Final Report for the IARU Fellowship 2014

Review of Biodiversity Strategies, their implementation within the Higher Education Sector, and the impact of future legislation for the University of Oxford

by Anna-Mateja Delas,
Research Assistant in Economics from ETH Zurich for the Environmental Sustainability Team, University of Oxford Estates Services

Contact Details: annamateja.delas@gmail.com
Address: Säntisstrasse 21, CH - 8008 Zürich

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The aim for this report was to examine how biodiversity on campus should be best approached. For the first step, I looked at what other universities (belonging to the Russell Group and IARU) do. For the second step, I investigated which kind of values can be attributed to biodiversity, i.e. by which methods "nature" can be evaluated. From there on, I aimed at developing my own toolkit for biodiversity, which should help practitioners and managers to get a grasp of the complexity of biodiversity and how it should be approached on a local level. The rationale of developing a toolkit with appropriate measurement techniques was also due to the fact that clear guidelines on how universities measure and manage campus biodiversity lack in biodiversity reports. The toolkit is not complete, but it covers all major aspects of the topic biodiversity, and what needs to be considered for its management. In a final step I give recommendations. A draft action plan is included in the appendix.

I hope that some of the methodologies I developed for this report can be used in practice.

1 INTRODUCTION

"Biodiversity is all living things, from the tiny garden ant to the giant redwood tree. You will find biodiversity everywhere, in window boxes and wild woods, roadsides and rain forests, snow fields and sea shore." [UK Biodiversity Report, 1995]

Habitat destruction (e.g. coral reefs), deforestation (e.g. mangrove forests), over-exploitation (e.g. fish), contamination and pollution, invasive species, and climate change belong to the many causes contributing to significant declines in biodiversity (BD)[1] rates. Induced by international [e.g. CBD] and national legislation it has become indispensable to approach BD enhancement on a local level, and universities can do much to act as role models for successful BD management.

What follows from the EAUC [2006][2] there exist several benefits for universities that actively pursue BD on campus:

1. better reputation & green image
2. valuable partnerships between staff & students
3. education opportunities & "curriculum greening"
4. healthy living & wellbeing
5. opportunities to volunteer
6. support from local authorities for future planning of retrofit & new buildings
7. reduced costs because of landscape maintenance
8. compliance to legislation (local, national, …)
9. further benefits such as CO_2 mitigation & flood prevention

Because of such advantages and because the University of Oxford is a major landowner (and therefore having a big role in decision-making), spurring BD on campus should be seen as a high priority goal.

[1] BD is the acronym for biodiversity, and will be used throughout the entire report.

[2] See < http://www.eauc.org.uk/home>.

For this goal it is important to know about how BD is best approached in terms of measurement and appropriate representation. The following report then aims at developing management guidelines and recommendations for the question of how to enhance nature on campus. In this sense it tries to further develop the BD Strategy Draft for the University of Oxford.

The following report is structured according to the following roadmap ("action" → "output"):

0) desktop assessment of what is already there relating to BD and what other universities do → *chapter 2: comparing university approaches* (plus *appendix 2*)

1) identify values & potential impacts → *chapter 3: putting a value on BD*

2) identify BD-related indicators → *chapter 4: a toolkit for BD* (in particular habitat identification / appropriate measurement (for setting the right kind of targets & objectives) / continuous monitoring), development of an own methodology

(3) determine guidelines for BD management → *chapter 5: recommendations* (plus *appendix 1*)

The report uses sources from academia (articles from e.g. *'Nature'*) but also practical sources such as handbooks and websites on BD, and thus represents a combination between the both.[3]

2 COMPARING UNIVERSITY APPROACHES

For the following report BD strategies from Russell Group Universities (UK) and IARU Universities were compared (see *appendix 2* with tables). Many Russell Group (RG)

[3] It seemed necessary to include research sources as well, since *chapter 4* develops an own methodology (quantifying the total value of a habitat).

universities have BD policies, but are not clear about how to approach BD enhancement. The problem with all universities (except for the University of Edinburgh, the University of Leeds, and the Loughborough University; see *footnote 28* & *appendix 2* with tables) was that there was no "qualitative" data on BD management (i.e. no targets, no BP indicators). Most documents only depict very general management guidelines in form of general recommendations and practical recommendations (see *chapter 5*). Furthermore, the University of Southampton and the London School of Economics and Political Science (LSE) have some recommendations for retrofit and new buildings (see again *chapter 5*). The University of Southampton has some recommendations on SUDS (sustainable urban drainage systems) (*chapter 6*). The University of Sheffield (RG) and the University of East London (UEL) (which is not given in *the Appendix* (since non-RG, non-IARU, non-other) are the only ones who have more systematic approaches (see *appendix 2*). Universities belonging to IARU showed no BD efforts (except for the Australian National University (ANU) in Canberra). For the Yale University and the University of California Berkeley, no legislative documents could be found, which specifically point at BD improvement approaches.[4] E.g. Berkeley does much about land use like planting trees (where students voluntarily help) (e.g. Strawberry Creek), but has no detailed approach. *Fig. 1* summarises these findings (for detailed findings refer to *appendix 2*).

[4] Besides „biodiversity" other keywords such as „land use", „environmental planning", ... were used in order to find legislative documents.

Figure 1: Legislative documents of other universities

university	*kind of information*
Edinburgh, Leeds, Loughborough	qualitative data (i.e. they have data on species numbers such as birds, badgers, types of trees…)
Southampton, LSE	retrofit & new buildings
Southampton	SUDS
Sheffield, UEL	systematic approaches about BD in general
IARU universities (except for Cambridge, Oxford, and ANU)	no legislative documents about BD (no information)

Because of not having any tangible strategies, I had to develop my own strategy: in particular my own methodology (see *chapter 4*).[5]

3 PUTTING A VALUE ON BIODIVERSITY

No organism lives in isolation from others. Species interact with each other contributing to the ecosystem balance. They provide us with many valuable services such as food, fuel, health, or wealth (and are therefore called *eco-system services*; so we have to account for them).

[5] Also, there was no point in categorising or reviewing strategies (i.e. which strategy is followed by which university), since all strategies are only qualitatively described (except for three of them (see above)). E.g. no point was seen in trying to compare which university "collects dead wood" or "installs bat or bird boxes" (because such 'strategies' seemed to general).

An important question has thus always been how to evaluate environmental goods such as biodiversity in this case. Putting a value means nothing else than putting a "price" on the public good (here environment).[6]

The general procedure of evaluating environmental goods involves the following steps [ETHZ, 2012]:

1) Evaluate relationship between an action & change in environmental quality.
2) Impacts of a change in environmental quality on individuals.
3) Monetary evaluation / quantification of such impacts.

Informational requirements for this usually imply inventories of environmental change, inventories of impacts, as well as an evaluation / quantification of impacts. However, problems at this point include that there is often no information on e.g. how much BD is worth to people and how to put a value to it. Furthermore, there exist different evaluation methods, and every method has its own pros and cons. The method, which is the most practical for the case of BD on campus, should be chosen for evaluation.[7]

There exist several values such as aesthetic, recreational, or economic values, which make it worthy to protect and enhance biodiversity. BD plays a crucial role for our health and wellbeing. Goals (e.g. species conservation; ecosystem function enhancement) usually exhibit intrinsic values, whilst instruments help to achieve this goal (e.g. habitat conservation; increase species diversity).
Besides having intrinsic values, BD furthermore is crucial for the Earth's life support system because it provides clean water / air and pollination. It also helps in flood prevention and CO_2 mitigation.

[6] In order to build a business case the approach of putting a value in economic (monetary) terms seems most suitable, i.e. giving BD an economic value [e.g. TEEB, 2014].

[7] A practical methodology is developed in *Chapter 4*.

There are different types of values (*fig. 2*) [ETHZ, 2012]. Utility-dependent can directly or indirectly be measured, whilst non-utility-dependent values are individual-specific and much harder to determine.

Facts, which relate to such values, are for example that 92% of people who took part in a survey stated a "fairly or very" important preference for having public gardens, parks, commons, or other green areas. Moreover, 46% stated they use public gardens, parks, commons, and other green spaces once per week at minimum [DEFRA, 2011].

An interview with a forester from Wytham Woods [talk, 30/7/2014] indicated that the (intrinsic) value of BD, or a forest as in the case of Wytham, might not be quantifiable in monetary units (or should be 'infinite').[8] E.g. the forester gave an example about a mathematician who regularly visits Wytham Woods in order to get inspired for his research and be able to 'think'. The forest thus has an 'existential' value for the mathematician, and therefore might have 'infinite' value.

