



Food and Agriculture
Organization of the
United Nations



DRAFT FOR PUBLIC REVIEW

Principles for the assessment of livestock impacts on biodiversity



DRAFT FOR PUBLIC REVIEW

**Principles for the assessment of
livestock impacts on biodiversity**

The designations employed and the presentation of material in this information product do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations (FAO) concerning the legal or development status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. The mention of specific companies or products of manufacturers, whether or not these have been patented, does not imply that these have been endorsed or recommended by FAO in preference to others of a similar nature that are not mentioned.

The views expressed in this information product are those of the author(s) and do not necessarily reflect the views of FAO.

All rights reserved. FAO encourages reproduction and dissemination of material in this information product. Non-commercial uses will be authorized free of charge, upon request. Reproduction for resale or other commercial purposes, including educational purposes, may incur fees. Applications for permission to reproduce or disseminate FAO copyright materials, and all queries concerning rights and licences, should be addressed by e-mail to copyright@fao.org or to the Chief, Publishing Policy and Support Branch, Office of Knowledge Exchange, Research and Extension, FAO, Viale delle Terme di Caracalla, 00153 Rome, Italy.

1	Contents	
2	Acknowledgements	5
3	Abbreviations	8
4	Glossary.....	9
5	A. Summary and key principles	16
6	B. LEAP and the preparation process	21
7	B.1. Development of principles for biodiversity assessment.....	22
8	B.2 Biodiversity TAG and preparation process	23
9	B.3. Period of validity	23
10	C. Structure of the document	23
11	1. Goal and scope	25
12	1.1. An initial step for biodiversity assessment in LEAP.....	25
13	1.2. Objectives and intended users	25
14	1.3. Scope	27
15	1.3.1. Assessment approaches.....	27
16	1.3.2. Categories of impact.....	28
17	1.3.3. Livestock species and production systems.....	30
18	1.3.4. Biodiversity	30
19	2. Assessment methods	30
20	2.1. Generic framework and two main approaches	30
21	2.2. General information on the assessment methods	31
22	2.2.1. The LCA approach.....	31
23	2.2.2. The PSR approach.....	32
24	2.3. Complementarities between the LCA and PSR approaches.....	33
25	2.3.1. Complementarity in scope.....	34
26	2.3.2. Complementarity in perspective.....	34
27	2.3.3. Complementarities along the environmental cause-effect chain.....	35
28	3. Background information on biodiversity and livestock	36
29	3.1. Biodiversity and its complexity	37
30	3.2. Global patterns in biodiversity	39
31	3.3. Global-scale priorities for biodiversity conservation	42

Principles for the assessment of livestock impacts on biodiversity

1	3.4.	Global patterns of livestock distribution	44
2	3.5.	Summary of the influences of livestock on biodiversity	46
3	4.	Principles applying to biodiversity assessment in LCA	49
4	4.1.	Overview of the main steps of an LCA	50
5	4.2.	Conceptual framework: land use change in LCA	52
6	4.3.	Current development of biodiversity indicators and modelling in LCA	54
7	4.3.1.	Towards a consensus on LCA for biodiversity	55
8	4.4.	Applying biodiversity LCA to livestock production	55
9	5.	Principles applying to biodiversity assessment within the Pressure-State-Response	
10		indicator approach	57
11	5.1.	Common issues for biodiversity assessment using PSR approach	57
12	5.2.	Pressure indicators	68
13	5.3.	Summary of the pressure and benefit categories and their indicators	68
14	5.3.1.	Scoping and hotspot analysis	69
15	5.3.2.	Principles for application of pressure indicators to analysis of livestock impacts	
16		74	
17	5.4.	State indicators	77
18	5.4.1.	General information	77
19	5.4.2.	Scoping and hotspot analysis	79
20	5.4.3.	Principles	81
21	5.5.	Response indicators	85
22	5.5.1.	Principles	85
23	5.5.2.	Scoping and hotspot analysis	85
24	5.5.3.	Principles	86
25	5.5.4.	Farm-scale response indicators	87
26	5.5.5.	Sector Response Indicators	88
27	5.5.6.	Considerations	91
28	6.	Future challenges for improved biodiversity assessment in LCA and its application to	
29		livestock production	94
30	6.1.	Inclusion of several midpoint impacts on biodiversity	95
31	6.2.	Biodiversity representation	96
32	6.2.1.	Cross-representation of taxonomic groups	96

Principles for the assessment of livestock impacts on biodiversity

1	6.2.2. Inclusion of ecosystem services	96
2	6.3. Land use representation	97
3	6.3.1. Land use cover and geographic scope	97
4	6.3.2. Incorporation of landscape-scale processes	97
5	6.4. Reference states for biodiversity	98
6	6.4.1. Choice of reference state in LCAs for biodiversity.....	98
7	6.4.2. What is currently done?.....	98
8	6.4.3. Geographical scale of the metrics for PNV.....	98
9	6.4.4. Choice of reference state and representation of positive influences of livestock	
10	systems	99
11	7. Future priorities for LEAP & Biodiversity	101
12	7.1. Ensure links between LEAP and other biodiversity initiatives	101
13	7.2. Identify best practices in Biodiversity Action Plans	103
14	7.3. Improved identification of biodiversity indicators for livestock systems	104
15	7.4. Progress towards comprehensive environmental assessments in LEAP.....	104
16	References	106

17
18
19

1 **Acknowledgements**

2 These principles are a product of the Livestock Environmental Assessment and Performance
3 (LEAP) Partnership. Various groups contributed to their development:

4 The Technical Advisory Group (TAG) on biodiversity developed the core technical content of
5 the guidelines. The TAG was led by John Finn (Teagasc, Ireland) and Mohammed Said
6 (ILRI, Kenya) who coordinated the activities of the TAG. The TAG leaders were supported
7 by Félix Teillard (FAO) who, as technical secretary of the biodiversity TAG, conducted
8 background research and processed inputs from TAG members and reviewers.

9 The biodiversity TAG was composed of: Rob Alkemade (PBL, Netherlands – TAG member
10 until March 2014), Assumpció Anton (IRTA, Spain), Bertrand Dumont (INRA, France),
11 Fernando R. Funes Monzote (Sociedad Científica Latinoamericana de Agroecología, Cuba -
12 TAG member until Aug 2014), Beverley Henry (Queensland University of Technology,
13 Australia), Danielle Maia de Souza (Swedish University of Agricultural Sciences, Sweden),
14 Pablo Manzano (IUCN CEM, Kenya & UAM, Spain), Llorenç Milà I Canals (UNEP,
15 France), Catherine Phelps (Dairy Australia, Australia), Sandra Vijn (WWF, USA), Shannon R.
16 White (Government of Alberta, and Alberta Biodiversity Monitoring Institute, Canada), and
17 Hans-Peter Zerfas (World Vision, Germany – TAG member until March 2014).

18 The LEAP Secretariat coordinated and facilitated the work of the TAG, guided and
19 contributed to the content development and ensured coherence between the various
20 guidelines. The LEAP secretariat, hosted at FAO, was composed of: Pierre Gerber
21 (Coordinator until Jan 2015), Camillo De Camillis (LEAP manager), Carolyn Opio
22 (Technical officer and Coordinator since Feb 2015), Félix Teillard (Technical officer) and
23 Aimable Uwizeye (Technical officer).

24 Three external experts provided a thorough review of the guidelines: Leslie Firbank
25 (University of Leeds), Jeremy Radachowski (Wildlife Conservation Society) and Serenella
26 Sala (European Commission, Joint Research Centre).

27 The LEAP Steering Committee provided overall guidance for the activities of the Partnership
28 and helped review and cleared the principles for public release. During development of the
29 principles the LEAP Steering Committee was composed of:

30 *Steering committee members*

31 Alejandro Acosta (Food and Agriculture Organization of the United Nations, Global Agenda
32 For Sustainable Livestock, in LEAP since Feb 2015), Monikka Agarwal (World Alliance of
33 Mobile Indigenous People, in LEAP since Oct 2014), Douglas Brown (World Vision),
34 Giuseppe Luca Capodiecì (The European Livestock And Meat Trading Union, International
35 Meat Secretariat), Camillo De Camillis (Food and Agriculture Organization of the United
36 Nations), Richard de Mooij (The European Livestock And Meat Trading Union, International
37 Meat Secretariat), Elsa Delcombel (Government of France), Lalji Desai (World Alliance of

Principles for the assessment of livestock impacts on biodiversity

1 Mobile Indigenous People - 2014 LEAP Chair), Jeroen Dijkman (Food and Agriculture
2 Organization of the United Nations, Global Agenda For Sustainable Livestock - in LEAP
3 until Jan 2015), Neil Fraser (Food and Agriculture Organization of the United Nations, Global
4 Agenda For Sustainable Livestock), Pierre Gerber (Food and Agriculture Organization of the
5 United Nations - LEAP secretariat coordinator until Jan 2015), Mathias Ginet (Government of
6 France, in LEAP since Oct 2014), Jan Grenz (Bern University of Applied Sciences,
7 Government of Switzerland, in LEAP until Mar 2014), Vincent Guyonnet (International Egg
8 Commission), Dave Harrison (International Meat Secretariat), Matthew Hooper (Government
9 of New Zealand), Hsin Huang (International Meat Secretariat), Delanie Kellon (International
10 Dairy Federation), Lionel Launois (Government of France), Pablo Manzano (International
11 Union for Conservation of Nature), Nicolas Martin (European Feed Manufacturers'
12 Federation, The International Feed Industry Federation), Ian McConnel (World Wide Fund
13 for Nature, in LEAP since Jan 2015), Paul Melville (Government of New Zealand), Paul
14 McKiernan (Government of Ireland), Frank Mitloehner (University of California, Davis, The
15 International Feed Industry Federation, 2013 LEAP Chair), Anne-Marie Neeteson-van
16 Nieuwenhoven (International Poultry Council), Frank O'Mara (Teagasc, Government of
17 Ireland), Antonio Onorati (International Planning Committee for World Food Sovereignty)
18 Carolyn Opio (Food and Agriculture Organization of the United Nations, LEAP secretariat
19 coordinator since Jan 2015), Lara Sanfrancesco (International Poultry Council), Fritz
20 Schneider (Bern University of Applied Sciences, Government of Switzerland, in LEAP until
21 Feb 2015), Rogier Schulte (Teagasc, Government of Ireland - 2015 LEAP chair), Henning
22 Steinfeld (Food and Agriculture Organization of the United Nations - LEAP Partnership vice-
23 chair), Nico van Belzen (International Dairy Federation), Elsbeth Visser (Government of the
24 Netherlands), Alison Watson (Food and Agriculture Organization of the United Nations
25 LEAP manager until Dec 2013), Bryan Weech (World Wide Fund for Nature, in LEAP until
26 2014), Geert Westenbrink (Government of the Netherlands), and Hans-Peter Zerfas (World
27 Vision).

28 *Observers*

29 Rudolph De Jong (International Wool Textile Organization, in LEAP until Oct 2014),
30 Matthias Finkbeiner (International Organization for Standardization), Michele Galatola
31 (European Commission, DG Environment), James Lomax (United Nations Environment
32 Programme), Llorenç Milà i Canals (United Nations Environment Programme), Paul Pearson
33 (International Council of Tanners, in LEAP since Feb 2015), Erwan Saouter (European
34 Commission, Joint Research Centre), Sonia Valdivia (United Nations Environment
35 Programme), and Elisabeth van Delden (International Wool Textile Organization)
36 LEAP is funded by its Members, with additional support from FAO and the Mitigation of
37 Climate Change in Agriculture (MICCA) Programme.

- 1 **Recommended citation:** LEAP, 2015. *Principles for the assessment of livestock impacts on*
- 2 *biodiversity*. Draft for public review. Livestock Environmental Assessment and Performance
- 3 Partnership. FAO, Rome, Italy.

DRAFT

1 **Abbreviations**

BAP	Biodiversity Action Plan
BDP	Biodiversity Damage Potential
CBD	Convention on Biological Diversity
CF	Characterization Factor
EC	European Commission
EDP	Ecological Damage Potential
EEA	European Environment Agency
FAO	Food and Agriculture Organization of the United Nations
GAP	Good Agricultural Practices
GHG	Greenhouse Gas
GRI	Global Reporting Initiative
ISO	International Organization for Standardization
IUCN	International Union for Conservation of Nature
KPI	Key Performance Indicator
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
LEAP	Livestock Environmental Assessment and Performance Partnership
LPI	Living Planet Index
LU	Land Use
LUC	Land Use Change
LULUC	Land Use and Land Use Change
MEA	Millennium Ecosystem Assessment
NGO	Non Governmental Organization
OECD	Organization for Economic Cooperation and Development
PDF	Potentially Disappeared Fraction (of species)
PNV	Potential Natural Vegetation
PSR	Pressure-State-Response
SETAC	Society for Environmental Toxicology and Chemistry
TAG	Technical Advisory Group
UN	United Nations
UNEP	United Nations Environment Programme
WWF	World Wide Fund for Nature

2

1 **Glossary**

2 **Terms relating to biodiversity**

Biodiversity	Variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic systems and the ecological complexes of which they are part, including diversity within species, between species and of ecosystems. [Article 2 of the CBD]
Biome	The world's major communities, classified according to the predominant vegetation and characterized by adaptations of organisms to that particular environment. For instance, tropical rainforest, grassland, tundra. [Campbell 1996]
Ecosystem	A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit [Article 2 of the CBD]
Ecosystem services	The benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual and recreational benefits; and supporting services such as nutrient cycling that maintain the conditions for life on Earth. [MEA 2005]
Endemism	Association of a biological taxon with a unique and well-defined geographic area. [The Encyclopedia of Earth, http://www.eoearth.org]
Endemic species	See Endemism
Habitat	The place or type of site where an organism or population naturally occurs. [Article 2 of the CBD]
Hotspot analysis	Hot spot analysis aims to define areas of high occurrence versus areas of low occurrence of a feature of interest. Here, it refers to an assessment of the relative contribution of e.g. different pressures and threats, with the aim of identifying those that make the strongest contribution to biodiversity loss. [LEAP Biodiversity TAG]
Hotspot, biodiversity	A hotspot for biodiversity represents a geographical areas where there is a coincidence of high biodiversity and high level of biodiversity threats. [LEAP Biodiversity TAG]

3

4

5

6 **Terms relating to life cycle assessment and environmental assessment**

7

Principles for the assessment of livestock impacts on biodiversity

Acidification	Impact category that addresses impacts due to acidifying substances in the environment. Emissions of NO _x , NH ₃ and SO _x lead to releases of hydrogen ions (H ⁺) when the gases are mineralised. The protons contribute to the acidification of soils and water when they are released in areas where the buffering capacity is low. Acidification may result to forest decline and lake acidification. [Adapted from Product Environmental Footprint Guide, European Commission, 2013]
Allocation	Partitioning the input or output flows of a process or a product system between the product system under study and one or more other product systems [ISO 14044:2006, 3.17]
Background system	The background system consists of processes on which no or, at best, indirect influence may be exercised by the decision-maker for which an LCA is carried out. Such processes are called “background processes.” [UNEP/SETAC Life Cycle Initiative, 2011].
Characterization	Calculation of the magnitude of the contribution of each classified input/output to their respective impact categories, and aggregation of contributions within each category. This requires a linear multiplication of the inventory data with characterisation factors for each substance and impact category of concern. For example, with respect to the impact category “climate change”, CO ₂ is chosen as the reference substance and kg CO ₂ -equivalents as the reference unit. [Adapted from: Product Environmental Footprint Guide, European Commission, 2013]
Characterization factor	Factor derived from a characterization model which is applied to convert an assigned life cycle inventory analysis result to the common unit of the category indicator [ISO 14044:2006, 3.37]
Classification	Assigning the material/energy inputs and outputs tabulated in the Life Cycle Inventory to impact categories according to each substance’s potential to contribute to each of the impact categories considered.[Adapted from: Product Environmental Footprint Guide, European Commission, 2013]
Data quality	Characteristics of data that relate to their ability to satisfy stated requirements [ISO 14044:2006, 3.19]
Dataset (both LCI dataset and LCIA dataset)	A document or file with life cycle information of a specified product or other reference (e.g., site, process), covering descriptive metadata and quantitative life cycle inventory and/or life cycle impact assessment data, respectively. [ILCD Handbook, 2010]
Direct Land Use Change (dLUC)	Change in human use or management of land within the product system being assessed [ISO/TS 14067:2013, 3.1.8.4]
Downstream	Occurring along a product supply chain after the point of referral. [Product Environmental Footprint Guide, European Commission, 2013]
Eco-toxicity	Environmental impact category that addresses the toxic impacts on an ecosystem, which damage individual species and change the structure

Principles for the assessment of livestock impacts on biodiversity

and function of the ecosystem. Eco-toxicity is a result of a variety of different toxicological mechanisms caused by the release of substances with a direct effect on the health of the ecosystem. [Adapted from: Product Environmental Footprint Guide, European Commission, 2013]

Elementary flow	Material or energy entering the system being studied that has been drawn from the environment without previous human transformation, or material or energy leaving the system being studied that is released into the environment without subsequent human transformation [ISO 14044:2006, 3.12]
Emissions	Release of substance to air and discharges to water and land.
Environmental impact	Any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organization's activities, products or services [ISO/TR 14062:2002, 3.6]
Eutrophication	Excess of nutrients (mainly nitrogen and phosphorus) in water or soil, from sewage outfalls and fertilized farmland. In water, eutrophication accelerates the growth of algae and other vegetation in water. The degradation of organic material consumes oxygen resulting in oxygen deficiency and, in some cases, fish death. Eutrophication translates the quantity of substances emitted into a common measure expressed as the oxygen required for the degradation of dead biomass. In soil, eutrophication favors nitrophilous plant species and modifies the composition of the plant communities. [Adapted from: Product Environmental Footprint Guide, European Commission, 2013]
Foreground system	The foreground system consists of processes which are under the control of the decision-maker for which an LCA is carried out. They are called "foreground processes" [UNEP/SETAC Life Cycle Initiative, 2011]
Functional unit	Quantified performance of a product system for use as a reference unit [ISO 14044:2006, 3.20]. It is essential that the functional unit allows comparisons that are valid where the compared objects (or time series data on the same object, for benchmarking) are comparable.
Greenhouse gases (GHGs)	Gaseous constituent of the atmosphere, both natural and anthropogenic, that absorbs and emits radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere, and clouds [ISO 14064-1:2006, 2.1].
Indirect Land Use Change (iLUC)	Change in the use or management of land which is a consequence of direct land use change, but which occurs outside the product system being assessed [ISO/TS 14067:2013, 3.1.8.5].
Impact category	Class representing environmental issues of concern to which life cycle inventory analysis results may be assigned [ISO 14044:2006, 3.39].
Impact category	Quantifiable representation of an impact category [ISO 14044:2006,

Principles for the assessment of livestock impacts on biodiversity

indicator	3.40].
Land occupation	Impact category related to use (occupation) of land area by activities such as agriculture, roads, housing, mining, etc. [Adapted from: Product Environmental Footprint Guide, European Commission, 2013]
Land use change	Change in the purpose for which land is used by humans (e.g. between crop land, grass land, forestland, wetland, industrial land) [PAS 2050:2011, 3.27]
Life cycle	Consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to final disposal [ISO 14044:2006, 3.1]
Life Cycle Assessment	Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle [ISO 14044:2006, 3.2]
Life cycle GHG emissions	Sum of GHG emissions resulting from all stages of the life cycle of a product and within the specified system boundaries of the product.[PAS 2050:2011, 3.30]
Life Cycle Impact Assessment (LCIA)	Phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential impacts for a product system throughout the life cycle of the product [Adapted from: ISO 14044:2006, 3.4]
Life Cycle Inventory (LCI)	Phase of life cycle assessment involving the compilation and quantification of inputs and outputs for a product throughout its life cycle [ISO 14046:2014, 3.3.6]
Life Cycle Interpretation	Phase of life cycle assessment in which the findings of either the inventory analysis or the impact assessment, or both, are evaluated in relation to the defined goal and scope in order to reach conclusions and recommendations [ISO 14044:2006, 3.5]
Normalization	After the characterisation step, normalisation is an optional step in which the impact assessment results are multiplied by normalisation factors that represent the overall inventory of a reference unit (e.g. a whole country or an average citizen). Normalised impact assessment results express the relative shares of the impacts of the analysed system in terms of the total contributions to each impact category per reference unit. When displaying the normalised impact assessment results of the different impact topics next to each other, it becomes evident which impact categories are affected most and least by the analysed system. Normalised impact assessment results reflect only the contribution of the analysed system to the total impact potential, not the severity/relevance of the respective total impact. Normalised results are dimensionless, but not additive. [Product Environmental Footprint Guide, European Commission, 2013]
Ozone depletion	Impact category that accounts for the degradation of stratospheric ozone due to emissions of ozone-depleting substances, for example long-lived chlorine and bromine containing gases (e.g. CFCs, HCFCs,

Principles for the assessment of livestock impacts on biodiversity

Halons). [Product Environmental Footprint Guide, European Commission, 2013]

Particular matter	Impact category that accounts for the adverse health effects on human health caused by emissions of Particulate Matter (PM) and its precursors (NO _x , SO _x , NH ₃) [Product Environmental Footprint Guide, European Commission, 2013]
Photochemical ozone formation	Impact category that accounts for the formation of ozone at the ground level of the troposphere caused by photochemical oxidation of Volatile Organic Compounds (VOCs) and carbon monoxide (CO) in the presence of nitrogen oxides (NO _x) and sunlight. High concentrations of ground-level tropospheric ozone damage vegetation, human respiratory tracts and manmade materials through reaction with organic materials.[Product Environmental Footprint Guide, European Commission, 2013]
Primary data	Quantified value of a unit process or an activity obtained from a direct measurement or a calculation based on direct measurements at its original source [ISO 14046:2014, 3.6.1]
Product(s)	Any goods or service [ISO 14044:2006, 3.9]
Product system	Collection of unit processes with elementary and product flows, performing one or more defined functions, and which models the life cycle of a product [ISO 14044:2006, 3.28]
Raw material	Primary or secondary material that is used to produce a product [ISO 14044:2006, 3.1.5]
Reference flow	Measure of the outputs from processes in a given product system required to fulfil the function expressed by the functional unit [ISO 14044:2006, 3.29]
Releases	Emissions to air and discharges to water and soil [ISO 14044:2006, 3.30]
Reporting	Presenting data to internal management and external users such as regulators, shareholders, the general public or specific stakeholder groups [ENVIFOOD Protocol: 2013]
Resource depletion	Impact category that addresses use of natural resources either renewable or non-renewable, biotic or abiotic. [Product Environmental Footprint Guide, European Commission, 2013]
Secondary data	Data obtained from sources other than a direct measurement or a calculation based on direct measurements at the original source [ISO 14046:2014, 3.6.2]. Secondary data are used when primary data are not available or it is impractical to obtain primary data. Some emissions, such as methane from litter management, are calculated from a model, and are therefore considered secondary data.
Sensitivity analysis	Systematic procedures for estimating the effects of the choices made regarding methods and data on the outcome of a study [ISO 14044:2006, 3.31]

Soil Organic Matter (SOM)	The measure of the content of organic material in soil. This derives from plants and animals and comprises all of the organic matter in the soil exclusive of the matter that has not decayed. [Product Environmental Footprint Guide, European Commission, 2013]
System boundary	Set of criteria specifying which unit processes are part of a product system [ISO 14044:2006, 3.32]
Uncertainty analysis	Systematic procedure to quantify the uncertainty introduced in the results of a life cycle inventory analysis due to the cumulative effects of model imprecision, input uncertainty and data variability [ISO 14044:2006, 3.33]
Unit process	Smallest element considered in the life cycle inventory analysis for which input and output data are quantified [ISO 14044:2006, 3.34]
Upstream	Occurring along the supply chain of purchased goods/services prior to entering the system boundary. [Product Environmental Footprint Guide, European Commission, 2013]
Water body	Entity of water with definite hydrological, hydrogeomorphological, physical, chemical and biological characteristics in a given geographical area Examples: lakes, rivers, groundwaters, seas, icebergs, glaciers and reservoirs. Note 1 to entry: In case of availability, the geographical resolution of a water body should be determined at the goal and scope stage: it may regroup different small water bodies. [ISO 14046:2014, 3.1.7]
Water use	Use of water by human activity. Note 1 to entry: Use includes, but is not limited to, any water withdrawal, water release or other human activities within the drainage basin impacting water flows and/or quality, including in-stream uses such as fishing, recreation, transportation. Note 2 to entry: The term “water consumption” is often used to describe water removed from, but not returned to, the same drainage basin. Water consumption can be because of evaporation, transpiration, integration into a product, or release into a different drainage basin or the sea. Change in evaporation caused by land-use change is considered water consumption (e.g. reservoir). The temporal and geographical coverage of the water footprint assessment should be defined in the goal and scope. [ISO 14046:2014, 3.2.1]
Water withdrawal	Anthropogenic removal of water from any water body or from any drainage basin, either permanently or temporarily [ISO 14046:2014, 3.2.2].
Weighting	Weighting is an additional, but not mandatory, step that may support the interpretation and communication of the results of the analysis. Impact assessment results are multiplied by a set of weighting factors, which reflect the perceived relative importance of the impact categories considered. Weighted impact assessment results can be

Principles for the assessment of livestock impacts on biodiversity

directly compared across impact categories, and also summed across impact categories to obtain a single-value overall impact indicator. Weighting requires making value judgements as to the respective importance of the impact categories considered. These judgements may be based on expert opinion, social science methods, cultural/political viewpoints, or economic considerations. [Adapted from: Product Environmental Footprint Guide, European Commission, 2013]

1

DRAFT

1 **A. Summary and key principles**

2 Livestock production is widespread around the world, with up to 26% of terrestrial areas
3 dedicated to rangelands and 33% of croplands dedicated to fodder production. Demand for
4 livestock products is projected to grow 1.3% *per annum* until 2050 (although these estimates
5 vary), driven by a combination of global population growth, changes in patterns of food
6 consumption due to increasing wealth and urbanization (Alexandratos and Bruinsma, 2012).
7 The influence of livestock production on biodiversity is therefore obvious, although the exact
8 effects are diverse. Whether livestock yields a positive or negative impact on biodiversity will
9 very dependent on the intensity of production, the nature of specific practices, the livestock
10 species used, and the local ecological conditions. Livestock pressures on biodiversity are
11 manifested through, for example, conversion of natural habitats, land use change, impacts on
12 water quality and quantity, as well as contributions to climate change. The quantitative
13 assessment of the impacts of livestock systems and other sectors on biodiversity is an
14 emerging area of work that meets a growing demand to expand sustainability assessments to
15 include biodiversity. This document represents an initial step where international experts
16 shared their views on biodiversity assessment. This work is clearly at an early stage, and
17 should be considered as preparatory work for future and more detailed guidance on
18 biodiversity assessment within livestock systems.

19 This document identifies a number of broad principles to assist stakeholders in the assessment
20 of livestock impacts on biodiversity. Part II contains a state-of-the-art introduction to Life
21 Cycle Assessment approaches for biodiversity, with a major emphasis on the land use impacts
22 associated with livestock systems. Part III addresses the use of the Pressure-State-Response
23 (PSR) indicator approach to assess biodiversity within livestock systems. An overview of
24 these two approaches is presented in Section 2.2.

25 The key principles from this report are presented here. Throughout this document, key
26 principles are highlighted in the text where they apply (sometimes in more than one place).

27 The following principles are overarching in nature, in that they should be considered to
28 equally apply to the content of the LCA and PSR sections:

- 29 • Biodiversity is complex and multivariate by nature. The assessment of biodiversity is
30 complicated by the lack of a common ‘currency’ for biodiversity, and by it being
31 extremely context-dependent. For a contrasting example from greenhouse gas (GHG)
32 assessments, a molecule of CO₂ has the same radiative forcing no matter how or where
33 it is produced, impacts are potentially global even if the severity can vary
34 geographically, and all GHG emissions can be expressed in carbon equivalents. In
35 contrast, due to societal value judgements, there is great variation in the conservation
36 value of different species and habitats which complicates decision making about
37 conservation objectives and priorities. Thus, this will also complicate the assessment
38 of impacts on biodiversity.

Principles for the assessment of livestock impacts on biodiversity

- 1 • The objectives of a biodiversity assessment and the objectives of any related initiatives
2 should be clearly stated, and appropriate indicators and methodologies chosen to
3 reflect these objectives.
- 4 • For all geographical areas within the system boundary, assessments of livestock
5 systems should identify and recognize designation frameworks for biodiversity at both
6 habitat level (e.g. protected habitats) and species level (e.g. protected species, IUCN
7 red list, and equivalent frameworks at national and sub-national scales). These and
8 related (e.g. WWF) frameworks provide important guidance on the relative
9 conservation value and status of habitats and species.
- 10 • The effects of livestock production can have both negative and positive impacts. To
11 increase the relevance of assessment methodologies to the livestock sector, methods
12 need to be capable of reflecting the range of beneficial as well as detrimental impacts
13 due to livestock systems
- 14 • As a priority issue, processes such as feed production, especially off-farm feed
15 production, should be included in the system boundaries of livestock systems. This is
16 due to its substantial and increasing contribution to overall impacts on biodiversity.
- 17 • The choice of reference state (the level of biodiversity that is used as a baseline for
18 comparisons) has a strong influence on the interpretation of results; thus, it is
19 important to clearly describe the situation that is being used as a reference level, and to
20 interpret the results accordingly.

21 We provide principles that address two main approaches for biodiversity assessment, the LCA
22 and PSR indicators. These principles are presented separately but the two approaches present
23 opportunities for complementarity in assessment of biodiversity impacts. Complementarity in
24 scope allows the two approaches to address different types of questions.

- 25 • Complementarity in quantification between the LCA and PSR approaches means that
26 one approach could be used to fill the quantification gaps of the other.

27 As more specific examples of this important point:

- 28 • Livestock systems have multiple important impacts on biodiversity, including land use
29 and land use change, acidification, eutrophication, climate change, ecotoxicity.
30 Biodiversity assessment that focuses on a limited number of impacts (e.g. because of
31 data or method availability) should discuss the relative importance of other impact
32 categories and evaluate it at least qualitatively. For instance, there is consensus on
33 LCA methodologies for LULUC; however, PSR approaches could be used to broaden
34 this scope to include other categories of impact.
- 35 • LCA can be used to reveal supply chain or spatial hotspots for further investigation
36 with more detailed and complementary assessment methods. These complementary
37 assessments can use Pressure-State-Response indicators (see below) to fill the gaps of
38 current LCA methodologies. For instance, PSR indicators can be applied to

Principles for the assessment of livestock impacts on biodiversity

1 differentiate the effect of higher-resolution land use categories or livestock farming
2 practices.

3 Some key principles in relation to LCA for biodiversity are as follows:

- 4 • The comprehensive scope of LCA is important and useful in order to avoid problem-
5 shifting, for example, from one phase of the life-cycle to another, from one region to
6 another, or from one environmental problem to another.
- 7 • For the impact category of land use, there is broad consensus on the impact
8 assessment framework, and several methods are already available to quantify
9 biodiversity impacts through land use and are especially useful for assessment of the
10 biodiversity impacts of globally traded products. Currently, impacts on biodiversity in
11 LCA are mainly modelled as a result of land use and land use change interventions.
12 Other impact categories can also be incorporated although further methodological
13 development is needed.
- 14 • Existing LCA methods describe land use through relatively coarse categories, which
15 makes LCA more adapted to assessments at large spatial scales. For small-scale
16 assessments aimed at discriminating the relative impact of different practices on
17 biodiversity, indicators are likely to need further adaptation and development.
- 18 • There will be continued development of methods for the identification and calculation
19 of reference state and consequent characterisation factors, and users should keep up-
20 to-date with such developments.

21

22 Some key principles in relation to the use of Pressure-State-Response indicators for
23 biodiversity assessments are as follows.

- 24 • Pressure, state and response (PSR) indicators are complementary and the PSR
25 approach provides a way to articulate them to facilitate interpretation and decision
26 making. Combining several categories of indicators is strongly encouraged.
- 27 • The system boundaries should be defined to include off-farm feed cultivation when
28 nominating and calculating pressure indicators. As a minimum, the off-farm land use
29 pressure should be quantified (Case Study 1 provides a simple example to estimate it
30 with national yield data) and other categories should also be addressed if possible.
- 31 • The following ten major issues should be referred to when doing an assessment of
32 biodiversity impacts and provide overarching guidance that is relevant to indicator-
33 based approaches in general. Note especially that the following introduce a life-cycle
34 perspective to the selection of PSR indicators.

35 1. Goal definition

36 2. Scoping and hotspot analyses

37 3. Setting the boundaries

Principles for the assessment of livestock impacts on biodiversity

- 1 4. Identifying the scope of P, S and / or R
- 2 5. Engagement with stakeholders and experts
- 3 6. Identifying and prioritizing indicators
- 4 7. Identifying relevant information
- 5 8. Analysing data
- 6 9. Understanding and managing the impacts
- 7 10. Developing effective communications.

8

9 Principles applying to pressure indicators include:

- 10 • The scoping and hotspot analyses should aim to define a shortlist of pressures and
- 11 benefits to be quantified because of their importance for the user's livestock system
- 12 and its context. At least one indicator should be computed for each pressure and
- 13 benefit categories within the shortlist identified in the scoping analysis.
- 14 • Pressure and benefit are often two sides of the same gradient – both should be
- 15 considered when conducting the hotspot analysis and, when relevant, the same
- 16 indicator should reflect the whole gradient. An example includes grazing level
- 17 (livestock units/ha) which results in different impacts from low to high grazing levels
- 18 (e.g. see Case Study 4 and 5)

19

20 Principles applying to state indicators include:

- 21 • Species richness can be an important state indicator; however, where possible, state
- 22 indicators should also include information that reflects the species composition and
- 23 conservation value of species. (e.g. see Case Studies 3, 4 and 5).
- 24 • In assessments that rely on species richness, care should be taken to use information
- 25 on species composition to measure the occurrence of undesirable species e.g. non-
- 26 native invasive species, native invasive species, pest species, and indicators of low
- 27 habitat quality. These should constitute a separate state indicator of biodiversity, and
- 28 reflect a negative contribution (threat) to biodiversity (e.g. see Case Studies 4 and 5).
- 29 • When choosing state indicators, the contribution of species or species' groups to
- 30 ecosystem functions and services should be considered e.g. pollination, carbon
- 31 sequestration, hydrological services.
- 32 • Integrity of data collection should be ensured, including a breadth of state indicators
- 33 representing both those negatively and positively affected by livestock production
- 34 • Habitat area/semi-natural land cover is generally straightforward to assess, and can be
- 35 an informative state indicator for farmland biodiversity

1

2 Principles applying to response indicators include:

- 3 • Response indicators should be based on scientifically sound and verifiable evidence
4 that details a clear link between adoption of the response indicator and the expected
5 biodiversity outcome.
- 6 • Response indicators may be general, e.g. whether a biodiversity action plan is in place,
7 or more specific e.g. the level of expenditure on conservation of native grasslands or
8 the decision to preserve an endangered species. Such specific indicators are
9 determined by the scoping review and hot spot analysis.

10

11 FUTURE DIRECTIONS

12 More remains to be done to guide the quantitative assessment of impacts on biodiversity due
13 to livestock systems. To this end, Life Cycle Assessment and PSR indicators will be key
14 approaches. We identify a number of priority issues to improve their applicability to the
15 assessment of biodiversity impacts due to livestock systems, as follows:

- 16 • There is a need to identify and disseminate examples of best practice in biodiversity
17 assessments in the livestock sector. These should include examples of the effective use
18 of LCA of biodiversity impacts for improved decision-making about livestock systems
19 and supply chains. There is also a need for examples of the effective inclusion of life-
20 cycle perspectives into Biodiversity Action Plans and related methods (e.g.
21 certification standards) that rely on PSR indicators.
- 22 • A key outcome of this document is a recognition of the complementarity that can be
23 achieved through a combinations of LCA and PSR approaches. LCA could be used to
24 reveal supply chain or spatial hotspots for further investigation. Having broadly
25 identified such hotspots, more detailed assessment could be achieved through use of
26 PSR indicators. It would be highly desirable to identify examples that achieve this
27 complementarity.
- 28 • Examples of completed, quantitative Life Cycle Assessment in livestock systems are
29 needed to provide both further guidance and examples for developing and critiquing
30 the state-of-the-art for LCA for biodiversity. In particular, there is a need for:
 - 31 ○ development of local characterization factors for different livestock systems;
 - 32 ○ inclusion and recognition of positive and negative impacts
 - 33 ○ incorporation of impacts on landscape-scale processes;
 - 34 ○ the inclusion of several different mid-point impacts e.g. the biodiversity
35 impacts of acidification and eutrophication that cover a large geographic area,
36 as well as land use impacts;
 - 37 ○ improvement of the assessment of ecosystem services in LCA;

Principles for the assessment of livestock impacts on biodiversity

- methods and examples of characterization for a wide variety of taxa and of the use of weighting approaches to recognise the differences in conservation value of habitats and species (e.g. IUCN designation.)

Looking to the future, it is clear that more remains to be done to guide the assessment of livestock impact on biodiversity. There are several opportunities for additional work to be conducted by LEAP in this area. A number of priority issues could be addressed, as follows.

- Ensure links between LEAP and other biodiversity initiatives
- Identify examples of the complementarity between LCA and PSR approaches
- Identify best practices in Biodiversity Action Plans
- Improved identification of biodiversity indicators for livestock systems
- Progress towards comprehensive environmental assessments in LEAP

This ultimate goal of comprehensive environmental assessments is a challenging one, but a necessary requirement if we are to have more complete guidance on the environmental consequences of choices and decisions about the design and management of livestock systems.

B. LEAP and the preparation process

LEAP is a multi-stakeholder initiative launched in July 2012 with the goal of improving the environmental performance of livestock supply chains. Hosted by the Food and Agriculture Organization of the United Nations, LEAP brings together the private sector, governments, civil society representatives and leading experts who have a direct interest in the development of science-based, transparent and pragmatic guidance to measure and improve the environmental performance of livestock products.

In the context of climate change and increasing competition for natural resources, this projected growth places significant pressure on the livestock sector to perform in a more sustainable way. The identification and promotion of the contributions that the sector can make towards more efficient use of resource and better environmental outcomes is also important.

Currently, many different methods are used to assess the environmental impacts and performance of livestock products. This causes confusion and makes it difficult to compare results and set priorities for continuing improvement. With increasing demands in the marketplace for more sustainable products, there is also the risk that debates about how sustainability is measured will distract people from the task of driving real improvement in

Principles for the assessment of livestock impacts on biodiversity

1 environmental performance. And there is the danger that labelling or private standards based
2 on poorly developed metrics could lead to erroneous claims and comparisons.

3 The LEAP Partnership addresses the urgent need for a coordinated approach to developing
4 clear guidelines for environmental performance assessment based on international best
5 practices. The scope of LEAP is not to propose new standards but to produce detailed
6 guidelines that are specifically relevant to the livestock sector, and refine guidance as to
7 existing standards. LEAP is a multi-stakeholder partnership bringing together the private
8 sector, governments and civil society. These three groups have an equal say in deciding work
9 plans and approving outputs from LEAP, thus ensuring that the guidelines produced are
10 relevant to all stakeholders, widely accepted and supported by scientific evidence.

11 The work of LEAP is challenging but vitally important to the livestock sector. The diversity
12 and complexity of livestock farming systems, products, stakeholders and environmental
13 impacts can only be matched by the willingness of the sector's practitioners to work together
14 to improve performance. LEAP provides the essential backbone of robust measurement
15 methods to enable assessment, understanding and improvement in practice. More background
16 information on the LEAP Partnership can be found at www.fao.org/partnerships/leap/en/.

17

18 **B.1. Development of principles for biodiversity assessment**

19 Within LEAP, other Technical Advisory Groups (TAGs) focused mainly on greenhouse gas
20 (GHG) emissions and on specific livestock sub-sectors (Feed, Small Ruminants, Poultry, and
21 Large Ruminants). They produced guidelines taking into account the specific nature of the
22 livestock supply chain under investigation and aimed to provide sufficient definition of
23 calculation methods and data requirements to enable consistent application of LCA across
24 differing large ruminant supply chains.

25 The environmental impacts of livestock production are not restricted to GHG emissions. In
26 particular, livestock influence biodiversity, both positively and negatively (LEAP
27 Biodiversity Review, Teillard et al., in prep.). The objective of LEAP was to gather experts
28 from different background and to provide a forum for discussing biodiversity assessment in
29 the livestock sector. Because of the earlier stage of the discussions on biodiversity
30 assessment, this document provides general principles rather than the detailed quantitative
31 guidelines such as those focusing on GHG emissions within specific livestock sub-sectors.

32

33

1 **B.2 Biodiversity TAG and preparation process**

2 The Biodiversity TAG of the LEAP Partnership was formed at the beginning of 2014. The
3 core group included twelve experts in ecology, biodiversity assessment in LCA and livestock
4 production systems. Their backgrounds, complementary between systems and regions,
5 allowed them to understand and address different perspectives. The TAG was led by Dr. John
6 Finn (Teagasc, Ireland) and Dr Mohammed Said (ILRI, Kenya).

7 The role of the TAG was to:

- 8 • Identify biodiversity assessment approaches applicable to livestock production;
- 9 • Develop principles for the sound use of these approaches; and
- 10 • Describe future work needed to include meaningful biodiversity quantification in
11 livestock environmental assessments and their related guidelines.

12 The TAG met for three face-to-face workshops on 12–14 March 2014, Rome Italy, 2-3 July
13 2014, Madrid, Spain and 15-16 October 2014, Tivoli, Italy. Between these workshops, the
14 TAG worked via emails and teleconferences. Prior to the first workshop, the technical
15 secretary prepared a review on biodiversity indicators and assessment methods to serve as a
16 common base of work (Teillard et al., in prep.). This LEAP Biodiversity Review has been
17 revised by the whole TAG before publication.

18

19 **B.3. Period of validity**

20 It is intended that these guidelines will be periodically reviewed to ensure the validity of the
21 information and methodologies on which they rely. At the time of development, no
22 mechanism is in place to ensure such review. The user is invited to visit the LEAP website
23 (www.fao.org/partnerships/leap) to obtain the latest version.

24

25 **C. Structure of the document**

26 **Part I** provides a general introduction to the aims of this document, and its overall
27 framework. Major ecoregions and global hotspots of biodiversity are introduced. It also
28 outlines some of the major global patterns in the distribution of livestock. A major outcome of
29 this work is the identification of complementarity between the area of methodological
30 development of biodiversity assessment through Life Cycle Assessment (LCA), and the well-
31 established Pressure-State-Response indicator approach for assessing environmental impact.
32 Each of these is first introduced separately.

Principles for the assessment of livestock impacts on biodiversity

1 **Part II** contains a state-of-the-art introduction to Life Cycle Impact Assessment (LCIA)
2 approaches for biodiversity, with an emphasis on the land use impacts associated with
3 livestock systems. Life Cycle Assessment is typically a rigorous and demanding form of
4 assessment (with several distinct features and advantages), and this nature of LCA is reflect
5 here. Nevertheless, this introduction to LCA helps describe and understand the current state of
6 LCA for biodiversity, but importantly, points to how this can currently address assessment
7 challenges for the livestock sector.

8 **Part III** addresses the use of the Pressure-State-Response indicator approach to assess
9 biodiversity within livestock systems. We begin by providing ten overarching principles for
10 the use of indicators, and then discuss in further detail three widely-used categories of
11 indicators: Pressure indicators, State indicators and Response indicators. We discuss these
12 different approaches, with reference to specific examples of indicators, and with reference to
13 several Case Studies conducted as part of this work.

