant crops, conservation agriculture and integrated crop, livestock and forestry systems. It is crucial to recognise the natural capital value of soil coupled with the need to avoid incentives promoting soil degradation and instead devise incentives to reward sustainable land management.

Incentives for safeguarding soil health and raising awareness about the values of ecosystem services can help to avoid, reduce and reverse soil degradation. Mainstreaming an appreciation of soil as natural capital and the soil ecosystem services into decisions taken by farmers will have benefits for society in reducing costs of environmental damage.

SDG: 02 03 06 07 12

Climate Change

Anthropogenic climate change affects both terrestrial and marine environments in numerous ways including increases in temperature and ocean acidification. These impacts are occurring at such a rapid rate that species do not have the opportunity to adapt.

© Mario Hoppmann

Atmospheric Carbon

As a greenhouse gas, carbon dioxide contributes to global warming by trapping solar energy in the atmosphere. Rather than being dissipated into space, this additional energy warms our planet's surface. Since the industrial revolution, we have exponentially increased our input of greenhouse gases into the atmosphere, causing unprecedented rates of change in the global climate.

Many countries have developed extensive decarbonisation strategies aimed at limiting global warming to +2°C or +1.5°C against the pre-industrial global average temperature. However, these strategies often rely on the large-scale implementation of atmospheric carbon sequestration through Carbon Capture and Storage (CCS) facilities, a technology which is still in its infant stages of development.


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Feature

Ecosystem-based Carbon Sequestration

The reduction of atmospheric carbon through carbon sequestration is a technique that scientists have been researching for several years. Currently, the implementation of CCS technlogies is mostly theoretical, expensive and not proven in the field.

Before relying on expensive and potentially ineffective technological innovation, we must exhaust environmental regeneration as a solution for CO_2 sequestration. Vegetated coastal ecosystems occupy just 0.2% of the ocean's surface; however, they play a disproportionately large role in capturing and storing carbon. This bio-sequestration in coastal habitats can store carbon for millennia and may be one the most effective methods of carbon sequestration and storage. If we aim for a net zero carbon future, we need to rely on transformative changes in land use on a global scale. Technologies like CCS are only transitional measures on the route to decarbonisation.

SDG: 09 12 13 14 15

A Warming Ocean

The oceans are fundamental to regulating the global climate. Covering around 71% of Earth's surface, they sequester over 26% of CO_2 from fossil fuel burning, industry and land use changes. Over the past 100 years, global surface temperatures have increased by approximately 0.07°C per decade. In this period, temperatures in the upper few metres of the ocean have increased twice as fast as on land. This buffering of higher temperatures and continued absorption of elevated CO_2 levels by the ocean is now adversely affecting marine systems.

Combined with human activities, such as pollution, overfishing and whaling, the capacity of marine ecosystems to sequester carbon is rapidly diminishing. Crucially, the degradation of ecosystes, including species loss, plays a role in undermining the resilience of oceans.

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Climate Change

Application

The Ultimate Nature-Based Solution

Scientists have discovered that whales play a crucial role in CO_2 sequestration in the ocean. The array of microscopic life, such as algae and plankton, in the oceans captures almost 37 billion metric tons of CO_2. Whales catalyse this process; commonly referred to as the "whale pump," they move carbon into the deep sea by transporting minerals such as iron and nitrogen to the surface where they feed on plankton. These minerals combined with whale dung act as fertilisers and dramatically increase carbon-capturing algae.

If whales were allowed to return to their pre-whaling numbers (4 to 5 million), they would drive the sequestration of an additional 1.7 billion tons of CO_2 per year. In comparison, for a forest to sequester the same amount of CO_2, it would require an area of up to 3.8 million km², or half of the size of Australia.


