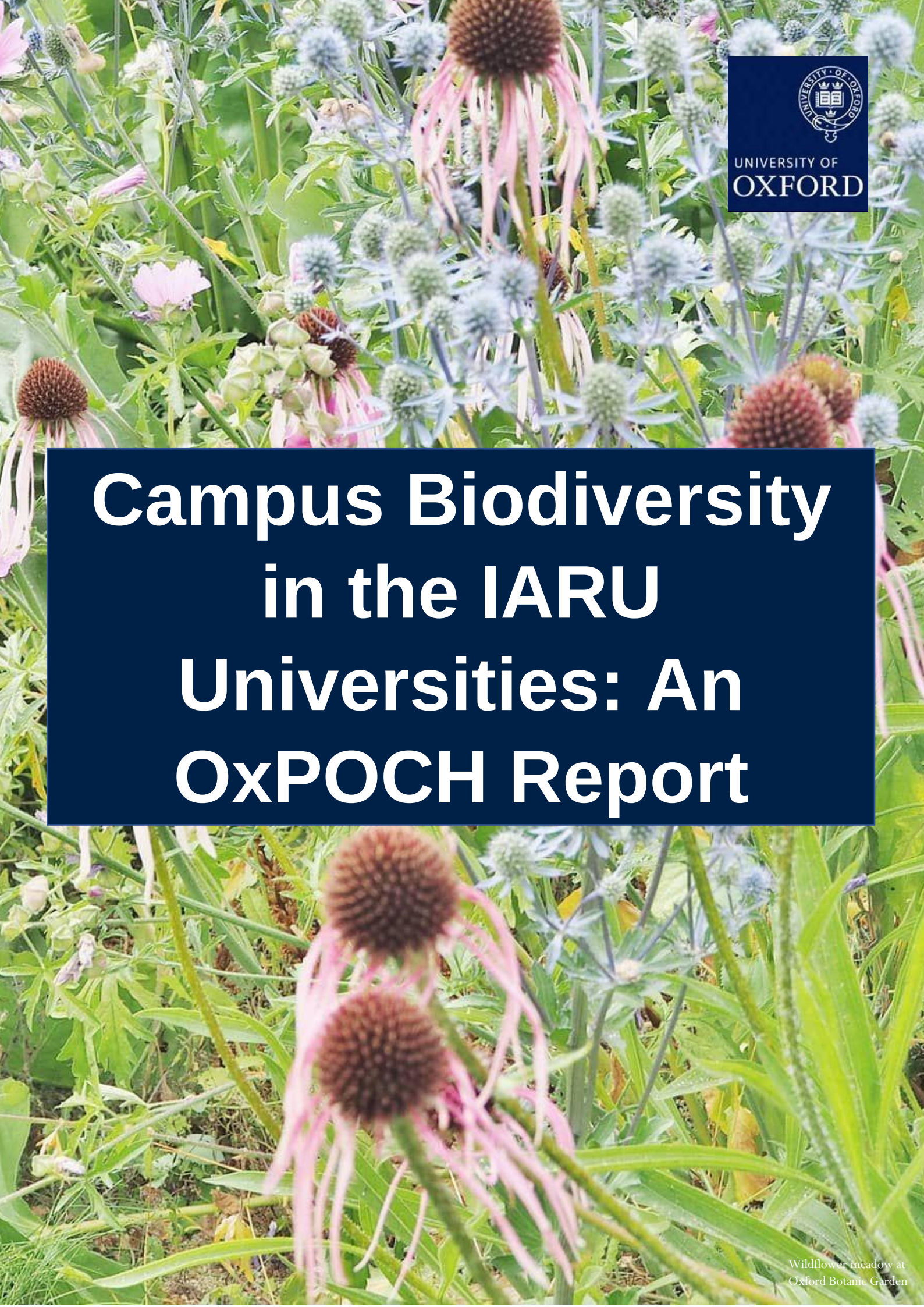


UNIVERSITY OF OXFORD

Campus Biodiversity in the IARU Universities: An OxPOCH Report

Wildflower meadow at Oxford Botanic Garden

Foreword

This report, funded by the International Alliance of Research Universities (IARU), provides an overview of the approaches to biodiversity taken by IARU institutions and acts as a platform for highlighting examples of good practice within institutions. We demonstrate areas of similarity and difference amongst the IARU institutions and assess the impact of their practices and policies in the context of various themes.

It should be noted that the main focus of this report is campus biodiversity and the role of universities as catalysts for integrating nature into the lives of its members, stakeholders, and wider community. Thus, biodiversity is mostly discussed in the context of campus-level measures rather than the most significant biodiversity impacts that universities accumulate via operations and supply chains, which is beyond the scope of this report.

We acknowledge that biodiversity measures on university landholdings in isolation cannot enable universities to properly fight the global biodiversity crisis. Even if all areas of 'natural' environment owned by a university were fully restored as natural habitat, this would be an insignificant biodiversity gain in the context of total embodied biodiversity losses caused by university activities. Nevertheless, this should not discourage institutions for setting targets and creating strategies for campus biodiversity, nor should we ignore great potential that campuses have as arenas for raising awareness of global issues and fostering engagement with nature. Such initiatives will be important in terms of contribution to peoples' wellbeing, raising awareness about environmental sustainability efforts, communicating the importance of nature conservation, and collaborating with external efforts to restore biodiversity.

We hope that this report will encourage universities and colleges to reconsider how biodiversity fits into their sustainability agenda and inspire new opportunities for life to flourish on campuses across the world.

Author: Caleb Bram

INTERNATIONAL ALLIANCE OF RESEARCH UNIVERSITIES

Introduction

The OxPOCH Project

The following report has been produced on behalf of the Oxford Partnership for Operationalising the Conservation Hierarchy (OxPOCH)[1]. This is a programme which aims to support the University of Oxford to improve its environmental sustainability as an institution, while testing the application of the 'Mitigation Conservation Hierarchy', or 4Rs (Figure 1). Based upon decades of research, this is a framework which builds upon the existing mitigation hierarchy and is designed to help all sectors of society contribute towards global goals for biodiversity. Sustainability interventions are categorised into preventative or compensatory measures tied to impacts (reactionary), as well as those measures that are proactive and not implemented in response to impacts.

