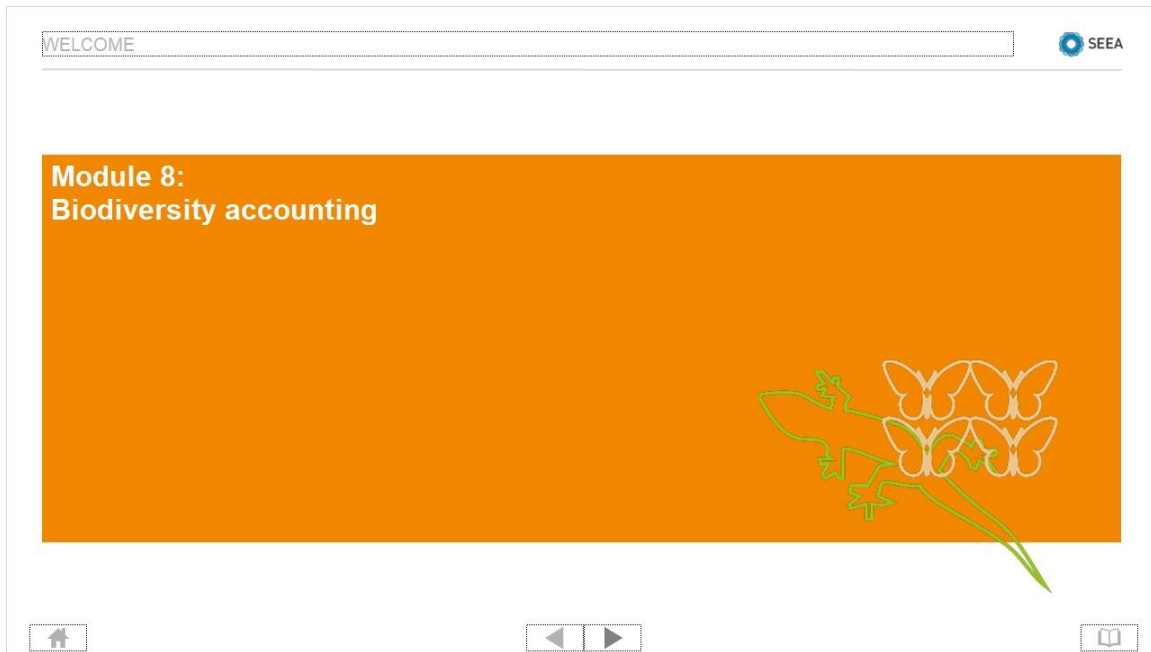


1. Module 1 - Introduction


1.1 Welcome



Notes:

1.2 Module units

MODULE 8: BIODIVERSITY ACCOUNTING

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Module units

The biodiversity accounting module will take you through four units, as listed below. We recommend completing these units in order.

**Unit 1:
Biodiversity
accounting**

- What is it?
- Why do we need it?
- What does it look like?
- Expertise and data required.

**Unit 2:
Compilers**




- Basic concepts for measuring biodiversity.
- Steps for compiling biodiversity accounts.

**Unit 3:
Data providers**

- Concepts
- Biodiversity accounting information uses.
- Data options, examples and issues.


**Unit 4:
Review**

- Quiz
- Summary



1.3 Module objectives

MODULE 8: BIODIVERSITY ACCOUNTING, UNIT 1: BIODIVERSITY ACCOUNT

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Module objectives

After completing the SEEA Biodiversity Accounting module you will be able to:




Understand the importance of biodiversity accounting.

Consider biodiversity in the SEEA context.

Understand the basic concepts behind measuring biodiversity.

Follow the steps to compile a biodiversity account.

Understand the data options and sources for biodiversity accounting.



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1.4 What is Biodiversity Accounting?

MODULE 8: BIODIVERSITY ACCOUNTING, UNIT 1: BIODIVERSITY ACCOUNT

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What is biodiversity accounting?





Biodiversity accounting contains detailed data on ecosystem areas (from the **extent account**) and all recorded information on biodiversity key species.

Biodiversity accounts provide spatially-detailed information on species diversity such as, abundance, richness, conservation status, and other characteristics (e.g., health).

In addition, spatially detailed **summary statistics** (index) on species diversity (used in condition accounts).

Hover over the highlighted words to learn more.





Explanation 1 (Slide Layer)

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What is biodiversity accounting?





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Explanation 2 (Slide Layer)

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SEEA


What is biodiversity accounting?

Biodiversity accounting contains detailed data on ecosystem areas (from the **extent account**) and all recorded information on biodiversity key species.





Biodiversity accounts provide spatially-detailed information on diversity such as, abundance, richness, conservation status, and characteristics (e.g., health).

In addition, spatially detailed **summary statistics** (index) of biodiversity (used in condition accounts).

Summary statistics are generated from the information contained in the biodiversity account. As an index, they provide an indicator of overall biodiversity and information on the condition of an ecosystem.



Hover over the highlighted words to learn more.



1.5 Importance of Biodiversity Accounting

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Importance of biodiversity accounting

Creating biodiversity accounts is important since biodiversity plays a vital role in the environment and the economy.

This is why we need to create biodiversity accounts:

- To compare trends in biodiversity with economic and social activity in a **spatially explicit manner**.
- To connect biodiversity information with other SEEA EEA **accounts** (condition, services supply).
- To meet global commitments under the Convention on Biological Diversity's **(CBD)** Strategic Plan for Biodiversity (2011 – 2020)
- To support **sustainable development**

Hover over the highlighted keywords to learn more.



Explanation 1 (Slide Layer)

MODULE 8: BIODIVERSITY ACCOUNTING, UNIT 1: BIODIVERSITY ACCOUNT

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Importance of biodiversity accounting

Creating biodiversity accounts is important since biodiversity plays a vital role in the environment and the economy.

This is why we need to create biodiversity accounts:

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- To support **sustainable development**

Hover over the highlighted keywords to learn more.

Biodiversity accounting, through the SEEA EEA framework, allows **trends in biodiversity** (and the benefits it provides) to be compared with economic and social activity in a spatially explicit manner. This helps users to understand trade-offs and synergies and inform policy decisions.

Explanation 2 (Slide Layer)

MODULE 8: BIODIVERSITY ACCOUNTING, UNIT 1: BIODIVERSITY ACCOUNT

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Importance of biodiversity accounting

Creating biodiversity accounts is important since biodiversity plays a vital role in the environment and the economy.

This is why we need to create biodiversity accounts:

- To compare trends in biodiversity with economic and social activity in a **spatially explicit manner**.
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- To meet global commitments under the Convention on Biological Diversity's **(CBD)** Strategic Plan for Biodiversity (2011 – 2020)
- To support **sustainable development**

Hover over the highlighted keywords to learn more.

Biodiversity accounts provide the information required to incorporate biodiversity, and the benefits it provides, with other accounts in the SEEA framework.

Explanation 3 (Slide Layer)

MODULE 8: BIODIVERSITY ACCOUNTING, UNIT 1: BIODIVERSITY ACCOUNT

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Importance of biodiversity accounting





Creating biodiversity accounts is important since biodiversity plays a vital role in the environment and the economy.

This is why we need to create biodiversity accounts:

- To compare trends in biodiversity with economic and social activity in a **spatially explicit manner**.
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- To meet global commitments under the Convention on Biological Diversity's **(CBD)** Strategic Plan for Biodiversity (2011 – 2020)
- To support **sustainable development**

Hover over the highlighted keywords to learn more.

Internationally, the **CBD's** Strategic Plan for Biodiversity (2011 – 2020) provides a vision for fully valuing and integrating biodiversity into national decision making, and taking concrete actions to reverse biodiversity loss during the next decade. Biodiversity accounting provides a framework to accomplish this.



Explanation 4 (Slide Layer)

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Importance of biodiversity accounting





Creating biodiversity accounts is important since biodiversity plays a vital role in the environment and the economy.

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- To meet global commitments under the Convention on Biological Diversity's **(CBD)** Strategic Plan for Biodiversity (2011 – 2020)
- To support **sustainable development**

Hover over the highlighted keywords to learn more.

Understanding trends and impacts on biodiversity, as well as the benefits it provides, can support more sustainable decision making.



1.6 Biodiversity Accounting Representation

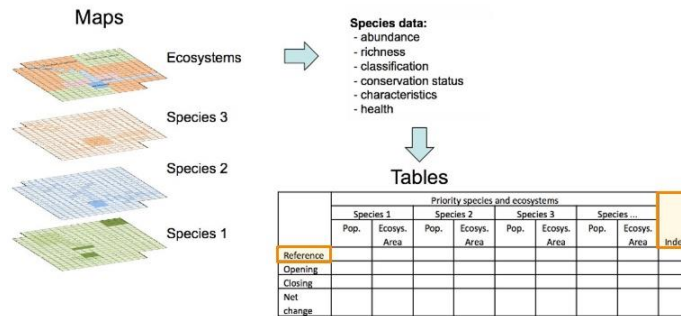
Biodiversity accounting representation

What does a biodiversity account look like?

It is good to note that a biodiversity account is useful for bringing together data on species and ecosystems from many sources.

Biodiversity accounts can be represented using maps and tables (as shown in the figure) that contain spatial information on ecosystems, species data (abundance, richness, classifications, etc.), index, reference, closing, opening, and net change.

Explore the highlighted boxes with the cursor for more information about index and reference sections.



Explanation 1 (Slide Layer)

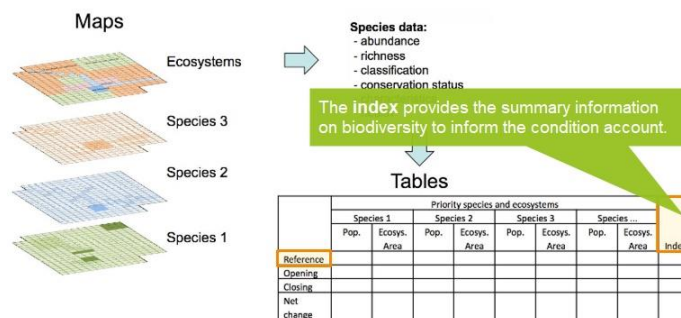
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Explanation 2 (Slide Layer)

MODULE 8: BIODIVERSITY ACCOUNTING, UNIT 1: BIODIVERSITY ACCOUNT

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Biodiversity accounting representation

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Explore the highlighted boxes with the cursor for more information about index and reference sections.

Maps

Ecosystems

Species 3

Species 2

Species 1

Species data:

- abundance
- richness
- classification
- conservation status
- characteristics
- health

Tables

	Priority species and ecosystems								
	Species 1		Species 2		Species 3		Species		
	Pop.	Ecosys. Area	Pop.	Ecosys. Area	Pop.	Ecosys. Area	Pop.	Ecosys. Area	Index
Reference									
Opening									
Closing									

The SEEA EEA describes a reference condition as one of minimal human disturbance. However, in some contexts, this may be difficult to define. The reference condition could instead comprise species measures at the beginning of the first accounting period or a level representative of ecological sustainability (as per the Norwegian Nature Index).

1.7 Biodiversity Account Data and Expertise Requirements

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Biodiversity account data and expertise requirements

Compiling biodiversity accounts requires determining **key policy questions and goal** of the biodiversity account, list of **key or priority species**, list of main **data sources**, and **expertise required** to mobilize data and plug the gaps.

To learn more about these requirements, please take a look at the figure.

Click on each section to learn more.

Policy and goal

Key or priority species

Biodiversity account

Expertise

Data

Explanation 1 (Slide Layer)

MODULE 8: BIODIVERSITY ACCOUNTING, UNIT 1: BIODIVERSITY ACCOUNT

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Biodiversity account data and expertise requirements

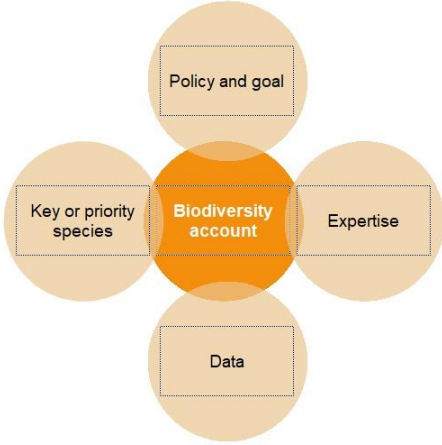
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To learn more about these requirements, please take a look at the figure.

Click on each section to learn more.

Biodiversity - the diversity of ecosystems, species and genes - plays an essential role in supporting human well-being. Biodiversity helps maintain functioning and resilient ecosystems that in turn deliver ecosystem services such as food, the regulation of our climate, aesthetic enjoyment and other cultural benefits.

The biodiversity account will be restricted to a subset of key species for which data are available. The species chosen also depend on what features of biodiversity are of greatest interest and the objective of the biodiversity account.





Explanation 2 (Slide Layer)

MODULE 8: BIODIVERSITY ACCOUNTING, UNIT 1: BIODIVERSITY ACCOUNT

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Biodiversity account data and expertise requirements

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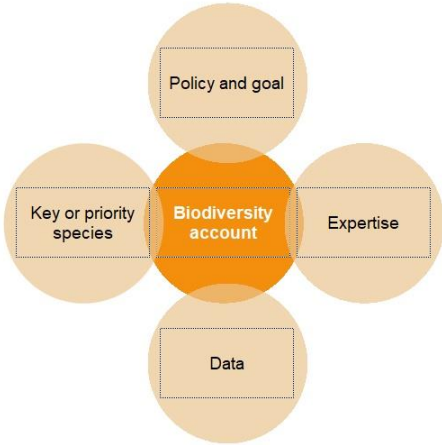
To learn more about these requirements, please take a look at the figure.





Click on each section to learn more.

Information on key or priority species:

- Species classifications (family, genus)
- Species measures (ranges, richness, population counts over time)
- Characteristics (e.g., habitat, specialist/generalist, health)
- Conservation status

Extent account or some form of spatial infrastructure for ecosystems using spatial units is useful because information needs to be assigned to ecosystems in a spatially explicit manner. Ideally, the spatial units are described in the extent account.





Explanation 3 (Slide Layer)

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SEEA

Biodiversity account data and expertise requirements

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To learn more about these requirements, please take a look at the figure.

Click on each section to learn more.

Expertise

- Species measurement
- Biophysical modeling, GIS
- Indicator development
- Statistical analysis

Explanation 4 (Slide Layer)

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Biodiversity account data and expertise requirements

Compiling biodiversity accounts requires determining **key policy questions and goal** of the biodiversity account, list of **key or priority species**, list of main **data sources**, and **expertise required** to mobilize data and plug the gaps.

To learn more about these requirements, please take a look at the figure.

Click on each section to learn more.

Data may be available from a variety of sources. International reporting commitments to multilateral environmental agreements require parties to report, for example, on fauna species in important wetland sites as part of the Ramsar Convention.

