

Institut Henri Poincaré
Quarterly thematic program MABIES
Mathematics of Bio-Economics
2013, January 7 – April 5

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(CERMICS, École des Ponts) and (CNRS-MNHN)

May 10, 2013



Mathematics of Bio-Economics
January 7th - April 5th 2013
Organized by Michel De Lara and Luc Doyen



Programme coordinated by the Centre Emile Borel of IHP
Registration is free however mandatory on <http://www.ihp.fr>
Participation of postdocs and Ph.D. students is strongly encouraged
Deadline for financial support: June 25th, 2012
For further informations, contact Claire Bérenger mabies@ihp.fr
Scientific programme on <http://cermics.enpc.fr/~delara/MABIES/MABIES/>
Supported also by: FSMP



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IHP MABIES website

<http://www.ihp.fr/en/ceb/mabies>

Abstract

The quarterly thematic program entitled *Mathematics of Bio-Economics* (MABIES) focused on the interfaces of mathematics with both ecology and economics in the prospect to contribute to the sustainable management of biodiversity and ecosystem services. It was part of the Mathematics of Planet Earth <http://www.mpe2013.org>, an international scientific event proposed by the North American Mathematical Science Institutes. On the one hand, the trimester has shown that original mathematics can be inspired by issues from ecology and from economics of sustainable development. On the other hand, it has also displayed to a biological and economic audience how mathematics, with both their concepts and methods, can contribute to the knowledge, understanding and the management of ecosystems and renewable resources. MABIES relied on a combination of workshops (3), tutorials, seminars and more informal exchanges between participants. It has been a great opportunity of interdisciplinary and international exchanges between students (masters, PhD, post-docs), young and senior researchers within a stimulating scientific place in the center of Paris.

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1 Motivations and goals

Biodiversity and ecosystems are experiencing accelerating changes with some alarming trends and largely unknown consequences. A major cause of these threats on biodiversity observed in many ecosystems is related to man's development and anthropogenic activities including fishing, agriculture, forestry or hunting. The changes in biodiversity in turn affect human activities relying on it and alter important economic commodities (typically food, energy, drugs) or services (typically tourism, pollination, carbon cycle, water cycling) provided by biological diversity and renewable resources. As a consequence, the sustainable management of biodiversity is now questioned and has become a major issue for national and international agencies involved in their regulation (ICES, FAO, IUCN, etc.).

In this context, the IPBES (Intergovernmental Science Policy Platform for Biodiversity and Ecosystem Services), an "IPCC-like" platform launched in 2010, will play a major role to articulate the scientific knowledge on the changes and degradation of the natural world, with knowledge on effective solutions and public policies. In particular, the effectiveness of management instruments including quotas, protected areas, taxes, etc. has to be considered in both ecological and socio-economic dimensions. Thus bio-economic quantitative methods, indicators, models, management and scenario methods are needed.

The aim of the quarterly thematic program *Mathematics of Bio-Economics* (MABIES) was to foster cooperation and information interchange among those engaged or interested in the mathematical modeling of systems related to the management of natural renewable resources and scenarios of biodiversity (marine and terrestrial). This includes specialists in control of dynamical systems, management of uncertainty and risk. Such goal requires interdisciplinary exchanges between mathematics, ecology, economics and computer sciences. Particular attention has been paid to the following applied fields: fisheries, agricultural systems, forest management, wildlife management and invasive species issues. Mathematics — by providing integrated concepts, models and methods — favor the interactions between these applied disciplines. In particular, of interest is the use of various methods in different mathematical domains such as optimal control, stabilization methods, viable control and invariance methods, stochastic and robust control, adaptive control, multi-criteria approaches, game theory.

Furthermore, the North American Mathematical Science Institutes proposed that 2013 be a year of [Mathematics of Planet Earth - MPE2013](#). The trimester MABIES was a contribution of IHP to MPE 2013.

