



INLAND NORWAY
UNIVERSITY
OF APPLIED SCIENCES

PhD in Applied Ecology

The curriculum for the study-program,
including course descriptions and tentative reading lists

Content

Introduction	2
The learning outcomes	3
Knowledge	3
Skills	3
Competence.....	3
Target group.....	3
Requirements for admission	4
Career.....	4
The length, extent and level of the study	4
The scientific dissertation	4
Internationalization.....	5
Content, Structure and organization of the study.....	5
Course descriptions.....	6
Seminars in applied ecology	7
Adaptive Ecological Monitoring.....	9
Applied models for fish and wildlife management	11
Large herbivores and ecosystem interactions – top-down or bottom-up.....	12
Specialisation in applied ecology	14
Specialisation in applied ecology	15
Specialisation in applied ecology	16

Introduction

Ecology is the scientific study of the interactions that determine the distribution and abundance of organisms¹. An applied perspective often refers to how ecology can be applied to management questions to obtain certain goals. Hence, in applied ecology we use ecological concepts, theories, models and methods to address real-world problems, and the PhD-study in Applied Ecology focuses on the application of these ecological principles to understand the effects of manipulating or exploiting biological resources, with the ultimate aim to develop improved management practices (see also 2,3).

The objectives of applying ecological science can be linked to human exploitation of nature, such as sustainable harvesting of fish and wildlife, or the utilisation of other ecosystem services. However, ecological science may also be applied to preserve the biological diversity of ecosystems affected by man. Human impacts such as habitat destruction and fragmentation, harvesting, biological control, the introduction of alien species, and discharge of environmental poisons or climatic gasses all contribute to changes in the environment. Today these changes are occurring at a much faster rate and to a greater extent than species are able to adapt to. We aim at training PhD students in applying ecological knowledge to reduce these detrimental effects.

We focus on how humans impact ecological systems, but also on mitigating these impacts so that we can utilise biological resources sustainably. To validate the desired effect of mitigation efforts, we need effective and long term monitoring of the natural environment. Hence, the bulk of our study program is focused towards human impacts and the application of ecological principles for the mitigation, use and monitoring of biological resources. Sustainable management will be a topic through all our courses as we intend to educate candidates well suited for doing applied research in ecology, but also skilled in communicating with management and the public.

The overall aim of the study is to advance the quality of the PhD education in Applied Ecology, thereby producing competent and responsible future scientists, managers and advisors that can advance the field of Applied Ecology³.

¹ Krebs, C. J. 2001. Ecology. 5th edition. Benjamin Cummings, California.

² Freckleton, R.P., Hulme, P., Giller, P. and Kerby, G. 2005. The changing face of applied ecology. *Journal of Applied Ecology* 42: 1-3.

³ Memmott, J., Cadotte, M., Hulme, P. E., Kerby, G., Milner-Gulland, E.J. and Whittingham, M.J. 2010. Putting applied ecology into practice. *Journal of Applied Ecology* 47: 1-4.

The learning outcomes

The learning outcome⁴ is a result of the dissertation, participation in the educational component and participation in an active research environment. By completing the PhD-study in Applied Ecology, the candidate shall:

Knowledge

- understand research topics at the most advanced frontier in applied ecology, including research methods used in applied ecology
- have contributed, through his/her own research, to the development of new knowledge in the application of ecological theory
- have an understanding of how ecosystems are impacted by human interventions
- have an understanding of processes, dynamics, functions, and composition of ecosystems
- have an understanding of how biological resources may be exploited sustainably and how they can be monitored to confirm sustainable use

Skills

- be capable to utilize specialized methods and techniques to further develop his/her own research at an international level
- be able to analyse and evaluate theory and methods within applied ecology, and extend and redefine existing knowledge and professional practice
- be able to critically evaluate scientific results and conclusions
- be able to identify key research problems
- be able to search knowledge through scientific media
- be able to communicate to a variety of audiences complex issues in applied ecology

