



RMA newsletter Spring 2018

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RMA

The Resource Modeling Association is an international association of scientists working at the intersection of mathematical modeling, environmental sciences, and natural resource management. We formulate and analyze models to understand and inform the management of renewable and exhaustible resources. We are particularly concerned with the sustainable utilization of renewable resources and their vulnerability to anthropogenic and other disturbances.

RMA Newsletter

Spring 2018



#WCNRM2018

by SCAU executive

As in the past, the World Conference on Natural Resource Modeling (WCNRM) is bringing together scientists and stakeholders interested in mathematical and numerical modeling of renew-

able and exhaustible resources. #WCNRM 2018 is co-organized by Resource Modeling Association and South China Agricultural University. It will be held on June 9-13, 2018 in Guangzhou, China.



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The theme of the conference is biodiversity conservation and sustainable development. It aims to look for a socio-ecological solution especially in developing countries where economic growth and environmental quality are competing objectives. The conference will pay particular attention to biodiversity conservation, ecological resilience, management of protected areas, and sustainable utilization of natural resources.



The conference will be held at the College of Economics and Management, SCAU. The fieldtrip is to go to Nansha wetland park, the details are in the following.

CONFERENCE TOPIC:

- Biodiversity conservation
- Ecological resilience
- Management of protected areas
- Sustainable utilization of natural resources
- Others

AREA

- Forest management
- Fishery management
- Farming
- Biodiversity
- Water resource
- Climate change impacts

CONFERENCE HIGHLIGHTS:

- Two days of oral and poster presentation
- Four guest lectures
- One fieldtrip to Nansha Wetland

Park and Nansha Tianhou Temple

- More than 60 confirmed oral and poster presentations



FIELDTRIP IN NANSHAN DISTRICT

On Sunday morning, June 10, there will be excursions to Nansha Wetland Park in Nansha District, Guangzhou. Nansha Wetland Park is a national scenic spot. It is located at the south of Guangzhou and the geometric center of the Pearl River Delta, and is between the 18th Chong and 19th Chong, Wanqingsha Town, Nansha District. Nansha Wetland Park is the largest one in area of Guangzhou, and which is the important station of the birds migration routes and food supply. It is also the important part of the wetlands ecosystem in the Pearl River Delta.

With the total area of about 6.67 km², Nansha Wetland Park is divided into two areas, between them that is Lingxin Road. The area of the first phase is 2.28 km² and the second phase is 4.02 km². The first phase focuses on birds' protection, ecosystem study, popular science education, planting mangroves and enjoying the view of birds. On the base of the repairing and enlarging the wetland ecosystem, the second phase develops ecological tourism, entertainment and holidays, business meetings and so on.

Nansha Wetland park has about 300 kinds of plants. Among them there are 11 kinds of true mangrove and 4 kinds of semi-mangrove. They are

Sonneratiacaseolaris(L.), *Kandelia candel* (Linn.) Druce, *Sonneratia apetala*, *Pongamia pinnata* (L.) Pierre, *Cerbera manghas* and so on. As to 2016, according to the data collected by South China Institute of Endangered Animals, the kind of birds has reached to over 175. However, the survey data and document record said, the kind of birds is 200 in Nansha Wetland. Among them there are one kind of the first-class national protected birds, which is called *Haliaeetus albicilla*, and 16 kinds of the second-class national protected birds.

Facing the Pearl River estuary-Lingding Ocean, Nansha Tianhou Temple is a mazu temple on the south-eastern of the Dajiao Mountain in Nansha district of Guangzhou and covers about 100 hectares. It was built to worship the goddess of sea (called Mazu by the local people), whose real name is Linmo (960-987). The architecture combines the style of the Forbidden City in Beijing and the sublimity of Dr. Sun Yatsen's Mausoleum in Nanjing. It is the largest Mazu Temple in southeastern Asia and reputed as the best Tianhou Temple in the world. The Mazu statue is nearly 14.5 metres high, which is located in the center of Tianhou Temple Square.



PRESIDENT'S COLUMN

by Luc DOYEN

The publication of the 'spring' RMA newsletter is always a major stage for the Resource Modeling Association because spring is the period of our annual international conference which is a pivotal event for RMA and for interdisciplinary research at the interface of ecology, economics, mathematics and computer sciences...