14 In **Part IV**, the final section concludes with guidance on Future Directions. This addresses
15 some of the medium-term needs for the livestock sector to improve methodology for
16 assessment of biodiversity. To provide leadership, there is a need to identify and disseminate
17 examples of good practice in application of biodiversity assessments in the livestock industry.
18 The development of relevant LCA methods is a fast-developing area, and LEAP can make a
19 significant contribution by being part of this development, and ensuring that such progress is
20 compatible with the needs of livestock systems.

21 Throughout the document, we refer to a number of Case Studies. As Case Studies, these are
22 not intended to be representative of the global distribution of livestock systems, nor are they
23 necessarily representative of the global challenges to biodiversity in global livestock systems.
24 Nevertheless, they do provide useful and practical examples of the interactions between
25 livestock and biodiversity. Most importantly they serve to highlight quantitative and
26 qualitative indicators and methods that have been used to assess livestock impacts on
27 biodiversity (within both the LCA and PSR approaches). The Case Studies also illustrate
28 some of the variety of challenges and solutions and, in some cases, actions to mitigate these
29 challenges.

30

PART I – Overview and general information

1. Goal and scope

1.1. An initial step for biodiversity assessment in LEAP

The provision of guidance for the quantitative assessment of biodiversity in livestock and other sectors is an emerging area of work. This document represents an initial step in which international experts with various backgrounds – ecologists, LCA experts, members of NGOs and the private sector – shared their views on biodiversity assessment. Because of the early stage of the discussions of the topic, we did not recommend a specific methodology nor provide the associated, detailed quantitative guidelines on how to use it to conduct a biodiversity assessment.

This document provides principles that can assist best practice in biodiversity assessment in livestock systems. Specific principles applying to two main approaches are provided: (i) LCA which is important for the link with the other LEAP guidelines and with the assessment of other environmental impacts (Section 2.2.1 and Part II); and (ii) an approach based on PSR indicators which is intuitive and covers a wide range of indicators and methods currently used by many stakeholders (Section 2.2.2 and Part III). This document also assesses the strengths and weaknesses of the two approaches and potential complementarities.

This document clearly is an initial step but it paves the way for future work on how to conduct biodiversity assessments in the livestock sector. Identifying priorities and challenges for this future work is another important contribution, addressed in Part IV. We identify research directions to make biodiversity assessment in LCA more ecologically relevant and more adapted to the specificities of the livestock sector. We also detail priorities for future developments within LEAP. They include strengthening links within LEAP and between LEAP and other initiatives; capitalizing on the link between the LCA and PSR approaches; identifying best practices and key performance indicators; and progressing towards comprehensive environmental assessments of the livestock sector.

1.2. Objectives and intended users

This document provides a number of broad principles for the assessment of livestock impacts on biodiversity. The general objective of this document was to develop principles applicable to different assessment methods in order to guarantee a minimum level of soundness, transparency, scientific relevance, and completeness. The level of generality of these

Principles for the assessment of livestock impacts on biodiversity

1 principles means that they are not well-adapted to make comparisons between different
2 systems and assessments. These principles can be used to identify crucial elements of
3 livestock systems that affect biodiversity, monitor changes and make improvements, and to
4 produce assessment results for internal or external communication.

5 This document is intended to be used by stakeholders at different scales, including:

- 6 • Local spatial scales (e.g., farm, landscape, agro-ecosystems)
- 7 • Intermediate scales (e.g., territory, supply chain, region)
- 8 • Large spatial scales (national to global)

9 It was assumed that the primary users of this document will be individuals or organisations
10 with a certain level of expertise in sustainability and/or biodiversity expertise, such as
11 sustainability or LCA practitioners, people involved in research or education, and
12 environmental NGOs. This document can be used by stakeholders in all countries and across
13 the wide range of livestock production systems.

14 Different users will have different goals and biodiversity assessment methods could also
15 differ as they are adapted to their goals (Table 1). The LCA approach (Part II) is adapted to
16 identify hotspots along a product's life cycle or spatial hotspots across large areas. It is also
17 adapted to users conducting an LCA on other environmental criteria (e.g., GHG emissions)
18 and wanting to expand its scope to include biodiversity. Current LCA methodologies have
19 limitations: the most elaborated focus on impacts on biodiversity through land use and only a
20 few land use classes are differentiated (e.g., *cropland*, *grassland*, without considering
21 differences in practices or intensity) With the current state of development in LCA, pressure
22 state or response indicators are likely to be more adapted to small scale assessment aimed at
23 discriminating the relative impact of different practices on biodiversity.

24

25

Principles for the assessment of livestock impacts on biodiversity

1 Table 1: Types of users at different scales along with their possible goals for conducting a biodiversity
 2 assessment. Different assessment tools that are adapted to these goals are suggested.

	Spatial dimension		Supply chain dimension
	Small scale (farm, landscape, agro-ecosystem)	Large scale (national to global)	Product scale
Users	<ul style="list-style-type: none"> • Farmers • Land managers • Communities • Processors and multinationals 	<ul style="list-style-type: none"> • Policy makers • Import/export companies 	<ul style="list-style-type: none"> • Sector and sub-sector sustainability managers • Processors • Other companies
Goals Across scales: monitor biodiversity performances	<ul style="list-style-type: none"> • Reveal positive and negative practices for biodiversity • Identify cost-effective practices to mitigate the impact • Identify local and regional programs that support appropriate responses. 	<ul style="list-style-type: none"> • Identify hotspots of positive/negative impact along the supply chains, among different systems, or spatially • Identify cost-effective practices to mitigate the average (e.g. national) impact • Analyse the impact from a constraint perspective 	<ul style="list-style-type: none"> • Identify hotspots of impact along the supply chain • Identify cost-effective practices to mitigate the average impact
Tools	<ul style="list-style-type: none"> • Pressure, state, response indicators • Life-cycle perspective 	<ul style="list-style-type: none"> • LCA • Indicators for biodiversity trends at large scales 	<ul style="list-style-type: none"> • LCA • Indicators for biodiversity trends at large scales • Specific tools for the supply chain/region

3

4 **1.3. Scope**5 **1.3.1. Assessment approaches**

6 This document addresses two main approaches for the assessment of livestock impacts on
 7 biodiversity: LCA, and PSR indicators. This document is intended to be objective which is the
 8 first reason why we selected these two approaches that are both widely used in the scientific
 9 literature. More specific reasons for selecting these two approaches are detailed below.

10 The rationale for selecting the LCA approach was based on three related points. (i) LCA is the
 11 only formal and standardized tool to quantitatively measure environmental performance: it is
 12 ruled by ISO and other standards. It could thus be used for overseeing different environmental
 13 certification at various levels (e.g., individual farms, companies, supply chains). (ii) LCA is

Principles for the assessment of livestock impacts on biodiversity

1 increasingly used for decision making, including in policies and environmental labelling
2 schemes for food products. There is therefore a risk for environmental impact categories not
3 addressed by LCA to be left out of such policies and labelling schemes. (iii) The other LEAP
4 documents address livestock sub-sectors (animal feed, poultry, small and large ruminants,
5 pigs) and provide specific LCA guidelines to quantify one main impact category: GHG
6 emissions. LCA is widely recognized as the predominant tool to quantify this impact.
7 Covering the LCA approach in this document increases the consistency with the other LEAP
8 activities and can facilitate broadening the scope of the sectoral LEAP guidelines to include
9 other environmental impacts, such as biodiversity.

10 The rationale for selecting the PSR approach was also based on three main points. (i) The
11 PSR approach is widely used and its relative simplicity and intuitiveness makes it easy to
12 grasp by users and stakeholders, including those with less biodiversity expertise. This reason
13 also explains why we used the PSR approach rather than one of its several elaborations (e.g.,
14 the DPSIR, EEA 1999). (ii) The PSR approach is a way to structure indicators and it has the
15 ability to cover a very wide range of methods. For instance, state indicators cover all direct
16 measures of biodiversity while response indicators can apply to environmental policies,
17 farming practices or private certifications. (iii) The PSR approach follows the same
18 environmental cause-effect chain as the LCA, which facilitates identification of
19 complementarities between the two approaches (Section 2.3).

20 **1.3.2. Categories of impact**

21 This document recognizes that livestock production can have both negative (pressures) and
22 positive (benefits) effects on biodiversity (Section 3.5, Figure 8).

23 Part III on pressure, state and response indicators can apply to the whole range of pressure and
24 benefit categories presented in Figure 8.

25 Part II on Life Cycle Assessment largely focuses on a single impact category: the impact on
26 biodiversity through land use. This focus on land use is justified because it is the category for
27 which the relevant scientific methodology is most developed and for which consensus on
28 assessment methods seems reachable in the relatively short term. LCA methodologies exist
29 for other midpoint impact categories, acidification, eutrophication, ecotoxicity, water use and
30 climate change in particular; however, these tend to be implemented at very coarse spatial
31 scales; there are relatively few alternatives from which one can compare and select the most
32 appropriate, and; there is relatively little consensus on their use and applicability to
33 agricultural systems. The most important methodologies are mentioned in Table 2 and
34 presented in more details in the LEAP Biodiversity Review (Teillard et al., in prep.).

35 Land use is likely to be an important category of impact, as livestock systems are a major user
36 of land resources. However, impacts of livestock on biodiversity are not restricted to land use
37 and other impact categories could have a comparable effect. It means that LCA focusing on

Principles for the assessment of livestock impacts on biodiversity

1 the impact of livestock systems through land use alone will underestimate the total impact on
 2 biodiversity. Focusing on land use also limits the comparability of impacts on biodiversity
 3 because the relative importance of impact categories will vary among regions and systems.
 4 For instance, intensive livestock systems use less land by unit of product by definition;
 5 however, they are often associated with higher use of inputs and higher concentrations of
 6 animals that can lead to nutrient pollution. For these systems, the relative impact on
 7 biodiversity through land use may be lower than the impact through pollution (this highlights
 8 the need for comprehensive environmental assessment, Section 7.4). When focusing on
 9 impacts on biodiversity through land use, the relative impact of other categories should be
 10 discussed and, if possible, assessed quantitatively or qualitatively. As emphasized in the key
 11 principles (Section A) and in Section 2.3, PSR indicators allow one to address additional
 12 impact categories and could thus be used to broaden the scope of LCA.

13

14 Table 2: Summary of LCA methods for assessing the impact of several midpoint categories on biodiversity.
 15 More details can be found in the LEAP Biodiversity Review (Teillard et al., in prep.)

Midpoint category & method	Biodiversity indicator	Geographic coverage
Land use		
Alkemade et al. (2009, 2012)	Mean Species Abundance	Global
deBaan et al. (2013)	Species richness (PDF)	Global
Koellner (2000, 2003), Koellner & Scholz (2008), Schmidt (2008)	Species richness, number of threatened species (EDP)	Central Europe, SE Asia (Schmidt 2008)
Michelsen (2008)	Ecosystem scarcity and vulnerability	Norway
Souza et al. (2013)	Functional diversity of species	Global
Acidification		
Azevedo et al. (2013c)	Species richness (PNOF)	Global
Van Zelm et al. (2007)	Species richness (PDF)	Europe
Eutrophication		
Azevedo et al. (2013a, 2013b)	Species richness (PNOF)	Global, Europe
Struijs et al. (2011)	Species richness (PDF)	Netherlands
Ecotoxicity		
Rosenbaum et al. (2008)	Species richness (PAF)	Global
Water use		
Pfister et al. (2009)		Global
Climate change		
	Net Primary Productivity	
De Schryver (2009)	Species richness (PDF)	Global

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32

1.3.3. Livestock species and production systems

These principles are intended to be relevant to the variety of livestock species and production systems.

1.3.4. Biodiversity

This document is and intended to be relevant to assessments addressing biodiversity at the ecosystem level (terrestrial or aquatic) or at the species level (plants or animals). Biodiversity at the genetic level is beyond the scope of this document.

The Case Studies tend to focus on terrestrial ecosystem and on plants. This reflects the general focus of existing biodiversity assessments in the context of agriculture.

The scope of a biodiversity assessment is also influenced by the scope in terms of impact categories (Section 1.3.2). Certain categories of impact are only relevant for terrestrial biodiversity, such as those related to land use and other habitat changes. For an LCA focusing on impact through land use, it means that only terrestrial biodiversity will be considered. Table 2 provides examples of methods for addressing other impact categories, including categories that are relevant to aquatic biodiversity, eutrophication and ecotoxicity in particular. However, Table 2 also shows that most of the LCA methods that are currently available to include biodiversity assessment do not cover all levels and dimensions of biodiversity. Most of them focus on species richness.

2. Assessment methods

2.1. Generic framework and two main approaches

The generic framework underlying these principles is the environmental cause-effect chain presented in Figure 1. Livestock production generates various kinds of pressures and benefits that lead to changes in the state of biodiversity, causing *responses* (decision and actions) of the stakeholders (political, socio-economic) that are undertaken to improve the state of biodiversity.

Under this generic framework, these principles address two main types of assessment methods:

- Life cycle assessment (LCA) also follows the cause-effect chain and models the components and link between them. A first step of LCAs aims to model the links between inventory items along the product’s life cycle and midpoint impact categories

Principles for the assessment of livestock impacts on biodiversity

(pressures). Optionally in a second step, midpoint impacts are translated into endpoint impacts, such as changes in the state of biodiversity (ISO 14044:2006).

- Indicators, i.e. metrics describing one of the three following components of the cause-effect chain: pressures/benefits, state or response. The Pressure-State-Response structure permits identification of indicators which facilitate interpretation and decision making.

This document addresses separately the two assessment approaches (LCA and PSR indicators). These two approaches rely on contrasting assessment methods which require specific principles. Principles for the LCA approach are described in Part II while those for PSR indicators are described in Part III. Part III also gives specific principles for the different categories of indicators: pressure, state and response; for all three, it recommends the adoption of a life-cycle perspective. The choice of the assessment method will mostly depend on the goal of the assessment (Section 1.2).



Figure 1: Generic framework (environmental cause-effect chain) for assessing the biodiversity performances of livestock production.

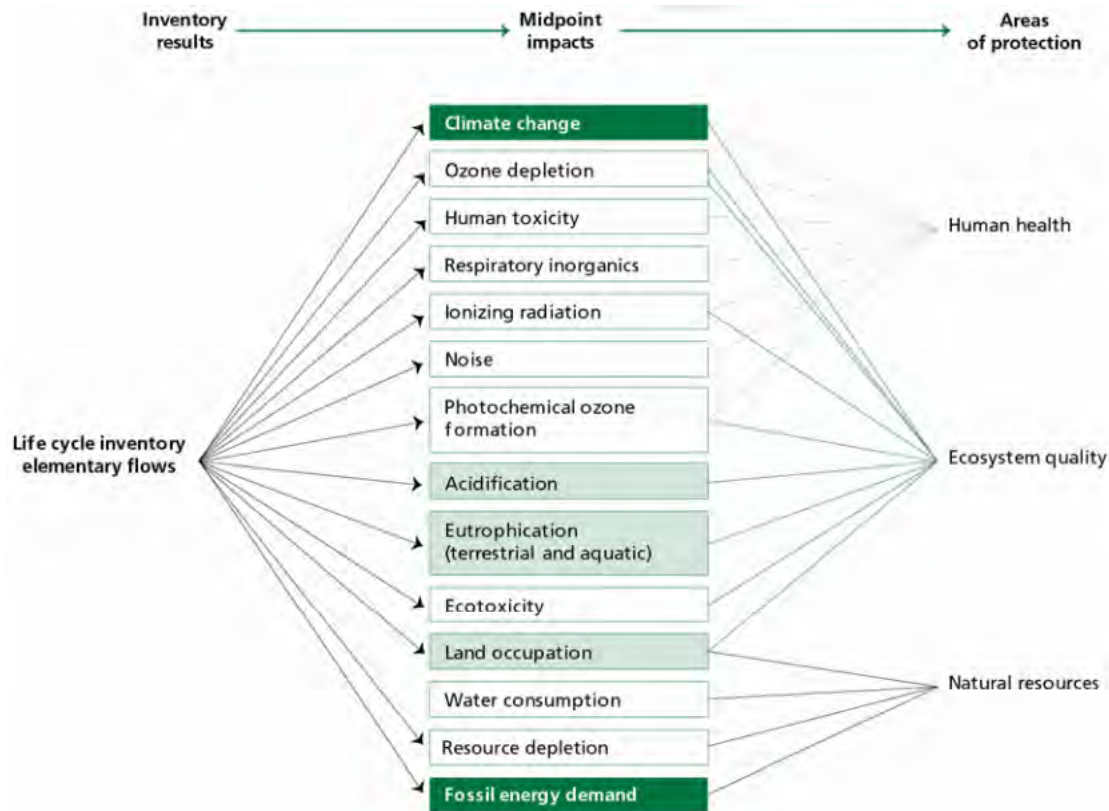
2.2. General information on the assessment methods

2.2.1. The LCA approach

Life Cycle Assessment is a tool to assess the potential environmental impacts and resources used throughout a product's life cycle, i.e., from raw material acquisition, via production and use phases, to end-of-life treatment, i.e. from cradle to grave¹ (ISO, 2006a). In the case of livestock, it corresponds to primary animal products, e.g., milk, meat, eggs, fibre and other by-products. The end-of-life treatment includes product and waste management practices such as disposal, recycling and incineration. The term 'product' includes goods, services and processes (ISO, 2006a). LCA is intended to be a comprehensive assessment and considers all attributes or aspects of natural environment, human health, and resources (ISO, 2006a). The comprehensive scope of LCA is useful in order to avoid problem-shifting, for example, from one phase of the life-cycle to another, from one region to another, or from one environmental problem to another (Finnvenden *et al.*, 2009).

¹The term "cradle-to-grave" refers to the assessment of impacts from raw-materials extraction to end-of-life treatments, such as recycling or landfilling.

Principles for the assessment of livestock impacts on biodiversity



1
2 Figure 2: Schematic representation of the environmental cause-effect chain and mechanisms of impacts.

3
4 Impacts can be characterized anywhere along the environmental cause-effect chain, either at
5 the midpoint, or endpoint level (Figure 2). The midpoint impact categories can be defined as
6 part of a problem-oriented approach, translating impacts into environmental themes such as
7 global warming, land use, acidification or human toxicity. Endpoint impact categories provide
8 a damage-oriented approach (ISO, 2006b). Traditional characterization methods are examples
9 of midpoint modelling while nowadays there is an increasing acceptance that results from
10 inventory results should interpret into their potential damage on endpoint impact categories
11 (such as biodiversity loss) and areas of protections (human health, natural environment and
12 natural resources, EC, 2010). The goal of this damage modelling is to aid in understanding
13 and interpreting midpoints by computing endpoint categories corresponding to areas of
14 protection that form the basis of decisions in policy and sustainable development.

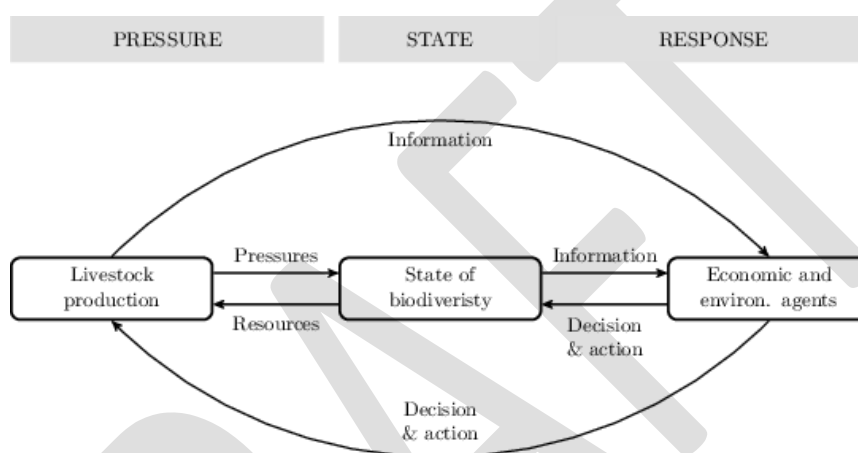
15 **2.2.2. The PSR approach**

16 Indicators are a crucial tool to monitor either biodiversity impacts or the improvement in
17 biodiversity performance. Making a selection among the many existing biodiversity indicators
18 (EEA 2003 identified more than 600 of them at the European scale) should be based on
19 logical frameworks (EEA, 2007). The pressure-state-response (PSR) framework (OECD,
20 1993) has been widely used to develop and structure biodiversity indicators. The PSR
21 framework is based on causality. Indicators evaluate the pressures of human activities that

Principles for the assessment of livestock impacts on biodiversity

1 lead to changes in environmental states, causing responses (decision and actions) of the
 2 stakeholders (political, socio-economic), undertaken to reach a sustainable state. Focusing on
 3 livestock production among other human activities and on biodiversity among other
 4 environmental components is a straightforward application of the PSR framework to this
 5 specific context (Figure 3).

6 The PSR framework helps to inform policy-makers by providing indicators that are structured
 7 and easier to interpret (Smeets et al., 1999). At the global and European levels, the CBD
 8 (CBD, 2006) and the European Environmental Agency (EEA, 2007) proposed headline
 9 biodiversity indicators following the PSR structure.



10
 11 Figure 3: The Pressure-State-Response framework applied to livestock production and biodiversity (adapted
 12 from OECD 1993).

13

14 **2.3. Complementarities between the LCA and PSR approaches**

15 **Key principles**

- 16 • Complementarity in quantification between the LCA and PSR approaches means that
- 17 one approach could be used to fill the quantification gaps of the other.
- 18 • Livestock systems have multiple important impacts on biodiversity, including land use
- 19 and land use change, acidification, eutrophication, climate change, ecotoxicity.
- 20 Biodiversity assessment that focuses on a limited number of impacts (e.g. because of
- 21 data or method availability) should discuss the relative importance of other impact
- 22 categories and evaluate it at least qualitatively. For instance, there is consensus on
- 23 LCA methodologies for LULUC; however, PSR approaches could be used to broaden
- 24 this scope to include other categories of impact.

- LCA can be used to reveal supply chain or spatial hotspots for further investigation with more detailed and complementary assessment methods. These complementary assessments can use Pressure-State-Response indicators (see below) to fill the gaps of current LCA methodologies. For instance, PSR indicators can be applied to differentiate the effect of higher-resolution land use categories or livestock farming practices.

Principles for the PSR indicators and the LCA approaches are presented separately in this document (Parts II and III). Until now, they have generally been studied separately in different scientific disciplines. However, they have complementarities and follow the same environmental cause-effect chain. This complementarity would allow them to be combined within the same assessment, and we explore this here.

2.3.1. Complementarity in scope

The methods that are currently available to characterize biodiversity in LCA are reliant on relatively coarse spatial scales and capture only part of the links between livestock and biodiversity. For instance:

- they rely on wide land use classes,
- they have a low level of biogeographical differentiation,
- they include a limited number of midpoint impact categories, and
- they focus on the species level of biodiversity and on certain taxa.

With this current state of knowledge, LCA approaches are not well suited to answer some questions. This is especially the case for questions such as ‘is livestock production practice A better than practice B for its effect on biodiversity?’ when both production practices occur within one of the broad land use classes of the current LCA approaches. Such approaches that are based on large geographical scales are much more suited to assessing land use changes impacts across bioregions, and not suited to assessing other more qualitative changes (such as the impacts of over- or under-grazing) within a bioregion. However, LCA is a very useful tool to conduct broad assessment of impacts on biodiversity at large spatial scales and to find hotspots of impact along the supply chain or among spatial entities. LCA could be used to reveal supply chain or spatial hotspots for further investigation with more detailed assessment methods. PSR indicators are part of these more detailed assessment methods as they could be used to differentiate the effect of different practices or expand the analysis to other pressures and biodiversity levels and taxa.

2.3.2. Complementarity in perspective

LCAs address the environmental impact of a product and take into account all stages of production along its life cycle. In contrast, most PSR indicators have focused on environmental impact within a bounded spatial area such as a farm, a landscape or a region.

Principles for the assessment of livestock impacts on biodiversity

1 These principles propose a first step to bridge the gap between these two dimensions by
2 adopting a life-cycle perspective when computing PSR indicators (Section 5.1). In particular,
3 it is recommended to at least include the impact of feed that is cultivated off farm when
4 selecting and calculating PSR indicators. This life cycle-perspective could also be extended to
5 other production stages. Conversely, the spatial perspective of PSR indicators demonstrates
6 the ecological importance of certain scales that are not necessarily those of the production
7 units, such as the impact of landscape-scale processes on biodiversity. Adopting the spatial
8 and landscape perspective could be an important step in improving the ecological relevance of
9 LCA approaches that can otherwise be insensitive to these issues.

10 As LCA focuses on products, impacts are often calculated on a ‘per unit of production’ basis.
11 This approach could also be relevant to PSR indicators in order to tackle the issue of
12 minimizing biodiversity impact while producing a certain amount of food. PSR indicators
13 from the field of ecology and agricultural or animal sciences also show that livestock systems
14 provide a much wider range of goods and services than just food production. Agricultural and
15 livestock systems also provide environmental, social and economic services. There is a
16 complex relationship between livestock production and ecosystem services. Livestock
17 systems have an impact on a wide range of ecosystem services, that can be either positive,
18 neutral or negative. A future challenge will be to incorporate the complexity of these
19 relationships in LCA studies of livestock systems (Section 6).

20 **2.3.3. Complementarities along the environmental cause-effect chain**

21 Reflecting similarities in the environmental cause-and-effect chain, it is not surprising that
22 there are several similarities between the LCA and PSR approaches. The LCA approach and
23 the recommended PSR approach (Section 5.1) both highlight the need of an assessment to
24 define the goal; conduct scoping and hotspot analysis; define the system boundaries; reliance
25 on relevant data to support analysis, and careful interpretation of the results. As might be
26 expected, there important differences in the nomenclature that they use.

27 An important difference in approach is that the PSR approach describes the different points of
28 the environmental cause-effect chain with certain metrics used as indicators, while the LCA
29 approach models the link between them. At the different points of the environmental cause-
30 effect chain, the two approaches could be combined.

- 31 • Many biodiversity pressures (e.g. GHG emissions, land use, eutrophication, water use)
32 correspond to midpoint impact categories. Other pressures such as land use and land
33 use change stand between inventory flows and midpoint impacts. At this level of the
34 environmental cause-effect chain, combining the two approaches could provide
35 mutual benefits to better quantify impacts. For example, widely accepted LCA models
36 could be used to compute pressure indicators that would account for the whole life
37 cycle of the livestock product. To date, such models mainly concern climate change
38 and land use. In contrast, for other impact categories with less availability of LCIA

Principles for the assessment of livestock impacts on biodiversity

1 models, PSR indicators could be used to complement the results. They would allow
2 one to assess (qualitatively or quantitatively) additional midpoint impact categories
3 and broaden the scope to include other categories of impact e.g. acidification,
4 eutrophication, climate change, ecotoxicity.

- 5 • At endpoint level, LCA describes the impact on biodiversity using a specific indicator,
6 most often based on species richness and plants (see LEAP Biodiversity Review,
7 Teillard et al., in prep.). This focus on species richness is constrained by data
8 availability at a large scale, which is needed to calculate characterisation factors. In
9 addition to the biodiversity impact assessed by LCA, state indicators could also be
10 computed that would allow one to (i) address biodiversity levels, taxa and dimensions
11 that are not covered by existing LCA methods or (ii) validate the LCA estimations by
12 comparison with locally-calculated indicators. Moreover, state indicators could also be
13 used to derive characterization factors for LCIA methods (Section 5.4.3).

14 Response indicators are closely linked to management decisions but their relationship with the
15 state of biodiversity can be indirect. Some LCA models (consequential LCA in particular)
16 make it possible to explore different scenarios or mitigation options and their effect on
17 midpoint and endpoint impacts. Such LCA models could thus be used to estimate the effect of
18 various response indicators and to select the most relevant.

19 Several elaborations of the PSR approach have been developed, such as the EEA (1999)
20 Driver-Pressure-State-Impact-Response (DPSIR). The main difference with PSR is the
21 distinction between pressures (resources use and emissions), state (state of the habitats and
22 ecosystems) and impact (biodiversity loss or ecosystem collapse). The environmental cause-
23 effect chain proposed by the DPSIR approach also allows complementarily with LCA. In
24 particular, there is a good match between DPSIR pressures and LCA interventions. The
25 DPSIR state and impacts are often equivalent to LCA midpoints and endpoints, respectively.

27 3. Background information on biodiversity and livestock

28 Key principles

- 29 • Biodiversity is complex and multivariate by nature. The assessment of biodiversity is
30 complicated by the lack of a common ‘currency’ for biodiversity, and by it being
31 extremely context-dependent. For a contrasting example from greenhouse gas (GHG)
32 assessments, a molecule of CO₂ has the same radiative forcing no matter how or where
33 it is produced, impacts are global even if the severity can vary geographically, and all
34 GHG emissions can be expressed in carbon equivalents. In contrast, due to societal
35 value judgements, there is great variation in the conservation value of different species
36 and habitats which complicates decision making about conservation objectives and
37 priorities. Thus, this will also complicate the assessment of impacts on biodiversity.

- For all geographical areas within the system boundary, assessments of livestock systems should identify and recognize designation frameworks for biodiversity at both habitat level (e.g. protected habitats) and species level (e.g. protected species, IUCN red list, and equivalent frameworks at national and sub-national scales). These and related (e.g. WWF) designation frameworks provide important guidance on the relative conservation value and status of habitats and species.

7

8 **3.1. Biodiversity and its complexity**

9 Biodiversity is a multivariate entity, which complicates its measurement to a considerable
10 degree (for an accessible introduction, see Section 2 of OECD, 2002). There are many units of
11 measurement for biodiversity but common ones include species richness (the number of
12 species), evenness (the relative abundance of different species), community composition (the
13 group of particular species that are present), functional group richness (the number of
14 different groups of species in which each group performs a specific ecosystem function),
15 genetic similarity and community similarity. Unfortunately, one can usually identify cases
16 where the use of any one of these measures alone can lead to counter-intuitive situations that
17 do not necessarily optimise the measurement (and conservation) of biodiversity e.g. see
18 Solow et al. (1993). A flavour of the complexity involved in measuring biodiversity at the
19 species level is touched upon in Table 3. Site 1 and Site 2 have the same richness, but very
20 different evenness. Site 2 and Site 3 have the same richness and evenness, but differ in
21 composition (with two of the four occurring in both sites). Site 4 has the highest species
22 richness and Site 5 the lowest, and they have one species in common. A simple measure of
23 diversity (Simpson's index of diversity) is also shown, in which higher values indicate greater
24 diversity (the probability that two randomly selected individuals belong to the same species).

25 As mentioned above, the composition of the community (the particular species that are
26 present) is another important dimension. This is all the more complicated by several
27 conventions that assign importance weights to species, habitats and ecosystems, resulting in
28 some being considered more important than others.

29

Principles for the assessment of livestock impacts on biodiversity

1 Table 3: Example of the distribution of different species across different sites, illustrating differences in richness,
 2 evenness, species composition and Simpson's diversity (1-D). See main text for further discussion.

	Site 1	Site 2	Site 3	Site 4	Site 5
Species 1	91	25	-	30	-
Species 2	3	25	-	20	-
Species 3	3	25	25	15	
Species 4	3	25	25	15	
Species 5	-	-	25	10	99
Species 6	-	-	25	10	-
Species 7	-	-	-	-	1
Simpson's diversity (1-D)	0.17	0.75	0.75	0.81	0.02
Richness	4	4	4	6	2

3
 4 Implicitly, such conventions place a higher value on ecosystems that reflect the historic state
 5 before human-dominated interventions. Thus, species that reflect the composition of the
 6 historic state are considered to be more important, and other species are considered to be of
 7 less importance e.g. non-native species; endemic species (species that only occur within a
 8 defined geographical region or area) are considered to be of very high importance. (For an
 9 example of the importance of species composition, see Case Study 4 for an example of
 10 'positive' and 'negative' species that indicate favourable and bad conservation status,
 11 respectively.) Simple measurements of species richness alone cannot incorporate such
 12 categories and importance levels (see below). Thus, the relative conservation value of Site 5
 13 in Table 3 can very much depend on the identity of Species 7, and whether it is a common and
 14 widespread species in that region or a rare endemic species with a very restricted distribution.
 15 The latter would make this an 'irreplaceable' site. As one environmental dimension of
 16 environmental sustainability, such issues result in the assessment of biodiversity and its
 17 conservation being exceptionally context-dependent. It is worth noting that this is likely to
 18 become more complex, rather than less complex, as biodiversity conservation and its
 19 assessment in the future is likely to pay more attention to functional traits of biodiversity, the
 20 health of ecosystems, and the degree of provision of ecosystem services, all of which are
 21 related to biodiversity.

22 These and other value judgements pervade priority-setting and objectives for the conservation
 23 of biodiversity. It is beyond the scope of this document to detail the factors that contribute to
 24 priority-setting for conservation, but a thorough assessment of the impacts of livestock on
 25 biodiversity must necessarily address whether these have been adequately taken into account
 26 (for an accessible introduction to some of these issues, see e.g. Section 2 of OECD, 2002; IFC
 27 2012). Any system of biodiversity conservation, no matter how much it claims to be science-
 28 based or objective, ultimately reflects value judgements about what features of biodiversity

1 are important, and how they are weighted in terms of importance, "...decisions about where,
2 what and how to conserve may be based on hard data and scientific principles, but are
3 ultimately a reflection of different values within society or the global conservation
4 community" (Ladle and Whittaker, 2011). The use of multi-stakeholder consultation that
5 includes environmental NGOs is one way to incorporate relevant expertise on these issues,
6 and can be an extremely effective process by which to improve understanding of local
7 priorities and features of biodiversity.

8 Further aspects of biodiversity and its conservation are discussed in the following section,
9 which also introduces some conventional conservation priorities for global biodiversity.

10 **3.2. Global patterns in biodiversity**

11 Biodiversity is not uniformly distributed and there are several global initiatives that can assist
12 an assessment of biodiversity impacts. For example, global patterns (at 10 km x 10 km scale)
13 of terrestrial diversity and conservation are available for selected major taxonomic groups at:
14 www.biodiversitymapping.org and there are several similar resources available. Such maps
15 typically indicate pronounced differences in the global distribution of biodiversity based on
16 species richness for e.g. birds, mammals and amphibians (Figure 4). There is further variation
17 in the distribution of species categorised according to their conservation status (vulnerable,
18 endangered, or critically endangered in the IUCN Red List in Figure 4).

19 More generally, this variation in patterns of diversity has a number of consequences that
20 affect the assessment of biodiversity impacts of livestock systems:

- 21 - Different conservation priorities and goals mean that different actions for biodiversity
22 conservation may be more or less appropriate at a given site.
- 23 - the same magnitude of pressure can have different consequences for biodiversity in
24 different locations. This means that assessments need to be able to incorporate the
25 geographical variation in biodiversity, and the relative conservation of different
26 species and ecosystems (this challenge for assessments is discussed in Parts II and III).
- 27 - Biodiversity conservation cannot be effectively achieved by confining conservation
28 actions to biodiversity hotspots, prioritised areas and protected areas alone. Even a
29 quick comparison of Figure 4 and Figure 6 (diversity patterns and ecoregions)
30 indicates that there can be quite high diversity in many areas that lie outside of the
31 Global Ecoregions and biodiversity hotspots (see Section 3.3). Even in countries and
32 areas with relatively low diversity on a global scale, there can also be local, national or
33 international priorities for biodiversity conservation.
- 34 - The geographical variation in biodiversity can result in trade-offs between local and
35 global biodiversity goals. For example, the control or restriction of arable conversion
36 to protect local farmland diversity in temperate areas may result in disproportionate

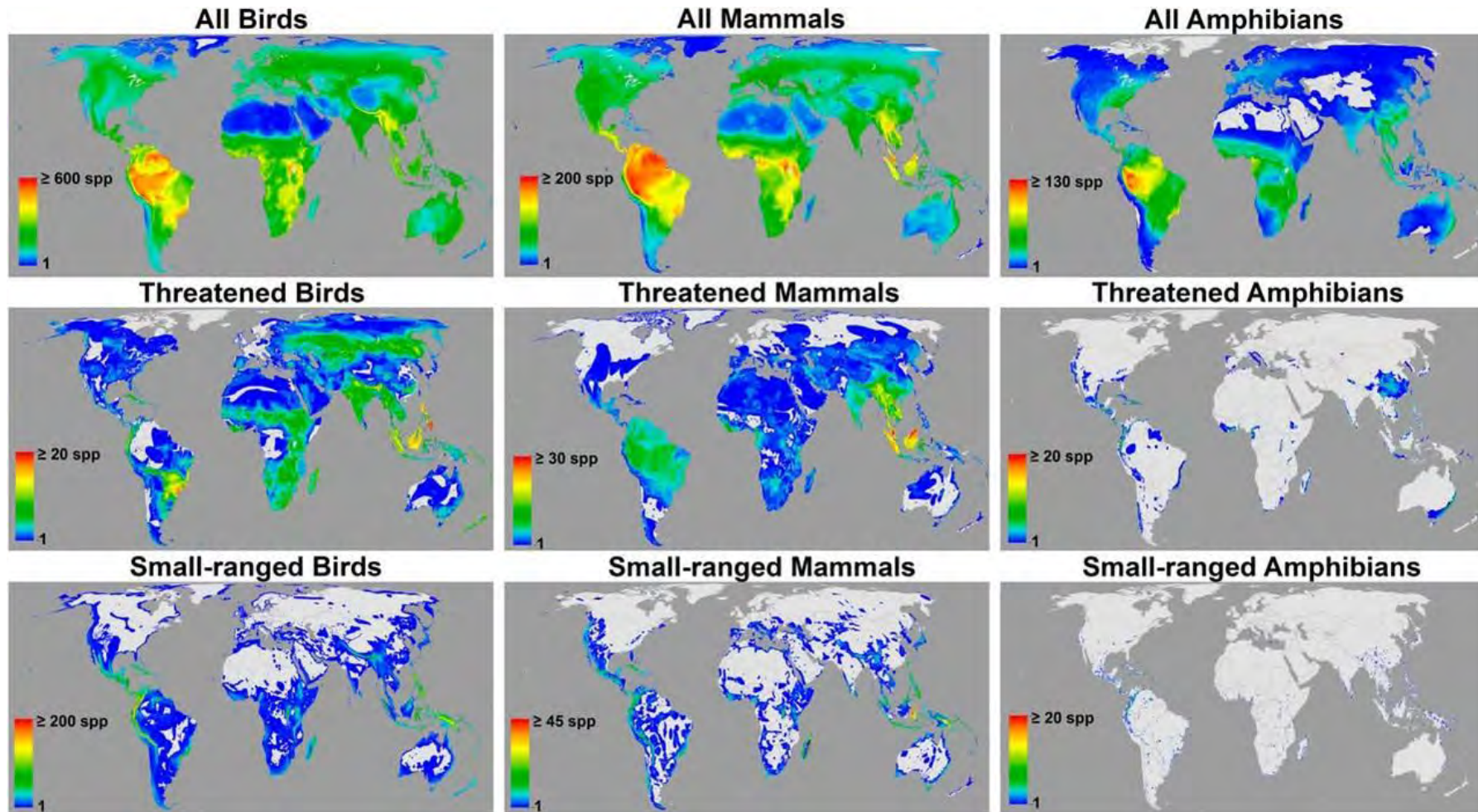
Principles for the assessment of livestock impacts on biodiversity

1 effects on biodiversity if the consequence is to shift arable production for livestock
2 consumption to areas of higher biodiversity e.g. tropical or sub-tropical areas.

3

DRAFT

Principles for the assessment of livestock impacts on biodiversity



1

2 Figure 4: Illustration of the variation in the global distribution of biodiversity using global maps of species richness for different categories of species (birds, mammals and
3 amphibians). The top row shows the richness of all species in the taxon. The middle row shows the richness of threatened species (vulnerable, endangered, or critically
4 endangered in the IUCN Red List). The bottom row shows the richness of species whose geographic ranges are smaller than the median range size for that taxon. Maps used a
5 10×10 km grid and the Eckert IV equal-area projection. Source: Jenkins et al. (2013).

1 **3.3. Global-scale priorities for biodiversity conservation**

2 As mentioned above, priorities for biodiversity conservation tend to the outcome of value
3 judgements. While this can introduce subjectivity and complexity in goal-setting (especially
4 at the regional scale), there has also been considerable progress in achieving international
5 consensus on the prioritisation of global geographical areas for biodiversity conservation.

6 In an initiative led by WWF, the Global Ecoregions is a criteria-based global ranking of the
7 Earth's most biologically outstanding terrestrial, freshwater and marine habitats (Olson et al.
8 2002). The Ecoregions are defined as relatively large units of land or water containing a
9 distinct assemblage of natural communities sharing a large majority of species, dynamics, and
10 environmental conditions (Olson et al. 2002). They are chosen for their species richness,
11 endemism, taxonomic uniqueness, unusual ecological or evolutionary phenomena, and global
12 rarity. Each of the Ecoregions is assigned a conservation status and the three classes used are
13 1) critical or endangered; 2) vulnerable; and 3) relatively stable or intact. Over half of the
14 Global Ecoregions are rated as endangered (
15 Figure 5).

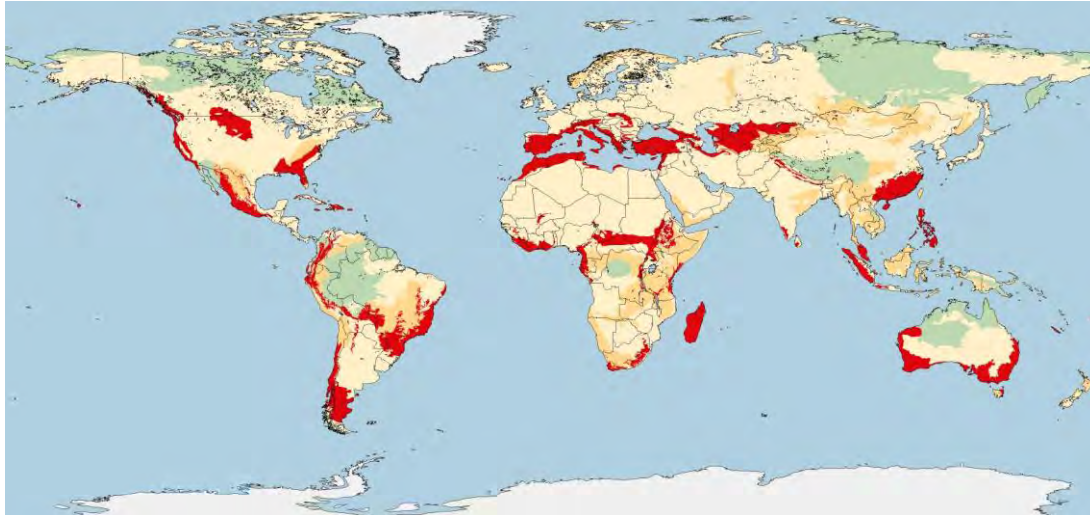
16 Based on the Global Ecoregion maps, Conservation International further derived biodiversity
17 hotspot regions. They defined biodiversity hotspots as an area at least having about 1,500
18 endemic vascular plants as endemics — implying a high percentage of plant life found
19 nowhere else on the planet. As a second criterion, a hotspot is required to have 30% or less of
20 its original natural vegetation, showing high threat levels (Conservation International 2011).
21 Thus, biodiversity hotspots represent areas of exceptionally high biodiversity that are also
22 highly threatened.

23 Around the world, 35 areas qualify as biodiversity hotspots (Figure 6). They represent 2.3%
24 of Earth's land surface, but they support more than half of the world's endemic plant
25 species— i.e., species found no place else — and nearly 43% of endemic bird, mammal,
26 reptile and amphibian species (Conservation International 2011).