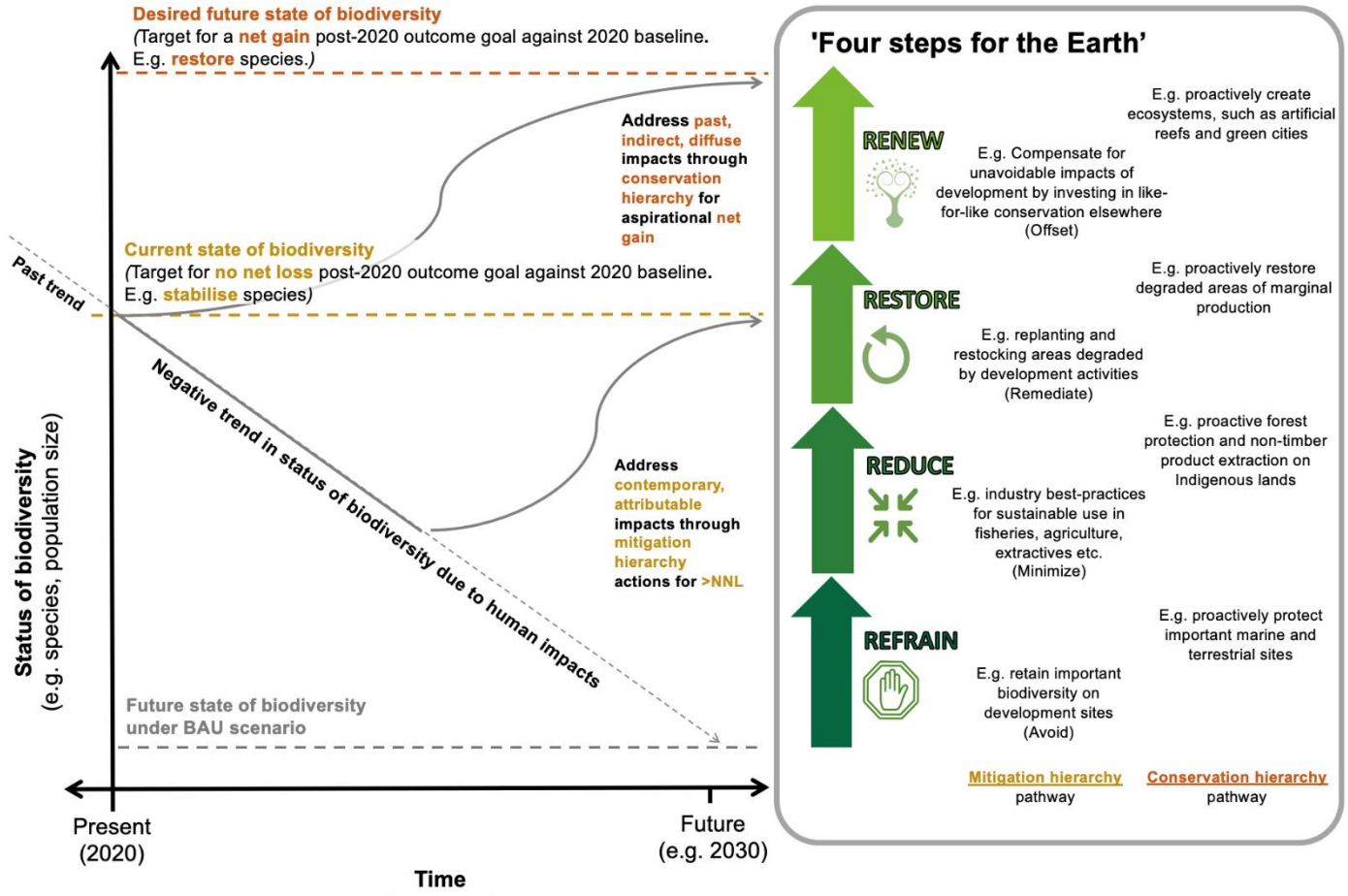


Figure 1: Representation of the Mitigation and Conservation Hierarchy concept

(Left) In the absence of conservation action, biodiversity will continue to decline due to ongoing human impacts. The Mitigation Hierarchy stream of the Mitigation and Conservation Hierarchy compensates for contemporary, attributable impacts toward a goal of "biodiversity net gain," while the Conservation Hierarchy stream recovers nature to a desirable future endpoint through addressing past, indirect, and diffuse impacts.

(Right) The "Four Steps for the Earth" framing of the Mitigation and Conservation Hierarchy has four consecutive steps of: refraining from causing negative impacts; reducing the impacts that are caused; restoring impacted nature; and renewing our relationship with nature through offsets and proactive conservation actions. These four steps can be implemented via to pathways: the

[1] Oxford Partnership for Operationalising the Conservation Hierarchy (OxPOCH) | Interdisciplinary Centre for Conservation Science (iccs.org.uk)

mitigation hierarchy, for mitigating future negative impacts, and the conservation hierarchy, for delivering additional conservation potential.

The Case For Biodiversity: why should we care?

Biodiversity is a distinct component of environmental sustainability

Biodiversity is defined as the variability among living organisms from all sources including inter-alia terrestrial, marine and other aquatic ecosystems, and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems[2].

Biodiversity is often seen as having little to do with the activities of a university and can sometimes be the forgotten element of sustainable campus operations. Frequently, we see institutions disregarding the need to treat biodiversity as a separate issue with claims that initiatives on climate will also tackle the global biodiversity crisis. It is true that biodiversity loss is caused by multiple interacting factors, of which climate change is increasingly important among these. However, addressing climate change alone will not solve biodiversity loss and maintenance of ecosystem services cannot be achieved by climate policy alone. Thus, since climate change and biodiversity loss are separate but interacting issues, they need to be tackled separately yet there are also benefits to addressing both in combination. In line with this perspective, our report highlights the benefits of using systematic biodiversity strategies, as well as the benefits of individual practices or projects that focus on biodiversity enhancement.

Universities have a duty to tackle global issues

By their very nature, universities are focused on research, teaching and service. Universities already play a leading role in tackling environmental issues through the application of their research, policy advice and educating its students. It therefore seems only right that a university should develop a strategy for addressing the negative biodiversity impacts of our own operations. As universities' mission and activities are not directly tied to financial or political gain, they have the capacity to test systems and technologies, and to advance innovative solutions to global challenges in ways that companies and municipalities cannot. Universities are one of very few settings in which active scientists, operational staff, and the youth (students) can all interact and collaborate to tackle a global issue, such as biodiversity loss. This unique community should be capitalised on in order to set an example for the institutions around us.

[2] Secretariat of the Convention on Biological Diversity, 2001. Handbook of the convention on biological diversity, London: Earthscan Publications.

Biodiversity plays a crucial role in sustainable development

Universities are incredibly important institutions that support and deliver on national and global environmental sustainability objectives, and UN Sustainable Development Goals (SDGs). Biodiversity components (that is, ecosystems, species, and genes) directly and indirectly deliver benefits that may contribute to the achievement of individual SDGs[3] other than goals 14 (life below water) and 15 (life on land). Recognition that benefits provided by biodiversity may help to fulfil all SDGs, and mainstreaming biodiversity considerations across a broad range of sectors, is crucial if universities are to take SDGs seriously.

Table 1 | How biodiversity benefits may contribute directly to SDGs:

Goal	How biodiversity may contribute
Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture.	Improves dietary quality Improves soil fertility, structure, quality, and health Provides crop pollination Provides pest control
Goal 3: Ensure healthy lives and promote well-being.	Provides source of medicines, vitamins, and minerals Improves immunity and reduces allergic dispositions Decreases stress and substance dependence Improves and restores mental health and well-being
Goal 6: Ensure availability and sustainable management of water and sanitation for all.	Reduces water pollution and improves water quality Reduces and delays run-off Contributes to freshwater provision
Goal 7: Ensure access to affordable, reliable, sustainable, and modern energy for all.	Provides sources of heat and power Reduces energy use through cooling, shade and shelter
Goal 8: Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all.	Enables sustainable economic growth Provides cost-efficient solutions Provides employment, for example, in natural-resources management, protected areas and tourism
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.	Provides green infrastructure Increases resilience of grey infrastructure Provides environmentally sound technologies
Goal 11: Make cities and human settlements inclusive, safe, resilient, and sustainable.	Improves air quality Provides urban cooling, heat-island mitigation Buffer's noise Reduces economic losses from disaster and recovery Contributes to sense of place and cultural value
Goal 12: Ensure sustainable consumption and production patterns.	Enables sustainable management Provides biodegradation and decontamination

[3] Blicharska, M., Smithers, R.J., Mikusiński, G., Rönnbäck, P., Harrison, P.A., Nilsson, M. and Sutherland, W.J., 2019. Biodiversity's contributions to sustainable development. *Nature sustainability*, *2*(12), pp.1083-1093.