Competence

- demonstrate substantial authority, innovation, autonomy and professional integrity to develop new ideas and bring research to completion
- be able to communicate research and its applications through well known national and international publishing channels, and to policy makers, stakeholders and the general public
- be able to present and debate important topics in the field of ecology in international forums

Target group

Our aim is to target students and professionals who have a dedicated interest in ecology, and the interaction between man and the environment. Primarily we target students with a master in ecology, (wildlife) biology, evolution, environmental sciences and similar subjects, and who are interested in developing their research expertise in Applied Ecology. However, we encourage applicants with other master degrees, or who can show an interdisciplinary master degree, as long as they fulfil the entrance requirements (see below). We also target professionals within conservation and wildlife management who want to extend their competence in the field of ecology above the level of a master.

⁴The learning outcomes are described according to the national framework of qualifications.

Requirements for admission

To enter the program, students are required to confirm they have achieved:

1. At least the degree of a 5-year master from a university or university college in ecology, (wildlife) biology, evolution, environmental sciences or similar subjects.
2. An average weighted (ECTS credits) mark for the master study of at least B. In cases where all or part of the program is approved with the use of the marks Pass / Fail, the applicants are taken up by individual assessment.

Applicants with a master's degree from another subject area than is approved as a basis for admission to the program, or with lower grade basis, may be admitted after special review. These applicants must be able to document that it is very likely that they will be able to complete the PhD study. If necessary, additional documentation or a preliminary examination will be required to evaluate the professional level. Such applicants may also, if necessary, be ordered to take certain disciplines within a deadline to qualify for admission. These disciplines cannot be part of the formal requirements for a doctoral degree.

Career

The PhD in Applied Ecology qualifies for:

- Research, scientific communication and other scientific work in educational and research institutions. For work as teachers in educational institutions additional pedagogic course may be needed
- Work in private and public management of biological resources at all levels from licensees, local authorities and ministries

The length, extent and level of the study

The nominal length of the PhD in Applied Ecology is 3 years full-time study, ending with a doctoral dissertation for the degree of Philosophiae Doctor. The dissertation has to be defended in a public forum within 8 years after entering the study. The PhD educational program combines academic and methodological schooling amounting to 30 ECTS credits in total.

The scientific dissertation

The dissertation should be an independent, scientific work that meets international standards with regard to scientific merit, methodology and ethical requirements⁵. It should contribute new scientific knowledge and achieve a level of scientific merit, which suggests that it could be published as part of the peer-reviewed scientific literature in the subject area.

⁵ See for instance *Ethical guidelines for Inland Norway University of Applied Sciences* (<http://www.hihm.no/om-hoegskolen/sentrale-dokumenter>); *Ethical guidelines for science and technology* (<http://www.etikkom.no/no/forskningsetikk/etiske-retningslinjer/naturvitenskap-og-teknologi>); The Vancouver convention and the new standards for authorship from the Council of Science Editors (e.g. <http://openwetware.org/wiki/authorship>).

We recommend that the dissertation be a compilation of 3-5 international scientific publications or manuscripts for international scientific publication provided that these are interrelated. An introductory synthesis should generalize the topic and results into a broader academic context, and show the interrelation between the papers.

The individual papers may be written by several participants of a joint project, as long as it is possible to identify the individual contributions made by each author. Co-authorship must adhere to the norm commonly accepted in the international research community such as the Vancouver Convention.

The dissertation should be the result of cooperation with supervisor(s), and the student should be part of an active scientific environment.

The dissertation should be written in English, including an abstract both in English and Norwegian.

Internationalization

A combination of national and international students creates a student environment that improves the quality of the study through discussions of various 'schools' in ecology and human attitudes. We will encourage and make allowances for students to study abroad for at least 3 months of their degree. Such an international experience is recommended to take place in the second half of the study.

The PhD-student will also have to put his/her work in a broader academic context by presenting some of his/her results in international conferences, and gain experience through the international forum of the International Research School in Applied Ecology (IRSAE)⁶ with several partner institutions from Europe.