27 Standard tools exist to identify species that are endangered and to identify their distribution
28 area, the most popular being the IUCN Red List of Species. The IUCN Red List of
29 Threatened Species is widely recognized as the most comprehensive, objective global
30 approach for evaluating the conservation status of plant and animal species
31 (www.iucnredlist.org). The IUCN has also initiated a complementary and standardised
32 approach to identify the conservation status of global ecosystems
33 (www.iucnredlistofecosystems.org). The IUCN Red List of Ecosystems will assign categories
34 of risk to ecosystems and is intended to help inform conservation, land use and investment
35 priorities.

36

Principles for the assessment of livestock impacts on biodiversity

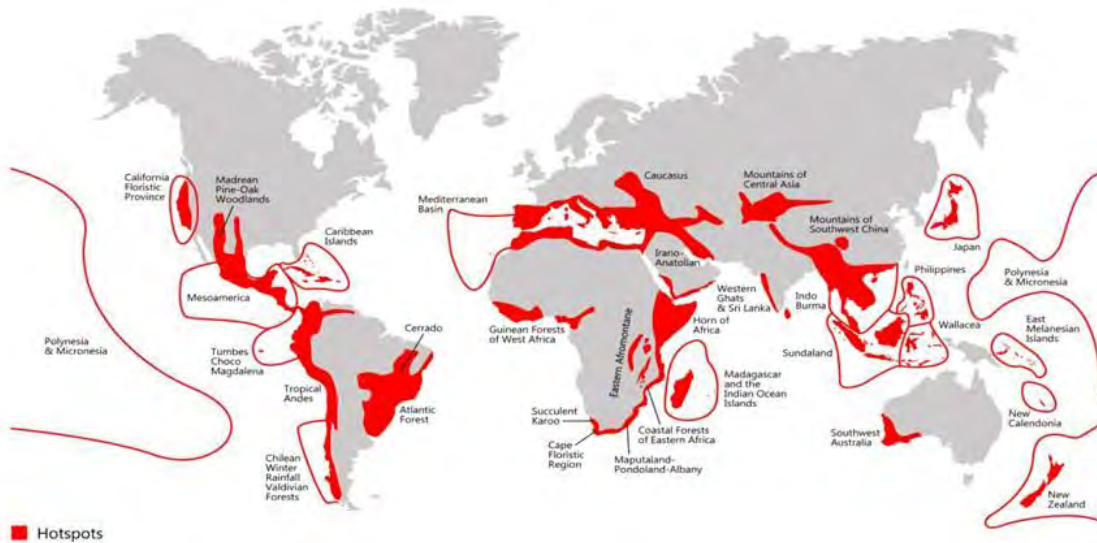


1



2

3 Figure 5: Global distribution and status of terrestrial Ecoregions (Source: Olson et al. 2002, WWF²)



4

5 Figure 6: Global distribution of biodiversity hotspots (Source: Conservation International 2011).

6

7 Another source of global biodiversity data is the WWF Living Planet Index, a measure of the
8 state of the world's biological diversity based on population trends of vertebrate species. The
9 LPI has been adopted by the Convention on Biological Biodiversity (CBD) as an indicator of

² <http://www.worldwildlife.org/publications/global-200>

1 progress towards its 2011-2020 target to 'take effective and urgent action to halt the loss of
2 biodiversity'. Data on 14,971 populations from 3,204 species from around the world can be
3 accessed from the Living Planet Index data portal³.

4

5 **3.4. Global patterns of livestock distribution**

6 The world's human population is predicted to increase from 7.2 billion in 2013 to 9.6 billion
7 by 2050 (UN 2012). During that time, the demand for livestock products is expected to
8 increase even more rapidly, driven by economic growth and urbanisation. The livestock sector
9 that will emerge will heavily impact on the global environment, including biodiversity.

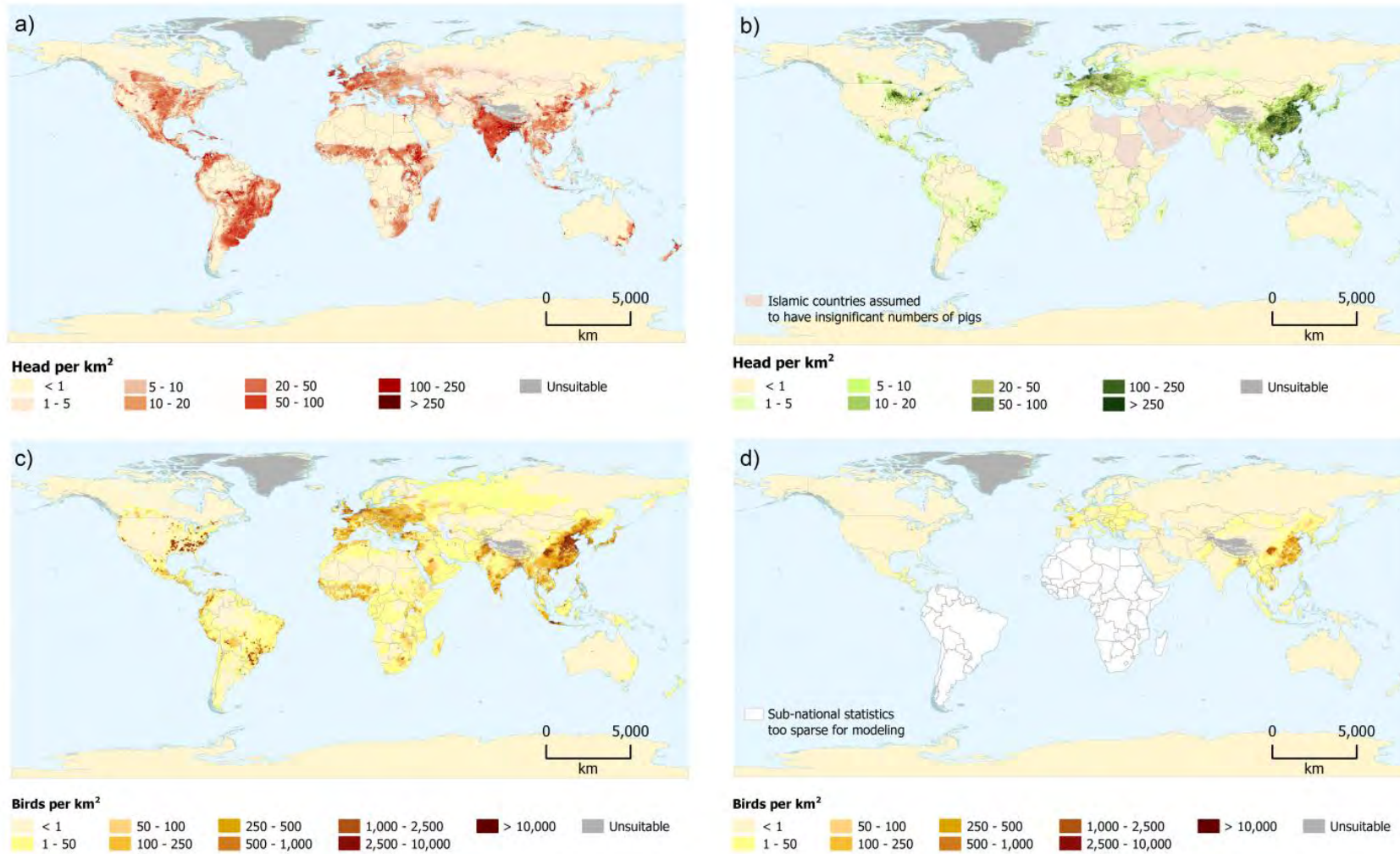
10 Livestock distribution varies globally and for the different species. The highest cattle densities
11 are found in India, East African highlands (particularly in Ethiopia), Northern Europe and
12 South America (Robinson *et al.* 2014; Figure 7a). The highest concentrations of pigs are
13 found in China, Eastern Pacific countries, with lower densities in Europe and even lesser in
14 Africa (Figure 7b). The distribution of chickens closely follows that of the humans with the
15 highest concentrations found in eastern China, Pakistan, India, and in Western Europe
16 (Robinson *et al.* 2014; Figure 7c). Ducks are far less common than chickens worldwide with
17 high densities found in South-East Asia and China where duck production is often integrated
18 with rice cropping and fish farming (Robinson *et al.* 2014; Figure 7d). Coincidentally, the areas
19 of high livestock densities coincide with ecoregions that are critically endangered or
20 vulnerable.

21

³ <http://www.livingplanetindex.org/home/index>

Principles for the assessment of livestock impacts on biodiversity

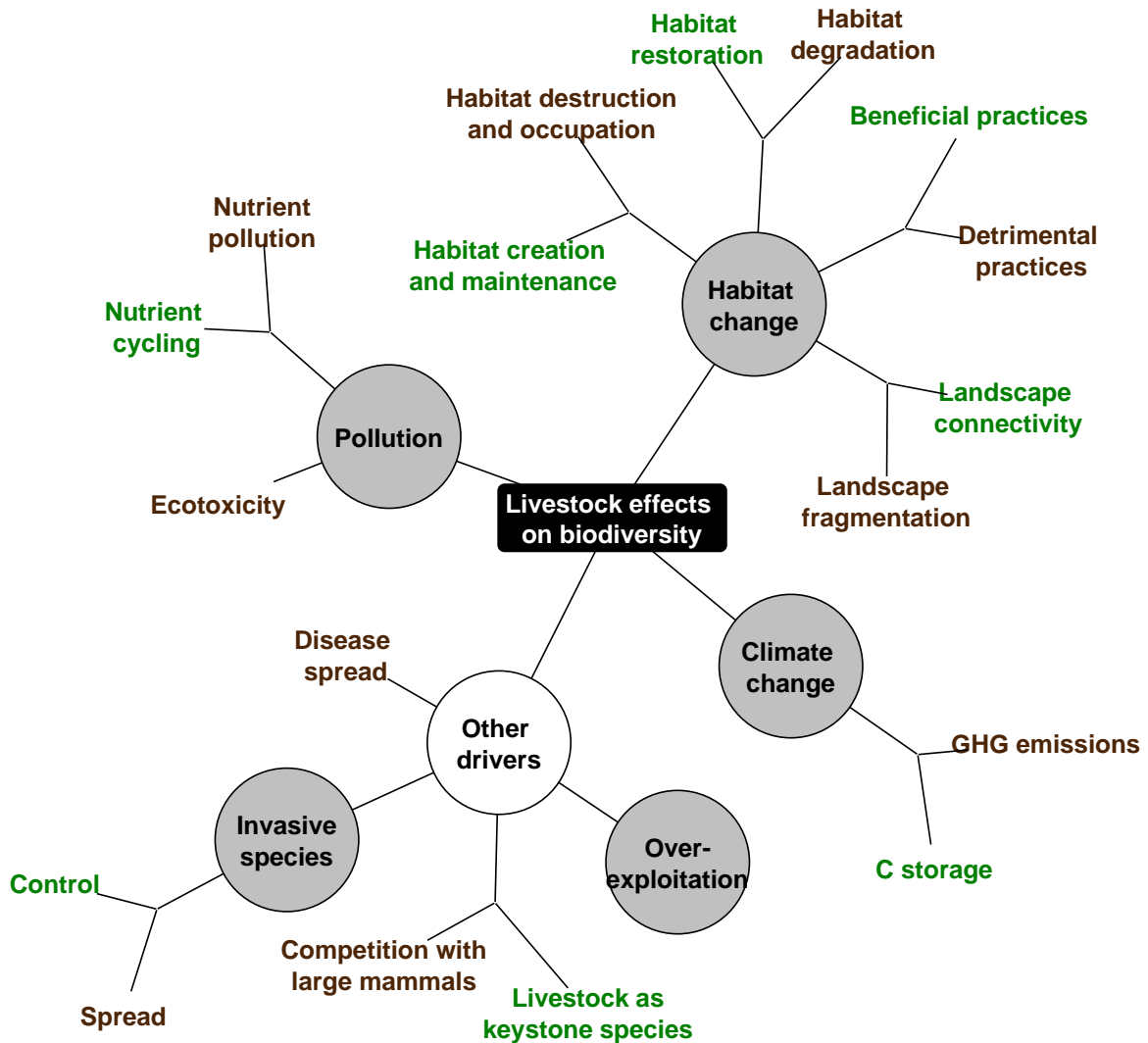
1



2

3 Figure 7: Global distributions of (a) cattle; (b) pigs; (c) chickens; and (d) distribution of ducks, excluding South America and Africa (Source: Robinson et al.
4 2014).

1 **3.5. Summary of the influences of livestock on biodiversity**



2

3 Figure 8: Pressure indicators: overview of the categories of influences that livestock have on biodiversity. The
 4 five main drivers of biodiversity loss recognized by the MEA & Assessment (2005) appear in grey circles.
 5 However, for most of these drivers, livestock can either exert negative pressure (red) or provide benefits (green)
 6 to biodiversity. For the detailed description of all categories, refer to the LEAP Biodiversity Review (Teillard et
 7 al., in prep.)

8

9 **Key principle**

10 The effects of livestock production can have both negative and positive impacts. To increase
 11 the relevance of assessment methodologies to the livestock sector, methods need to be capable
 12 of reflecting the range of beneficial as well as detrimental impacts due to livestock systems

13

Principles for the assessment of livestock impacts on biodiversity

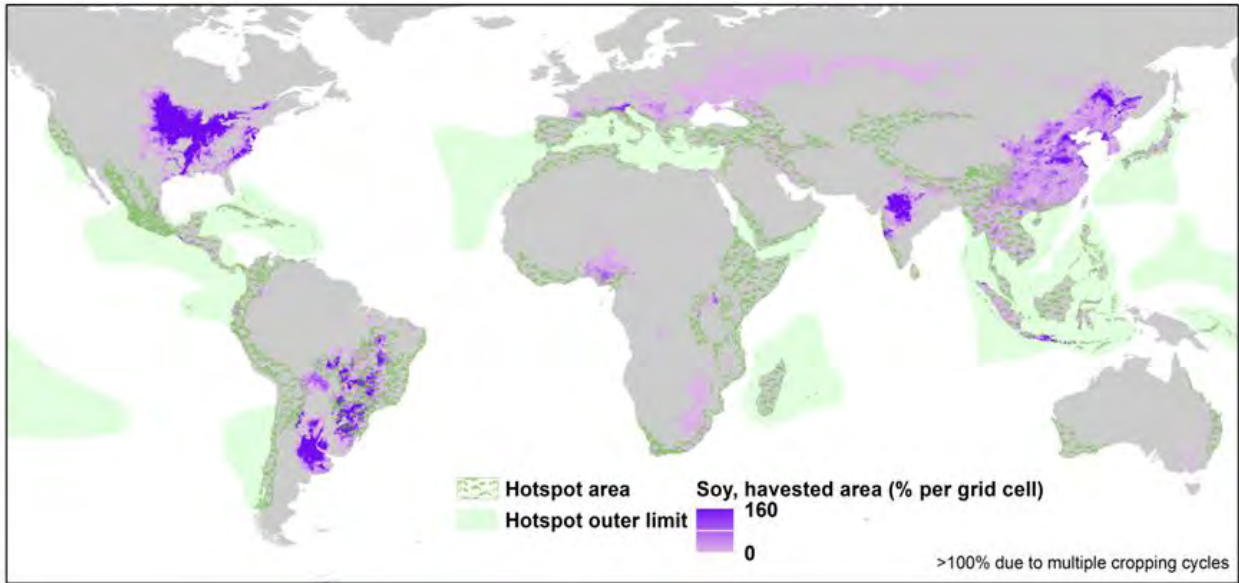
1 The Millennium Ecosystem Assessment (2005) recognizes five main direct drivers of
2 biodiversity loss: habitat change, climate change, pollution, overexploitation and invasive
3 species. Steinfeld et al. (2006) showed how livestock contributed directly or indirectly to each
4 of these drivers. Figure 8 identifies the specific categories of pressure that are relevant to
5 livestock systems. It also emphasizes that the link between livestock and biodiversity is not
6 restricted to pressures, and specific categories of benefits are also identified. Most often,
7 pressure and benefits are two sides of the same coin. For instance, livestock systems destroy
8 biodiversity habitats when forest is converted to pasture or feed crops, but grazing is the only
9 way to maintain semi-natural grasslands that have existed for hundreds of years and host a
10 rich and unique biodiversity. For more information about the different categories of pressures
11 and benefits, refer to the LEAP Biodiversity Review (Teillard et al., in prep.).

12 Grazed ecosystems naturally accommodate livestock better or even need livestock grazing for
13 the maintenance of key ecosystem functions, whereas ecosystems susceptible to cropland
14 conversion for livestock feed host the greatest negative impacts on biodiversity. Lands of
15 marginal plant productivity such as drylands, mountains or cold areas usually rely on grazing
16 animals for many of the key ecosystem functions such as seed dispersal, nutrient cycling or
17 preclusion of plant competition (FAO 2013). There, grazing abandonment can cause very
18 negative consequences on biodiversity (see Case Studies 4 and 6). Conversely, biodiversity
19 conservation can be threatened when socio-economic as well as ecological factors put
20 biodiversity hotspots under high pressure, especially when land use change is triggered and
21 forest or biodiversity-rich pastures are converted into croplands.

22 The impacts of livestock systems on biodiversity can be far-reaching, and not immediately
23 obvious. Under the ‘habitat destruction and occupation’ category of pressure, a striking
24 example is the global demand for soybean. Soy is a globally traded commodity produced in
25 both temperate and tropical regions, and serves as a key source of protein and vegetable oils
26 (Dros 2004). Since the 1950s, global soybean production has increased 15-fold, with the
27 United States, Brazil, and Argentina together producing about 80% of the world’s soy
28 (Shurtleff and Akiko 2004). Global soy production in 2012 was 270 million tonnes from an
29 area of 100 million ha, which is projected to increase to 514 tonnes from 141 million ha by
30 2050 (from WWF, 2014). Brazil, the United States and Argentina are the leading producers of
31 soy (WWF, 2014). China is the leading importer of soy (about 60 million tonnes in 2012), and
32 a significant increase in these imports is projected.

33 As increasing land area is allocated to soy production, important natural ecosystems face
34 increased pressure. An overlay of biodiversity hotspots and main areas of soybean production
35 indicates high coincidence of biodiversity hotspots and soybean production areas, with the
36 main threat areas being Brazil, Argentina, India and China (Figure 9).

Principles for the assessment of livestock impacts on biodiversity



1

2 Figure 9: Global biodiversity hotspots and main soy production areas (Source: Monfreda et al. 2008;
3 Conservation International 2011; “Biodiversity Hotspots”). This map also includes areas where soy is harvested
4 for purposes other than feed. While most soybean production in North and Latin America is used as feed, the soy
5 production hotspots in India and East Asia is mainly used for direct human consumption.

6

DRAFT

PART II – The LCA approach

4. Principles applying to biodiversity assessment in LCA

This section focuses on Life Cycle Assessment of impacts on biodiversity through land use. Livestock systems are a major user of land resources; however, we clearly recognise that the impacts of livestock on biodiversity are not restricted to land use. We also recognise that the relative importance of impact categories will vary among regions and systems. Nevertheless, we focus on land use as this is likely to be an important category of impact, and currently enjoys a quite advanced level of methodological development and increasing consensus. PSR indicators are presented in Part III of this report with a wider scope in terms of impact category; therefore, they could be used to complement an LCA study. In this Part, we introduce LCA and the main steps required to undertake a LCA, we present the conceptual framework that underpins how LCA treats the impacts of land use and land use change on biodiversity and we provide a brief overview of a number of different quantitative biodiversity indicators have been used in LCA. Some limitations of the limitations to current LCA methodologies, especially in relation to livestock systems, are discussed in Section 6.

Key principles

- The comprehensive scope of LCA is important and useful in order to avoid problem-shifting, for example, from one phase of the life-cycle to another, from one region to another, or from one environmental problem to another.
- For the impact category of land use, there is broad consensus on the impact assessment framework, and several methods are already available to quantify biodiversity impacts through land use and are especially useful for assessment of the biodiversity impacts of globally traded products. Currently, impacts on biodiversity in LCA are mainly modelled as a result of land use and land use change interventions. Other impact categories can also be incorporated although further methodological development is needed.
- Existing LCA methods describe land use through relatively coarse categories, which makes LCA more adapted to assessments at large spatial scales. For small-scale assessments aimed at discriminating the relative impact of different practices on biodiversity, indicators are likely to need further adaptation and development.
- There will be continued development of methods for the identification and calculation of reference state and consequent characterisation factors, and users should keep up-to-date with such developments.

4.1. Overview of the main steps of an LCA

Key principle

The objectives of a biodiversity assessment and the objectives of any related initiatives should be clearly stated, and appropriate indicators and methodologies chosen to reflect these objectives.

The procedures to conduct a LCA are governed by the ISO 14000 environmental management standards (ISO, 2006a,b). The procedure consists of four main steps: (1) definition of goal and scope of the study; (2) life cycle inventory (LCI) of the system's inputs and outputs; (3) life cycle impact assessment (LCIA), and (4) interpretation of the results (Figure 10). Here, we discuss the general nature of each of these four steps in turn, and make some specific references to the application of these steps to livestock systems.

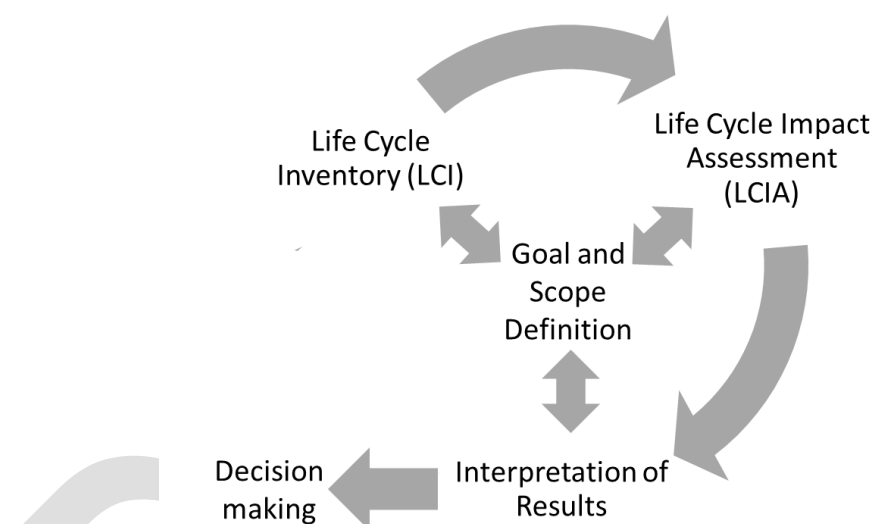


Figure 10: Schematic representation of the four steps of LCA: (1) definition of goal and scope; (2) life cycle inventory; (3) life cycle impact assessment; and (4) interpretation of results.

Goal and scope definition – In the first step, the aims and extent of the life cycle study are defined, including the reasons for carrying out the study, the intended application, and the intended audience (ISO, 2006a). It is also the stage at which the *system boundaries* of the study are described and the *functional unit* is defined. The functional unit is a quantitative measure of the functions that the goods (process or service) provide. For recommended functional units at farm gate and the primary processor gate, refer to the sectoral LEAP guidelines (on Feed, Poultry, Small Ruminants, Pigs or Large Ruminants). A clear definition of the goal and scope allows the baseline levels of system flows (inputs and outputs) to be determined, and facilitates comparisons among different options.

Principles for the assessment of livestock impacts on biodiversity

1 **Life cycle inventory** – The Life Cycle Inventory consists of an analysis (inventory) of input
2 flows (raw-materials, water and energy) and output flows (releases to land, air and water e.g.
3 wastes and emissions), associated with the defined functional unit. At this stage, *allocation*
4 *procedures* are defined and data sources and quality are identified. Data on the various input
5 and output flows is collected according to the system boundaries defined by the scope of the
6 study. For the impact of livestock production on biodiversity through land use, processes such
7 as feed production (including off-farm) should be included in the system boundaries, due to
8 its potentially substantial contribution to overall impacts. The definition of the study system's
9 boundaries will also depend on whether the scope of the study is attributional or
10 consequential.

11 **Life cycle impact assessment** – In the third step, LCIA, aims to evaluate the significance of
12 potential environmental impacts. Life cycle impact assessment typically consists of the
13 following elements:

- 14 • selection of impact categories, category indicators, and characterisation models;
- 15 • classification, where the inventory results are sorted and assigned to specific impact
16 categories; and
- 17 • characterisation, where potential impacts associated with a specific impact category
18 are calculated by using characterisation models and based on the category indicator,
19 i.e. the quantified representation of an impact associated with a specific impact
20 category (ISO 2006b).

21 Optional elements in LCIA consist of normalisation, grouping and weighting.

22 Thus, in the characterisation step, flows identified in the inventory (e.g. greenhouse gas
23 emissions, extent of occupied land) are associated with potential environmental impacts (e.g.
24 global warming, habitat loss) caused during the life cycle. Characterisation models are used to
25 derive the so-called *characterisation factors* (CFs), which are the values used to convert
26 emissions and resources from inventory to *common impact units* to make them comparable
27 (Curran, 1996). Impacts can be characterized anywhere along the environmental cause-effect
28 chain, either at the midpoint or endpoint level (Figure 2). The midpoint impact category can
29 be defined as a problem-oriented approach, translating impacts into environmental themes
30 such as global warming, land use, acidification or human toxicity. Endpoint impact categories
31 provide a damage-oriented approach (ISO, 2006b), which should be of direct relevance and
32 understanding to decision makers (Bare *et al.* 2000). Traditional characterisation methods are
33 examples of midpoint modelling; more recently, there is an increasing acceptance that results
34 from inventory results should be translated into their potential damage on endpoints (such as
35 biodiversity loss) and areas of protection (human health, natural environment and natural
36 resources) (EC-JRC, 2010).

37 **Interpretation** – Results are then finally interpreted and evaluated, based on the assumptions
38 made during the definition of goal and scope and LCIA model used. Specific attention is

Principles for the assessment of livestock impacts on biodiversity

1 given to the need and opportunities to reduce the impact of the product/ service on the
2 environment. According to ISO standards, the interpretation should include:

- 3 • identification of significant issues based on the results of the LCI and LCIA steps;
- 4 • completeness, sensitivity and consistency checks; and
- 5 • conclusions, limitations and recommendations.

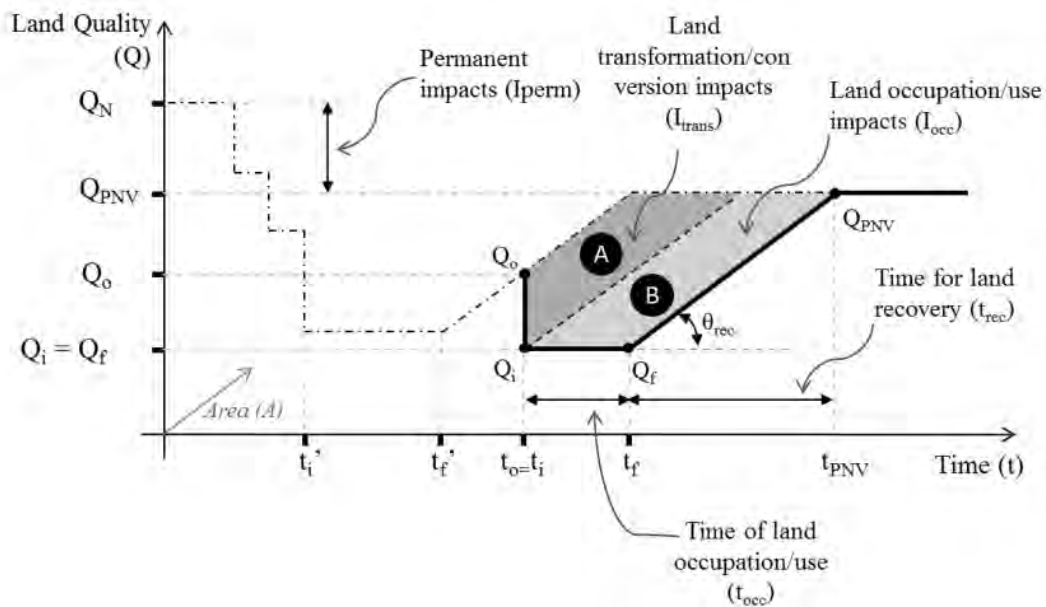
6

7 **4.2. Conceptual framework: land use change in LCA**

8 The current land use model recognizes two main interventions causing a change in the state of
9 ecosystem quality: land use and land use change (Milà i Canals *et al.*, 2007). The
10 environmental impact pathway linking these two interventions to biodiversity has been
11 detailed by Milà i Canals *et al.* (2014). Active restoration can also be considered as a third
12 intervention, when replacing the natural recovery of land. Figure 11 displays the current
13 conceptual framework for land use impacts on biodiversity. Land use change (LUC), or land
14 transformation, is assumed to be a sudden (instant in time) process during which human
15 activities convert the current land use/cover to make it suitable for a new use. In this process,
16 land quality may drop (land degradation) or increase (land restoration), from Q_0 (in the case
17 where the previous land cover was a natural area) to Q_i . Examples of land transformation
18 include deforestation to establish a pasture, or conversion of natural grassland to cropland.
19 Land use (LU), or land occupation lasts for a time t_0 to t_f , during which the new land use takes
20 place. During this time, land quality gradually evolves from Q_i , at the beginning of the
21 occupation, to Q_p when current land use ceases. These processes can lead to a loss (or a gain)
22 of biological diversity but also important changes in community or ecosystem composition. If
23 the area is no longer used and land is set aside, land recovery (natural ecological succession)
24 or active restoration (led by human intervention), processes may take place. The duration of
25 this process, before reaching a new steady land quality Q_{PNV} (if the land remains undisturbed),
26 can vary.

27

Principles for the assessment of livestock impacts on biodiversity



1
 2 Figure 11: Scheme of the conceptual framework for impact assessment in LCA, depicting two land interventions
 3 (occupation and transformation) and land recovery. Adapted from Souza *et al.* (2015). Q_N : land quality of natural
 4 state of land; Q_{PNV} : land quality reached during Potential Natural Vegetation; Q_o : land quality state just before
 5 land transformation; $Q_i=Q_f$: quality state during land occupation; $t_o=t_i$: time in which land occupation starts; t_f :
 6 time in which land occupation ends; t_{occ} : time of land occupation; t_{rec} : time of land recovery; t_{PNV} : time after
 7 which land reaches the PNV state.

8

9 **Key principle**

10 The choice of reference state (the level of biodiversity that is used as a baseline for
 11 comparisons) has a strong influence on the interpretation of results; thus, it is important to
 12 clearly describe the situation that is being used as a reference level, and to interpret the results
 13 accordingly.

14

15 At this point it is important to mention the importance of the choice of the reference state for
 16 the calculation of impacts from LULUC. The concept of Potential Natural Vegetation (PNV)
 17 is usually applied in current developed methods and corresponds to the vegetation that would
 18 develop if human activities would cease at once, not taking into consideration changes in
 19 climatic conditions. However, PNV may not be the most appropriate reference in the context
 20 of livestock production. Certain semi-natural grasslands that are extensively managed for
 21 livestock production may host higher biodiversity levels and be a more suitable reference than
 22 the PNV. Other alternative reference states exist, such as the use of the current land cover or
 23 the global land cover types in a reference year. The choice of the baseline is not obvious,
 24 involves value choices and should be carefully considered, explained and discussed as it may
 25 have substantial influence on the final results and their interpretation. We discuss this further
 26 in Section 6.4.4.

Principles for the assessment of livestock impacts on biodiversity

1 In general, current land use models mainly compute the impacts of occupation, since little or
 2 no information exists on the dynamics and time of natural recovery of land quality. Impacts of
 3 occupation (I_{occ}) are calculated as the product of the land area occupied (A_{occ}), the time of
 4 land occupation (t_{occ}) and the difference in land quality between the potential quality state
 5 (e.g. Potential Natural Vegetation, Q_{PNV}) and the quality state during land occupation (Q_f).

$$6 \quad I_{occ} = A_{occ} * t_{occ} * (Q_{PNV} - Q_f) \quad (3.1)$$

7 One problem with this approach is that land quality is supposed to remain constant during
 8 occupation, and impacts are calculated as an integration of the overall impacts due to the drop
 9 in quality during transformation. Impacts resulting from management practices are not
 10 explicitly taken into account. Soil biodiversity, for example, is particularly sensitive to
 11 chemical use and changes in soil quality (chemistry and structure), which not only occur
 12 during land conversion, but can also occur during land occupation. However, the current
 13 framework is unable to take these impacts into account, as land quality is assumed to remain
 14 constant as a general effect of land management practices.

15 The calculation of land transformation impacts (I_{trans}) take into account the time of land
 16 recovery (t_{rec}).

$$17 \quad I_{trans} = A_{occ} * t_{rec} * \frac{1}{2} (Q_{PNV} - Q_f) \quad (3.2)$$

18 Resulting occupation or transformation impacts can be classified as reversible or irreversible.
 19 For biodiversity, for example, Souza (2010) calculated as irreversible the loss of
 20 local/regional endemic species, classified as “extinct in the wild” and “extinct”, according to
 21 the IUCN red lists. Irreversible or permanent impacts (I_{perm}) are calculated as:

$$22 \quad I_{perm} = A_{occ} * t_{occ} * (Q_N - Q_{PNV}) \quad (3.3)$$

23 where Q_N represents the land quality of natural state. The results of land use impact
 24 assessment modelling will depend on the scale of reach and spatial resolution unit chosen for
 25 the calculation of characterisation factors.

26

27 **4.3. Current development of biodiversity indicators and modelling in LCA**

28 In the LCA approach, biodiversity indicators have been used in some impact categories in
 29 order to express potential damage to ecosystem quality. Research on biodiversity indicators
 30 for the assessment of land use impacts in LCA has been on-going for more than 15 years, with
 31 some reviews on the topic (e.g. Souza *et al.* 2015). Modelling efforts have yielded significant
 32 progress in this period; however, no consensus has yet been reached on the use of a specific
 33 method for biodiversity. This lack of consensus could limit the inclusion of biodiversity as an
 34 important impact pathway in LCA, and hamper its relevance and applicability as a decision-
 35 making tool.

1 The complex dynamics of natural ecosystems and their spatio-temporal variability makes it
2 difficult to simplify potential damage with practical biodiversity indicators; this is a distinct
3 challenge to be overcome in LCA. This is mainly true for several reasons. First of all,
4 biodiversity is a complex entity with multiple aspects that cannot be fully understood by one
5 single indicator. Second, some assumptions of the land use model represent a linearisation of
6 dynamic processes in nature and lead to an oversimplification of the model (Souza *et al.*
7 2015). Finally, LCA studies require globally-available characterisation factors and this makes
8 accurate modelling very data-hungry.

9 **4.3.1. Towards a consensus on LCA for biodiversity**

10 The UNEP-SETAC Life Cycle Initiative has launched a new flagship project to run a global
11 process aiming at global guidance and consensus building on a limited number of
12 environmental indicators, including indicators for impacts from land use on biodiversity (Milà
13 i Canals *et al.* 2014). A multi-year process engaging international experts and global
14 stakeholders has been initiated to carry out this program, with the intent to develop guidance
15 on Environmental Life Cycle Impact Assessment Indicators based on a consistently applied
16 set of selection criteria and rigorous analysis of different methods to assess biodiversity
17 damage produced by land use.

18

19 **4.4. Applying biodiversity LCA to livestock production**

20 Performing an LCI analysis of the land use elementary flows associated with a livestock
21 supply chain, applying an LCIA framework (as the one presented in Section 4.2) and using
22 existing biodiversity characterization factors (see Section 4.3 and the LEAP Biodiversity
23 Review, Teillard *et al.*, in prep) are reasonably straightforward steps to conduct a biodiversity
24 LCA in the context of livestock production. Case Study 9 describes a published study to detail
25 how these LCA steps can be applied to livestock (Figure 12). Existing LCA methods also
26 have some limitations for their application to livestock; these limitations are discussed in
27 Section 6.

28

29

30

31

32

33

34

1

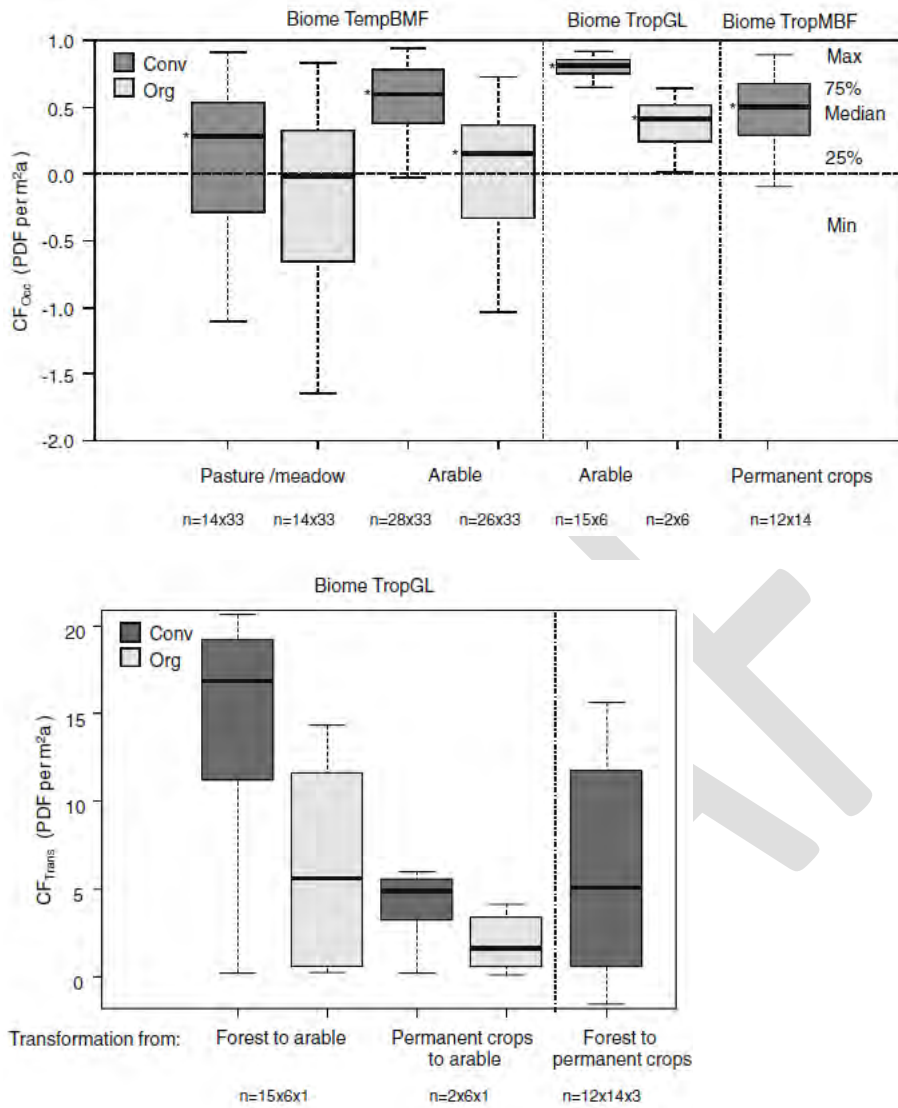


Figure 12: Box and whisker plot of characterization factors of a) occupation (CF_{Occ}) for each land use type, farming practice and biome. b) transformation (CF_{Trans}) for each farming practice, biome and land use type regenerating to after human abandonment. TempBMF temperate broadleaf and mixed forests; TropGL sub-/tropical grass-/shrublands and savannahs; TropMBF sub-/tropical moist broadleaf forests (source Mueller et al 2014).

2

3

4

PART III – The PSR indicator approach

5. Principles applying to biodiversity assessment within the Pressure-State-Response indicator approach

Part II of this report introduced the potential role of Life Cycle Assessment as a tool for use in the assessment of biodiversity within livestock systems. To date, however, there has been substantial focus on the use of indicators for this same goal. Given the likely continued prominence of indicator-based approaches within the livestock sector, Part III of this report addresses the use of indicators to assess biodiversity within livestock systems. We begin by providing broad guidance on the use of indicators, and then focus in turn on three widely-use categories of indicators: Pressure indicators, State indicators and Response indicators (PSR indicators). Note that the LCA-based and indicator-based approaches are not mutually exclusive, and we addressed this further in Section 2.3. In particular, we propose that PSR indicators should adopt a life-cycle perspective. The PSR indicators could also be used to complement the results of an LCA study; for instance, by addressing additional pressure categories.

Key principles

- Pressure, state and response (PSR) indicators are complementary and the PSR approach provides a way to articulate them to facilitate interpretation and decision making. Combining several categories of indicators is strongly encouraged.
- The system boundaries should be defined to include off-farm feed cultivation when nominating and calculating pressure indicators. As a minimum, the off-farm land use pressure should be quantified (Case Study 1 provides a simple example to estimate it with national yield data) and other categories should also be addressed if possible.

5.1. Common issues for biodiversity assessment using PSR approach

The issues included in this section provide the foundation for a biodiversity assessment process based on the PSR approach. These broad issues should be referred to when doing an assessment of biodiversity impacts and provide overarching guidance that is relevant to indicator-based approaches in general. Reflecting the complementarity in perspective discussed in Section 2.3.2, note especially that the following principles introduce a life-cycle perspective to the selection of PSR indicators. This is an important point, and is especially reflected in the use of scoping and hotspot analysis (the third principle), and in setting the boundaries to include off-farm impacts (the fourth principle).

1 We identify ten major issues and these are each discussed in further detail, as follows:

- 2 1. Goal definition
- 3 2. Scoping and hotspot analyses
- 4 3. Setting the boundaries
- 5 4. Identifying the scope of P, S and / or R
- 6 5. Engagement with stakeholders and experts
- 7 6. Identifying and prioritizing indicators
- 8 7. Identifying relevant information
- 9 8. Analysing data
- 10 9. Understanding and managing the impacts
- 11 10. Developing effective communications.

12

13 *1. Goal definition*

14 **Key principle**

15 The objectives of a biodiversity assessment and the objectives of any related initiatives should
16 be clearly stated, and appropriate indicators and methodologies chosen to reflect these
17 objectives.

18

19 The first step should be to set the goal of the assessment and to describe the intended use of
20 the results. Given the context-dependency and role of value judgements associated with
21 biodiversity and its conservation, definition of the goals of an assessment is an especially
22 important issue (see below). The engagement with multiple stakeholders at this stage can be
23 extremely useful to help define goals that are relevant to the specific livestock system, the
24 prominent biodiversity issues and the spatial scales under consideration (see also point 5,
25 below). All steps of the assessment should articulate with the defined goal, i.e. the goal,
26 scope, data, methods, results and conclusions should be aligned. Several aspects should be
27 addressed and documented during the goal definition phase (e.g. European Commission,
28 2010):

- 29 • Subject of the analysis;
- 30 • Key properties of the assessed system: organisation, location(s), dimensions, products,
31 sector, and position in the value chain;
- 32 • Purpose of performing the study and decision-context;

Principles for the assessment of livestock impacts on biodiversity

- 1 • Intended use of the results: will they be used internally for decision-making or shared
- 2 externally with third parties?;
- 3 • Target audience for the results;
- 4 • Commissioner of the study and other relevant stakeholders.

5 These steps are highlighted in the case studies presented in this document.

6

7 In addition to clarifying and assessing the stated biodiversity goals of a sustainability
8 initiative, or of a livestock systems, the goals of the assessment should include consideration
9 of over-arching priority issues such as: the extent to which Critically Endangered species are
10 affected; the extent to which key ecosystems are affected (e.g. Global Ecoregions,
11 biodiversity hotspots, IUCN Red List of Ecosystems); the extent to which ecosystem services
12 are maintained in areas of high conservation value, and; the extent to which other priority
13 goals in the study boundary are affected, etc. This list is not exhaustive. See Case Study 2 for
14 the goals of the Reef Water Quality Protection Plan for grazing management to reduce off-site
15 biodiversity impacts on the Great Barrier Reef in north-eastern Australia.