In that respect, I am very happy to know that the Guangzhou conference 2018 to be held at the South China Agricultural University on 9-13 June is already successful with many submissions from all around the world and many scientific disciplines. As reminded by Krishna Paudel and Yiming Liu in the first column of this newsletter, the central theme of the conference is "Biodiversity Conservation and Sustainable Development". The keynote speakers Georges Zaccour, Junchang Liu, Jeffrey Peterson and Jun Wang have contributed to the attractiveness of the conference. The awarding of both the Rollie Lamberson Medal and the prize of best student presentation during the conference also reinforces the attractiveness of the conference and more generally of the association.

Among the other good news for RMA, our communication through electronic networks such as ResearchGate, LinkedIn and Twitter is progressing well. Do not hesitate to use these networks to circulate far and wide scientific information in line with the management of natural resources including new academic positions, conferences, workshops, books, papers.

Regarding the content of this newsletter, we still continue to sustain its scientific content. This spring version contains a note on the viable control approach which is an emerging mathematical and numerical

framework to deal with sustainability and the management of risks and vulnerabilities. This modeling framework exemplifies the interest of linking dynamic systems, control theory and multiple-criteria approaches to address environmental challenges. Another scientific contribution of the newsletter from Quentin Grafton and Rich Little gives insights into resilience and risk management. Resilience is indeed a paradigm and concept that is receiving growing attention from several disciplines to face and cope with shocks. However definitions of resilience vary across disciplines and there is a need of clarification.

Another important recent news and step for RMA relates to the signature of the new agreement with our partner Wiley. The new agreement which extends the previous one signed in 2007 by Bob Fray, who was RMA president at these dates, will strengthen the sustainability in terms of functioning of both the association and our journal NRM (Natural Resource Modeling) and will make possible new activities to enlarge our membership and our scientific influence worldwide regarding the management of natural resources.

This president's column is also an opportunity for me to send a warm welcome to all new RMA members, especially those that have joined us for the upcoming conference in China. I will end up this column by saying how I am grateful to Anne-Sophie Masure and Sébastien Lavaud for the great work they do behind the scene for the edition of RMA newsletters.

Luc Doyen
President RMA,
Senior Scientist CNRS,
GREThA, University of Bordeaux

WCNRM 2018

Keynotes speakers



Dr. Georges Zaccour, Decision Sciences, Canada

Dynamic Games of International Environmental Agreements

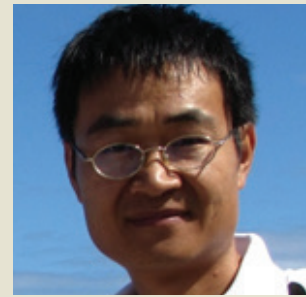
Abstract:

Transboundary environmental problems, e.g., global warming, have been running high on the agenda of scientists of many disciplines and decision makers during the last two decades. An established consensus is that dealing seriously and efficiently with this requires a concerted effort of all countries, for two reasons. First, from an environmental perspective, the larger the number of countries that commit to reducing greenhouse gases (GHG) emissions, the easier it would be to stabilize atmospheric GHG concentrations at "safe" levels, in accordance with the objectives of the United Nations Framework Convention on Climate Change (1992). Second, from an economic perspective, the larger the number of cooperating countries, the larger is the set of options to lower the cost of emission abatement. Notwithstanding the simplicity of these arguments, the design and implementation of an International Environmental Agreement (IEA), that is, a mechanism allocating to each country a collectively suitable emissions policy, is still a difficult task. Indeed, whereas cooperation (joint optimization) is globally efficient, it may not be the case that single countries find it optimal to participate in such an effort. Further, the temptation may be high to let the others bear the cost of pollution abatement while enjoying a better environment at no cost.

This free-riding behavior raises a big challenge when attempting to design a global environmental

agreement.

In this presentation, I will present the contribution of both non-cooperative and cooperative dynamic games to the design of IEAs.