1.8 Module units

MODULE 8: BIODIVERSITY ACCOUNTING

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Module units

The biodiversity accounting module will take you through four units, as listed below. We recommend completing these units in order.

**Unit 1:
Biodiversity
accounting**

- What is it?
- Why do we need it?
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**Unit 2:
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- Basic concepts for measuring biodiversity.
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- Data options, examples and issues.

**Unit 4:
Review**

- Quiz
- Summary

1.9 Unit 2

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SEEA

Unit 2: Compilers

In this unit, we will learn the basic concepts for measuring biodiversity and the basics for compiling biodiversity accounts.

Let's move on and start learning.



1.10 Biodiversity in the SEEA-EEA

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SEEA

Biodiversity in the SEEA-EEA

To get started with the concepts behind biodiversity, we quote the following statement from the Convention on Biological Diversity (CBD) - United Nations report issued in 1992,





"Biological diversity means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems".

Quoted from: [CBD - UN Report \(1992\)](#)



www.cbd.int/

Convention on Biological Diversity



1.11 Biodiversity in the SEEA-EEA

MODULE 8: BIODIVERSITY ACCOUNTING, UNIT 2: COMPILERS

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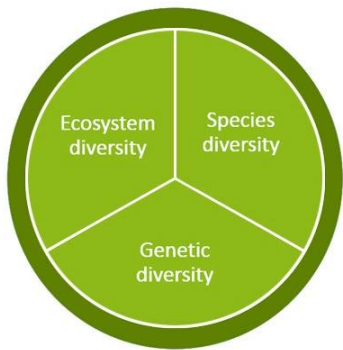
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Biodiversity in the SEEA EEA

The three components in the SEEA EEA for biodiversity are as follows:

- Ecosystem diversity,
- Species diversity, and
- Genetic diversity.

The measurement of biodiversity is focused on the assessment of **diversity of species**, although changes in the **diversity of ecosystems** is also an important output, derived from the measurement of changes in ecosystem extent and condition. The **genetic diversity** could be captured, but is not given a specific consideration due to the complexity involved in measuring this aspect of biodiversity.





1.12 Biodiversity in the SEEA-EEA

Biodiversity in the SEEA EEA

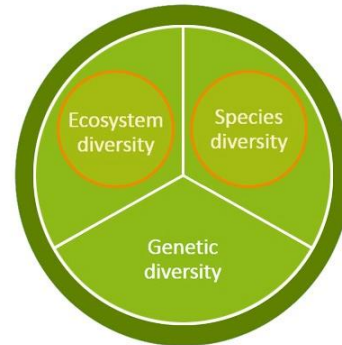
How do we measure biodiversity for inclusion in ecosystem accounts?

As mentioned previously, in general assessment of biodiversity considers the diversity of ecosystems and species, in the biodiversity account, we focus on species diversity.

These are the main reasons to focus on species diversity in the biodiversity account:

- Ecosystem diversity is largely already covered in the extent account.
- The conservation and sustainable use of species is addressed through a number of biodiversity-related multilateral environment agreements and national policies on biodiversity.
- Species are relatively conspicuous.
- There is considerable research on species, decades of science on the measurement of species, and many countries have long-term monitoring programs for species.
- Species are often used as a surrogate for biodiversity in general.

Hover over the highlighted keywords in the figure to learn more.



Explanation 1 (Slide Layer)

Biodiversity in the SEEA EEA

How do we measure biodiversity for inclusion in ecosystem accounts?

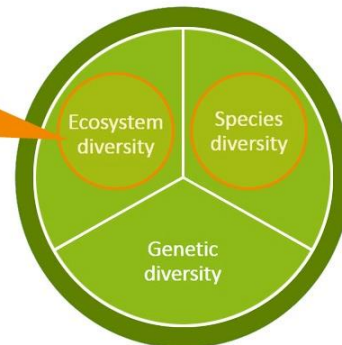
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- There is considerable research on species, decades of science on the measurement of species, and many countries have long-term monitoring programs for species.
- Species are often used as a surrogate for biodiversity in general.

Hover over the highlighted keywords in the figure to learn more.

Ecosystem diversity is captured (to some degree) by the extent account. It reflects the heterogeneity of ecosystems found in an area (e.g., number and extent of ecosystem types within a landscape).



Explanation 2 (Slide Layer)

MODULE 8: BIODIVERSITY ACCOUNTING, UNIT 2: COMPILERS

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SEEA

Biodiversity in the SEEA EEA

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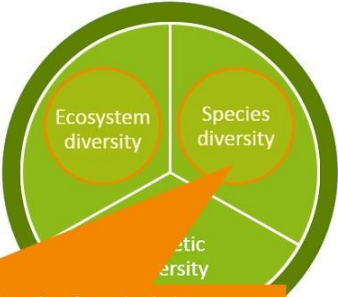
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- Ecosystem diversity is largely already covered in the extent account.
- The conservation and sustainable use of species is addressed through a number of biodiversity-related multilateral environment agreements and national policies on biodiversity.
- Species are relatively common in the biodiversity account.
- There is considerable interest in the measurement of species diversity.
- Species are often used in the assessment of biodiversity.

The measurement of biodiversity is focused on the assessment of diversity of species in the biodiversity account by looking at:

- **Species richness**: number of species within a given sample, area or community.
- **Species abundance**: total number of individuals of a species in an area, community or population.
- The dissimilarity between richness and abundance between areas.

Hover over the highlighted keywords in the figure to learn more.



1.13 Biodiversity Measurements

MODULE 8: BIODIVERSITY ACCOUNTING, UNIT 2: COMPILERS

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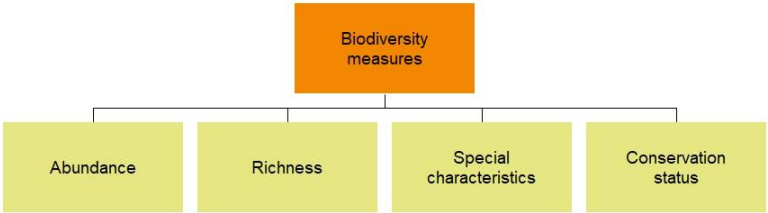
SEEA

Biodiversity measurement

Which measure of species biodiversity should be used?

Biodiversity accounts use several measures for species, like species abundance and richness (abundance is more sensitive than species richness). In addition, there are other useful measures such as species characteristics and conservation status that can be used for species measures.

Click on each measure to learn more.



Explanation 1 (Slide Layer)

MODULE 8: BIODIVERSITY ACCOUNTING, UNIT 2: COMPILERS

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SEEA

Biodiversity measurement

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Click on each measure to learn more.

The **abundance** of a species in danger will decrease long before the species is no longer detected. Abundance is therefore more sensitive than species richness.

```
graph TD; A[Biodiversity measures] --> B[Abundance]; A --> C[Richness]; A --> D[Special characteristics]; A --> E[Conservation status];
```

Explanation 2 (Slide Layer)

MODULE 8: BIODIVERSITY ACCOUNTING, UNIT 2: COMPILERS

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SEEA

Biodiversity measurement

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Biodiversity accounts use several measures for species, like species abundance and richness (abundance is more sensitive than species richness). In addition, there are other useful measures such as species characteristics and conservation status that can be used for species measures.

Click on each measure to learn more.

Species **richness** is the most common measure of species diversity, but species richness also does not differentiate between healthy and threatened populations of species.

Example of issue: ecosystems that have been invaded by alien species have an increased species richness! Simply measuring species **richness** will also mask declines in populations of individual species.

```
graph TD; A[Biodiversity measures] --> B[Abundance]; A --> C[Richness]; A --> D[Special characteristics]; A --> E[Conservation status];
```


Explanation 3 (Slide Layer)

MODULE 8: BIODIVERSITY ACCOUNTING, UNIT 2: COMPILERS

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SEEA

Biodiversity measurement

Which measure of species biodiversity should be used?

Biodiversity accounts use several measures for species, like species abundance and richness (abundance is more sensitive than species richness). In addition, there are other useful measures such as species characteristics and conservation status that can be used for species measures.

Click on each measure to learn more.

While the biodiversity account must include fundamental information on species biodiversity, some aspects of the **species characteristics** may also be useful to record. For example, a measure of species health.

```
graph TD; A[Biodiversity measures] --> B[Abundance]; A --> C[Richness]; A --> D[Special Characteristics]; A --> E[Conservation status];
```

Explanation 4 (Slide Layer)

MODULE 8: BIODIVERSITY ACCOUNTING, UNIT 2: COMPILERS

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SEEA

Biodiversity measurement

Which measure of species biodiversity should be used?

Biodiversity accounts use several measures for species, like species abundance and richness (abundance is more sensitive than species richness). In addition, there are other useful measures such as species characteristics and conservation status that can be used for species measures.

Click on each measure to learn more.

Another piece of useful information is the species' **conservation status**. Recording this provides information on the stock of species and is important for monitoring progress towards conservation goals. A standardized way of assessing extinction risk is the IUCN's extinction categorization (e.g., endangered, critically endangered, extinct in the wild ...).

```
graph TD; A[Biodiversity measures] --> B[Abundance]; A --> C[Richness]; A --> D[Special characteristics]; A --> E[Conservation Status];
```


1.14 Biodiversity Measurements

Biodiversity measurement

How do we select species to prioritize?

To prioritize the species to be measured, we need to base our selection on specific **criteria**. Which criteria should be used depends on the **goal of the biodiversity account**. For example, rare species may be the focus of conservation, but common species are more important for the functionality of communities and are more likely to be significant contributors to ecosystem services.

Given that the collection of species measures is resource intensive, however, how should we prioritize species for inclusion in the biodiversity accounts?

[Click here](#) for some examples of possible criteria that could be used to prioritize species for inclusion.



Explanation 1 (Slide Layer)

Biodiversity measurement

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[Click here](#) for some examples of possible criteria that could be used to prioritize species for inclusion.



- Species that directly deliver particular ecosystem services (e.g. pollinators)
- Economically important species (e.g. game species related to tourism)
- Culturally important species (e.g. sacred plants/animals)
- Ecologically important species (e.g. keystone species)
- Endemic species
- Threatened species with a risk of extinction in the wild
- Species selected should represent different taxonomic and trophic groups (e.g. mammals, birds etc.)



1.15 Biodiversity Measurements

MODULE 8: BIODIVERSITY ACCOUNTING, UNIT 2: COMPILERS

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Biodiversity measurement


How do we select which species to prioritize?





We're going to focus on two criteria that are used in prioritizing the selection of ecosystem species.

Taxonomic groups:
Refers to the units that designate an organism to a particular rank based on shared characteristics.

Trophic groups:
Refers to the level an organism occupies in a food chain.

Hover over each group to learn more.





Explanation 1 (Slide Layer)

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Biodiversity measurement

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Taxonomic groups:
Refers to the units that designate an organism to a particular rank based on shared characteristics.


Trophic groups:
Refers to the level an organism occupies in a food chain.





Hover over each group to learn more.

Taxonomic groups are how scientists categorize life. Recording species across different taxonomic groups/ranks will make the species account more representative of biodiversity, in particular having species from different classes.

The different ranks in this group are:

- Kingdom, e.g. animals
- Phylum, e.g. vertebrates
- Class, e.g. mammals, birds, amphibians
- Order, e.g. carnivores
- Family, e.g. cats
- Genus, e.g. panthers
- Species, e.g. lions





Explanation 2 (Slide Layer)

MODULE 8: BIODIVERSITY ACCOUNTING, UNIT 2: COMPILERS

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SEEA

Biodiversity measurement

How do we select which species to prioritize?

We're going to focus on two criteria that are used in prioritizing the selection of ecosystem species.


Taxonomic groups:
Refers to the units that are based on shared characteristics.

Trophic groups:
Refers to the level a species occupies in a food chain in an ecosystem. For example, plants use sunlight to produce their own food and are, in turn, eaten by animals known as herbivores. Herbivores are then hunted by animals that eat other animals known as carnivores. In addition, there are carnivores that eat other carnivores. Trophic levels are part of how an ecosystem functions. Imbalance can lead to a decline in ecosystem condition.

Hover over each group to see more details.

The different levels in this category are:

- Producers, i.e. plants
- Consumers, i.e. animals that eat plants (herbivores) or other animals (carnivores)
- Decomposers, i.e. organisms that break down dead plants and animals



1.16 Biodiversity Measurements

MODULE 8: BIODIVERSITY ACCOUNTING, UNIT 2: COMPILERS

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Biodiversity measurement


How do we communicate measures of biodiversity?

In SEEA biodiversity accounting there are **measures** that are the actual measurement of a state, quantity, or process, derived from observations or monitoring, (e.g. counts of individuals in an area). Sometimes, several measures can be combined in a particular way to derive an **index**, a particular type of **indicator**.

Thus, in brief:

- **Measure** is the phenomenon to be measured in a data set and are the basis for deriving indicators.
- **Indicator** is a data element that represents statistical data for a specified time, place, and other characteristics.
- **Index** is composed when a number of measures or indicators is combined.

[Click here to learn about an example of communicating measures of biodiversity.](#)



Explanation 1 (Slide Layer)

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Biodiversity measurement

How do we communicate measures of biodiversity?

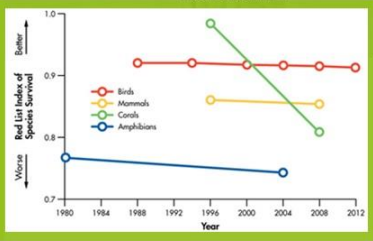

In SEEA biodiversity accounting there are **measures** that are the actual measurement of a state, quantity, or process, derived from observations or monitoring, (e.g. counts of individuals in an area). Sometimes, several measures can be combined in a particular way to derive an **index**, a particular type of **indicator**.

Thus, in brief:

- **Measure** is the phenomenon to be measured in a basis for deriving indicators.
- **Indicator** is a data element that represents state at a specified time, place, and other characteristics.
- **Index** is composed when a number of measures are combined.

[Click here to learn about an example of communicating measures of biodiversity.](#)

For example, the Red List Index for birds shows changes in threat status over time, obtained through a specific formula. Indices, like those of the Red List, make up an important set of indicators due to their ability to communicate processes in a way that's easy to understand. They include some very popular social and ecological indicators, for example, the Human Development Index and Living Planet Index.



Year	Birds	Mammals	Corals	Amphibians
1980	0.92	0.88	0.88	0.75
1984	0.92	0.88	0.88	0.75
1988	0.92	0.88	0.88	0.75
1992	0.92	0.88	0.88	0.75
1996	0.92	0.88	0.88	0.75
2000	0.92	0.88	0.88	0.75
2004	0.92	0.88	0.88	0.75
2008	0.92	0.88	0.88	0.75
2012	0.92	0.88	0.88	0.75

1.17 Biodiversity Measurements

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SEEA

Biodiversity measurement

How do we use data and information in biodiversity accounts?