16

17 *2. Scoping and hotspot analyses*

18 **Key principle**

19 An initial step should be to perform scoping and hotspot analyses. A scoping analysis aims to
20 identify the important biodiversity issues in the user's context, with specific inclusion of off-
21 farm inputs and off-farm impacts on biodiversity. A hotspot analysis aims to provide a
22 qualitative evaluation of the relative contribution of the livestock system to different
23 biodiversity issues, and to identify the most prominent positive and negative impacts.

24

25 An initial step should be to perform scoping and hotspot analyses. A scoping analysis aims to
26 identify the important biodiversity issues in the user's context. This context should be
27 addressed at the local, regional, national and up to the global scale, where relevant to the
28 activities of the user. The scoping analysis will, for example, clarify what features of
29 biodiversity are of concern (see Section 3) and whether ecosystem services are to be included.
30 Important biodiversity issues will be identified, for example, through the review of
31 information coming from the scientific literature, reports from environmental NGOs – local or
32 international (e.g., WWF, IUCN), laws, international frameworks, and consultation with
33 stakeholders (see Section 3.2). At the local scale, important biodiversity issues could include
34 the presence of endemic, protected or threatened species, and of protected habitat or habitat
35 with high conservation value. It could also include local legislation regulating certain
36 practices such as habitat conversion or the use of pesticides/fertilizers. Similar regulations for

Principles for the assessment of livestock impacts on biodiversity

1 species and habitat protection also exist at regional to national scale. Many countries have
2 agri-environmental programs offering subsidies for the voluntary adoption of certain
3 environmentally sound practices. These practices can also reveal important local biodiversity
4 issues and objectives. At the global scale, the Convention on Biological Diversity (CBD) is a
5 multilateral treaty with the goal of biodiversity conservation and sustainable use of its
6 components. It includes the Aichi targets to reach this objective. These internationally agreed
7 targets can be relevant to the user and included in the scoping analysis. See Case Studies 2, 4
8 and 8 for examples in which locally important aspects of biodiversity were assessed and
9 prioritised. The case studies are all located within sites of high conservation value and pay
10 particular attention to land use on or nearby: the Great Barrier Reef; traditional livestock
11 systems on the Aran Islands, Ireland, and; large herbivores in the Serengeti National Park.

12 A hotspot analysis aims to provide a qualitative evaluation of the relative contribution of the
13 livestock system to different biodiversity issues, and to identify the most prominent ones.
14 Both local and delocalized contributions should be considered. Delocalized contribution
15 occurs when local pressures have an impact on biodiversity outside of the user's system, such
16 as water pollution (Case Study 2) or GHG emissions. They also occur when the product's
17 supply chain is not contained within a single area. The hotspot analysis should include this
18 life-cycle perspective and qualitatively evaluate the relative contribution of the different steps
19 of the supply chain. These concepts are illustrated in Case Studies 1, 5 and 9 that used the
20 LCA approach. These included an analysis of the off-farm impacts of livestock through land
21 use impacts in: a global-scale analysis of off-farm livestock feed production; and two studies
22 of the land use impacts on biodiversity of different dairy systems.

23

24

25 *3. Setting the boundaries*

26 **Key principle**

27 As a priority issue, processes such as feed production, especially off-farm feed production,
28 should be included in the system boundaries of livestock systems. This is due to its substantial
29 and increasing contribution to overall impacts on biodiversity.

30 When the appropriate goals have been identified, the boundaries of the assessment should be
31 clearly defined. Boundaries should include the geographical scope of the areas to be included
32 in the assessment of the impacts of the livestock operations as in the case of the study in
33 eastern Australia. They defined the boundaries as the coastal catchment – and include 2900
34 reefs as well as extensive seagrass meadows, mangrove forests and soft bottom habitats (refer
35 to case Study 2). A life-cycle perspective should also be adopted: the supply chain in which
36 the user is included often covers different geographical areas. In particular, if the livestock
37 operations are using feed that is purchased off-farm, then the off-farm biodiversity impacts of

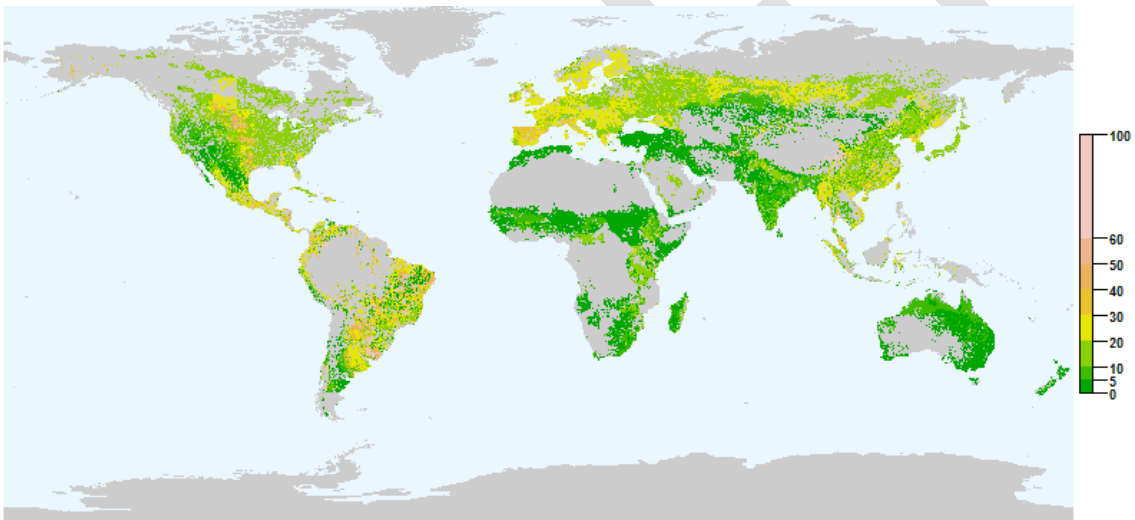
Principles for the assessment of livestock impacts on biodiversity

1 feed production should be included where possible (see Case Studies 1, 5 and 9). Figure 9
 2 shows how important areas for feed production can overlap with biodiversity hotspot. This
 3 suggests that if even if a farm uses a small share of feed coming from this area, it could have a
 4 high relative impact on biodiversity.

5 Case study 1 analyzed the impact of livestock on biodiversity through land use for feed. The
 6 objective was to estimate the relative shares of this impact occurring on-farm (grassland, feed
 7 crops cultivated on the farm) and off-farm (imported feed). The output was a global map
 8 showing the impact of dairy cattle production on biodiversity occurring off-farm vs. on farm,
 9 which shows that the off-farm impacts are very significant (Figure 13).

10 Livestock sectors and commodity grain sectors could be encouraged to work together to
 11 measure and assess biodiversity throughout the supply chain. In this way, livestock farmers
 12 that buy (off-farm) feed from the market can be more informed of and understand the
 13 biodiversity impacts of the products that they buy.

14



15
 16 Figure 13: Percentage of the estimated impact of dairy cattle production on biodiversity (MSA) through land use
 17 occurring off -farm, *i.e.* from imported feed. Refer to Case Study 1 for details.

18

19 *4. Identifying the scope of Pressure, State and/or Response indicators*

20 There is a need to identify the scope and needs of an assessment. Depending on the
 21 assessment, there will be a need to select specific pressure, state and/or response indicators.

22 Pressure indicators stand at an intermediate point between management decisions and
 23 biodiversity. There is often a strong body of literature to evidence the link between pressure
 24 categories and biodiversity. Because they are closely related to management decisions, data
 25 required to calculate pressure indicators may be readily available. Pressure indicators should
 26 be used when there is a significant contribution of the user to pressure categories and good
 27 scientific evidence of the link between these categories and biodiversity (see Case Studies 1, 7

Principles for the assessment of livestock impacts on biodiversity

1 and 8 where a scientific approach informed the choice of indicators). They could also be used
2 when the user does not have the capacity to collect data and calculate indicators of the state of
3 biodiversity. The relative importance of the different pressure categories to the overall impact
4 on biodiversity is difficult to quantify and this limitation should be discussed when using
5 pressure indicators.

6 State indicators provide a direct measure of biodiversity which is ultimately what the user
7 should act upon and improve. State indicators should be used when the user has the capacity
8 to compute them and collect adequate data, which often requires a significant amount of time,
9 financial resources and expertise. State indicators describing habitats rather than species may
10 be computed more easily. The user should also identify a specific target concerning the state
11 of biodiversity, e.g., reversing the decline of bird populations (Figure 15), ensuring the
12 conservation of certain species or habitats (see the Case Studies for several examples).
13 Although state indicators can be a proxy for wider biodiversity, they cannot be comprehensive
14 and this limitation in scope should be discussed. A very broad diversity of state indicators can
15 be used and their values will often be uncorrelated. The choice of state indicators will have a
16 huge influence on the outcome of the study; therefore stakeholder engagement will be very
17 valuable to define key biodiversity issues and select the corresponding state indicators (see
18 point #5 below). State indicators are not directly related to management decisions because
19 many other factors can have an influence on biodiversity.

20 Response indicators are directly related to management decisions; therefore, the data required
21 to compute them are often already available. Response indicators should be used to measure
22 and monitor impacts on biodiversity. (See Case Study 7 which used information from a large-
23 scale biodiversity monitoring program to link multi-taxa biodiversity to land use supporting
24 livestock production in western North America.) The link between the different response
25 indicators and the positive influence on biodiversity should be strongly supported by the
26 scientific literature, legal frameworks or private audit or certification. There is no guarantee
27 that responses will actually lead to biodiversity improvement, for instance because of the
28 effect of other factors, responses taken at inadequate scale or lack of coordination between the
29 responses of different stakeholders.

30 Pressure, state and response indicators are complementary and the PSR approach provides a
31 way to articulate them to facilitate interpretation and decision making. Combining several
32 categories of indicators is strongly encouraged. When response indicators are used in
33 combination with other pressure and state indicators, it allows one to show the changes
34 adopted to improve biodiversity performance. Conversely, it allows one to monitor whether
35 responses actually result in lower pressures, higher benefits or improvement of the state of
36 biodiversity (Case Studies 4, 5 and 6 use indicators to show the importance of traditional
37 practices in maintaining heterogeneous landscapes and biodiversity). Pressure and state

Principles for the assessment of livestock impacts on biodiversity

1 indicators are also useful to combine in order to reveal the relative importance of the different
2 categories of pressure and to prioritize action (e.g. Plantureux *et al.* 2014).

3

4 *5. Engagement with stakeholders and experts*

5 Given the context-dependency of biodiversity conservation and priority-setting, engagement
6 with multiple stakeholders (anyone who may be impacted by or have an impact on an issue)
7 can improve several facets of an assessment. The role of stakeholders may include, but is not
8 limited to:

- 9 - Contributing to more effective goal definition (see point 1, above)
- 10 - Improving awareness of traditional knowledge and practices about biodiversity
- 11 - Contributing to the selection of indicators
- 12 - Informing on the availability of other studies and existing data
- 13 - Providing feedback on the goal, methods and outcomes of an assessment
- 14 - Providing feedback on the acceptability and feasibility of recommended actions

15 It is important to engage stakeholders, consult experts and identify relevant information from
16 other resources to identify the current or past biodiversity state within the system boundaries,
17 and whether any plans or projects might be in place or being developed to improve the state of
18 biodiversity. These stakeholders can also support the identification of assessment methods
19 and tools, as well as the identification of solutions for the mitigation of impacts. Experts can
20 also provide such information, and have a more important role in providing specialised skills
21 that can assist the validity, efficiency and effectiveness of an assessment. Depending on the
22 goal of an assessment, there may be a need to employ experts to conduct some of the
23 assessment (e.g. measuring population trends in a threatened species, conducting habitat
24 surveys, analysing ecological data). If it is to be effective and credible, engagement with
25 stakeholders and experts should be a continuous approach with regular interaction at key
26 points in the planning, implementation and interpretation of a biodiversity assessment.

27 Where an assessment results in recommended actions, stakeholder engagement is necessary to
28 achieve ‘buy-in’, especially if there is need for a coordinated response, which is often
29 required to improve the state of biodiversity. For instance, this could include coordination of
30 several farmers or groups of farmers to provide a response at the landscape level, or
31 coordination along the supply chain to ensure that both on-farm and off-farm feed cultivation
32 lead to biodiversity improvements. Stakeholders will provide a good indication of the wider
33 response to an assessment, and whether it has sufficient content and clarity of communication
34 to be trustworthy and likely to be accepted.

35

1 *6. Identifying and prioritizing indicators*

2 Based on expert input and consulted resources, identify the indicators and prioritize these for
3 the assessment. Selected indicators should be SMART (Specific, Measurable, Actionable,
4 Relevant and Timely) and economically feasible to measure. The selected response indicators
5 should be used to identify opportunities to address impacts. The response indicators can
6 provide recommendations for practices that enhance the biodiversity in livestock operation or
7 feed crop areas. The state indicators can be used to assess whether the practices have led to
8 the desired outcomes. Each category of impact should be considered, and effort made to
9 identify an appropriate pressure, state and/or response indicator for each of the major impact
10 categories identified in the scoping and hotspot analysis (See Section 5.2 on pressure
11 indicators for further discussion on this general approach).

12 Note that the desired outcomes may not be apparent because of long delays (and sometimes
13 distances) between practice change and measureable change in state indicators. Therefore lack
14 of apparent response in state indicators cannot always determine whether the response
15 practices have been successful or not. An understanding of the underlying cause-and-effect
16 relationships can help guide expectations on the temporal scale over which responses should
17 be evident.

18 Various initiatives have developed indicators and guidance for these different levels of
19 assessment as described in Sections 5.2 to 5.5, and we give an overview of some relevant
20 initiatives/organisations/frameworks. The reader can identify which ones are most relevant for
21 the desired assessment based on location, sector, or other criteria.

22 However, the user can select the indicators that are most relevant to the circumstances of the
23 livestock production operations. If the operation is located in an area of low biodiversity
24 conservation value (e.g., there are no forests, wetlands, grasslands that are directly and
25 indirectly impacted by the livestock operation) then the user can choose not to measure these
26 indicators. When indicators are relevant to the livestock system, but there isn't information to
27 quantify the indicator, then a reason should be provided for omission of information in its
28 communication, and possible ways to collect the relevant information should be identified.

29

30 *7. Identifying relevant information*

31 Indicators are only useful if they address the goals of the assessment, and if there is available
32 data with which to quantify trends in the indicator. Existing information available to assess
33 biodiversity impacts should be identified. If data are not available, it may be possible to
34 collect data through the establishment of a new monitoring campaign. Limited data
35 availability should not be used as a criterion to exclude important pressure/benefit categories
36 if the user has the capacity and financial resources to collect additional data. In some cases,
37 there may be options for structured and organised self-reporting by farmers, although more

Principles for the assessment of livestock impacts on biodiversity

1 specialised biodiversity monitoring will probably require the use of specialist expertise. The
2 willingness of an organisation to commit resources to an effective monitoring programme that
3 collects quantitative information is viewed by many stakeholders as a strong test of
4 commitment to a sustainability programme. See also Case Studies 2, 3, 4, 5, 6, 7, 8 and 10 for
5 examples of monitoring programmes).

6 In any event, it is imperative that the data have been collected in a way that is fit for purpose.
7 The design of a monitoring programme and data collection protocols is a key activity that
8 should be undertaken by personnel with the appropriate specialist expertise in this area.

9 Thus, for example, there should be a stratification of the sample of farms and randomised
10 selection of farms from the relevant suite of farms. (Stratification based on sensitivity of
11 habitat, connectivity, capacity to monitor or implement practice change and/or location
12 relevant to off-site impacts may provide more information and greater improvement.) Many
13 universities, NGOs and other local conservation groups concerned with biodiversity have
14 relevant expertise that can contribute toward the valid design of a monitoring programme.

15

16 *8. Analysis of data*

17 The impacts on biodiversity can be identified through analysis and interpretation of data that
18 has been collected for the chosen indicators. Data analysis and interpretation is another key
19 activity that should be undertaken by personnel with the appropriate specialist expertise in this
20 area.

21 The user should assess that the following aspects in data collection have been taken into
22 consideration when carrying out the assessment (adapted from ISO 14044:2006):

- 23 • Representativeness: qualitative assessment of the degree to which the data set reflects
24 the true population of interest. Representativeness covers the three following
25 dimensions:
- 26 • temporal representativeness: age of data and the length of time over which data was
27 collected;
- 28 • geographical representativeness: geographical area from which data for unit processes
29 was collected to satisfy the goal of the study;
- 30 • technology representativeness: specific technology or technology mix;
- 31 • Precision: measure of the variability of the data values for each data expressed (e.g.
32 standard deviation);
- 33 • Completeness: percentage of flow that is measured or estimated;
- 34 • Consistency: qualitative assessment of whether the study methodology is applied
35 uniformly to the various components of the analysis;

Principles for the assessment of livestock impacts on biodiversity

- 1 • Reproducibility: qualitative assessment of the extent to which information about the
2 methodology and data values would allow an independent practitioner to reproduce
3 the results reported in the study;
- 4 • Sources of the data;
- 5 • Uncertainty of the information (e.g. data, models and assumptions).

6 Two types of data can be collected:

- 7 • Primary data: defined as directly measured or collected data representative of
8 processes at a specific facility or for specific processes within the product supply
9 chain.
- 10 • Secondary data: defined as information obtained from sources other than direct
11 measurement. Secondary data are used when primary data are not available or are
12 impractical to obtain. Some data are calculated from a model, and are therefore
13 considered secondary data.

14 Primary data should preferably be used to describe foreground processes, i.e. the processes
15 that are under the direct control of the user. Secondary data can be used for background
16 processes. In this case, they should be as specific as possible: specific for the supplier of a
17 given input and communicated by this supplier, product specific or country specific. Case
18 Study 5 shows an example where primary data are combined with country-specific secondary
19 data to assess the land use pressure related to the cultivation of off farm feed included in the
20 composition of feed concentrates used in the farm.

21 Biodiversity data collection can represent important efforts in terms of time, cost and
22 expertise. In the case of biodiversity, users will be more likely to use secondary data. These
23 data are often collected for other purposes and can greatly vary in quality. Even in the case of
24 secondary data, quality should be discussed in relation with the criteria mentioned above. The
25 adequacy between the purpose of the collection of the secondary data, and the purpose of the
26 assessment using them should also be discussed.

27 Two important criteria should be discussed when using primary data: sensitivity and
28 uncertainty. Sensitivity reflects how data and methodological choices such as the choice of
29 indicators or system boundaries influence the results. Sensitivity should be assessed
30 qualitatively and a quantitative sensitivity analysis should be conducted if relevant and
31 possible. Uncertainty is important, especially if pressure indicators are computed on sample
32 data or if secondary data are used. Average value of pressure indicators should always be
33 provided with a measure of variability, such as the standard deviation.

34

35 *9. Understanding and managing the impacts*

36 Ultimately, the aim of data collection and analysis is to inform understanding and evaluation.
37 The interpretation of the data for this purpose is an important activity that can improve

Principles for the assessment of livestock impacts on biodiversity

1 knowledge of the relative impact of different activities in the life cycle of a product, assist
2 judgement on the extent to which goals are being attained, and inform the degree to which
3 corrective actions are required.

4 Within LCA, there are clear guidelines for the interpretation of results, as in Section 4.1:

- 5 • identification of significant issues based on the results of the LCI and LCIA steps;
- 6 • completeness, sensitivity and consistency checks; and
- 7 • conclusions, limitations and recommendations.

8 For both LCA and PSR-based approaches, this phase of a study should directly address the
9 goal of the study. It should deliver answers to the question(s) raised in the goal definition
10 stage and recommend appropriate actions to the intended audience, within the context of the
11 goal and scope. The study should explicitly discuss the limitations to robustness, uncertainty
12 and applicability. For instance, if the goal is improvement over time and to mitigate pressures,
13 then action plans and a plan to monitor (possibly context specific) progress should be
14 detailed. Thus, the Discussion phase of a study should not just set goals to be attained, but
15 also to provide clear guidance on how to measure and monitor specific, stated indicators over
16 time to understand whether policies or practices have led to improved biodiversity state in
17 livestock or feed crop operations.

18 For example, in Case Study 2, monitoring confirmed reductions in sediment, pesticide and
19 nitrogen loads to the Great Barrier Reef system. Case Study 7 provided a clear link between
20 the Biodiversity Intactness Index and different land uses. In Case Study 8 in the Serengeti-
21 Mara ecosystem, large herbivores and carnivores were surveyed to assess human impacts on
22 the system.

23

24 *10. Developing effective communications*

25 A major success factor in maintaining and improving sustainability (including biodiversity) is
26 the successful transfer of information, and the achievement of cultural awareness and
27 appreciation of biodiversity. As part of a wider set of activities to foster such cultural
28 awareness and appreciation, the results of monitoring programmes should also be
29 communicated externally. This can help to illustrate successes where they occur, and be a
30 source of motivation for farmers, consumers and other stakeholders. Where appropriate, the
31 wider public should be kept informed of progress with biodiversity initiatives. Where
32 monitoring indicates a lack of success, such quantitative information should also be useful in
33 guiding and justifying changes to management actions that are more likely to be successful.

34 Communicated information should provide with transparency about the aims and methods of
35 an assessment. This should include: the methods chosen, the outcomes, the action plans
36 following the assessment and any limitations related to the assessment or information. In
37 particular, the information should be communicated in a clear and understandable format, be

Principles for the assessment of livestock impacts on biodiversity

1 complete, reliable, comparable (over time) and accurate. The communication should include
2 information about the boundaries, timelines, assumptions, resources consulted and
3 stakeholders engaged. Tools may include guidance about communication of biodiversity
4 assessment outcomes. For more guidance on communication on biodiversity, see the G4
5 Sustainability Reporting Guidelines of the Global Reporting Initiative (GRI,
6 <https://www.globalreporting.org/reporting/g4/Pages/default.aspx>).

7 For transparent communication, the limitations of the assessment should be clearly described
8 and discussed. First, a completeness check should ensure that the consistency between the
9 goals of the assessment, its scope, system boundaries and assessment methods selected.
10 Secondly, sensitivity checks should assess the extent to which the study outcomes are affected
11 by methodological choices such as system boundaries, data sources, and the choice of
12 indicators. If relevant, a quantitative sensitivity analysis can be performed. Biodiversity is a
13 complex issue and its assessment will always involve simplifications and assumptions which
14 consequences should be discussed. Examples of simplification include when a limited number
15 of pressure categories or biodiversity levels, dimensions or taxa are considered.

16

17 5.2. Pressure indicators

18

Key principles

- 19 • The scoping and hotspot analyses should aim to define a shortlist of pressures and
20 benefits to be quantified because of their importance for the user's livestock system
21 and its context. At least one indicator should be computed for each pressure and
22 benefit categories within the shortlist identified in the scoping analysis.
- 23 • Pressure and benefit are often two sides of the same gradient – both should be
24 considered when conducting the hotspot analysis and, when relevant, the same
25 indicator should reflect the whole gradient. An example includes grazing level
26 (livestock units /ha) which results in different impacts from low to high grazing levels
27 (e.g. see Case Study 4 and 5)

28

29 5.3. Summary of the pressure and benefit categories and their indicators

30 Figure 8 identifies the categories of pressure and benefits that link livestock production to
31 biodiversity. These categories are detailed in Table 4 which provides a summary for the broad
32 mechanism of their effect on biodiversity, their relative importance among regions and
33 production systems as well examples of key indicators to describe them.

1 **5.3.1. Scoping and hotspot analysis**

2 A scoping analysis should be conducted. This analysis will evaluate the relative importance of
3 the different pressure and benefit categories (Table 4), based on two main criteria: (i) the
4 contribution of the user's livestock system to the category and (ii) the contribution of the
5 category to biodiversity changes (below). Based on this evaluation, a shortlist of pressure and
6 benefit categories selected for quantitative assessment should be defined.

- 7 • Conduct a qualitative hotspot analysis of the relative contribution of the user to the
8 different pressure and benefit categories. All the categories that are under the control
9 of the user should be included in this analysis. A life cycle-perspective should be
10 adopted for this hotspot analysis and for each pressure/benefit category, the relative
11 contribution of the different stages of the supply chain should also be assessed
12 qualitatively. Certain categories are under direct control of the user although they lead
13 to biodiversity changes outside of the user's system (e.g., imported feed, climate
14 change, nutrient pollution in water). For example, this qualitative analysis could reveal
15 that the most important categories are habitat creation/maintenance benefit and GHG
16 emissions from enteric fermentation for a given extensive system, or nutrient pollution
17 and habitat destruction from off-farm feed cultivation for an intensive system.
- 18 • Conduct a scoping review to identify the most important drivers of biodiversity
19 changes and pressure/benefits categories in the wider context of the user's system. For
20 instance, does habitat destruction driven by livestock occur in the region (e.g.,
21 conversion of forest to pasture) or does the area endure important nutrient pollution
22 from livestock farms? This review should include scientific literature, reports and
23 legal frameworks aimed at mitigating certain pressures or at promoting certain
24 benefits. For instance, laws banning deforestation or setting maximum thresholds for
25 the spreading of manure/slurry on fields, voluntary schemes offering payments for the
26 adoption of biodiversity friendly practices at the field or landscape level.

27 The pressure/benefit categories presented in Table 4 (and Figure 8) remain relatively broad
28 and can include several, more specific mechanisms of impact. For instance, habitat
29 destruction includes the conversion of primary forest to either grassland or cropland, as well
30 as conversion of grassland to cropland; nutrient pollution includes atmospheric, soil,
31 terrestrial and coastal water pollution. The shortlist of pressure/benefit categories should also
32 detail these specific mechanisms.

33 Certain pressure/benefit categories presented in Table 4 (and Figure 8) have received a lack of
34 attention in previous biodiversity assessment and their importance should be carefully
35 examined. They include the spatial configuration at landscape scale (e.g., fragmentation,
36 simplification, connectivity), the livestock/wildlife conflicts (competition for resources with
37 wild herbivores, retaliatory kill of predators) and the wildlife/health issues. A detailed

Principles for the assessment of livestock impacts on biodiversity

- 1 description of these pressure/benefit categories can be found in the LEAP Biodiversity
- 2 Review (Teillard et al. in prep.)

DRAFT

Livestock Environmental Assessment and Performance (LEAP) Partnership

Principles for the assessment of livestock impacts on biodiversity

1 Table 4: Overview of the categories of pressures and benefits for the effects of livestock production on biodiversity. For the detailed description of all
2 categories, refer to the LEAP Biodiversity Review (Teillard et al., in prep.)

Main drivers and sub categories	Mechanisms	Relative importance among regions and systems	Examples of indicators
Pressures			
1. Habitat change			
Habitat destruction/fragmentation	Deforestation and fragmentation	Tropical forests converted to pastures (in majority) and feed crops	Rate of conversion Extent of the original habitat Patch size/isolation to describe fragmentation
	Grassland to cropland conversion	Grassland in temperate countries	
	Land abandonment (see also the "Habitat creation/maintenance" category below)	Grassland systems in temperate countries	
Habitat degradation	Over-grazing	Over-grazing is always one factor	Normalized Difference Vegetation Index Rain use efficiency Over grazing
	Desertification	In semi-arid rangeland	
	Woody encroachment	In arid climate and grazed woodland	
	Soil degradation	All regions but humid/arid systems more fragile	
Detrimental practices	Higher use of inputs in feed crops (including pesticides, herbicides, fertilizers, irrigation) Grassland improvement, fertilisation, higher stocking rates Mechanization	Intensive systems in developed countries that do not have nutrient recapture and recycling systems, and where animals spend time on pasture.	Output oriented (yield) Input oriented (inputs/area) Stocking rate
Landscape simplification	Composition (loss of semi natural habitats and habitat diversity) Configuration (loss of connectivity)	Different meaning in grassland which are historically homogeneous at landscape scale but can be heterogeneous at smaller scale (e.g., species diversity, heterogeneity in the vegetation structure)	% of semi natural habitats Habitat diversity (e.g. Shannon index) Spatial configuration indicators

Livestock Environmental Assessment and Performance (LEAP) Partnership

Principles for the assessment of livestock impacts on biodiversity

2. Pollution			
Nutrient pollution	Soil and water pollution (acidification and eutrophication)	Heavily fertilized feed crops Livestock concentration (in intensive systems) can increase the risk of nutrient pollution if the system does not incorporate nutrient capture and recycling technologies	Fertilisation Nitrogen/Phosphorus balance Nutrients in transition in water Increase in vegetation of high nutrient status
	Atmospheric pollution		Emissions of N gases Nutrient load exceedance
Ecotoxicity	Ecotoxic products such as pesticides and veterinary products (including hormones, antibiotics, anthelmintics)	Level of intensity of the system	Number/quantity of application of pesticides Molecule concentration in the environment
3. Climate change GHG emissions	GHG emissions originating from livestock and causing climate change	Concerns all species/systems but ruminants with low productivity have the highest emission intensities	GHG emissions in CO ₂ -eq Climate change itself (but does not isolate the effect of livestock)
4. Other drivers			
Over exploitation	Mainly overfishing for livestock fishmeals	Mainly intensive pig and poultry systems	
Competition	Competition with other herbivores	Extensive systems in all regions	Intensity indicators combined with presence of wild herbivores
	Predator kill by farmers		Number of kill
Invasive species	Degradations by livestock can favour invasions	Africa, India and Australia seem more at risk than Europe and China All systems leading to degradation could increase the risk	Presence/number of invasive species Other indicators reflecting degradation
Disease emergence	Disease outbreaks in livestock spreading to wild animals	Emerging countries with newly industrial systems lacking disease control	Outbreak events Factors favoring emergence
Benefits			
Habitat change			
Habitat creation/maintenance, beneficial	Extensively managed livestock can maintain species rich, semi natural grassland	Extensive grazing systems In all ecoregions where grassland naturally occur, and in Europe because of the long	Area of semi natural grassland Practices (moderate livestock density, no fertilisation)

Livestock Environmental Assessment and Performance (LEAP) Partnership

Principles for the assessment of livestock impacts on biodiversity

practices	Livestock abandonment leads to biodiversity loss	history of livestock grazing	
Habitat restoration	Restoration of abandoned grassland	Extensive grazing	See indicators for the habitat maintenance benefit
	Restoration of degraded grassland	Extensive/rotational grazing	See indicators for the habitat degradation pressure
Landscape connectivity	Semi-natural habitats and habitat diversity maintenance Spatial connectivity maintenance Plant dispersal by mobile herds	Extensive systems with management measures favoring landscape elements/connectivity or mosaic systems containing a mixture of intensive systems and extensive systems managed for biodiversity	See indicators for the landscape simplification pressure Enhancement of wildlife/biodiversity corridors
Pollution Nutrient cycling	Nutrient supply from livestock dung/urine	Extensive systems	Amount of inorganic fertilizer spared Animal excreta
Climate change C sequestration	Grassland managements enhancing C sequestration in grassland	Grassland systems but management practices have a strong effect	C storage quantity Practices favoring sequestration
Other drivers			
Food web maintenance	Resources for scavengers Resources for arthropods (e.g., dung beetles, crane fly larvae) which in turn provide benefits to plants and birds	Extensive grazing systems	Biodiversity state indicators are more adapted
Invasive species control	Maintenance of the system stability and resistance to invasions When invasive species are selectively grazed	Extensive grazing systems	See indicators for the invasive species pressure

1

2

1 **5.3.2. Principles for application of pressure indicators to analysis of livestock impacts**

2 **Minimum requirement.** As a minimum requirement, there should be at least one pressure
3 indicator for every category of pressure/benefit in the shortlist. Within each pressure/benefit
4 category, several indicators should be computed if more than one mechanism of impact on
5 biodiversity has been identified.

6 **Choice of indicators.** Pressure indicators should follow the SMART properties detailed in
7 Section 5.1. In addition, they should be derived from the scientific literature or from technical
8 reports that are cited by the user. In the event that a user chooses to develop a new indicator, a
9 critical discussion of the strengths and limitation of the new indicator and a comparison with
10 existing indicators should be provided. The LEAP Biodiversity (Teillard et al., in prep.) gives
11 several examples of pressure indicators (summarized in Table 4). Ideally, pressure indicators
12 should include those that affect different dimension of impact on biodiversity, e.g. habitat
13 area, configuration, quality, benefits for different species traits, risk of invasive species.
14 Ideally, pressure indicators should include those that affect different dimension of impact on
15 biodiversity, e.g. habitat area, configuration, quality, benefits for different species traits, risk
16 of invasive species.

17 **System boundaries and off-farm pressures.** As outlined in Section 5.1, a life-cycle
18 perspective should be adopted when calculating indicators. The scope of the analysis in terms
19 of system boundaries should at least be extended to feed cultivation, especially if this stage
20 occurs off-farm. The qualitative hotspot analysis should also give an idea of the relative
21 contribution of the different life cycle stages to the different pressures and benefit categories.
22 This information should also be considered when defining the system boundaries.

23 Pressure indicators related to the habitat change driver should always consider both the feed
24 that is grown on farm and the feed that is grown off-farm and imported onto the farm. Case
25 Study 1 compares the relative impact of on-farm and off-farm feed on biodiversity on a global
26 scale and shows a very significant contribution from off-farm feed. For instance, a simple
27 pressure indicator of habitat change is the area of land used for feed cultivation. This pressure
28 indicator should detail the type of feed, include both on-farm areas and off-farm areas along
29 with their origin. Information about the geographical origin of off-farm feed (e.g.,
30 concentrates) is often not directly available but the user should try to request it if possible.
31 However, the composition of off-farm feed is known in most cases. If more precise
32 information is not available, country-level or regional average yields (e.g., accessible through
33 FAOSTAT) could be used to estimate areas from the amount of the different feed
34 components. Case Study 5 illustrates an example of this approach and compares it with on-
35 farm indicators for two different systems that contrast in their relative use of off-farm feed.

36 Ideally, pressure indicators related to drivers other than habitat change should also consider
37 the stage of off-farm feed cultivation e.g. fertilizer use or GHG emissions associated with the
38 cultivation of off-farm crops for feed. For assessing GHG emissions associated with feed

Principles for the assessment of livestock impacts on biodiversity

1 cultivation, including off-farm feed, the user can refer to the LEAP guidelines for feed.
2 Various databases (e.g., LEAP feed database) also provide the value of GHG emissions
3 associated with feed cultivation. It is recognized that data availability may be an important
4 limiting factor for addressing pressures other than habitat changes associated with off-farm
5 feed cultivation.

6 Off-farm impacts also correspond to pressures originating on the farm but having an impact
7 outside of it, such as biodiversity, climate change or atmospheric and water nutrient pollution.
8 The user should make sure that the pressure indicator computed at farm level adequately
9 reflects these impacts occurring off-farm. Case Studies, 1, 2 and 9 shows that these
10 downstream, off-farm impacts can be very significant and it they also gives examples of
11 indicators which are able to capture them.

12 **The pressure-benefit gradient.** It is recognized that the effects of livestock production on
13 biodiversity can be both positive and negative (Table 4, Figure 8). The switch between
14 pressures and benefits can depend on the region (e.g., grasslands recently converted from
15 forest in tropical regions vs. species-rich grassland maintained by livestock in temperate
16 regions) or there can be a continuous gradient between negative and positive effects (e.g.,
17 within the same production system and regions, different management practices leading to
18 either degradation or restoration). Case Study 4 shows how differences in management
19 practices within the same livestock system can lead to either the maintenance or the
20 degradation of high conservation value farmland. When pressures and benefits are part of the
21 same gradient, indicators should capture this and reflect both negative effects and positive
22 effects. When pressures and benefits are not part of the same gradient, the scoping analyses
23 should have determined whether the pressure category, the benefit category or both of them
24 should be described by a specific indicator. Case Study 3 presents the interaction between
25 historical and current farm management and biodiversity values across a range of New
26 Zealand high country sheep properties producing fine merino and mid-micro wool. The Case
27 Study illustrates how balancing the capabilities of each land type to meet nutritional
28 requirements of animals will maximise grazing opportunities, identify areas for resting and
29 recovery, prevent overgrazing and maintain native species. If the balance is not right,
30 vigorous introduced species can take over and native plant species can disappear.

31
32 **Reference value.** The absolute value of a pressure indicator is not necessarily very
33 informative, and it should therefore be provided along with a reference value. In the case of
34 pressure indicators, the “natural state” (without human activities) corresponds to an absence
35 of pressure, therefore, it is not necessarily an informative reference. Three main types of
36 references can be used and the choice of the reference mainly depends on the goal of the study
37 (Table 5).

38

Principles for the assessment of livestock impacts on biodiversity

1 Table 5: Type of reference for pressure indicators and associated assessment goal.

Reference type	Example of goal	Case studies
1. Temporal reference (value at a specific type)	Repeated measure of the pressure indicator to improve the system over time	Historical and current farm management practices such as stock type, stocking rate, timing of grazing, fertiliser and seed inputs can be monitored over time to help assess pressures on indigenous grasslands (Case Study 3). See Fig. 11 for temporal trends in different groups of farmland birds.
2. Average system reference (average value for system, e.g. in the region)	Communicate about the relative performance of the system	In areas of the Aran Islands without livestock grazing, the species-rich vegetation reverts to species-poor scrub that shades out grassland species. This represents a negative effect on biodiversity when livestock grazing is removed (Case Study 4)
3. Specific system reference (value for one key system or performance level, e.g. a system performing particularly well)	Transform the system towards the best-performing examples	The case of transhumance in Spain illustrates how the reference state without livestock is more homogenous and has lower biodiversity than states under moderate livestock use (Case Study 6). The Biodiversity Intactness Index in Case Study 7 uses native grassland, including rangeland, as a reference state.

2

3 **Spatial and temporal scale.** The user should consider the spatial and temporal scales of the
4 ecological mechanisms linking the pressure to its impacts on biodiversity. If the pressure has
5 a delayed effect on biodiversity (e.g., climate change, pollution), the pressure indicator should
6 be computed as an average of the past years. An average should also be used if the level of the
7 pressure is likely to have significantly changed in recent years.

8 There can also be a mismatch in scale between the area controlled by the user and the
9 ecological mechanism underlying the pressure that is measured. The principles in Section 5.1
10 and the example of catchment effects on the Great Barrier Reef (Case Study 2) show how
11 pressure indicators should reflect off-farm impacts (see also Case Study 1). Potential scale
12 mismatches can also occur with the landscape scale processes and wildlife/livestock
13 interactions pressure categories. The most relevant scales to address these pressure categories
14 are small to intermediate scales (e.g., landscape, municipal, departmental, national, regional).
15 Although pressure indicators could be measured at farm level (e.g., edges, semi natural
16 habitats to describe the landscape structure), their effect on biodiversity will also depend on a
17 wider scale. In this case, if possible, the pressure indicator should be measured both within the
18 farm and in the surrounding relevant scale. Land use planning and zoning are key aspects of
19 biodiversity conservation that are not well captured when restricting the assessment at farm
20 scale, even when considering off-farm impacts with a global perspective.

21 **Limitations.** The study should include a discussion of the results limitation. In particular,
22 how pressure indicators could underestimate the impacts on biodiversity because (i) a limited
23 number of pressure/benefits categories are considered, (ii) a limited number of indicators is
24 used within each pressure/benefits category.

1 Note that the different pressures may have different relative effects on biodiversity. For
2 instance, the low value of one specific pressure indicator could ultimately have more effects
3 on biodiversity than the high value of another pressure indicator. The results should include a
4 qualitative discussion on how the different pressures are expected to influence the state of
5 biodiversity itself (species vs. ecosystem level, what species in particular, see Table 6 and
6 Section A).

7

8 **5.4. State indicators**

9

Key principles

- 10 • Species richness can be an important state indicator; however, where possible, state
11 indicators should also include information that reflects the species composition and
12 conservation value of species. (e.g. see Case Studies 3, 4 and 5).
- 13 • In assessments that rely on species richness, care should be taken to use information
14 on species composition to measure the occurrence of undesirable species e.g. non-
15 native invasive species, native invasive species, pest species, and indicators of low
16 habitat quality. These should constitute a separate state indicator of biodiversity, and
17 reflect a negative contribution (threat) to biodiversity (e.g. see Case Studies 4 and 5).
- 18 • When choosing state indicators, the contribution of species or species' groups to
19 ecosystem functions and services should be considered e.g. pollination, carbon
20 sequestration, hydrological services.
- 21 • Integrity of data collection should be ensured, including a breadth of state indicators
22 representing both those negatively and positively affected by livestock production
- 23 • Habitat area/semi-natural land cover is generally straightforward to assess, and can be
24 an informative state indicator for farmland biodiversity

25

26 **5.4.1. General information**

27 State indicators can be used to describe the three dimensions of biodiversity - composition,
28 structure and function - apply across these hierarchical levels (Table 6).

1 Table 6: Overview of levels and dimensions of biodiversity, and potential state indicators

Level and dimension	Description	Example of indicators
Species		
Composition	Describes the identity and variety of species	<ul style="list-style-type: none"> Abundance (number of individuals), richness (number of species) and diversity (combining abundance and richness) Can be computed for specific groups of species, i.e. taxa (e.g. birds, arthropods, vascular plants) or groups with particular conservation value (e.g. European farmland birds, see Figure 15 below) Abundance/richness/diversity can be computed over time or at a specific instant only
Structure	Spatial structure in the landscape Structure in age classes	<ul style="list-style-type: none"> Information on age structure of the population, especially for species of high conservation value, to ensure that there are individuals of breeding age, and to ensure that progeny are being produced and surviving.
Function	Functional groups (i.e. groups of species sharing the same function)	<ul style="list-style-type: none"> Information on trophic level for fauna Description of functional groups for flora (e.g. legumes, grasses, herbs)
Ecosystem		
Composition	Describes the identity and variety of ecosystems	<ul style="list-style-type: none"> As for species, the abundance (extent), richness and diversity can also be computed at the ecosystem level, either over time or as a snapshot Can focus on ecosystems and habitats with special designations that reflect a higher level of conservation value At smaller spatial scales (e.g. farm-scale), the area, type and quality of habitats/native land-cover is an important farm-scale state indicator. Formal keys exist for different vegetation types in some parts of the world
Structure	Vegetation structure Soil structure Structure is closely related to function at the ecosystem level	<ul style="list-style-type: none"> Architecture of the vegetation Dominant species of trees Habitat fragmentation across landscape
Function	Ecosystem processes, functions, which may translate into ecosystem services from the human point of view	<ul style="list-style-type: none"> Quantification of ecosystem function or services (e.g. biomass production, pollination etc.). This quantification can be done in specific units (e.g. t ha⁻¹ yr⁻¹ of carbon sequestration) or monetized in order to sum the different types of ecosystem services

2

1 **5.4.2. Scoping and hotspot analysis**

2 An important part of any biodiversity assessment is to delineate the physical boundaries of the
3 scope of interest, which should correspond to the main geographical areas where biodiversity
4 is influenced by the livestock system being assessed. This generally refers to the geographic
5 scope, and includes indicators on the immediate farm(s), as well as those associated with off-
6 farm feed production, and end impacts which extend past the livestock production boundary
7 (see Case Studies 1, 2, 5 and 9). In some systems where land use changes inter- or intra-
8 annually, it may also be necessary to define a temporal scope as well. For example, if the use
9 of a land parcel varies from year to year between feed for cattle and other land use types that
10 are not related to livestock production, biodiversity indicators for livestock production should
11 be derived from years when cattle feed is produced.

12 The scale of the analysis should also be detailed and defined, whether it is local, regional,
13 global, or multi-scale. The final indicator list should consist of indicators which can be
14 directly controlled by the user, at the scale of consideration. For example, in a farm-scale
15 investigation, if a wetland species is a patrimonial species⁴ in the region, but there is no
16 current or historical aquatic land cover on the farm, this will lie outside of scope for a local
17 (farm-scale) assessment.