Dr. Jun Wang, Marine Pollution and Ecotoxicology, China

Microplastics Pollution in Different Water Ecosystem

Abstract:

The global production of plastics increased rapidly in recently years. Although a large proportion of the plastics waste has been recycled or landfilled, still a considerable amount of plastic waste entered into the aquatic system. Microplastics are defined as small plastic particles with a size of < 5 mm. Billions of microplastics have been found in the oceans, rivers and lakes and even in inaccessible locations such as the Arctic and the Southern Ocean. Microplastics have been considered as an emerging pollutant in the aquatic environment. Concerns about potential threats of microplastics to aquatic organisms, birds, mammals and even human beings via mistaken ingestion or food web are rising. Nevertheless, little information is available about microplastics in freshwater systems, especially in China, the largest producer of plastics around the world. Our recent studies focus on microplastic pollution levels in surface waters and sediments from different lakes and rivers in China.

Risks, resilience and natural resource management

by Q. Grafton^a & L.R. Little^b

^a: Australian National University, ^b: CSIRO

Key challenges faced by natural resource managers are to understand, to predict, and to respond to risks. In this context we define risks as future possible events with uncertain or probabilistic consequences, and where decision makers have some knowledge or understanding about these possible consequences. Various strategies have been developed and used to manage risk in natural resources, such as adaptive management (Hilborn and Walters 1992), robust decision-making and also precautionary management (Charles 1998), adopting 'conservative' management targets, and spatial and population zones. In our view, the current methods used by many resource managers to manage risk are inadequate. Frequently, managers lack appropriate methods to assess and manage risks; and users often lack the tools to respond to risks. We respond to this challenge by highlighting key findings from a selected review of recent published literature to which we have contributed.

Responding to Risk

Natural resource managers have multiple ways to respond to risk. Typically, managers assess or evaluate risks and consider both the likelihood of an event and the consequences that arise from the event. A standard approach is to construct a consequences and likelihoods table where risk, in this context, is defined as the product of the likelihood of the event and its consequences. The consequences-likelihoods approach assumes that risk is the product of a consequence and its likelihood such that there could be the same risk when there is a high consequence event with a low likelihood as when there is a low consequence event with a high likelihood. We contend that events that are of high consequence and of low likelihood are circumstances that rarely arise, and for which management agencies may have little or no experience in understanding,

predicting, or responding to effectively. In other words, for high consequence-low likelihood situations, a consequences-likelihood assessment is insufficient. An alternative way of responding to uncertain events and their consequences is to develop a causal risk pathway that makes it as transparent as possible what is being managed, and why, by relating management actions to risks. Such a response allows managers to connect risks to possible, immediate triggers (such as a storm surge in terms of sea-level rise) or the threat itself (rising surface temperatures) and how actions might be prioritized. Causal risk pathways can be formal and probabilistic, as in the case of Bayesian network or belief modeling (Pearl 2000) with defined initial probabilities, or probability intervals (Hall et al. 2005), and with conditional probabilities along the causal risk pathway. Such approaches have already been applied to a large number of applications (Fenton and Neil 2012).

Environmental Derivatives

Responding to risk requires much more than risk assessment, causal or otherwise. A tool that offers much promise in natural resource management, and employs risk analysis while allowing for risk sharing, is the use of derivatives, suitably modified from how they are applied in the financial sector.

With an environmental derivative, for example, an investor may accept the risk to fund the recovery of a natural resource should it fall below a critical trigger level. The benefit to the investor is an upfront payment and the possibility that the biophysical risks accepted as part of the contract are negatively correlated with the investor's existing portfolio, thereby reducing the variance of the overall return of the portfolio. In return, the party seeking to transfer the risk of declines in a natural resource stock below a critical trigger, such as

a natural resource manager, would provide an up-front payment to the investor. In this transaction, the natural resource manager is able to have additional funds available for recovery in an undesirable state of the world (stock is beneath a population threshold), but incurs a cost (payment to the investor) in the more desirable state of the world (stock is above the population threshold).

The potential benefits, if implemented, of environmental derivatives include: (i) maintain population capacity in the presence of shocks; and (ii) generate derivative prices that provide resource managers with an indicator of the riskiness of alternative management strategies that help avoid negative shocks.