The data recorded for compiling biodiversity accounts are both **measures** and **indicators**. The measures are the main data in the biodiversity account, comprising the opening and closing species information. The information contained within the biodiversity account can be summarized with one or more indicators.

Click on either measures or indicators to learn more about their role in the biodiversity accounts.

Measures

Indicators

Explanation 1 (Slide Layer)

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SEEA

Biodiversity measurement

How do we use data and information in biodiversity accounts?

The data recorded for compiling biodiversity accounts are both **measures** and **indicators**. The measures are the main data in the biodiversity account, comprising the opening and closing species information. The information contained within the biodiversity account can be summarized with one or more indicators.





Click on either measures or indicators to learn more about their role in the biodiversity accounts.

Measures

Indicators

Measures ...

- They consist of opening and closing measures for species richness, abundance or other information for priority species over a specific period.
- May be supplemented with information on the sources of any additions (e.g. births) and reductions (e.g. migrations or deaths).



Explanation 2 (Slide Layer)

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SEEA

Biodiversity measurement

How do we use data and information in biodiversity accounts?

The data recorded for compiling biodiversity accounts are both **measures** and **indicators**. The measures are the main data in the biodiversity account, comprising the opening and closing species information. The information contained within the biodiversity account can be summarized with one or more indicators.





Click on either measures or indicators to learn more about their role in the biodiversity accounts.

Measures

Indicators

Indicators ...

- Provide an overall headline indicator (output indicator) of species diversity.
- The output indicators captured from biodiversity accounts can link information on biodiversity to the ecosystem condition account (or progress to policy goals).
- Constructing an index from relevant information in the biodiversity account can generate a biodiversity output indicator for the ecosystem condition account.



1.18 Biodiversity Index

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SEEA

Biodiversity index

A **biodiversity index** is a mathematical measure for quantifying species diversity in a community. In this unit, we will address the **Shannon Index** and **species evenness** (or **equitability**) as two quantitative mathematical measures to reflect the biodiversity index of different types of species in a particular environment.





The **Shannon Index** can summarize information on all the biodiversity information recorded in the biodiversity account as a single indicator of species diversity.

Diversity indices provide more information about community composition than simply species richness (the number of species present). They also take the relative abundances of different species (the **evenness of species**) into account.

Click on each measure to learn more.

Shannon index

Species evenness



Explanation 1 (Slide Layer)

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SEEA

Biodiversity index

A **biodiversity index** is a mathematical measure for quantifying species diversity in a community. In this unit, we will address the **Shannon Index** and **species evenness** (or **equitability**) as two quantitative mathematical measures to reflect the biodiversity index of different types of species in a particular environment.

The **Shannon Index** can summarize information on all the biodiversity information recorded in the biodiversity account as a single indicator of species diversity.

Diversity indices provide more information about community composition than simply species richness (the number of species present). They also take the relative abundances of different species (the **evenness of species**) into account.

Click on each measure to learn more.

Shannon index

Species evenness

The **Shannon Index** can be represented by the following formula:





$$H' = - \sum_{i=1}^R p_i \ln(p_i)$$

Where,

- H' is the Shannon index;
- R is the total number of species in the sample;
- \ln is the natural logarithm;
- p_i is the proportion of individuals in the i th species in the sample.

Maximum value depends on number of species = $\ln(R)$.

Source: Shannon, C.E. (July and October 1948), "A mathematical theory of communication," Bell System Technical Journal, 27: 379–423 and 623–656
You can refer also to:
<http://www.tiem.utk.edu/~gross/bioed/bealsmodules/shannonDI.html>



Explanation 2 (Slide Layer)

Biodiversity index

A **biodiversity index** is a mathematical measure for quantifying species diversity in a community. In this unit, we will address the **Shannon Index** and **species evenness** (or **equitability**) as two quantitative mathematical measures to reflect the biodiversity index of different types of species in a particular environment.

The **Shannon Index** can summarize information on all the biodiversity information recorded in the biodiversity account as a single indicator of species diversity.

Diversity indices provide more information about community composition than simply species richness (the number of species present). They also take the relative abundances of different species (the **evenness of species**) into account.

Click on each measure to learn more.

Shannon index

Species evenness

Species evenness (or **equitability**) can be represented by the following formula:

$$E_{H'} = \frac{H'}{\ln(R)}$$

Where,

- $E_{H'}$ is the equitability factor, with a value between 0 and 1, where 1 is complete evenness;
- R is the number of species in the sample;
- \ln is the natural logarithm.
- H' is the Shannon diversity index value.

Source: <http://www.tiem.utk.edu/~gross/bioed/bealsmodules/shannonDI.html>
Begon, M., J. L. Harper, and C. R. Townsend. 1996. *Ecology: Individuals, Populations, and Communities*, 3rd edition. Blackwell Science Ltd., Cambridge, MA.

1.19 Biodiversity Account Exercise

Biodiversity account exercise

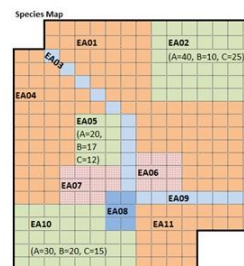
Let's practice calculating some of the information you have learned so far.

In the following exercise we will determine both the biodiversity (Shannon Index) and species evenness for three forest ecosystem assets (EAs).

For that, we will use the following data and tables as shown:

- **Species map** that depicts the Ecosystem Accounting Area (EAA) in study with its Ecosystem Assets (EAs). For the three forest EAs (EA02, EA05 and EA10) details about the population of species is provided.
- There are only **three species** analyzed (A, B and C) and their counts are presented in the species map for the forest EAs.
- **Species table** that will be used for recording the information on each species in each EA.
- **Summary table** will be used to record the Shannon Index and the species evenness.

Let's move on and learn about the steps required for the exercise.



Species Table				
EA	Individuals	p _i	ln(p _i)	p _i ln(p _i)
EA02 = Forest tree cover				
Species (A)				
Species (B)				
Species (C)				
EA05 = Forest tree cover				
Species (A)				
Species (B)				
Species (C)				
EA10 = Forest tree cover				
Species (A)				
Species (B)				
Species (C)				

Summary Table		
EA	Shannon Index	Evenness
EA02 = Forest tree cover		
EA05 = Forest tree cover		
EA10 = Forest tree cover		

1.20 Biodiversity Account Exercise

Biodiversity account exercise

Based on the given data and tables, we need to follow the following steps to determine both the biodiversity (Shannon Index) and species evenness.

Steps:

1. Record species population data in appropriate cells in a species table for each forest EA.
2. Using formulas provided, calculate a Shannon Index value and the species evenness for each forest EA.
3. Record this in the summary table.

Alright, let's go ahead and do some math.

Species Map

Species Table

EA	Individuals	p _i	ln(p _i)	p _i *ln(p _i)
EA02 = Forest tree cover				
Species (A)				
Species (B)				
Species (C)				
EA05 = Forest tree cover				
Species (A)				
Species (B)				
Species (C)				
EA10 = Forest tree cover				
Species (A)				
Species (B)				
Species (C)				

Summary Table

EA	Shannon Index	Evenness
EA02 = Forest tree cover		
EA05 = Forest tree cover		
EA10 = Forest tree cover		

1.21 Biodiversity Account Exercise

(Drag and Drop, 10 points, 1 attempt permitted)

Biodiversity account exercise

Calculate Shannon Index and evenness for three forest EAs:

The first step is to record species population data from the species map in its appropriate cells in the species table for each forest EA. Transfer the counts of individuals for each species from the map to the species table for EA02, EA05 and EA10.

Drag the numbers to their correct positions (in the white fields) and hit "OK".

Species Table

EA	Individuals	p _i	ln(p _i)	p _i *ln(p _i)
EA02 = Forest tree cover				
Species (A)				
Species (B)				
Species (C)				
EA05 = Forest tree cover				
Species (A)				
Species (B)				
Species (C)				
EA10 = Forest tree cover				
Species (A)				
Species (B)				
Species (C)				

OK

Species Map

Drag Item	Drop Target
Picture 4	Rectangle 1
Picture 5	Rectangle 2
Picture 6	Rectangle 3

Drag and drop properties
Snap dropped items to drop target (Stack random)
Delay item drop states until interaction is submitted

Feedback when correct:

This is the correct solution.

Feedback when incorrect:

Take a look at the solution.

Very good! (Slide Layer)

Biodiversity account exercise

Calculate Shannon Index and evenness for three forest EAs:

The first step is to record species population data from the species map in its appropriate cells in the species table for each forest EA. Transfer the counts of individuals for each species from the map to the species table for EA02, EA05 and EA10.

Drag the numbers to their correct positions (in the white fields) and hit "OK".

Species Table				
EA	Individuals	p_i	$\ln(p_i)$	$p_i * \ln(p_i)$
EA02 = Forest tree cover				
Species (A)				
Species (B)				
Species (C)				
EA05 = Forest tree cover				
Species (A)				
Species (B)				
Species (C)				
EA10 = Forest tree cover				
Species (A)				
Species (B)				
Species (C)				

Very good!

This is the correct solution.

Not quite right. (Slide Layer)

Biodiversity account exercise

Calculate Shannon Index and evenness for three forest EAs:

The first step is to record species population data from the species map in its appropriate cells in the species table for each forest EA. Transfer the counts of individuals for each species from the map to the species table for EA02, EA05 and EA10.

Drag the numbers to their correct positions (in the white fields) and hit "OK".

Species Table				
EA	Individuals	p_i	$\ln(p_i)$	$p_i * \ln(p_i)$
EA02 = Forest tree cover				
Species (A)	40			
Species (B)	10			
Species (C)	25			
EA05 = Forest tree cover				
Species (A)	20			
Species (B)	17			
Species (C)	12			
EA10 = Forest tree cover				
Species (A)	30			
Species (B)	20			
Species (C)	15			

Not quite right.

Take a look at the solution.

1.22 Biodiversity Account Exercise

(Drag and Drop, 10 points, 1 attempt permitted)

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Biodiversity account exercise

Good, now you have transferred the individual counts, so we need to sum the total number of individuals (A + B + C) for EA02, EA05 and EA10 respectively.
For example for EA02, the total sum is $40 + 10 + 25 = 75$.

Drag the total of individuals for each EA to their fields and hit "OK".

EA	Individuals	p_i	$\ln(p_i)$	$p_i \cdot \ln(p_i)$
EA02 = Forest tree cover				
Species (A)	40			
Species (B)	10			
Species (C)	25			
EA05 = Forest tree cover				
Species (A)	20			
Species (B)	17			
Species (C)	12			
EA10 = Forest tree cover				
Species (A)	30			
Species (B)	20			
Species (C)	15			

75

65

45

OK

Species Map

Drag Item	Drop Target
Picture 4	Rectangle 1
Picture 5	Rectangle 2
Picture 6	Rectangle 3

Drag and drop properties
Snap dropped items to drop target (Stack random)
Delay item drop states until interaction is submitted

Feedback when correct:

This is the correct solution.

Feedback when incorrect:

Take a look at the solution.

Very good! (Slide Layer)

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SEEA

Biodiversity account exercise

Good, now you have transferred the individual counts, so we need to sum the total number of individuals (A + B + C) for EA02, EA05 and EA10 respectively.
For example for EA02, the total sum is $40 + 10 + 25 = 75$.

Drag the total of individuals for each EA to their fields and hit "OK".

Species Table

EA	Individuals	p_i	$\ln(p_i)$	$p_i \cdot \ln(p_i)$
EA02 = Forest tree cover				
Species (A)	40			
Species (B)	10			
Species (C)	25			
EA05 = Forest tree cover				
Species (A)	20			
Species (B)	17			
Species (C)	12			
EA10 = Forest tree cover				
Species (A)	30			
Species (B)	20			
Species (C)	15			

Species Map

EA01 EA02 (A=40, B=10, C=25) EA03

Very good!

This is the correct solution.

Continue

65

45

Biodiversity account exercise

Good, now you have transferred the individual counts, so we need to sum the total number of individuals (A + B + C) for EA02, EA05 and EA10 respectively.

For example for EA02, the total sum is $40 + 10 + 25 = 75$.

Drag the total of individuals for each EA to their fields and hit "OK".

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Species Table

EA	Individuals	p_i	$\ln(p_i)$	$p_i * \ln(p_i)$
EA02 = Forest tree cover	75			
Species (A)	40			
Species (B)	10			
Species (C)	25			
EA05 = Forest tree cover	49			
Species (A)	20			
Species (B)	17			
Species (C)	12			
EA10 = Forest tree cover	65			
Species (A)	30			
Species (B)	20			
Species (C)	15			

Species Map

Not quite right.

Take a look at the solution.

Continue

1.23 Biodiversity Account Exercise

(Drag and Drop, 10 points, 1 attempt permitted)

Biodiversity account exercise

Perfect, now you have all the counts of species individuals and totals. Let's move on and calculate the p_i (species individuals as a proportion of total number of individuals in the EA) as well as the natural logarithm of p_i [$\ln(p_i)$]. Then we multiply p_i with its natural logarithm.

For example, for Species (A) of EA05, the p_i = Count of Species A / Total of Individuals (EA05) = $20 / 49 = 0.41$. The Natural Logarithm of 0.41 is $\ln(0.41) = (-0.90)$

The product of multiplication of p_i and its natural logarithm is $0.41 \times (-0.90) = (-0.37)$

Drag the calculations to their fields and hit "OK".

EA	Individuals	p _i	ln(p _i)	p _i *ln(p _i)
EA02 = Forest tree cover				
Species (A)	40			
Species (B)	10			
Species (C)	25			
EA05 = Forest tree cover				
Species (A)	20			
Species (B)	17			
Species (C)	12			
EA10 = Forest tree cover				
Species (A)	30			
Species (B)	20			
Species (C)	15			

0.46	-0.77	-0.36
0.31	-1.18	-0.36
0.23	-1.47	-0.34

0.53	-0.63	-0.34
0.13	-2.01	-0.27
0.33	-1.10	-0.37

0.41	-0.90	-0.37
0.35	-1.06	-0.37
0.24	-1.41	-0.34

OK

Drag Item	Drop Target
Picture 4	Rectangle 1
Picture 5	Rectangle 2
Picture 6	Rectangle 3

Drag and drop properties
Snap dropped items to drop target (Stack random)
Delay item drop states until interaction is submitted

Feedback when correct:

This is the correct solution.

Feedback when incorrect:

Take a look at the solution.

Very good! (Slide Layer)

MODULE 8: BIODIVERSITY ACCOUNTING, UNIT 2: COMPILERS

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SEEA

Biodiversity account exercise

Perfect, now you have all the counts of species individuals and totals. Let's move on and calculate the p_i (species individuals as a proportion of total number of individuals in the EA) as we natural logarithm of p_i [$\ln(p_i)$]. Then we multiply p_i with its natural logarithm.

