Interdisciplinary Science

PA1013

Biosphere

University of Leicester

Contents

Welcome

The World's biodiversity is in serious decline. We do not know the total number of species that were on this planet, say, at the beginning of the Second millennium, but by the beginning of the Third, we have identified 1.4 million species and we think there are at least 20 million, based upon individual studies of trees in rain forest for example (Erwin, 1991) and estimates of ecosystem diversity (May,1998; also at http://www.ciesin.org/docs/002-253/002-253.html). Regardless of how many species there are in the 'bank' that we call the Biosphere, it is feared we'll lose one-fifth of them by 2030 (http://www.well.com/user/davidu/extinction.html).

Some people argue that all species have an intrinsic right to be on this planet. Others argue that their continued existence depends only on their usefulness to the one species – Homo sapiens – the one that is a part of, but dominates every process in, the Biosphere. If we accept the latter viewpoint, it begs the questions, how can we measure the usefulness of species to us (Costanza, & Daly, (1992) and how many of them do we need to maintain the Biosphere sustainably? This Module will seek the answers to those two questions.

Module Author

Dr David Harper

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http://www.flickr.com/photos/butsky/357672637/

Problem Statement 01

A far-sighted UK billionaire has indicated that he will put up the money to buy enough land and put in the work, to recreate one native ecosystem somewhere in Leicestershire – for example woodland, wetland or grassland – but it must create space for endangered species and it must have a sound framework for educating citizens about the imminent problem of biodiversity loss. You have been asked to investigate the particular needs of one specific UK ecosystem that could be recreated and present the case for its inclusion in the project. Its area will be approximately 100 hectares.

As only one ecosystem can be rebuilt in this way, it is important that you present a well-researched case, since the judges will have to evaluate between competing presentations.

Problem Statement 02

An ecology journal hears about your work on the Leicestershire ecosystem project and approaches you to write an article. They have a forthcoming issue with a theme of ecosystem stability; as part of this issue they want to present their readers with a series of "Great Debate" articles from leading experts in the field (~2000-5000 words).

They would like you to think about the following questions when writing your article;

- How strong is the evidence for the contention that ecosystems are unstable with few species compared with many species?
- What are the implications for human society?

Staff

Dr David Harper	Biology

Learning Objectives

- Terminology used in ecology,
- Basics of an 'environment',
- Species population and distribution,
- Food chains,
- Predator-prey interactions,
- Diversity,
- Communities,
- Ecosystems.
- Entropy,
- Energy.
- Nutrient flow and use,
- Solutions and outgassing,
- Recycling of elements and molecules.
- History of ecological research.
- Exhibits vs ecosystems.
- Current and future projects.
- Endangered and alien species in the UK.
- Scaling up these processes from ecosystem to biome to a biosphere.
- Predicting causality using statistics and computer modelling.
- Timetabling and scheduling.
- Project management.

Reading List

Papers

- Costanza, R. & Daly, H.E. (1992) *Natural capital and sustainable development*. Conservation Biology, **6**, 37-46.
- Chapin, F.S., Sala, O.E., Burke, I.C. et al. (1998) Ecosystem consequences of changing biodiversity: experimental evidence and a research agenda for the future. BioScience, **48**, 45-52.
- Dalton, H. & Brand-Hardy, R. (2003) *Nitrogen; the essential public enemy*. Journal of Applied Ecology, **40**, 771-781.
- Erwin, T. (1991) *How many species are there?* Conservation Biology, **5**, 330-333.
- Grace, J. (2004) *Understanding and managing the global carbon cycle*. Journal of Ecology, **92**, 189-202.
- Kibria, G., Nugegoda, D., Lam, P., Fairclough, R. (1996), *Aspects of phosphorus pollution from aquaculture*. Naga. *(Manila)*, **19**, 20-24.
- May, R.M., (1988) *How many species are there on earth*? Science, **247**, 1441-49.
- Odum, E.P. (1969) *The Strategy of Ecosystem Development*. Science, **164**, 262-270.

Books

- Braithwaite, M.E., Ellis, R.W. & Preston, C.D. (2006). *Change in the British Flora 1987-2004*. BSBI Publications
- Campbell, N.A. & Reece, J.B. (2005). *Biology, 7th Ed*. Pearson/ Benjamin Cummings.
- Perring, F. (1976) *Atlas of British Flora, 2nd Ed*. BSBI Publications/E.P. Publishing.
- Preston, C. D. (2002). New atlas of the British and Irish flora: an atlas of the vascular plants of Britain, Ireland, the Isle of Man and the Channel Islands. Oxford University Press.