[8] The same problem of non-quantifiability plays a role for e.g. how much the existence of polar bears is worth to people.

Figure 2: Types of Values

VALUES

utility-dependent values

- economic utility values & symbolic values [direct values] – e.g. food, free time, health
- functional values [indirect values] – e.g. flood prevention
- option values (future values, inheritance values)

non-utility-dependent values

- existential values (preferences for BD, landscape; determined by moral values…) – e.g. habitats, endangered species
- (option values)

Indirect methods involve *the compensation method (i)*, *the efforts method (ii)*, and *hedonic pricing (iii)* [ETHZ, 2012].

(i) is only applicable if reversibility / compensation exists. I.e. for *(i)* the following question can usually be asked: "Which value has to be introduced in order to prevent an environmental damage?" Examples include e.g. bad soil productivity because of acid rain; dry soil because of climate change; health problems because of bad air / water quality.

(ii), on the other hand, asks: "Which effort has to be undertaken for using / improving an environmental good (in this case, a habitat)"? Clawson [1959] states this methodology to be especially useful for the importance for recreational landscapes. Empirical tests could involve the prediction of interested people using the habitat for recreation (refer to the DEFRA [DEFRA, 2011]).

(iii) is an intuitively appealing method since it asks the question how a price of a house changes if air quality / water quality / noise (at the location of the house) rises by 1%.[9]

[9] This is rather economics-related, but hedonic pricing also plays a crucial role for a question such as: "How much do you value the existence of polar bears?"

Direct methods involve the *willingness to pay (I)*, *willingness to accept (II)*. For the former *(I)* environmental quality can be increased (e.g. by converting a habitat into a recreational area, and by asking people how much they would pay for improving an ecosystem), whilst for the latter *(II)* people receive (monetary) compensation to not go fishing anymore (e.g. because of a declining fish population at a lake site). *Contingent Valuation Methodologies (CVM)* is the generic term capturing *(I)* and *(II)*. Such methods also help in determining non-use values such as existential, option, or future values *(fig. 2)*.

Deciding which method should be used for evaluating environmental goods (in this case BD on campus), each one exhibits advantages and disadvantages. For the case of developing / fostering campus BD it is important to pick the most reasonable and practical methodology. This seems to be the indirect *efforts method (ii)*. Relying on *(ii)*, *chapter 4* therefore develops a practical approach.

4 A TOOLKIT FOR BIODIVERSITY

Since the University of Oxford is already in the stage of developing a toolkit for BD,[10] this chapter is dedicated to giving practitioners a better image about the complexity of BD, and thus how it should be approached in the field. A toolkit is not only about calculating the number of swifts, bees, or badgers, or about comparing species numbers to BD numbers from other universities. To understand why this chapter first tries to give an introduction of BD in a more extended manner (especially *step (2), the measurement part*). Based on the theoretical understanding, the chapter then develops a practical method (*step (2)*).

[10] See <http://www.admin.ox.ac.uk/estates/environment/biodiversity/biodiversitytoolkit/>.

The general rationale of having a toolkit with techniques on *identifying problems (1) / objectives & targets for improvement (with prioritisation of tasks) (2)* / and *continuous monitoring of progress (3)* gives practitioners a way to effectively manage BD.
Another benefit of developing a toolkit would serve communication. I.e. it would provide the local community / governmental agencies, or just the general public, with information, which in turn is necessary to get e.g. funding.

Taking action usually implies more than one step. The following toolkit is thus divided into the steps *(1) – (3)*, and tries to adhere (deviations exist) to the following roadmap sketch:

(1) Identify – assess which species / habitats are under threat the most & asses the current status and numbers
(2) Define goals - for species / habitats and use measurable conservation targets (e.g. given time, financial, and resources constraints use SMART-targets (= specific, measurable, achievable, relevant, time-bounded targets))
(3) Implement – implement action & continuously monitor / review progress

(1) – IDENTIFYING

Even though the BD Strategy Draft for the University of Oxford has already identified four sites to be important for its campus (i.e. the Old Road Campus (ORC), Begbroke Science Park (BSP), Iffley Road Sports Ground (IRS), and the Radcliffe Observatory Quarter (ROQ)), a general procedure of potential other key sites should happen according to the following steps [TESSA, 2013]:[11]

[11] The *toolkit for rapid assessment of ecosystem services at sites of biodiversity conservation importance* has been published in the Journal of Ecosystem Services by more than 20 authors in 2013, and thus represents a very new approach (TESSA = Toolkit for Ecosystem Service at Site-based Assessment; i.e. a Multi-Ecosystem Service Assessment Technique). Another toolkit, which might be of relevance for BD on campus, is

1) Preliminary Work

- define site (i.e. assess biological importance & possible threads)
- investigate policy context
- identify & engage stakeholders[12]

2) Rapid Appraisal

- identify habitats & drivers of land-use change
- identify services (e.g. global climate regulation / water-related services, harvested wild goods, cultivated goods, nature-based recreation (*)) & beneficiaries
- *identify which species (not only plant species, but also animal species) should be enhanced or newly introduced to the site![13]*

3) Identify plausible alternative state (typically for the next 1-20 years)

4) Methods Selection

- select relevant assessment services (see (*))
- identify how to assess alternative state
- select appropriate methods for each service (e.g. field work, household questionnaires, key informant interviews)

5) Data Acquisition

- collect data for *current* state
- collect data for site in *alternative* state

Nature2000 [Nature, 2009], which assesses socio-economic benefits and value of a habitat, and quantifies individual benefits in monetary units (refer to *Chapter 4*).

[12] The engagement of stakeholders should happen throughout all steps 1) - 6).

[13] This is to identify the „biological" importance (and not stated by TESSA [2013]). This has already been partly identified by Oxford's existing toolkit <http://www.admin.ox.ac.uk/estates/environment/biodiversity/biodiversitytoolkit/>.

Fig. 3 gives a hypothetical example how 5) could be illustrated in a table (whether it is better to conserve (orientation towards status quo of the state) or convert the state (e.g. introduce new plants / animal species; improve water quality)):

Figure 3: The alternative state - Is it better to conserve or convert the state?

	Conservation State	Converted State
Water quality	1	5
Water provision	5	5
GHG (greenhouse gas) sequestration	4	2
Nature-based recreation	3	5
Cultivated goods	1	2

Details: The scale here is 1 (= low) – 5 (= high). The rows here ("water quality", "water provision", etc.) could also be replaced or extended by rows such as "introduction of new animal/plant species" or "enhancement of living conditions of existing species". However, in order to successfully introduce new species, or support existing ones, "water quality", "water provision", etc. play an important role. In order to improve e.g. swift numbers, a possible row could be "improvement of nesting sites".[14] *As is depicted in this figure, it is probably not possible to have high numbers (e.g. 4 or 5) in every cell of just one column (e.g. whilst water quality is better in the converted state, GHG sequestration is better in the conserved state). The same problem can be applied to enhancing swifts. Whilst swift numbers could be increased in a converted state, nature-based recreation would go down (since swifts need undisturbed nesting sites).*

6) Analysis & Communication

- analyse data for comparing *current* / *alternative* state
- identify potential changes and benefits
- communicate messages → important for engaging further stakeholders & informing decision makers

[14] Thus „sites" can also be associated with „buildings" (since swifts usually nest in holes of old buildings).

1) – 6) help in measuring and monitoring ecosystem services at a site scale (see steps *(2)* – *(3)*). Resource requirements for steps 1) – 6) involve high computing skills (because of high data demand) but low specialist technical knowledge. Time, manpower, and costs (e.g. equipment for field work) are said to be low for it [Waage & Steward, 2008].

According to these six steps ecologists could now look whether the four key sites of Oxford (ORC, BSP, IRS, ROQ) have been properly selected, and whether the alternative vs. the current state assessed. Since Waage & Steward [2008] state that high expertise is not required for 1) – 6), site identification could also be done by biologist or chemist students on a voluntary basis for example. Collecting field data could by this be achieved at relatively low cost and effort.

Further, to test which site it is most cost-effective to enhance the population of a species, a table in the manner of *fig. 4* can be created [Watson et al., 2011, p. 139], which indicates that site 2 is able to enhance three types of species for a cost of $20, whilst site 5 can enhance only one species (species 2) for a cost of $2.

Figure 4: Testing cost-effectiveness for every habitat

	Site 1	**Site 2**	**Site 3**	**Site 4**	**Site 5**
Species 1	1	1	1	0	0
Species 2	0	1	0	0	1
Species 3	0	1	1	1	0
Species 4	1	0	0	0	0
Cost	$5	$20	$5	$4	$2

Since in step *(1)* the focus was laid on the variable "site", step *(2)* is more about investigating the variable "species".

