Workshop
Risk and Learning in Biodiversity Management
2013, March 4 – 6
Institut Henri Poincaré
quarterly thematic program MABIES
Mathematics of Bio-Economics

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Abstract

The objective of this interdisciplinary workshop is 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 are presented.

The first day is devoted to courses and tutorials. The two other days are dedicated to research presentations, with a single session (no parallel session): 45 mn is allocated to each talk including 35 mn of presentation, and 10 mn for exchanges with the audience.

PLANNING

1 Monday 4, March 2013

- Monday 4, March, 14h00–17h00: tutorial by Nicolas Treich
  The precautionary principle: an economic viewpoint slides

  The Precautionary Principle has become a key principle of risk management under conditions of scientific uncertainty. But does it have an economic foundation? We present two economic theories of precaution. The first is based on the standard model of expected utility with a Bayesian revision of beliefs.

The second is based on ambiguity aversion. We discuss the advantages, but also the weaknesses of these two approaches.

2 Tuesday 5, March and Wednesday 6, March

- Michael Bode *Rules of thumb for protecting connectivity in coral reef fisheries: is there any signal above the noise?*

  Reef fishes and other marine species occur in patchily distributed benthic populations that are interlinked by a larval stage where individuals disperse throughout the pelagic environment. This larval connectivity will play a critical role in determining whether marine protected area (MPA) networks can effectively promote the persistence of increasingly exploited reef fish populations. However, the amount, direction and variation of this connectivity is highly spatially and temporally complex. Connectivity is therefore unknown for most species, and for most reef ecosystems of conservation concern. Furthermore, connectivity data are difficult and expensive to measure. We were interested in whether MPA locations that are chosen according to certain easily-measurable reef characteristics — connectivity surrogates, or rules of thumb — can maintain connectivity between reef fish populations, and/or sustain high fishery harvests. We use a high-resolution biophysical model of reef fish larval connectivity on the Great Barrier Reef (GBR) to assess whether the performance of commonly proposed connectivity rules of thumb can be distinguished from the noise created by the ecosystems' highly complex and stochastic dynamics.

- Carlos Castillo-Chavez, *On the role of cross-immunity and vaccines on the survival of less fit flu-strains*

  New strains of influenza are created continuously as a result of mutations within its HA and NA molecules. The identification of what strains are most likely to invade its human host successfully is critical for the development of the annual vaccine and the design and implementation of public health policy. A pathogen's route to survival involves various mechanisms including its ability to invade (host's susceptibility), its reproductive success within an invaded host ("infectiousness"), and the immunological history of an individual. The cross-immunity generated by prior infections to influenza A strains from the same subtype provides the most significant example. A two-strain epidemic model that incorporates host isolation (during primary infection) and cross-immunity is discussed and applied to the study of the role of invasion mediated cross-immunity within a host population where a precursor related strain (within the same subtype, i.e. H3N2 or H1N1) has already become established. We carry out uncertainty and sensitivity analyses that

assess the ability of invading strains to survive under given cross-immunity regimes. It is shown that the coexistence of invading "unfit" strains is possible in the presence of public intervention policies like isolation. In short, the development of "flu" vaccines that minimally enhance herd cross-immunity levels may, by increasing genotype diversity help facilitate the generation and survival of novel strains under the umbrella of policies that favor isolation or quarantine.

- Christopher Costello, *Optimal biodiversity protection in an uncertain environment*

  We model biodiversity protection as a problem of preserving an optimal collection where there is an opportunity cost of protection. In this model biodiversity provides diverse research "leads" from which we sample for "successes". Larger collections are therefore desirable, but owing to the opportunity cost, there is some optimal collection size. We focus on the problem of how that collection size responds to uncertainty over the future. This is motivated, e.g., by climate change which may change in uncertain ways the future matching of leads with successes. In this theoretical model we find that higher future uncertainty may often imply a smaller, not larger, optimal collection. This seems to contradict our usual option value intuition, and may suggest circumstances under which the private sector would decrease current biodiversity holdings in the face of high future uncertainty.