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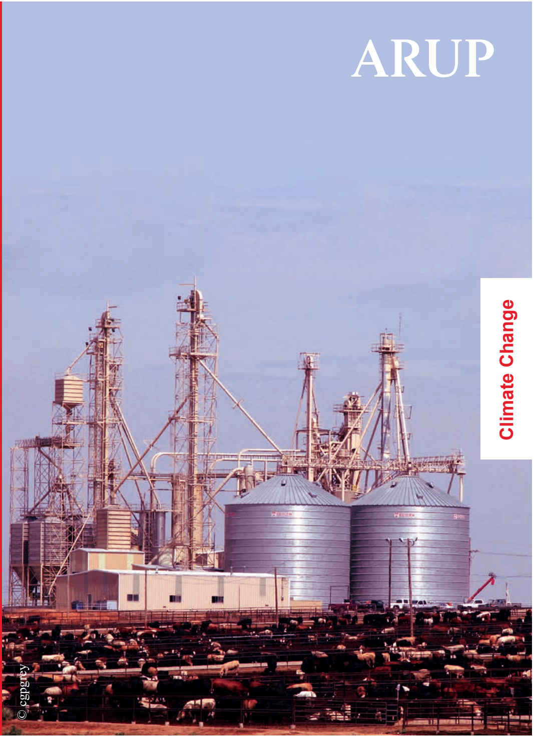
Methane Emissions

Methane is one of the most potent greenhouse gases in our atmosphere. It is roughly 84 times more potent as a heat-trapping gas than CO_2 over the first 20 years of its release and 30 times more potent a century after its release. Methane is emitted from various natural sources, for example wetlands, but over 60% of its global emissions can be attributed to human activities, with agriculture being the primary source. Since 2000, the number of livestock in the world has increased from 15 billion to 24 billion, the majority of which is held in intensive farms.

Reducing methane emissions into the atmosphere will contribute to reducing current rates of climate change. A radical overhaul in agricultural practices like livestock management is crucial if we wish to succeed in mitigating climate change.



© cgpgrey

Application

Rethinking Livestock Management

Current strategies for minimizing methane emissions in livestock include enzyme inhibition, dietary supplements, vaccination and animal selection. However, if animal consumption remains at its current levels, livestock management will have to be reformed to reduce the emission footprint of the livestock industry.

Grassland and livestock management can adversely affect pastoral ecosystems and their ability to sequester carbon and methane emissions from livestock. Studies show that herding practices based on natural behaviour called rotational stocking emit 64% less methane per hectare than traditional livestock farming. This promotes grassland productivity and increases feeding efficiency, contributing to food security by enhancing the amount and quality of food products. Crucially, it also mitigates impacts of grazing by decreasing methane emissions and benefiting farmers by reducing their dependence on enzyme inhibitors or dietary supplements.


© The Pasture Project

Extreme Weather

The frequency of extreme weather events is steadily increasing due to climate change. The pressures on both the natural environment and humans are many; droughts, flooding and storm surges can have disastrous consequences in the absence of resilient adaptation measures.

According to the European Academies' Science Advisory Council, the number of floods has doubled since 2004. Similarly, events related to extreme heat, such as forest fires, have more than doubled since 1980. Five of the ten hottest global years on record occurred between 2013 and 2018. Heatwaves like that of 2019, during which temperatures of over 40°C were recorded in several European capitals, are becoming more likely under current rates of global heating.

© Michael Held

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Climate Change

Application

Nature-Based Solutions

Nature-based solutions utilise underlying ecosystem functions to deliver multiple benefits like the use of increased rainwater retention in green infrastructure to reduce flood risk. Similarly, nature-based solutions are implemented globally to mitigate extreme heat in urban centres in the shape of urban trees, parks and retrofitting of green walls and roofs.

Sponge cities in China, which are designed for ecological restoration and environmental protection, have already shown great success. Tongzhou in Beijing can now accommodate 70% of rainwater on the surface by storing it in ponds, rainwater gardens, green roofs and permeable paving.

Nature-based solutions have the potential to play an important role in delivering climate change adaptation measures at a global scale.

Coastal Habitat Erosion

Coastal habitats are under immense pressure worldwide from intensified coastal development, the increased occurrence and severity of tropical storms and sea-level rise. Additionally, land use change can further increase the vulnerability of coastlines through the removal of protective ecosystems (e.g. mangroves, salt marshes or other coastal wetlands). Coastal defences are often designed in a uniform manner, which can lead to ineffective and expensive coastal defence efforts.

At a global scale, about 28,000km² of land has been lost to coastal erosion between 1984 and 2015. In the United Kingdom, coastal erosion is occurring along 17% of the coastline and two-thirds of intertidal profiles in England and Wales have steepened over the past 100 years. This is being exacerbated by 'Coastal Squeeze', where coastal habitats are trapped between a fixed sea defence and rising sea levels. The habitat is 'squeezed' between these two forces and diminishes greatly in quantity and quality.