For example, for Species (A) of EA05, the p_i = Count of Species A / Total of Individuals (20 / 49 = 0.41. The Natural Logarithm of 0.41 is $\ln(0.41) = (-0.90)$
The product of multiplication of p_i and its natural logarithm is = $0.41 \times (-0.90) = (-0.37)$

Drag the calculations to their fields and hit "OK".

EA	Individuals	p_i	$\ln(p_i)$	$p_i \times \ln(p_i)$
EA02 = Forest tree cover	75			
Species (A)	40			
Species (B)	10			
Species (C)	25			
EA05 = Forest tree cover	49			
Species (A)	20			
Species (B)	17			
Species (C)	12			
EA10 = Forest tree cover	65			
Species (A)	30			
Species (B)	20			
Species (C)	15			

0.46	-0.77	-0.36
0.31	-1.18	-0.36
0.23	-1.47	-0.34

0.41	-0.90	-0.37
0.35	-1.06	-0.37
0.24	-1.41	-0.34

Species Map

Very good!

This is the correct solution.

Continue

Not quite right. (Slide Layer)

MODULE 8: BIODIVERSITY ACCOUNTING, UNIT 2: COMPILERS

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SEEA

Biodiversity account exercise

Perfect, now you have all the counts of species individuals and totals. Let's move on and calculate the p_i (species individuals as a proportion of total number of individuals in the EA) as we natural logarithm of p_i [$\ln(p_i)$]. Then we multiply p_i with its natural logarithm.

For example, for Species (A) of EA05, the p_i = Count of Species A / Total of Individuals (20 / 49 = 0.41. The Natural Logarithm of 0.41 is $\ln(0.41) = (-0.90)$
The product of multiplication of p_i and its natural logarithm is = $0.41 \times (-0.90) = (-0.37)$

Drag the calculations to their fields and hit "OK".

EA	Individuals	p_i	$\ln(p_i)$	$p_i \times \ln(p_i)$
EA02 = Forest tree cover	75			
Species (A)	40	0.53	-0.63	-0.34
Species (B)	10	0.13	-2.01	-0.27
Species (C)	25	0.33	-1.10	-0.37
EA05 = Forest tree cover	49			
Species (A)	20	0.41	-0.90	-0.37
Species (B)	17	0.35	-1.06	-0.37
Species (C)	12	0.24	-1.41	-0.34
EA10 = Forest tree cover	65			
Species (A)	30	0.46	-0.77	-0.36
Species (B)	20	0.31	-1.18	-0.36
Species (C)	15	0.23	-1.47	-0.34

0.46	-0.77	-0.36
0.31	-1.18	-0.36
0.23	-1.47	-0.34

0.41	-0.90	-0.37
0.35	-1.06	-0.37
0.24	-1.41	-0.34

Species Map

Not quite right.

Take a look at the solution.

Continue

1.24 Biodiversity Index

Biodiversity account exercise

Well done! You've completed the species table using the species map. Now we need to summarize the results and calculate the Shannon Index and evenness for each EA in the summary table below. Let's go over the formulas behind the two mathematical measures for quantifying the biodiversity index.

Hover over the fields to re-check the formulas.

Species Table

EA	Individuals	p_i	$\ln(p_i)$	$p_i * \ln(p_i)$
EA02 = Forest tree cover	75			
Species (A)	40	0.53	-0.63	-0.34
Species (B)	10	0.13	-2.01	-0.27
Species (C)	25	0.33	-1.10	-0.37
EA05 = Forest tree cover	49			
Species (A)	20	0.41	-0.90	-0.37
Species (B)	17	0.35	-1.06	-0.37
Species (C)	12	0.24	-1.41	-0.34
EA10 = Forest tree cover	65			
Species (A)	30	0.46	-0.77	-0.36
Species (B)	20	0.31	-1.18	-0.36
Species (C)	15	0.23	-1.47	-0.34

Shannon index formula

Species evenness formula

Summary Table

EA	Shannon Index	Evenness
EA02 = Forest tree cover		
EA05 = Forest tree cover		
EA10 = Forest tree cover		

Explanation 1 (Slide Layer)

Biodiversity account exercise

Well done! You've completed the species table using the species map. Now we need to summarize the results and calculate the Shannon Index and evenness for each EA in the summary table below. Let's go over the formulas behind the two mathematical measures for quantifying the biodiversity index.

Hover over the fields to re-check the formulas.

Species Table

EA	Individuals	p_i	$\ln(p_i)$	$p_i * \ln(p_i)$
EA02 = Forest tree cover	75			
Species (A)	40	0.53	-0.63	-0.34
Species (B)	10	0.13	-2.01	-0.27
Species (C)	25	0.33	-1.10	-0.37
EA05 = Forest tree cover	49			
Species (A)	20	0.41	-0.90	-0.37
Species (B)	17	0.35	-1.06	-0.37
Species (C)	12	0.24	-1.41	-0.34
EA10 = Forest tree cover	65			
Species (A)	30	0.46	-0.77	-0.36
Species (B)	20	0.31	-1.18	-0.36
Species (C)	15	0.23	-1.47	-0.34

Shannon index formula

Species evenness formula

The Shannon Index can be represented by the following formula:

$$H' = - \sum_{i=1}^R p_i \ln(p_i)$$

Where,

- H' is the Shannon index;
- R is the total number of species in the sample;
- \ln is the natural logarithm;
- p_i is the proportion of individuals in the i th species in the sample.

Maximum value depends on number of species = $\ln(R)$.

Source: Shannon, C.E. (July and October 1948), "A mathematical theory of communication," Bell System Technical Journal, 27: 379-423 and 623-656
You can refer also to:
<http://www.tiem.utk.edu/~gross/bioed/bealsmodules/shannonDI.html>

Explanation 2 (Slide Layer)

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SEEA

Biodiversity account exercise

Well done! You've completed the species table using the species map. Now we need to summarize the results and calculate the Shannon Index and evenness for each EA in the summary table below. Let's go over the formulas behind the two mathematical measures for quantifying the biodiversity index.

Hover over the fields to re-check the formulas.

EA	Individuals	p_i	$\ln(p_i)$	$p_i \times \ln(p_i)$
EA02 = Forest tree cover	75			
Species (A)	40	0.53	-0.63	-0.34
Species (B)	10	0.13	-2.01	-0.27
Species (C)	25	0.33	-1.10	-0.37
EA05 = Forest tree cover	49			
Species (A)	20	0.41	-0.90	-0.37
Species (B)	17	0.35	-1.06	-0.37
Species (C)	12	0.24	-1.41	-0.34
EA10 = Forest tree cover	65			
Species (A)	30	0.46	-0.77	-0.36
Species (B)	20	0.31	-1.18	-0.36
Species (C)	15	0.23	-1.47	-0.34

Shannon index formula

Species evenness formula

Species evenness (or equitability) can be represented by the following formula:

$$E_{H'} = \frac{H'}{\ln(R)}$$

Where,

- $E_{H'}$ is the equitability factor, with a value between 0 and 1, where 1 is complete evenness;
- R is the number of species in the sample;
- \ln is the natural logarithm.
- H' is the Shannon diversity index value.

Source: <http://www.tiem.utk.edu/~gross/bioed/bealsmodules/shannonDI.html>
 Begon, M., J. L. Harper, and C. R. Townsend. 1996. *Ecology: Individuals, Populations, and Communities*, 3rd edition. Blackwell Science Ltd., Cambridge, MA.

1.25 Biodiversity Account Exercise

(Drag and Drop, 10 points, 1 attempt permitted)

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SEEA

Biodiversity account exercise

Now that you've reviewed the formulas, let's first calculate the Shannon Index by adding all values of $p_i \times \ln(p_i)$ for each species in an EA. Make sure to multiply by (-1). Then, calculate the evenness = Shannon Index / $\ln(\text{number of species})$.

For example, for Species (A) of EA10, Shannon Index will be: Additions of all $p_i \times \ln(p_i)$ values = $(-0.36) + (-0.36) + (-0.34) = (-1.06)$. Multiply it by $(-1) = (-1) \times (-1.06) = 1.06$.
 For its evenness = Shannon Index / [natural logarithm of number of species = 3 (i.e. A, B, C)] = $1.06 / \ln(3) = 0.96$

EA	Individuals	p_i	$\ln(p_i)$	$p_i \times \ln(p_i)$
EA02 = Forest tree cover	75			
Species (A)	40	0.53	-0.63	-0.34
Species (B)	10	0.13	-2.01	-0.27
Species (C)	25	0.33	-1.10	-0.37
EA05 = Forest tree cover	49			
Species (A)	20	0.41	-0.90	-0.37
Species (B)	17	0.35	-1.06	-0.37
Species (C)	12	0.24	-1.41	-0.34
EA10 = Forest tree cover	65			
Species (A)	30	0.46	-0.77	-0.36
Species (B)	20	0.31	-1.18	-0.36
Species (C)	15	0.23	-1.47	-0.34

EA	Shannon Index	Evenness
EA02 = Forest tree cover		
EA05 = Forest tree cover		
EA10 = Forest tree cover		

Shannon index formula

Species evenness formula

Drag the figures to their fields and hit "OK".

0.97

1.08

0.98

1.06

0.96

0.88

OK

Drag Item	Drop Target
Picture 6	Rectangle 1
Picture 4	Rectangle 2
Picture 5	Rectangle 3
Picture 8	Rechteck 4
Picture 10	Rechteck 5
Picture 9	Rechteck 6

Drag and drop properties
Snap dropped items to drop target (Stack random)
Delay item drop states until interaction is submitted

Feedback when correct:

This is the correct solution.

Feedback when incorrect:

Take a look at the solution.

Very good! (Slide Layer)

Biodiversity account exercise

Now that you've reviewed the formulas, let's first calculate the Shannon Index by adding all values of $p_i \times \ln(p_i)$ for each species in an EA. Make sure to multiply by (-1). Then, calculate the evenness = Shannon Index / $\ln(\text{number of species})$.

For example, for Species (A) of EA10, Shannon Index will be: Additions of all $p_i \times \ln(p_i)$; $(-0.36) + (-0.36) + (-0.34) = (-1.06)$. Multiply it by $(-1) = (-1) \times (-1.06) = 1.06$.
For its evenness = Shannon Index / [natural logarithm of number of species = 3 (i.e. A, B, C)]

Species Table				
EA	Individuals	p_i	$\ln(p_i)$	$p_i \times \ln(p_i)$
EA02 = Forest tree cover	75			
Species (A)	40	0.53	-0.63	-0.34
Species (B)	10	0.13	-2.01	-0.27
Species (C)	25	0.33	-1.10	-0.37
EA05 = Forest tree cover	49			
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Species (C)	12	0.24	-1.41	-0.34
EA10 = Forest tree cover	65			
Species (A)	30	0.46	-0.77	-0.36
Species (B)	20	0.31	-1.18	-0.36
Species (C)	15	0.23	-1.47	-0.34

Summary Table		
EA	Shannon Index	Evenness
EA02 = Forest tree cover	0.97	0.88
EA05 = Forest tree cover	1.08	0.98
EA10 = Forest tree cover	1.06	0.96

Very good!

This is the correct solution.

Continue

Not quite right. (Slide Layer)

Biodiversity account exercise

Now that you've reviewed the formulas, let's first calculate the Shannon Index by adding all values of $p_i \times \ln(p_i)$ for each species in an EA. Make sure to multiply by (-1). Then, calculate the evenness = Shannon Index / $\ln(\text{number of species})$.

For example, for Species (A) of EA10, Shannon Index will be: Additions of all $p_i \times \ln(p_i)$; $(-0.36) + (-0.36) + (-0.34) = (-1.06)$. Multiply it by $(-1) = (-1) \times (-1.06) = 1.06$.
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Species Table				
EA	Individuals	p_i	$\ln(p_i)$	$p_i \times \ln(p_i)$
EA02 = Forest tree cover	75			
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Species (B)	10	0.13	-2.01	-0.27
Species (C)	25	0.33	-1.10	-0.37
EA05 = Forest tree cover	49			
Species (A)	20	0.41	-0.90	-0.37
Species (B)	17	0.35	-1.06	-0.37
Species (C)	12	0.24	-1.41	-0.34
EA10 = Forest tree cover	65			
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Species (C)	15	0.23	-1.47	-0.34

Summary Table		
EA	Shannon Index	Evenness
EA02 = Forest tree cover	0.97	0.88
EA05 = Forest tree cover	1.08	0.98
EA10 = Forest tree cover	1.06	0.96

Not quite right.

Take a look at the solution.

Continue

Explanation 1 (Slide Layer)

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Biodiversity account exercise

Now that you've reviewed the formulas, let's first calculate the Shannon Index by adding all values of $p_i \times \ln(p_i)$ for each species in an EA. Make sure to multiply by (-1). Then, calculate the evenness = Shannon Index / $\ln(\text{number of species})$.

For example, for Species (A) of EA10, Shannon Index will be: Additions of a (-0.36) + (-0.36) + (-0.34) = (-1.06). Multiply it by (-1) = (-1) × (-1.06) = 1.06

For its evenness = Shannon Index / [natural logarithm of number of species =

Shannon index formula

Species evenness formula

The **Shannon Index** can be represented by the following formula:

$$H' = - \sum_{i=1}^R p_i \ln(p_i)$$

Where,

- H' is the Shannon index;
- R is the total number of species in the sample;
- \ln is the natural logarithm;
- p_i is the proportion of individuals in the i th species in the sample.

Maximum value depends on number of species = $\ln(R)$

Source: Shannon, C.E. (July and October 1948), "A mathematical theory of communication," Bell System Technical Journal, 27, 379-423 and 623-656. You can refer also to: <http://www.tiem.utk.edu/~gross/bioed/bealsmodules/shannonDI.html>

Species Table

EA	Individuals	p_i	$\ln(p_i)$	$p_i \times \ln(p_i)$
EA02 = Forest tree cover	75			
Species (A)	40	0.53	-0.63	-0.34
Species (B)	10	0.13	-2.01	-0.27
Species (C)	25	0.33	-1.10	-0.37
EA05 = Forest tree cover	49			
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Species (B)	17	0.35	-1.06	-0.37
Species (C)	12	0.24	-1.41	-0.34
EA10 = Forest tree cover	65			
Species (A)	30	0.46	-0.77	-0.36
Species (B)	20	0.31	-1.18	-0.36
Species (C)	15	0.23	-1.47	-0.34

Summary Table

EA
EA
EA02 = Forest tree
EA05 = Forest tree
EA10 = Forest tree

Drag the fig

Explanation 2 (Slide Layer)

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Biodiversity account exercise

Now that you've reviewed the formulas, let's first calculate the Shannon Index by adding all values of $p_i \times \ln(p_i)$ for each species in an EA. Make sure to multiply by (-1). Then, calculate the evenness = Shannon Index / $\ln(\text{number of species})$.