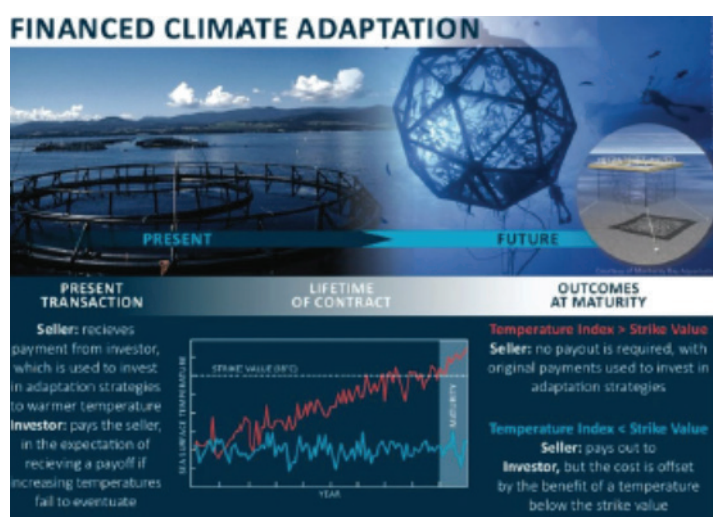


Figure 1: How a climate derivative might work

Another possible environmental derivative is described in Figure 1. In this case, the derivative owner is the salmon farmer. The farmer who enters into the contract receives an up-front payment from an investor to help adapt salmon farming to higher sea surface temperatures. In return for making this payment, the investor can receive a payment from the salmon farmer, but only if the sea-surface temperature does not exceed the 18 degrees Celsius threshold. In this cooler state of the world, the salmon farmer is likely to have a more profitable business and, thus, is better able to make the payment. If the sea-surface temperature equals or exceeds 18 degrees Celsius, the salmon farmer is not obliged to make any payment and is better off than she would otherwise have been because the up-front payment from the

investor would have been used to assist with adapting the business to a warmer state of the world that has, in fact, been realized.

Resilience

Robustness resilience can be measured by the probability of going beyond a critical threshold that, if crossed, the system is unable to return to its former capacity or retain its underlying characteristics. The challenge for natural resource managers is to determine ahead of time the critical threshold.

One approach to modeling robustness resilience with a threshold has been developed by Katic and Grafton (2011) in the context of groundwater extraction. The critical threshold arises when a well is drilled to a sufficient depth that the saline water moves vertically upwards to the freshwater aquifer resulting in much greater salt concentrations in the closer-to-the-surface freshwater aquifer. In their modeling, Katic and Grafton examined a case where all key parameters were known with certainty and optimal management generated a benchmark case that maximizes the returns from groundwater extraction.

Groundwater extraction can be managed by two variables: (i) the rate of extraction per well and (ii) the vertical distance of each well to the initial freshwater-saline water interface. The model was solved, under uncertainty, using a perturbation technique so as to maximize the expected net benefits of groundwater extraction across all wells.

Figure 2 presents a Resilience - Present Value of Net Return trade-off diagram. The horizontal axis measures the vertical distance control to the initial interface, the left vertical axis the increase in the value function from a change in the vertical distance relative to no vertical distance control (0 meter vertical distance control) and the right vertical axis represents the decrease in probability of crossing the critical threshold. The continuous line maps the value function for different vertical distance controls while the dotted line measures robustness resilience.