2 Invited speakers

- [Michael Bode](#) (quantitative ecologist, Australia) [2 March–2 April 2013]
- [Carlos Castillo-Chavez](#) (mathematician, USA) [19 February–3 April 2013]
- [Christopher Costello](#) (economist, USA)

- [Michael Finus](#) (economist, UK) [21 January–17 February 2013]
- [Pedro Gajardo](#) (mathematician, Chile) [15 January–16 February 2013]
- [Eladio Ocaña](#) (mathematician, Perú) [20 January–16 March 2013]
- [Gerard Olivar Tost](#) (mathematician, Colombia) [7 January–5 April 2013]
- [Hugh Possingham](#) (quantitative ecologist, Australia) [10 February–30 March 2013]
- [Martin F. Quaas](#) (economist, Germany) [25 February–30 March 2013]
- [Anders Skonhoft](#) (economist, Norway) [15 January–15 February 2013]
- [Tony Smith](#) (ecologist, Australia) [26 February–5 April 2013]
- [Scott Taylor](#) (economist, Canada) [1–31 March 2013]
- [Anastasios Xepapadeas](#) (economist, Greece) [21 January – 22 February 2013]
- [Georges Zaccour](#) (mathematician, Canada) [11–15 February; 10 March–10 April 2013]
- [Alan Hastings](#) (Ecology, University of California) [26 March – 4 April 2013]
- [Paul Armsworth](#) (Ecologist, University of Tennessee, USA) [26 March – 4 April 2013]
- [Hugo Salgado Cabrera](#) (Economist, Chile)
- [Nicolas Treich](#) (Economist, Toulouse School of Economics, France)
- [Michèle Breton](#) (Mathematics, HEC Montréal, Canada) [11 – 13 February 2013]
- [Alejandro Caparrós](#) (Economist, CSIC, Madrid, Spain) [11 – 13 February 2013]
- [L. Richard Little](#) (Modeling, CSIRO, Hobart, Australia) [11 – 22 February 2013]
- [Olivier Thébaud](#) (Economist, CSIRO, Australia)[11 February – 22 February 2013]
- [Charles Figuières](#) (economist, LAMETA, Montpellier, France)
- [Bernard Cazelles](#) (ecologist, Ecole Normale Supérieure, Paris, France)
- [Michel Langlais](#) (mathematician, Institut de Mathématiques de Bordeaux, France)
- [Michel Loreau](#) (ecologist, Station d’Ecologie Expérimentale du CNRS à Moulis, France)
- [Jean-Christophe Pereau](#) (economist, University Montesquieu Bordeaux IV, France)
- [Katheline Schubert](#) (economist, University Paris 1, France)

3 MABIES scientific planning

The quarterly thematic program *Mathematics of Bio-Economics* has followed the path of progressively introducing mathematical concepts and methods, woven with sustainable management issues and applications. Every two week on Monday morning, the organizers delivered a course (also open to Master students especially those from the Master EDDEE), followed on the next week by a computer practical session. The theme gave the mathematical color of the two coming weeks: dynamical systems, controlled dynamics and equilibria, optimal control and sustainability, viability. During the last month, more advanced material was provided: stochastic control, game theory. Every week, but for workshops, tutorials by invited professors were programmed to provide the participants either with more specialized theoretical material or with applications in biodiversity management: fisheries, agricultural systems, forest management, wildlife management and invasive species, epidemiology. Every Friday afternoon was devoted to talks by students participants on their research topics. Three regularly spaced workshops were the opportunity for researchers to present their recent results on Mathematics of Ecological Economics, Risk and Learning in Biodiversity Management, Spatial Management of Biodiversity.

3.1 Introduction to decision modelling for the management of renewable resources

- Monday 7, January 9h00–10h00: *Opening welcome talk* by Michel De Lara
- Monday 7, January 10h00–13h00: course by Luc Doyen
Introduction to decision modelling for sustainable management of natural resources
[slides](#)
- Tuesday 8, January 9h30–11h30: conference by [Christopher Costello](#)
Overcoming the tragedy of the (spatial) commons ([paper 1](#) – [paper 2](#) – [paper 3](#) – [paper 4](#))
- Thursday 10, January 10h00–11h00: conference by [Michel Loreau](#)
Ecosystem services: key to overcoming the biodiversity crisis?
- Monday 14, January 14h00–17h00: computer session by Luc Doyen
Introduction to the scientific software Scicoslab [click here](#)