(2) – TARGETS & OBJECTIVES

It is essential to define targets and objectives. Something, which we are unable to measure, we definitely cannot manage. Clearly defined measures manage to uncover success / failure of alternative conservation strategies (i.e. if goals / targets were achieved, and whether conservation strategies worked out or not). A common strategy or an action / enhancement plan (see *chapter 2*) is often insufficient in proposing ways 'how' BD is best measured and which kind of targets (in form of numbers)[15] should be set.[16]

Moreover, the UK-based organisation *People & the Planet*[17] states that BD should "identify time-bound actions to improve BD or reduce negative environmental impacts (e.g. increase x species by xx / build green roof by 20xx). But doing so is very difficult. No single university (RG or IARU) states such targets in their legislative documents, so there exists absolutely no orientation towards some "anchor" target. Coming up with just a random number is imprudent. More important is to understand what BD means and to get a grasp of how complex the matter is (at least beforehand). Only after this step, we can think about defining targets.[18] For this, only an ecologist or a biologist can state by how much e.g. swift numbers should be (or *have the potential* to be) increased (and by which time constraint). Thus, working with specialists is indispensable in defining BD targets!

---

[15] At this point it should (however) be mentioned that targets are in many cases just an arbitrary number of choice (based on preferences of decision makers). Also, usually legislative documents only include qualitative data (instead of quantitative data w.r.t. which target number should be set) (see *chapter 2*). This makes it harder to propose a number or a "quantitative" target.

[16] In general, sustainability reports involve solutions or recommendations (refer to *chapter 2*), but no information on what is to be measured [Sukhdev, 2013].

[17] See <http://peopleandplanet.org/greenleague/methodology/environmental-policy>.

[18] This also speaks in favour of a closer relationship between estates managers and BD researchers, where the latter ones help the managers in coming up with reasonable targets (since they are the ones who understand the topic). But again, people who usually understand something about a topic are not the ones who make decisions (who "manage" the topic), etc., etc., etc.

BD-related SMART-targets should be [Monitoring, 2013][19]:

- simple and relate to something that people can understand and use
- able to address a need (e.g. be established through stakeholder dialogue or respond to a predicted significant impact)
- sensitive to anthropogenic impacts, i.e. able to measure changes caused specifically by humans
- dynamic and responsive to ongoing changes
- able to address positive and negative changes
- spatially relevant across the required geographical level (i.e. local, regional, global)

Setting the right kind of targets and objectives requires knowledge about how BD can be measured. Measuring means to look at the (current) wellbeing of ecological systems and their variety of life. However, elaborating suitable measurement techniques for BD (there exist many measurement techniques [Teacher's Guide, 2013]) is difficult.[20]

But BD can never be measured in one single number, and no single method is without pitfalls [Purvis & Hector, 2000].[21] This is on one hand caused by the definition of BD (which follows shortly) – i.e. "what is captured by the term 'BD'?" – and, on the other hand, caused by the circumstance that scientists have not yet estimated all species existing on this planet. The 1.75 million described types (= species) of organisms (in 1995) might only account to 10% of the total [Hawksworth & Kalin-Arroyo, 1995]. Also, it seems that ecologists only know about 5% of how the biodiversity cycle works (which is same to as e.g. the carbon cycle where fluxes between the atmosphere and the carbon sinks still

[19] This is similar to define targets by using the CARE principles, which stand for Comprehensiveness, Adequacy, Representation, and Efficiency [Possingham et al., 2006].

[20] There are a couple of species diversity indices besides the Simpson diversity (presented here) such as the Shannon diversity & the Fisher's "alpha" [Purvis & Hector, 2000].

[21] However, policy-makers often want one single number (which captures it all).

remain a "black box" for scientists) [Wytham Woods talk, 30/7/2014]. Therefore, managing BD is a very complicated task.

BD basically captures the term "nature" and is therefore the variety of life, i.e. the living fabric of the planet [CBD, 2014]. In economic terms BD can be thought as natural capital.

More precisely, BD can be divided into three components (see *fig. 5* [TEEB, 2013]): *Species diversity (a)*, *ecosystem / habitat diversity (b)*, and *genetic diversity (c)*:

Figure 5: Technical definition of BD with examples

BD strata	**quality dimensions**	**quantity dimensions**	**ecosystem services**
- ecosystems	variety	extent	e.g. recreation, water regulation, carbon storage
- species	diversity	abundance	food, fibre, fuel (or firewood), design inspiration, pollination
genes	variability	population	medicine, discovery disease, resistance, adaptive capacity

Species diversity (a) refers to the number (i.e. #) of different species (= species richness *(*)*) & that of individuals of each species (= species abundance *(**)*).

Species richness *(*)* is the current number of different species (i.e. types of animals & plants) in a specific area. Thus, this does not take into account the number of individuals of each species (which would be *(**)*).

Ecosystem (habitat) diversity (b) means the diversity of habitats / ecosystems within a specific landscape area. I.e. a landscape area having grasslands, wooded areas, rivers, ponds, or hedgerows will exhibit more species diversity than an area having no ponds, experiencing drainage.

Genetic diversity (c) is the genetic variability of a species.[22] Inside a species, there exist several subspecies (i.e. subspecies of bees, swifts, etc.).[23]

Measuring BD means attaching units to BD. Because BD by definition has a multidimensional character [Whittaker, 1972; Magurran, 1988], there is no methodology, which is complete in itself. For example, *(a)* always faces the trade-off between "evenness" vs. "richness" of a species [Purvis & Hector, 2000] – and both concepts cannot be mathematically measured in one single number.

For nature on campus *(a)* and *(b)* seem relevant. There exist many ways how to measure BD, and ecologists use a wide range of sampling techniques and indices.[24] The most commonly used index for Species Richness Indices is the *Simpson's Index* [Simpson, 1949], an index for *(a)*, which is given by the following formula:

$$D = 1 - \frac{\sum_{i=1}^{S} n_i (n_i - 1)}{N (N-1)}$$

→ n_i = # of organisms of each individual species i

→ N = # of organisms of all species

→ S = # of species

D ranges between 0 (no diversity) and 0.999... (infinite diversity) (i.e. ∈[0, 1)). The bigger the value D becomes, the higher diversity gets (D gets closer to 1 in the limit). Simpson gives the probability that two specimen belong to *different* species (drawn at random from an infinitely large community).[25] It incorporates the number of species present, as well as

[22] E.g., the Irish famine in the 19th century was the result of having only two potato varieties, which were both prone to the potato blight.

[23] See < http://www.swr.de/swr2/wissen/was-ist-eine-spezis-artenschutz//id=661224/nid=661224/did=13139478/w7nqdh/index.html>.

[24] For *(a)* there exist many measures (relative to *(b)*).

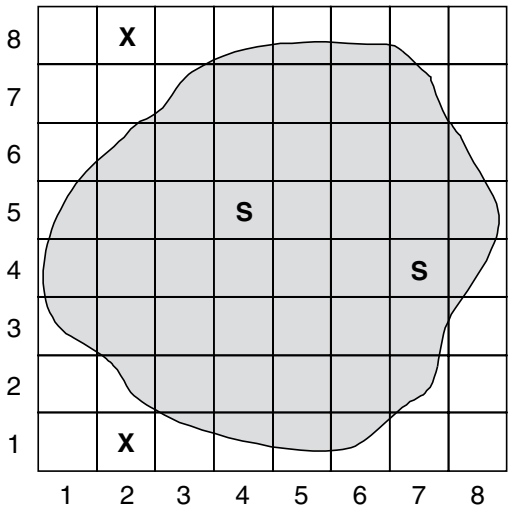
the abundance of each species. Also, it is independent of the number (i.e. #) of each species; e.g. 1 buttercup has as much effect on species richness as 100 daisies. A drawback of the index, however, still exists since it is more weighted towards abundance (than to richness).

Management guidelines [Khan, 2013; Teacher's Guide, 2013]:

For recording vegetation it is not important to count individual species but to estimate the surface area of every species. By dividing the surface area in smaller sub-areas (e.g. quadrants or grids) the number of plant and animal species can be calculated. I.e. working with "percentage covers" instead of "count of individuals" is possible.

Sampling techniques involve grid mapping of an area, and could look like *fig. 6* [Handbook, 2005, page 33].[26]

Fig. 6: Grid technique for counting species: an example



[25] It can easily be checked that if D was written as the reverse, i.e. $D_{reverse} = 1 - D$, then the measure would give the probability that any two individuals belong to the *same* species.