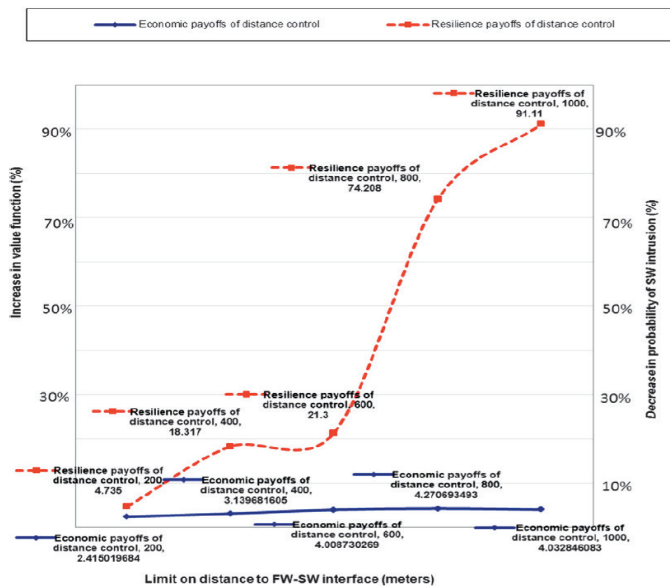


Figure 2: Resilience-NPV Trade-offs

The value of Figure 2 to resource managers is that it allows them to assess the trade-offs between resilience and the present value of net returns. For example, an increase in the vertical distance control from 600 meters to 800 meters indicates that the value function increases slightly (0.26%) and this also greatly lowers the probability of saline water intrusion, a win-win outcome. An increase in the vertical interface from 800 meters to 1000 meters would reduce the value function slightly, but would marginally decrease the probability of saline intrusion, a trade-off.

Conclusions

Arguably, one of the greatest challenges faced by natural resource managers is how to respond to risk. Typically, managers are well prepared for events that impose small or moderate consequences and that happen regularly. Managers also prioritize efforts to events that impose both large negative consequences and are likely or highly likely to occur. This is consistent with the typical way risk is assessed through the use of consequences and likelihoods tables. An important deficiency with the consequences times likelihood approach to risk is that events that are of high consequence and rare may be treated as of equal risk as events with minor consequences and of high frequency. To respond to high consequence-low frequency events,

alternative risk and resilience approaches are needed. Based on our experience and a selected review of the literature, we highlight three complementary insights.

First, in the past decade or so applications of causal risk pathways and Bayesian belief networks have become increasingly used to manage environmental risk. If done properly, causal risk analysis provides a comprehensive review of threats and triggers and, importantly, an indication of the effectiveness of different management controls or options before and after a trigger that may generate negative consequences.

Second, approaches that allow resource users and managers to share risks offer potential. These approaches include environmental and climate derivatives that are linked to biophysical rather than financial measures, and allow for either up-front payments to adapt to future climate change, or for payments after a negative shock that reduces resource performance.

Third, risk analysis can support management approaches that promote resilience of natural resources through the use of: marine protected areas to support capacity resilience in ocean environments; vertical distance controls in groundwater extraction to increase robustness resilience and reduce the likelihood of saline intrusion; and management of the number and quality of connections to accelerate the speed of recovery resilience for meta-populations.

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Dr. Junchang Liu, Forest statistics, China

Study on the human activities interference in Asian Elephants development

Abstract:

With the intensification of human activities, the population development of Asian elephants has been greatly affected. However, the degree of the human interference and the ways to control the interference are still unknown. In general, the human impact on Asian elephants is mainly in two aspects: one is illegal hunting which has direct impact on the elephant population; the second is the impact on Asian elephant habitats, mainly including the impact on habitat area and food sources. This study selected three influencing factors: illegal hunting, rubber plantation, and prevention and control of human-elephant conflicts. Based on the Asian elephant population growth model, a logical framework for the impact of the selected factors on Asian elephants was carried out to construct a population growth and distribution diffusion model, and an environmental-economic control model for the development of Asian elephant population. The data for the two models were collected by a research group. The modeling results are as follows. (1) Illegal hunting and other human interference caused the population growth rate to decrease from 0.0193 to 0.0023 during the study period. (2) Current interference caused by human activities is serious, and has influenced the natural increase rate of the elephants by 37.38%~58.97%. (3) Theoretical analysis shows the environmental-economic control model for the development of Asian elephants is applicable to the analysis of wildlife protection and regulatory management policies. (4) The expansion of the area under rubber plantations has affected the habitat of Asian elephants through the influence on habitat area, habitat fragmentation, and food

sources. As the result, the habitat bearing capacity has decreased currently. (5) Under the dual influence of rubber plantations expansion and the growth of elephant populations in Asia, the conflict between human and elephant is expected to be more serious in the future. Therefore, appropriate measures towards preventing elephant damage and compensatory policy for the damage are getting more important for the development of Asian elephants today.