3.2 Equilibria, bifurcations and controlled dynamics

- Tuesday 15, January 14h00–17h00: tutorial by [Gerard Olivar](#)
Introduction to dynamical systems [slides](#)
- Wednesday 16, January 14h00–17h00: tutorial by [Gerard Olivar](#)
Bifurcations in dynamical systems [slides](#)

- Monday 21, January 9h00–12h00: course by Michel De Lara
Controlled dynamics and equilibria [slides](#)
- Tuesday 22, January 9h00–12h00: conference by [Anastasios Xepapadeas](#)
Controlled spatio-temporal dynamics of resources [slides](#)
- Wednesday 23, January 14h00–16h00: conference by [Anders Skonhøft](#)
MSY MEY in bio-economics and their extension to class-structured population or metapopulations [slides](#)
- Thursday 24, January 10h00–12h00: conference by [Bernard Cazelles](#)
Nonlinearity and nonstationarity in population dynamics (ecology and epidemiology)
[slides](#)
- Wednesday 30, January 15h00–18h00: computer session by Michel De Lara
Equilibria and Stability in the Management of a Renewable Resource [click here](#)

3.3 Optimality and sustainability

- Tuesday 29, January 10h00–12h00: tutorial by [Pedro Gajardo](#) and [Eladio Ocaña](#)
Introduction to optimization [slides 1](#) [slides 2](#)
- Monday 4, February 9h00–12h00: course by Michel De Lara
Optimality and sustainability [slides](#)
- Wednesday 6, February 14h00–17h00: tutorial by [Pedro Gajardo](#)
Optimization, sustainable indicators and application to the design of a recovery program for overexploited fish species [summary](#) [slides](#) [slides](#)
- Thursday 7, February 14h00–17h00: tutorial by [Mabel Tidball](#)
Sustainability criteria: between efficiency and equity [slides](#)
- Tuesday 19, February 14h00–17h00: tutorial by [Hugh Possingham](#)
Optimal monitoring

3.4 Viability

- Monday 18, February 9h00–12h00: course by Luc Doyen
Viability
- Thursday 21, February 14h00–17h00: tutorial by [Eladio Ocaña](#)
Applications of viability theory in fisheries management
- Wednesday 27, February 9h00–12h00: tutorial by [Hugh Possingham](#)
Problem formulation in conservation decision making
- Friday 1, March 9h00–12h00: tutorial by [Carlos Castillo-Chavez](#)
Disease dynamics [slides](#)

3.5 Game theory, coordination, strategic interactions and trade

- Thursday 31, January 10h00–12h00: conference by [Michael Finus](#)
Analysing international environmental agreements: approaches and equilibrium concepts [slides.pdf](#) [slides.pptx](#) [references.pdf](#) [slides.docx](#)
- Monday 11, March, 9h00–12h00: tutorial by [Jean-Christophe Perea](#)
Game theory and renewable resources management
- Monday 11, March, 14h00–17h00: tutorial by [Scott Taylor](#)
Trade and Renewable Resources: An Introduction to the Three Core Hypotheses [slides](#)
- Thursday 14, March, 9h00–12h00: tutorial by [Martin F. Quaas](#)
Consumer preferences for seafood diversity and multi-species fisheries
- Thursday 14, March, 14h00–17h00: tutorial by [Georges Zaccour](#)
Differential games and environmental applications [slides](#)
- Tuesday 19, March, 9h30–12h00: tutorial by [Hugh Possingham](#)
Two tools: Information-gap theory and the Gini coefficient in Natural Resource Management

3.6 Ecosystems and biodiversity indicators

- Monday 18, March, 14h00–17h00: tutorial by [Tony Smith](#):
New strategies to support biodiversity management and sustainable fisheries
- Tuesday 19, March, 14h00–17h00: tutorial by [Charles Figuières](#)
Biodiversity indicators, decision-making and conceptual premisses [slides](#)
- Thursday 21, March, 9h00–12h00: tutorial by [Carlos Castillo-Chavez](#)
Indicators in epidemics control
- Thursday 21, March, 14h00–16h00: conference by [Jianhong Wuz](#)
Decision systems and geo-simulation tools for infectious disease spread: contributions to the prevention and control of H5N1 outbreaks

3.7 Workshop Mathematics of Ecological Economics

[Webpage](#)