For example, for Species (A) of EA10, Shannon Index will be: Additions of a (-0.36) + (-0.36) + (-0.34) = (-1.06). Multiply it by (-1) = (-1) × (-1.06) = 1.06

For its evenness = Shannon Index / [natural logarithm of number of species =

Shannon index formula

Species evenness formula

Species evenness (or equitability) can be represented by the following formula:

$$E_{H'} = \frac{H'}{\ln(R)}$$

Where,

- $E_{H'}$ is the equitability factor, with a value between 0 and 1, where 1 is complete evenness;
- R is the number of species in the sample;
- \ln is the natural logarithm;
- H' is the Shannon diversity index value.

Source: <http://www.tiem.utk.edu/~gross/bioed/bealsmodules/shannonDI.html> Begon, M., J. L. Harper, and C. R. Townsend, 1990. Ecology: Individuals, Populations, and Communities, 3rd edition. Blackwell Science Ltd., Cambridge, MA.

Species Table

EA	Individuals	p_i	$\ln(p_i)$	$p_i \times \ln(p_i)$
EA02 = Forest tree cover	75			
Species (A)	40	0.53	-0.63	-0.34
Species (B)	10	0.13	-2.01	-0.27
Species (C)	25	0.33	-1.10	-0.37
EA05 = Forest tree cover	49			
Species (A)	20	0.41	-0.90	-0.37
Species (B)	17	0.35	-1.06	-0.37
Species (C)	12	0.24	-1.41	-0.34
EA10 = Forest tree cover	65			
Species (A)	30	0.46	-0.77	-0.36
Species (B)	20	0.31	-1.18	-0.36
Species (C)	15	0.23	-1.47	-0.34

Summary Table

EA
EA
EA02 = Forest tree
EA05 = Forest tree
EA10 = Forest tree

Drag the fig

1.26 Biodiversity Account Exercise

(Text Entry, 10 points, 1 attempt permitted)

Biodiversity account exercise

Great. The summary table of species for three forest EAs is completed.

Can you figure out which one of the forest EAs is the least diverse and why?

Type your answer here.

Species Table

EA	Individuals	p_i	$\ln(p_i)$	$p_i \ln(p_i)$
EA02 = Forest tree cover	75			
Species (A)	40	0.53	-0.63	-0.34
Species (B)	10	0.13	-2.01	-0.27
Species (C)	25	0.33	-1.10	-0.37
EA05 = Forest tree cover	49			
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Species (B)	17	0.35	-1.06	-0.37
Species (C)	12	0.24	-1.41	-0.34
EA10 = Forest tree cover	65			
Species (A)	30	0.46	-0.77	-0.36
Species (B)	20	0.31	-1.18	-0.36
Species (C)	15	0.23	-1.47	-0.34

Summary Table

EA	Shannon Index	Evenness
EA02 = Forest tree cover	0.97	0.88
EA05 = Forest tree cover	1.08	0.98
EA10 = Forest tree cover	1.06	0.96

OK

Not serious, but anyway ... (Slide Layer)

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SEEA

Biodiversity account exercise

Great. The summary table of species for three forest EAs is completed.

Can you figure out which one of the forest EAs is the least diverse and why?

Type your answer here.

Not serious, but anyway ...

EA	Individuals	p_i	$\ln(p_i)$	$p_i \cdot \ln(p_i)$
EA02 = Forest tree cover	75			
Species (A)	40	0.53	-0.63	-0.34
Species (B)	10	0.13	-2.01	-0.27
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EA	Shannon Index	Evenness
EA02 = Forest tree cover	0.97	0.88
EA05 = Forest tree cover	1.08	0.98
EA10 = Forest tree cover	1.06	0.96

Continue

Thank you, that was close. (Slide Layer)

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SEEA

Biodiversity account exercise

Great. The summary table of species for three forest EAs is completed.

Can you figure out which one of the forest EAs is the least diverse and why?

Type your answer here.

Thank you, that was close.

So you just finished Unit 2.

EA	Individuals	p_i	$\ln(p_i)$	$p_i \cdot \ln(p_i)$
EA02 = Forest tree cover	75			
Species (A)	40	0.53	-0.63	-0.34
Species (B)	10	0.13	-2.01	-0.27
Species (C)	25	0.33	-1.10	-0.37
EA05 = Forest tree cover	49			
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EA	Shannon Index	Evenness
EA02 = Forest tree cover	0.97	0.88
EA05 = Forest tree cover	1.08	0.98
EA10 = Forest tree cover	1.06	0.96

Continue

1.27 Module units

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SEEA

Module units

The biodiversity accounting module will take you through four units, as listed below. We recommend completing these units in order.

**Unit 1:
Biodiversity accounting**

- What is it?
- Why do we need it?
- What does it look like?
- Expertise and data required.

**Unit 2:
Compilers**

- Basic concepts for measuring biodiversity.
- Steps for compiling biodiversity accounts.

**Unit 3:
Data providers**

- Concepts
- Biodiversity accounting information uses.
- Data options, examples and issues.

**Unit 4:
Review**

- Quiz
- Summary

1.28 Unit 3

MODULE 8: BIODIVERSITY ACCOUNTING, UNIT 3: DATA PROVIDERS

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SEEA

Unit 3: Data providers

In this unit, we'll explore different sources of data and methods used to compile biodiversity accounts.

At this point it's important to note the uses of information and the data requirements for biodiversity accounting.

Hover over the arrows to learn more about the information needs and flows in the diagram.

National or regional biodiversity information

Biodiversity observations and measurements

Available data

Biodiversity indicators

Biodiversity account

Ecosystem

Key questions and SEEA EEA framework

Information uses

Reporting on policy goals

Sustainable management of biodiversity

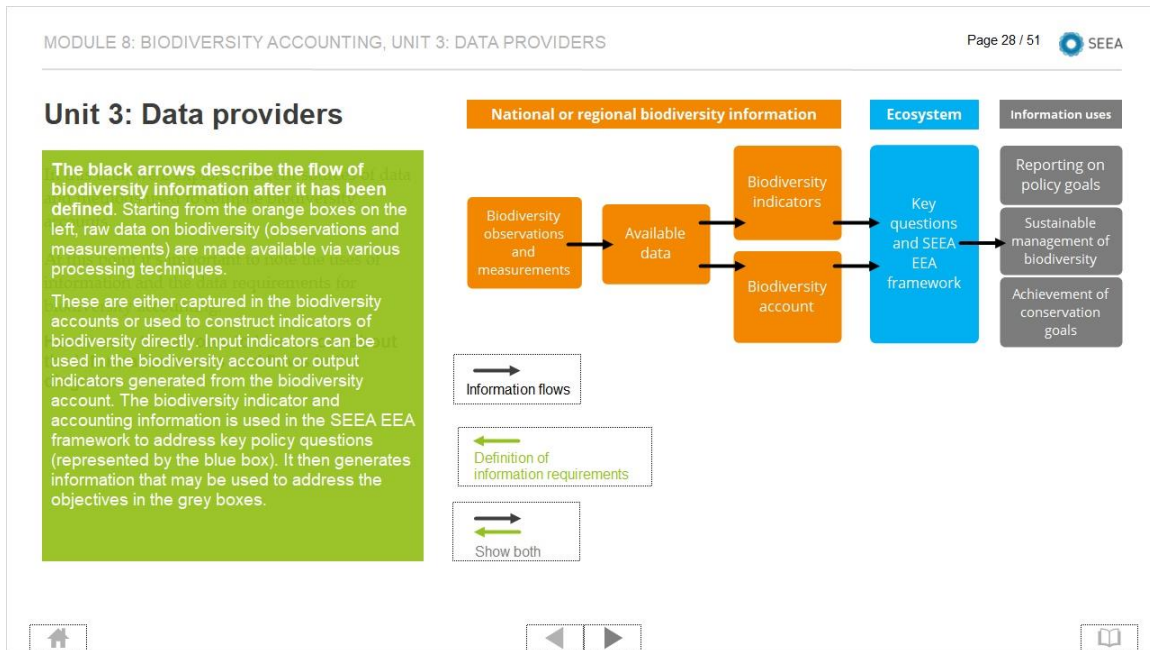
Achievement of conservation goals

Information flows

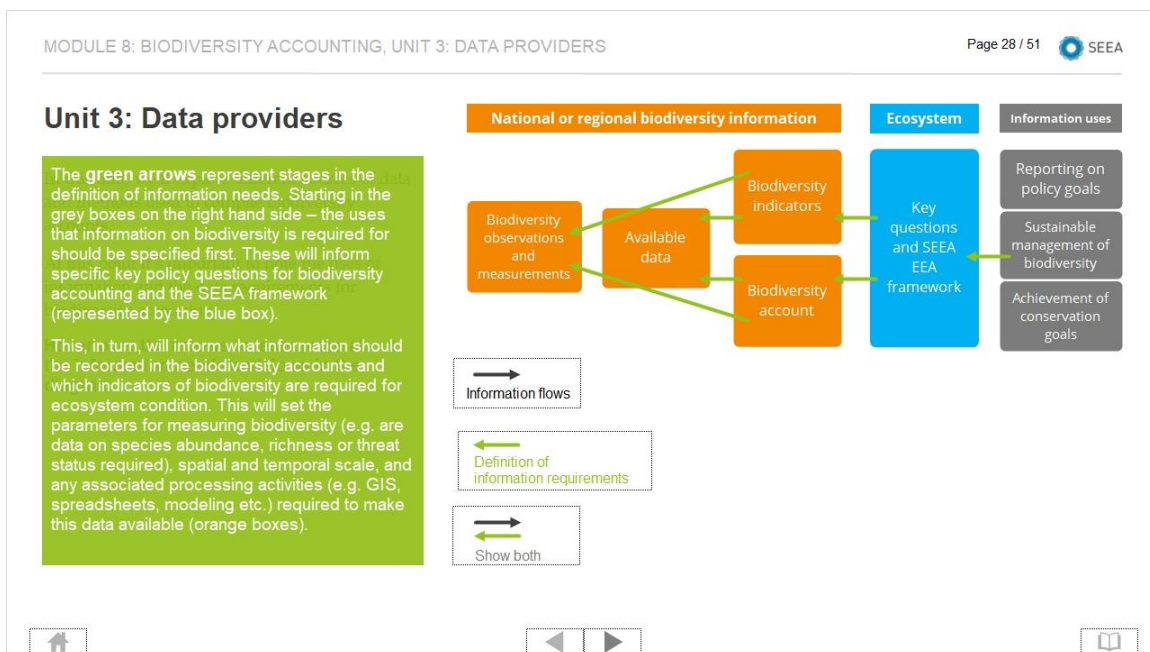
Definition of information requirements

Show both

Explanation 1 (Slide Layer)



Explanation 2 (Slide Layer)



Explanation 3 (Slide Layer)

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SEEA

Unit 3: Data providers

In this unit, we'll explore different sources of data and methods used to compile biodiversity accounts.

At this point it's important to note the uses of information and the data requirements for biodiversity accounting.

Hover over the arrows to learn more about the information needs and flows in the diagram.

The diagram illustrates the flow of biodiversity information. It is organized into three main columns: 'National or regional biodiversity information' (orange), 'Ecosystem' (blue), and 'Information uses' (grey). In the first column, 'Biodiversity observations and measurements' (orange box) has a black arrow pointing to 'Available data' (orange box). 'Available data' has two black arrows pointing to 'Biodiversity indicators' (orange box) and 'Biodiversity account' (orange box). 'Biodiversity indicators' and 'Biodiversity account' both have black arrows pointing to 'Key questions and SEEA EEA framework' (blue box). The 'Ecosystem' column contains this blue box. The 'Information uses' column contains three grey boxes: 'Reporting on policy goals', 'Sustainable management of biodiversity', and 'Achievement of conservation goals'. Black arrows point from the blue box to each of these three grey boxes. Below the diagram, there are three legend boxes: 'Information flows' (black arrow), 'Definition of information requirements' (green arrow), and 'Show both' (black and green arrows).

Information flows

Definition of information requirements

Show both

1.29 Policy questions - Example

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SEEA

Policy questions – example

Two examples of policy questions will be discussed in this section. We'll follow each question from understanding its meaning to the relevant biodiversity accounting information, along with the other information required for the policy. The two key policy questions are:

- How should species of economic importance to ecotourism be managed?
- How should biodiversity for local ecosystem service delivery be sustainably managed?

Click on each key policy question to learn more.

Diagram 1 (Slide Layer)