Goal 13: Take urgent action to combat climate change and its impacts.	Sequesters and stores carbon and thereby mitigates climate change Reduces climate vulnerabilities and increases resilience

Financial benefits

Incorporating biodiversity into campus design may help universities to save money. For example, natural cooling from living walls and roofs can cut the cost of running air conditioning equipment and landscaping costs can be reduced by incorporating soft landscape features and systems, such as Sustainable Urban Drainage Systems (SUDS).

Managing land for biodiversity rather than for 'high intervention horticulture' can also lead to many cost savings. This includes:

- Leaving grass unmown for part of the year.
- Using native species, particularly that are chosen specifically for the local conditions (e.g. micro-climate, soil type, shade, sun), that are more likely to thrive with less management or watering.
- Reducing or eliminating chemical use.
- Using less water on lawns.
- Making your own mulch and compost by shredding tree and shrub waste.

Health and wellbeing benefits

Human wellbeing is intimately connected with our natural environment. Green spaces can improve physical and psychological health and biodiversity is increasingly being recognised as a cornerstone of a healthy, happy, prosperous, and sustainable society. A green campus enhances the work and study environment and provides opportunities for exercise and recreation. This can mean that a green campus may contribute to staff retention and student recruitment.

Biodiversity projects also provide an opportunity to form partnerships within an institution and beyond. Involving staff and students in projects will give them a common sense of ownership and interest whilst simultaneously stimulating awareness and interest in environmental issues. Additionally, involving local residents in projects demonstrates an active interest in the local environment which can enhance relations between local communities and their nearby universities, proving for more harmonious living.

Biodiversity Strategy

The Informal Approach

Informal approaches to biodiversity management are those which are not complemented by an overarching biodiversity strategy or plan. Most often, informal approaches ad-hoc biodiversity projects and initiatives that may be undertaken according to funds and resources available at a given time. An informal approach can often enable an institution to implement individual biodiversity projects quickly without being delayed by the process of developing institutional policy or strategies.

Informal approaches can be useful when trying to make quick improvements on the ground that are visible to everyone, thus making them effective at putting biodiversity on the map within an institution. However, limitations of informal approaches include often being limited to small-scale projects only and lacking larger funding.

Nevertheless, an informal approach to biodiversity management can still be an effective starting point to 'get the ball rolling' among peers before eventually forming a more formal commitment to biodiversity management as an institution.

The Strategic Approach

Strategic approaches are systematic and formally demonstrate how an institution will maintain and improve biodiversity on its campus. This embodies transformative, institution-wide change and can allow for more stable. Long-term allocation of funds.

Strategic approaches are characterised by:

1. **A formal sustainability/environmental/biodiversity group with budgets assigned to its activities**
2. **A biodiversity plan/strategy OR an environmental sustainability plan that explicitly incorporates biodiversity.**
3. **Institutional commitments to promoting biodiversity and wide publicity of these commitments.**
4. **Regular review of approaches and strategy.**

Table 2 | Approaches to Biodiversity by IARU universities:

University	Strategies Incorporating Biodiversity	Major Commitments & Targets
University of Oxford	Environmental Sustainability Strategy (2035) Estates Services Sustainability Design Guide	Biodiversity net gain across all estates by 2035. 20% net gain on all new developments.
University of Cape Town	Environmental Sustainability Strategy (2020) Landscape Framework Plan Green Campus Action Plan (2009)	To integrate various green campus elements that support UCT's aim to be a global leading green campus including biodiversity and sustainable food procurement.
University of Cambridge	Biodiversity Action Plan (2030)	Adopt Defra and Natural England intent to ensure new development projects will deliver a biodiversity net gain in excess of the statutory 10%. Achieve the metric-based biodiversity gain targets calculated for each habitat type.
University of Copenhagen	Knowledge and Responsibility – Sustainability 2030	Examine the areas in which UCPH's activities have the greatest impact on biodiversity and, on this basis, develop specific goals, targets, initiatives, and actions for UCPH as an institution.
UC Berkeley	Sustainability Plan inc. Built & Natural Environment and Land	Optimize sustainable development and renewal of facilities and infrastructure and enhance ecosystems and biodiversity as integral campus amenities. Enhance flora and fauna biodiversity and have proactively responsive preservation programs to address changing conditions such as climate disruption By 2023, produce a comprehensive sustainable built environment policy.
Yale University	Sustainability Plan (2025) Biodiversity Plan (in development)	By 2025, establish campus best practices, standards, benchmarks, and biodiversity goals and strategies to meet and measure performance.
ETH Zurich	Annual Sustainability Report Hönggerberg 2040 master plan.	Commitment to fulfilling the targets of the UN's Sustainable Development Goals (SDGs), including Goals 14 (Life Below Water) and 15 (Life on Land).
National University of Singapore	Sustainability Plan (2020)	Increase the number of Green Mark certified buildings to 40 by 2020. Green Spaces (in buildings) - Increase area of green spaces to 45,000 m2 by 2020.

Australian National University	Acton Conservation Area Plan Landscape Protection Guidelines	Identify aims, methods, and procedures to protect the landscape during any works that have the potential to cause damage and identify the respective responsibilities of University staff and external consultants and contractors in these processes.
University of Tokyo	Green Transformation Task Force	N/A
Peking University	N/A	N/A

Good Practice For Biodiversity Strategies

Consultation

Working with a wide range of stakeholders allows for a strategy that truly represents the interests and needs of the community, while a greater diversity of perspectives can allow for a more creative strategy with novel solutions to biodiversity problems. During strategy development, institutions should consider consulting:

- University policy/operations decision makers
- Grounds and Landscaping teams
- Academics and researchers
- Students
- Alumni
- Local and national environmental groups

Baselines

In order to make measurable improvements in certain areas a university must understand the biodiversity it currently has. To this end, biodiversity baselines can be used to inform the targets set by a biodiversity strategy. For example, Cambridge's 2018 biodiversity baseline formed the basis of most targets set in its 10-year Biodiversity Action Plan. Similarly, Yale plans to establish baseline data through mapping species diversity which will then advise target setting, following the same principle of establishing baselines prior to target setting.

The following practices will aid biodiversity baseline audits:

- Obtain or create suitable base maps that indicate the main features of the site.
- Use ecologist input where needed to help identify particular plants and animals
- Check for existing records, which may be in-house or held by the local Wildlife Trust or a biological records centre.
- Get details of any campus developments proposed by your institution.

SMART target setting

Institutions should aim to set biodiversity targets that are specific, measurable, achievable, relevant, and timed (SMART), as well as ensuring that any proposed biodiversity initiatives are SMART too. This evidence-based approach will enable progress to be easily tracked and ensure that strategies stay on track.

Ensure that these targets consider:

- Ecological priorities.
- Funding and staff availability.
- The timing of related management activities.

Regular review

Continual review of progress contributes to the SMART element of a strategy while also making sure that long-term plans do not lose their vigour within the first few years. Reviews are most well-accompanied with a publicly available annual report which exhibits progress.

However, most importantly, regular review means that biodiversity strategies can be kept as dynamic, live documents that are subject to be updated in response to new information. For example, the Cambridge BAP is to be checked annually with a horizon scan of any new internal or external factors for consideration and reflection in the BAP, including policies, research, and results to date. This means that targets and initiatives can be altered as the University learns more about its existing habitats and species, or response to other factors such as changing funds.