Websites

- www.plantlife.org.uk/.../saving-species-publications/People-and-plants-mapping-the-UKs-flora.pdf
- Alkaline wetlands (http://www.greatfen.org.uk/),

- Deciduous woodland (http://www.nationalforest.org/),
- Lowland heaths (http://www.ukbap.org.uk/UKPlans.aspx?ID=15),
- Rivers (http://www.wwf-k.org/core/about/scotland/sc_0000000380.asp),
- Lowland grasslands (http://www.jncc.gov.uk/page-2097).
- Shallow water (http://www.rutlandwater.org.uk/)
- Floodplains (http://www.floodplains.org.uk/)
- Geology of Leicestershire (http://www.soton.ac.uk/~imw/jpg/leic.jpg)
- Leicestershire ecology and biodiversity conservation (http://www.naturalengland.org.uk/regions/eastmidlands/default.htm)
- http://www.lrwt.org.uk/

A Guide to Module pacing

Session	Preparation	Learning Outcomes
FS01	Section 01 “What is Ecology” from An Ecology Primer	Fundamentals of Ecology
FS02	Section 02 “The Concept of Species” from An Ecology Primer	The Concept of Species
ES01		Ecology
FS03	Section 03 “Population Ecology” from An Ecology Primer The introduction to Braithwaite, Ellis & Preston (2006); Change in the British Flora 1987-2004	Population Ecology Life tables Change in British Flora
FS04	The introduction to Braithwaite, Ellis & Preston (2006); Change in the British Flora 1987-2004	Change in British Flora
FS05	Section 04 “Ecology of Communities” from An Ecology Primer	Ecology of Communities
FS06	Section 05 “Ecological Succession” from An Ecology Primer	Ecological Succession
ES02		Ecological Succession
FS07	Section 06 “The Ecosystem and its Key Biological Processes” from An Ecology Primer	Ecological Succession Ecosystems
FS08		Ecosystems
FS09	PA1013_ConservationBiology_Chapter1 PA1013_ConservationBiology_Chapter2 PA1013_ConservationBiology_Chapter3 PA1013_ConservationBiology_Chapter4	Conservation Biology Biodiversity Action Plans
FS10	PA1013_ConservationBiology_Chapter1 PA1013_ConservationBiology_Chapter2 PA1013_ConservationBiology_Chapter3 PA1013_ConservationBiology_Chapter4 Weblinks: Ecological restoration examples.	Examples of ecological restoration
ES03		Ecological Restoration I
FS11		Ecosystem restoration
LS01	Field Trip	Nature Reserve
FS12		Ecosystem restoration
FS13	Weblinks: Leicestershire	Geology, soil and topography of Leicestershire.
FS14		Ecological restoration Ecosystem stability
ES04		Ecological Restoration II
FS15		Ecological restoration Ecosystem stability
FS16		Ecological restoration Ecosystem stability

Facilitation Sessions

Theme 1: What are the fundamentals of Ecology?

This will start with basic terminology and will cover species, their distribution patterns and their evolution, then populations, their characteristics and their dynamics.

Theme 2: What is the basic structure of an ecosystem?

This will move on from species and populations to study communities and ecosystems. A community is defined as an interacting group of two or more species at the same location. An ecosystem is a living community, interacting with non-living components, to produce a group of organisms with a recognisable and predictable structure (such as a woodland). The important non-living components are energy and materials.

Theme 3: Why care about biodiversity and loss of species?

This will consider what are the causes of species loss in the world today, both locally (i.e. a species is lost from Leicestershire) and globally (i.e. a species becomes extinct). It will then examine what is being done about the losses.

Theme 4: The restoration of an ecosystem.

This will consider how to restore an ecosystem in the Midlands of England, synthesising the knowledge of the past three weeks. Your ecosystem must fit into the geology, soils and topography, somewhere within Leicestershire.

Facilitation Session 01

Pre Session Preparation

Read section 01 “What is Ecology?” from *An Ecology Primer*.

Key Terms

Working as groups identify a series of key terms and phrases contained within section 01 of *An Ecology Primer*. Using your own words produce a definition for each of these terms; DO NOT copy from the Primer or from web sources. It is important that you understand what you are writing rather than copying verbatim.

Discussion: What is Ecology?

Using the material contained within section 01 of *An Ecology Primer* discuss the topic of Ecology as a whole class.

Preparing Questions for Expert Session 01

During the group and class discussions you should note down any outstanding questions to ask in the Expert Session. You will be expected to do before every Expert Session: it will not be explicitly stated in the documentation hereafter.