Content, Structure and organization of the study

The PhD degree is conferred on the basis of a satisfactory completion of the educational component, an approved scientific dissertation, a trial lecture, and satisfactory performance in the PhD examination.

The scientific dissertation is to be developed together with one or more supervisors. The educational component consists of 30 ECTS credits, and will give a broader insight into the academic, methodological and ethical field of applied ecology, necessary to complete the dissertation. The educational component will also give practice in written and oral communication of scientific results for both professionals and the general public. Three courses of 7.5 ECTS credits each are compulsory, while 7.5 ECTS credits are optional. The International Research School in Applied Ecology will provide an extensive curriculum with PhD-courses from all partner institutions that may be chosen as optional courses. In addition, the student may choose optional courses from other national or international universities, for instance the host university during the international stay. The selection of courses should be done in cooperation with the supervisor(s) of the scientific dissertation.

⁶ See <http://www.irsae.no/>

In general, the courses are given as intensive courses with one-week long meetings separated with self-study or practical exercises. The intensive teaching consists of lectures by teachers and guest lecturers and requires participation by prepared students in seminars and workshops. In addition to the intensive weeks the compulsory course 'Seminars in applied ecology' will consist of seminars at least once a month.

All courses are evaluated as passed or failed.

The educational part has to be completed before the candidate applies to have the dissertation evaluated.

Course descriptions

Inland Norway University of Applied Sciences will provide the following courses:

Course type	ECTS credits	Course title
Compulsory	7.5	Seminars in applied ecology
Compulsory	7.5	Adaptive ecological monitoring
Compulsory	7.5	Applied models for fish and wildlife management
Optional	7.5	Spatiotemporal scaling in ecosystem management
Optional	7.5	Large herbivores and ecosystem interactions – top-down or bottom-up
Optional	7.5	Environmental and human dimension of nature tourism, <u>outdoor recreation and related ecosystem services</u>

In addition to the courses described above the students can take a self-study specialization course with a maximum of 5 ECTS credits.

Below we describe the courses available at Inland Norway University of Applied Sciences for the PhD programme in Applied Ecology, with suggested reading list.

Compulsory course**Course title** **Seminars in applied ecology**

ECTS credits 7.5**Responsible teachers** Harry P. Andreassen, Jon M. Arnemo, Tomas Willebrand, Peter Kiffney, Christina Skarpe, Torstein Storaas, Petter Wabakken and others**Content** SEMINARS ON THE PHILOSOPHY OF ECOLOGICAL AND BIOLOGICAL SCIENCE

- theories, hypotheses and models
- explanation, laws, prediction, causation and understanding
- scientific theories and models
- acquiring knowledge
- community, niche, diversity and stability
- rationalism and empiricism
- ecology and evolution

LECTURES ON NATIONAL AND INTERNATIONAL ETHICAL CONVENTIONS AND GUIDELINES

- good research practice
- ethical guidelines regarding the use of animals in applied ecological research
- ethical guidelines regarding the use of questionnaires and interviews in applied ecological research
- ethical guidelines for cooperation and authorship

LECTURES ON WRITING, READING AND PRESENTING SCIENTIFIC RESULTS BOTH TO SCIENTIFIC AND POPULAR AUDIENCES

- the structure of scientific papers and popular science
- characteristics of (good) review papers, original research papers, popular papers and other literature
- writing, reading and presenting scientific results orally for academics and laymen – the popular scientific presentations
- interactions and communications with the public media and on the world wide web

WORKSHOPS ON THE REFEREE PROCESS

- how to referee scientific papers and research proposal

COLLOQUIUMS IN APPLIED ECOLOGY

- discussions on:
 - some major human impacts on the environment such as habitat fragmentation and loss, pollution, climate change, alien species and biological control
 - ecosystem services, biological diversity, state transitions, regime shifts, resilience
 - management, mitigation, conservation

Learning outcomes After the course the student shall:

Knowledge

- have knowledge on the frontiers in applied ecology
- understand how new knowledge develops in applied ecology
- have an understanding of how ecosystems are impacted by human interventions
- have an understanding of processes, dynamics, functions, and composition of ecosystems

Skills

- be able to analyse and evaluate theory and methods in applied ecology, and extend and redefine existing knowledge and professional practice
- be able to critically evaluate scientific results and conclusions

- be able to identify key research problems
- be able to search knowledge through scientific media
- be able to communicate to a variety of audiences complex issues in applied ecology
-

Competence

- demonstrate substantial authority, innovation, autonomy and professional integrity to develop new ideas and bring research into completion
- be able to communicate research through well known national and international publishing channels
- be able to present and debate the field of applied ecology in international forums

Organisation Lectures, seminars, workshops and colloquiums. Some seminars with the presence of management.

Required components Participation in 80% of the seminars

Evaluation Passed or failed. To pass the student has to pass evaluations of the following:

- 1 written essay in collaboration with other students, and preferably also management following the concept of Hulme (2011)⁷ on practitioner's perspective: *"...contributions by anyone who has a strong opinion on the current state of applied ecology research, whether academic or not, as long as they can provide an original perspective and a constructive way forward."*
- 4 oral presentations

⁷ Hulme, PE. 2011. Practitioner's perspectives: Introducing a different voice in applied ecology. *Journal of Applied Ecology* 48: 1-2

Compulsory course**Course title** **Adaptive Ecological Monitoring**

ECTS credits 7.5**Responsible teachers** Peter Kiffney, Tomas Willebrand, Maria Willebrand, Kjartan Østbye, Michael A. D. Ferguson, Petter Wabakken and others

Content Humans touch all parts of the globe affecting ecological systems in a variety of ways, with these impacts ranging from relatively small changes to species extinctions. To minimize and understand human impacts on the environment, managers intervene through regulations (e.g., water quality criteria), species conservation, habitat restoration, etc. Biological monitoring is used to understand the nature of anthropogenic impacts and mitigation measures in both space and time; information gained from monitoring is used with an adaptive management framework to improve conservation, restoration and management. Thus, monitoring has the potential to be an important link between ecological theory and fish and wildlife management. To be effective in an ecological and management sense, monitoring should be adaptive and have the following attributes: (1) be hypothesis-driven, (2) based on an understanding of the ecology of the system, (3) a rigorous sample design, (4) results analysed using appropriate models, and (5) embedded in an adaptive management framework. In this course, we will use lectures, review of the scientific literature, and case studies to link ecology, management, and study design and analysis to develop a solid foundation in this form monitoring. In the course we will put most emphasis on monitoring of populations and communities, but the course will cover the principles of adaptive monitoring for all the following levels of organisation:

- *Monitoring on genetic level:* Ecological significance of and methods for monitoring of inbreeding, gene flow, genetic diversity etc.
- *Monitoring on individual level:* Ecological significance of and methods for monitoring of size and growth, reproduction, diseases, damage, survival
- *Monitoring of populations:* Ecological significance of and methods for monitoring of population size and density (indices, density estimators, mark-recapture, distribution, etc), and population composition (age and sex composition)
- *Monitoring of communities:* Ecological significance of and methods for monitoring of communities (taxonomic or functional groups); How to monitor taxonomic and functional composition, richness, dominance and diversity in plants and animals
- *Monitoring of ecosystems:* Ecological significance of and methods for monitoring of ecosystem function, food webs, uptake and cycling of resources and contaminants from soil, water, air; significance of climate, atmospheric composition. How to monitor decomposition, nutrients dynamics and cycling, cycling, fate and effects of contaminants.