18 Table 6 provides an overview of the levels and dimensions of biodiversity that can be
19 considered in an assessment; see also the LEAP Biodiversity Review (Teillard et al., in prep.)
20 for additional biodiversity indicators. With these potential indicators in mind, the user should
21 conduct a scoping analysis to identify relevant biodiversity indicators in these categories, at
22 the scale of interest. This analysis should also include a scan of existing biodiversity survey or
23 monitoring programs or data, as in many cases data availability will drive indicator selection.
24 Of the potential indicators listed in Table 6 (and these are not exhaustive), it is likely that the
25 composition indicators will be most widely relevant. Particular attention should be paid to the
26 ecosystem level which tended to be neglected in previous assessments. Maintaining healthy
27 ecosystems is key to ensure their function and their ability to provide ecosystem services
28 crucial for the economy and human wellbeing (MEA, 2005).

29 Some species and ecosystems are accorded higher conservation priority than others, and it is
30 fundamental to any biodiversity assessment that these are adequately recognised. This raises
31 an important distinction between habitats and species that are not designated, or are not of
32 high conservation priority, and species and habitats that are considered to be of high
33 conservation value and of higher priority. This is not to say that native, undesignated habitats
34 are unimportant, but simply highlights conventional recognition that not all habitats are of
35 equal conservation value. For example, in a discussion of how a greater differentiation of
36 farmland biodiversity can be achieved to help guide the prioritisation and development of

⁴Pervanchon (2004) proposed a definition of a patrimonial species which covers the concepts of both flagship and threatened species. A patrimonial species is “a rare or threatened species which needs local management and which may be a flagship species and may have cultural importance”.

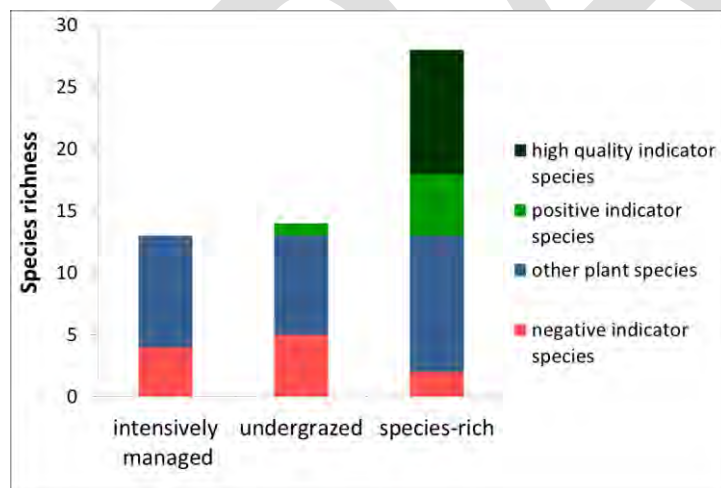
Principles for the assessment of livestock impacts on biodiversity

1 agri-environment measures, Finn & Ó hUallacháin, (2012) described broad categories of
 2 farmland wildlife and habitats that varied from highest to lower levels of conservation value.
 3 These different categories represented a broad spectrum of conservation value of species and
 4 habitats (which are not necessarily mutually exclusive), as follows:

- 5 • protection (including restoration) of priority habitats/species on Natura 2000 sites;
- 6 • protection of priority habitats/species that occur outside of Natura 2000 sites;
- 7 • protection of rare and threatened species (e.g. those associated with Red Data Lists,
 8 Species Action Plans, Flora Protection Orders etc.);
- 9 • protection of other species and habitats (neither rare nor threatened) of high
 10 conservation value;
- 11 • protection of species that are declining, but are not yet rare;
- 12 • protection of other common farmland habitats and species
- 13 • creation of farmland habitat to support named species;
- 14 • creation of common farmland habitats.

15 Although this specific list was developed in Ireland, and strongly reflects conservation
 16 values derived from European conservation policy and designations, a primary lesson is
 17 that the nature and extent of wildlife designations can be used to infer greater or lesser
 18 conservation value.

19



20

21 Figure 14: Example of the impact of intensive management and undergrazing on the species richness and nature
 22 conservation value of calcareous species-rich grasslands on the Aran Islands. The ‘high quality indicator species’
 23 include orchids and other plant species that are rare on an Irish and European scale. Data from 2m x 2m quadrat
 24 samples.

25 Case Study 4 provides an example of assessment of high-conservation status species and
 26 ecosystem state indicators: for example, number of species and habitats on national and
 27 European priority list (Figure 14). Importantly, the scoping analysis should go beyond
 28 conservation status. The lack of a designated conservation status should not be used to
 29 conclude that there is less need for biodiversity management.

Principles for the assessment of livestock impacts on biodiversity

1 To identify threatened species and ecosystems in the area of interest, global sources of
2 potential indicators should be scanned, for example the IUCN Red List of Threatened Species,
3 the IUCN Red List of Threatened Ecosystems and the Living Plant Index. (see also Section
4 3.2). The scoping analysis should also review corresponding lists compiled at the regional or
5 local scale, such as national or sub-national endangered species frameworks. Due to elevated
6 conservation value, these species are also likely to have increased data availability at the
7 national or sub-national scale.

8 Local sources of knowledge will likely have to be utilized for identification of other potential
9 species of interest such as culturally-important (patrimonial) species and ecologically-
10 important (keystone, umbrella) species. Potential sources of information include local
11 extension documents, as well as regionally-relevant research. See Case Study 5 for an
12 example of research which has produced a tool that can be used to guide assessment of state
13 indicators, specifically ecosystem composition. Other indicators, such as functional groups,
14 are descriptive in nature and as such require less guidance.

15 5.4.3. Principles

16 **Indicator selection** – From the indicators identified in the scoping analysis, the user will
17 choose those to be included in the assessment. The user should specify which aspects of
18 biodiversity the chosen indicators correspond to, both in terms of level (genetic⁵, species,
19 ecosystems) and dimension (composition, structure, function). Note that information on
20 intermediate levels of biodiversity, such as community or population, can also be included.
21 Most assessments will focus on the composition level for species and ecosystems as the most
22 basic and information level of information. However, the assessment can acquire further
23 information if resources or data exist to survey the additional components. The indicators
24 chosen can be influenced by the objectives of the assessment. For example, if the assessment
25 was motivated by a goal to maintain native land cover, the indicators can focus on this aspect.
26 Case Study 10 provides an example of application of state indicators to specific objectives. In
27 this Case Study, the objective was to use management practices to stabilize sand dunes in
28 Botswana. State indicators included: area of bare sand dunes, and; percent of land area
29 covered in thorn bush and poor quality grazing grasses.

30 **Minimum guidelines** – Ideally, indicators that reflect both species and ecosystem
31 composition should be included. Information included should be comprehensive rather than
32 redundant – i.e. species-level indicators should encompass varying taxa levels, and indicators
33 should be chosen that are not known to be congruent in their response to livestock pressures
34 on biodiversity. In Case Study 7, a wide range of state indicators are surveyed, including
35 comprehensive surveying of richness and abundance of vascular plant, lichen, moss, mite,
36 mammal and bird species, comparable information for ecosystems, and a composite Range
37 Health indicator. Case Study 2 provides another example of a broad, complementary suite of

⁵ These general principles do not cover the genetic level of biodiversity

Principles for the assessment of livestock impacts on biodiversity

1 state indicators, including area and connectivity of reserves, density of invasive animals and
2 plants, fire regime, and area protected from invasive predators. Further, species that are
3 known to be sensitive to livestock pressures should be preferentially included. For example,
4 species that are known to increase or decrease with grazing would be valuable components of
5 a biodiversity assessment in rangeland (Case Studies 3, 4, and 6).

6 Different types of species can be monitored, such as common or rare species, or generalist or
7 specialist species. Rare species have a higher conservation value and their maintenance
8 typically requires specific attention while common species make a higher contribution to the
9 overall ecosystem function and their wide distribution allows one to calculate large-scale
10 biodiversity trends; therefore both type of species are relevant to monitoring programmes.
11 Specialist species may be more important to monitor than generalist species because
12 generalists are less sensitive or even benefit from disturbance (e.g. see Case Studies 4 and 5).
13 Human disturbance poses a threat of biotic homogenization where a few generalist species
14 replace many specialist species.

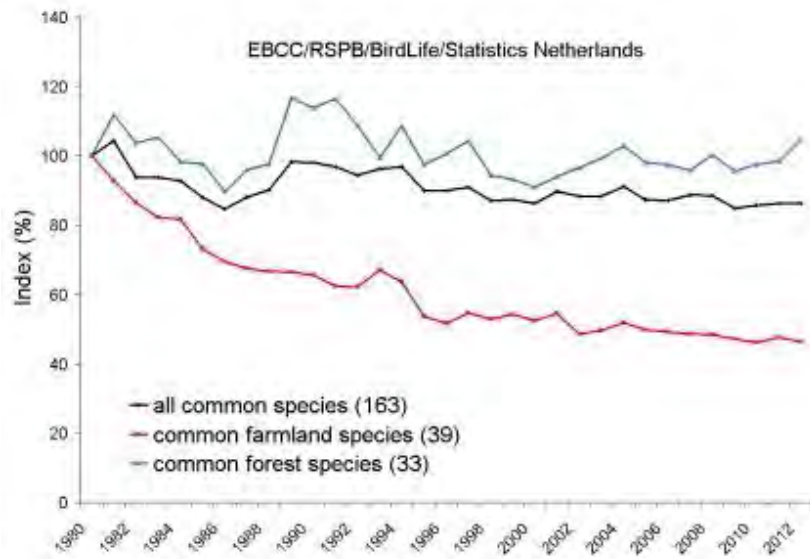
15 **Considerations** – Data sources should be appropriate to the scale of interest. For example, if
16 discussing species composition at the local level, data should be derived from local field
17 studies, rather than extrapolated from similar habitat in the region. For other indicators, local
18 information may not exist, but if proxy from similar habitats might be able to inform the
19 indicator. The ramifications of these decisions should be discussed as study limitations.

20 Methods should also be appropriate to the scale. For example, locally-developed ecosystem
21 health measures are appropriate at a local scale, but not at a global scale. An example of this
22 would be the Range Health Index described in Case Study 7, which would not be directly
23 applicable in other locations.

24 Robust data may not exist for a suite of indicators, or at multiple scales. When deciding
25 whether to include or omit data, err on the side of inclusivity. However, data of poor or
26 unknown quality should be flagged as qualitative or exploratory.

27

Principles for the assessment of livestock impacts on biodiversity



1
2 Figure 15: Wild birds index for 27 European countries, with separate indicators for common farmland, common
3 forest and common bird species. Numbers in parentheses show the number of species in each indicator. This
4 index uses 1980 as a reference year. Source: <http://www.ebcc.info/index.php?ID=28>

5
6 **Reference conditions** – A reference state for biodiversity should be established, where
7 possible. For example, a specific livestock system may support five bird species, and there is
8 value in knowing the extent to which this level of bird diversity changes over time. Without
9 information on how this level compares to a reference state (e.g. the number and types of bird
10 species on an area of native land cover, or representative wildlife habitat), however, the
11 interpretation of such information is more limited. Either quantitative or qualitative
12 information on reference state can help set objectives and track progress. Reference
13 conditions are especially important for index indicators such as species richness. Care needs
14 to be taken when using these composite indices as important information may be lost in
15 aggregation. For example, invasive species may contribute to a measure of species diversity,
16 but they contribute negatively to diversity when viewed in the context of a reference area, and
17 should be interpreted as such (see use of negative indicator species in Case Study 4).

18 Reference conditions will further vary by historical and geographical context. For example, in
19 Europe reference conditions may be based on culturally important habitats and semi-natural
20 habitats shaped by historical human activities. In contrast, western North American reference
21 conditions would likely be those free of direct human influence. In this context, care should
22 be taken to include both negative and positive impacts of livestock production on biodiversity.
23 For further information see also Section 6.4.

24 When possible, enumeration-type indicators should be accompanied by further information on
25 condition. For example, information on species richness can be combined with that of species
26 population trends to provide insight on condition (See Figure 15). Case Study 8 provides an
27 example of comprehensive monitoring of wildlife as a state indicator. In this case study,

Principles for the assessment of livestock impacts on biodiversity

1 wildlife and livestock density have been monitored for over 40 years in both pastoral and
2 protected areas. Similarly, beyond a survey of ecosystem services provided by the ecosystems
3 of interest, how do the provision of the services compare to what is expected of a healthy
4 ecosystem? Case Study 5 provides an example of quantification of ecosystem services, by
5 combining information on biodiversity state with information on the effect of management
6 practices for individual grassland typologies.

7 **Monitoring** – Monitoring typically involves surveying over time with the intention of
8 collecting data to assess the extent to which a quantitative management objective is being
9 achieved (Case Study 7 and 8 - there is need of long term monitoring of biodiversity in many
10 ecoregions of the world). In this case, it is likely that monitoring for biodiversity purposes
11 would include a number of indicators that reflect appropriate biodiversity goals. (The
12 assessment of appropriateness is partly addressed in Section 5.3.1 on scoping and hotspot
13 analysis.) Note that many monitoring programmes for biodiversity have clearly defined target
14 levels for species richness, species abundance, species composition, as well as numbers and
15 abundances of species that are designated and/or are of high conservation value (see various
16 Case Studies). Some programmes can also indicate threshold values of indicators that trigger
17 corrective actions if the thresholds are crossed (see use of negative indicator species in Case
18 Study 4).

19 Components such as species population size will vary over time due to influences
20 independent of livestock production. There should be a consideration of what these influences
21 are, how to account for them, and whether thresholds can be identified.

22 **Discussing limitations** – Discussion of the limitations should include ramifications of the
23 selected indicators. For example, there may be poor data availability for the most sensitive
24 species and thus the state of biodiversity may be overestimated. If not all scales have been
25 included in the analysis, discuss the ramifications of omitting certain scales. For example, if
26 the assessment is conducted at a regional scale, biodiversity may vary considerably and be at
27 risk at the local scale comprising the region.

28 **Links to other indicators** – If the monitoring results from state indicators suggest mitigating
29 actions are necessary, then information from pressure or response indicators can be used to
30 guide and target the mitigating actions. Responses could include species recovery or
31 ecosystem conservation/rehabilitation programs. Combining response and state indicators
32 make it possible to monitor how actions lead to the expected biodiversity goals.

33 **Using state indicators to derive LCIA characterization factors** – State indicators could be
34 used to derive characterization factors for LCIA methods. Several elements would have to be
35 considered. LCIA methods generally strive for a broad geographical scope. State indicators
36 computed at a very local scale may not be adapted to derive characterization factor. However,
37 a quantitative meta-analysis of such local studies to compute an average size effect would be a
38 way to broaden the geographical scope and to derive characterization factors. Another

1 approach would be to use data on the state of biodiversity that already available on a large
2 scale (e.g., on birds in Europe, Figure 15). In any case, the state indicators would have to be
3 clearly linked to a midpoint impact category and use a defined LCIA framework. For land
4 use, this LCIA framework should be the one detailed in Section 4.2. A standardized
5 classification for land use and biogeographical differentiation (e.g., as in Koellner et al.
6 2013b) should also be used in order to ensure the genericity of the characterization factors.
7 Finally, careful attention should be paid to the choice of the reference state as it will have a
8 strong influence on the results of the assessment and their interpretation. Section 6.4 describes
9 different options for this reference state and a discussion on which reference is better adapted
10 in the context of livestock production.

11

12 **5.5. Response indicators**

13 **5.5.1. Principles**

14 **Key principles**

- 15 • Response indicators should be based on scientifically sound and verifiable evidence
16 that details a clear link between adoption of the response indicator and the expected
17 biodiversity outcome.
- 18 • Response indicators may be general, e.g. whether a biodiversity action plan is in place,
19 or more specific e.g. the level of expenditure on conservation of native grasslands or
20 the decision to preserve an endangered species. Such specific indicators are
21 determined by the scoping review and hot spot analysis.

22 **5.5.2. Scoping and hotspot analysis**

23 Response indicators describe the decisions and actions that can be undertaken by stakeholders
24 to mitigate pressures and improve the state of biodiversity. The stakeholders will vary with
25 the scale and the farming system and may include policy makers, sustainability managers and
26 farmers/livestock managers (users). Decisions and actions cover laws, incentives,
27 certifications, biodiversity management plans or practices. A strength of response indicators is
28 that they can describe decisions and actions that target improvement in both pressure
29 indicators and state indicators.

30 **Scoping review** – The purpose of the scoping review is to identify the most important drivers
31 of biodiversity change in the area under consideration. The main drivers of biodiversity
32 change are outlined in Figure 8 and include habitat change, nutrient pollution, over-
33 exploitation, climate change and invasive species. The boundary should include habitat areas
34 adjacent to, or potentially impacted by the livestock operation, for example waterways and

Principles for the assessment of livestock impacts on biodiversity

1 wildlife corridors. The biodiversity impacts of off farm feed production should also be
2 included within the boundary.

3 **Hotspot analysis** – Qualitative hotspot analysis identifies the relative importance of the
4 different drivers of biodiversity change, and should prioritise those drivers that can be
5 controlled or influenced by the land manager (or user). Categories or drivers under the control
6 of the land manager are not confined to the selected area but include pressures that impact
7 surrounding or connected areas. For example, an extensive grazing system may exert very low
8 nutrient pressure in its own area but may exert greater nutrient pressure on aquatic
9 biodiversity in adjacent water ways through nutrient and sediment run-off (Case Study 2).
10 When conducting hotspot analysis particular attention should be paid to pressures potentially
11 affecting protected areas and species.

12 An example of using hotspot analysis to identify the most critical driver is provided in Case
13 Study 4. In this example the driver of biodiversity change is traditional livestock grazing, and
14 removal of livestock reduces biodiversity, whereas in other areas removal of livestock can
15 enhance biodiversity (e.g. in semi-arid areas or in landscapes with a short grazing history;
16 Milchunas *et al.*, 1988). For a fully housed, intensive livestock enterprise with full nutrient
17 capture and water recycling, the critical drivers for biodiversity change are likely to be located
18 where feed is sourced and produced.

19 **5.5.3. Principles**

20 **Minimal requirement** – Response indicators should be based on scientifically sound,
21 verifiable evidence detailing a clear link between adoption of the response indicator and the
22 expected biodiversity outcome. There is a significant body of research available to aid the
23 identification of context-relevant response indicators for livestock systems in Europe, North
24 America and Oceania. In regions where these data may be lacking, or have significant gaps,
25 selection of response indicators should be informed by an adaptive outcome-based
26 management approach founded on regular monitoring of changes in pressure and state
27 indicators in response to actions taken by stakeholders.

28 **Indicator selection** – Selection of effective response indicators requires a good understanding
29 of (i) the baseline conditions and (ii) the drivers of biodiversity change, both positive and
30 negative.

- 31 • **Baseline conditions**

32 When selecting response indicators, the baseline condition encompasses more than just the
33 current state of biodiversity. As response indicators reflect actions and decisions implemented
34 by stakeholders, an understanding of the social, cultural and economic and biophysical assets
35 is also required. For example, a key economic barrier is security of land tenure; nomadic
36 graziers with no land tenure have limited potential to implement biodiversity response
37 indicators, in contrast to corporate-owned, intensive livestock systems.

Principles for the assessment of livestock impacts on biodiversity

1 An understanding of the effectiveness of existing biodiversity regulations and policies is
2 essential when prioritising non-regulated response indicators in comparison to regulated
3 response indicators. Although many countries have regulated biodiversity response indicators
4 (such as banning deforestation and protection of threatened species habitat), they are not
5 always effectively implemented. Some countries may have minimal regulation but have
6 effective stakeholder-initiated programs e.g. Dairying for Tomorrow (Australia), and
7 increased recognition of the value of permanent grasslands for providing ecosystem services
8 (Case Study 5, France).

9 The level of biodiversity management knowledge and skills among livestock enterprise
10 managers and their advisors is also an important consideration as is access to biodiversity
11 education programs and financial support to help implement biodiversity response actions.

12 • Drivers of biodiversity change

13 At the farm scale, the most important drivers can either be listed/organized based on Figure 8,
14 or based on the framework for Good Agricultural Practices (GAP) formalized by the FAO
15 Committee on Agriculture in 2003 (<http://www.fao.org/docrep/meeting/006/y8704e.htm>).

16 **5.5.4. Farm-scale response indicators**

17 These are actions or management practices implemented on the farm to limit its negative
18 effects on biodiversity, for example minimizing the impact of operations such as tillage and
19 agrochemical use on wildlife, establishing protected areas on river banks and around ponds to
20 reduce the run-off of agrochemicals and erosion which can cause sediment loads in waterways
21 and coastal lagoons, prohibiting wildlife habitat destruction and hunting, and controlling of
22 invasion of weeds and pest animals. Depending on the system, farm-scale planning as part of
23 sustainability initiatives can also pose questions such as are there actions on the farm to:
24 promote biodiversity-friendly practices such as planting of wildlife/connectivity corridors;
25 preserve field margins that constitute habitats for insects providing pest control and
26 pollination; promote a diverse cropping pattern, and; reduce invasive and predatory species?
27 Selected farm response indicators may include both qualitative and quantitative indicators.
28 Qualitative response indicators may include: developing a biodiversity action plan; existence
29 of (counter-active) compensation for wildlife habitat destruction, or; participation in industry
30 and/or public community biodiversity programs, including biodiversity education programs.
31 Examples of quantitative indicators include the proportion of farm area managed according to
32 biodiversity-friendly practices; metres of riparian zone fenced to exclude livestock; trends in
33 measures such as species numbers; ground cover or reduction in pest animals as identified in
34 monitoring activities.

35 In summary, farm-scale response indicators must:

- 36 • fit within the Good Agricultural Practice Framework by FAO or any equivalent
37 recommendations,

Principles for the assessment of livestock impacts on biodiversity

- 1 • be consistent with proposed pressure and state indicators,
2 • be supported by education actions⁶ conducted on the farm or with the community to
3 inform people on local biodiversity, preservation priorities, and on the effects of
4 agricultural practices and landscape features on biodiversity, and;
5 • aim to overcome the financial barriers to adoption of biodiversity-friendly practices.
6 For instance, in Colombia a recent rural capital incentive aims to promote the planting
7 of trees. As it does not depend on farm size or farmer's capital, this incentive is
8 available to all farmers (Murgeitio *et al.*, 2011). More globally, the amount of funding
9 for sustainable development can be seen as a response indicator.

10

11 Education actions can be included as response indicators (i.e. *Agricultural education and*
12 *extension*, and *Agricultural research intensity ratio*) in the UN working list of SDI (1996)
13 together with more classical indicators based on land use and percentage of protected areas. In
14 the UN Core Indicators (2001), the response indicator associated with biodiversity
15 preservation was also the *Extent of protected area as a percent of total area*; it focussed on
16 ecosystem preservation and combined with two state indicators: *Area of selected key*
17 *ecosystems* and *Abundance of selected key species*.

18 **5.5.5. Sector Response Indicators**

19 Sector-specific biodiversity response indicators are developed by livestock sector
20 organisations, corporate sustainability consortia (e.g. Sustainable Agricultural Initiative - SAI
21 Platform, Global Roundtable for Sustainable Beef⁷ and other initiatives (e.g. Unilever
22 Sustainable Agriculture Code, Dairy Implementation Guide⁸, SAI Platform Farmer Self-
23 Assessment 2.0).

24 Biodiversity response indicators developed by the sector tend to be qualitative as opposed to
25 quantitative, to allow for multiple regional approaches to achieving biodiversity outcomes.
26 The rationale is that the broad range of ecosystems in which livestock production occurs
27 makes it unrealistic to develop a 'one-size-fits-all' global standard for pressure and state
28 indicators. The majority of sector sustainability guidelines recommend the development of a
29 farm- or enterprise-scale Biodiversity Action Plan as a key response indicator. For example,
30 the Global Roundtable for Sustainable Beef considers context-specific elements, including
31 metrics, that are only applicable in a narrow range of environments and systems and therefore
32 need to be developed at the regional or local level.

⁶ Education actions were mentioned as response indicators (i.e. *Agricultural education and extension*, and *Agricultural research intensity ratio*) in the UN working list of SDI (1996) together with more classical indicators based to land use and percent of protected areas. In the UN Core Indicators (2001), the response indicator associated with biodiversity preservation was also the *Extent of protected area as a percent of total area*; it focussed on ecosystem preservation and combined with two state indicators: *Area of selected key ecosystems* and *Abundance of selected key species*. Interestingly, it also combined with institutional response indicators that are National sustainable development strategy, Implementation of ratified global agreements, and Expenditure on Research and Development as a percent of Gross Domestic Product.

⁷ <http://grsbeef.org>

⁸ <http://www.growingforthefuture.com/unileverimpguid/>

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31

Examples of sector initiatives and response indicators include:

SAI Platform Farmer Self-Assessment 2.0

- Priority actions to preserve biodiversity identified
- Biodiversity plan to maintain or improve biodiversity developed and implemented.
- Primary forest, wetland, peat land, and protected grassland or other native eco-systems preserved in their original condition
- Deforestation and grassland removed only if legally permitted.
- Area of habitat restored
- Livestock activities do not harm adjacent or connected biodiversity protected areas.
- Global Roundtable for Sustainable Beef Biodiversity Principles and Practices

The Global Roundtable for Sustainable Beef (GRSB, <http://grsbeef.org>) is a multi-stakeholder initiative with broad beef industry, NGO and consumer representation. In late 2014, the GRSB published a set of high-level Principles and Criteria defining sustainability across the global beef value chain. Some of the Criteria most relevant to biodiversity are listed here:

1. Environmental stewardship objectives are attained through adaptive management, with activities monitored to achieve continuous improvement of measurable natural resource management outcomes.
4. Native forests are protected from deforestation. Grasslands, other native ecosystems, and high conservation value areas are protected from land conversion and degradation.
5. Land management practices conserve and enhance the health of ecosystems and high conservation value areas throughout all sectors of the beef value chain.
6. Water resources (including quality and quantity attributes), are responsibly and efficiently managed to support ecological function and availability.
7. Soil health is maintained or improved through implementation of appropriate management practices.
8. The beef value chain contributes to the maintenance or enhancement of native plant and animal biological diversity.
9. Where available, feed sources are sustainably-produced.

Tropical Forest Alliance 2020

TFA (TFA 2020) is a public-private partnership in which partners take voluntary actions, individually and in combination, to reduce the tropical deforestation associated with the sourcing of commodities such as palm oil, soy, beef, and paper and pulp and does so by

Principles for the assessment of livestock impacts on biodiversity

1 tackling the drivers of tropical deforestation using a range of market, policy, and
2 communications approaches (for more information refer to www.tfa2020.com). TFA 2020 is
3 engaging with governments around the world, a range of civil society organizations active in
4 both producer and consumer nations, and multinational corporations.

5

6 **Field to Market: The Alliance for Sustainable Agriculture**

7 The Habitat Potential Index (HPI) for Biodiversity explores the potential impact of
8 agricultural land use on habitat quality and quantity of production and non-production lands.
9 It offers a qualitative estimate of the potential of a grower's farm to provide habitat for
10 biodiversity. Biodiversity under the HPI includes a variety of native species and ecosystems
11 that may be found on or near the farm – for example, plants, invertebrates (such as pollinators
12 and other insects), birds, mammals, reptiles and amphibians, or fish. The HPI considers
13 current land cover types present at the farm scale– including production lands and non-
14 production lands – as well as the producer's management activities (response indicators) for
15 each land cover type. Land cover types included in the HPI are crop production areas, forest,
16 grasslands and savannas, wetlands, surface waters, and edge-of-field areas such as buffer
17 strips. The approach is intended to promote practical protection and enhancement of existing
18 on-farm habitat attributes, as opposed to the conversion of production area back to pre-
19 agricultural conditions. The HPI approach emphasizes the ecological benefits afforded by
20 effective stewardship of non-agricultural and agricultural land cover types. By design, best
21 management practices and sound environmental stewardship incorporate relevant ecosystem
22 services, including biodiversity⁹.

23

24 Examples of national and international quantitative response indicators that are taken from
25 selected initiatives:

26 **Seamless¹⁰**

- 27 • Protected area as % of total land area
- 28 • Existence of national biodiversity regulations or guidelines
- 29 • Expenditure on biodiversity research in livestock systems
- 30 • Expenditure on agri-environmental education and extension relevant to biodiversity
- 31 • Amount of new or additional funding for sustainable development
- 32 • Technical cooperation grants
- 33 • Share of area under agri-environmental support

34

35 **Environmental Sustainability Index¹¹**

⁹ <https://www.fieldtomarket.org/fieldprint-calculator/>

¹⁰ p. 105, http://ageconsearch.umn.edu/bitstream/57937/2/Report_49_PD2.2.1.pdf

- 1 • Percentage of country's territory in threatened ecoregions
- 2 • Threatened bird species as percentage of known breeding bird species in each country
- 3 • Threatened mammal species as percentage of known mammal species in each country
- 4 • Threatened amphibian species as percentage of known amphibian species in each
- 5 country

6

7 **Eurostat list of Sustainable Development Indicators**

- 8 • Level II: Share of production from enterprises with a formal sustainable management
- 9 system
- 10 • Level II: Enterprises with an environmental management system
- 11 • Level III: Eco-label awards, by country and by product group
- 12 • Level II: Land use change, by category
- 13 • Level II: Exceedance of critical loads of acidifying substances and nitrogen in
- 14 nitrogen-sensitive areas.

15

16 **5.5.6. Considerations**

17 Response indicators may be general, for example the development of a Biodiversity Action
18 Plan, or they may be more specific as determined by the scoping review or hotspot analysis.
19 The decision to use more general response indicators as opposed to specific indicators will
20 depend on the goal. If the goal is continuous improvement through the adoption of good
21 practice, then a Biodiversity Action Plan is an appropriate response indicator.

22 Many sectoral sustainability tools and guidelines include biodiversity management as a
23 component of a whole farm/enterprise sustainability assessment. This approach can make
24 prioritisation of biodiversity issues over other sustainability issues difficult from the
25 perspective of an individual enterprise. There are some sector-specific biodiversity guidelines
26 and these may be a more useful resource for identifying appropriate response indicators (see
27 Table 7 for examples from Australia).

28 The potential for climate change to impact on the effectiveness of response indicators over
29 time should be considered when selecting response indicators. Some major livestock
30 producing regions are already experiencing increased climate variability and climate extremes
31 as documented in the IPCC Assessment Report; Climate Change 2014: Impacts, Adaptation,
32 and Vulnerability- Summary for policy makers [https://ipcc-](https://ipcc-wg2.gov/AR5/images/uploads/IPCC_WG2AR5_SPM_Approved.pdf)
33 [wg2.gov/AR5/images/uploads/IPCC_WG2AR5_SPM_Approved.pdf](https://ipcc-wg2.gov/AR5/images/uploads/IPCC_WG2AR5_SPM_Approved.pdf).

¹¹ <http://envirocenter.yale.edu/programs/environmental-performance-management/environmental-sustainability-index>

Principles for the assessment of livestock impacts on biodiversity

1 Possible climate change considerations when prioritising response indicators are; *Will the*
2 *response management practices be appropriate in 30 years' time, based on IPCC regional*
3 *climate change predictions?;* and, *Is the management practice likely to assist or hinder the*
4 *target species/habitat to adapt to climate change?*

5 Resources to assess potential climate change impacts on biodiversity for many key livestock
6 producing regions are available from the Convention on Biological Diversity website,
7 <http://adaptation.cbd.int/>. National and local level resources are also available, one example
8 being *Climate Change Adaptation Plan for Australian Birds*, (Garnett and Franklin, D. 2014.
9 CSIRO).

10 **Monitoring** – Response indicators are the decisions and actions taken by stakeholders to
11 improve biodiversity. Where a scientifically validated link between adoption of the response
12 indicator and the expected improvement in pressure and /or state indicators is known,
13 monitoring of actions as opposed to monitoring of species and resource condition is
14 appropriate. Where clear links do not exist an adaptive management approach based on
15 regular monitoring should be implemented. For example monitoring changes in species and/or
16 resource condition in response to the implementation of decisions and actions taken by
17 stakeholders. Stakeholder actions can then be altered if they are not achieving the desired
18 goal.

19 Monitoring of species and resource condition can be resource expensive and impractical. In
20 this situation selection of response indicators should be biased towards indicators where clear
21 links between actions and biodiversity impacts are well validated. Emerging sensor and
22 satellite technologies have the potential to enable cost effective monitoring of response
23 decisions and actions in the near future.

24 **Limitations** – A key role of response indicators is to monitor progress, both in pressure
25 indicators and state indicators. Effective implementation of response indicators is generally
26 dependent on the capacity of the livestock manager (or user) to monitor the effectiveness of
27 their actions over time and adapt where necessary. Where appropriate management capacity is
28 lacking additional support for training and education may be required. Alternatively, other
29 interested stakeholders may take on the responsibility for monitoring progress and providing
30 advice on appropriate response actions. These stakeholders may include policy makers,
31 conservation agencies, industry associations and private corporations.

32 General response indicators, such as biodiversity action plans will be limited in their capacity
33 to monitor progress against specific pressure and response indicators, for example the
34 destruction of habitat supporting a red list species. In this situation, a more specific response
35 indicator may be appropriate.

36

Principles for the assessment of livestock impacts on biodiversity

1 Table 7: Recommended biodiversity management practices for the Australian dairy industry. (Australian Dairy
2 Industry Biodiversity Action Plan template).

<ul style="list-style-type: none"> • Improving aquatic biodiversity 	<ul style="list-style-type: none"> • Habitat restoration 	<ul style="list-style-type: none"> • Building ecosystem resilience 	<ul style="list-style-type: none"> • Building skills and capacity to manage biodiversity
<ul style="list-style-type: none"> • Waterways (riparian zones) protected from nutrient runoff and stock access through fencing, buffer strips and off stream watering points • Groundcover maintained at 70% or higher • Fert\$mart¹ plan used to inform fertiliser application • Precision irrigation technologies implemented (e.g. automation) • 	<ul style="list-style-type: none"> • Remnant vegetation protected through fencing and removal of invasive (pest) species • Riparian zones replanted with appropriate native species • Connectivity corridors established between remnants where feasible • Vegetative wind and shelter breaks established around pasture • Locally threatened species have their habitat established/protected 	<ul style="list-style-type: none"> • Soil fertility enhanced through Fert\$mart planning, conservation tillage, and precision irrigation. • Fire- and climate- resilient species included in revegetation plantings 	<ul style="list-style-type: none"> • Participation in biodiversity stewardship programs (e.g. 20 Million Trees²) • Member of a local Landcare/industry NRM group³ • Species list of farm native flora and fauna maintained • Experience and knowledge of local biodiversity issues and management •

3 ¹ <http://fertsmart.dairyingfortomorrow.com.au/>

4 ² <http://www.nrm.gov.au/national/20-million-trees>

5 ³ Natural Resource Management group: <http://nrmregionsaustralia.com.au/w>

6

PART IV – Future directions

Key principles

More remains to be done to guide the quantitative assessment of impacts on biodiversity due to livestock systems. To this end, Life Cycle Assessment and PSR indicators will be key approaches. We identify a number of priority issues to improve their applicability to the assessment of biodiversity impacts due to livestock systems, as follows:

- There is a need to identify and disseminate examples of best practice in biodiversity assessments in the livestock sector. These should include examples of the effective use of LCA of biodiversity impacts for improved decision-making about livestock systems and supply chains. There is also a need for examples of the effective inclusion of life-cycle perspectives into Biodiversity Action Plans and related methods (e.g. certification standards) that rely on PSR indicators.
- A key outcome of this document is a recognition of the complementarity that can be achieved through a combinations of LCA and PSR approaches. LCA could be used to reveal supply chain or spatial hotspots for further investigation. Having broadly identified such hotspots, more detailed assessment could be achieved through use of PSR indicators. It would be highly desirable to identify examples that achieve this complementarity.

6. Future challenges for improved biodiversity assessment in LCA and its application to livestock production

Key principles

Examples of completed, quantitative Life Cycle Assessment in livestock systems are needed to provide both further guidance and examples for developing and critiquing the state-of-the-art for LCA for biodiversity. In particular, there is a need for:

- development of local characterization factors for different livestock systems;
- inclusion and recognition of positive and negative impacts
- incorporation of impacts on landscape-scale processes;
- the inclusion of several different mid-point impacts e.g. the biodiversity impacts of acidification and eutrophication that cover a large geographic area, as well as land use impacts;
- improvement of the assessment of ecosystem services in LCA;

- methods and examples of characterization for a wide variety of taxa and of the use of weighting approaches to recognise the differences in conservation value of habitats and species (e.g. IUCN designation.)

The development of LCA methodologies for biodiversity has clearly undergone a rapid and sustained development since about 2000, and considerable progress has been achieved.

A specific limitation to date is the lack of application to livestock systems. Nevertheless, there are some examples of LCA for biodiversity from other systems that may serve to inform how LCA could be implemented in livestock systems. Some of these are described in the LEAP Biodiversity Review (Teillard et al., in prep.).

Some methodological challenges remain; some of the main ones are presented here. Some of these challenges should be a priority in order to make LCA more adapted to livestock production. They include the need for:

- development of local characterisation factors for different livestock systems (e.g., intensive, mixed, extensive, pastoralism)
- the inclusion of a number of mid-point impacts e.g. the biodiversity impacts of land use, nutrient pollution acidification and eutrophication;
- further clarification of reference state and more guidance on how to make it operational. At the very least, the consequences about the specific choice of reference need to be clearly explained. The choice of the reference state has key consequences for LCA approach to allow consideration of positive effects of livestock on biodiversity. Failing to consider such positive effects is a weakness of some current LCA methods for their application to livestock production.

Other developments are needed to make LCA methodologies more ecologically relevant:

- improved inclusion and assessment of ecosystem services in LCA;
- improved inclusion of landscape-scale and spatial processes;
- methods and examples of the use of weighting approaches to recognise the differences in conservation value of habitats and species e.g. IUCN designation

Several of these challenges are discussed in more details in the next sub sections.

6.1. Inclusion of several midpoint impacts on biodiversity

The highest level of methodological development and consensus for including biodiversity impacts in LCA concerns impacts through land use. However, livestock production affects biodiversity through other midpoint impact categories. Further methodological developments will be needed to include these other categories of biodiversity impacts. For instance, climate change is the second most important driver of biodiversity loss after habitat change and it is

1 growingly influential. Livestock production has a significant production to climate change –
2 Gerber et al. (2013) estimated that GHG emissions related livestock production represented
3 14.5% of human induced emissions. To date, a single operational method exists to assess the
4 impact of GHG emissions and climate change on biodiversity in LCA (de Shryver et al.
5 2009). A single global method also exists for assessing the impact of water use (Pfister et al.
6 2009) which is another resource extensively used by livestock (e.g., 112 m³ of water are
7 necessary to produce 1kg of beef protein as estimated by Mekonnen & Hoekstra, 2012).
8 Accounting for the impact of acidification and eutrophication on biodiversity would also be
9 very important in the context of livestock production. Firstly, because some livestock systems
10 cause significant nutrient concentrations that can give rise to pollution which contributes to
11 these midpoint impacts, and because this contribution varies greatly between production
12 systems. Secondly, because considering eutrophication is key to account for impacts on
13 aquatic biodiversity while the other midpoint categories tend to focus on terrestrial
14 biodiversity. A few characterization factors are available to link acidification and
15 eutrophication to species richness, both at regional (Van Zelm et al. 2007, for acidification in
16 Europe; Struijs et al. 2011 for eutrophication in the Netherlands) and global scales (Azevedo,
17 et al. 2013a; Azevedo, et al. 2013b; Azevedo, et al. 2013c). Accurate and broadly-agreed
18 methods to address the impacts of other midpoint categories on biodiversity are needed to
19 avoid underestimating the total impact of livestock on biodiversity (see Section 7.4) and to
20 ensure that the relative impact of the wide range of livestock systems is reflected accurately.

21

22 **6.2. Biodiversity representation**

23 **6.2.1. Cross-representation of taxonomic groups**

24 The assumption that vascular plant diversity is reasonably well correlated with other
25 terrestrial species (Weidema & Lindeijer, 2001), together with their data availability, has
26 generally resulted in vascular plants being chosen as representative biodiversity indicators for
27 other taxonomic groups. However, other studies question the extent to which vascular plants
28 can serve as a predictor for all other groups (Souza *et al.*, 2015). Recent studies include other
29 taxonomic groups as arthropods, other invertebrates and vertebrates (de Baan *et al.*, 2013a)
30 mammals, birds, amphibians and reptiles (de Baan *et al.*, 2013b). Elshout *et al.* (2014)
31 recommended that species of multiple groups should be included whenever possible. Vascular
32 plants and arthropods should at least be well represented for agricultural studies.

33 **6.2.2. Inclusion of ecosystem services**

34 The activities of species in ecosystems result in services that can be environmentally, socially
35 and economically important. Such services include soil fertility, production of food and fibre,
36 nutrient cycling, supply of freshwater of sufficient quality, erosion control, pollution

1 attenuation and degradation, pollination, pest and disease control, and many others including
2 biodiversity conservation, and cultural or spiritual values associated with ecosystems. There is
3 increased scientific understanding about how biodiversity regulates the delivery of ecosystem
4 services, and there is considerable concern about the knock-on effects of biodiversity loss on
5 their delivery. Given the importance of these services to human welfare and to the integrity of
6 many livestock systems, LCA methods will be increasingly challenged to develop
7 methodologies to account for impact on ecosystem services. In the context of livestock, these
8 methodologies should allow to consider for the range of positive and negative impacts of
9 livestock systems on ecosystem services.

10

11 **6.3. Land use representation**

12 **6.3.1. Land use cover and geographic scope**

13 Existing LCA methods describe land use through relatively coarse categories, which makes
14 LCA more adapted to assessments at intermediate to large spatial scales. For small-scale
15 assessments aimed at discriminating the relative impact of different practices on biodiversity,
16 indicators are likely to need further adaptation and development.

17 In terms of land use cover and geographic scope, the approach developed by Koellner *et al.*
18 (2013b) consists of four levels of detail ranging from very general global land cover classes to
19 more refined categories and very specific categories indicating land use intensities.
20 Regionalisation is built on five levels, first distinguishing between terrestrial, freshwater, and
21 marine biomes and further specifying climatic regions, specific biomes, eco-regions and
22 finally indicating the exact geo-referenced information of land use. Unfortunately, there are
23 not yet characterisation factors for every scenario, but this seems a promising approach to
24 advance their development.

25 **6.3.2. Incorporation of landscape-scale processes**

26 A limitation of LCA for biodiversity is that it may underestimate biodiversity impacts through
27 low ability to measure the disruption of landscape-scale processes that support species'
28 populations. Land use occupation can not only alter the species richness in the local area that
29 is occupied, but may also have impacts across the wider region. These different scales of
30 damage are known as local and regional. The local damage describes the change in species
31 richness on the occupied area compared with the species richness on the baseline state of land
32 use. The regional damage describes the species change in the surrounding area (de Schryver *et*
33 *al.*, 2010).

34

1 **6.4. Reference states for biodiversity**

2 **6.4.1. Choice of reference state in LCAs for biodiversity**

3 As mentioned above, the use of a reference state is a common feature of LCA approaches that
4 aim to assess the impact of LULUC on biodiversity. The reference state serves as a baseline
5 that generally reflects the situation that would occur after the cessation of human influence,
6 and can be used as a comparison for the biodiversity effects of alternative land classes/covers
7 and as a measure of biodiversity impacts resulting from LULUC (Figure 11). The choice of a
8 reference state reflects value judgements and the goal of the assessment. It is a critical issue
9 because it has an important influence on the results of the assessment. Natural vegetation is
10 often considered as the reference state, and reflects the biodiversity level of vegetation that
11 would have occurred in the absence of human influence. Through comparison of the
12 biodiversity state of different land uses/covers, LCA aims to develop characterisation factors
13 that reflect the impact of land transformation and occupation on biodiversity. The
14 UNEP/SETAC Life Cycle Initiative is currently (2014-2015) hosting a platform to build
15 consensus on existing methodologies to assess the impacts of land use on biodiversity in
16 LCA, taking into account different aspects, including the choice of baseline for comparison of
17 impacts.