© Gordon Hatton

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Application

Adaptive Management of Coasts

Many coastlines are being eroded due to human pressures. For example, increased demand for food drives the destruction of coastal wetlands to allow for aquaculture. Such drastic changes in shoreline morphology result in coastlines becoming vulnerable to erosion. The natural restoration of coastal habitats, such as mangroves, salt marshes or sand dunes, can reduce coastal erosion, by acting as physical barriers against storm surges and the pull of the tides.

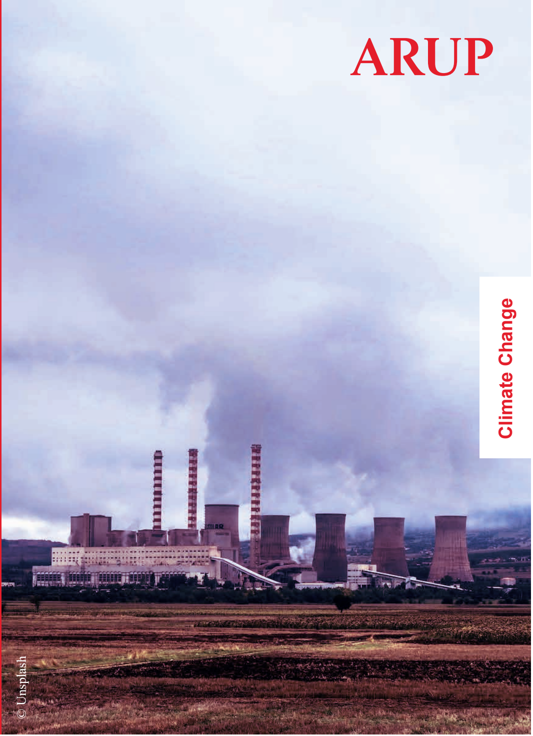
Innovative projects involving local communities in Java have pioneered integrated approaches to nature-based coastal defence solutions. Interventions include sediment dams to trap and slow water flow, and mangrove forest restoration along the shoreline and between aquaculture ponds. Such projects have delivered multiple successful outcomes for local communities, businesses and wider society.

© Guyana Mangrove Restoration Project

Energy Production

According to the Intergovernmental Panel on Climate Change, 29% of global greenhouse gas emissions are attributed to the burning of fossil fuels for energy generation. In 2017, 56% of global energy demand was met with fossil fuels, half of which was used to cool or heat homes, industry and other applications. While reliance on coal is reducing, many countries are shifting towards generating energy with gas (a less carbon-intensive fossil fuel) or renewables.

Reliance on fossil fuels for energy production must significantly decrease to limit global warming to 1.5°C by 2050. Nevertheless, persistent growth in oil and natural gas use in 2017 and 2018 has increased CO_2 emissions by up to 2.7% per year. Despite global efforts, only 19 countries have managed to reduce their emissions without decreasing their GDP in the past two years. Urgent innovation, multilateral agreements and legislation are required to decouple economic growth and emissions on a global scale.



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Climate Change

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Application

Living Insulation

Green infrastructure provides a wide range of environmental, social and economic benefits within cities. For example, green roofs/walls can deliver direct reductions in energy usage by improving the thermoregulatory capacity of buildings.

The inclusion of a green infrastructure 'living layer' can shade buildings from direct solar heat, and insulate against heat loss during winter. Research in Germany has demonstrated that residential buildings with green roofs save up to 10% on winter fuel bills and reduce emissions by 1.5kg CO2 m2 of green roofs. Additionally, large cities such as Toronto can achieve approximately $22 million in savings by reducing the energy demand for air conditioning and cooling during summer.

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Parasite-borne Diseases

Since the Industrial Revolution, the average global temperature has risen by about 0.8°C. Warmer, shorter winters are creating a climate favourable for ticks in the northern hemisphere. Rather than dying during cold winter months, more ticks survive alongside their offspring, in some cases increasing in numbers significantly.

The increase in tick numbers, as well as northward range shifts, will have serious implications for both animal populations and human health. In North America, moose populations are already drastically impacted, with some individuals being infested with up to 14,000 ticks. Moreover, tick-borne diseases, such as Lyme disease have become more common in many temperate regions across the globe. By drastically increasing the risk of infection, this could have major repercussions on the health of millions of people.