Learning outcomes After the course the student shall:

Knowledge

- Have knowledge of theory and practice of monitoring ecological systems

Skills

- be able to design and carry out a rigorous monitoring program
- be able to analyse and interpret monitoring data

Competence

- demonstrate substantial authority, innovation, autonomy and professional integrity to develop new ideas related to ecological monitoring and bring research into completion
- be able to communicate research and results based on ecological monitoring

through well known national and international publishing channels

Organisation Lectures /workshop by teachers/researcher from Inland Norway University of Applied Sciences and invited guest lecturers, oral presentations by students; computer and field exercises; group project on designing monitoring program

Required components Attendance and participation in lectures;

Evaluation Pass/fail. To pass the student has to pass the following evaluations:

- Completion of exercises
- 2 oral presentations
- Final oral exam

Compulsory course**Course title** Applied models for fish and wildlife management

ECTS credits 7.5**Responsible teachers** Tomas Willebrand, Peter Kiffney, Harry P. Andreassen, Kjartan Østbye and others

Content Theory for population dynamics and sustainable harvest has advanced greatly in recent decades. Important aspects of harvest modelling involve new ways to handle different sources of uncertainty (e.g., process and measurement errors, lack of controllability), and the communication of this uncertainty to management. Uncertainty in harvest strategies can be reduced by a more rigorous adaptive management approach, which may integrate several indicators of the on-going processes. The idea of adaptive management was developed in the late 1980s, and has since broadened into different types, which will be compared in this course. Active adaptive management is suited for top-down management with high controllability (i.e., where management actions can be controlled in the real world), whereas adaptive co-management is better suited for systems in which several stakeholder groups participate in decision making. Implementation of these models in local harvest management is rarely straightforward, and this course focuses on the problems of scaling-down general theory to applied management (i.e., development of robust guidelines for local harvest management). Important issues include not only understanding the effect of changing spatial scales when interpreting population change and the relevance of different demographic processes, but also optimizing resource use through risk analysis and decision theory. We will use examples from small and big game and fish subject to some kind of harvest, and include species interactions (e.g., predation). We will model the resilience of populations and the management system, and analyze how human impact through harvest and policy decisions may push populations into alternative states.

Learning outcomes After the course the student shall:

Knowledge

- have knowledge at the most advanced frontier in harvesting models, including advanced research methods used in applied ecology

Skills

- be able to utilize advanced techniques to develop and apply models for fish and wildlife harvest management
- be able to analyse and evaluate the applicability of harvesting models

Competence

- be able to communicate the applicability of harvesting models
- be able to debate the applicability of harvesting models

Organisation Intensive course with lectures and workshop by teachers from Inland Norway University of Applied Sciences and invited guest lecturers; oral presentations by students

Required components Participation in lectures and workshops

Evaluation Passed or failed. To pass the student has to pass evaluation of a report which should explore alternative strategies of a given harvest management.

Optional course**Course title** **Large herbivores and ecosystem interactions – top-down or bottom-up**

ECTS credits 7.5**Responsible teachers** Christina Skarpe and others

Content

LARGE HERBIVORES

- foraging strategies of browsers, grazers and “mixed feeders”
- significance of body size (within and between species) and digestive system
- importance of social organization

LARGE HERBIVORES, PLANTS AND VEGETATION

- plant strategies in relation to herbivory and resource limitation, and subsequent herbivore responses
- direct and indirect impact by large herbivores on vegetation composition/structure
- effects on plants/vegetation of interactions between herbivores and between herbivores and abiotic factors (e.g. soil nutrients)

LARGE HERBIVORES AND SOIL FERTILITY

- direct and indirect effects of large herbivores on soil processes

LARGE HERBIVORES AND PREDATORS

- predation-related strategies in large herbivores
- direct (trophic) and indirect (habitat mediated) effects of large herbivores on predators
- density dependence in predation, parasitism and disease

LARGE HERBIVORES, ECOSYSTEMS AND THE HUMAN SOCIETY

- significance of top-down and bottom-up processes for controlling large herbivore populations
- large herbivores as agents for ecosystem change/state transitions
- humans as direct and indirect determinants of large herbivore populations and communities
- large herbivores, human land use and biological diversity; resilience and sustainability in different spatial and temporal scales
- large herbivores in the boreal forest ecosystem, competitors with humans for resources and providers of ecosystem services
- adaptive management and monitoring of large herbivores