18 **6.4.2. What is currently done?**

19 The LEAP Biodiversity Review (Teillard et al., in prep.) refers to a number of different
20 approaches to assess the impacts of land use on biodiversity, including the Ecological
21 Damage Potential; the ReCiPe methodology; and the Mean Species Abundance.

22 The UNEP/SETAC Life Cycle Initiative recommended the use of the potential natural
23 vegetation (PNV) as a reference when assessing land use impact on a global scale (Koellner &
24 Geyer, 2013). However, it is also acknowledged that the definition of the reference state
25 requires further exploration; depending on the goal and scope of a study, a different choice of
26 reference state might be more appropriate (see below for further discussion).

27 As mentioned in Section 6.4.1, the choice of the reference state is not obvious, and can
28 involve value choices that have considerable consequences for assessment of impacts and
29 interpretation. This is an area in which there is likely to be on-going need for discussion, and
30 development of guidance on best practice. A number of different considerations and caveats
31 occur about the choice of reference state and the consequent development of characterisation
32 factors (reviewed in Souza *et al.*, 2015; see also Milà i Canals, 2014).

33 **6.4.3. Geographical scale of the metrics for PNV**

34 Recent years have seen an impressive increase in the data that is available to develop
35 quantitative estimates of the reference state of biodiversity that is associated with a range of
36 biomes and eco-regions (e.g. Mueller-Wenk, 1997; Weidema & Lindeijer, 2001; Koellner &

Principles for the assessment of livestock impacts on biodiversity

1 Scholz, 2008; Alkemade *et al.* 2009). These approaches allow LCA practitioners to achieve
2 geographically broad-scale assessments that can reflect the global inter-linkages of supply
3 chains associated with livestock systems e.g. de Baan *et al.* (2014); Geyer *et al.* (2010a,b).
4 These general approaches can facilitate assessments that do not have detailed and local
5 availability of information on how biodiversity is affected by livestock systems. In addition to
6 these large scale assessments, however, there is also a recognised need for more locally-
7 adapted LCAs that will use more locally-relevant data for the development of characterisation
8 factors.

9 The use of local data has some advantages: in principle, there may be excellent local
10 availability of data on the state of biodiversity across different livestock systems and reference
11 states. Such data can allow the calculation of characterisation factors that better reflect the
12 state of local biodiversity in different land use types/cover and allow them to be used in more
13 locally-specific LCA studies. This may allow the comparison between, for example, different
14 levels of grazing pressure which may exist, ranging from: undergrazed; extensively grazed on
15 semi-natural pastures; intensively grazed on grass monocultures and/or imported feed, to;
16 overgrazed). In addition, there may be data on biodiversity responses to the relaxation of
17 grazing pressure, whether it be from overgrazed to intensively grazed, or from extensively
18 grazed to no grazing. Where such examples can be used to develop local characterisation
19 factors, a strong advantage is the possibility to conduct very detailed LCAs with a high degree
20 of precision to inform about the relative impacts of different aspects of livestock systems at
21 the local scale. Looking to future assessments, it is likely that there will be an increase in the
22 incidence of LCAs taking into account impacts on biodiversity, requiring the use of more of
23 the 'bottom-up' approaches, and there may be a benefit from hybrid approaches that combine
24 the bottom-up and top-down approaches.

25 **6.4.4. Choice of reference state and representation of positive influences of livestock** 26 **systems**

27 There are several alternatives for selection of a reference state. In addition to potential natural
28 vegetation, these include the use of historical land cover types; the natural climax vegetation,
29 the current land cover in the absence of human activity, and mosaics of land cover types at a
30 specific time. In practice, the use of historical land cover types as reference states gives
31 similar weights to land use impacts that are currently occurring (e.g. contemporary tropical
32 deforestation) and land use impacts that occurred a long time ago (e.g. deforestation of
33 European woodlands). Therefore, with this approach, species-rich grasslands in Europe are
34 seen as deforested areas and the impact on biodiversity appears to be mostly negative.
35 Alternatively, the selection of recent land use states as the reference state (e.g., land cover in
36 year 2000) results in a higher impact for current land use change processes, and historical land
37 transformations are treated as a sunk cost. With this approach, although there cannot be a
38 positive effect of land use that continues to support livestock production, it can be neutral if

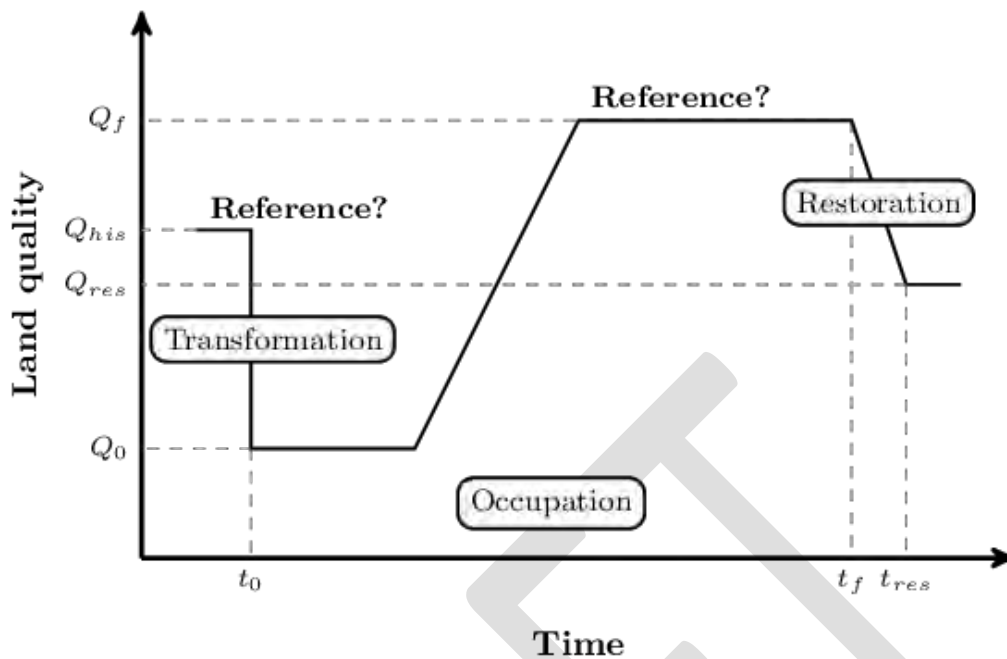
Principles for the assessment of livestock impacts on biodiversity

1 no land use change has occurred since the reference year. To improve the quality of
2 interpretation of impacts, Koellner & Geyer (2013) advised practitioners to compare the
3 effects on the results of the potential natural vegetation *versus* the current land use mix.

4 An important caveat of existing LCA methodologies is that they may not necessarily consider
5 all of the positive impacts of livestock on biodiversity (Section 6.4.1) Characterisation factors
6 are typically calculated based on an undisturbed reference state that corresponds to the
7 counterfactual situation that would occur in the absence of human activity, and informs the
8 quantification of the full complement of species against which the effect of human activity
9 can be compared. From this perspective, land uses that support livestock production are
10 considered as a disturbed state involving a loss of biodiversity. Characterisation factors are
11 not adapted to more specific situations in the context of livestock production; for instance,
12 when livestock maintains key biodiversity habitats and when the abandonment of production
13 leads to biodiversity loss (LEAP Biodiversity Review, Teillard et al., in prep.). Such specific
14 situations would have to be added to existing biodiversity LCA methodologies in order to
15 make them relevant to the livestock sector.

16 For example, many grazed semi-natural grasslands in Europe (and elsewhere) illustrate such a
17 situation, idealized in Figure 16. Conversion from forest/woodland to pastures (land
18 transformation) and the associated decrease in biodiversity took place hundreds of years ago.
19 The very long duration and the extensive nature of the land occupation for livestock farming
20 have allowed time for a unique biodiversity to co-evolve with grazing. Today, when livestock
21 farming is abandoned in these semi-natural grassland areas, the natural process of habitat
22 succession to original forest results in a loss of biodiversity (See Case Studies 4 and 5).

1



2

3 Figure 16: Evolution of land quality over time, as a result of land transformation and occupation. Idealized
 4 situation that could apply to the livestock context: occupation lasts for a very long time and biodiversity adapts
 5 to it. *his* = historical, *0* = initial (after land transformation and at the beginning of land occupation), *f* = final (at
 6 the end of land occupation), *res* = restoration (at the end of restoration). Source: LEAP Biodiversity Review
 7 (Teillard et al., in prep.)

8

9 7. Future priorities for LEAP & Biodiversity

10 7.1. Ensure links between LEAP and other biodiversity initiatives

11 Many (but certainly not all) current initiatives by the livestock and food sector are indicated in
 12 Section 5.5, and these suggest a strong reliance on PSR indicators (response indicators in
 13 particular) as opposed to LCA. There is considerable opportunity for LEAP to continue to
 14 provide guidance to the sector, and also to learn from the sector about its most pressing needs
 15 for biodiversity assessment, and assist in addressing these needs.

16 Future work can build on existing examples of guidance for biodiversity conservation for
 17 commercial sectors, which could be tailored for livestock systems. For example, the Open
 18 Standards for the Practice of Conservation provides tools and stepwise methodology for
 19 scoping (conceptual models), strategic planning, and monitoring impacts on conservation
 20 goals¹². This is likely most useful for PSR-type assessment at the farm, landscape, national, or
 21 regional level. At the level of supply chains, the Business and Biodiversity Offsets

¹² <http://cmp-openstandards.org/>

Principles for the assessment of livestock impacts on biodiversity

1 Programme (BBOP¹³), and especially their standards and guidelines for companies ‘Standards
2 on Biodiversity Offsets¹⁴’. Similarly, the International Finance Corporation has developed
3 Sustainability Performance Standards that include ‘Performance Standard 6: Biodiversity
4 Conservation and Sustainable Management of Living Natural Resources¹⁵’.

5 The livestock and related industries have continued to develop approaches to guide the
6 adoption of more sustainable production practices, and these include biodiversity to varying
7 extents. Several of these are mentioned in Section 5, and there are other examples e.g. the
8 Round Table on Responsible Soy certification scheme includes reference to biodiversity
9 (<http://www.responsiblesoy.org/>). There is obviously a demand for best practice in the design
10 and assessment of the biodiversity standards in certification schemes, and this should feature
11 in future LEAP initiatives.

12 For many years, NGOs have championed the awareness and practical development of
13 biodiversity conservation, including programmes for livestock production. LEAP should
14 continue to maintain professional links with NGOs, and ensure that their expertise is
15 maintained in the future work of LEAP on biodiversity.

16 It has been recognized that the LCA approach for biodiversity assessment needs substantial
17 improvements as it is unable to grasp the real and complex dynamics of ecosystem
18 interactions (Milà i Canals *et al.* 2014; Souza *et al.* 2015). Souza *et al.* (2015) discuss some of
19 the issues to be improved, such as the choice of appropriate ecological model; the
20 identification of adequate surrogate species and indicators and; the integration of the spatial
21 and temporal variability of biodiversity and biological processes. Life cycle inventory flows
22 need more refinement, in order to incorporate the differences between different management
23 practices. These methodological constraints and the lack of agreement on the application of
24 currently existing models led the UNEP/SETAC Life Cycle Initiative¹⁶ to conduct a deeper
25 analysis of the land use impact assessment framework, aiming to provide global guidance and
26 consensus building on important aspects of impact categories such as land use (Jolliet *et al.*
27 2014). According to Milà i Canals *et al.* (2014), the lack of consensus also imposes
28 constraints on the comparison of land use impact results among two or more studies. There is
29 an on-going need for LEAP to maintain communication with UNEP-SETAC as it continues
30 its work to develop LCA methods for biodiversity. There will also be an on-going need to
31 articulate the more general UNEP-SETAC guidelines with the more specific needs of
32 livestock systems. This ensures a role for LEAP to further contribute to the development of
33 LCA approaches that recognise and incorporate the needs of livestock systems.

34

¹³ <http://bbop.forest-trends.org/>

¹⁴ http://www.forest-trends.org/documents/files/doc_3078.pdf

¹⁵ <http://www.ifc.org>

¹⁶ <http://www.lifecycleinitiative.org/>

1 **7.2. Identify best practices in Biodiversity Action Plans**

2 From this description, there is a clear overlap between the development of BAPs for livestock
3 systems and these LEAP principles for assessment of biodiversity impacts. Looking to the
4 future, it would be highly desirable to identify examples of best practice in the development,
5 implementation and assessment of Biodiversity Action Plans in livestock systems, especially
6 those that have a transparent process for qualitative and quantitative evaluation of the
7 Biodiversity Action Plan. The following list provides examples of elements of a Biodiversity
8 Action Plan for livestock systems that largely relies on PSR indicators, and uses these to
9 include a life cycle perspective (Sections 2.3.2 and 5.1). As well as corresponding with the
10 principles in Section 5.1, specific features to exemplify would include the following:

- 11 • identification of biodiversity goals;
- 12 • clear statement of the method and outcome of scoping and hotspot analyses
- 13 • recognition of off-farm impacts
- 14 • approaches that recognise and differentiate between habitats of high conservation
- 15 value and more common farmland habitats;
- 16 • selection of quantitative indicators;
- 17 • practical management strategies undertaken by farmers;
- 18 • implementation of a well-designed monitoring programme;
- 19 • valid and objective analysis of data;
- 20 • use of data to confirm success or the need to further improve management;
- 21 • successful knowledge transfer to farmers;
- 22 • wider communication of the biodiversity benefits and achievements in agricultural
- 23 sustainability;
- 24 • use of mitigation of biodiversity impacts to improve green labelling and business
- 25 performance.

26 A key message from these LEAP principles is the complementarity between LCA and PSR
27 approaches (Section 2.3). It is highly desirable to identify and disseminate examples of best
28 practice that demonstrate the effective complementarity in scope, perspective and
29 quantification that can exist between LCA and PSR indicators. As mentioned in Section 2.3.1,
30 this might be in the form of an LCA assessment of impacts on biodiversity at large spatial
31 scales and to reveal hotspots of impact along the supply chain or among spatial entities. Once
32 supply chain or spatial hotspots are identified, PSR indicators can be used to conduct further
33 investigation with more detailed assessment methods. The use of PSR indicators may be more
34 readily adapted to differentiate the effect of different livestock practices. Within an identified
35 hotspot, PSR indicators might also be used to expand the assessment to, for example, provide
36 more information on other pressures, other biodiversity levels and taxa and to include impacts
37 on ecosystem services.

1

2 **7.3. Improved identification of biodiversity indicators for livestock systems**

3 The LEAP Biodiversity Review (Teillard et al., in prep.) provides several examples of
4 indicators that could be used in compliance with these LEAP principles for assessment of
5 biodiversity impacts, which make these two documents interdependent. A next step towards
6 consistency and operationality should be to recommend specific indicators, i.e. key
7 performance indicators (KPIs) for biodiversity in livestock systems. Potentially different
8 indicators would be recommended for different users, livestock production systems and
9 regions, because the main biodiversity issues vary among these categories. Additional reviews
10 of the literature and expert consultation would be necessary to identify these issues and
11 corresponding KPIs. The final outcome would be a toolbox that details indicators for each
12 system along with guidelines for their calculation. The development of such a toolbox would
13 also be an opportunity to target an audience of users that are not biodiversity specialists, by
14 providing ready-to-use indicators and simple guidelines on how to apply them. Such a toolbox
15 should include a decision-support step that aims to recognise different goals, different
16 ecological contexts, and different livestock systems, and provide guidance on the most
17 relevant indicators. A specific challenge will be to define and address the needs of the
18 ‘audience of users’, which may vary in nature to include individual farmers and producers,
19 national governments, livestock processing companies, certification schemes, and those
20 conducting regional- to global-scale assessments of livestock impacts.

21 **7.4. Progress towards comprehensive environmental assessments in LEAP**

22 Because, ideally, livestock assessment relies on several environmental impact categories (e.g.,
23 land use, climate change, water, nutrient pollution, biodiversity), there is a need for a more
24 holistic assessment of the environmental performance of livestock supply chains.

25 With these principles for biodiversity assessment, there is a great opportunity to expand the
26 scope of the LEAP sector guidelines (for feed, poultry, small and large ruminants, and pigs) to
27 include the environmental category of biodiversity. This would require specific changes
28 during the next revision of the LEAP sector guidelines. As part of future activity, a parallel
29 review will identify what elements of the sector guidelines can be used as an input for the
30 biodiversity assessment, and where additional efforts will have to be invested. In particular,
31 this will concern currently available data for inventory flows and midpoint impact categories
32 that can be used as pressure indicators for biodiversity, or transformed into a biodiversity
33 value using proper characterisation factors. For instance, the LEAP Animal Feed Guidelines
34 cover land occupation as a midpoint impact category. Limited additional effort would be
35 needed to provide guidance on how to measure land use (within different categories), which is
36 a crucial category in biodiversity LCIA. A parallel revision of the biodiversity guidelines will

Principles for the assessment of livestock impacts on biodiversity

1 ensure that the link between these outputs of the sector guidelines and the biodiversity
2 assessment is straightforward. The Biodiversity Principles will have to be properly cited along
3 the sector guidelines, and specific elements could also be inserted into the main text of other
4 LEAP sector guidelines.

5 As a future priority, a joint case study should be developed in order to illustrate how multiple
6 impact categories - e.g., GHG emissions and biodiversity - can be assessed for the same
7 livestock system. It will show which data and LCI elements are common for the two criteria
8 and which of them are different. It will also indicate how to inform on the synergies and
9 trade-offs between the two criteria, which can be a very important issue in multi-criteria
10 assessment.

11 The LCA methodologies for assessing impacts of land use on biodiversity need further
12 development (Section 6). Nevertheless, a focus on land use impacts alone will be insufficient
13 to capture the full impacts of livestock systems on biodiversity and ecosystem services
14 (Section 6.1). The full characterisation of the livestock effects of the range of global livestock
15 systems will not be properly reflected until LCA methods can incorporate multiple
16 environmental dimensions e.g. water use, biodiversity, carbon dynamics, soil quality. A first
17 step toward meeting this challenge would be to conduct a joint LCA that assesses, for
18 example, both the biodiversity and climate change effects associated with a specific livestock
19 system. To our knowledge, this would be one of the first times that such a combined LCA
20 approach would be undertaken within a livestock system.

21 This is a challenging goal, but a necessary requirement if we are to have more complete
22 guidance on the environmental consequences of choices and decisions about the design and
23 management of livestock systems. In the absence of such more holistic approaches, then there
24 will remain the possibility of pollution swapping, and unrecognised trade-offs among
25 different dimensions of agri-environmental sustainability.

26

27

References

- 1
- 2
- 3 Andrén, H. (1994) Effects of Habitat Fragmentation on Birds and Mammals in Landscapes with
4 Different Proportions of Suitable Habitat: A Review. *Oikos*, 71, 355-366.
- 5 Alexandratos and Bruinsma, 2012 p. 9
- 6 Archibald, E.E.A. (1949). The specific character of plant communities: II. A quantitative approach.
7 *The Journal of Ecology*, pp. 274–288.
- 8 Arrhenius, O. (1921). Species and area. *Journal of Ecology*, 9, 95–99.
- 9 Azevedo, L.B., Henderson, A.D., et al., 2013a. Assessing the importance of spatial variability versus
10 model choices in life cycle impact assessment: the case of freshwater eutrophication in Europe.
11 *Environmental science & technology*, 47(23), pp.13565–13570.
- 12 Azevedo, L.B., van Zelm, R., et al., 2013b. Global assessment of the effects of terrestrial acidification
13 on plant species richness. *Environmental Pollution*, 174, pp.10–15.
- 14 Azevedo, L.B., Zelm, R., et al., 2013c. Species richness--phosphorus relationships for lakes and
15 streams worldwide. *Global Ecology and Biogeography*, 22(12), pp.1304–1314.
- 16 Bare JC, Hofstetter P, Pennington DW, Udo de Haes HA (2000) Life Cycle Impact Assessment
17 Workshop Summary: Midpoints versus Endpoints: The Sacrifices and Benefits. *The International
18 Journal of Life Cycle Assessment* 5(6). 319-326.
- 19 Campbell, N.A. (1996). *Biology*, 4th Edition. The Benjamin/Cummings Publishing Company,
20 Inc., Menlo Park, California.
- 21 CBD, 2006)
- 22 Chytrý M (1998) Potential replacement vegetation: an approach to vegetation mapping of cultural
23 landscapes. *Applied Vegetation Science*, 1, 177-188.
- 24 Connor EF & Mccoy ED. (2001). Species-area relationships. *Encyclopaedia of biodiversity*. Volume
25 5.
- 26 Curran M (1996) *Environmental Life-Cycle Assessment*, pp. 432. McGraw-Hill, New York.
- 27 Curran, M., de Baan, L., De Schryver, A.M., Van Zelm, R., Hellweg, S., Koellner, T., Sonnemann, G.
28 & Huijbregts, M.a.J. (2011). Toward meaningful end points of biodiversity in life cycle
29 assessment. *Environmental science & technology*, 45, 70–9.
- 30 de Baan, L., Alkemade, R. & Koellner, T. (2013a). Land use impacts on biodiversity in LCA: a global
31 approach. *The International Journal of Life Cycle Assessment*, 18, 1216–1230.
- 32 de Baan L, Mutel CL, Curran M, Hellweg S, Koellner T (2013b) Land Use in Life Cycle Assessment:
33 Global Characterization Factors Based on Regional and Global Potential Species Extinction.
34 *Environmental Science & Technology*, 47, 9281–9290.
- 35 de Schryver, A.M., Brakkee, K.W., Goedkoop, M.J. & Huijbregts, M.A.J. (2009) Characterization
36 Factors for Global Warming in Life Cycle Assessment Based on Damages to Humans and
37 Ecosystems. *Environmental Science & Technology*, 43, 1689-1695.

Principles for the assessment of livestock impacts on biodiversity

- 1 Dros, M. Jan 2004. Managing the soy boom: Two scenarios of soy production expansion in South
2 America, AIDEnvironment, Amsterdam.
- 3 (EEA, 2007)
- 4 Elshout *et al.* (2014 p.90
- 5 European Commission (2000) Directive 2000/53/EC of the European Parliament and of the Council of
6 18 September 2000 on end-of life vehicles - Commission Statements.
- 7 European Commission (2003) Communication from the Commission to the Council and the European
8 Parliament. COM(2003) 302 Integrated Product Policy: Building on Environmental Life Cycle
9 Thinking.
- 10 European Commission (2004) Directive 2004/12/EC of the European Parliament and of the Council of
11 11 February 2004 amending Directive 94/62/EC on packaging and packaging waste.
- 12 European Commission (2011) Communication from the Commission to the European Parliament, the
13 Council, the European Economic and Social Committee and the Committee of the regions
14 COM(2011) 571: Roadmap to a Resource Efficient Europe.
- 15 FAO (2013) ROLES OF SMALL-SCALE LIVESTOCK KEEPERS IN THE CONSERVATION
16 AND SUSTAINABLE USE OF ANIMAL GENETIC RESOURCES. Fourteenth Regular
17 Session of the COMMISSION ON GENETIC RESOURCES FOR FOOD AND
18 AGRICULTURE.
- 19 Finn, J.A. and Ó hUallacháin, D. 2012. A review of evidence for the environmental effectiveness of
20 Ireland's Rural Environmental Protection Scheme. *Biology and Environment* 112B: 1-24.
- 21 Finnvenden *et al.*, 2009
- 22 Frankl P, Rubik F (2000) Life Cycle Assessment in Industry and Business: adoption of patterns,
23 applications and implications. Springer-Verlag, Berlin.
- 24 Garnett and Franklin, D. 2014. CSIRO p.84
- 25 Geyer R, Lindner J., Stoms, D., Davis, F&., Wittstock, B. (2010a). Coupling GIS and LCA for
26 biodiversity assessments of land use. Part 2: Impact assessment. *The International Journal of Life
27 Cycle Assessment*, **15**, 467692–703.
- 28 Geyer R, Stoms D, Lindner J, Davis F, Wittstock B (2010b). Coupling GIS and LCA for biodiversity
29 assessments of land use. Part 1: Inventory modeling. *The International Journal of Life Cycle
30 Assessment*, **15**, 454–467.
- 31 Gleason HA (1925). Species and area. *Ecology*, **6**, 66–74.
- 32 Goedkoop M, Huijbregts M, Heijungs R, De Schryver A, Struijs J, van Zelm R. (2012). ReCiPe 2008.
33 A life cycle impact assessment method which comprises harmonised category indicators at the
34 midpoint and the endpoint level. First edition (revised). Tech. rep.
- 35 Guerci M, Knudsen MT, Bava L, Zucali M, Schönbach P, Kristensen T (2013) Parameters affecting
36 the environmental impact of a range of dairy farming systems in Denmark, Germany and Italy.
37 *Journal of Cleaner Production*, **54**, 133–141.

Principles for the assessment of livestock impacts on biodiversity

- 1 Hauschild MZ (2005) Assessing environmental impacts in a life cycle perspective. *Environmental*
2 *Science & Technology* **39**(4):81-88A.
- 3 IFC (2012) Performance Standard for Biodiversity Conservation and Sustainable Management of
4 Living Natural Resources. International Finance Corporation.
- 5 ISO (2006a) ISO 14040. Environmental Management - Life Cycle Assessment – Principles and
6 framework. International Organization for Standardization, Geneva, p. 20.
- 7 ISO (2006b) ISO 14044. Environmental Management - Life Cycle Assessment – Requirements and
8 Guidelines. International Organization for Standardization, Geneva, pp. 46.
- 9 Jenkins, C. N., Pimm, S. L., & Joppa, L. N. (2013). Global patterns of terrestrial vertebrate diversity
10 and conservation. *Proceedings of the National Academy of Sciences*, 110(28), E2602-E2610.
- 11 Jolliet O, Frischknecht R, Bare J, Boulay A-M, Bulle C, Fantke P, Gheewala S, Hauschild M, Itsubo
12 N, Margni M, McKone TE, Milà i Canals L, Postuma L, Prado-Lopez V, Ridoutt B, Sonnemann G,
13 Rosenbaum RK, Seager T, Struijs J, van Zelm R, Vigon B, Weisbrod A with contributions of the
14 other workshop participants (2014) Global guidance on environmental life cycle impact assessment
15 indicators: findings of the scoping phase. *The International Journal of Life Cycle Assessment*, **19**,
16 962-967.
- 17 Koellner T, Baan L, Beck T, Brandão M, Civit B, Goedkoop M, Margni M, Milà I Canals L, Müller-
18 Wenk R, Weidema B, Wittstock B (2013a). Principles for life cycle inventories of land use on a
19 global scale. *The International Journal of Life Cycle Assessment*, 18, 1203–1215.
- 20 Koellner T, de Baan L, Beck T, Brandão M, Civit B, Margni M, Milà i Canals L, Saad R, Souza DM,
21 Müller-Wenk R. (2013b). UNEP-SETAC guideline on global land use impact assessment on
22 biodiversity and ecosystem services in LCA. *The International Journal of Life Cycle Assessment*,
23 18, 1188-1202.
- 24 Koellner T, Scholz R (2008). Assessment of land use impacts on the natural environment-Part 2:
25 Generic characterization factors for local species diversity in Central Europe. *International Journal*
26 *of Life Cycle Assessment*, 13, 32–48.
- 27 Ladle and Whittaker, 2011
- 28 Mekonnen & Hoekstra 2012. A Global Assessment of the Water Footprint of Farm Animal Products,
29 *Ecosystems* (2012) 15: 401–415
- 30 Michelsen O (2008). Assessment of land use impact on biodiversity: proposal of a new methodology
31 exemplified with forestry operations in Norway. *The International Journal of Life Cycle*
32 *Assessment*, **13**, 22-31.
- 33 Milà i Canals L, Bauer C, Depestele J., Dubreuil A, Knuchel RF, Gaillard G, Michelsen O, Müller-
34 Wenk R, Rydgren B (2007). Key elements in a framework for land use impact assessment within
35 LCA. *The International Journal of Life Cycle Assessment*, **12**, 5–15.
- 36 Milà i Canals, L., Michelsen O, Teixeira RFM, Souza DM, Curran M, Assumpció A (2014) Building
37 consensus for assessing land use impacts on biodiversity in LCA. In 9th International Conference
38 LCA Food 2014, San Francisco, USA. Available at <http://lcafood2014.org/papers/128.pdf>.
- 39 Milà i Canals L, de Baan L (in press) Land Use. In: Hauschild M and Huijbregts M Life Cycle Impact
40 Assessment, Volume 4 in *The Life Cycle Assessment Encyclopaedia*. Springer.

Principles for the assessment of livestock impacts on biodiversity

- 1 Milchunas D.G., Sala O.E., Lauenroth W.K. (1988) A generalized model of the effects of grazing by
2 large herbivores on grassland community structure. *American Naturalist*, 132, 87-106.
- 3 Monfreda C, Ramankutty, N., Foley, J. A., (2008). Farming the planet: 2. Geographic distribution of
4 crop areas, yields, physiological types and net primary production in the year 2000, *Global*
5 *Biogeochemical Cycles*, 22, GB1022, doi:10.1029/2007/GB002947
- 6 Müller-Wenk R (1998) Land use the main threat to species: How to include land use in LCA. 64.IWÖ
7 Diskussionsbeitrag, pp 45. Universität St. Gallen, St. Gallen, Switzerland.
- 8 OECD 1993 p. 23 fig 2
- 9 OECD 2002. Handbook of Biodiversity Valuation. A guide for policy makers. Paris, France.
- 10 Olson, D. M. & E. Dinerstein (1998). The Global 200: A representation approach to conserving the
11 Earth's most biologically valuable ecoregions. *Conservation Biol.* 12:502–515
- 12 Olson, D. M., Dinerstein, E. 2002. The Global 2000: Priority ecoregions for global conservation.
13 *Annals of the Missouri Botanical Garden* 89(2):199-224.
- 14 Palmer, M.W., White, P.S. (1994). Scale dependance and the species-area relationship. *The American*
15 *Naturalist*, **144**, 717-740.
- 16 Pervanchon F., Modélisation de l'effet des pratiques agricoles sur la diversité végétale et la valeur
17 agronomique des prairies permanents en vue de l'élaboration d'indicateurs agri-environnementaux,
18 Ph.D. Thesis, Nancy, INPL, 2004.
- 19 Pfister, S., Koehler, A. & Hellweg, S., 2009. Assessing the environmental impacts of freshwater
20 consumption in LCA. *Environmental science & technology*, 43(11), pp.4098–104.
- 21 Plantureux, S., Dumont, B., Rossignol, N., Taugourdeau, S. Huguenin-Elie, O. (2014) An indicator-
22 based tool to assess environmental impacts of multi-specific swards. *Grassland Science in Europe*
23 19,756-758.
- 24 Robinson T. P., Wint G. R. W., Conchedda G., Van Boeckel T. P., (2014) Mapping the Global
25 Distribution of Livestock. *PLoS ONE* 9(5): e96084. doi:10.1371/journal.pone.0096084
- 26 Rybicki, J., Hanski, I. (2013). Species-area relationships and extinctions caused by habitat loss and
27 fragmentation. *Ecology Letters*, 16, 27-38.
- 28 Schmidt, J.H. (2008). Development of LCIA characterization factors for land use impacts on
29 biodiversity. *Journal of Cleaner Production*, **16**, 1929–1942.
- 30 Shurtleff, W. and Aoyagi, Akiko 2004 History of world soyabean production and trade. A chapter
31 from the unpublished manuscript, History of soyabeans and soyfoods, 1100 B.C. to the 1980s.
- 32 Smeets et al., 1999
- 33 Solow, A., Polasky, S. and Broadus, J. 1993. On the measurement of biological diversity. *Journal of*
34 *Environmental Economics and Management* 24: 60-68.
- 35 Souza, D.M. (2010) Proposta de um modelo de caracterização de impactos do uso da terra, segundo
36 indicadores de biodiversidade, em AICV: cálculo de fatores de caracterização para ecorregiões
37 brasileiras. Universidade Federal de Santa Catarina. PhD Dissertation.

Principles for the assessment of livestock impacts on biodiversity

- 1 Souza, D.M., Flynn, D.F.B., DeClerck, F., Rosenbaum, R.K., Lisboa, H.M., Koellner, T. (2013). Land
2 use impacts on biodiversity in LCA: proposal of characterization factors based on functional
3 diversity. *The International Journal of Life Cycle Assessment*, **18**, 1231-1242.
- 4 Souza, D.M., Teixeira R.F.M., Ostermann, O.P. (2015). Assessing biodiversity loss due to land use
5 with Life Cycle Assessment: Are we there yet? *Global Change Biology*, **21**(1), 32-47.
- 6 Steinfeld et al. (2006) pg 41
- 7 Struijs et al. 2011 p. 90
- 8 Teillard, F., Anton, A., Dumont, B., Finn, J., Henry, B., Souza, D.M., Manzano, P., Milà i Canals L.,
9 Phelps, C., Said, M., Vijn, S., White, S. (in prep.) A review of indicators and methods to assess
10 biodiversity – application to livestock production at global scale. Livestock Environmental
11 Assessment and Performance Partnership (LEAP). FAO, Rome, Italy
- 12 Van Zelm et al. 2007 p. 90
- 13 Weidema BP, Ekvall T, Heijungs R (2009) Guidelines for applications of deepened and broadened
14 LCA. Deliverable D18 of work package 5 of the CALCAS project. Available at
15 http://www.leidenuniv.nl/cml/ssp/publications/calcas_report_d18.pdf (accessed 15 August 2013)
- 16 Weidema, BP, Lindeijer, E. (2001). Physical impacts of land use in product life cycle assessment.
17 Technical University of Denmark, pp. 1–52.
- 18 WWF (2014) The Growth of Soy: Impacts and Solutions. WWF International, Gland, Switzerland
- 19 Zerbe S (1998) Potential natural vegetation: validity and applicability in landscape planning and
20 nature conservation. *Applied Vegetation Science*, **1**, 165-172.
- 21

PART V – Case studies

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40

Case Study #1 *On-farm vs. off-farm impact of livestock through land use on a global scale*

The case study focuses on the impact of livestock on biodiversity through land use for feed. The objective was to estimate the relative shares of this impact occurring on-farm (grassland, feed crops cultivated on the farm) and off-farm (imported feed) at a global scale.

Case Study #2 *Grazing management to reduce off-site biodiversity impacts in north-eastern Australia*

The case study describes the implementation of a program to reduce impacts on biodiversity in the Great Barrier Reef lagoon arising from management of land for livestock production in coastal catchments.

Case Study #3 *Biodiversity conservation and high country sheep production in New Zealand*

The case study shows the interaction between historical and current farm management and biodiversity values across a range of New Zealand high country sheep properties producing fine merino and mid-micro wool.

Case Study #4 *Plant diversity in traditional livestock systems on the Aran Islands, Ireland*

The case study demonstrates the dependence of biodiversity on traditional livestock systems in the Aran Islands, Ireland. The Aran Islands are an extremely important site for a number of priority terrestrial habitats under the European Habitats Directive

Case Study #5 *Dairy systems in upland PDO cheese production areas, France*

The assessment provides overview of grassland biodiversity and of the aptitude of each grassland type to provide services (agronomic, ecological and quality of dairy products) species-rich humid grasslands of Central France.

Case Study #6 *Mobile and sedentary models of extensive livestock keeping compared along the Conquense Drove Road in Eastern Spain*

The study highlights the impact of drove road mediated seed dispersal on the genetic structure of plant populations and impacts of management type on tree regeneration in dehesas comparing sedentary, motorized and walking transhumant sheep.

Case Study #7 *Aa large-scale, wide-scope biodiversity monitoring program links multi-taxa biodiversity to land use supporting livestock production in western North America*

The case study demonstrates development of statistical models linking land cover and land use to species abundance to estimate an overall index of Biodiversity Intactness. Biodiversity Intactness has been reported as 53% in Alberta’s prairie region, where land use is largely dedicated to supporting livestock production.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18

Case Study #8 *Distribution of large herbivores in relation to environmental and anthropogenic factors in East Africa savannah ecosystem*

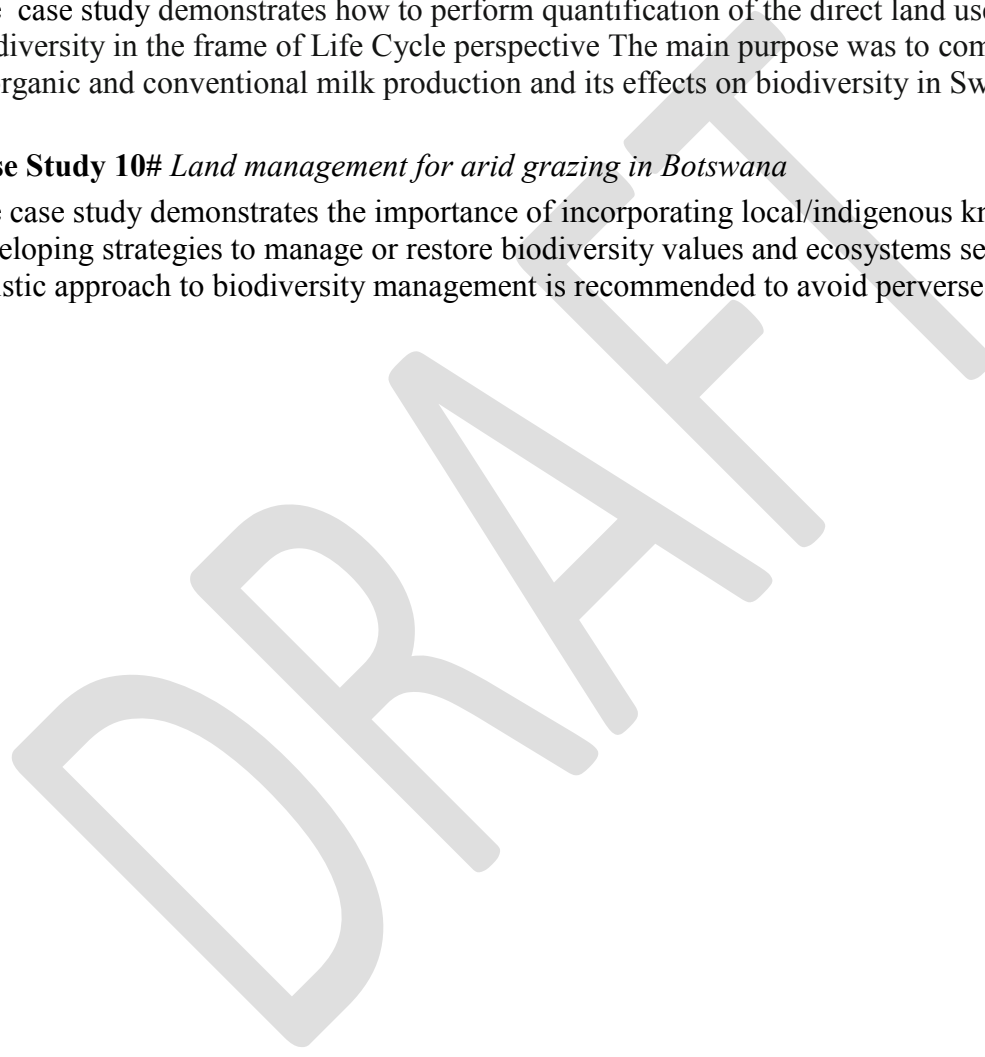
The study demonstrates how competition with and facilitation by livestock, predation risk, forage quantity and quality and water interact with life history traits, seasons and land use in shaping the dynamics of herbivore hotspots in protected and human-dominated savannas.

Case Study #9 *Comparing direct land use impacts on biodiversity on conventional and organic milk – based on a Swedish case study (Mueller et al. 2014)*

The case study demonstrates how to perform quantification of the direct land use impacts on biodiversity in the frame of Life Cycle perspective. The main purpose was to compare land use in organic and conventional milk production and its effects on biodiversity in Sweden.

Case Study 10# *Land management for arid grazing in Botswana*

The case study demonstrates the importance of incorporating local/indigenous knowledge in developing strategies to manage or restore biodiversity values and ecosystems services. The holistic approach to biodiversity management is recommended to avoid perverse outcomes.



Case Study #1

On-farm vs. off-farm impact of livestock through land use on a global scale

General Principles illustrated by this case study

- System boundaries and off-farm impacts. This case study illustrates how the boundaries of the system can be extended beyond the boundaries of the farm, i.e. to off-farm feed cultivation. It also demonstrates the importance of this boundary extension as a significant share of the impact on biodiversity occur off-farm.
- LCA principles. This case study illustrates a global LCA approach and the use of characterization factors to link land use elementary flows to a biodiversity impact indicator.
- Large scale and high resolution. This case study shows the advantages of addressing a large scale with a high resolution, which makes it possible to compute average, aggregated impacts across nested scales.
- State indicator. This case study uses the MSA as a biodiversity indicator. The MSA indicator is a compound indicator combining the abundance of several species. Its computation follows a standardized methodology based on a meta-analysis of the scientific literature. Reliability, comprehensiveness and large-scale applicability are several advantages of the use of state indicators that have been published and widely used, such as the MSA.

Overall objectives

Most ecological studies assessing the impact of livestock on biodiversity have computed biodiversity indicators on a finite area such as the farm or the landscape. The Life Cycle Assessment (LCA) field offers a new perspective by computing impacts along the whole life cycle of a product. For livestock production, it draws attention to the fact that ecological indicators computed at farm level do not capture indirect impacts of the farm occurring elsewhere, from imported feed in particular. We focused on the impact of livestock on biodiversity through land use for feed. The objective was to estimate the relative share of this impact occurring on-farm (grassland, feed crops cultivated on the farm) and off-farm (imported feed).

Scale, users and goal

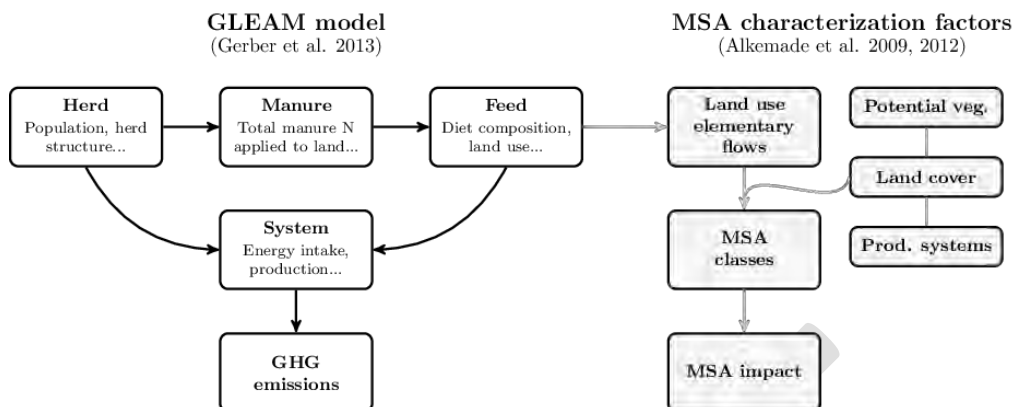
The case study used a GIS model at a global scale, with a resolution of 3 arc minutes (5kmx5km at the equator). Due to the coarse spatial scale at which global biodiversity indicators are available, such data are not suited to support management decision at local scale (*e.g.* farmers' decision on individual farms), although they can inform decision at sector, country or regional scale. In particular, we show the importance of not restricting biodiversity assessment to the farm boundaries.

Description of geographical area and main drivers

The case study addresses the global scale and focuses on 'land use' as a driver. We used the GLEAM model which describes global livestock supply chains in details and computes the GHG emission (Gerber et al. 2013). Computing the land use for feed is an intermediary output of the model (Figure 1). We used this intermediary output to develop a new component of GLEAM, which estimated the impact of livestock on biodiversity through land use. For this biodiversity component, we relied on the MSA methodology which provides a

Principles for the assessment of livestock impacts on biodiversity

1 biodiversity value (expressed as Mean Species Abundance) for several classes of land use and
 2 intensity (Alkemade et al. 2009; 2012).