- Michel De Lara *Robust viable management of a harvested ecosystem model. Application to the anchovy-hake couple in the Peruvian upwelling ecosystem.*

  The World Summit on Sustainable Development (Johannesburg, 2002) encouraged the application of the ecosystem approach by 2010. In this perspective, we propose a theoretical management framework that deals jointly with i) ecosystem dynamics, ii) conflicting issues of production and preservation and iii) robustness with respect to dynamics uncertainties. More specifically, we define the robust viability kernel as the set of initial species biomasses such that at least one harvesting strategy guarantees minimal production and preservation levels for all times, whatever the uncertainties. We apply our approach to the anchovy-hake couple in the Peruvian upwelling ecosystem. We find that accounting for uncertainty significantly reduces the robust viability kernel compared to the deterministic one (without uncertainties). We observe that, when we increase the set of uncertainties, the robust viability kernel very slightly decreases, expressing a moderate sensibility with respect to refining the set of uncertainties. We comment on the management implications of comparing robust viability kernels (with uncertainties) and the deterministic one (without uncertainties).

- Luc Doyen, *From PVA to stochastic eco-viability*

The present paper deals with the bio-economic viability and more generally the eco-viability for the management of renewable resources, ecosystems and biodi- versity. This approach focuses on the feasability and safety of controlled dy- namics systems though constraints applying throughout time. It first shows the interest of the co-viability approach for sustainable and integrated managements and assessments. In particular it points out the strong links between co-viability methods and more usual equilibrium, optimality, risk methods. This paves the road for a reconcilation between conservation biology, ecological economics and bio-economics. Several examples inspired by agro-ecology or fisheries manage- ment illustrates the pathway either through mathematical results or through simulations.

- Hugh Possingham, *Adaptive management for conservation*

  Passive adaptive management involves doing what is best now but modifying decisions based on what we learn. Experimental management maximises the speed at which we learn, compromising management outcomes. Active adaptive management optimises the trade-off between learning and management and can be solved by formulating the decision-making problem as a Markov Decision Process. I illustrate these different approaches and puzzle about the minimal benefits of true active adaptive management.

- Martin F. Quaas, *Optimal management of fisheries under uncertainty*,

  We study optimal fishery management under uncertainty about the reproduction of the fish stock. We show that the effect of environmental uncertainty on the optimal size of a fish stock may be positive or negative, depending on the prudence of the value function associated with the stochastic programming problem. Furthermore, we consider a situation where the fishery manager does not know the exact reproduction function, but only has a prior distribution on the model parameters, which he can update using observations about actual stock reproduction. We show that the effect of learning on optimal management crucially depends on which aspect of the reproduction function is ambiguous. We quantify the effects in an application to Baltic fisheries.

- Hugo Salgado Cabrera, *Who should set quotas in fisheries: The effects of uncertainty, learning and multiple objectives*

  In this paper we analyze the effects of letting different stakeholders decide about the size of the quota in fisheries. We use a model in which three groups: fishermen, external experts and the fisheries manager make decisions about increasing or decreasing the quota under uncertainty. The different groups might have different priors regarding the occurrence of good and bad states of the stock, receive different signals and have a different valuation of costs

and benefits of making wrong decisions. We show that the optimal decision under uncertainty will depend on the prior, the distribution of the signal received and the valuation of costs and benefits of each group, compared to a social optimal and informed behavior. We conclude that who should decide about the quota is a matter of having a group that can accurately represent social preferences and incorporate all available signals in their decision. Nevertheless, the social acceptability and legitimacy among fishermen of the group making decisions need to be considered.

- Tony Smith, *Scientific tools to support ecosystem based management*

  Biodiversity management is often seen as a subset of a wider "ecosystem based management" (EBM) approach that integrates ecological, economic and social aspects. For the marine environment, a number of (model based) scientific tools have been developed to support practical implementation of EBM, many of them at the intersection of conservation and fishery management. This talk will review briefly a range of these tools and their areas of application. The tools range from qualitative to quantitative and from simple to complex. All are set in a decision making context (management strategy evaluation) and are useful in identifying tradeoffs across multiple objectives.