Learning outcomes

After the course the student shall:

Knowledge

- have a knowledge of the most advanced models and theories on the ecological significance of large herbivores worldwide, and particularly of their role in the processes, dynamics and functioning of boreal forest ecosystems

Skills

- be able to analyze and evaluate theory, results and conclusions related to the ecological roles of large herbivores
- be able to identify key research questions to solve “real-world” problems related to large herbivores

Competence

- demonstrate substantial authority and autonomy to develop new ideas related to large herbivore ecology and to design and complete research on these
- be able to communicate research through well known national and international publishing channels as well as through local media

- be able to debate important concepts such as top-down / bottom-up effects, resilience and sustainability in relation to large herbivores and ecosystem dynamics and management.

Organisation Intensive course with meetings in two separate weeks with self study in between. Lectures /workshop by teachers/researcher from Inland Norway University of Applied Sciences and invited guest lecturers, oral presentations by students.

Required components Participation in the lectures / workshop

Evaluation Passed or failed. To pass the student has to pass evaluations of the following:

- 1 written essay formatted as a scientific paper on a student-selected topic
- 1 oral presentation
- A 3 hour written exam

Compulsory course**Course title** **Specialisation in applied ecology**

ECTS credits 2.5**Responsible teachers** PhD supervisor**Content** Individual readings as agreed by the student and the supervisor of the PhD consisting of 150-300 pages depending on the nature of the readings (less pages for very technical chapters and/or scientific publications than for general book chapters).**Learning outcomes** After the course the student shall:

Knowledge

- The student has an in-depth understanding of a selected topic in applied ecology

Skills

- The student is able to read and critically evaluate scientific publications concerning the specialization topic.
- The student can apply this knowledge to other ecological or societal systems

Competence

- The student can discuss recent challenges of human impacts on ecological systems based on a profound knowledge in applied ecology

Organisation Individual reading**Required components** None**Evaluation** Oral exam. Passed or failed. To pass the student has to pass evaluation of a report which should explore alternative strategies of a given harvest management.

Compulsory course**Course title** **Specialisation in applied ecology**

ECTS credits 5**Responsible teachers** PhD supervisor**Content** Individual readings as agreed by the student and the supervisor of the PhD consisting of 300-600 pages depending on the nature of the readings (less pages for very technical chapters and/or scientific publications than for general book chapters).**Learning outcomes** After the course the student shall:

Knowledge

- The student has an in-depth understanding of a selected topic in applied ecology

Skills

- The student is able to read and critically evaluate scientific publications concerning the specialization topic.
- The student can apply this knowledge to other ecological or societal systems

Competence

- The student can discuss recent challenges of human impacts on ecological systems based on a profound knowledge in applied ecology

Organisation Individual reading**Required components** None**Evaluation** Oral exam. Passed or failed. To pass the student has to pass evaluation of a report which should explore alternative strategies of a given harvest management.

Compulsory course**Course title** **Specialisation in applied ecology**

ECTS credits 7.5**Responsible teachers** PhD supervisor**Content** Individual readings as agreed by the student and the supervisor of the PhD consisting of 450-900 pages depending on the nature of the readings (less pages for very technical chapters and/or scientific publications than for general book chapters).**Learning outcomes** After the course the student shall:

Knowledge

- The student has an in-depth understanding of a selected topic in applied ecology

Skills

- The student is able to read and critically evaluate scientific publications concerning the specialization topic.
- The student can apply this knowledge to other ecological or societal systems

Competence

- The student can discuss recent challenges of human impacts on ecological systems based on a profound knowledge in applied ecology

Organisation Individual reading**Required components** None**Evaluation** Oral exam. Passed or failed. To pass the student has to pass evaluation of a report which should explore alternative strategies of a given harvest management.