3
4

5 Figure 1. Overview of the modeling procedure used to compute biodiversity impact, through the GLEAM model
 6 (Gerber et al. 2013) and Mean Species Abundance methodology (MSA, Alkemade et al. 2009; 2012). Prod. =
 7 production. Adapted from Gerber et al. 2013.

8

9 Description of livestock system

10 We focused on dairy cattle production.

11

12 Description of primary biodiversity features

13 We describe biodiversity using the Mean Species Abundance (MSA) indicator which sums
 14 the abundance of species belonging to various taxa. Alkemade et al. (2009; 2012) provide an
 15 MSA value for different land use and intensity classes (Table 1), following a meta-analysis
 16 and selected articles that presented data on species composition in disturbed vs. undisturbed
 17 land uses. Studies in the meta-analysis addressed both plants and animals (mainly birds,
 18 mammals and insects). The MSA value of each land use class was derived from the ratio of
 19 the abundances of the different species in the occupied land use class compared to a reference
 20 land use. MSA values vary between 0 and 1. MSA = 1 in undisturbed ecosystems where
 21 100% of the original species abundances remains, conversely, MSA = 0 in a destroyed
 22 ecosystem with no original species left.

23

24 Table 1. Mean Species Abundance (MSA) value of the different land use and intensity classes
 25 of rangelands/grasslands, and croplands (Alkemade et al. 2009; 2012).

Land use and intensity classes	MSA value
<i>Rangelands/grasslands</i>	
Natural rangelands	1
Moderately used rangelands	0.6
Intensively used rangelands	0.5
Man-made grasslands	0.3
<i>Croplands</i>	
Low input agriculture	0.3
Intensive agriculture	0.1

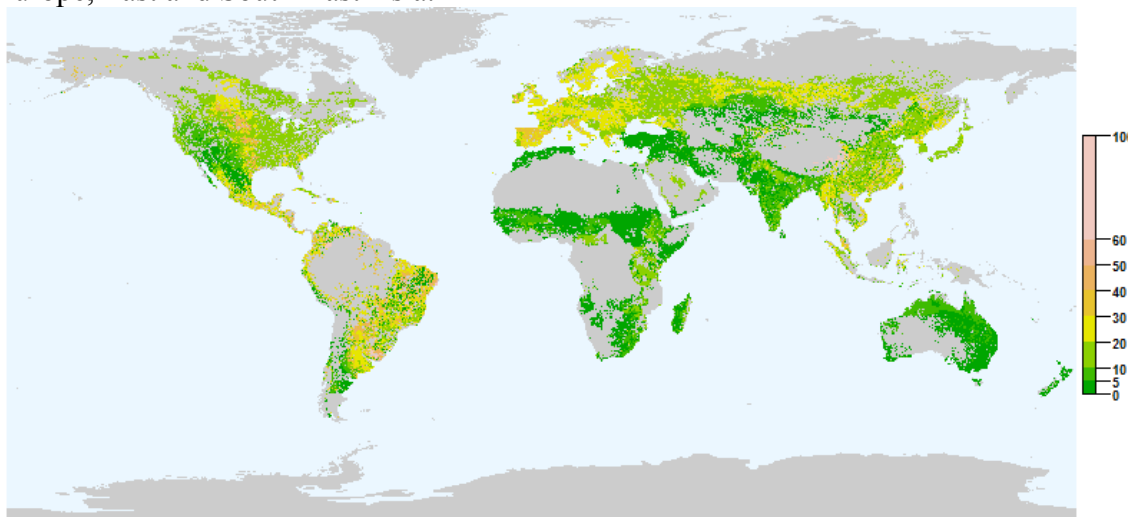
26

27

28 Main findings and impacts

Principles for the assessment of livestock impacts on biodiversity

1 We computed the percentage of MSA impact from feed land use occurring off-farm
 2 (relatively to the total on-farm + off-farm impact). Figure 2 shows the global distribution of
 3 this percentage of off-farm impact. According to the model estimations it ranged from 0 to
 4 100%. A significant percentage of the impact occurred off-farm, especially in America,
 5 Europe, East and South-East Asia.



6
 7 Figure 2. Percentage of the impact of dairy cattle production on biodiversity (MSA) through
 8 land use occurring off -farm, *i.e.* from imported feed. Examples of country averages: Australia
 9 = 4%, Brazil = 26%, Canada = 15%, France = 23%, Ireland = 28%, Kenya = 6%, Spain =
 10 31%, USA = 17%.

11
 12 Limitations

13 The MSA indicator is one of the very few characterization factors linking land use to
 14 biodiversity which are available at the global scale, however it has certain limitation:

- 15 • The MSA indicator is based on a sum of the abundances of various species. It does not
 16 recognise that certain species have a higher conservation value than others (e.g., IUCN
 17 red list, patrimonial species).
- 18 • The MSA value of each land use and intensity class is global and does not account for
 19 regional differences. It means that the biodiversity value of undisturbed forest – or the
 20 biodiversity loss following its conversion to pasture – is the same in Siberia and
 21 Amazonia for example.
- 22 • The land use and intensity classes of the MSA characterization factors are coarse. It is
 23 not possible to differentiate between the biodiversity impact of different grassland
 24 types or management practices associated with livestock production.
- 25 • Our approach was restricted to land use which under estimate the impact on
 26 biodiversity because other categories of pressures (e.g., nutrient pollution, climate
 27 change, habitat fragmentation) are not addressed.

28
 29 Further Information

30 Alkemade, R., M. van Oorschot, L. Miles, C. Nellemann, M. Bakkenes, and B. ten Brink.
 31 2009. GLOBIO3: A Framework to Investigate Options for Reducing Global
 32 Terrestrial Biodiversity Loss. *Ecosystems* 12:374-390.

33 R. Alkemade, R.S. Reid, M. Van den Berg, J. De Leeuw, M. Jeuken (2012). Assessing the
 34 impact of livestock production on biodiversity in rangeland ecosystems. *Proceedings*
 35 *of the National Academy of Sciences of the United States of America (PNAS Early*
 36 *edition)*, doi: <http://dx.doi.org/10.1073/pnas.1011013108>

Principles for the assessment of livestock impacts on biodiversity

- 1 Gerber PJ, Steinfeld H, Henderson B, Mottet A, Opio C, Dijkman J, Falcucci A, Tempio, G.
- 2 2013. Tackling climate change through livestock – A global assessment of emissions
- 3 and mitigation opportunities. Rome: Food and Agriculture Organization of the United
- 4 Nations.
- 5
- 6

DRAFT

Case Study #2

Grazing management to reduce off-site biodiversity impacts in north-eastern Australia

1 2 General principles illustrated by this case study

- 3 • *System boundaries and off-site impacts:* This case study illustrates an approach that
4 integrates information and develops an action plan across management practices,
5 regional/catchment indicators, catchment loads and ecosystem health for the Great
6 Barrier Reef coastal lagoon. It highlights the importance of monitoring across scales
7 and of considering off-site effects of land use for livestock production.
- 8 • *Indicators:* State indicators for farm to catchment scale include wetland and riparian
9 loss, groundcover and catchment loads; off-site indicators include species change, e.g.
10 seagrass abundance, and ecosystem status, e.g. coral cover and macroalgal richness.
11 Response indicators include the percentage of cattle producers implementing the
12 Grazing Best Management Practices as set out in technical information provided under
13 the Reef Plan. Annual pollutant loads corrected for the influence of climate variability,
14 and area of the Great Barrier Reef in good health are reported as the baseline for
15 reporting in the next period.
- 16 • The case study also provides a practical example of how multiple land uses and
17 natural (e.g. climate variability) and anthropogenic factors can be considered in a
18 program that aims to improve habitat condition and ecosystem health for biodiversity
19 values.

20 21 Overall objectives

22 This case study demonstrates how management practices for extensively grazed beef cattle
23 can have off-site as well as on-site biodiversity impacts. Biodiversity values in coastal
24 catchments in north-eastern Australia include endemic species of plants and animals on land,
25 coastal wetlands and the iconic coral reef communities of the Great Barrier Reef. Complex
26 interactions between climate, livestock production, intensive cropping and other human
27 activities such as tourism with natural ecosystems must be considered in managing these
28 sensitive biodiversity hot-spots (Figure 1). This case study describes the implementation of a
29 program to reduce impacts on biodiversity in the Great Barrier Reef lagoon arising from
30 management of land for livestock production in coastal catchments.

31 32 Scale, users and goal

33 The goal of this case study is to demonstrate the importance of understanding off-site as well
34 as on-site outcomes for biodiversity of livestock management in areas where run-off and
35 water flows have the potential to affect water quality in terrestrial and aquatic ecosystems.
36 The Reef Water Quality Protection Plan was implemented in 2003 with a view to improving
37 water quality and reducing sediment flows to the coastal lagoons of the Great Barrier Reef.
38 This program was developed on sound scientific research to provide guidance on good
39 grazing and cropping practices in major catchments which affect the quality of run-off.
40 Monitoring of outcomes has demonstrated progress and highlighted areas of ongoing concern
41 where accelerated action is required.

42 43 Description of geographical area and main drivers

Principles for the assessment of livestock impacts on biodiversity

1 The area of the case study is the coastal catchments adjacent to the Great Barrier Reef lagoons
2 of north-eastern Australia (Figure 2). The Great Barrier Reef is the largest coral reef
3 ecosystem in the world and has been World Heritage listed in recognition of the international
4 importance of its ecology and beauty. It extends over 2300 kilometres along the Queensland
5 coast covering an area of 350,000 square kilometres and includes over 2900 reefs as well as
6 extensive seagrass meadows, mangrove forests and soft bottom habitats. Protecting the
7 biodiversity of the region is important for the continued survival of many iconic and rare
8 species.

9
10 Description of livestock system

11 The major livestock system is low input extensively grazed beef cattle production. There is a
12 smaller contribution from dairy cattle systems on the better land areas.

13
14 Description of primary biodiversity features

15 The region has iconic biodiversity value due to the Great Barrier Reef which represents about
16 10% of the world's total coral reef area. There are also unique terrestrial and wetland
17 ecosystems in the coastal catchments.

18
19 Main interactions between livestock and biodiversity

20 The most sensitive impact of livestock on biodiversity in the case study region is through the
21 quality of water flowing into the Great Barrier Reef lagoons.

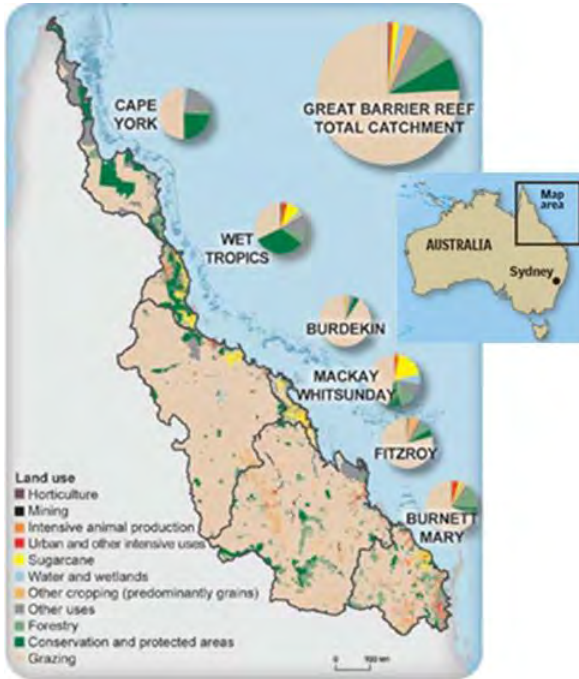
22
23 Main findings and impacts

24 The Reef Catchments Grazing Program provides financial assistance to graziers in the region
25 to implement grazing Best Management Practice designed to benefit landscape condition,
26 including biodiversity, on-site and off-site, and improve efficiency and long-term viability of
27 cattle production. Periodic 'report cards' provide an estimate of the status of the key
28 indicators in the Plan relative to assessment in 2003 and 2009 giving an historic baseline.
29 Ongoing scientific research and monitoring of response and state indicators identifies progress
30 and where accelerated action is needed, sometimes requiring revision of recommended
31 practices. Overall the estimated annual average sediment load, pesticide load and nitrogen
32 load to the GBR declined by 11%, 28% and 10% respectively from 2009-2013.



34
35
36
37 Fig. 1. Multiple land uses and impacts in the Great Barrier Reef catchments.

1



2

3 Fig. 2. Land use in the Great Barrier Reef Catchments (<http://www.reefplan.qld.gov.au>)

4



5

6 Fig. 3. The Reef Rescue program helped fund 130 off-stream watering points and over 160
7 km fencing of riparian and land-types to assist in managing stock access to creeks and river
8 systems on farms.

9

10

11

12

13

14 Further information:

15 <http://reefcatchments.com.au/>

16 <http://www.reefplan.qld.gov.au>

Principles for the assessment of livestock impacts on biodiversity

- 1 O'Reagain PJ, Bushell JJ. (2011). *The Wambiana Grazing Trial: Key Learnings for*
- 2 *Sustainable and Profitable Management in a Variable Environment*. Department of
- 3 Employment, Economic Development and Innovation.
- 4 O'Reagain PJ, Brodie J, Fraser G, Bushell JJ, Holloway CH, Faithful JW, Haynes D. (2005).
- 5 Nutrient loss and water quality under extensive grazing in the upper Burdekin river
- 6 catchment, North Queensland. *Marine Pollution Bulletin*, 51(1), 37-50.
- 7 Queensland Government (2009) *Reef Water Quality Protection Plan 2009*. The State of
- 8 Queensland, Brisbane.
- 9

DRAFT

Case Study #3

Biodiversity conservation and high country sheep production in New Zealand¹

1

2 General Principles illustrated by this case study

3 The case study illustrates how balancing the capabilities of each land type to meet nutritional
4 requirements of animals will maximise grazing opportunities, identify areas for resting and
5 recovery, prevent overgrazing and maintain native species. If the balance is not right,
6 vigorous introduced species can take over and native plant species can disappear.

7 *Pressure Indicators:* Historical and current farm management practices such as stock type,
8 stocking rate, timing of grazing, fertiliser and seed inputs have reduced or modified indigenous
9 grasslands

10 *State Indicators:* This case study showed the value of a clear methodology for describing the
11 baseline and developing terrestrial and aquatic state indicators for biodiversity on productive
12 sheep pastoral properties.

13 *Response Indicators:* Response indicators for management of grazing regimes and
14 subdivision of paddocks were developed based on understanding of sheep grazing behaviour
15 obtained using GPS collars. Over the 3-5 years (2007-2010) monitoring provided reassurance
16 that, in general, the farming systems that have evolved in the high country of the South Island
17 are effectively balancing the need for agricultural production with the need to preserve
18 indigenous biodiversity ecosystems and confirmed the very high quality of water in high
19 country waterways by comparison to streams draining more intensive land use catchments.
20

21 Overall Objectives

22 This case study shows the interaction between historical and current farm management and
23 biodiversity values across a range of New Zealand high country sheep properties producing fine
24 merino and mid-micro wool. The overall objective was to provide farmers with information and
25 tools to better manage both livestock and biodiversity values within the environments they farm.
26 Equally importantly, was the provision of robust scientific data to validate claims in regard to
27 sustainable merino production.
28

29 Scale, Users and Goal

30 The study considered eight high country merino sheep stations. The properties covered a total of
31 139,000 ha, carrying 113,000 stock units. Property sizes range from 4,000 – 40,000 ha, with an
32 average size of 19,720 ha. The properties have similar overarching farming strategies, in that
33 their management centres on pastoral-based systems.
34

35 The project looked at two spatial scales and provides information for farmers and policy, firstly
36 across eight high country farms, and secondly at the scale of individual grazing units within
37 farms. At the farm scale, the project addressed the following questions:

- 38
- What are the trends in terrestrial and aquatic biodiversity?
 - Are there patterns in biodiversity indices that can be related to management inputs?
- 39

¹⁷ Prepared by Ministry for Primary Industries, New Zealand, October 2014

Principles for the assessment of livestock impacts on biodiversity

- 1 • How can the monitoring information be used to develop more sustainable farm
2 management practices?

3 At the grazing unit scale, specific questions related to the interaction between merino sheep and
4 the environment they inhabit:

- 5 • How do wethers and ewes utilise different parts of the landscape with respect to
6 biodiversity?
7 • How do wethers and ewes respond in habitat use to different weather conditions?
8 • How is animal comfort correlated with habitat use and weather conditions?
9

10 Description of geographical area and main drivers

11 The study area spanned an altitudinal gradient from 300m to 2500m in the rain-shadow region to
12 the east of New Zealand's Southern Alps from the Marlborough to Otago regions (that is,
13 spanning two-thirds of the South Island, approximately 600km) (Figure 1). This region was
14 dominated in the pre-European period by indigenous low to mid-altitude tussock grassland that
15 sits below the climatic tree-line. The species are mainly narrow-leaved snow tussock (*C. rigida*)
16 with slim snow tussock (*C. macra*) at higher altitudes. Moister regions also contain red or copper
17 tussock (*C. rubra* subsp. *cuprea*). These indigenous grasslands have been modified to varying
18 degrees by the indirect or direct effect of human activity; in particular, the over-sowing of legume
19 species (mostly white clover, *Trifolium repens*) and other exotic grass forage species.
20

21 Description of Livestock System

22 The eight high country farms have a mix of cultivated flat land, mid slope country and high steep
23 country. Farmers face a challenge in balancing the capabilities of these land types to meet the
24 nutritional needs of animals while maintaining indigenous biodiversity. Merino sheep were a
25 substantial part of the management enterprise on all case study farms although they spanned a
26 range of environments and management approaches that are found in the New Zealand South
27 Island high country.
28

29 Description of Primary Biodiversity Features

30 The study found four major vegetation groups across all the monitoring sites:

31 Vegetation Type 1 – Snow tussock/blue tussock/mouse-ear hawkweed grassland

32 Vegetation Type 2 – Hard tussock/brown-top-sweet verna/mouse-ear hawkweed grassland

33 Vegetation Type 3 – Brown-top-Kentucky blue grass/mouse-ear hawkweed grassland

34 Vegetation Type 4 – Brown-top/hares-foot trefoil/mouse-ear hawkweed herbfield.
35

36 Main interactions between Livestock and Biodiversity

37 Assessment of the interaction between historical and current farm management and biodiversity
38 values across the eight New Zealand high country sheep properties (Figure 1) found that pastoral
39 farming and in particular past management practices have reduced or modified these indigenous
40 grasslands.
41

42 Main findings and impacts

43 The monitoring network comprised 309 land-cover and 54 aquatic monitoring sites.

44 Land-cover monitoring identified changes in the overall abundance of the 20 most abundant
45 species across the four major vegetation types. Aquatic monitoring collected and evaluated
46 overall condition of high country waterways and compared this to the overall condition of dairy

Principles for the assessment of livestock impacts on biodiversity

1 and sheep/beef farms. Indicators of contamination such as nutrient concentrations and turbidity,
 2 recorded across the 40 high country streams were 2-3 orders of magnitude lower than those
 3 recorded for dairy and less than a third of the average sheep/beef farm value. In addition, values
 4 for the percentage of total number of taxa and the macro invertebrate community index recorded
 5 from the high country properties were high compared to those recorded in other New Zealand
 6 farming systems.

7
 8 Over the 3-5 years covered by the monitoring programme in the study properties, land cover and
 9 aquatic systems have changed relatively little overall.
 10
 11



12
 13 Fig. 1. Location of the eight high country study properties (left picture) and example of lot
 14 layout with 20m x 20m transect for biodiversity monitoring (middle picture) (NZ Merino Co.
 15 2013), Map showing areas used intensively by sheep for the three main activities (right picture):
 16 Resting (red), Grazing (green) and Night camping (blue). Differences relate to altitude and
 17 vegetation type.

18
 19 Further Information

20 NZ Merino Co. (2013). *Biodiversity conservation and high country sheep production*. Summary
 21 Report. [http://maxa.maf.govt.nz/sff/about-projects/search/09-125/biodiversity-](http://maxa.maf.govt.nz/sff/about-projects/search/09-125/biodiversity-conservation-and-high-country-sheep-production-Summary.pdf)
 22 [conservation-and-high-country-sheep-production-Summary.pdf](http://maxa.maf.govt.nz/sff/about-projects/search/09-125/biodiversity-conservation-and-high-country-sheep-production-Summary.pdf)

23 Fact Sheet Developed from the Case Study - [http://maxa.maf.govt.nz/sff/about-](http://maxa.maf.govt.nz/sff/about-projects/search/09-125/Biodiversity.pdf)
 24 [projects/search/09-125/Biodiversity.pdf](http://maxa.maf.govt.nz/sff/about-projects/search/09-125/Biodiversity.pdf)

25 Final Project Report - [http://maxa.maf.govt.nz/sff/about-projects/search/09-125/09-125-Final-](http://maxa.maf.govt.nz/sff/about-projects/search/09-125/09-125-Final-Report-Web-Update-2013.pdf)
 26 [Report-Web-Update-2013.pdf](http://maxa.maf.govt.nz/sff/about-projects/search/09-125/09-125-Final-Report-Web-Update-2013.pdf)

27 Norton, D.A. (2008) *Guidelines for preparing whole property management plans for high*
 28 *country farms* (School of Forestry, University of Canterbury, Christchurch).

29 <http://maxa.maf.govt.nz/sff/about-projects/search/04-063/guidelines.pdf>

1
2

Case Study #4
Plant diversity in traditional livestock systems on the Aran Islands, Ireland



3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26

Principles illustrated by this case study

State indicators: designation status (IUCN, continental, national, regional); number of species and habitats on national and European priority list; area (km²) of designated area; conservation status of habitats (favourable condition, not in favourable condition); species richness; presence of invasive species, area of scrub, change in area of scrub over time.

For priority habitats, the EU Habitats Directive (92/43/EEC) specifies that habitats protected by the Directive must be maintained in ‘Favourable Conservation Status’ within their range in the member states. The conservation status of a natural habitat will be taken as favourable when:

- its natural range and the area it covers within that range are stable or increasing, and;
- the specific structure and functions which are necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future, and;
- the conservation status of its typical species is favourable.

For some more specific examples, there are species lists and quantitative indicators for vegetation structure for calcareous grasslands, which are important orchid sites. The lists of plant species include named high quality indicator species, positive indicator species, and negative indicator species (see Fig. 1). Vegetation characteristics for these grasslands require, for example, a broadleaf herb component of 40-90%, and for scrub encroachment by woody species to be ≤ 10% cover.



27

Principles for the assessment of livestock impacts on biodiversity

1 *Mid-point indicators*: livestock density; change in livestock density over time; amounts of
2 inorganic fertiliser applied (kg/ha/yr)

3
4 *Response Indicators*: number of farmers participating in conservation programme; amount of
5 expenditure on conservation actions; number of awareness-raising events, workshops and
6 demonstration activities.

7
8 *Reference state*: without livestock grazing, the species-rich vegetation reverts to species-poor
9 scrub that is dominated by brambles, blackthorn and hazel that shade out grassland species.
10 This represents a negative effect on biodiversity when livestock grazing is removed.

11
12
13 Overall objectives

14 The Aran Islands are represented by a group of three islands located on the western seaboard
15 of Ireland, and have long supported traditional, extensive livestock systems. This case study
16 describes appropriate indicators to assess the interaction between livestock and biodiversity.

17
18 Scale, users and goal

19 This case study demonstrates the dependence of biodiversity on traditional livestock systems
20 in the Aran Islands, Ireland.

21
22 Description of geographical area and main drivers

23 The Aran Islands have a highly fragmented and small structure. Herd size is low, with most
24 herds numbering less than 10. Poor economic return from such small holdings is leading to a
25 reduction of farming on the islands (active farms have decreased by more than 30% in the last
26 15 years due to abandonment and consolidation). There is a traditional agricultural landscape,
27 with a rich mosaic of habitats that include a high density of stone walls, and rocky fields with
28 pastures and meadows that contain a high diversity of flora.

29
30 Since the 1970s the Aran Islands have come under a succession of national and European
31 environmental designations. These include ASIs (Areas of Scientific Interest), and more
32 recently proposed NHAs (Natural Heritage Areas), SACs (Special Areas of Conservation) and
33 SPAs (Special Protection Areas). Over 75% of the total land area of the Aran Islands is now
34 designated as Natura 2000 sites.

35
36 Description of livestock system

37 The traditional livestock system is a very extensive beef production system. The High Nature
38 Value farming systems on the islands (and there are similar areas on the mainland) are
39 dependent on regular grazing at a low stocking density. Thus, the main biodiversity features
40 are reliant on extensive livestock systems.

41
42 Description of primary biodiversity features

43 The Aran Islands are an extremely important site for a number of priority terrestrial habitats
44 under the European Habitats Directive (Annex 1). Since the 1970s the Aran Islands have
45 come under a succession of national and EU environmental designations, such that over 75%
46 of the total land area of the Aran Islands is now designated as EU Natura 2000 sites.
47 Dominated by species-rich grasslands with many orchids and alpine flora, there is also
48 machair, and many plant species of high conservation status.

49
50 Main interactions between livestock and biodiversity

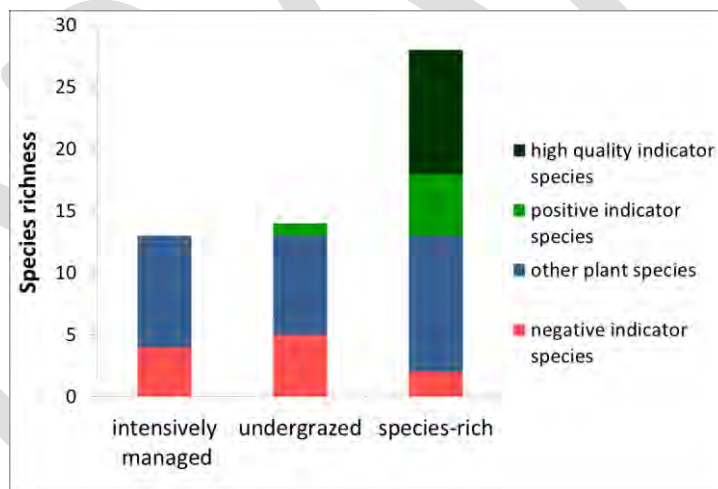
Principles for the assessment of livestock impacts on biodiversity

1 The flora (and associated fauna) have co-evolved as part of a traditional grazing system that is
 2 characterised by low stocking density. Grazed areas are characterised by high floral diversity
 3 and includes habitats and species that are a high priority for conservation in the European
 4 Union. The main threats from changes to the traditional livestock systems include: land
 5 abandonment, under-grazing, inappropriate management practices, intensification, loss of
 6 traditional farm knowledge and skills and lack of understanding and engagement among key
 7 stakeholders.

8
 9 On semi-natural limestone habitats, undergrazing results in increased dominance by a limited
 10 number of species such as *Sesleria albicans*, *Molinia caerulea* and a range of bryophytes.
 11 Within a few years, plant species diversity is significantly reduced. On sheltered sites,
 12 undergrazing is leading to scrub encroachment, particularly *Rubus fruticosus*. Scrub
 13 encroachment is affecting the conservation status of the priority habitats and is adding to the
 14 seed source of scrub for future colonisation of new areas.

15
 16 In contrast, some areas are also subject to intensification in the form of ploughing, reseeded
 17 and fertiliser applications to increase forage production. Such actions can result in rapid
 18 transformations of the species-rich vegetation to a type that is dominated by e.g. *Lolium*
 19 *perenne* and other grasses that dominate for as long as fertiliser applications continue.
 20 Recovery to the original vegetation state takes many years, and would be measured in
 21 decades.

22
 23 Main findings and impacts
 24



25
 26
 27 Fig. 1. Example of the impact of intensive management and undergrazing on the species
 28 richness and nature conservation value of calcareous species-rich grasslands on the Aran
 29 Islands. The ‘high quality indicator species’ include orchids and other plant species that are
 30 rare on an Irish and European scale. Data from 2m x 2m quadrat samples.

31
 32 Further information:
 33 <http://www.aranlife.ie/>
 34 Case Studies on High Nature Value Farming in Ireland: North Connemara and the Aran
 35 Islands. The Heritage Council. 2010
 36 [http://www.npws.ie/publications/irishwildlifemanuals/IWM73%20Limestone%20pavement.p](http://www.npws.ie/publications/irishwildlifemanuals/IWM73%20Limestone%20pavement.pdf)
 37 [df](http://www.npws.ie/publications/irishwildlifemanuals/IWM73%20Limestone%20pavement.pdf)

Case Study #5

Dairy systems in upland PDO cheese production areas, France

1

2 General principles illustrated by this case study

3 - Definition of system boundaries: we compared two systems, one importing off-farm feed,
4 not the other. We demonstrate that the area of off-farm land use for feed can be significant
5 and should be measured. We also illustrate one way to estimate this area with easily
6 accessible information.

7 - Quantification of biodiversity state and of the effect of practices based on a regional
8 grassland typology. For the user, using this typology to identify grassland types and to derive
9 the associated biodiversity indicators requires a limited level of expertise (e.g. it is based on
10 the identification of dominant grass species and of some flowering plant species used as
11 indicators). The typology is user-friendly while underpinned by science (mainly plot-scale
12 experiments) that also allows quantification of biodiversity and various ecosystem services.
13 Its use leads to consistency across hierarchical spatial scales: plot, farm and landscape (this
14 last scale is not shown in the case study).

15 - Multiple state indicators cover both the species (plant species richness and rarity index) and
16 ecosystem levels (pollination, carbon sequestration, patrimonial and landscape interest).

17

18 Overall objectives

19 This case-study emphasizes the multiple state indicators covering both species and ecosystem
20 levels in species-rich humid grasslands of Central France. Community structure and species
21 richness of plants and insects are recorded at plot scale under different management regimes,
22 while a user-friendly grassland typology underpinned by science leads to consistency among
23 hierarchical scales: plot, farm and landscape. This tool also allows analysis of multiple
24 ecosystem functions in grassland and associated ecosystem services, in order to communicate
25 with farmers on how to adapt management and deal with (preserve and benefit from)
26 grassland diversity.

27

28 Scale, users and goals

29 The goals and scale of our projects are:

30

31 • to propose win-win strategies for pasture management that combine good production
32 levels with biodiversity preservation. Research is conducted at the plot scale, and is
33 based on either medium- or long-term surveys of biodiversity dynamics under
34 contrasting management rules,

35

36 • to construct a science-based typology, which includes an in-depth description of the
37 23 main types of grassland observed in dairy systems of certified Protected
38 Designation of Origin (PDO) geographical areas. This allows an overview of
39 grassland biodiversity and of the aptitude of each grassland type to provide services
40 (agronomic, ecological and quality of dairy products). It thus offers a basis for
41 discussion with livestock farmers when it comes to the question of adapting
42 management practices (Carrère *et al.*, 2012),

43

44 • to design and evaluate innovative dairy systems that combine good economic
performances and reduced environmental footprint. Interdisciplinary research is
conducted in two contrasting systems (on an experimental farm) that differ according
to grassland diversity, management rules, use of off-farm concentrate feed, etc.

Principles for the assessment of livestock impacts on biodiversity

1 (Pomiès *et al.* 2013; Farruggia *et al.*, 2014). Management is kept relatively constant
2 for 4-5 years (to allow systems to adapt), before being modified to test for a new set of
3 rules.

4
5 Users are farmers, agricultural advisors, Protected Designation of Origin (PDO) inter-branch
6 organization, NGOs involved in biodiversity conservation and land managers. Our aim is to
7 produce both references and tools.

8
9 Description of geographical area and main drivers

10 In the French ‘Massif-Central’, a region dominated by semi-natural grasslands, PDO dairy
11 production and tourism are the main drivers of local economy. These semi-natural upland
12 grasslands are usually species-rich and are important refuges for insect populations (including
13 butterflies and bumblebees). The type of grass that is fed to cattle contributes to the typical
14 flavour (and nutritional properties) of traditional cheese.

15
16 Description of livestock system

17 Dairy farming systems are dominant in this area with farmers engaged in PDO cheese supply
18 chain, including farm-house cheese producers. The main sustainability challenge is to
19 reconcile the agricultural and environmental performances of these systems in an environment
20 with strong emphasis on biodiversity conservation. These are grassland-based systems with a
21 stocking rate between 0.8 and 1.1 LU/ha. Technical challenges are related to an efficient use
22 of grasslands to minimize feed and fertilizer inputs, while complying with specifications of
23 the PDO inter-branch organization.

24
25 Description of primary biodiversity features

26 Grassland diversity: 23 types of semi-natural upland grasslands are relevant regionally.
27 High species richness in grasslands for plants and insects (e.g., Dumont *et al.*, 2009), with
28 some red-list species (e.g. butterfly *Maculinea arion*), iconic species (*Narcissus jonquilla*) or
29 endangered habitats (peatlands)

30
31 Main interactions between livestock and biodiversity

32 In semi-natural grasslands, species diversity is known to decline as the result of grassland
33 intensification (fertilization, stocking rate; Dumont *et al.*, 2009). An alternative rotational
34 grazing in which some of the plots are excluded from grazing at flowering peak can benefit
35 flower-visiting insects, but presents risk for farmers in terms of providing livestock with
36 sufficient forage under unfavourable grass growth during spring (Farruggia *et al.*, 2012).
37 Biodiversity is also assumed to be higher at the farm/landscape levels when a wider range of
38 grassland types are maintained.

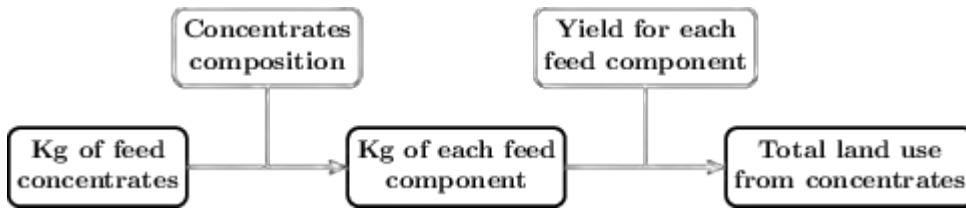
39
40 Main findings and impacts

41 We compared the two contrasted dairy farm for the biodiversity performance within their on-
42 farm grassland area and for their use of off-farm feed. System ‘Bota’ was an almost
43 exclusively grassland-based system while ‘Pepi’ also relied on the use of concentrates. The
44 grassland typology described in this case study gives the value of various production and
45 sustainability indicators for different grassland types. We computed the mean value of four
46 biodiversity indicators for each farms: the number of grassland types, the species richness
47 (average number of species per plot) and rarity index (relative value varying between 0 and
48 0.65) of plant species, as well as a pollinator index (relative score varying between 1 and 3).

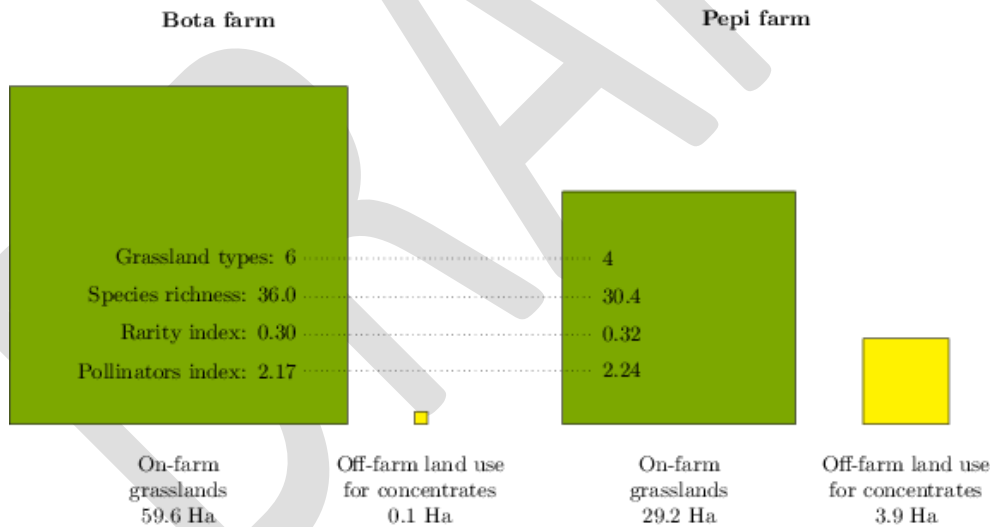
49

Principles for the assessment of livestock impacts on biodiversity

1 The annual consumption and composition of the different types of concentrates used by the
 2 farm, i.e. the percentage of each feed components (e.g., barley, maize, triticale, rapeseed) was
 3 available so the equivalent consumption of each feed component in kg could be computed.



4
 5
 6 In the Bota farm, the estimated off-farm area corresponding to feed concentrates use was very
 7 low: 0.1 ha while the farm included 59.6 a of grassland. In the Pepi farm, the off-farm area for
 8 feed concentrates represented 3.9 ha, i.e. approximately 13% of the on-farm grassland area.
 9 Depending on the relative impact of grassland and feed crops on biodiversity, these 13% of
 10 off-farm feed could have a significant contribution to the total biodiversity impact of the farm.
 11 For instance, Case Study 1 estimated that on average, off-farm feed accounts for 23% of the
 12 total land use impact of French dairy farms. There was a higher diversity of grassland types
 13 within the Bota farm and higher plant species richness. Rarity and pollinator indices were
 14 similar for the grassland area of the two farms. There was no straightforward correlation
 15 between the biodiversity indicators computed on the farm and the use of off-farm feed. It
 16 shows the importance not to focus on on-farm measures and to estimate the off-farm impact
 17 as well.



18
 19
 20
 21
 22
 23
 24
 25
 26
 27
 28
 29

Further information

Carrère P., Seytre L., Piquet M. *et al.*, 2012. A multifunctional typology of grassland in AOP-certified dairy systems in the Massif Central combining an agronomic and ecological approach. *Fourrages*, 209: 9-21

Dumont B., Farruggia A., Garel J.P. Bachelard P., Boitier E. & Frain M., 2009. How does grazing intensity influence the diversity of plants and insects in a species-rich upland grassland on basalt soils? *Grass For. Sci.*, 64: 92-105

Farruggia A., Dumont B., Scohier A., Leroy T., Pradel P. & Garel J.P., 2012. An alternative rotational stocking management designed to favour butterflies in permanent grasslands. *Grass For. Sci.*, 67: 136-149

Principles for the assessment of livestock impacts on biodiversity

- 1 Farruggia A., Pomiès D., Coppa M. *et al.*, 2014. Animal performances, pasture biodiversity
2 and dairy product quality: How it works in contrasted mountain grazing systems.
3 *Agriculture, Ecosystems & Environment* 185: 231-244
4 Pomiès D., Martin B., Pradel P. *et al.*, 2013. Design of low-input dairy farming systems in
5 mountain areas: animal performance and cheese sensory properties. In: 17th Meeting of
6 the FAO-CIHEAM Mountain Pasture Network, 5-7 June 2013, Trivero, Italy, pp. 22-26
7

DRAFT

Case Study #6

Mobile and sedentary models of extensive livestock keeping compared along the Conquense Drove Road in Eastern Spain

- 1
- 2 General principles illustrated by this case study
- 3 *Pressure indicators*: management type, fossil fuel use
- 4 *State indicators*: measures of biodiversity & biodiversity loss, Red List Species indicators, tree regeneration rate, genetic structure of plant populations
- 5
- 6 *Response indicators*: agroenvironmental schemes supporting transhumance; contribution to
- 7 resilience towards climate change
- 8 *Reference state*: this case illustrates how the reference state without livestock lacks forces
- 9 driving to heterogeneity which actually cause it to host lower biodiversity than states under
- 10 moderate use.
- 11 *Setting the boundaries* – in this case, it can be seen how the boundaries are variable depending
- 12 on the system considered, with mobile systems or intensive systems depending on external
- 13 inputs having much wider boundaries than intermediate systems in the intensification
- 14 gradient.
- 15
- 16 Overall objectives
- 17 To compare the environmental impacts of sheep-grazed systems along an intensification
- 18 gradient, including:
- 19 - Transhumant sheep performing semi-annual 600km-long displacements by foot
- 20 - Transhumant sheep performing the same displacements by lorry
- 21 - Sedentary sheep under extensive conditions, Semi-intensive sedentary sheep, Sheep on
- 22 feedlots
- 23
- 24 All of these systems occur in the same geographical area. It is an exceptional circumstance as
- 25 the most extensive practices are usually abandoned as countries undergo industrialization.
- 26
- 27 Scale, users and goal
- 28 The scale of the study encompasses a whole ecosystem bounded by summer and winter
- 29 pastures. We aim to know the effects of intensification vs. extensification on the environment,
- 30 as a way to inform policy decisions on the livestock sector.
- 31
- 32 Description of geographical area and main drivers
- 33 Spain has a rich transhumance history dictated by the climatic and geographic configuration
- 34 of the country. Wide areas are under a combination of ecosystems that include:
- 35 - lowland areas to the south with the typical Mediterranean summer droughts and winter rains
- 36 - highland areas to the north with orographic-related summer rains and heavy winter frosts
- 37 - connection areas that experience two semiannual plant productivity peaks
- 38 The climatic conditions promoted the practice of transhumance since ancient times. The
- 39 Conquense drove road is the only one of the whole medieval drove road system that has
- 40 remained in use in its full length up to the present. It extends along 600 km and it has been
- 41 conserved because of the presence and continuous use of bullfighting herds.
- 42
- 43 Description of the livestock system
- 44 About 10,000 head of sheep are walking between seasonal pastures nowadays. Additionally,
- 45 ca. 20,000 sheep practice the motorized transhumance in the area, while there are sedentary

Principles for the assessment of livestock impacts on biodiversity

1 extensive sheep farms both in the summer and winter pastures. The local meat industry in the
 2 summer pastures facilitates the presence of specialized intensive farms.
 3

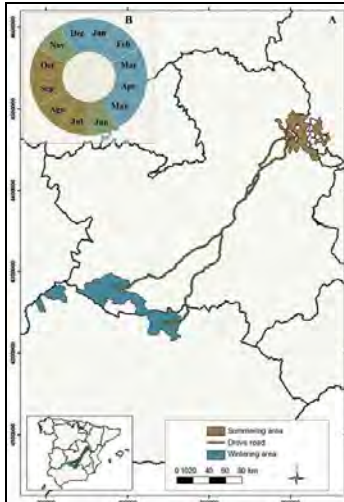


Fig. 1. Study area map, with summer and winter areas (A) and annual cycle of transhumant movements on foot (B). Reproduced from: www.ecologyandsociety.org/vol18/iss3/art33/figure1.html



Fig. 2. The Conquense drove road crosses agricultural land and is therefore both a source of landscape heterogeneity and a vector for organism dispersal (Picture by Raquel Casas).

4
 5 Description of primary biodiversity features

6 Spain is the major host of biodiversity in Europe, with ca. 5,000 plant species. Its condition as
 7 a glacial refugium during the last ice age is combined with its rugged physiography that
 8 multiplies ecological niches and causes frequent biogeographic island effects. A predominant
 9 semi-arid climate in the country also facilitates further biodiversity.

10
 11 Main interactions between livestock and biodiversity

12 Extensive livestock is found in most of the mountainous and dry areas found in the country.
 13 Its role as a biodiversity maintaining force has been identified in ecosystems that were
 14 subjected to heavy perturbation since their appearance after the glaciation. Many species are
 15 dependent on grazing. The biodiversity loss experienced, mainly through shrub encroachment
 16 and closing of landscapes, has been well characterized and linked with the lack of grazing.
 17 Dispersal mechanisms mediated by livestock have also been measured, and identified as very
 18 important.