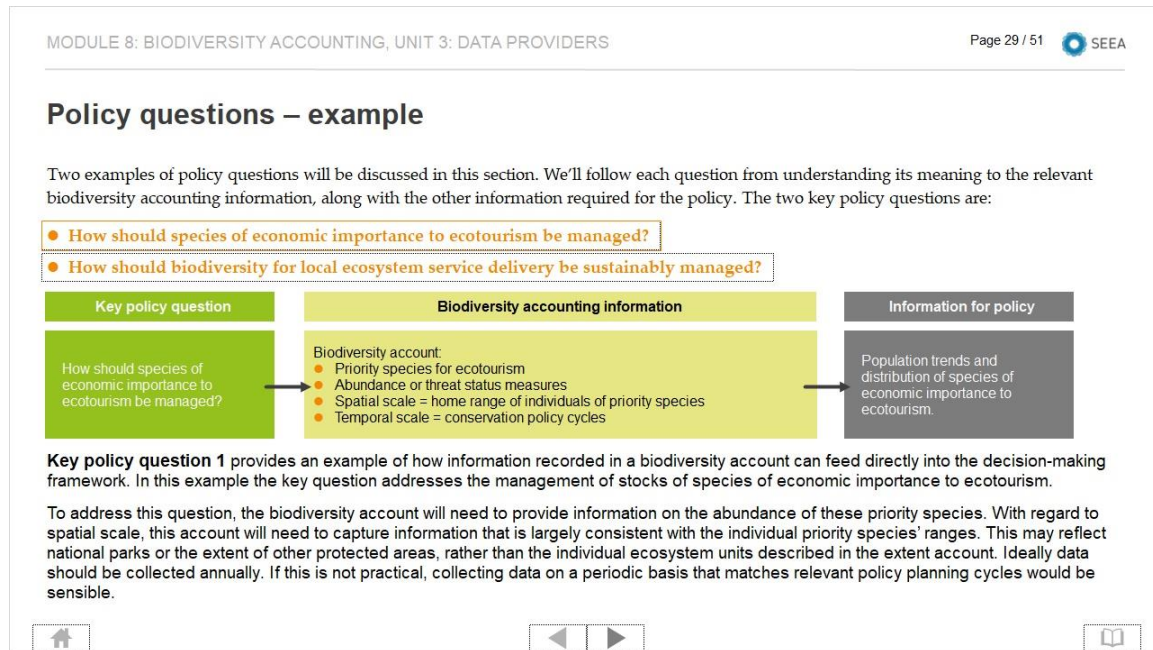
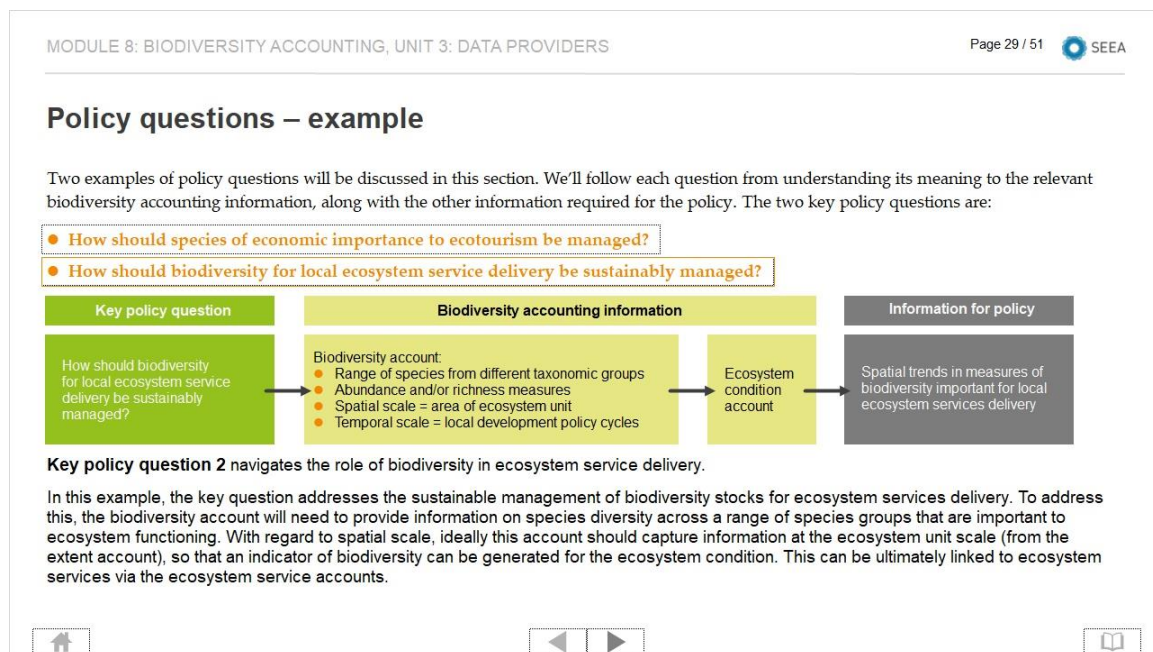


Diagram 2 (Slide Layer)



1.30 Data options and sources

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Data options and sources

Once policy questions have been determined, a pragmatic next step in constructing accounts of biodiversity is to construct an inventory of existing species data. This allows information captured by ecosystem diversity to be recorded as well.

These steps are detailed below:

- **Conduct an inventory of existing species diversity information, including:**
 - National and sub-national monitoring schemes
 - **National Red List**
 - **Governmental Agencies, NGOs, universities and museums**
 - **Reporting** to regional processes and international conventions
- **Ecosystem diversity - Some information recorded in the extent account:**
 - Land cover, vegetation maps (spatially-detailed)
 - River system maps (e.g. linearly delineated by **Strahler stream order**)
 - Marine habitat maps (spatially delineated on basis of bathymetry and other characteristics)

You can hover over the highlighted terms to learn more.



Explanation 1 (Slide Layer)

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SEEA





Data options and sources

Once policy questions have been determined, a pragmatic next step in constructing accounts of biodiversity is to construct an inventory of existing species data. This allows information captured by ecosystem diversity to be recorded as well.

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You can hover over the highlighted terms to learn more.



Explanation 2 (Slide Layer)

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SEEA





Data options and sources

Once policy questions have been determined, a pragmatic next step in constructing accounts of biodiversity is to construct an inventory of existing species data. This allows information captured by ecosystem diversity to be recorded as well.

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 - River system maps (e.g. linearly delineated by **Strahler stream order**)
 - Marine habitat maps (spatially delineated on basis of bathymetry and other characteristics)

You can hover over the highlighted terms to learn more.



NGOs, universities and museums may hold information on species diversity even if they are outside of the country. For example, Kew Royal Botanic Gardens in the UK houses botanical and mycological collections from around the world.

Explanation 3 (Slide Layer)

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SEEA





Data options and sources

Once policy questions have been determined, a pragmatic next step in constructing accounts of biodiversity is to construct an inventory of existing species data. This allows information captured by ecosystem diversity to be recorded as well.

These steps are detailed below:

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 - National and sub-national monitoring schemes
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 - **Governmental Agencies, NGOs, universities and museums**
 - **Reporting** to regional processes and international conventions
- **Ecosystem diversity - Some information recorded in the **extent account**:**
 - Land cover, vegetation maps (spatially-detailed)
 - River system maps (e.g. linearly delineated by **Strahler stream order**)
 - Marine habitat maps (spatially delineated on basis of bathymetry and other characteristics)

You can hover over the highlighted terms to learn more.



Examples of regional reporting obligations include the EU's Habitats Directive and Birds Directive. International reporting obligations include status of fauna species under the Convention on Migratory Species.

Explanation 4 (Slide Layer)

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SEEA

Data options and sources





Once policy questions have been determined, a pragmatic next step in constructing accounts of biodiversity is to construct an inventory of existing species data. This allows information captured by ecosystem diversity to be recorded as well.

These steps are detailed below:

- **Conduct an inventory of existing species diversity information, including:**
 - National and sub-national monitoring schemes
 - **National Red List**
 - **Governmental Agencies, NGOs, universities and museums**
 - **Reporting** to regional processes and international conventions
- **Ecosystem diversity - Some information recorded in the extent account:**
 - Land cover, vegetation maps (spatially-detailed)
 - River system maps (e.g. linearly delineated by **Strahler stream order**)
 - Marine habitat maps (spatially delineated on basis of bathymetry and other characteristics)

You can hover over the highlighted terms to learn more.

Global data sources include the IUCN data on species ranges and observational data held by the Global Biodiversity Information Facility. Information on ecosystem diversity can be captured in the extent account. If this is unavailable, there may be other habitat classification maps available that can provide the basis for an extent account, including for rivers and marine areas.



Explanation 5 (Slide Layer)

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SEEA

Data options and sources





Once policy questions have been determined, a pragmatic next step in constructing accounts of biodiversity is to construct an inventory of existing species data. This allows information captured by ecosystem diversity to be recorded as well.

These steps are detailed below:

- **Conduct an inventory of existing species diversity information, including:**
 - National and sub-national monitoring schemes
 - **National Red List**
 - **Governmental Agencies, NGOs, universities and museums**
 - **Reporting** to regional processes and international conventions
- **Ecosystem diversity - Some information recorded in the extent account:**
 - Land cover, vegetation maps (spatially-detailed)
 - River system maps (e.g. linearly delineated by **Strahler stream order**)
 - Marine habitat maps (spatially delineated on basis of bathymetry and other characteristics)


You can hover over the highlighted terms to learn more.

The Strahler stream order is a measure of branching complexity. For hydrology this is used to define stream size based on the hierarchy of tributaries (e.g. the smallest streams are first-order; when two first-order streams come together, they form a second-order stream, and so on).



1.31 Data options and sources

MODULE 8: BIODIVERSITY ACCOUNTING, UNIT 3: DATA PROVIDERS




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Data options and sources

The format of biodiversity data in biodiversity accounts may be organized as follows:


- **Measures**
 - This includes raw, on the ground data (e.g. species abundance or richness for different taxonomic groups).
- **Relative Measures**
 - This compares the measure to a reference condition.
 - Normalized around 1 or 100
 - Sources: minimal human disturbance (SEEA), ecological sustainability (Norway's Nature Index), first accounting period (accrual, Living Planet Index).
- **Headline output indicator(s)**
 - Index of all relevant biodiversity data in account
 - May need more than one (e.g. one for ecosystem condition, one for conservation goals)
 - Will require expert ecological knowledge

You can hover over the formats to learn more.



Explanation 1 (Slide Layer)

MODULE 8: BIODIVERSITY ACCOUNTING, UNIT 3: DATA PROVIDERS




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Data options and sources

The format of biodiversity data in biodiversity accounts may be organized as follows:

- **Measures**
 - This includes raw, on the ground data (e.g. species abundance or richness for different taxonomic groups). **Measurements will include actual observations of biodiversity. These may be supplemented with estimated data to address data gaps.**
- **Relative Measures**
 - This compares the measure to a reference condition.
 - Normalized around 1 or 100
 - Sources: minimal human disturbance (SEEA), ecological sustainability (Norway's Nature Index), first accounting period (accrual, Living Planet Index).
- **Headline output indicator(s)**
 - Index of all relevant biodiversity data in account
 - May need more than one (e.g. one for ecosystem condition, one for conservation goals)
 - Will require expert ecological knowledge

You can hover over the formats to learn more.



Explanation 2 (Slide Layer)

MODULE 8: BIODIVERSITY ACCOUNTING, UNIT 3: DATA PROVIDERS

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SEEA

Data options and sources

The format of biodiversity data in biodiversity accounts may be organized as follows:

- **Measures**
 - This includes raw, on the ground data (e.g. species abundance or richness for different taxonomic groups).
- **Relative Measures**
 - This compares the measure to a reference condition.
 - Normalized around 1 or 100
 - Sources: minimal human disturbance (SEEA), ecological sustainability (Natura 2000), Nature Index), first accounting period
- **Headline output indicator(s)**
 - Index of all relevant biodiversity data in account
 - May need more than one (e.g. one for ecosystem condition, one for conservation goals)
 - Will require expert ecological knowledge

You can hover over the formats to learn more.



Explanation 3 (Slide Layer)

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Data options and sources

The format of biodiversity data in biodiversity accounts may be organized as follows:


- **Measures**
 - This includes raw, on the ground data (e.g. species abundance or richness for different taxonomic groups).
- **Relative Measures**
 - This compares the measure to a reference condition.
 - Normalized around 1 or 100
 - Sources: minimal human disturbance (SEEA), ecological sustainability (Natura 2000), Nature Index), first accounting period
- **Headline output indicator(s)**
 - Index of all relevant biodiversity data in account
 - May need more than one (e.g. one for ecosystem condition, one for conservation goals)
 - Will require expert ecological knowledge

You can hover over the formats to learn more.



1.32 Plugging species diversity data gaps

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Plugging species diversity data gaps

There are several approaches to fill the gaps in the species diversity data, such as:


- **Development of a national species monitoring programme**
- **Use of estimation approaches**
 - Human drivers based models (e.g. Alkemade, 2009)
 - Statistical habitat suitability models (e.g. Phillips, 2006)
 - Expert judgement (e.g. Scholes and Biggs, 2005)
 - Species-area curve (e.g. Brooks et al., 2002)
 - Issues: Species may not exist in areas of suitable habitat.
 - Solutions: validation and calibration of species diversity measures using targeted monitoring programmes
- **Application of qualitative approaches**
 - For example 'very abundant', 'abundant', 'common', 'rare' and 'very rare' as broad classes for species abundance.

You can hover over the approaches to learn more.



Explanation 1 (Slide Layer)

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Plugging species diversity data gaps

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You can hover over the approaches to learn more.



Ideally data gaps could be filled by instituting new monitoring programme. However, this may not always be practicable.

Explanation 2 (Slide Layer)

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Plugging species diversity data gaps





There are several approaches to fill the gaps in the species diversity data, such as:

- **Development of a national species monitoring programme**
- **Use of estimation approaches**
 - Human drivers based models
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 - Expert judgement (e.g. Scholes and Biggs, 2005)
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 - Solutions: validation and calibration of species monitoring programmes
- **Application of qualitative approaches**
 - For example 'very abundant', 'abundant', 'common', 'rare' and 'very rare' as broad classes for species abundance.

Species data can also be estimated using a variety of approaches:

- Models, such as GLOBIO, estimate relative metrics on species diversity measures due to human-induced changes in land cover and land use (e.g. Alkemade et al., 2009).
- Other statistical approaches, such as Maxent, estimate species diversity on the basis of habitat suitability factors.
- A related approach involves exploiting the relationship between species and ecosystem area to estimate species diversity (e.g. Brooks et al., 2002).
- Species diversity data can also be estimated using expert judgement and data on a range of environmental factors (e.g. Biodiversity Intactness Indicator - Scholes and Biggs, 2005).
- An intrinsic issue with these types of estimation procedures is the assumption that species occur in areas that can support them. This may not always be the case. As such, if these approaches are employed, they must be supported with a comprehensive validation program.

You can hover over the approaches to learn more.



Explanation 3 (Slide Layer)

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Plugging species diversity data gaps

There are several approaches to fill the gaps in the species diversity data, such as:

- **Development of a national species monitoring programme**
- **Use of estimation approaches**
 - Human drivers based models (e.g. Alkemade, 2009)
 - Statistical habitat suitability models (e.g. Phillips, 2006)
 - Expert judgement (e.g. Scholes and Biggs, 2005)
 - Species-area curve (e.g. Brooks et al., 2002)
 - Issues: Species may not exist in areas of suitable habitat.
 - Solutions: validation and calibration of species monitoring programmes
- **Application of qualitative approaches**
 - For example 'very abundant', 'abundant', 'common', 'rare' and 'very rare' as broad classes for species abundance.


Where quantitative data is difficult to collect, consideration could be given to adopting a qualitative classification of species diversity. For example: 'very abundant', 'abundant', 'common', 'rare' and 'very rare' as broad classes for species abundance.

You can hover over the approaches to learn more.



1.33 Conceptual issues

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Conceptual issues

There are some conceptual issues that should be considered when compiling biodiversity accounts, such as:


- Data on **species ranges and characteristics** are often incomplete.
- **Migration and mobility** (e.g. birds are often recorded where they breed and bears can range over many habitat types).
- **Functional diversity**: some species are more important to the functioning of the ecosystem; some overlap in function.
- **Conservation priority** species may not be of high importance for ecosystem condition.
- The need for more than one **biodiversity account** to answer different policy questions.
- **Invasive species**.
- **Reference conditions**.
- More than one indicator may be required to track policy progress and report ecosystem condition.
- How can biodiversity measures be aggregated across **ecosystems**?

You can hover over the conceptual issues to learn more.