February 11 – February 13

This workshop dedicated to the Mathematics of Ecological Economics was at the core of the quarterly thematic program MABIES not only in terms of dates but in terms of scientific topics and issues. The workshop shed important lights on three major modeling challenges related to ecological economics : (i) How to operationalize sustainability ? (ii) How to

operationalize the ecosystem based approach ? (iii) Which governance for sustainability ? The workshop organized during five half-days in the amphitheater Lhermitte was successful with 15 international speakers and about 80 participants. The cocktail organized at the Muséum National d'Histoire Naturelle (restaurant La Baleine) has been the opportunity for more friendly exchanges between participants and invited speakers.

- Michèle Breton: A Great Fish War Model with Asymmetric Players
- Alejandro Caparrós: Spatial green accounting for terrestrial ecosystems: from theory to practice
- Christopher Costello: The distributional effects of the transition to property rights for a common pool resource
- Luc Doyen: The triple bottom line with Individual Transferable Quotas
- Michael Finus: The Incentive Structure Of Impure Public Good Provision; The Case of International Fisheries
- Pedro Gajardo: Trade-offs in the debate for setting biological and productive thresholds that are sustainable
- L. Richard Little: Sustainable management with environmental derivatives
- Jean-Christophe Perea: Cooperative and non-cooperative harvesting in a multi-species fish war model
- Hugh Possingham: Optimal conservation outcomes require both restoration and protection
- Martin F. Quaas: Who gains from sustainable fisheries ? and who loses ?
- Katheline Schubert: Modeling of interactions between aquaculture and capture fisheries.
- Anders Skonhøft: Spatial effects of climate changes in an animal - grazing system.
- Olivier Thébaud: Identifying viability thresholds for stochastic bio-economic systems managed with multiple objectives
- Anastasios Xepapadeas: Mitigation and Solar Radiation Management in Climate Change Policies
- Georges Zaccour: An Empirical Differential Game for Sustainable Forest Management

3.8 Workshop Risk and Learning in Biodiversity Management

[Webpage](#)

March 4 - March 8

Uncertainties and stochasticities on data, on ecological dynamics or on economic drivers are invasive in bio-economic issues and can be a reason to postpone or avoid decisions facing major dangers. The objective of this interdisciplinary workshop was to present courses, tutorials and research articles related to the modelling of risk and uncertainty in sustainable management and conservation of biodiversity. Both theoretical and more applied works typically focusing on fisheries, agro-ecology, forestry, epidemiology or wildlife management were presented. The workshop especially shed important lights on how to operationalize the precautionary principle. The first day was devoted to courses and tutorials. The two other days were dedicated to research presentations, with a single session (no parallel session).

- [Nicolas Treich](#) *The precautionary principle: an economic viewpoint*
- [Michael Bode](#) *Rules of thumb for protecting connectivity in coral reef fisheries: is there any signal above the noise?*
- [Carlos Castillo-Chavez](#), *On the role of cross-immunity and vaccines on the survival of less fit flu-strains*
- [Christopher Costello](#), *Optimal biodiversity protection in an uncertain environment*
- [Michel De Lara](#) *Robust viable management of a harvested ecosystem model. Application to the anchovy-hake couple in the Peruvian upwelling ecosystem.*
- [Luc Doyen](#), *From PVA to stochastic eco-viability*
- [Hugh Possingham](#), *Adaptive management for conservation*
- [Martin F. Quaas](#), *Optimal management of fisheries under uncertainty,*
- [Hugo Salgado Cabrera](#), *Who should set quotas in fisheries: The effects of uncertainty, learning and multiple objectives*
- [Tony Smith](#), *Scientific tools to support ecosystem based management*

On Thursday 7, March, we programmed a special afternoon *Optimization, smart grids and renewable energies*

- Michel De Lara, *Smart Power Systems: the Optimization Challenge*
- Pierre Girardeau, *The value of smart grids from the optimizer's viewpoint* and Maxime Chammas, *A multi-scale optimization model to assess the benefits of a smart charging policy for electrical vehicles*
- Laurence Grand-Clement and Antoine Nogier, *Optimizing a pumping station to store wind and solar energy*
- Michel De Lara, presentation of the CIRM School *Stochastic Control for the Management of Renewable Energies*

3.9 Workshop Spatial Management of Biodiversity

[Webpage](#)

March 25 - March 27

The role of connectivity and spatial arrangements is important for the sustainable management of ecosystems as stressed by marine protected areas or land-use scenarios. The objective of this interdisciplinary workshop was to present courses, tutorials and research articles related to spatial management of biodiversity. Both theoretical and more applied works typically focusing on fisheries, agro-ecology, forestry, epidemiology or wildlife management were presented. The first morning was devoted to a tutorial. The afternoon and the next day were dedicated to research presentations, with a single session.