Facilitation Session 02

Pre-Session Preparation

Read section 02 “The Concept of Species” from *An Ecology Primer*. Highlight a series of key terms and phrases as before.

Key Terms from FS01

Class discussion of your definitions for the key terms picked out in facilitation session 01.

Discussion: The Concept of Species

Using the material contained within section 02 of *An Ecology Primer* discuss the topic “the concept of species” as a whole class.

Population Ecology

If there is sufficient time during the facilitation session you should start reading section 03 “Population Ecology” from *An Ecology Primer*. Highlight a series of key terms and phrases as before.

Post Session Tasks

Sometime during the day, go out onto Victoria Park and look at the sea gulls which over winter there. Ninety nine out of every hundred people who walk across the Park think of them just as individuals of a ‘seagull’. But look closely, each one of you, at about 20 birds. Look at the back and tail; the legs; and the head. Make notes about what you see, describing the different possible colour patterns and work out how many species there are from a different combination on those three areas. Try to think why there should be more than one species of gull apparently doing exactly the same thing in exactly the same place, which contradicts what you have just been reading.

When you have finished Section 3, go out across University Road into the City Cemetery, in pairs. Each of you should choose 50 gravestones at random from EITHER the nineteenth century or the twentieth. Back in your groups, pool the results, which will be 100 from each century. Produce a Life Table analysis for the two different centuries and, individually in your lab notes, write if there are differences and, if so, why it is likely.

The results from both of these tasks are required for facilitation session 03.

Facilitation Session 03

Pre-Session Preparation

- Read section 03 “Population Ecology” from *An Ecology Primer*. Highlight a series of key terms and phrases as before.
- Complete the ‘Seagull’ and ‘Cemetery’ tasks from the previous facilitation session.
- Read the introduction to Braithwaite, Ellis & Preston (2006); *Change in the British Flora 1987-2004*.

Discussion: Seagulls

As a class discuss the notes you made on the Victoria Park seagulls.

Discussion: Human Life Tables

As a class discuss the human Life Tables you constructed using data collected from the cemetery.

Change in British Flora

In groups discuss the introduction to *Change in the British Flora 1987-2004*. Each group member should choose one species; the changes to which you should summarise in a few sentences (plus a map if you think this would be useful), plus an explanation for the changes. These summaries will be discussed in facilitation session 04.

Facilitation Session 04

Pre Session Preparation

Read the introduction to Braithwaite, Ellis & Preston (2006); *Change in the British Flora 1987-2004*.

Discussion: Change in British Flora

In this session, within your individual groups, you will present your summary of the changes to your chosen species, allowing for a *maximum* of 10 minutes per person.

Each group member of the group should explain what species that have looked at (what kind of plant it is), the change in its distribution and the likely reasons for the change to the others. The other members of the group who are listening will mark the presentation out of 5 for the following two criteria:

- How well did he/she explain it?
- How well did I understand the presentation?

There each presenter should get two marks from each group member. These marks should be collated and handed into the facilitator at the end of the session.

At the end of the presentations you should forward your notes pertaining to your presentation to other group members. Remember that these will be useful for completing the CLEs as well as helping you to revise for your module exam.

General discussion

The final segment of this session has been set aside for any further questions you may have on this week's work. There is also an opportunity to gain *guidance* on specific questions within the CLEs.

Facilitation Session 05

Pre Session Preparation

Read section 04 “Ecology of Communities” from *An Ecology Primer*. Highlight a series of key terms and phrases as before.

Key Terms

Working as groups identify a series of key terms and phrases contained within section 04 of *An Ecology Primer*. Using your own words produce a definition for each of these terms.

Discussion: Ecology of Communities

Using the material contained within section 04 of *An Ecology Primer* discuss the topic “the ecology of communities” as a whole class.

Facilitation Session 06

Pre Session Preparation

Read section 05 “Ecological Succession” from *An Ecology Primer*. Highlight a series of key terms and phrases as before.

Key Terms from FS05

Class discussion of your definitions for the key terms picked out in facilitation session 05 (Ecology of Communities).

Key Terms

Working as groups identify a series of key terms and phrases contained within section 05 of *An Ecology Primer*. Using your own words produce a definition for each of these terms.

Post Session Tasks

- Sometime during the day, go out onto Freeman’s Common Nature Reserve, which is between the Halls and the Railway Line. It is a small area of original grassland, which has been inadvertently preserved from development by the telephone mast. Make notes describing the succession that you see on this site, compared with what you have read.
- Sometime during the day, go out onto Victoria Park, to the end closest to the Space Research Centre and walk down to the road, looking at what the City Council is doing. Try to describe the management of Victoria Park, in terms of succession.