© Unsplash

Application

Innovative Greenspace Management

Alongside climate change, greener cities may exacerbate the spread of ticks in urban environments by providing migration corridors to hosts, such as deer, foxes or rats. Management interventions, such as removal of leaf litter or the elimination of rodent nests can reduce the number of ticks and could potentially be carried out by autonomous robots.

Robots are already deployed for weed control, tree care and vertical farming and may become more relevant in the management of green infrastructure. The deployment of robots for urban green space management could reduce the risk of disease, as well as the cost of labour. Automated management will ensure the optimal condition and functional capacity of urban green infrastructure.

Loss of Natural Services

Human pressures and global climate change will have significant impacts on the benefits we gain from nature. There is a pressing need to ensure that key environmental services provided by nature remain available in the event of wider ecosystem collapse. Sustainable sources of energy, food production and other forms of natural resources will become more relevant for healthy and resilient cities in the future.

Degraded ecosystems can be more susceptible to environmental change. The Intergovernmental Panel on Climate Change postulates that there is robust evidence that a wide range of habitats, such as rainforests or coral reefs will be lost if the world warms beyond +2.5°C of pre-industrial levels. In addition to other anthropogenic pressures, this poses a serious threat to the functioning of our ecosystems and, in turn, to the benefits they provide us with.

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Climate Change

© Julian Meehan

Application

Investing in Natural Capital Stocks

It is estimated that the services and goods we derive from nature are worth around US$125 trillion a year. Land use change is one of the key drivers of environmental degradation, eroding all of our economic activity. A more comprehensive approach to land use change can be gained by accounting for the socio-economic value of land. This enables people to understand the total value of land, reflecting wider benefits and goods we receive from nature.

A wide range of projects have shown that environmental restoration can deliver cost savings and higher value than traditional development. Shrimp aquaculture in Indonesia, which requires the clearance of mangrove ecosystems, is estimated to have a net present value of US$8,340 per hectare. The retention or restoration of mangrove forests delivers services worth up to US$35,700 per hectare. This includes protection from coastal erosion and flooding and support for local and national fisheries.

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Pollution

There is a growing understanding of the impacts of different pollution types on biodiversity. With increases in the human population, urbanisation and consumption, it is important to address how we will mitigate pollution to protect biodiversity and natural resources.

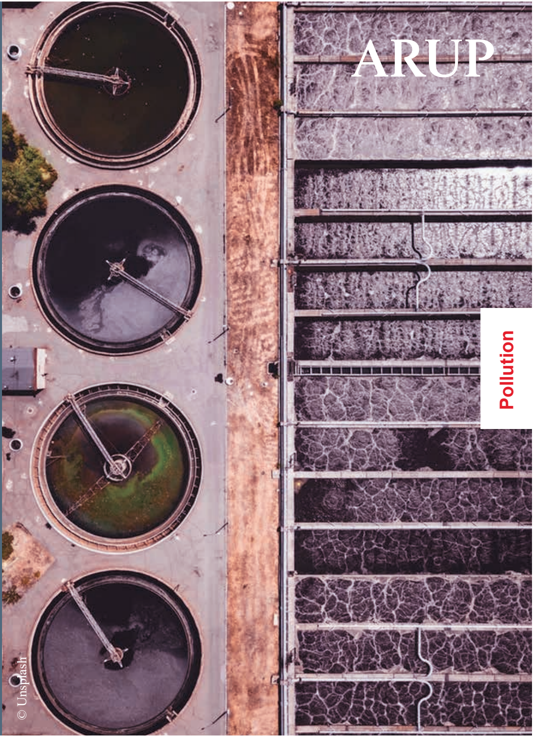
© kris krüg

Pollution

Pharmaceutical Water Pollution

The influence of pharmaceutical pollution on the freshwater environment has long been apparent. A vast range of commonly used pharmaceuticals can be found in waterbodies, e.g. Ibuprofen, Diclofenac and Propranolol, with concentrations ranging between 0.4 nanograms per litre to 18.7 micrograms per litre. These concentrations of pharmaceuticals can have significant negative impacts on natural ecosystems.

Recent research has identified the effects of six pharmaceuticals commonly detected in surface waters in the United States on stream biofilm respiration and photosynthesis. Biofilm, communities of microorganisms attached to surfaces, were found to be suppressed by up to 91%. Changes in species composition will affect the amount and quality of food for organisms, threatening food webs and biodiversity.