- [Alan Hastings](#), *Overview of Spatial Models in Ecology*
- [Paul Armsworth](#), *Designing cost effective conservation payment programs*
- [Michael Bode](#), *Larval dispersal patterns and inter-community cooperation in Melanesian fishing communities*
- [Carlos Castillo-Chavez](#), *Spatial patterns of infection: from foot and mouth disease to influenza*
- [Christopher Costello](#), *Partial Enclosure of the Commons*
- [Luc Doyen](#), *Bio-economic models and land-use for biodiversity*
- [Alan Hastings](#), *Simple spatial approaches to persistence and eradication*
- [Michel Langlais](#), *A multi-stages and multi-hosts parasite / predator-prey system within a spatially fragmented environment*
- [Hugh Possingham](#), *Problems in land-sea conservation planning*
- [Martin F. Quaas](#), *Efficiency and sustainability in territorial use rights in fisheries*
- [Scott Taylor](#), *A spatial approach to energy economics*

3.10 Open seminar

The "open" seminar was organized every Friday afternoon. The term "open" refers to the idea of less formal presentations only planned in a adaptive way along the trimester. One of its objective was especially to allow young students or researchers attending the trimester to present their own work.

- Friday 18, January: *Non-linear phenomena in socio-economical systems with natural resource management*, Jorge A. Amador (PhD Candidate, Universidad Nacional de Colombia, sede Manizales)

- Friday 25, January: Kate Helmstedt (PhD Candidate, the University of Queensland, Australia); Christopher Severen (PhD Candidate, University of California, Santa Barbara, USA)
- Friday 1, February: *Ecosystem Based Fisheries Management of Northern Bay of Bengal, India*, Sachinandan Dutta (Jadavpur University, Kolkata, India)
- Friday 8, February: *Viability and resilience for fisheries in Salomon Islands*, Pierre-Yves Hardy (PhD candidate, MNHN); Kunal Chakraborty (Indian National Centre for Ocean Information Services, Hyderabad, India)
- Friday 15, February: *Fleet diversity is a double-edged sword in fisheries*, Matthew G. Burgess (PhD Candidate, Department of Ecology, Evolution and Behavior University of Minnesota, USA); Kunal Chakraborty (Indian National Centre for Ocean Information Services, Hyderabad, India)
- Friday 1, March: *The Economics of Ecosystems and Biodiversity (TEEB)*, Andrea Kaim (Master student, University of Leipzig); *Rocket Science and Strategic Decision Concepts for the Management of Biological Populations*, Professor B. S. Goh (Curtin University Sarawak, Malaysia)
- Friday 8, March: *When do ecosystem services provide an economic incentive to protect biodiversity?*, Laura Dee (PhD Candidate, University of California, Santa Barbara) *Quantifying biting rates of Trypanosoma cruzi infected triatomine vectors on sylvatic hosts*, Kamuela E. Yong (Postdoctoral Research Associate, Arizona State University)
- Friday 15, March: *The socio economic impact of forest certification in the Congo Basin*, Jonas Ngouhouo Poufoun (PhD Candidate, Laboratory of forest Economics, Nancy, The University of Lorraine, the University of Yaoundé 2)

4 Financial Data

Mathematics of Bio-Economics
07 janvier-5 avril 2013

Exercice 2013 Budget T1

Fonds propres (CNRS + P6) : 130 000

RECETTES	
Origine des fonds	Montant
CNRS Paris B	80 000
UPMC Carmin	50 000
Total CNRS	80 000
Total UPMC	50 000
Total recettes IHP CEB	130 000