Facilitation Session 07

Pre Session Preparation

Read section 06 “The Ecosystem and its Key Biological Processes” from *An Ecology Primer*. Highlight a series of key terms and phrases as before.

Discussion: Ecological Succession

Using the material contained within section 05 of *An Ecology Primer* discuss the topic “ecological succession” as a whole class.

Ecosystems: Differing Perspectives

In your groups briefly discuss ecosystems from four perspectives;

- Carbon cycling,
- Nitrogen cycling,
- Phosphorous cycling,
- Energy flow.

Agree on one named ecosystem to focus on, then each group member should choose one of the perspective from the list above. Prepare to present your results to your group members in facilitation session 08 (as you did in facilitation session 04).

Facilitation Session 08

Discussion: Ecosystems

Using the material contained within section 06 of *An Ecology Primer* discuss the topic "ecosystems" as a whole class.

Discussion: Ecosystems and cycles

In this session, within your individual groups, you will present your summary of one of the cycles in your chosen ecosystem (see facilitation session 07), allowing for a *maximum* of 10 minutes per person.

The other members of the group who are listening will mark the presentation out of 5 for the following two criteria:

- How well did he/she explain it?
- How well did I understand the presentation?

There each presenter should get two marks from each group member. These marks should be collated and handed into the facilitator at the end of the session.

At the end of the presentations you should forward your notes pertaining to your presentation to other group members. Remember that these will be useful for completing the CLEs as well as helping you to revise for your module exam.

General discussion

The final segment of this session has been set aside for any further questions you may have on this week's work. There is also an opportunity to gain *guidance* on specific questions within the CLEs.

Facilitation Session 09

Pre Session Preparation

Read the pdf copies provided of the early chapters of a textbook on Conservation Biology;

- PA1013_ConservationBiology_Chapter1
- PA1013_ConservationBiology_Chapter2
- PA1013_ConservationBiology_Chapter3
- PA1013_ConservationBiology_Chapter4

Conservation Biology

Continue reading the pdf documents listed above.

Biodiversity Action Plans

Search the internet to begin to find out about “Biodiversity Action Plans” in the UK.

Facilitation Session 10

Pre Session Preparation

Continue to read the Conservation Biology pdf documents.

Ecological Restoration Examples

Read the websites, listed in the Reading List at the start of the module documentation, about ecological restoration. Search for additional resources online.

In groups discuss the habitat and ecosystem restoration examples that you have read so far. Agree on one example for each person and focus your research in this area in preparation for reporting back in facilitation session 12. Concentrate on reasons why the restoration was undertaken, the physical and spatial constraints on where it could be done, the issues which had to be resolved in order to make it successful and the probable main reasons for success/failure.

Facilitation Session 11

Discussion: Ecosystem restoration

As a class discuss the topic of ecosystem restoration posing questions, where necessary, to the facilitator.

Work on Deliverables

This part of the session provides you an opportunity to get some interim feedback on the progress of your Deliverables. Ensure that you have some documentation to discuss – at the very least you should have a sketch outline of the documents with associated notes.

Facilitation Session 12

Discussion: Ecosystem restoration examples

In this session, within your individual groups, you will present your summary of one of the ecosystem restoration examples (see facilitation session 10), allowing for a *maximum* of 10 minutes per person.

The other members of the group who are listening will mark the presentation out of 5 for the following two criteria:

- How well did he/she explain it?
- How well did I understand the presentation?

There each presenter should get two marks from each group member. These marks should be collated and handed into the facilitator at the end of the session.

At the end of the presentations you should forward your notes pertaining to your presentation to other group members. Remember that these will be useful for completing the CLEs as well as helping you to revise for your module exam.

General discussion

The final segment of this session has been set aside for any further questions you may have on this week's work. There is also an opportunity to gain *guidance* on specific questions within the CLEs.

Facilitation Session 13

Pre Session Preparation

Use the website links provided in the Reading List at the start of this module documentation to start finding out about the geology, soil and topography of Leicestershire.

Leicestershire

Continue your research into the geology, soil and topography of Leicestershire and hence the ecosystems which once covered the country before humanity started to shape the environment. Find out the conservation status of sites in the county and consider how they represent what was here, both in terms of ecosystems and of species. Begin to narrow down your list of possible ecosystems to restore.

Facilitation Session 14

Work on Deliverables

Continue work on your deliverables within your group.

Facilitation Session 15

Work on Deliverables

Continue work on your deliverables within your group.