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Pollution

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Application

Green Pharmaceuticals

The current processes of treating wastewater are not designed to remove pharmaceuticals and are generally ineffective at completely removing contaminants. Diclofenac was banned in India in 2006, yet it is still widely used in many European countries. Spain approved Diclofenac for veterinary use in 2013, despite its significant environmental impact.

To remediate their negative impacts, researchers are starting to alter pharmaceuticals to become more biodegradable. Scientists have recently successfully changed the molecular structure of the ß-Blocker Propranolol to reduce its environmental impacts. In its original form, Propranolol does not biodegrade after leaving the human body. After altering its structure, the new drug biodegraded by up to 30% after one month.

© Unsplash

Plastic Pollution

The production and use of plastics has increased exponentially since the 1950s. Poor management and the resulting waste have accumulated in the global oceans and on terrestrial habitats. The wide-ranging negative effects of plastic pollution have only recently become apparent, such as the ingestion of plastics by marine animals. When ingested, plastics limit the ability of animals to take in actual food, which significantly affects the survival of sea birds, marine mammals, fish and sea turtles.

In 2010, between 4.8 and 12.7 million tonnes of plastic waste were released into the oceans. It is difficult to quantify the total amount of marine plastic; some estimates suggest the presence of at least 5 trillion plastic pieces. Plastic production is constantly increasing; in 2015 448 million tons of plastic were produced and it is estimated that by 2050 the global production will double.

Feature

Mobilising Global Responses

Plastic can now be found in all marine habitats. Marine plastic pollution has negative effects on organisms, ecosystems, human well-being, and economic activities such as aquaculture, tourism and navigation. Floating plastic debris can also transport invasive species, diseases and harmful substances across the ocean.

Finding a solution to global plastic pollution is extremely challenging. Just like the impacts of plastic pollution, its sources are very diverse. As such, it is necessary to develop international, cross-disciplinary solutions to work alongside international agreements to curb plastic pollution before it becomes uncontrollable. Key areas of focus will be the design of policies related to the international trade in recyclables and reforms of waste management policies.

Water-borne Microplastics

Larger plastic pieces are weathered down to microscopic size over time and are then easily ingested by organisms. The ingestion of often toxic microplastics can cause deaths and can spread the distribution of plastic across all marine and many terrestrial food chains.

Microplastics have already been found in extremely remote places, such as the Antarctic and the Mariana Trench, far away from direct human influence. In addition, household sea salt and fish used for human consumption is now likely to contain microplastics. A study published in April 2019 presented evidence of microplastics in 128 brands of salt from 38 different countries across five continents. Many chemicals found in plastics have carcinogenic properties and may be extremely harmful to life.

© Florida Sea Grant

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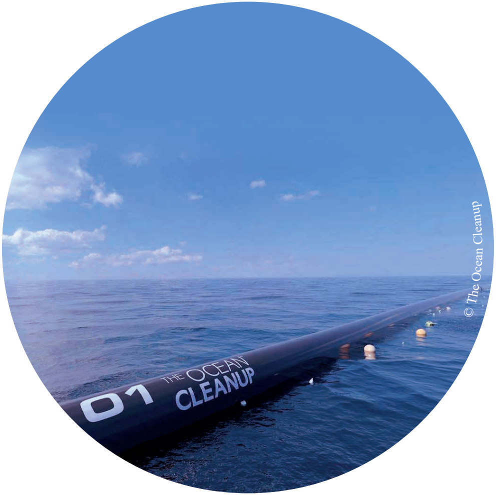
Pollution

Application

Innovative Ocean Clean-up

Microplastics from both cosmetics and from the breakdown of regular plastic waste must be reduced drastically to minimise health impacts on animals and humans. A potential solution may be to employ newly discovered bacteria to biodegrade microplastics. Several microbes have already adapted to metabolise man-made plastics with enzymes. Laboratory studies have explored the potential of engineering such enzymes to effectively break down plastics.

Researchers have argued that nearshore and riverine collection of plastic waste is more cost-effective and proactive than on open water. Limiting or stopping the influx of plastic into the oceans will reduce the challenge for clean-up operations, such as the employment of bacteria or 'Fishing for Litter' campaigns worldwide.