Explanation 1 (Slide Layer)

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Conceptual issues

There are some conceptual issues that should be considered when compiling biodiversity accounts, such as:

- Data on **species ranges and characteristics** are often incomplete. This makes protocols for addressing data-gaps necessary.
- **Migration and mobility** (e.g. birds are often recorded where they breed and bears can range over many habitat types).
- **Functional diversity**: some species are more important to the functioning of the ecosystem; some overlap in function.
- **Conservation priority** species may not be of high importance for ecosystem condition.
- The need for more than one **biodiversity account** to answer different policy questions.
- **Invasive species**.
- **Reference conditions**.
- More than one indicator may be required to track policy progress and report ecosystem condition.
- How can biodiversity measures be aggregated across **ecosystems**?

You can hover over the conceptual issues to learn more.



Explanation 2 (Slide Layer)

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SEEA

Conceptual issues

There are some conceptual issues that should be considered when compiling biodiversity accounts, such as:

- Data on **species ranges and characteristics** are often incomplete.
- **Migration and mobility** (e.g. birds are often recorded where they breed and bears can range over many habitat types).
- **Functional diversity**: some species are more important to the functioning of the ecosystem; some overlap in function. This will be important when prioritizing species.
- **Conservation priority** species may not be of high importance for ecosystem condition.
- The need for more than one **biodiversity account** to answer different policy questions.
- **Invasive species**.
- **Reference conditions**.
- More than one indicator may be required to track policy progress and report ecosystem condition.
- How can biodiversity measures be aggregated across **ecosystems**?

You can hover over the conceptual issues to learn more.



Explanation 3 (Slide Layer)

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SEEA

Conceptual issues

There are some conceptual issues that should be considered when compiling biodiversity accounts, such as:

- Data on **species ranges and characteristics** are often incomplete.
- **Migration and mobility** (e.g. birds are often recorded where they breed and bears can range over many habitat types).
- **Functional diversity**: some species are more important to the functioning of the ecosystem; some overlap in function. This will be important when prioritizing species.
- **Conservation priority** species may not be of high importance for ecosystem condition.
- The need for more than one **biodiversity account** to answer different policy questions.
- **Invasive species**.
- **Reference conditions**.
- More than one indicator may be required to track policy progress and report ecosystem condition.
- How can biodiversity measures be aggregated across **ecosystems**?

You can hover over the conceptual issues to learn more.



Explanation 4 (Slide Layer)

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SEEA

Conceptual issues

There are some conceptual issues that should be considered when compiling biodiversity accounts, such as:

- Data on **species ranges and characteristics** are often incomplete.
- **Migration and mobility** (e.g. birds are often recorded where they breed and bears can range over many habitat types).
- **Functional diversity**: some species are more important to the functioning of the ecosystem; some overlap in function.
- **Conservation priority** species may not be of high importance for ecosystem condition. Conversely, **non-conservation priority** species may be of high importance for ecosystem condition.
- The need for more than one biodiversity account to provide information on different biodiversity-related policy questions.
- **Invasive species**.
- **Reference conditions**.
- More than one indicator may be required to track policy progress and report ecosystem condition.
- How can biodiversity measures be aggregated across **ecosystems**?

You can hover over the conceptual issues to learn more.



Explanation 5 (Slide Layer)

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SEEA

Conceptual issues

There are some conceptual issues that should be considered when compiling biodiversity accounts, such as:

- Data on **species ranges and characteristics** are often incomplete.
- **Migration and mobility** (e.g. birds are often recorded where they breed and bears can range over many habitat types).
- **Functional diversity**: some species are more important to the functioning of the ecosystem; some overlap in function.
- **Conservation priority** species may not be of high importance for ecosystem condition. More than one biodiversity account may be required in order to provide information on different biodiversity-related policy questions. For instance, information on biodiversity relevant to ecosystem functioning may require a different accounting structure than information on species threat status.
- The need for more than one biodiversity account to provide information on different biodiversity-related policy questions.
- **Invasive species**.
- **Reference conditions**.
- More than one indicator may be required to track policy progress and report ecosystem condition.
- How can biodiversity measures be aggregated across **ecosystems**?

You can hover over the conceptual issues to learn more.



Explanation 6 (Slide Layer)

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SEEA

Conceptual issues

There are some conceptual issues that should be considered when compiling biodiversity accounts, such as:

- Data on **species ranges and characteristics** are often incomplete.
- **Migration and mobility** (e.g. birds are often recorded where they breed and bears can range over many habitat types).
- **Functional diversity**: some species are more important to the functioning of the ecosystem; some overlap in function.
- **Conservation priority** species may not be of high importance for ecosystem condition.
- The need for more than one biodiversity indicator.
- **Invasive species**: Invasive species require a separate consideration in biodiversity accounts, given their often significant negative impacts on ecosystem functioning.
- **Reference conditions**: More than one indicator may be required to provide information on both progress towards policy targets and on ecosystem condition.
- More than one indicator may be required to provide information on both progress towards policy targets and on ecosystem condition.
- How can biodiversity measures be aggregated across **ecosystems**?

You can hover over the conceptual issues to learn more.



Explanation 7 (Slide Layer)

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SEEA

Conceptual issues

There are some conceptual issues that should be considered when compiling biodiversity accounts, such as:

- Data on **species ranges and characteristics** are often incomplete.
- **Migration and mobility** (e.g. birds are often recorded where they breed and bears can range over many habitat types).
- **Functional diversity**: some species are more important to the functioning of the ecosystem; some overlap in function.
- **Conservation priority** species In many cases (e.g. much of Europe) it may be impossible to estimate reference conditions for species diversity due to the long history of human development. Furthermore, this needs to be considered in terms of the specific ecosystem services that biodiversity provides. For instance, a pristine biological assemblage may imply the loss of several economically and culturally important ecosystem services.
- The need for more than one biodiversity indicator. More than one indicator of biodiversity may be required to provide information on both progress towards policy targets and on ecosystem condition.
- **Invasive species**.
- **Reference conditions**.
- More than one indicator may be required to provide information on both progress towards policy targets and on ecosystem condition.
- How can biodiversity measures be aggregated across ecosystems?

You can hover over the conceptual issues to learn more.



Explanation 8 (Slide Layer)

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Conceptual issues

There are some conceptual issues that should be considered when compiling biodiversity accounts, such as:

- Data on **species ranges and characteristics** are often incomplete.
- **Migration and mobility** (e.g. birds are often recorded where they breed and bears can range over many habitat types).
- **Functional diversity**: some species are more important to the functioning of the ecosystem; some overlap in function.
- **Conservation priority** species may not be of high importance for ecosystem condition.
- The need for more than one **biodiversity account** to answer different policy questions.
- **Invasive species**.
- **Reference conditions**.
- More than one indicator may be required to track policy progress and report ecosystem condition.
- How can biodiversity measures be aggregated across **ecosystems**?

You can hover over the conceptual issues to learn more.

Under the SEEA EEA, biodiversity information should be collected for individual **ecosystem assets** and aggregated across spatial areas for reporting. However, further research and testing is required for processing information on diversity between ecosystems at these reporting scales.



1.34 Examples

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Examples

In the next few slides, we will present a couple of global and country examples of approaches to biodiversity accounting.

We'll begin with an example from Norway detailing its Nature Index approach. After that, we'll examine the National Red List approach. Finally we'll look at the data recorded for a montane coniferous forest ecosystem asset (EA) and the different tier approaches for measuring biodiversity.

Let's move on and check out these examples!





1.35 Example 1 - Norway

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Example 1 – Norway’s Nature Index (NI)


The first example comes from Norway. The Norwegian Nature Index provides a good example for selecting a comprehensive suite of measures of species diversity and other ecosystem indicators, comprising more than 300 indicators in total (Certain and Skarpaas, 2011).

The **indicators** are chosen from a variety of species groups for each ecosystem. They measure deviation from a reference state, which is intended to represent ecological sustainability.

[Click here](#) to see some of the indicators.

The NI incorporates expert judgment, monitoring-based estimates, and model-based estimates.

The NI is included in the Norwegian official set of indicators for sustainable development, reported annually by Statistics Norway and by the finance ministry as part of the national budget.



Explanation 1 (Slide Layer)

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Example 1 – Norway’s Nature Index (NI)

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The NI incorporates expert judgment, monitoring-based estimates, and model-based estimates.

The NI is included in the Norwegian official set of indicators for sustainable development, reported annually by Statistics Norway and by the finance ministry as part of the national budget.

- Taxonomic group
- Red list status
- Presence in region
- Specificity to habitat
- Trophic group (primary producer, herbivore, predator, carnivore)
- Keystone species
- Generality (specialist or generalist species)
- Community (indicator refers to population or community),
- Sub-habitat (description)
- Ecosystem service (contributing to)
- Quick response to environmental change
- Sensitive to which pressure
- Migrating
- Multiple major habitats
- Reference value (i.e., value of “reference state” chosen)

1.36 Example 1 - Norway

Example 1 – Norway's Nature Index (NI)

Norway's Nature Index approach consists of four steps that will eventually calculate the NI value for a species group over a spatial area of interest in the ecosystem.

The four steps are:

- A. **Construct** an index for a species group based on relative measures of key species in an ecosystem.
- B. **Combine** several indexes for ecosystem area.
- C. **Aggregate** the combined NI value across all ecosystems in a spatial area.
- D. The aggregated value of NI in a spatial area is **aggregated across** all spatial areas in the ecosystem.

Let's move on and go through each step in an example to learn more about the calculations.



1.37 Example 1 - Norway

Example 1 – Norway's Nature Index (NI)

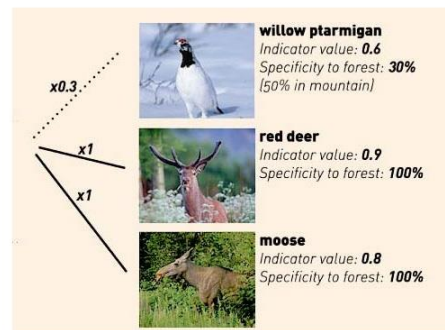
- A. Consider a set of indicator values in the same spatial unit, same major ecosystem and same trophic group.

As shown in the figure to the right, data about three indicators are provided for the primary consumer in the forest of a given spatial unit.

For example:

To calculate the indicator for primary consumers in a forest ecosystem, you need to calculate the weighted average of the **indicator value** according to the **specificity** of the indicators to the major ecosystem (i.e. 30 % for willow ptarmigan, 100 % for red deer, and 100 % for moose.) = $(0.6 * 0.3 + 0.9 * 1.0 + 0.8 * 1.0) / (0.3 + 1.0 + 1.0) = 1.88 / 2.3 = 0.82$

Thus, the Nature Index for the primary consumers in a forest ecosystem is **NI value = 0.82**



1.38 Example 1 - Norway

Example 1 – Norway's Nature Index (NI)

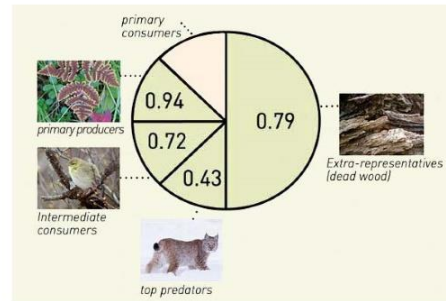
B. Consider the NI within a spatial unit and a major ecosystem:

As shown in the figure, several indicators for different trophic groups are combined to give an overall headline index or indicator. Different weights are determined based on the ecological importance of each indicator. For a forest ecosystem, 'deadwood' is the most important indicator of forest health. It contributes 50% to the overall NI, while the other four provide only 12.5% to overall NI.

For example:

To calculate the Nature Index =
 $0.79 * 0.5 + (0.82 + 0.43 + 0.94 + 0.72) * 0.125 = 0.76$

Therefore, the overall headline index or indicator (NI) value is **0.76** within this major ecosystem area.



1.39 Example 1 – Norway

Example 1 – Norway's Nature Index (NI)

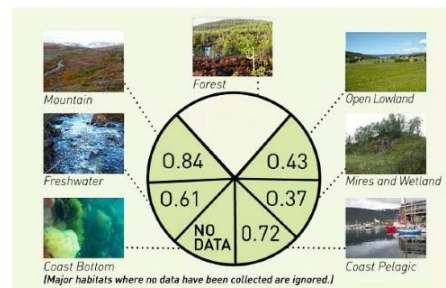
C. Considering the NI (0.76) for the forest from step B, we will aggregate all NI values from different ecosystems across a spatial area.

All the NI values for each ecosystem with data available within a spatial unit are aggregated using a **simple average** method.

For example:

There are six (6) ecosystems (mountain, freshwater, forest, open lowland, mires and wetland, coast pelagic) with NI data. Thus, the simple average of NI = $(0.61 + 0.84 + 0.76 + 0.43 + 0.37 + 0.72) / 6 = 0.62$.

Thus, the overall index or indicator (NI) value within this spatial unit is **0.62**.



1.40 Example 1 – Norway

Example 1 – Norway's Nature Index (NI)

D. Considering the NI (0.62) for the spatial unit calculated in step C, we will average NI values over several spatial areas (units).

All the NI values for each spatial unit are aggregated over a spatial area of interest, using an **area weighting average** to adjust NI values.

For example:

as per the figure, there are five (5) areas with NI data totaled as:

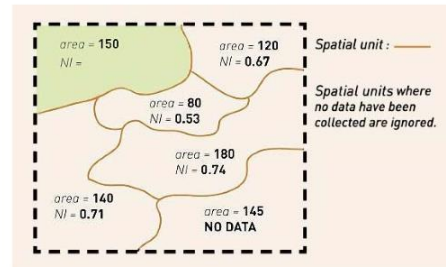
$150 + 120 + 80 + 140 + 180 = 670$ (total area)

NI weighted average per area = $\sum NI \cdot \text{Area} / \text{Total Area}$.

$\sum NI \cdot \text{Area} = 0.62 \cdot 150 + 0.67 \cdot 120 + 0.53 \cdot 80 + 0.71 \cdot 140 + 0.74 \cdot 180 = 448.4$

Thus, the NI values weighted average = $448.4 / 670 = 0.67$

Thus, the overall index or indicator (NI) value across all spatial units is **0.67**



1.41 Example 2 - IUCN

Example 2 – IUCN National Red List

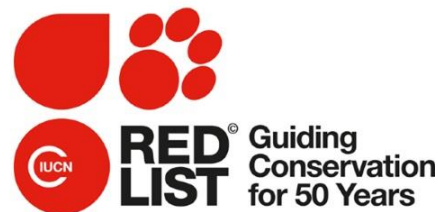
The second example examines the **National Red List** approach. It is useful for biodiversity accounting as it provides information on the status of the stock of species of concern within a country.

[Click here to learn more about the Red List](#)

Information relevant to species' extinction risk is considered from published and grey literature, museum records and specimen databases. They specifically relate to:

- Species distribution
- Population trend information
- Habitat, ecology and life history information
- Threats to the species
- Conservation measures currently in place

Species on the Red List are also mapped to their specific habitat, which allows the species to be mapped to land cover classification in the accounting framework. In theory, this implies that this information could be disaggregated to sub-national levels, however this would depend on the distribution of the species in question.