For those institutions with little understanding of their estates biodiversity, a system of regular reviewing will mean that biodiversity targets can still be set without having large amounts of data beforehand. Then, as data is retrieved, this can be incorporated into the strategy and targets adjust appropriately.

Specify the actions needed to achieve the targets

For example, agreeing changes to management practices such as grass cutting, hedge trimming and the species that are selected for planting and introducing projects and work programmes that benefit biodiversity. This information could be specified in a separate Implementation Plan or overseen by a Subcommittee for implementation.

Biodiversity Baselines

Table 3 | Summary of biodiversity data collection by IARU universities

University	Biodiversity Data Available	Accurate Mapping of Green Spaces?
University of Oxford	Phase 1 habitat surveys for some estates. Baseline of all university landholdings to be available by spring 2022.	✓
University of Cape Town	Periodic reviews and audits of different campus habitats but overall baseline incomplete.	✓ – Developing arial visuals and 3D drone mapping to better understand fire risk on estates.
University of Cambridge	Biodiversity baseline 2017-18 capturing habitats and 'notable' species data. Habitat data from phase 1 habitat surveys, , the University's Woodland Management Plan, and surveys of County and City Wildlife Sites by the Wildlife Trust. Grassland, wetland, and ditches to be re-surveyed every five years. Woodland, scrub, hedgerows, and lakes/ponds to be re-surveyed every ten years.	✓– ArcGIS 'Biodiversity Map' stores habitat data covering the entire University estate. The Biodiversity Map centralises information on the type and condition of existing habitats, as well as targets for improving habitat condition.
University of Copenhagen	Absent.	✓ – Limited to a few sites and does not cover all landholdings.
UC Berkeley	Renewed biodiversity baseline in campus Long Range Development Plant / Environmental Impact Report 2021 (LRDP/EIR) Full tree survey of main campus (200 acres developed land). Long term bird surveys.	✓ – EIR maps vegetative cover and wildlife habitat, potential for special-status species and sensitive natural communities, and presence of wetlands associated with the UC Berkeley campus.
Yale University	In process of developing baseline data through mapping species diversity across campus. Complete Tree Survey and Management Plan. Yale Biodiversity Hub for sharing biodiversity-related GIS data about Yale and the surrounding area.	Yes - ArcGIS mapping of campus parks and preserves, campus trees, and New Haven Urban Forest. Maps publicly available via the Yale Biodiversity Hub
ETH Zurich	Biodiversity audits done according to construction and maintenance needs.	✓ – Hönggerberg campus mapping includes accurate tree data.

National University of Singapore (NUS)	Absent.	✓ – GIS mapping of trees, with 6500 trees inventoried from 2012-2018.
Australian National University (ANU)	ANUgreen coordinates following monitoring programmes: - Major bird servery every 5 years. - Annual frog monitoring at 140 sites. - Monthly sampling of Sullivans Creek water quality. - Annual updates of campus weed database. - Tree database for all 10,500 trees on campus	✓ – Acton Conservation Map and Tree Management Database.
University of Tokyo	Tree data for university forests	✓ – Used for development purposes.

Overall, we find that most IARU institutions have demonstrated commendable systems for databasing trees and surveying habitat types. However, fewer institutions have made efforts to record or survey animals on campus.

Good Practice For Biodiversity Baselines

Biodiversity surveys of a campus can be broken into four elements:

1. **Pre-survey preparation**
2. **Habitats**
3. **Species**
4. **Monitoring and repeat surveys.**

1. Pre-survey preparation

Carry out any relevant risk assessments

- Preliminary assessment of existing survey information held by staff, students, biological records centres, local authorities, or local wildlife groups.
- If necessary, seek help from experts e.g., ecologists.
- Choose the best time of year for the organisms being surveyed – for most species this is spring and summer.
- Factor costs of equipment and labour.

2. Habitats

- Aim to indicate and describe habitats that are present on a large-scale map.
- Once broad habitats are described, these can be sub-divided to add details of management practices in each habitat e.g., managed/unmanaged grassland.

3. Species

- Identify notable and important species in your local area during preliminary research by consulting biological records centres, local authorities, or local wildlife groups.
- Undertake targeted surveys to see if notable or important species are present on campus.
- General surveys will provide insight into how the species richness of a campus.

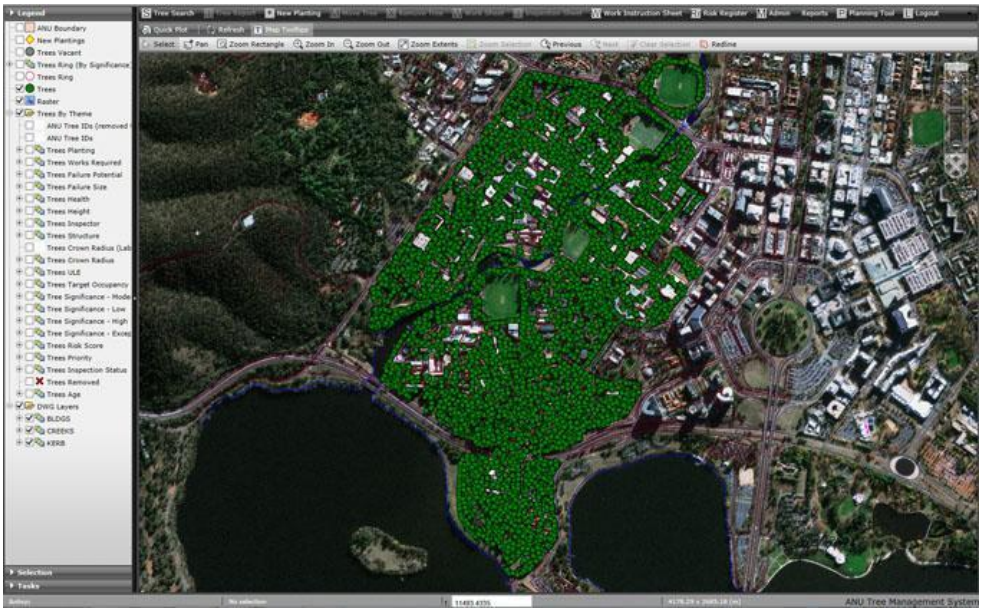
4. Monitoring and repeat surveys

- Make accurate initial observations.
- Make follow-up observations using the same methods in order to monitor fluxes in biodiversity. This could be done in a periodic fashion, for example, surveying one area each year on a multi-year rotation.
- Make use of electronic tools for record keeping. Many tools incorporate citizen science to allow for continuous monitoring which is contributed to by various members of the community.

Box 1: Tree monitoring at Australian National University (ANU)

Trees play a particularly important ecological role in both urban and rural landscapes. They increase biodiversity by providing plants and animals with a favourable habitat, food, and protection. Mature trees can also absorb up to 150 kg of CO_2 per year, cool the air to reduce urban heat island effects, filter urban pollutants, and regulate water flow to reduce flood risk. We must also not forget the cultural significance that trees can have in the effort to preserve the heritage of a landscape.

Generally, the IARU institutions have demonstrated commendable systems for databasing trees. The ANU Management Plan for Trees provides an excellent example of these efforts to both create and utilise databases for the conservation of trees.



The Tree Database includes over 10,500 trees, each with detailed information including:

- Genus and species
- Common name
- Dimensions
- Age
- Health and structure
- Significance
- Quality
- Useful life expectancy
- Works required and priority
- A risk score (recorded and updated each time a tree is inspected)
- Standardised Tree Protection Zone around which no activity can be undertaken unless stated otherwise by the ANU Arborist.