Recettes extérieures à l'IHP	
FSMP	25 000
MNHN	1005
CERMICS	5 282,09
Total recettes extérieures	31 287,09

Total IHP + extérieur	161 287,09
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Solde CEB	29 966,81
Solde CNRS	21 195,16
Solde UPMC	8 771,65



DEPENSES	
Répartition	Montant
CNRS	
Missions trimestre + colloque	52 546,11
Cocktail colloque	4 547,70
Pause café IHP	914
Fedex	546,66
Dépenses diverses: restaurants, rencontre vendredis	250,37
Total CNRS	58 804,84

DEPENSES	
Répartition	Montant
UPMC	
Participation pause café quotidienne	1251,18
Missions trimestre + colloque	32 198,19
Cocktail colloque	6 313,56
Pause café IHP	1 465,42
Total UPMC	41 228,35

Total dépenses IHP-CEB	100 033,19
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Dépenses extérieures à l'IHP	
FSMP	18 000
MNHN	1005
CERMICS	5 282,09
Total dépenses extérieures	24 287,09

Dépenses totales	142 320,28
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<i>Nbre mois</i>	<i>Financier</i>	<i>Nom-Université d'origine</i>	<i>Date de naissance</i>	<i>Nationalité actuelle</i>	<i>Dates séjour 2012</i>	<i>Remarques logement</i>
1	P6	FINUS Michael University of Bath- Royaume Uni	19/11/1965	Allemande	11 février-11 mars	Villa Pasteur
1	P6	GAJARDO Pedro Universidad Tecnica Federico Santa Maria- Chili	6/10/1976	Chilienne	16 janvier-17 février	F2 Jussieu
1	P6	SMITH Anthony CSIRO Marine and Atmospheric Research- Australie	25/01/1953	Australienne	26 février-5 avril	T1 Jussieu
1	P6	TAYLOR Michael Scott University of Calgary- Canada	30/07/1960	Canadienne	1er mars-31 mars	Appartement Aubin
1	P6	XEPAPADEAS Anastasios University of Economics and Business - Grèce	20/01/1954	Grecque	21 janvier-22 février	Recherche personnelle
1	P6	ZACCOUR Georges HEC, Montreal- Canada	14/09/1959	Canadienne	10 mars-10 avril	Villa pasteur
1	P11	BODE Michael University of Melbourne- Australie	15/03/1976	Australien	2 mars-2 avril	Recherche personnelle
1	P11	QUAAS Martin Christian Albrechts, University zu Kiel- Allemagne	28/01/1970	Allemande	25 février-30 mars	F3 Jussieu
2	CNRS	CASTILLO CHAVEZ Carlos Arizona State University	29/03/1952	USA	18 février-18 avril	F2 Jussieu
2	CNRS	OCANA ANAYA Eladio Instituto de Matematica y Ciencias Afines, IMCA- Pérou	09/01/1974	Péruvienne	15 janvier-15 mars	Studio Jussieu
2	CNRS	POSSINGHAM Hugh University of Queensland- Australie	21/07/1962	Australienne	10 février-10 avril	Appartement Darmois

5 Synthesis and Perspectives

The outcomes of the trimester MABIES are numerous. The results of MABIES are first significant in terms of interdisciplinarity, since the program has been able to bring together disciplines and scientists between mathematics, computer sciences, ecology and economics. In this respect, the role played by mathematics as a fruitful interface is major. In line with this, MABIES was also successful in the balance between mathematical theory and applications, including fisheries management, land-use and terrestrial biodiversity and wildlife management. The trimester has also shown to what extent original mathematics can be inspired by issues from ecology and from economics of sustainable development. MABIES has also been able to promote and reinforce exchanges and collaborations between the French and the international scientific community. Another positive outcome lies in the mix between generations as young and senior scientists were actively participating to the trimester.

The support of the CEB team played a decisive role to achieve all this. It was really a pleasure to work in such a stimulating, friendly, very professional and convenient framework in the center of Paris.

The perspectives induced by the trimester are also numerous. Many projects of collaborations, articles, special issues in journals, thesis, post-docs, networks, and workshops or summer schools have emerged from the three months. In this respect, some other events of the MPE 2013 should allow to crystallize some of these projects of international collaborations.