© The Ocean Cleanup

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Marine Munitions

Millions of tons of dumped munitions are lying on the bottom of the oceans. Much of the dumping dates back to conflicts during World War II and subsequent munition dumping in the aftermath of World War II. Regardless of their origin, conventional, chemical and radiological weaponry is slowly breaking down and releasing toxins, such as the carcinogen DNT or toxic mercury, into the environment.

Up to 385,000 tons of munitions have been lying at the bottom of the Baltic Sea for over 70 years. Marine studies of several dumping sites have confirmed that they are point sources for many toxic compounds such as mercury. Once released, these toxins enter the food chain and bioaccumulate in larger fish species, such as tuna, which are subsequently consumed by humans.

© Alexander Vasenin

Pollution

Application

Bioremediation

To mitigate the environmental effects of dumped munitions it is necessary to remove the sources of contamination and to clean up contaminated areas effectively. A wide range of plant species can, through bioremediation, be used to extract pollutants, including heavy metals, arsenic or uranium from aquatic and terrestrial environments.

Newly developed Munitions and Ordnance Remediation Blankets can be utilised to safely detonate explosives without releasing toxins. Contamination of water can be reduced by deploying floating treatment wetlands. Plants growing on floating structures are utilised to absorb pollutants, nutrients or other toxins from lakes, ponds, coastal areas or rivers.

Urban Air Pollution

Air pollution is caused by various factors including increases in transportation, non-renewable energy generation and agriculture. Sulphur and nitrogen emissions are deposited in natural systems, increasing acidity and affecting biodiversity. Additionally, air pollution has a significant impact on human health; it has been identified to be a major cause of chronic airway diseases such as asthma and rhinitis.

Air pollution from the livestock industry is increasing significantly. In China, annual emissions from livestock and poultry waste treatment account for 22% of nitrogen and 38% of phosphorous emissions. In addition to direct health impacts, nitrogen and phosphorous have been shown to exacerbate insect pests on crops, as well as harmful algal blooms in both marine and freshwater environments.


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Application

Green Infrastructure and Biofiltration

Trees in urban environments can remove pollutants such as particulate matter (PM), reducing impacts on biodiversity and humans. Additional benefits include the enhancement of biodiversity, interception of rainfall and reductions in stormwater run-off and urban heat. Modelled effects of trees on PM2.5 removal in ten American cities ranged from 4.7 tonnes in Syracuse to 64.5 tonnes in Atlanta.

Intensive livestock production and water treatment plants emit ammonia, a form of nitrogen, odour and fine dust. Conventional air filters effectively remove ammonia from the air but struggle with fine dust and odour. The use of organic materials and microorganisms for air filtration has been shown to increase air filtration efficiency, transforming up to 70% of emitted ammonia into substances which can be safely processed.

© Unsplash

Noise Pollution

Anthropogenic noise has a significant negative impact on wildlife communities and humans living in urban environments. One in three Europeans is impacted by noise at least once a day, and due to adversely affected urbanisation this trend will increase. Noise can have a variety of health impacts; for example, one in five people will be unable to have undisturbed sleep. As a direct consequence, noise can increase stress levels, as well as mental health problems and increase the risk of cardiovascular disease.

For animals, noise can negatively affect a suite of behavioural traits. Studies on noise impacts on birds have shown changes in vocal behaviour, such as calling on higher frequencies which requires more energy. Similarly, noise pollution negatively affects mating behaviour in a variety of terrestrial and aquatic species and directly affects the continuity of wildlife.

© Tony Webster

Application

Smart Cities Noise Management

Smart sensors and smartphones can provide live information about urban noise. Real-time noise mapping can be utilised to educate citizens about environmental and health impacts of noise pollution. Similarly, it can allow public administrators to take immediate action against extreme noise levels, for example through traffic control.

There has been an increased focus on how different sounds are perceived by society or an individual. Recent research suggests that other senses, such as sight, also influence the perception of noise in urban landscapes. For example, trees have been shown to reduce the perceived intensity of noise, while noise barriers increased reported noise annoyance.

Light Pollution

Artificial light at night is known to disrupt circadian rhythms, interfere with orientation and migration, alter predator/prey interactions and affect other social behaviours of many species. Increased use of artificial lighting, expansion of urban areas, and "24-hour" cities are having negative impacts on biodiversity around the globe.