Tree damage is minimised by making referral to the database a compulsory precondition for all work on the campus that has the potential to damage trees. In all cases where work may impact on the Tree Protection Zone of a tree (irrespective of its particular classification), the ANU Arborist, or designated University Officer, is to be consulted before any work commences.

Biodiversity Projects

Horticulture & Habitat Restoration

The Royal Horticultural Society (RHS) recognises that biodiversity has an essential role to play in gardening and grounds maintenance from the maintaining soil health and fertility to the provision of natural pest control and pollination. Horticulture and vegetation also play a significant role in restoration of both terrestrial and freshwater habitats primarily due to the role that plants can play in regulating environmental conditions.

Wildlife gardening, usually in the form of wildflower planting, has been a popular initiative across a range of IAUR institutions. This form of landscaping encourages grass and other plants to grow tall, with greater numbers of wildflowers and other native plants. Taller and more diverse vegetation improves habitat conditions for native species of plants and wildlife, including birds and butterflies.

In general, it is good practice to aim towards creating a mosaic of habitats using a variety of plants, trees and shrubs of different heights and flowering patterns. This will provide for as many animals, bird, and insect species as possible throughout the year.

Table 4 | Wildlife gardening and habitat restoration projects

University of Oxford	Old Road Campus: native cornfield wildflowers and fruit trees planted using seed mix of 10 native species of UK-harvested annual wildflowers Science Area Landscaping Project
University of Cambridge	Greenwich House: Bee-Friendly wildflower meadow, bird, and bat boxes. west Cambridge wildflower projects: - veterinary school: wildflower area. - Civil engineering building: planted two 75m wildflower strips. - Maths faculty building: 350m rooftop wildflower area. - West Cambridge lake: established wet grassland areas.
University of Copenhagen	Vild Campus 2015: built five natural areas in the University Park at Nørre Campus next to the Zoological Museum, Copenhagen. More than 10,000 flowers have been planted across 80 different wild species, transforming 620 m^2 of lawn. Plants represent native flora of Danish forests, grasslands, and meadows. Vild Campus has five times as many bees and over twice as many different species of bees compared to a traditional lawn. Maersk Tower Campus park: wild flower area, a diversity of tree species and a number of different biotopes.
UC Berkeley	Strawberry Creek habitat restoration: riparian enhancement, prairie restoration, ecological stabilisation. Certified Bee Campus USA
Yale University	7 urban meadows and rain gardens installed throughout campus. Urban meadows are designed to promote natural regeneration, leading to increased biodiversity, improved water quality, and a reduction in stormwater runoff and soil erosion.

	Urban Resources Initiative: planted more than 8,000 trees in the City of New Haven.
ETH Zurich	Landscapers cultivate 6 hectares of turf, sports fields, and alkaline grassland, as well as 13 hectares of meadowland. These grounds are not fertilised and have limited mowing to encourage biodiverse growth patterns. Grün Stadt Zürich initiative: One dozen native fruit and nut trees planted around the SeedCity garden (1000m^2)
Singapore	Greening NUS for Climate Action: 10,000 trees will have been planted across Kent Ridge and Bukit Timah campuses by the end of 2021, with a target of 80,000 new plantings by 2030.

Attracting Wildlife

Aside from planting vegetation and restoring habitats, universities can use artificial interventions to attract animals to their lands. Artificial structures can replace natural nest, roost, and hibernation sites. Alternatively, careful landscaping can be used to improve habitat connectivity by providing migration routes.

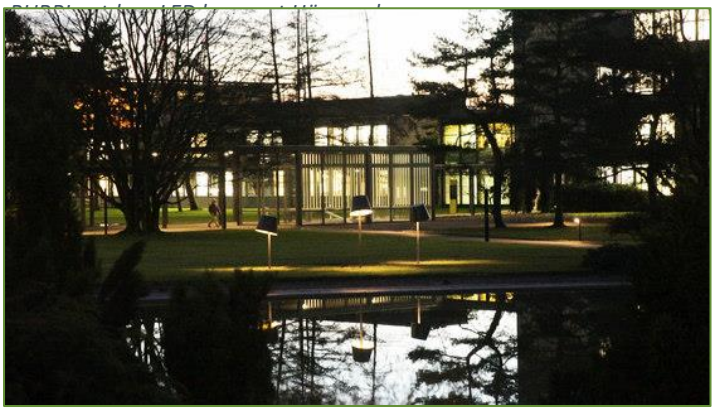
Plan Bee – University of Oxford

Bee hotel at Plant Sciences Department, Oxford.

The Plan Bee project aims to create a network of bee hotels across the city of Oxford and in Wytham Woods (an area of ancient woodland just outside the city). These bee hotels will improve the value of the University and city infrastructure as habitat for cavity-nesting solitary bees. Cavity-nesting solitary bees do not live in big colonies, are excellent pollinators, and are harmless to humans, so they're ideal for a space that is shared with people, such as gardens, courtyards, or any public area that includes flowering plants.

The nest-boxes also offer a research opportunity. It is possible to observe occupancy and species diversity year to year in the different habitats, collect bees and nest material from the hotels to analyse forage plant species (through pollen analysis), and study the population genetics of the bees.

Wildlife-friendly lighting – ETH Zurich



Employees cover all shafts on buildings with finely woven wire mesh or installed escape routes for the amphibians, saving the lives of hundreds of frogs, toads, and newts. The Bat Protection Plan informs staff and students on behaviours to prevent bats from becoming trapped inside buildings. Predominant use of downward focussed LED lights on Hönggerberg campus minimises light pollution and disruption of animals' biological clocks.

Green Infrastructure

Green infrastructure can be described as a network for solving urban and climatic challenges by building with nature[4], in order to regulate the external environment . The main components of this approach include stormwater management, climate adaptation, less heat stress, more biodiversity, food production, better air quality, sustainable energy production, clean water, and healthy soils.

Green Roofs – National University of Singapore

Aside from providing habitats for wildlife, green roofs also provide ecosystem services by extending the life of roofs, regulating surface temperatures, reducing energy consumption, reducing water run-off, and creating a visually attractive building.

National University of Singapore (NUS) increased green spaces in buildings (green roofs and vertical greenery) to **45,00m^2 between 2012 and 2020**, contributing to the University's 2030 target to cool campuses by over 4^{o}C.

The university finds that:

- Bare rooftops and concrete surfaces act as heat sinks, making urban areas 3 degrees hotter than forested rural areas, whereas skyrise greenery shields bare surfaces from the harsh tropical sun and creates more cooling areas.

- After 18 months without cutting, surface temperature of the 2500m^2 NUS Ventus garden was **4^{o}C lower** than surrounding lawns.

Green Roof designs on the NUS campus

- The carbon sequestration potential of skyrise greenery is about **0.375 kg/m^2 per year**. This can be used to guide the green plot ratio to be applied to the built-up area of a development during the design stage. This initiative can be used as a guid to determine optimum quantity of plants required to achieve desired carbon footprint off-set targets.

[4] Hiltrud, P. and Pierre, B., 2011. Urban Green-blue Grids for Sustainable and Dynamic Cities. *Coop for Life, Delft*.