[26] The "Handbook of Biodiversity Methods" [Handbook, 2005] is a great guidebook for survey, evaluation, and monitoring of BD.

Details: The shaded area represents the habitat (which is either to be conserved or converted). Lines are distances of 100 m for example. Numbering grids could happen from 1-8 on the x- and y-axis. Any "X" outside the shaded area should not be considered for sampling, but only "S". For every grid "S" count the number of species lying in this grid. This should be continuously repeated (see step (3) – monitoring) when managing a habitat in order to see whether the habitat improved in BD. Then every grid cell "S" with successful management should exhibit a higher species count ex-post.

What matters is the probability of picking two randomly chosen dots within a particular surface area (e.g. quadrants or grids), and not to encounter the same species. With such surface covers (i.e. instead of individuals) the formula is the same for the first and second dot. The formula from before becomes then

$$D^{prob} = 1 - \sum_{i=1}^{S} p_i^2$$

where p_i represents the fraction of species i at the sum of all surface area quadrants (grids).

D is close to 0 if…:

- … there are not many species exist in the habitat
- … much stress is put on the habitat (and only few organisms manage to live in this habitat)
- … food webs are not diverse
- … environmental change affects the habitat significantly

If D is close to 1 the reverse holds.

The Simpson's index is good for several reasons. On one hand, ecologists tend to get worried if a habitat experiences significant declines in species (if D is 0). On the other hand, if D moves around 1, managing an area or conservation is effective.

Fig. 7 gives a hypothetical example table for calculating richness and abundance in two habitats (in one single grid (see *fig. 6*)). According to this example it is easy to see that species abundance (i.e. 100 individuals in total) and richness (i.e. 3 types of species) is the same for both habitats, but that habitat 1 exhibits greater abundance evenness.

Figure 7: Example for species richness and abundance

	Habitat 1: e.g. BSP	Habitat 2: ORC
daisy	33	1
buttercup	33	10
swifts	34	89
TOTAL	100	100

The Simpson's index is given by $D_1 = 1 - (33*32 + 33*32 + 34*33]/(100*99) \approx 0.7$ for habitat 1, and $D_2 = 1 - (1*0 + 10*9 + 89*88]/(100*99) \approx 0.2$ for habitat 2.

The probability-based Simpson's index is given by $D_1^{prob} = 1 - [(33/100)^2 + (33/100)^2 + (34/100)^2] \approx 0.7$ for habitat 1, and $D_2^{prob} = 1 - [(1/100)^2 + (10/100)^2 + (89/100)^2] \approx 0.2$ for habitat 2.

After *step (1)* (identification of which habitat is the best to conserve / convert) this *step (2)* is more about species introduction or enhancement of existing species. This is presented in *fig. 8*, which gives a weighting method approach.[27]

[27] The value benefit analysis ("Standortanalyse – Nutzwertanalyse") acted as a source of inspiration in coming up with *fig. 8*'s methodology.

Figure 8: Example for a weighting methodology for EX ANTE & EX POST site management

- *EX ANTE site management (BASELINE)*

SPECIES (either animal, plant)	Weighting (e.g. 1 (low) – 5 (high))	***Habitat 1: BSP*** Evaluation **w.r.t. #** (e.g. 1 (rare occurrence of the species) – 10 (high occurrence of the species))	***Habitat 2: ORC*** Evaluation **w.r.t. #** (e.g. 1 (rare occurrence of the species) – 10 (high occurrence of the species))
swifts	5	**4**	**4**
badgers	3	**2**	**10**
bees	5	**3**	**2**
daisies	2	**10**	**9**
TOTAL VALUE OF THE HABITAT		5*4 + 3*2 + 5*3 + 2*10 = **61**	5*4 + 3*10 + 5*2 + 2*9 = **78**

- *EX POST site management (TARGET)*

SPECIES (either animal, plant)	Weighting (e.g. 1 (low) – 5 (high))	***Habitat 1: BSP*** Evaluation **w.r.t. #** (e.g. 1 (rare occurrence of the species) – 10 (high occurrence of the species))	***Habitat 2: ORC*** Evaluation **w.r.t. #** (e.g. 1 (rare occurrence of the species) – 10 (high occurrence of the species))
swifts	5	**6**	**5**
badgers	3	**6**	**5**
bees	5	**6**	**5**
daisies	2	**10**	**10**
TOTAL VALUE OF THE HABITAT		5*6 + 3*6 + 5*6 + 2*10 = **98**	5*5 + 3*5 + 5*5 + 2*10 = **85**

*Details: In a first step the relevant species have to be identified (see cells on the left hand side) (here four of them: **swifts, badgers, bees, daisies**). These species should be able to live in the habitats, which are investigated here (thus, the habitats should be able to offer living conditions for those species). Every species should then (in a second step) be attributed with a weighting, according to their relevance of introducing or enhancing it (question: "how important is it to introduce / enhance this species (considering endangered species)?"). Endangered species can be easily drawn from the IUCN Red List for example, or from local / regional / national lists of endangered species (here e.g. swifts and bees (main pollination actors) get a weighting of 5 because of high declines relative to historic numbers). Also, the weighting obviously stays the same for BASELINE (EX ANTE) site management and TARGET (EX POST) site management. In a third step it should be identified how common the species occurs in every habitat – here two habitats are under investigation (**habitat 1** and **habitat 2**) but the weighting method can easily be done for multiple habitats (habitat 1, habitat 2, habitat 3, habitat 4…). The occurrence of every species (i.e. the number (#)) can be measured by comparing it relative to other habitats, other local /regional / national areas, or historical numbers. E.g. the number of swifts has declined by 41% since 1994 [SwiftTour, 2014; Eaton et al., 2009] in the UK; this would thus be a relative orientation towards historical numbers. The **total value of the habitat** is to be calculated in a fifth (and final) step, and is simply the sum of the weighting numbers times the evaluation for every column (habitat) across all rows. The higher the total value of the habitat, the better is the habitat according to its BD.*

The exact same procedure (first until fifth step) can be done for ex post site management, in order to compare the total value of the habitat across time.

In the hypothetical example of *fig. 8* habitat 1 (BSP) has under status quo conditions a total value of 61, whereas habitat 2 (ORC) has one of 78. With successful management (or monitoring / reporting after 1 year for example (see *step (3) - monitoring*)), BSP has a new value of 98, and ORC one of 85. Thus, habitat 1 here always exhibits a higher value relative to habitat 2. The same methodology can continuously be applied for any ex ante and ex post period in time (not only t_0 (status quo) until t_1 (e.g. next year), but t_1 (next year) until t_2 (year two), t_2 (year two) until t_3 (year three), …), which then becomes

important for *step (3) – monitoring*, and allows comparison across time (i.e. allows for a dynamic approach).

The advantages of the weighting methodology (*fig. 8*) are:

- very simple method of quantifying the "value" of a habitat across time
- does not require much expertise, can be done by students → cost-effective
- field expertise however needed in order to quantify the number of species (see sampling technique in *fig. 7*) → cell "occurrence" of species
- method allows for comparing BD across universities (for a neutral investigation third parties should be consulted)
- clear communication possible
- allows easy monitoring across time

The disadvantages are:

- not comprehensive (trade-off between simplification and comprehensiveness)
- regular monitoring → costly but necessary for verification of progress (see *step (3)*)
- computing skills needed (high data demand) → costly

Going back to the question of which target numbers should be set (for every species) will not be investigated in this report (this report is a desktop assessment). It remains to be the work of an ecologist with much (field) expertise to set the "right" target numbers. Numbers could not be found in any BD-related legislative documents from other universities (see *fig. 1* in *chapter 2*).[28]

[28] Except for the University of Edinburgh, which states that it has 124 different tree species, with 23-33 native British trees (see *appendix*), and the University of Leeds stating that it has 32 birds species (of which 11 are birds of conservation concern [Eaton et al., 2009]), and Loughborough University, no species numbers could be found (see *fig. 1* in *chapter 2*). Also, orientating itself towards given numbers is difficult, since every habitat is different - and without expertise or field work - it is virtually impossible to define such. Numbers relating to 'targets' could not be found anywhere.

Step (1) and *step (2)* tried to handle the following questions (drawn from [Gaines et al., 1999]) (with possible answers):

1) What is the current level of landscape diversity and how does it compare with historic or sustainable levels?

→ see *weighting technique (fig. 8), and maybe step (1)*

2) What are the trends in habitats or populations of a particular species?