An estimated 80% of the world's population live under light-polluted night skies. For 60% of Europeans, the Milky Way is not visible at night. In addition, there are a variety of potential health risks related to light pollution, such as increased risk of cardiovascular disease. Artificial light can also change seasonal behaviour in animals, such as mating, by masking the detection of shorter days, often leading to reduced fitness and reduced breeding success.

© NASA

Application

Smart Lighting

Smart road lighting can be employed by utilising real-time traffic data, e.g. the average travel speed and number of cars on a road, to increase or decrease the light intensity for individual street lights during off-peak hours. A recent study showed that automation of this process can deliver up to a 40% reduction in energy usage for street lighting.

Developing smart street lighting systems can provide multiple benefits, including a reduced disruption of human circadian rhythm and reduced costs of street lighting. In addition, smart lighting can be implemented to reduce pressures on biodiversity. Dimmable lights near habitats used by nesting birds or mating invertebrates may improve their ability to live within urban habitats. Bat sensors could also be introduced, to dim lights along commuting corridors for bat species.

© Studio Roosegaarde

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Invasive Alien Species

Invasive species are exotic/alien species that disrupt the ecological function of natural systems. Invasives often out-compete local and indigenous species, negatively affecting biodiversity. Human activities, including climate change and increased international mobility, have exacerbated the spread of invasive alien species at a global scale.

Biodiversity
Achieving Restoration

© Unsplash

Invasive Species

Controlling the spread of invasive species is extremely challenging. Global change and globalisation have driven the extent and occurrence of species invasions drastically. There are significant and complex differences in addressing these issues; continuing the ‘business-as-usual’ in the control of invasive species or adopting a more dynamic view of ecological systems, where changes or naturalisation of species is accepted.

It is estimated that invasive species management has a total global cost of US$1.4 trillion per year, which urgently requires the development of more cost-effective management practices. However, increasing opportunities to generate new and innovative economic utility from invasive species are being investigated and applied.

© pedrik via Flickr

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Feature

Management in the Anthropocene

New and innovative ways of benefitting from harmful species invasions. The invasive lionfish has become established in many Caribbean marine environments; it adversely affects native commercial fisheries. Researchers have recently developed a remotely-operated vehicle/drone which has been deployed to target and stun the venomous fish. The stunned fish are retrieved by the drone and subsequently sold for human consumption, which drastically reduces the cost of management.

The invasive plant West Indian Lantana currently occupies approximately 13 million hectares in rural India. Commercial harvests could yield up to 8 tonnes of woody biomass per hectare, covering a significant proportion of global paper production. A focus on establishing related local enterprises in the region has the potential to provide a stable source of income to local communities.

Food Security

Invasive plant and animal species can have devastating consequences on food sources that heavily rely on the function of natural ecosystems. A single invasive species can dramatically reduce food sources, introduce new pathogens or simply disrupt conventional farming/fishing methods. Marine and freshwater habitats are particularly prone to species invasions, which have been exacerbated by global shipping.

The Mediterranean is the most invaded sea in the world. WWF listed 986 alien species in 2021, of which 10% are classified as invasive. Globalisation and climate change are accelerating the spread of invasive species on a planetary scale, across all ecosystems.


© Unsplash

Application

Adapting Livelihoods

Introduced into the Mediterranean through the Suez Canal, the invasive blue crab was first recorded off Tunisia's coast in 1993. In the following decades, the crab decimated local fish stocks, damaged traditional fishing equipment, and ultimately drastically reduced fish-catches. By 2014, blue crab consisted of over 70% of the catch of Tunisia's artisanal fisheries.

It is acknowledged that it is impossible to completely halt the spread of invasive species. However, there are opportunities to adapt and harness invasive species as sources of revenue. Tunisia has undergone a drastic change in fisheries management. Through engagement with fishermen, fishing and export of blue crab have become growing industries, with exports reaching $24m in 2021. The long-term effects on native ecosystems are difficult to assess, but the blue crab now supports many artisanal fishermen and fishing communities.

© wpop via Wikimedia Commons

Invasion Ecology

Our data-driven world requires new methods to identify and monitor invasive species. For example, identifying and tracking the spread of invasive plant species currently relies heavily on surveys to be carried out on foot. Limited funding for conservation projects, particularly in the most threatened habitats, often means that authorities are unable to monitor and manage the spread of invasive species.