Stormwater & Flood Management – UC Berkeley

The following building designs help to reduce flood risk in and around the UC Berkeley campus:

- **Rain Gardens –** Runoff from the roof of the Blum Centre is directed into a series of stormwater catchment gardens in front of the building. These gardens, which are landscaped with native plants, are fully irrigated by the water that runs off the roof in rainstorms. The plants absorb much of this runoff and the soil immobilizes pollutants that wash off the roof. Maintenance costs for these stormwater catchment gardens are much less than for lawns because they don't require fertilizer, irrigation or mowing.
- **Vegetated Bio-swale –** a landscaped feature designed to use plants and porous soil materials to catch and store runoff and filter out pollutants. Water that runs off from the surrounding asphalt will drain towards the centre of the swale, irrigating the planted vegetation.
- **Redwood Cribwall –** An effective solution to bank stabilisation for protection against floods. Entails a redwood wall designed for vegetation to grow over an interlocking structure of redwood logs. As the logs decompose over time, the roots from the vegetation will suffuse the logs themselves, locking the bank into place and creating a sustainable solution to erosion of the strawberry creek channel. Considered to be stronger and longer lasting than traditional retaining walls built out of concrete.

(Left) Catchment gardens planted with native vegetation in front of the Blum Centre. (Right) Vegetated

Native Biodiversity

Using native plants, shrubs and trees will contribute to the maintenance of species that will be adapted to local soils and climates. They will also, generally, provide better habitat and food sources for native animal species.

Understanding the balance between heritage and biodiversity – University of Cape Town

On the University of Cape Town (UCT) upper campus, sitting underneath Devil's Peak, exists a significant forest of non-indigenous trees including Mediterranean Cyprus trees, pines, and eucalyptus. Criticisms for the presence of such vegetation has been sparked due to the forests susceptibility to causing widespread fires. Efforts have been made to reintroduce endemic cape flora in the upper campus, particularly with colonisation of native geophytes which are less likely to catch fire. However, the non-native trees constitute a significant aspect of the site's cultural and historical heritage. Thus, university landscapers must strike a balance between reintroducing native biodiversity and preserving historical aspects of the landscape.

Using native biodiversity to manage fire ecology – UC Berkeley

In many areas of the Berkeley hill campus, invasive and non-native plant species have negative impacts on the fire ecology of the region and increase the risk of forest fires. This has resulted in the Policy to Manage the Hill Campus Landscape to Reduce Fire Risk and Restore Native Vegetation. General treatments used to meet targets:

- Reducing fuel load by removing dead material, reducing plant density, and favouring species with lower fuel content.
- Selective replacement of high hazard introduced species (E.g., broom, acacia, pampas grass), and aged Monterey pines and secondary growth eucalyptus, with native grasses and oak-bay woodlands.
- Reducing horizontal spread by reducing fine fuel material and by separating dense clusters of vegetation with areas of lower fuel load.

Pest control

Controlling the population of non-native species may occasionally be necessary on some campuses. In any case, pest management should always use humane methods that affect only the target

species and that do not persist in the environment or affect other species in the ecosystem. For example:

- **UCT's Pest Control Programme** removes alien species such as rats using non-pesticide approaches
- **UC Berkeley's Integrated Pest Management Plan** aims to reduce the use of synthetic herbicides. 95% of the campus landscape is managed organically.

Habitat Connectivity

A major component of an ecological community is habitat connectivity. Green spaces on university campuses tend to arrange in highly dispersed patches, which can limit dispersal and migration opportunities for wildlife. Though increasingly difficult in more urbanised settings, certain campuses and estates do have potential for establishing an ecological network to connect areas of high biodiversity value through physical habitat corridors or 'stepping stones'. Examples include:

- **'Back Garden Biodiversity' Initiatives:** Wildlife gardening or bird feeders to provide resources for travelling species. Modifications to fencing to allow small animals to move through garden complexes.
- **Farmland connectivity:** Establishing wildlife corridors via hedgerow extension, linear pond creation, selective tree planting and grassland creation on less productive areas of land.
- Assess, develop, and protect existing **natural corridors**

Development Projects

Development commonly consists of designing, building, operating, and maintaining - each of these stages of a development scheme generates opportunities to help achieve an overall benefit for biodiversity. This is perhaps best achieved by embedding biodiversity within campus development documentations. Table 5 highlights notable development strategies that specify biodiversity management.

Table 5 | Development strategies incorporating biodiversity

University	Strategy
University of Oxford	Sustainability Design Guide
University of Cambridge	Estates Strategic Framework
University of Copenhagen	University Campus Master Plan and campus plans to be developed 2021-23
UC Berkeley	Long Range Development Plan / Environmental Impact Report (LDR/EIR) 2021 Campus Master Plan (expected 2021).
Yale University	Framework for Campus Planning
ETH Zurich	Hönggerberg Campus Development Masterplan 2040
Australian National University	Landscape Protection Guidelines Tree Management System for Development Heritage Management Plans (HMPs)

Principles For Biodiversity Net Gain During Development

The development principles of **CIEEM**[5] (Chartered Institute of Ecology and Environmental Management) can be used as good practice principles for embedding biodiversity in campus development plans. The principles are designed for achieving net biodiversity gain, defined here as: development that leaves biodiversity in a better state than before and where developers work with local governments, wildlife groups, landowners, and other stakeholders in order to support their priorities for nature conservation.

[5] *10 principles for net gain.pdf

Table 6 | CIEEM good practice principles for development

Principle	Description
Principle 1: Apply the Mitigation Hierarchy	Do everything possible to first avoid and then minimise impacts on biodiversity. Compensation and offsetting should only be used as a last resort in agreement with external decision-makers.
Principle 2: Avoid losing biodiversity that cannot be offset by gains elsewhere	Avoid impacts on irreplaceable biodiversity.
Principle 3: inclusive and equitable	Engage stakeholders early, and involve them in designing, implementing, monitoring and evaluating the approach.
Principle 4. Address risks	Mitigate difficulty, uncertainty and other risks to achieving Net Gain.
Principle 5. Make a measurable Net Gain contribution	Achieve a measurable, overall gain1 for biodiversity and the services ecosystems provide while directly contributing towards nature conservation priorities.
Principle 6. Achieve the best outcomes for biodiversity	Delivering compensation that is ecologically equivalent in type, amount and condition. Compensating for losses of one type of biodiversity by providing a different type that delivers greater benefits for nature conservation. Enhancing existing or creating new habitat. Enhancing ecological connectivity by creating more, bigger, better and joined areas for biodiversity.
Principle 7. Be additional	Achieve nature conservation outcomes that demonstrably exceed existing obligations (i.e., do not deliver something that would occur anyway).
Principle 8. Create a Net Gain legacy	Engaging stakeholders and jointly agreeing practical solutions that secure Net Gain in perpetuity. Planning for adaptive management and securing dedicated funding for long-term management Designing Net Gain for biodiversity to be resilient to external factors, especially climate change.
Principle 9. Optimise sustainability	Prioritise Biodiversity Net Gain and, where possible, optimise the wider environmental benefits for a sustainable society and economy.
Principle 10. Be transparent	Communicate all Net Gain activities in a transparent and timely manner, sharing the learning with all stakeholders.

Sustainability Certifications

IARU universities utilise a variety of third-party certifications to verify the sustainability of development projects. Some use globally recognised certifications, while others use unique, national certification schemes. Furthermore, where some universities informally aim to achieve certification where possible, other universities have certification requirements embedded within development policy meaning that all projects must achieve a minimum level of certification.