→ do field work, use *grid technique (fig. 6)*

3) What are the trends in landscape features such as the amount of edge, patch size, forest interior, etc.?

→ see *step (1)*, ?

4) How have management activities or natural disturbances affected species diversity in a particular community?

→ field work, …

5) What is the function of a species in the community or ecosystem?

→ part of *step (1)*…

6) Where are the areas of high species richness, endemism, or rarity, and how are they protected?

→ *step (1)*

7) What is the trend in the species or population?

→ see *weighting technique (fig. 8)*

8) How is species or population abundance affected by land management activities or natural disturbances?

→ see *weighting technique (fig. 8)*

9) What is the probability of population or species persistence over a period of time in a specified area?

→ see *weighting technique (fig. 8) & Simpson's index*

(3) - MONITORING

The initial step is usually about estimating BD at a specific point in time and location (see before). The next step is about monitoring BD at the same location during multiple points in time (*fig. 8* copes with this already (since dynamic approach)).
It should continuously be evaluated whether BD conservation strategies work or not. If they do not work, then strategies and targets should be modified (key: "use the results").

Monitoring and evaluation are important for several reasons [NIA, 2014]:

- assess & progress towards achievement of pre-defined goals, i.e. targets & objectives
- share knowledge
- help building a relevant evidence base for the future
- monitor & report progress on overall contribution and legislation (international, national)
- win continuous stakeholders

Measuring (*step (2)*) or monitoring (here *step (3)*) does not require high science or technology. Simple counting, photographing, or student observations can be used for that [FSC, 2014]. Only "useful" and "meaningful" information should be collected (there is no need to try to collect "all" information about BD in a habitat (which is a common monitoring mistake, so costs can be saved)). Also, if expert information is collected then the information should be translated such that a (forest) manager can use it. It should be figured out by an ecologist how frequently monitoring should be done (also dependent on species [Handbook, 2005]) in order to review progress (picking the "right" frequency is important in order to obtain "useful" and "meaningful" information).

5 RECOMMENDATIONS

In addition to the techniques and equations (to help identify areas plus best practice; see *chapter 4*), general and practical recommendations are listed here.

The following recommendations are a compilation of BD strategies stated in legislative documents from the University of Oxford, as well as other universities (UK and IARU (see *appendix 2* & *chapter 2*)).

General recommendations:

- raise awareness of BD on campus (by e.g. communication of the BD policy to staff & students) ← inspire & educate them for natural conservation; use this (see points 3) & 4)) as an educational resource for everyone (i.e. for the wellbeing of staff, students, visitors, and the wider community); maintain & enhance the BD value (and therefore communicate at all levels of land management)
- maintain & enhance BD via species implementation & habitat action planning, and simultaneously promote the importance for healthy living & well-being (being outdoors, amenities, "green value has a value for everyone")
- engagement of staff & students in BD projects / voluntary opportunities (also provides teaching opportunities (e.g. use grasslands… as living laboratories)), then implement initiatives across campus (e.g. on birds & bees); work with "neighbours" (& other interested parties for sharing knowledge & resources)
- provision of learning resources via BD surveys & monitoring ← improves gathering / recording or information (maybe fund Ph.D. projects on campus BD)

…

- seek funding (through highlighting the value of BD (*chapter 3*)) & increase opportunities to work in partnership (with environmental groups, local authorities, etc.)
- provide specialist training programs (e.g. on how to protect badgers around known badger sites)

- identification of possible direct / indirect human-induced effects on BD ← assess risks & prevent negative impacts (by taking measures) ← actively promote BD
- integration of BD principles into daily campus activity

For retrofit & new buildings (see also *appendix 3* plus tables):

- assess impacts & enhancement opportunities for all new construction or re-construction work
- always take ecological enhancement into account when refurbishing OR when developing new capital projects

Monitoring & setting targets (see *chapter 4*):

- set ambitious but reachable targets (SMART); report continuously on BD performance → targets (how many bats, swifts, … can live in the habitat should be evaluated by qualified people with ecological expertise)
- identify, evaluate, and assess the relevant indicators
- annually review mgmt. techniques
- maintain grounds management practices (landscape & contractors)

…

- maintain a BD Working Group (for better coordination)
- develop & maintain a list of species → (up to date lists) of species & habitats (via field work and sight visits (e.g. swift tours, bat walks), (student) surveys, etc.)

  → for example, send out a mailing list for interested students to collect data on numbers of invertebrates, vegetation…

Practical recommendations (for the field):

- auditing should be done on native vegetation / planting / birds / mammals / fungi / some invertebrates (→ approach both species & habitat diversification (see definition

of BD; *chapter 4*)) → managing grasslands is useful because rich & varied in plant species; extensive & varied ground cover for small animals (i.e. invertebrate species)

in particular this means:

- "act w/o harming the environment"
- time operations to avoid disturbance (e.g. pay attention to bird nesting seasons)
- prioritise the planting of native species (plus remove invasive non-native species)
- no pesticides (or those not harming the environment)
- install bird / bat boxes, monitor regularly…
- leave habitat piles to provide shelter, sources of food, and hibernation sites
- incorporate new wetlands & SUDs for future planning
- consider "green roofs" in new construction & build "green walls" or artificial habitats
- break down the barriers between green & grey space

A possible draft of an action plan (i.e. a how-to-guide), which summarises *chapter 5* (in a more simplified version), can be found in the *appendix 1*.

6 BIBLIOGRAPHY

CBD [2014], *Convention on Biological Diversity,* 2011-2020, accessible via <http://www.cbd.int/idb/>.

Clawson, M. [1959], *Methods of measuring demand for and the value of outdoor recreation. U.S. Resources for the Future.* Reprint No. 10.

Colwell, R. K., *Biodiversity: concepts, patterns, and measurement*, accessible via <http://press.princeton.edu/chapters/s3_8879.pdf>.

DEFRA [2014], Department for Environment Food & Rural Affairs, accessible via <https://www.gov.uk/government/organisations/department-for-environment-food-rural-affairs>.

DEFRA [2011], survey about values…, accessible via <http://www.britishecologicalsociety.org/blog/2011/04/19/defra-release-statistics-on-public-attitudes-and-knowledge-about-the-environment/>.

Eaton, M. A., and co-authors [2009], Birds of conservation concern 3: the population status of birds in the United Kingdom, Channel Islands and the Isle of Man, British Birds 102, 296-341.

EAUC [2006], Environmental Association for Universities and Colleges, accessible via <http://www.eauc.org.uk/home>.

EAUC, *Biodiversity on campus, An EAUC practical guide,* accessible via <www.eauc.org.uk/file_uploads_bio/biog_pt1.pdf>.

ETHZ [2012], Environmental economics course, accessible via <http://www.vwl.ethz.ch>.

FSC [2014], Forest Stewardship Council, accessible via <https://ic.fsc.org/preview.simple-monitoring-methods.a-281.pdf>.

Gaines, W. L., Harrod, R. J., and Lehmkuhl, J. F. [1999], *Monitoring biodiversity: quantification and interpretation*, accessible via <http://www.fs.fed.us/pnw/pubs/gtr_443.pdf>.

Handbook [2005], *Handbook of Biodiversity Methods: Survey, Evaluation and Monitoring* (by David Hill, Matthew Fasham, Graham Tucker, Michael Shewry, and Philip Shaw (eds.)), Cambridge University Press, accessible via <http://sunsetridgemsbiology.wikispaces.com/file/view/Biodiversity+Handbook.pdf>.

Hawksworth, D. L., and Kalin-Arroyo, M. T. [1995], in "Global Biodiversity Assessment" (ed. Heywood, V. H.), 107-191, Cambridge University Press.

Hughes, J. B., Daily, G. C., and Ehrlich, P. R. [1997], *Population diversity : its extent and extinction, Science, 278, 689*-692.

IUCN red list, International Union for Conservation of Nature, accessible via <http://www.iucnredlist.org>.

Kelvin, S.-H. Peh, and co-authors [2013], *TESSA: A toolkit for rapid assessment of ecosystem services at site of biodiversity conservation importance., Ecosystem Services,* 5, 51-57.

Khan, S. A. [2013], *Methodology for assessing biodiversity*, Centre of Advanced Study in Marine Biology, Annamalai University, accessible via < http://ocw.unu.edu/international-network-on-water-environment-and-health/unu-inweh-course-1-mangroves/Methodology-for-Assessment-Biodiversity.pdf>.

Magurran, A. E. [1988], *Ecological diversity and its measurement. Croom Helm, London, 1, 988*.