Facilitation Session 16

Work on Deliverables

Continue work on your deliverables within your group.

General discussion

The final segment of this session has been set aside for any further questions you may have on this week's work. There is also an opportunity to gain *guidance* on specific questions within the CLEs.

Deliverables

Please name your deliverables in accordance with the standard naming convention (see the handbook for details). A sample filename is provided for you to cut and paste - please complete with submission date and username/group letter as appropriate.

All deliverables to be submitted to iscience@le.ac.uk

Please note that although deliverable deadlines (except for CLEs) are at the end of the module, you are strongly urged not to leave all work on the deliverables until the final weekend! In particular, if you would like formative feedback on your works-in-progress from your facilitator and/or experts, please provide them with draft copies in good time.

DELIVERABLES	TYPE	FILENAME	DUE	WEIGHTING
CLE01:	I	PA1013_I_CLE01_username_date.pdf	Week 2, Day 1	7.5%
CLE02:	I	PA1013_I_CLE02_username_date.pdf	Week 3, Day 1	7.5%
CLE03:	I	PA1013_I_CLE03_username_date.pdf	Week 4, Day 1	7.5%
CLE04:	I	PA1013_I_CLE04_username_date.pdf	Week 5, Day 1	7.5%
D01:	G	PA1013_G_D01_Ecosystem Report_groupletter_date.pdf	Week 5, Day 3	20.0%
D02:	G	PA1013_G_D02_Ecosystem Presentation_groupletter_date.pdf	Week 5, Day 3	20.0%
D03:	I	PA1013_I_D03_Article_username_date.pdf	Week 5, Day 3	30.0%

Core Learning Exercise 01

1. Explain Darwin's Theory of Evolution in not more than 6 sequential sentences. [10]

2. Name a common species, such as a Robin, and explain its niche. [10]

3. Make a Survivorship curve for your 20th Century Cemetery data and explain it. [10]

4. Look up the reason for the fact that northern hemisphere gull species look so similar and explain it in simple terms. [10]

5. Take a named species and classify it in a table, showing every taxonomic level you can find from Kingdom to species. [10]

Core Learning Exercise 02

1. Describe, concisely and in not more than a page, how an ecosystem is structured with the Laws of Thermodynamics. [15]

2. Describe, using a labelled illustration, a soil profile. [15]

3. Using your reading and your two field visits, describe succession from bare ground to a climax community over 200 years if, in theory, a football pitch on Victoria Park were to be abandoned as an experiment (not more than one page; use diagrams). [15]

Core Learning Exercise 03

1. Give a written summary, in not more than 3 pages, of the ecosystem restoration you have studied for your group. [50]

Core Learning Exercise 04

1. Describe the major geological and topographical features of Leicestershire and explain how they affect the natural vegetation types. [20]

2. Describe the major watercourses and water bodies in Leicestershire. [20]

Deliverable 01: Ecosystem Report

Write a report detailing which native ecosystem you advocate to be recreated covering all of the topics of interest highlighted in Problem Statement 01. The document should contain approximately ~5000 words and any supporting materials (i.e. maps, diagrams etc) that help to explain or support your case.

Deliverable 02: Ecosystem Presentation

You should present your case to a panel of judges regarding which ecosystem you advocate recreating. The presentation should be delivered via PowerPoint, or other presentation software, and should last no more than 20 minutes.

You should also be prepared to answer questions on your 'pitch' after the presentation; this will take approximately 5 minutes immediately *after* your presentation.

Deliverable 03: Great Debate Article

Write an article for the ecology journal for their “Great Debate” series. The document should contain approximately 2000-5000 words and any supporting materials (i.e. maps, diagrams etc) that help to explain or support your case.

Meta tags

Author: Harper, D.

Owner: University of Leicester

Title: Interdisciplinary Science Biosphere Student Document

Classification: PA1013 / Biosphere

Keywords: Biology; Ecology; Complex Systems; Problem-Based Learning; sfsoer; ukoer

Description: The World's biodiversity is in serious decline. We do not know the total number of species that were on this planet, say, at the beginning of the Second millennium, but by the beginning of the Third, we have identified 1.4 million species and we think there are at least 20 million, based upon individual studies of trees in rain forest for example and estimates of ecosystem diversity. How can we measure the usefulness of species to us and how many of them do we need to maintain the Biosphere sustainably?

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Version: 1.0

Additional Information

This module pack is the open student version of the teaching material. An expanded module pack for facilitators and additional information can be obtained by contacting the Centre for Interdisciplinary Science at the University of Leicester. http://www.le.ac.uk/iscience

This pack is the Version 1.0 release of the module.