Notable certifications for assessing biodiversity credentials of development project:

- **Building Research Establishment Environmental Assessment Method (BREEAM)**
- **Leadership in Energy & Environmental Design (LEED)**
- **Building Construction Authority (BCA) Green Mark**
- **Green Building Council of South Africa (GBCSA) Green Stars**

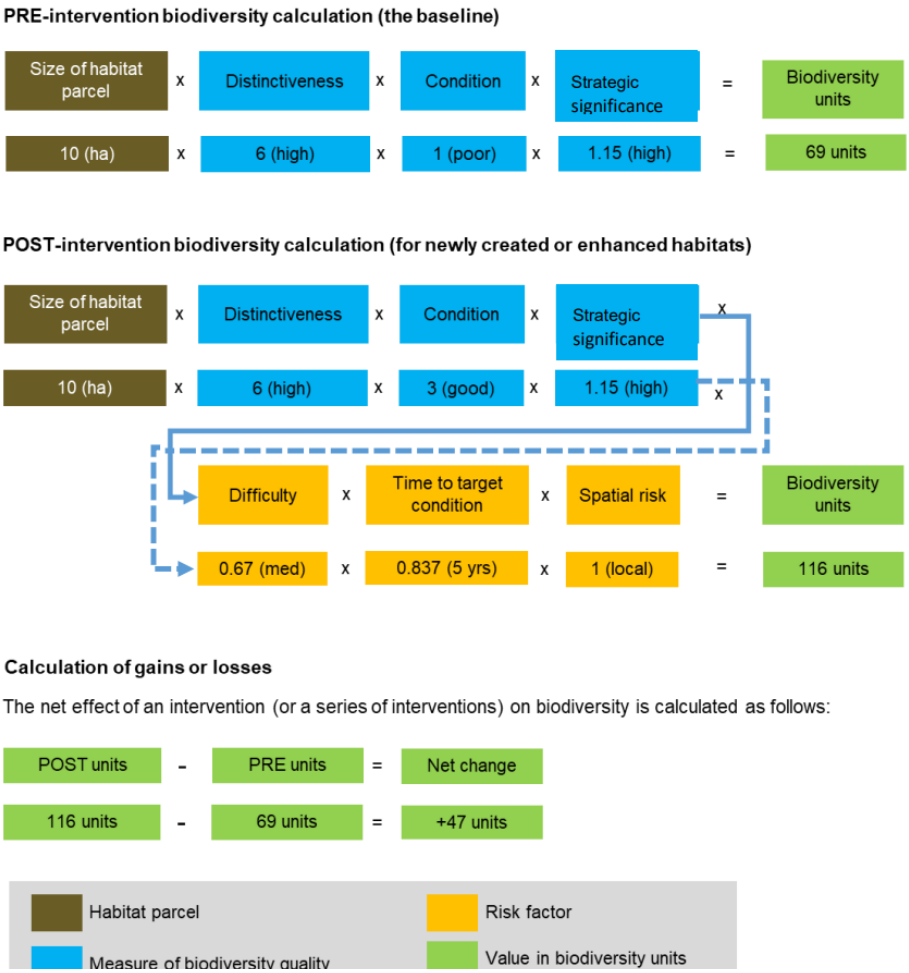
Biodiversity Metrics

Biodiversity metrics provide a way of measuring and accounting for biodiversity losses and gains resulting from development or land management change, as well as predicting the likely effectiveness of creating new or enhancing existing habitats. For example, box 3 summarises the calculation of biodiversity values using **Natural England's Biodiversity Metric (NEBM) 3.0**. This metric uses habitat area and quality as a proxy for wider biodiversity.

Why use a biodiversity metric?

- Take better account of biodiversity in designing plans and making land management decisions.
- Quantitatively demonstrate biodiversity net gains or losses in a robust and consistent manner.
- Compare different project proposals for a site using the same metric, allowing more objective assessments of alternative approaches to be made.
- Calculate the amount of offsetting required for projects involving unavoidable biodiversity losses.

Box 2: Using the NEBM 3.0 to calculate the biodiversity unit value of a habitat



Calculation of the biodiversity value for habitats is divided into categories:

1. The pre-intervention calculation that establishes the baseline biodiversity unit value of a habitat. In essence, that multiplies the size of a habitat parcel by its 'quality' scores.

2.The post-intervention calculation that gives you the biodiversity unit value of a habitat after it has been changed. This calculation also takes account of the difficulty, time, and risk associated with creating or enhancing habitats.

Metrics are highly versatile – Cambridge Biodiversity Metric

The **Cambridge Biodiversity Metric (CBM)** is a modified version of the NEBM. The primary purpose of the CBM is to quantify and set targets for biodiversity increases across existing habitats on the University's estate, or order to meet the ambitions of the University's BAP. The CBM highlights how biodiversity metrics are not just limited to development or construction projects but can also be used in efforts to measurably enhance and restore natural habitats. Thus, biodiversity metrics can be a powerful tool for measuring biodiversity gain on both developed and undeveloped lands.

Table 6 | Habitat biodiversity targets calculated using the CBM

Habitat type	Area or length of habitat with CBM target	Area or length of habitat whose condition will be increased	Target percentage CBM increase (%)	Target year for measuring target percentage CBM increase	Area or length of habitat whose condition will be maintained at its present (good) level	Target year for checking that CBM targets are 'on track'
Grassland	2 ha	N/A	N/A	N/A	2 ha	2025
Scrub	7 ha	2 ha	150	2030	5 ha	2030
Woodland	66 ha	59 ha	36	2050	7 ha	2030
Hedgerows	12.4 km	7.9 km	24	2030	4.5 km	2030
Lines of trees	2.4 km	2.1 km	123	2050	0.3 km	2030

Source: University of Cambridge Biodiversity Action Plan

Engagement

Universities are uniquely positioned to provide its members with sustainability learning both within and outside of the examined curriculum. By committing to fighting against biodiversity loss, universities should also be prepared to engage members with biodiversity on campus and stimulate them to think about the wider role of biodiversity in society. This engagement and education can then be extended to non-members from the wider community who share space and live amongst university campuses. By engaging students, staff, and the wider community with biodiversity projects and initiatives, universities may add an extra layer of impact to the good works already carried out. In the case of many small-scale campus initiatives, the value of a certain biodiversity project may actually lie with the indirect benefits of raising awareness amongst people rather than the direct biodiversity gains associated with the project.

Across the board, IARU institutions have done well to formalise commitments to engagement within sustainability policies, including:

- Offering all students, the opportunity to study environmental sustainability, either within or outside the examined curriculum.
- Encouraging students and staff to adopt more sustainable practices.
- Encouraging staff, students and the wider public to share their knowledge, skills and experience in ecology and natural history
- Keeping the community updated on advancements through effective communication.

Ways To Engage

Incorporate sustainability into student orientation programmes

- Ensure presence of the sustainability department (or similar university office) during orientation events (such as Fresher's fairs) so that staff can provide resources and inform new students about sustainability activities and programs around campus.
- Include sections on sustainable behaviour within any online or in-person orientation classes.
- Provide information about sustainable food systems for any large catered events, such as first-week welcome dinners.

Communications

Ensure that examples of good practice are effectively and publicly communicated so that stakeholders can easily find evidence of commitment to biodiversity and sustainability. For example:

- A central sustainability website that consolidates information about the institution's biodiversity efforts.
- An annual sustainability newsletter.
- Social media platforms (e.g., Facebook, Twitter, interactive blogs) that focus specifically on campus sustainability
- Brochures with maps that locate the university's key natural habitats and biodiversity areas.
- Signage on the grounds about groundskeeping and/or landscaping strategies employed.
- Labelling food choices in canteens with information on sustainable sourcing and/or environmental impacts associated with particular items.

Sustainability focused employment – Yale Urban Resources Initiative

Paid opportunity provides greater incentive for individuals to learn trades that benefit biodiversity, while also connecting people to their environment.