Margules, C. R., and Pressey, R. L. [2000], *Systematic conservation planning, Nature, 405,* 243-253.

May, R. M., Lawton, J. H., and Stork, N. E. [1995], in "Extinction Rates" (eds. Lawton, J. H. & May, R. M.), 1-24, Oxford University Press.

Monitoring Biodiversity: Quantification and Interpretation [1999], William L. Gaines, Richy J. Harrod, and John F. Lehmkuhl - United States Department of Agriculture – Forest Service – Pacific Northwest Research Station – General Technical Report – PNW-GTR-443, March 1999.

Monitoring Indicators [2014], *Biodiversity indicators for monitoring impacts and conservation actions; the energy & BD initiative,* accessible via <http://www.theebi.org/pdfs/indicators.pdf>.

NIA [2013], Nature Improvement Areas, Monitoring and evaluation of nature improvement areas: year 1 (2012-13), Progress report, September 2013, accessible via <http://publications.naturalengland.org.uk/publication/5542385517854720>.

Oxford's Action Plan [2013], Biodiversity Action Plan – Department of Social Policy and Intervention, February 2013, DSPI Biodiversity Action Plan, *accessible via the internal database.*

Possingham, H. P., Wilson, K. A., Andelman, S. J., and Vynne, C. H. [2006], Protected areas: goals, limitations, and design. In "Principles of conservation biology" (by Groom, M. J., Meefe, G. K., fand Carroll, C. R. (eds.)), Sinauer Associates, Sunderland, MA, USA.

Purvis, A., and Hector, A [2000], *Getting the measure of biodiversity, Macmillian Magazines Ltd., Nature, 405.*

Simpson, E. H. [1949], *Measurement of diversity, Nature, 163,* 163-688.

Sukhdev, P. [2013], TED-talk, "putting a value on nature", accessible via <https://www.ted.com/talks/pavan_sukhdev_what_s_the_price_of_nature>.

Swift Tour [2014], held in August 2014.

Teacher's Guide [2013], *Measuring Biodiversity,* available via <http://www.rewardinglearning.org.uk>.

TEEB [2014], The economics of ecosystems and biodiversity, accessible via <http://www.teebweb.org>.

Waage, S., and Stewart, E. [2008]. *Ecosystem services management: a briefing on relevant public policy developments & emerging tools, Fauna & Flora International,* accessible via <http://www.naturalvalueinitiative.org/download/documents/Publications/Ecosystem_Services_Management.pdf>.

Watson, J. E. M., Grantham, H. S., Wilson, K. A., and Possingham, H. P. [2011], chapter 6: systematic conservation planning: past, present, and future (published by Blackwell Publishing Ltd., Conservation Biogeography, first edition, edited by Richard J. Ladle, and Whittaker, R. J.).

Whittaker, R. H. [1972], *Evolution and measurement of species diversity, Taxon 21,* 213-251.

Wytham Woods [2014], talk with Niguel, 30/7/2014.

APPENDIX

1. DRAFT OF A POSSIBLE ACTION PLAN FOR THE UNIVERSITY OF OXFORD

In addition to the developed toolkit (in *chapter 4*) with the corresponding measurement techniques (to help identify areas and best practice), the following example of an action plan can be used.

amenity space

objective:

- create an atmosphere of uniqueness within the city
- improve the "green value"

tips/targets:

- mow weekly
- cut hedges 2 / 3 times per week
- replace trees when necessary
- regularly check green roofs & replant when necessary
- plant flower beds which provide species with food (e.g. nectar)

actions:

- implement a tree mgmt. plan (by landscape services e.g.)
- talk to grounds maintenance team (hedge cutting outside bird nesting season)
- develop a planting scheme & species lists; continuously review; improve targets

employee & student engagement

objective:

- increase the use of green space for wellbeing
- use it as a "living laboratory" for education

tips/targets:

- provide health & psychological advantages
- diverse activities like active engagement (volunteering) & also passive engagement (relaxing / enjoying at lunch)
- formally educate staff & students (inspire people to enhance BD in their own gardens or simply to pursue BD as a hobby)
- initiatives
- enhance engagement / awareness via communication on site

actions:

- develop educational resources
- develop active & passive engagement (by e.g. student organisations)
- connect city & habitat via nature trails (talk to landscape services)

development

objective:

- integrate design, mitigation, and add value from beginning of any project planning

tips/targets:
- work with architect, project manager, BD steering group from day one of a planning project
- develop strategies for retrofit & new builds

actions:
- produce a guidance document for the design team & building contractors

surveying & monitoring

objective:

- survey and monitor (= repeat surveys) of endangered species, ensure for baseline information and monitor progress against SMART-targets
- report & communicate to stakeholders

tips/targets:

1st phase
habitat surveys, use e.g. NVC (National Vegetation Classification),[29] desktop surveys

2nd phase
site-specific surveys for species (which kind of animal species such as mammals, birds, invertebrates living on land or in water, and which kind of plant species (botanical surveying))

actions:

- define surveys to collect data
- define monitoring (for feedback of data to check progress)
→ some surveys can be conducted by students (not necessarily by professionals) which allows for a cost-effective approach; students in turn can do field work which might be important for they studies (e.g. biology…) and get basic learning training for later employability[30]

[29] See <http://jncc.defra.gov.uk/page-4259> and <http://jncc.defra.gov.uk/page-5281>.

[30] See < http://www.cieem.net>. The Chartered Institute of Ecology and Environmental Management is a valuable source for the question how local biodiversity management should be done (see *appendix, last page*).

2. BIODIVERSITY ON CAMPUS – WHAT DO OTHER UNIVERSITIES DO?

Russell Group Universities

University of Birmingham

→ *not much information*

https://intranet.birmingham.ac.uk/collaboration/environment/biodiversity/index.aspx

- BD policy & a working group in the process of developing an action plan (with e.g. undertaken ecological surveys)

→ BD policy statements:

- compliance with UK legislation on BD / formulation & implementation of an action plan (with continuous revision)

- maintenance & enhancement of BD

- working partnerships with environmental groups & local authorities

- good practice related to new buildings & refurbishment projects

- awareness raising

- grounds & gardens: grass-cutting, planting, pruning, tree work, litter collection, road sweeping

- bees on campus

University of Bristol

→ *not much information*
http://www.bristol.ac.uk/external-estate/biodiversity/

- major land owner (i.e. many diverse habitats & ecosystems), feel responsible to conserve BD & protect wildlife

- proactive mgmt. of land & resources, e.g. woodland mgmt., grassland mgmt., the

minimal use of chemicals & recycling, recycling of waste, endeavoured to use native species when planting new sites

- adherence to legislative measures & mgmt. principles (supports UK BD Action Plan (BAP) & Avon Plan (BAP)), Avon BAP species; including such species is important for the local population

- have 8 Habitat Action Plans (HAPs) → locally & nationally important; there exist action plans for e.g. scrub, woodland, species rich grassland, ponds, and open water. The HAPs show the current status of the habitat, its threats, and give potential mgmt. objectives.

University of Cambridge

→ *not much information (see also DB-folder)*[51]

http://www.environment.admin.cam.ac.uk/what-are-we-doing/buildings-and%0Dgrounds

http://www.conservation.cam.ac.uk (Cambridge Conservation Initiative (CCI))

- their BD is part of their Sustainability Strategy; no detailed biodiversity policy

Cardiff University

→ *some information*

http://www.cardiff.ac.uk/osheu/environment/biodiversity/biodiversity.html

- adopted a BD Policy Statement (for "The Built Environment; Formal Plantings; Grassland; Shrubberies and Hedges; Trees; and Derelict Land")

→ objectives:

- comply with relevant UK legislation on BD

- conserve existing habitats

[51] *DP = internal database (previous: Dropbox); path: „InterDrive" → „OUED" → „Administration" → „Environmental Sustainability" → „Sustainability Team" → „Team Policies and Procedures" → „Biodiversity" → „folder_AMD"*

- develop relations between appropriate & interested parties; involve staff / students / local community via volunteering & educational programs

- work with students on habitat conservation; work with landscape contractors (i.e. develop mgmt. practices)

- create a BD Action Plan with recommendations

- assess ecological impacts & opportunities for BD enhancement of new and retrofit buildings

- currently in the process of developing a BD Action Plan

- aims at completing a BD Survey, there exists a short interim BD Action Plan to reflect on the status quo

→ current actions:
- native species if new planting or replacement
- annual inspection of trees (with maintenance of a database)
- pruning/hedge cutting not within nesting periods
- do composting (of e.g. grass cuttings) & allow habitats to develop
- allow native wildflowers & grasses to regenerate
- install bat boxes