Many nature reserves around the world rely on volunteers to collect data on the spread of invasive species between and within reserves. With limited funding and resources available, it is crucial to develop technologies that will assist the monitoring of invasives automatically, accurately and inexpensively.

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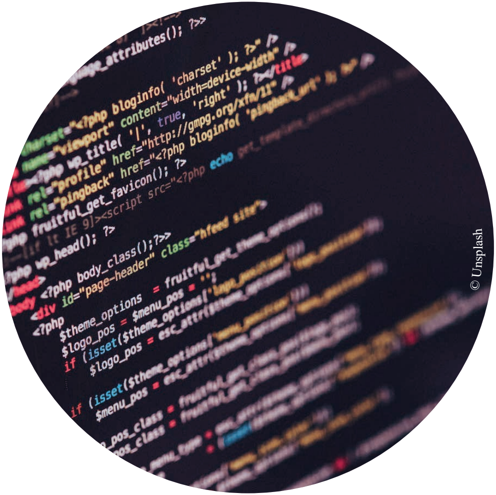
Application

Artificial Intelligence & Big Data

Several studies have shown that deep learning can be employed to identify and monitor invasive plant and animal species with extremely high accuracy. Such algorithms are already being trialled to analyse images from cameras mounted on cars driving at high speeds. Machine learning algorithms are able to classify 2,000 images per minute, providing information on species abundance and behaviour with extremely high accuracy, which is often equal to the accuracy of crowdsourced volunteers.

When combined with data collection from cars driving with mounted cameras or unmanned aerial vehicles, artificial intelligence can significantly reduce cost and time spent monitoring the spread of invasive species. Automatic, real-time identification of protected or unwanted animal species can allow rapid responses and enables proactive conservation management.



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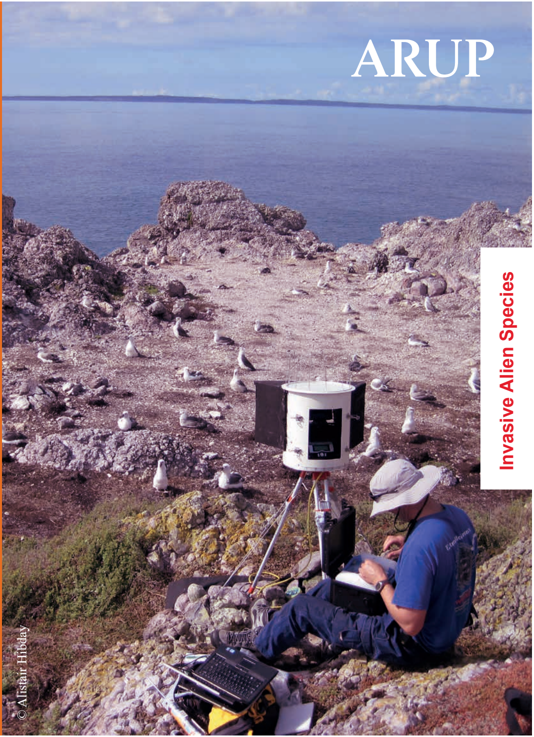
Invasive Species Surveying, and Control

Surveying animal and plant communities and monitoring the presence of invasive species can be very time consuming, expensive and ineffective. Efforts to measure abundance and distribution of individual species or communities often depend on time intensive surveys and/or tagging or trapping, which in some cases can be harmful to species.

The US National Oceanic and Atmospheric Administration has estimated that surveying, controlling and eradicating invasive species in marine and estuarine environments costs $137 billion per year. However, it is immensely important that ecologists generate and collect survey data to develop metrics or indicators to understand local and global environmental changes.



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Application

Metabarcoding and eDNA

Advancements in survey techniques can assist with data collection, interpretation and biodiversity monitoring. Sampling for the detection of great crested newts via environmental DNA (eDNA), already has a number of applications within the field of applied ecology. Metabarcoding is currently used to determine freshwater community composition and the presence of amphibious species in waterbodies.

Metabarcoding has also been used to survey marine communities by sampling water, and can also be used on airborne eDNA, to analyse changes in the distribution of invasive plants and animals. Metabarcoding and eDNA data can also be utilised to map food webs and the community structure of aquatic habitats. This process can inform decision-making for invasive species management more effectively by providing a rapid, cost-effective and consistent survey protocol.


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