Yale's Urban Resources Initiative (URI) offers both:

- **Greenspace internships (Yale students)** – Provides materials, technical advice, and classroom-based and hands-on training to support resident-driven community greening projects. Since 1995, Greenspace has completed more than 310 diverse urban restoration projects.
- **GreenSkills local jobs programme (high school students and adults with employment barriers)** – provides employees with marketable job skills while also fostering a sense of environmental stewardship and learning about local ecology.

Sustainable food systems

Urban agriculture projects are an effective way for students to gain experience in organic agriculture and learn the importance of sustainable food systems. Even in heavily urbanised settings, Sustainable Community Agriculture (SCA) can run with relatively little space and low maintenance.

ETH Zurich's Seed City is maintained by a volunteer association of students and staff. It aims to:

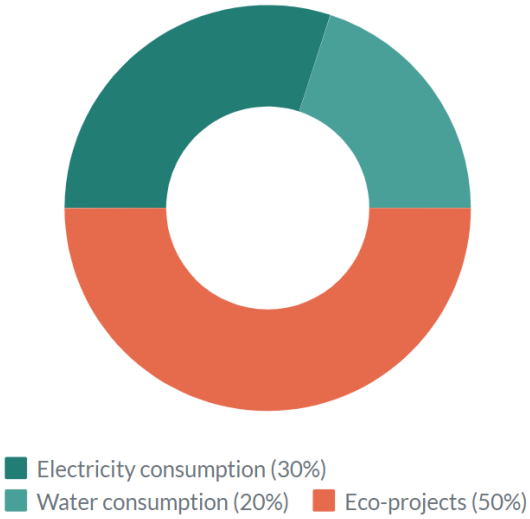
- Promote local waste recycling, food production and biodiversity conservation.
- create a closed-loop system of local vegetable gardens of rare and endangered crop varieties fed with composted waste from the campus.
- Establish a vegetable delivery scheme with organic producers in the region.

Outreach Programmes

Biodiversity-related outreach campaigns can yield measurable, positive results in advancing people's knowledge of biodiversity. Outreach campaigns of this nature can take the form of a competition and/or a collective university challenge.

Box 3: Outreach Competitions

NUS Inter-hall environmental award:



Source: uci.nus.edu.sg

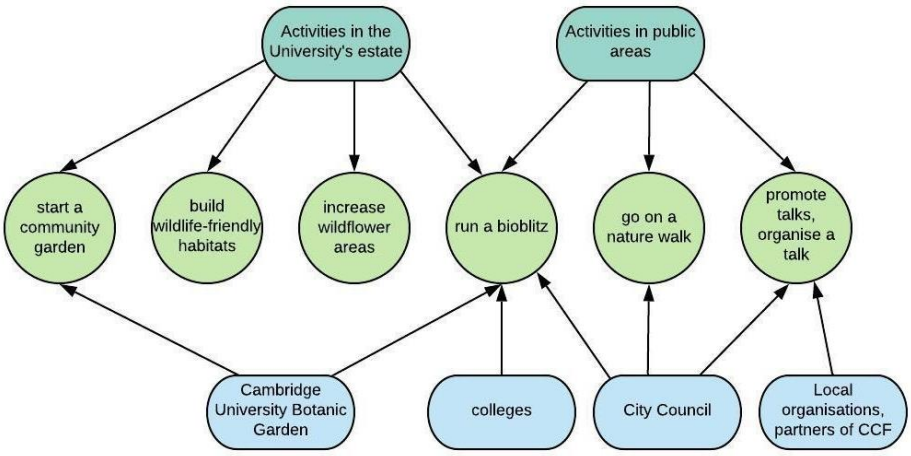
A yearly award that seeks to engage the Halls to reduce NUS' environmental impacts and to cultivate environmentally responsible citizens amongst the Hall residents.

Eco-project components comprises 50% of the award.

Prizes ranging from $800-3000.

University of Cambridge 'BiodiversiTeams':

- Part of the Wilder Cambridge project for engaging with biodiversity in the University.
- Teams are put together and provided with an engagement pack containing ideas of activities, identification charts, 'how to' sheets, and a list of local partners who can be contacted.
- The competition encourages **any** activity related to biodiversity, whether it is mentioned in the engagement pack or not.
- Range of different prizes available.



Source: Cambridge Biodiversity engagement Plan

Citizen Science

The involvement of non-professionals in scientific research and environmental monitoring, termed Citizen Science (CS), has now become a mainstream approach for collecting data on earth processes, ecosystems, and biodiversity[6]. An increasing need for species data collection can now be met by ordinary non-scientists equipped with smartphone applications and user guides. Wildlife records do not only play an important role in making planning and development decisions but are also one of the most important sources of data informing conservation science and policy.

Source: Cambridge Festival 2021

iRecord is a website for recording and sharing observations of insects, birds, mammals, and plants.

Data is collected, checked by experts and made available to support research and decision-making.

Examples of iRecord in action include Oxford's Wytham Woods, and the Cambridge Festival 2021.

Bioblitz:

- An intense period of biological recording with the goal to record all the living species within a designated area.
- These can be led by experts that train and supervise the visiting public, ensuring their involvement does not compromise accurate methodology.
- In collaboration with the University Museum of Zoology and conservation partners across Cambridge, the Cambridge Botanic Garden has held Bioblitz successful events in 2011, 2012, 2015, 2019, 2020, and 2021.


Migrant Hawker, Cambridge Botanic Garden Bioblitz 2020, by Geoff Oliver

[6] Chandler, M., See, L., Buesching, C.D., Cousins, J.A., Gillies, C., Kays, R.W., Newman, C., Pereira, H.M. and Tiago, P., 2017. Involving citizen scientists in biodiversity observation. In *The GEO handbook on biodiversity observation networks* (pp. 211-237). Springer, Cham.

Curriculum

From an academic perspective, universities can capitalise on their campus by using its own green spaces and green initiatives as learning tool for course curricula. By adopting the **Living Lab** concept, research and learning does not need to be limited to the classroom and the laboratory with only academic staff leading this work. Instead, the campus itself should be considered a classroom in which elements of research and learning can occur through the campus and its operations. Consequentially, as efforts to enhance campus biodiversity increase, so will opportunities to use the campus as a learning resource for teaching in the fields of biodiversity and the natural world.

Living Lab

Vild Campus – University of Copenhagen

The University's Vild Campus project is used for teaching biology undergraduates plant recognition and ecology.

Living Lab Associates – University of Cambridge

Students can become a Living Lab Associate by using the university as a case study or 'testing ground' for a research project, dissertation, or thesis. This includes access to data, contacts, information, or funding to carry out research and projects with tangible impacts. Projects can be focused on biodiversity or a range of other topics.

Additional Considerations

The following commitments may also contribute to improving accessibility of environmental courses as well as improving institutional expertise in areas such as climate, biodiversity, and sustainability:

Ensuring that all courses with sustainability content are easily identifiable

- **Yale University's 'Green Courses' guide** is catered to students interested in exploring sustainability through Yale's curriculum.

- **ETH Zurich's Sustainability Catalogue** describes each course and how it relates to the 17 SDGs of the UN Agenda 2030.
- Berkeley has identified over 1,000 courses (almost 50% of the curriculum) that are sustainability related and mapped these courses to the SDGs.

Upgrade the curriculum

- Encourage and monitor existing degree programmes' development of further environmental sustainability streams in the core curriculum.
- Consider and support new courses related to interdisciplinary environmental and social sustainability questions.

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