Durham University

→ *much information (see also DP-Folder for documents)*

BD Project: *http://dunelmbiodiversity.blogspot.co.uk*

https://www.dur.ac.uk/greenspace/internalpartners/biodiversity/

- deciduous woodland / coniferous woodland / grassland / wetland habitats

- Greenspace Advisory Group; established a BD Working Group → most important task: develop a comprehensive database of the flora & fauna; thorough knowledge of what is already present as a pre-requisite for future planning / conservation

- Durham University BD Survey; offers all staff / students the opportunity ot participate in a survey of the plants / animals / fungi;

which objectives?:

increase BD awareness; foster greater appreciation; encourage conservation

- Durham's Wildlife Habitats: woodland / grassland / ponds & wetlands

- Wildlife Animals: birds / insects / mammals / trees / fungi / flowers / reptiles & amphibians

University of Edinburgh

→ *much information (see also DP-Folder for documents)*

http://www.ed.ac.uk/schools-departments/estates-buildings/waste-recycling/biodiversity

- legislative documents: Scottish Executive → Scottish BD Strategy (which …"aims to conserve and enhance BD for the health, enjoyment, and well-being of the people of Scotland")

→ taking action:
- e.g. "Scottish BD Week 2012"
- garden / window-boxes… or plant nectar-rich flowers for butterflies / fruit-bearing trees & shrubs for birds
- do not use peat-based composts (decline of peat in Scotland and around the world)
- do not use many chemicals in your garden

→ BD Policy:
Estates / Buildings commissions BD Baseline Reviews (BBR) of the larger campuses at University of Edinburgh; additionally to that the Estates and Buildings do BREEAM related ecology surveys

University of Exeter

→ *much information (see also DP-Folder for documents)*

http://www.exeter.ac.uk/visit/campuses/gardens/biodiversity/

→ objectives:

- identification of specific measures for vulnerable species (e.g. protect badger sites)

- set up signs for valuable habitats

- lower use of pesticides (e.g. bark mulch / natural predators)

- zero green waste policy

- use "eco-strips" next to streams & woodland edges (?)

- install bird & bat boxes (and monitor them regularly)

- before tree felling works are done check hedges for bird nests & do it outside nesting season

- habitat piles left in appropriate areas to provide sources of food / shelter / hibernation

- planting schemes: use various plants / trees / shrubs (with different flowering times for encouraging year round wildlife activity

University of Glasgow

→ *only a report (makes sure that the uni complies with legal obligations on BD reporting (i.e. with The Wildlife and Natural Environment (Scotland) Act (2011))*

http://www.gla.ac.uk/services/estates/organisationstructure/estatesoperations/carbonenergymanagement/biodiversity/

- have a rich heritage of flora & fauna

- campus extends over semi-natural & landscaped sites

- feel responsible for protecting and enhancing the heritage for their own intrinsic value & for the wellbeing of all (e.g. staff / students / visitors / local & national & global communities…)

Imperial College London

→ *not much information (since in the city)*

http://www3.imperial.ac.uk/estatesfacilities/services/energy/environmentalpolicy/biodiversity

→ aims for reducing effect on local ecology & BD:
- protect existing natural habitats
- commission landscape design (on existing as well as new sites)

- enhance ecological diversity
- provide specifications & briefing documents on BD
- ecology targets
- encourage land use by BD
- encourage stakeholders to redevelop contaminated land
- encourage ecological enhancement
- encourage planting maintenance & other areas (built & natural ones)
- ensure protection of natural features during constructions

King's College London

→ *ONLY environment and sustainability policy!! no information on BD*

University of Leeds

→ *very much information (see also DP-folder for documents)*

http://www.leeds.ac.uk/sustainability/biodiversity.html

University of Liverpool

→ *much information (but no BD plan in general…)*

https://www.liv.ac.uk/sustainability/on-campus/biodiversity/

- has a rich range of various habitats

- animals e.g. amphibians, birds, insects, mammals, and reptiles (and other ecological niches)

- ensures that BD is preserved/enhanced, diverse / healthy environment

- ensures continuous improvement (assessment of existing BD & identify opportunities)

- need for better education & awareness (i.e. people's actions and their impacts on loss of BD nationally and locally)

- aim to provide green space on campus & promote BD & provide social space for everyone

→ BD draft approved in 2013-14 (by the Sustainability Advisory Board):

- aim to collect more data on BD (across campus, types of potential services, continue to develop BD conservation) → resulting in the BD Action Plan

- there is a Grounds Maintenance team which is responsible for looking after the university; programme of landscaping improvements, refurbishments, & new landscape developments

→ tips:

- diversify plants to improve resilience (wild flowers for pollinators & mixed species for natural disease control)

- use native plants to reduce water need / attract native birds & insects

- grow own fruit / vegetables / herbs → diversification of garden & organic and local food supply

- gardening as exercise; e.g. "Food & Nature" projects at Transition University of Liverpool

London School of Economics & Political Science

→ *not so much information (since in the city; only Sustainable Landscape Strategy) (see DB-folder, but not much)*

http://www.lse.ac.uk/intranet/LSEServices/estatesDivision/sustainableLSE/policyObjectives/biodiversityAndUrbanLandscape/home.aspx

→ objective: "monitor, maintain, & enhance BD / habitats on the school estate"

University of Manchester

→ *have a Sustainability Plan, but no BD plan…*

http://www.estates.manchester.ac.uk/services/es/biodiversity/

- responsibility & opportunity to protect / enhance local BD

- currently in the process of developing a BD plan, & manage / control BD development on campus

- e.g. Manchester City Council BD Action Plan

- targets developed during 2013

- currently in the process of writing a Masterplan & a BD Plan (ensures that BD is taken into account …)

→ BD Working Group (quarterly meetings..):

- oversee / implement BD targets contained within Uni's Environmental Sustainability Plan

- help to develop / implement / monitor BD Plan

- promote BD at uni via teaching / learning / research / volunteering opportunities for staff / students

- identify measures to manage / control BD development

- ensure that needs of key species & habitats are taken into account in campus mgmt.

- promote activities for communicating BD

- identify opportunities for co-ordinating campus activities with e.g. Manchester City Council

- engage local communities with BD & BD-related research via public events

Newcastle University

→ *so so information*

http://www.ncl.ac.uk/sustainable-campus/biodiversity/activity.htm

University of Nottingham

→ *information, but no BD strategy / policy (see also DB-folder, but nothing special there)*

http://www.nottingham.ac.uk/sustainability/grounds/biodiversity.aspx

- utilise various organic gardening practices & manage grounds / gardens to enhance BD

- practice: horticultural green waste → compost / mulching materials; no peat since soil amelioration; prunings & felled timber left as piles for woodlife habitat

- bird & bat boxes

- planting species which host invertebrates & insects, e.g. bees & butterflies

- coppice willow as an example of energy crops

- no mowing

- allow wildflowers to develop & set seed

- enhance bee population (e.g. 10 hives at King's Meadow Campus)

- foster drought-tolerant species → lower irrigation need

→ BD Mgmt. Plan
- 10 year programme for enhancing BD
- "University Park" as one of most attractive UK uni campuses (i.e. "English Landscape")

- rolling grass / land / individual & clumped trees / shrub groups / water features / long grass "wild" areas / different plant species from around the world / "Green Flag Award" winner 11 yrs running! → the " 'Green Flag Award' indicates that the park or garden is a well-maintained, well-managed and environmentally sustainable green space with excellent facilities"

University of Oxford

…

Queen Mary University of London

- no BD in general, but specific BD audit reports (see also DB-folder…)

http://ukbars.defra.gov.uk/action/show/113746

(

→ Projects on campus (but from UEL – University of East London):

- "grow your own" – UEL's allotments

- "urban orchard" – fruit tree collection

- "Stratford Bees" – their own honey bees

- "UEL's Beetlebump" – 15 streaked bombardier beetles

)

Queen's University Belfast

→ so so information; they have a BD policy, but not very clear, more under "Grounds & Gardens" (look DB-folder)

https://www.qub.ac.uk/sites/CarbonManagementatQueens/ToolsResources/MonthlyCampaigns/Biodiversity/

http://www.qub.ac.uk/directorates/EstatesDirectorate/Services/GroundsandGardens/

→ Grounds & Gardens:

- Environmental Mgmt. Aims & Objectives:

Long term aims ← nice aesthetically looking campus area with wildlife mgmt. conservation; BD opportunity mgmt.