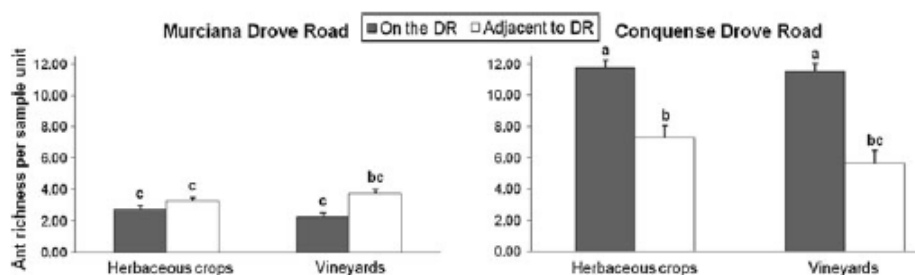
19
 20 Principles, framework, data, tools or statistical approaches used

21 Comparative approaches have been followed to characterize the impact of the different
 22 livestock management types. LCA and fossil fuel analyses have been done for all the
 23 livestock intensification gradient. The impact of management type on tree regeneration in
 24 dehesas (savanna-like landscapes with live oaks scattered in a matrix of pastures) have been
 25 measured comparing sedentary, motorized and walking transhumant sheep. The contribution
 26 of drove roads to spatial heterogeneity and creation of habitats for arthropods, especially
 27 harvester ants as a bioindicator, has been examined. The impact of drove road mediated seed
 28 dispersal on the genetic structure of plant populations has also been examined.

29
 30 Main findings and impacts

Principles for the assessment of livestock impacts on biodiversity

1 A clear positive correlation between fossil fuel use, channeled water and fodder use, on the
 2 one side, and degree of intensification, on the other, can be observed, with fuel and fodder
 3 consumption at the sedentary extensive system being 4 times bigger than at transhumance by
 4 foot. This has clear consequences for biodiversity both at the global scale (oil spills,
 5 infrastructure build-up, landscape transformation, climate change) and at the local scale
 6 (grazing abandonment). Tree regeneration was also observed to be negatively affected by
 7 intensification along the whole gradient. Drove roads decisively contribute to habitat
 8 heterogeneity in non-pasture landscapes and they act as a general species reservoir when
 9 crossing agricultural landscapes and a reservoir for species typical of open spaces when
 10 crossing forests. The collection of results on genetic structure of populations is still ongoing.



11
 12 **Fig. 3.** Biodiversity
 13 indicators are
 14 consistently higher in
 15 drove roads under use
 16 than in abandoned drove
 17 roads. Reproduced from
 18 Hevia et al 2013.

20

21 **Fig. 4.** Transhumance practices are positive for forest
 22 conservation and regeneration, especially in the case of
 23 the Iberian savanna-like dehesa and montado landscapes
 24 (picture by Raquel Casas).



25
 26
 27
 28
 29 Further information

30 Azcárate, F.M.; Robleño, I.; Seoane, J.; Manzano, P. & Peco, B. (2013) Drove roads as local
 31 biodiversity reservoirs: effects on landscape pattern and plant communities in a
 32 Mediterranean region. *Applied Vegetation Science* 16, 480-490.
 33 Carmona, C. P.; Azcárate, F. M.; Oteros-Rozas, E.; González, J. A.; Peco, B. (2013)
 34 Assessing the effects of seasonal grazing on holm oak regeneration: Implications for the
 35 conservation of Mediterranean dehesas. *Biological Conservation* 159, 240-247
 36 Casas Nogales, R.; Manzano Baena, P. (2010) Hagamos bien las cuentas. Eficiencia y
 37 servicios de la trashuman-cia en la Cañada Real Conquense. II Congreso Nacional de Vías
 38 Pecuarias, Cáceres, Spain, 302-315
 39 Hevia, V.; Azcárate, F.M.; Oteros-Rozas, E.; González, J.A. (2013) Exploring the role of
 40 transhumance drove roads on the conservation of ant diversity in Mediterranean
 41 agroecosystems. *Biodiversity and Conservation* 22, 2567-2581.
 42 Manzano, P. and Casas, R. (2010) Past, present and future of trashumancia in Spain:
 43 nomadism in a developed country. *Pastoralism: Research, Policy and Practice (Practical
 44 Action)* 1, 72-90.

45
 46

Case Study #7

A large-scale, wide-scope biodiversity monitoring program links multi-taxa biodiversity to land use supporting livestock production in western North America

1

2 General principles illustrated by this case study

- 3 • *State indicators*: comprehensive, multi-taxa species occurrence and aggregated
- 4 richness indices; habitat conversion, fragmentation, and degradation
- 5 • Data integrity: data are publically available and consistent data collection methods are
- 6 used
- 7 • Scoping of system boundaries: the scope of the data extend from extensive rangeland
- 8 to intensive crop production for feed, whether on-farm or off-farm.
- 9 • Linking Pressure-State-Response Indicators: the index of Biodiversity Intactness links
- 10 Pressure Indicators (e.g. land use) to the biodiversity State Indicators.
- 11 • Reference state: in its calculation of the Biodiversity Intactness, ABMI uses all native
- 12 grassland, including rangeland, as reference state. This is consistent with the premise
- 13 that plant species in this region co-evolved with grazing pressure from bison, and that
- 14 the pressures from cattle grazing can be largely analogous to those of bison.
- 15 • Scale: this case study is an example that is most applicable at the intermediate scale
- 16 (supply chain, territory), although there are applications of information at the small
- 17 and large scales as well.
- 18

19 Overall objectives

20 The Alberta Biodiversity Monitoring Institute (ABMI) operates a large-scale monitoring
21 program producing publically-available information on biodiversity and land use.
22 Comprehensive land cover, land use, and multi-taxa species monitoring is performed at 1656
23 permanent sampling sites arranged in a systematic grid across the Canadian province of
24 Alberta.

25

26 Scale, users, and goal

27 ABMI operates at the provincial scale; the province of Alberta is 661,848 km², making it one
28 of few biodiversity monitoring programs of its depth and extent. ABMI operates at arms-
29 length from government and industry, and is thus well-positioned to deliver on its goal of
30 providing high-quality information on biodiversity to a host of users, including government,
31 NGOs, academia, and industry.

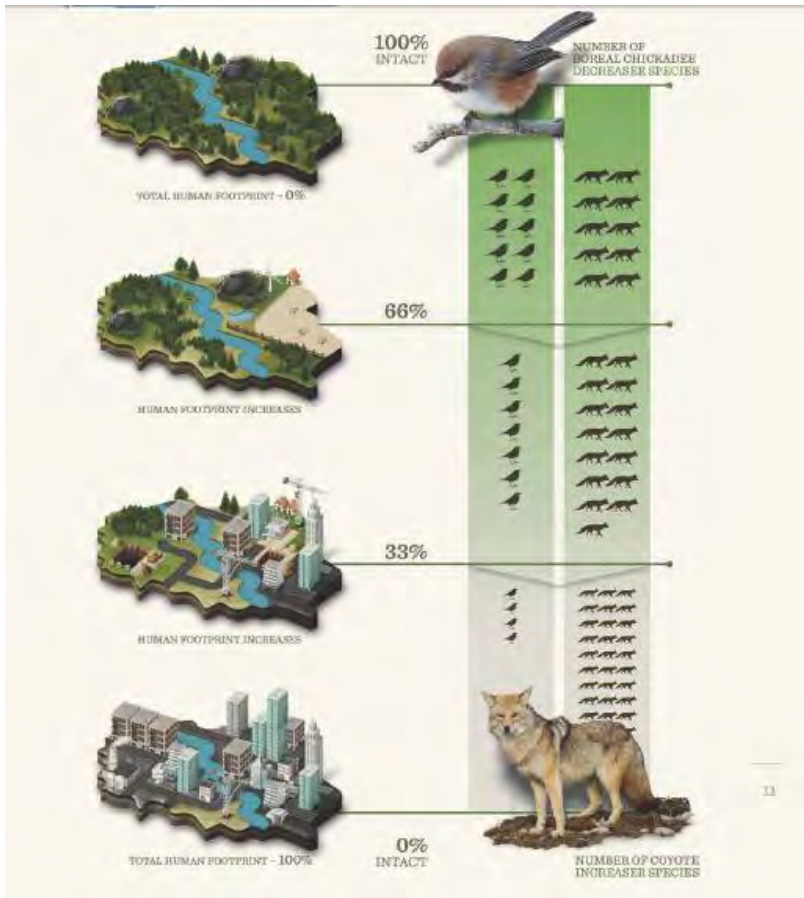
32

33 Description of geographical area and main drivers

34 Livestock production occurs throughout much of Alberta, which is predominantly composed
35 of grassland (prairie) in the south, transitioning to savannah and forest in the north, with
36 livestock production occurring throughout but less so in forested areas. Prior to the late
37 1800's, the area supported bison herds, and fire was a common natural disturbance. This
38 region comprises the northern most extent of the North American Great Plains, and the
39 climate is continental; drought is an important climatic driver. Soils are fertile, and much of
40 the region, especially the prime agricultural soil, has been converted to cultivated annual
41 cropland, although habitat conversion has not been as pronounced as in the rest of the Great

Principles for the assessment of livestock impacts on biodiversity

1 Plains. As a major economic driver in the region, activities related to petroleum energy
 2 production, such as well sites, contribute to rangeland habitat conversion, degradation, and
 3 fragmentation.
 4



5
 6 **Fig. 1.** The Biodiversity Intactness Index ranges from 0% to 100%. At 100% intact, the
 7 abundance of both species is equal to the abundance expected in an undisturbed area-one with
 8 0% human footprint. As the intactness index declines toward 0%, it reflects a change in the
 9 abundance of a species in response to human footprint. For the Baird’s Sparrow, a grassland
 10 specialist species, a decrease in number is observed; for the Coyote, which thrives in
 11 disturbed habitat, an increase in number is observed (ABMI, 2011).

12
 13 Description of livestock system

14 Alberta is home to 4.9 billion beef cattle, generating approximately \$3.1 billion farm income
 15 annually. Ranchers use a variety of grazing management practices ranging from high
 16 intensity rotational grazing, to low intensity continuous grazing. Cattle generally spend a
 17 portion of their lives in feedlots, where feed is derived from crops such as barley and oats; the
 18 majority of feed is sourced locally.
 19

20 Description of primary biodiversity features

21 Rare habitat: globally, temperate grassland is one of the most converted and least protected
 22 ecosystems. These species-rich grasslands are habitat for rare and endangered species, such as
 23 the burrowing owl, sage grouse, piping plover, and swift fox. A variety of native mammals
 24 including bears, pronghorn antelope, elk, wolves, and deer share use of the grassland with
 25 cattle. The grassland also provides habitat for diverse pollinators.

Principles for the assessment of livestock impacts on biodiversity

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35

Main interactions between livestock and biodiversity

The data come from a variety of land uses associated with livestock production – from cropland with relatively low biodiversity value, to extensively grazed native grassland with high biodiversity value, and thus illustrate many of the possible relationships between livestock and biodiversity.

Principles, framework, data, tools or statistical approaches used

ABMI uses site-level data to develop statistical models linking land cover and land use to species abundance. These models are coupled with the remotely-sensed land use and land cover data and averaged across species to estimate an overall index of Biodiversity Intactness at the landscape-scale (Fig. 1). Another tool employed at the monitored sites is the Range Health Assessment developed by the Government of Alberta (Adams, 2009). Grassland sites are scored on a variety of criteria including litter production, weed cover, and plant community composition, to provide information on grassland condition.

Main findings and impacts

Although the reporting of Biodiversity Intactness specifically for land uses associated with livestock production is in progress, Biodiversity Intactness has been reported as 53% in Alberta’s prairie region (ABMI, 2015), where land use is largely dedicated to supporting livestock production.

Further information

Adams, B.W., G. Ehlert, C. Stone, M. Alexander, D. Lawrence, M. Willoughby, D. Moisey, C. Hincz, A. Burkinshaw, J. Carlson, and K. France. 2009. Range Health Assessment for Grassland, Forest, and Tame PASTURE. Public Lands and Forests Division, Alberta Sustainable Resource Development. Pub. No. T/-44.

Alberta Biodiversity Monitoring Institute. In prep. The Status of Biodiversity in the South Saskatchewan Planning Region: Preliminary Assessment. Alberta Biodiversity Monitoring Institute, Alberta, Canada. Report available at www.abmi.ca.

Alberta Biodiversity Monitoring Institute. 2011. The Status of Biodiversity in the South Saskatchewan Planning Region: Preliminary Assessment. (00063) Version 2011-08-13. Alberta Biodiversity Monitoring Institute, Alberta, Canada. Report available at www.abmi.ca. Published August 2011.

Case Study #8

Distribution of large herbivores in relation to environmental and anthropogenic factors in East African savannah ecosystem

General principles illustrated by this case study

- *Illustration of possible indicators:* Because of its biodiversity and ecological significance, Serengeti National park has been listed by the UNESCO as a World Heritage Site. As a national park, it is designated as a Category II protected area which means that it should be managed, through either a legal instrument or another effective means, to protect the ecosystem or ecological processes as a whole.
- *Mid-point indicators:* wildlife density and livestock density; monitoring on both wildlife and livestock over long time in protected and pastoral areas. The wildlife and livestock counts have been conducted in SME for the last 40 years forming the benchmark but also where you can study the human impacts on the system.
- *Response Indicators:* Since 2007 more than 100 conservancies have been developed and signs of improvement of biodiversity in these landscapes are increasing. In many of these conservancies livestock keeping is an integral part of the land use.

Overall objectives

In African savannas, native wildlife and humans have coexisted for centuries under moderate traditional human activities. However, because of intensifying anthropogenic activities, strong gradients often emerge between protected areas and their surrounding human-dominated pastoral ranches, creating spatial heterogeneity in predation risk, resource availability and quality. Consequently, locations with conditions that maximize the net effects of forage availability and quality and minimize predation risk will support above-average herbivore abundances.

Scale, users and goal

This case study demonstrates the dependence of large wildlife herbivore on traditional livestock systems in African savannah ecosystems.

Description of geographical area and main drivers

The Greater Serengeti-Mara Ecosystem (GSME) is undoubtedly one of Africa's most iconic regions with a long history of popular, human and scientific interest. It stretches across two countries Kenya and Tanzania and covers a total area of about 25,000 km². The region is characterized by high spatial heterogeneity in human pressures, yielding a "natural experiment" for studying how drivers of change affect ecosystem services. The GSME is surrounded by pastoral and agro-pastoral communities.

Description of livestock system and primary biodiversity features

The livestock system in SME consists of both pastoral and agro-pastoral system having the highest densities of both wildlife and livestock with increasing population of livestock and people. The ecosystem hosts about 1.8 million migratory wildebeests, more than 600,000 plain zebras, more than 300,000 Thomson gazelles, more than 3000 elephants, about 3000 lions, about 9000 spotted hyenas and many other antelope and carnivore species.

Main interactions between livestock and biodiversity

Principles for the assessment of livestock impacts on biodiversity

1 The dominant traditional conservation paradigm emphasizes the importance of national parks
2 and reserves in protecting terrestrial biodiversity against human activities. This paradigm
3 implicitly assumes that human activities, such as agricultural and livestock production,
4 predominantly harm wildlife.

5

6 Principles, framework, data, tools or statistical approaches used

7 Multivariate semi-parametric quantile regression analysis was adopted to relate herbivore
8 density to Normalized Difference Vegetation Index (NDVI) (considering seasonal, annual and
9 lagged components), livestock density/mean density, distance to the nearest river, total
10 wetness index (TWI) and human population density measured within each grid cell in each of
11 the three landscapes (park, inner and outer group ranch) covering the entire Mara ecosystem,
12 for each species and season. The model enabled exploration of how density responds to
13 variation in the covariates near its upper limit, a region more relevant to understanding
14 variation in hotspots of abundance than the median.

15

16 Main findings and impacts

17 These results reveal how competition with and facilitation by livestock, predation risk, forage
18 quantity and quality and water interact with life history traits, seasons and land use in shaping
19 the dynamics of herbivore hotspots in protected and human-dominated savannas.

20

21 In response to the changes occurring in pastoral areas, wildlife conservancies have recently
22 been formed as part of new initiatives aimed at enhancing wildlife conservation and
23 improving livelihoods of pastoralists through partnerships in which private investors. Through
24 these partnerships both the managers and community are managing land for the benefits of
25 both conservation and pastoral livelihood.

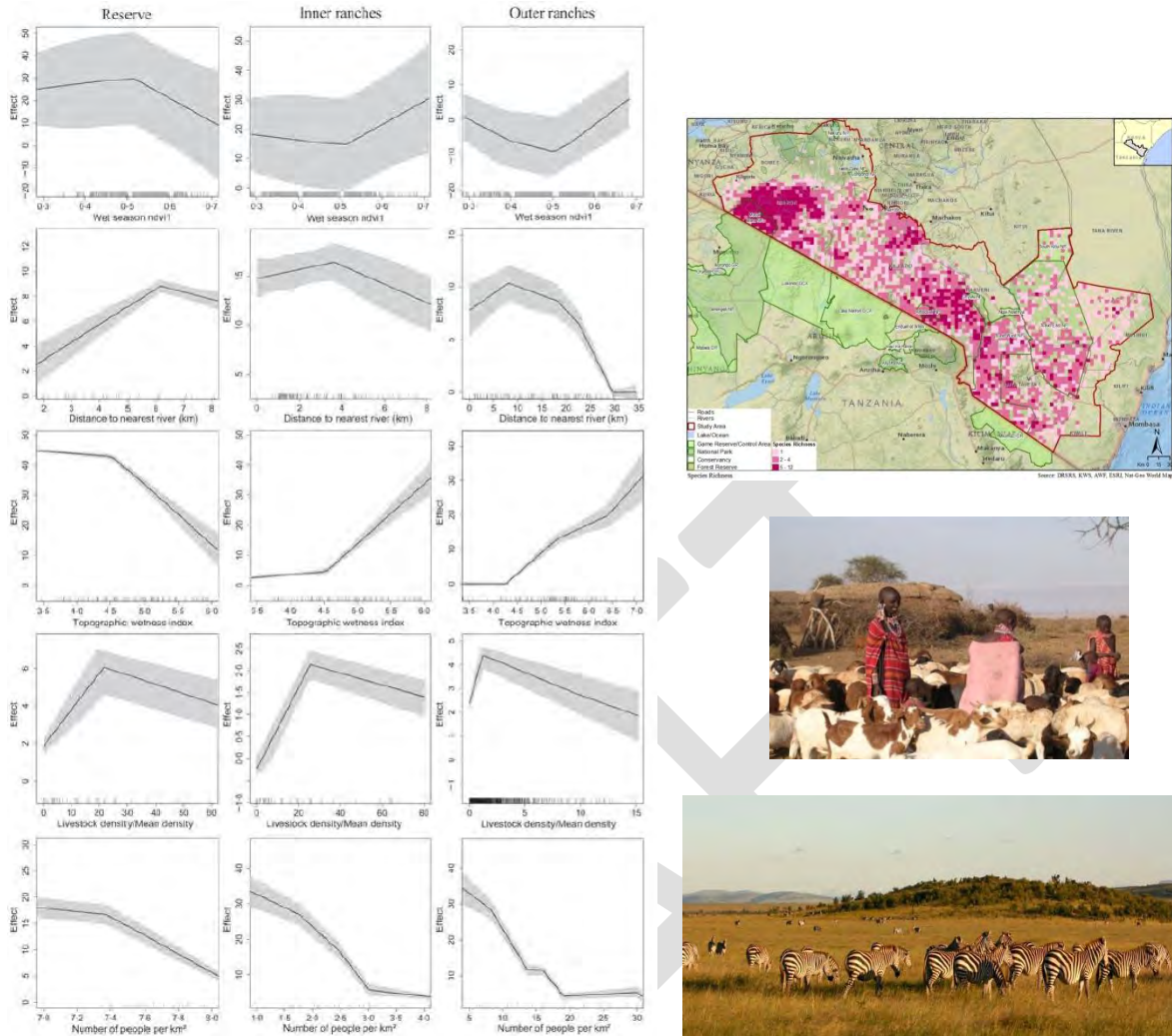
26

27 Our analytical approach may be used to assess the extent to which these conservation efforts
28 are beneficial for wildlife by comparing changes in wildlife densities in grid cells located
29 within the conservancies before and after their formation, against contemporaneous changes
30 in similar grid cells located deep within neighbouring protected reserves as benchmarks.

31

32

Principles for the assessment of livestock impacts on biodiversity



9

10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

Fig. 1: The graph shows partial predictions of the expected density and its 95% confidence limits based on the multivariate semi parametric quantile regression models for Thomson’s gazelle hotspots in the Mara region of Kenya in the wet season. Tick marks on the x-axis represent locations of observations along the predictor space. Photo: Species richness in the southern Kenya rangelands (top); pastoralist with livestock (middle) and zebra migration in the Serengeti-Mara (bottom): Source: Bhola et al., 2012; Maps and Photos: DRSRS, ILRI and Rob O’Meara

Further information

Bhola, N., Ogutu, J.O., Said, M.Y., Hans-Peter Piepho and Oloff, H. (2012). The distribution of large herbivore hotspots in relation to environmental and anthropogenic correlates in the Mara region of Kenya. *Journal of Animal Ecology*, 18, 1268-1287.

Reid, R.S., Nkedianye, D., Said, M.Y., Kaelo, D., Neselle, M., Makui, O., Onetu, L., Kiruswa, S., Ole Kamuaro, N., Kristjanson, P., Dickson, N.M., and Clark, W.C. 2009. Evolving models to support communities and policy makers with science: balancing pastoralism and wildlife conservation in East Africa. *Proceedings of the National Academy of Science*, www.pnas.org_cgi_doi_10.1073_pnas.0900313106.

Case Study #9

Comparing direct land use impacts on biodiversity of conventional and organic milk—based on a Swedish case study (Mueller et al. 2014)

1
2 General Principles illustrated by this case study

- 3 • *LCA approach*: This case study shows the possibility to adapt a clear LCA
4 methodology for applying a biodiversity indicator and solve the drawbacks suggested
5 due to the lack of data.
- 6 • *Characterization factors*: The factor proposed by de Baan et al (2013) is easy to apply
7 and consistent over ecoregions on a global level. The inclusion of the biodiversity
8 weighting factor allows to compare different intensiveness of agricultural practice and
9 account for specific regions in more detail. So, relative species richness could be a
10 suitable indicator as far as regional differences of absolute species richness could be
11 included.

12
13 Although organic land requires about double the area than conventional milk, the direct
14 impacts on biodiversity were less than half. This illustrates the importance of differentiating
15 CF_{Occ} depending on the land use intensity (e.g. organic versus conventional).

16
17 This case study provides guidelines on how to adapt life cycle impact methods to be applied
18 to assess and compare different livestock scenarios. Results show the importance of the
19 inclusion of cow's feed production as part of the whole life cycle of milk production..

20
21 Overall Objectives

22 This published case study can be set as an example to demonstrates how to perform
23 quantification of the direct land use impacts on biodiversity in the frame of Life Cycle
24 perspective based on the methodology presented in de Baan et al. (2013), Mueller et al.
25 (2014). The main purpose was to compare land use in organic and conventional milk
26 production and its effects on biodiversity in Sweden. The overall objective of this case study
27 is to provide guidelines to technicians on which data needs to be collected for inventory and
28 the development of specific characterization factors as well as help in the interpretation of the
29 results.

30
31 Scale, Users and Goal

32 The study carried out by Mueller et al (2014) was to assess direct land use impacts of 1l of
33 milk leaving the farm gate. The project looked at the whole life cycle to provide milk focusing
34 on biodiversity impacts due to land use based on livestock feed production. Following the
35 framework of the United Nations Environment Programme/Society of Environmental
36 Toxicology and Chemistry Life Cycle Initiative (Milà i Canals et al. 2013; Koellner et al.
37 2013a, b), authors distinguished two land use impacts: land occupation (using land) and land
38 transformation (changing the land use). The Biodiversity Damage Potential (BDP) of land use
39 can be calculated as the sum of the transformation and the occupation impacts.

40
41 Description of geographical area and main drivers

42 Livestock farms were located west of Sweden, in the Halland and Vastra Göteland regions.

43 Direct land use impacts due to feed production were ascribed to the region in which the crop

Principles for the assessment of livestock impacts on biodiversity

1 was most likely cultivated according to Cederberg and Flysjoe (2004) and for organic soy
2 according to FiBL (2012) (Table 1).

3
4
5 **Table 1.** Bioma corresponding to the different crops and land cover

Bioma	Crop	Land cover
Temperate broadleaf and mixed forests	Legumes	Arable
	Grains	Arable
	Rapeseed	Arable
	Sugar beet	Arable
	Pastures/Meadows	Permanent
Tropical and subtropical grass-/shrublands and savannahs	Soy bean	Arable
Tropical and subtropical moist broadleaf forest	Oil Palm	Permanent

6
7 In this study, it was assumed that the land was occupied for one whole year for most crops, as
8 in temperate latitudes only and one fodder crop can be grown per year and oil palm fruit,
9 meadows and pastures are cultivated permanently (Milà i Canals et al. 2013). For
10 transformation impacts or land use change authors calculated the inventory data for
11 transformed area as proposed by Milà i Canals et al. (2013). This approach only associates
12 direct land transformation with a fodder crop if (1) in its country of origin the harvested area
13 of this specific crop increased in the last 20 years and if additionally (2) the area of its land
14 use type (i.e. arable land, permanent crops or meadows and pastures) increased. In case these
15 two conditions applied, the transformed area for every occupied hectare and year was
16 calculated by dividing the increase in land use type area over the last 20 years by the current
17 area of this land use type (as proposed in Milà i Canals et al. 2013).

18 Description of Livestock System

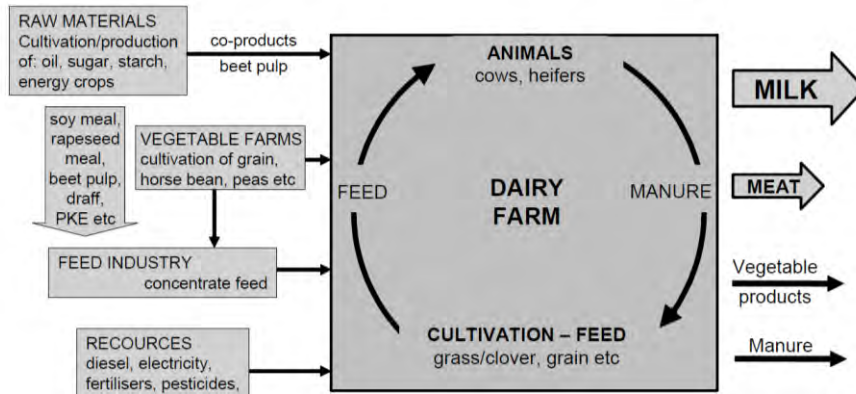
19 Data for livestock feed assessment were collected from fifteen dairy farms, nine high intensity
20 conventional and six organic. Conventional farms purchased more concentrated feed, 2.951
21 kg per cow and year as they had more cows on their farms, 65 cows per farm, while in the
22 organic the average number of cows per farm is 39 with a total purchased feed of 1457 kg per
23 cow and year. The functional unit (FU) of the study was "1 kg of energy corrected milk per
24 cow and year" leaving the farm gate, i.e. transportation and processing of raw milk were
25 excluded. Roughage feed in the diets of organic cows results in lower milk yields from
26 organic, 9.400 kg compared to 10.100 kg from conventional cows.

27 Description of Primary Biodiversity Features

28 The Biodiversity Indicator used to express potential livestock damage was calculated as a
29 relative species richness and a biodiversity weighting factor was applied to account for
30 differences in absolute species numbers as well as conservation value between ecoregions as
31 recommended in de Baan et al. (2013). The analysis of a biodiversity measure was restricted to
32 vascular plants because data availability for organic land use types is relatively good for this
33 taxon.
34
35

Principles for the assessment of livestock impacts on biodiversity

1

2
3

4 **Fig.1.** Flow diagram for a farm production of milk (Cederberg and Flysjoe 2004)

5
6

7 As sampling area varied strongly among studies, sampled species richness (S) was
8 standardized to an area (A) of 100 m^2 using the transformed power model of the species–area
9 relationship proposed in Kier et al. (2005), where z is the species accumulation factor:

10

$$S_{100 \text{ m}^2} = S_{\text{sampled}} \left(\frac{A_{100 \text{ m}^2}}{A_{\text{sampled}}} \right)^z$$

11

12 The biodiversity weighting factor was based on absolute species richness, irreplaceability and
13 vulnerability:

14

- 15 • *Data*: to solve the lack of data on organic land uses or data from the biome sub-
16 /tropical grass-/shrubland and savannahs authors performed a literature search in the
17 Web of Science database. Overall, this search resulted in 66 studies, providing 111
18 data points for the different land use types and 53 data points for the reference
19 situations in three different biomes of feedstock production for Swedish milk.
- 20 • *Biodiversity weighting factor*: The three indices to quantify biodiversity value of each
21 ecoregion were calculated as follows:
 - 22 ○ Absolute species richness (S) was calculated as area-corrected total number of
23 amphibian, reptile, mammal and bird species per ecoregion. As sampling area
24 varied strongly among studies, sampled species richness (S) was standardized
25 to an area (A) of 100 m^2 using the transformed power model of the species–
26 area relationship proposed in Kier et al. (2005)
 - 27 ○ Irreplaceability was quantified as the area-corrected number of strict endemic
28 species of amphibians, reptiles, mammals and birds (EndS). For endemism,
29 these are the only taxonomic groups where data per ecoregion are available.
30 For consistency, the same selection of taxonomic groups was also chosen for
31 species richness, and data on plants were excluded.
 - 32 ○ Vulnerability was expressed as the 'Conservation Risk Index' (CRI), which is
33 calculated as the ratio of converted ecoregion area in per cent to protected
34 ecoregion area in per cent. The latter concept assumes that the more area is
35 occupied the more damaging an occupation or transformation will be for the
36 remaining ecosystem (Koellner 2000). To prevent division by zero, all values
37 below 1 % were set to 1 % as such low habitat proportions are likely below the
threshold necessary

1
2
3
4
5
6

Table 2. Applied z-values by biome Results of normalisations of species richness (S), endemic species richness (EndS) and Conservation Risk Index (CRI) and their product, the BWF per ecoregion^a(Source Mueller et al, 2013)

Biome	Ecoregion	z-value	S ^c	End S ^c	CRI ^c	BWF ^c
Sub-/tropical moistbroadleaf forest	Peninsular Malaysian rain	0.26 ^b	4.6	1.5	3.0	18.1
Temperate broadleaf & mixed forests	Atlantic mixed forests	0.17	2.4	1.0	7.8	18.6
	Baltic mixed forests		2.4	1.0	5.4	12.8
	Sarmatic mixed forests		2.1	1.0	1.6	3.4
Sub-/tropical grass-/shrublands and savannahs	Cerrado	0.18	3.3	1.8	5.4	31.7

^a Results of normalisations for all ecoregions are provided in Mueller et al (2013)

^b Specifically for Asia as for this biome region-specific z-values were given

^c Results of normalisations

7
8
9
10
11

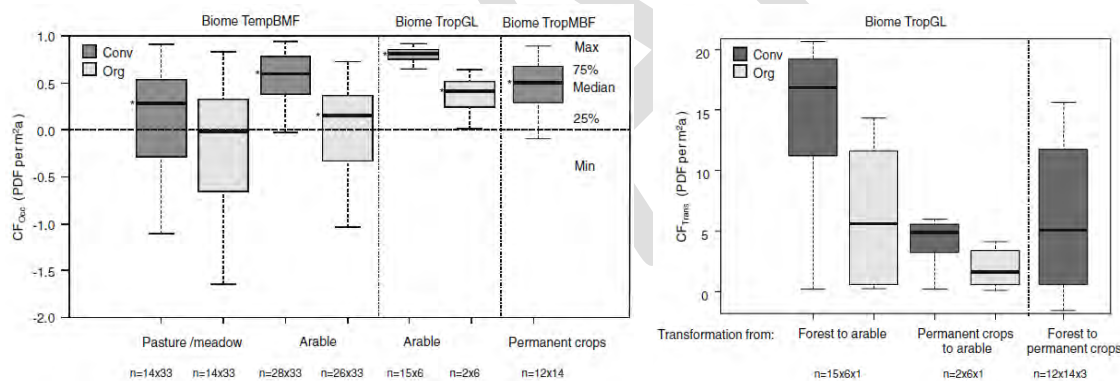


Fig.2. Box and whisker plot of characterization factors of a) occupation (CF_{Occ}) for each land use type, farming practice and biome. b) transformation (CF_{Trans}) for each farming practice, biome and land use type regenerating to after human abandonment. TempBMF temperate broadleaf and mixed forests; TropGL sub-/tropical grass-/shrublands and savannahs; TropMBF sub-/tropical moist broadleaf forests (source Mueller et al 2014).

12

Main findings and impacts

13 Although organic milk required about double the amount of agricultural land to produce 1 kg
 14 of milk, the occupation impact of organic milk was only half the one of conventional. CF_{Occ}
 15 of organic land use types were always considerably lower than the conventional ones thus
 16 leading to smaller occupation impacts. In addition, the different composition of the feedstock,
 17 with larger shares of roughage feed and grazing for the organic cows and larger shares of
 18 concentrate feed for the conventional cows, considerably influenced the result. Results found
 19 here also stress the importance of subsidies for organic agriculture as this type of farming
 20 practice makes an important contribution to the maintenance of species richness in the
 21 agricultural landscape. More details of the results including graphs and tables are available in
 22 Mueller et al (2014).
 23

- 1
2 Further information
3 Cederberg C, Flysjoe A (2004) Life cycle inventory of 23 dairy farms in south-western
4 Sweden. SIK-report Nr 728. The Swedish Institute for food and biotechnology,
5 Goeteborg
6 de Baan L, Alkemade R, Koellner T (2013) Land use impacts on biodiversity in LCA: a
7 global approach. *Int J Life Cycle Assess* 18(6):1216–1230
8 FiBL (2012) Data tables from the FiBL-IFOAM survey on organic agriculture worldwide
9 Research Institute of Organic Agriculture FiBL, Frick, Swiss. [http://www.organic-](http://www.organic-world.net/statistics-data-tables.html)
10 [world.net/statistics-data-tables.html](http://www.organic-world.net/statistics-data-tables.html) (Accessed December 2014)
11 Koellner T, de Baan L, Beck T, Brandão M, Civit B, Margni M, Milà i Canals L, Saad R, de
12 Souza DM, Mueller-Wenk R (2013a) UNEP SETAC guideline on global land use
13 impact assessment on biodiversity and ecosystem services in LCA. *Int J Life Cycle*
14 *Assess* 18(6):1188–1202
15 Koellner T, de Baan L, Beck T, Brandão M, Civit B, Goedkoop M, Margni M, Milà i Canals L,
16 Mueller-Wenk R, Weidema B, Wittstock B (2013b) Principles for life cycle inventories
17 of land use on a global scale. *Int J Life Cycle Assess* 18(6):1203–1215
18 Milà i Canals L, Bauer C, Depestele J, Dubreuil A, Freiermuth KR, Gaillard G, Michelsen O,
19 Mueller-Wenk R, Rydgren B (2007) Key elements in a framework for land use impact
20 assessment within LCA. *Int J Life Cycle Assess* 12(1):5–15
21 Milà i Canals L, Rigarlsford G, Sim S (2013) Land use impact assessment of margarine. *Int J*
22 *Life Cycle Assess* 18(6):1265–1277
23 Mueller C, de Baan L, Koellner T (2014) Comparing direct land use impacts on biodiversity
24 of conventional and organic milk—based on a Swedish case study. *Int J Life Cycle*
25 *Assess* 19:52–68
26
27

Case Study #10 Land management for arid grazing in Botswana

General principles illustrated by this case study

Pressure indicators: livestock density and wildlife species status (including invasive species cover), adoption of appropriate grazing management practices, fire regime, extent of fencing.

State indicators: area of bare sand dunes, % of land area covered in thorn bush and poor quality grazing grasses, water table depth, invasive species prevalence, area of communal land use

Response indicators:

Planting of trees on sand dunes (*Eucalyptus* spp, Salt bush; *Prosopis* spp, etc.).

Fencing of sand dunes to protect them from livestock

Establishment of beekeeping and horticultural projects within fenced sand dunes

Participation in communal land use regulated by local authorities

“Capacity building and environmental awareness courses or seminars including recording condition and comparing to ‘old veld’ or veld rarely grazed by cattle.

Reference State: Wildlife species status, % of stabilised sand dunes.

Description of geographical area

Southern Kgalagadi District, south west Botswana has an arid climate (annual av. rainfall 250 mm, summer temperatures of 20 – 38°C, winter temperatures of –2 – 12°C). It consists of 11 villages located along the Nosop-Molopo valley (Fossil River), close to the Kalahari. The area has a gently undulating sand-covered plain topography and a diverse array of now fossil dune systems.

Description of livestock system

The Southern Kgalagadi region has an environment with very low productivity and which is highly susceptible to land degradation or desertification if subjected to wrong interventions.

Grazing is based on small-holder or nomadic systems which rely on the utilization of communal lands and boreholes, particularly in the context of drought-coping strategies.

Livestock management is conditioned both through the changing conditions of the vegetation across the season as well as by the absence of superficial water streams.

With the establishment and promotion of privatized, fenced cattle ranches the area has become degraded. Poor management practices have exacerbated the impacts of naturally present environmental threats that include wild fires, wind erosion, loss of vegetation, sand dune movement and frequent droughts and heat waves. Poor practices have also translated into increases in the depth of the water table, with increased investment costs for livestock keepers.

Description of primary biodiversity features

The region consists of poorly structured and infertile sandy soils of low moisture retaining capacity. There is no permanent surface water and very little run-off. However, the area is home to well conserved ecosystems hosting wildlife that boosts local tourism, and which triggered the creation of the Kgalagadi Transfrontier Park, a national park shared by Botswana and South Africa. The regional trends of wildlife abundance have been consistently declining.

There has been an increase in bare dunes and the amount of bush growing between dunes and increase in thornbush over the last 20 years and poor grasses are becoming more common in

Principles for the assessment of livestock impacts on biodiversity

1 southwest Kgalagadi ranches. There has also been an increase in invasive species, particularly
2 the honey mesquite (*Prosopis glandulosa*)

3 Main interactions between livestock and biodiversity

4 Traditionally, the interactions between livestock and biodiversity in the area have been
5 positive as well as negative. Customary land use and mobility patterns have guaranteed the
6 sustainability of fodder resources and the maintenance of palatable species among the plant
7 communities, as well as the availability of ground water for livestock – both elements in turn
8 having favoured wild herbivores. Livestock has nevertheless competed to a certain degree
9 with wild herbivores and livestock keepers have traditionally fought with wild predators.

10 On the assumption of the “Tragedy of the Commons” thinking, during the last decades the
11 government has discouraged the communal land tenure systems oriented for meat production
12 for local markets, and promoted instead private ranches with production aimed for beef
13 exports to the European market. Extensive fencing has been undergone along all the country,
14 including the Kgalagadi area, both for veterinary and for privatization reasons. This has had
15 direct pervasive consequences for wildlife by reducing its capacity to cope with the
16 environmental threats cited above. Given that much of the private land has been established
17 on former communal areas, the poorest livestock keepers with reduced investment capacity
18 have been forced to concentrate on the few communal areas left. This has added to the
19 disruption of mobility to create a situation that triggered land degradation.

20 In early 1980s the Ministry of Agriculture through the Drought Relief Programme (supported
21 by UNCCD) initiated establishment of Sand Dune Stabilization projects in the Kgalagadi
22 South region. The projects covered 9 villages in areas ranging from 2ha to 10ha. The
23 objective was to stabilize sand dunes through effective sustainable land management practices
24 including grazing and support to communities to implement their own management actions,
25 hence contributing to improved livelihoods and maintenance of ecosystems integrity. The
26 intervention did however not tackle the underlying causes of reduced mobility or overuse of
27 remaining communal lands. Instead, species such as the alien *Prosopis glandulosa* were used
28 for sand dune stabilization. But given their high water demand during the dry season they
29 ended up deepening the water accessibility issues (an issue also known for other mesquites
30 introduced in Africa), further displacing poorer livestock keepers and further promoting the
31 ranching model.

32 Further policy development such as through the Community Based Natural Resources
33 Management policy, and latter interventions such as the ones developed by IUCN through
34 UNEP-GEF funding, have however concentrated on promoting local knowledge on their
35 ecosystem and local governance structures. Results start to be encouraging through the
36 identification of some enthusiastic livestock keepers that are improving the biodiversity status
37 of the surrounding lands while at the same time increasing their resilience and their
38 livelihoods options. The reconnection of ecosystems through restoration of livestock mobility
39 and communal land use is also a promising tool to improve conservation status of wildlife
40 species.

41 Main findings

42 This case study shows the importance of incorporating local/indigenous knowledge in
43 developing strategies to manage or restore biodiversity values and ecosystems services.
44 It also shows the need to take a multi-category holistic approach to biodiversity management
45 and monitor to avoid perverse outcomes or trade-offs with other biological or ecological
46 values.

47

Principles for the assessment of livestock impacts on biodiversity



1
2

3 Further information:

- 4 Bartlam-Brooks, H.L.A., Bonyongo, M.C. & Harris, S. (2011). *Will reconnecting ecosystems allow*
5 *long-distance mammal migrations to resume? A case study of a zebra *Equus burchelli**
6 *migration in Botswana. *Oryx*, 45, 210–216. [http://www.guidetrainingcourses.com/wp-](http://www.guidetrainingcourses.com/wp-content/uploads/2013/10/A-case-study-of-a-zebra-Equus-burchelli-migration-in-Botswana.pdf)
7 [content/uploads/2013/10/A-case-study-of-a-zebra-Equus-burchelli-migration-in-Botswana.pdf](http://www.guidetrainingcourses.com/wp-content/uploads/2013/10/A-case-study-of-a-zebra-Equus-burchelli-migration-in-Botswana.pdf)*
- 8 Buckham-Walsh, L. & Mutambirwa, C.C. (2014). *Strengthening communal rangelands management*
9 *in Botswana. Legal and policy opportunities and constraints*. In: Herrera, P.M.; Davies, J. M.;
10 Manzano Baena, P. (eds.), *The Governance of Rangelands: Collective Action for Sustainable*
11 *Pastoralism*. Routledge, London , pp. 214-235.
- 12 Dougill, A.J., Perkins, J.S., Akanyang, L., Eckardt, F., Stringer, L.C., Favretto, N., Atlhopheng, J. &
13 Mulale, K. (2014). *Land Use, Rangeland Degradation and Ecosystem Service Provision: New*
14 *Analyses from southern Kalahari, Botswana. Report for the Economics of Land Degradation*
15 *Initiative*. Leeds, UK, 18 pg [online]. Available from:
16 <http://www.see.leeds.ac.uk/research/sri/eld/>
- 17 Mbaiwa, J.E. & Mbaiwa, O.I. (2006). *The effects of veterinary fences on wildlife populations in*
18 *Okavango Delta, Botswana*. *International Journal of Wilderness* 12: 17–24.
19 http://www.wilderness.net/library/documents/ijwdec06_mbaiwa.pdf
- 20 McGahey, D. (2011). *Livestock mobility and animal health policy in southern Africa: the impact of*
21 *veterinary cordon fences on pastoralists. *Pastoralism: Research, Policy and Practice* 2011,*
22 *1:14. <http://www.pastoralismjournal.com/content/1/1/14>*
- 23 Mosalagae, D. & Mogotsi, K. (2013). *Caught in a sandstorm: an assessment of pressures on*
24 *communal pastoral livelihoods in the Kalahari Desert of Botswana. *Pastoralism: Research,**
25 *Policy and Practice* 2011, 3:18. <http://www.pastoralismjournal.com/content/3/1/18>

26
27