Explanation (Slide Layer)

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Example 2 – IUCN National Red List


The second example examines the **National Red List** approach. It is useful for biodiversity accounting as it provides information on the status of the stock of species of concern within a country.

[Click here to learn more about the Red List](#)

Information relevant to species' extinction risk is considered from published and grey literature, museum records and specimen databases. They specifically relate to:

- Species distribution
- Population trend information
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- Threats to the species
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Species on the Red List are also mapped to their specific habitat, which allows the species to be mapped to land cover classification in the accounting framework. In theory, this implies that this information could be disaggregated to sub-national levels, however this would depend on the distribution of the species in question.



RED LIST® Guiding Conservation for 50 Years

The Red List is an assessment of extinction risk under current circumstances. Assessment of extinction is made based on exhaustive surveys' ability to record an individual in known and/or expected habitat in comparison to its historic range – the reference condition.

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1.42 Example 2 - IUCN

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Example 2 – IUCN National Red List

The IUCN National Red List ...

- suggests that the **IUCN Red List of Threatened Species** be used together with National Red Lists for accounting, to reveal differences in the extinction risk of species on global and national levels.
- is supported by national workshops that rely on local species experts to provide validation.
- is implemented in many countries (e.g. Ecuador, Finland, Norway, Spain, Sri Lanka, Thailand, etc.)



RED LIST® Guiding Conservation for 50 Years

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1.43 Example 3

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Example 3 – Montane coniferous forest ecosystem asset

Here is an example of information recorded for a montane coniferous forest ecosystem asset (EA) as shown in the adjoining figure.

Hover over each tier to learn more about the information requirements for a montane coniferous forest.

Tier 1
Ecosystem extent, potentially weighted by species indicators

Tier 2
Species richness data, extinction risk and/or health data

Tier 3
Species abundance data

Increasing information requirements

Explanation 1 (Slide Layer)

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Example 3 – Montane coniferous forest ecosystem asset

Here is an example of information recorded for a montane coniferous forest ecosystem asset (EA) as shown in the adjoining figure.

Hover over each tier to learn more about the information requirements for a montane coniferous forest.

Tier 1
Ecosystem extent, potentially weighted by species indicators

Tier 2
Species richness data, extinction risk and/or health data

Tier 3
Species abundance data

Increasing information requirements

Montane coniferous forest EA extent, weighted by an input condition indicator (e.g. deadwood).
'Tier 1' biodiversity accounting provides a framework for organizing information on ecosystem diversity, and potentially weighting it using measures (or indicators) of species diversity. This may limit resources. This approach is conceptually similar to the Norway's Natural Index just described.

Explanation 2 (Slide Layer)

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Example 3 – Montane coniferous forest ecosystem asset

Here is an example of information recorded for a montane coniferous forest ecosystem asset (EA) as shown in the adjoining figure.

Hover over each tier to learn more about the information requirements for a montane coniferous forest.

Tier 1
Ecosystem extent, potentially weighted by species indicators

Tier 2
Species richness data, extinction risk and/or health data

Tier 3
Species abundance data

Species richness of montane coniferous forest EA supplemented with information on species Red List status.

'Tier 2' species diversity accounts can be produced by collecting data on species richness or ranges, and other characteristics, such as threatened status. However, these provide limited information on the actual 'stock' of biodiversity.

Explanation 3 (Slide Layer)

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Example 3 – Montane coniferous forest ecosystem asset

Here is an example of information recorded for a montane coniferous forest ecosystem asset (EA) as shown in the adjoining figure.

Hover over each tier to learn more about the information requirements for a montane coniferous forest.

Tier 1
Ecosystem extent, potentially weighted by species indicators

Tier 2
Species richness data, extinction risk and/or health data

Tier 3
Species abundance data

Species abundance monitoring data for montane coniferous forest EA.

'Tier 3' species diversity accounts can be produced by collecting information on species abundance. This provides the most detailed accounts but requires the most resources – The example presented in Unit 1 is a Tier 3 account as it contains information on species abundance. Further testing is required in order to generate these types of accounts in real world situations, given the difficulties in obtaining population measures.

1.44 Example 4

Other examples by tier 1, 2 and 3

Let's take a look at the approaches in tiers 1, 2 and 3 for measuring biodiversity as applied in different parts of the world.

Click on each box and have a look at their examples.

"Tier 1" approach, using indicator weighted by habitat area

"Tier 2" approach, based on species richness and status

"Tier 3" approach, based on species abundance

Explanation 1 (Slide Layer)

Other examples by tier 1, 2 and 3

Let's take a look at the approaches in tiers 1, 2 and 3 for measuring biodiversity as applied in different parts of the world.

Click on each box and have a look at their examples.

"Tier 1" approach, using indicator weighted by habitat area

"Tier 2" approach, based on species richness and status

"Tier 3" approach, based on species abundance

	Habitat Area	Bird Population (x)	Species Richness (y)	Butterfly population (z)	Headline Indicator (HI)	Stock
Indicator Weight		0.25	0.50	0.25	$HI = 0.25x + 0.50y + 0.25z$	$Stock = HI * Area$
Open (2000)	5.0	0.90	0.80	0.70	0.8000	4.000
Additions	1.0	0.00	0.10	0.15	0.0875	0.525
Reductions	0.0	0.10	0.05	0.05	0.0625	0.375
Close (2010)	6.0	0.80	0.85	0.80	0.8250	4.950
Net Change	+1.0	-0.10	+0.05	+0.10	+0.0250	+0.950
Reference	N/A	Level in 1970	Level in 1970	Level in 1970	N/A	N/A

Example based on Norwegian Nature Index approach

Example of a biodiversity asset account using the Norwegian Nature Index approach using imaginary data. This accounting table presents data on changes in habitat areas and input indicator values between 2000 and 2010. This is shown in the rows with the green rectangles.

To populate this table, information has been obtained on three input indicators of species diversity selected for the ecosystem unit being considered. These are identified by orange rectangles.

Explanation 2 (Slide Layer)

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Other examples by tier 1, 2 and 3

	Introduced species	Native species			Total native species	Total species
		Unprotected	Protected	Rare and endangered		
Animals						
- Vertebrates						
- Mammals	15	2	112	20	114	129
- Birds	10	0	458	33	458	468
- Reptiles	2	0	202	26	202	204
- Amphibians	1	0	51	9	51	52
- Bony fish	4	56	0	0	56	60
- Cartilaginous fish	NA	NA	NA	NA	NA	NA
- Insects	0	11	2	0	13	13
Subtotal	32	69	825	88	894	926
Plants						
- Subtotal	376	5	3239	91	3244	6320
Fungi						
- Subtotal	0	0	68	0	68	68
Protista						
- Subtotal	0	0	148	0	148	148
TOTAL	408	74	4280	179	4354	4762

“Tier 1” approach, using indicator weighted by habitat area

“Tier 2” approach, based on species richness and status

“Tier 3” approach, based on species abundance

Example from an Australian terrestrial area for year 2000 (Bond et al., 2011)

This experimental accounting example provides a species account for the Burdekin Natural Resource Management area, Queensland, Australia for the year 2000. This account is based on species richness measures for different species groups – identified with the **orange rectangle**. The account is supported with information on the species threat status as well – identified by the **green rectangle**.

Explanation 3 (Slide Layer)

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Other examples by tier 1, 2 and 3

Let's take a look at the approaches in tiers 1, 2 and 3 for measuring biodiversity as applied in different parts of the world.

Click on each box and have a look at their examples.

“Tier 1” approach, using indicator weighted by habitat area

“Tier 2” approach, based on species richness and status

“Tier 3” approach, based on species abundance

	Animals				Plants	Headline Indicator (HI)
	Mammals	Birds	Reptiles	Invertebrates		
Weight	u	v	x	y	z	
Open (2000)	1.00	1.00	1.00	1.00	1.00	
Additions	0.05	0.00	0.00	0.15	0.10	
Reductions	0.10	0.15	0.05	0.05	0.05	
Close (2010)	0.95	0.85	0.95	1.10	1.10	
Net Change	-0.05	-0.15	-0.05	+0.10	+0.05	
Reference	Level in 2000	Level in 2000	Level in 2000	Level in 2000	Level in 2000	

Example based on based on species abundance

This accounting table presents some imaginary data on changes in the relative abundance of different taxonomic groups between 2000 and 2010. An accrual approach is used to set the reference condition (i.e. based on species abundance recorded when accounts were initiated) – as indicated by the **orange rectangle**. The account presents the net change in relative species abundance for each group – this is shown in the row identified by the **green rectangle**.

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Last page

Great!
You have now completed Units 1, 2, and 3.

Let's move on to the **questions and answers** section to review the biodiversity accounting knowledge you've learned in this module.





1.46 Module units

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Module units

The biodiversity accounting module will take you through four units, as listed below.
We recommend completing these units in order.

Unit 1: Biodiversity accounting <ul style="list-style-type: none">• What is it?• Why do we need it?• What does it look like?• Expertise and data required.	Unit 2: Compilers <ul style="list-style-type: none">• Basic concepts for measuring biodiversity.• Steps for compiling biodiversity accounts.	Unit 3: Data providers <ul style="list-style-type: none">• Concepts• Biodiversity accounting information uses.• Data options, examples and issues.	Unit 4: Review <ul style="list-style-type: none">• Quiz• Summary
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1.47 Quiz

(Multiple Response, 10 points, 1 attempt permitted)

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Quiz 1

You have learned about different **measures** for biodiversity accounting, can you identify them?

Check all the answers you think are correct!





☒ Abundance

☒ Richness

☒ Species Characteristics

☒ Conservation Status

OK



Correct	Choice
X	Abundance
X	Richness
X	Species Characteristics
X	Conservation Status

Feedback when correct:


All answers are correct.

Feedback when incorrect:

All answers would have been correct.

Correct (Slide Layer)

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Quiz 1

You have learned about different **measures** for biodiversity accounting, can you identify them?

Check all the answers you think are correct!

- ☒ Abundance
- ☒ Richness
- ☒ Species Characteristics
- ☒ Conservation Status


Very good!

All answers are correct.

Continue

Incorrect (Slide Layer)

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Quiz 1

You have learned about different **measures** for biodiversity accounting, can you identify them?

Check all the answers you think are correct!

- ☒ Abundance
- ☒ Richness
- ☒ Species Characteristics
- ☒ Conservation Status

Not quite right.

All answers would have been correct.

Continue

1.48 Quiz

(Multiple Response, 10 points, 1 attempt permitted)

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Quiz 2

The Norwegian Nature Index (NI) provides an example for selecting a comprehensive suite of measures of species diversity and other ecosystem **indicators**.
Can you select some indicators from the list below that were included in the NI?

Check all the answers you think are correct!

- ☒ Taxonomic group
- ☒ Specificity to habitat
- ☒ Red list status
- ☒ Trophic group
- ☒ Generality (specialist or generalist species)

OK



Correct	Choice
X	Taxonomic group
X	Specificity to habitat
X	Red list status
X	Trophic group
X	Generality (specialist or generalist species)

Feedback when correct:


All answers are correct.

Feedback when incorrect:

All answers would have been correct.

Correct (Slide Layer)

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Quiz 2

The Norwegian Nature Index (NI) provides an example for selecting a comprehensive suite of measures of species diversity and other ecosystem **indicators**.
Can you select some indicators from the list below that were included in the NI?

Check all the answers you think are correct!

- ☒ Taxonomic group
- ☒ Specificity to habitat
- ☒ Red list status
- ☒ Trophic group
- ☒ Generality (specialist or generalist species)


Very good.

All answers are correct.

Continue

Incorrect (Slide Layer)

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Quiz 2

The Norwegian Nature Index (NI) provides an example for selecting a comprehensive suite of measures of species diversity and other ecosystem **indicators**.
Can you select some indicators from the list below that were included in the NI?

Check all the answers you think are correct!

- ☒ Taxonomic group
- ☒ Specificity to habitat
- ☒ Red list status
- ☒ Trophic group
- ☒ Generality (specialist or generalist species)

Not quite right.

All answers would have been correct.

Continue

1.49 Quiz

(Multiple Response, 10 points, 1 attempt permitted)

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Quiz 3

Part of compiling biodiversity accounting is conducting an inventory of **existing species diversity information**. Can you tell which of the following information sources would be used for such inventory?

Check all the answers you think are correct!

☒

National and sub-national monitoring schemes

☒

National Red List





☒

Governmental Agencies, NGOs, universities and museums

☒

Reporting to regional processes and international conventions

OK



Correct	Choice
X	National and sub-national monitoring schemes
X	National Red List
X	Governmental Agencies, NGOs, universities and museums
X	Reporting to regional processes and international conventions

Feedback when correct:


All answers are correct.

Feedback when incorrect:

All answers would have been correct.

Correct (Slide Layer)

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Quiz 3

Part of compiling biodiversity accounting is conducting an inventory of **existing species diversity information**. Can you tell which of the following information sources would be used for such inventory?

Check all the answers you think are correct!

- ☒ National and sub-national monitoring schemes
- ☒ National Red List
- ☒ Governmental Agencies, NGOs, universities and museums
- ☒ Reporting to regional processes and international conventions


Very good.

All answers are correct.

Continue

Incorrect (Slide Layer)

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Quiz 3

Part of compiling biodiversity accounting is conducting an inventory of **existing species diversity information**. Can you tell which of the following information sources would be used for such inventory?

Check all the answers you think are correct!

- ☒ National and sub-national monitoring schemes
- ☒ National Red List
- ☒ Governmental Agencies, NGOs, universities and museums
- ☒ Reporting to regional processes and international conventions

Not quite right.

All answers would have been correct.

Continue

1.50 Summary

Summary

Now that you've reached the end of this module, you've been equipped with the knowledge and skills to:

- Understand biodiversity accounting
- Incorporate biodiversity accounting in the wider framework of SEEA
- Understand the basic concepts for measuring biodiversity
- Learn the steps for compiling a biodiversity account
- Navigate the data options and sources behind biodiversity accounting
- Understand the important conceptual issues for biodiversity
- Learn from other countries' approaches to measuring biodiversity

Further Information:

- System of Environmental-Economic Accounting 2012 – Experimental Ecosystem Accounting (**SEEA EEA**)
- System of Environmental-Economic Accounting 2012 – Central Framework (**SEEA CF**)
- SEEA-EEA [Technical Recommendations](#) (forthcoming)
- Secretariat for the Convention on Biological Diversity (SCBD) - Quick Start Package (QSP) (Weber, 2014). Available online at www.ecosystemaccounting.net. Includes free GIS software and tutorials.
- National Biodiversity Strategies and Action Plans (Training modules at www.cbd.int/nbsap/training/)
- World Bank **WAVES**
- Statistics Canada - [Measuring Ecosystem Goods and Services Teacher's Kit](#)



1.51 References

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