Short term aims ← continuous development of mechanisms & new techniques for enhancing BD (e.g. in Coservation Planning and Development / Control of Invasive Species / Information and Research / Local Initiatives); peat & composting, procurement of goods&services / promote education on conservation / pestidices / waste / mgmt. of woodlands

- in the process of developing a BD policy

University of Sheffield

→ *have a good BD action plan (look DB-folder)*

https://www.sheffield.ac.uk/polopoly_fs/1.246719!/file/bap.pdf

- makes commitment to develop a BD action plan (BAP) / and because wanted to have legal obligations → the BAP to identify opportunities for protecting & enhancing BD; should fit in the context of national / regional / local BAPs; the BAP aims to maximise the ecological value / green space to enhance range of flora & fauna whilst simultaneously retain functionality; contribute to national / regional / local BAPs; to provide well-being to students, etc.

→ the steering group developed the BAP differently compared to other models, i.e. instead of conforming to Habitat Action Plans & Species Action Plans it focuses on a range of themes through which BD can be improved (e.g. amenity planting / development projects)

→ regular meetings by the steering group to assess / review / plan production of the document / monitor progress against objectives & targets

University of Southampton

→ *very much information (see DB-folder)*

http://www.southampton.ac.uk/susdev/estates_and_biodiversity/

- promote the principles of sustainable development

- aim to provide an attractive landscape for all

- protect / enhance BD; e.g. Valley Gardens

- animals: e.g. badger sett & population of the rare great crested newt

- areas will be protected & form green space amenities

- BD Policy (2012) (e.g. "Gardening for Wildlife"→ provide food & shelter for wildlife), BD Plan, BD Action Plan

- "Bioblitz" → intense period of biological surveying in an attempt to record all the living species within a designated area; intensively conducted field study of groups of scientists / naturalists / volunteers

- sustainable buildings: seeking to build new OR refurbish / maintain existing estate; incorporate sustainability criteria / Sustainable Buildings Policy / guidance for both New Build & Refurbishment Guide for Project Managers

- expect the buildings contractors to implement robust environment & sustainability policies & procedures to deliver high quality buildings / finishes

University College London

→ *not much information, but a BD action plan*

http://www.ucl.ac.uk/news/news-articles/1302/15022013-UCL-partner-London-wildlife-Trust

University of Warwick

→ *only ecology statement (see DB-folder)*

http://www2.warwick.ac.uk/about/environment/wildlife

University of York

→ *only ecology mgmt. statement, not more information (see DB-folder)*

http://www.york.ac.uk/admin/estates/operations/grounds/biodiversity/

→ how to encourage wildlife:

- time mgmt. operations to lower negative effect on species who are breeding / feeding / hibernating

- lower chemical usage

- horticulture practice

- compost

- install nest boxes / wood stacks / habitat piles

- encourage foraging insects, e.g. bees / butterflies

OTHER relevant universities (non-IARU, non-RG)

Loughborough University

→ *very much information (see DB-folder)*

http://www.lboro.ac.uk/sustainability/biodiversity/

- ¾ of Loughborough's land is green
- > 7'500 trees on campus (w/o those in woodland areas)
- UK BD Action Plan: fen meadow and the Holywell and Burleigh ancient woodlands

- local BAP habitats and other ecologically valuable habitats on campus

- e.g. Charnwood forest / Sherwood Forest

- BD wildlife: e.g. 40 types of wild birds, 50 species of fungus, Carbon offsetting → Julia Blasch; for planting additional trees (offsetting of CO_2 travels)

- voluntary 'Trees for Loughborough' initiative, trees for Loughborough' fund

- …has a Woodland Mgmt. Group & BD Working Group who „conservation volunteer days"

- from the LUBAP 09/2009 (Loughborough Biodiversity Action Plan (LUBAP))

- BD as a valuable teaching resource → opportunities for under- and post-graduate research projects

IARU universities

Australian National University

→ *very much (see DP-folder & link hier)*

http://sustainability.anu.edu.au/themes/landscape-and-biodiversity

ETH Zurich

→ *no information regarding BD / land use / habitat conservation … (tried many key words..)*

https://www.ethz.ch/de/die-eth-zuerich/nachhaltigkeit/eth-sustainability.html

National University of Singapore

→ *nothing except some reforestation stuff*

http://www.nus.edu.sg/oes/prog/natural/natural.html

Peking University

→ *nothing*

University of California, Berkeley

→ *much but not sure whether BD-related…*

http://sustainability.berkeley.edu/land-use

http://www.facilities.berkeley.edu/GreenBuildings/Resources/Campus_Sustainability_Assessment_2008.pdf

http://strawberrycreek.berkeley.edu/creekmgmt/scmgmtplan.html

http://www.cp.berkeley.edu/LMP/Sec-4.pdf

University of Cambridge

→ *SEE ABOVE*

University of Copenhagen

→ *no BD-related info*

http://climate.ku.dk/green_campus/home/

University of Oxford

→ *SEE ABOVE*

…

The University of Tokyo

→ *nothing*

http://www.tscp.u-tokyo.ac.jp/en/

Yale University

→ *much information but not sure whether BD-related… (i.e. related to any BD specific reports..)*

http://sustainability.yale.edu/planning-progress/areas-focus/landscape

University of Liverpool	yes (but not specified)	yes (2013/2014)
London School of Economics & Political Science	no	no
University of Manchester	yes (currently written)	yes (currently written)
Newcastle University	no	yes (but very short, since March
University of Nottingham	yes (a BD mgmt. plan)	no
University of Oxford	...draft	...
Queen Mary University of London	yes (specific BD reports)	yes
Queen's University Belfast	yes (in the process of developing a BD policy)	yes (?)
University of Sheffield	yes (an action plan)	yes
University of Southampton	yes (much)	yes (much)
University College London	no	no
University of Warwick	no (only ecology statement)	no
University of York	no (only ecology mgmt. statement)	yes/no (part of their statement)

OTHER		
Loughborough University	yes	yes

UNIVERSITY (BELONGING TO IARU)		
Australian National University	yes	yes
ETH Zurich	no	no
National University of Singapore	no	no
Peking University	no	no
University of California, Berkeley	no (?)	no (?)
University of Cambridge	SEE ABOVE	SEE ABOVE
University of Copenhagen	no	no
University of Oxford	SEE ABOVE	SEE ABOVE
The University of Tokyo	no	no
Yale University	no (?)	no (?)

University of Liverpool			
London School of Economics & Political Science		(✓)	
University of Manchester			
Newcastle University			
University of Nottingham			
University of Oxford			
Queen Mary University of London			
Queen's University Belfast			
University of Sheffield			
University of Southampton	✓	✓	
University College London			
University of Warwick			
University of York			
OTHER			
Loughborough University			✓
UNIVERSITY (BELONGING TO IARU)			
Australian National University			
ETH Zurich			
National University of Singapore			
Peking University			
University of California, Berkeley			
University of Cambridge			
University of Copenhagen			
University of Oxford			
The University of Tokyo			
Yale University			

Which documents (can be found in the internal database) are ESPECIALLY GOOD (see also summarising tables above):

3. RECOMMENDATIONS FOR NEW & RETROFIT BUILDINGS

directly related to BD:

prior to any building work, complete a habitat, and biodiversity survey to identify habitats and species; during construction work minimise disturbance on species; use SUDS & slowing down run-off

Recommendations for new buildings:

1) lower environmental impact of all new build, refurbishment, and maintenance projects → identify & manage risks

2) all buildings should consider economic (whole life costs), social, and environmental aspects

3) comply to BREEAM (http://www.breeam.org/about.jsp?id=66) standards, for buildings of > £1M try to comply to an „excellent" rating standard

4) mean-lean-clean energy use

5) try to achieve at least a B-rating in Energy Performance Certification

6) design all labs in such a way where energy, water, and waste are minimised

7) think long-term & design accordingly

8) allow for easy refurbishment in the future

9) set SMART-targets for reuse / recycling (define time constraints); use KPI (key performance indicators)

10) use sustainable timber (e.g. FSC-standards)

11) educate staff & students about proper (& sustainable) use of new buildings → raise awareness about their environmental impact

12) educate staff about sustainable buildings design & let (architect, building engineer) students help in delivering such design

13) partner with suppliers & contractors, and inform them

14) partner with the higher education sector, other important (external) authorities / bodies, ...; share good practice & communicate!

Recommendations for retrofit buildings (similar to the guidelines for retrofit buildings):

- implement a sustainable buildings policy to design / build / maintain world class research & teaching facilities (upgrade & ensure maintenance for future)