Dr. Jeffrey Peterson, Environmental policy analysis, USA

Innovation as a policy strategy for water resource protection

Abstract:

Water resources are under strain globally, with rising food and bioenergy production in intensively cultivated regions as a primary driver. Whether the impacts are in the quantity or quality dimension of water resources, these cases can be modeled as dynamic externalities in which an input to food and bioenergy production generates resource damage. A large volume of literature addresses these issues through the traditional market failure paradigm, in which welfare-improving policies target the use of the harmful input either through taxes or quantity restrictions. The resulting policy typically reduces input use and private gains from production in early periods for the benefit of improved resource conditions in later period. With some exceptions, studies in this paradigm assume that technology is fixed. This presentation incorporates technological change, and specifically focuses on the role of public investments in innovation to generate input-saving and harm-reducing technologies. Treating the resource condition and innovation capital as state variables, the model explores policy approaches where dynamically adjusting input restrictions are combined with public investments in research and innovation.

From sustainability to viability kernels

by Luc Doyen

The need for sustainability - spaces

Achieving the 'Millennium Development Goals' and operationalizing a sustainable development reconciling human well-being, food security, economic performance, the production of ecosystem services with biodiversity conservation is among the greatest challenges of the century, especially in the face of global changes including climate change and the world demographic transition. The creation of the IPBES (International Panel for Biodiversity and Ecosystem Services) at the interface between decision support and scientific knowledge is in direct line with these concerns. In that respect, the production and assessment of model-based scenarios and policies constitute major scientific challenges.

The heterogeneity of stakeholders tied to biodiversity and ecosystem management, contributes to the complexity in the evaluation and design of public decision making policies, management and scenarios. Stakeholders including fishers, farmers, hunters, conservation and regulation agencies, consumers, tourists or NGO's can indeed differ in their interpretations of the world, preferences, strategies, levels of information and inputs in the dynamics of systems. In this context, what may be more readily available to regulating agencies and decision makers is information about what is acceptable / non-acceptable to the various stakeholders.

In other words, a realistic goal for management may often be to avoid undesirable states that lead to non-compliance or rejection from stakeholders. Such a goal function has been called the minimum sustainable whinge (MSW) in Pope (1983). Interestingly the word 'sustainable' is used in MSW because piecemeal measures to silence short term complaints (for example, subsidy) may lead to worse long term complaints.

To meet the challenge of sustainable development, Rockstrom et al. (2009) also proposed a framework based on boundaries that define the safe operating space (SOS) for humanity, associated with the planet's biophysical subsystems. The framework relies on the idea that most environmental systems react in a nonlinear, often abrupt, way, and are particularly sensitive around tipping levels of certain key variables. If these thresholds are crossed, then these systems could shift into a deleterious state or collapse with disastrous consequences. By contrast, as long as the thresholds are not crossed, humanity has the freedom to pursue social and economic development. Similarly the concept of Safe Minimum Standards (SMS) as in Ciriacy-Wantrup (1952) relates to tipping thresholds and risky areas. Tolerable Windows Approach (TWA) as introduced in Petschel-Held et al. (1999) also relies on safe boundaries and feasibility regions for the assessment of climate policies. We here argue that the MSW, SOS, SMS, or TWA, all constitute instances of a relevant approach to ecosystem and biodiversity management for sustainability, if they also account for the interactions and dynamics between ecological and economic systems. In that perspective the use of viability modeling framework (Béné, Doyen et al. 2001, Oubraham & Zacour, 2018) makes possible the delineation of spaces for sustainable management, policies and scenarios of ecological-economic systems.

Viability Kernels

Viability modeling is now recognized by a growing number of scientists and stakeholders as a relevant framework for sustainability and the management of ecological-economic risks and vulnerabilities. In the context of dynamic systems, the aim of the viability approach is to explore states and controls that ensure the 'good health' and safety of the system over time.

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By identifying the viability conditions that allow various constraints to be satisfied throughout time, considering both present and future states of a dynamic system, the viability approach conveys information on sustainability and especially strong sustainability (Baumgartner & Quaas, 2009). It accounts for dynamic complexities, uncertainties, risks and multiple sustainability objectives. In that sense, links with the MSW, TWA and SOS are very strong. The approach has already been successfully applied to socio-ecosystem management in several contexts (Oubraham & Zaccour, 2018) including land-use issues, biodiversity valuation or fisheries management and scenarios (Doyen et al., 2017) as exemplified by Figure 1.

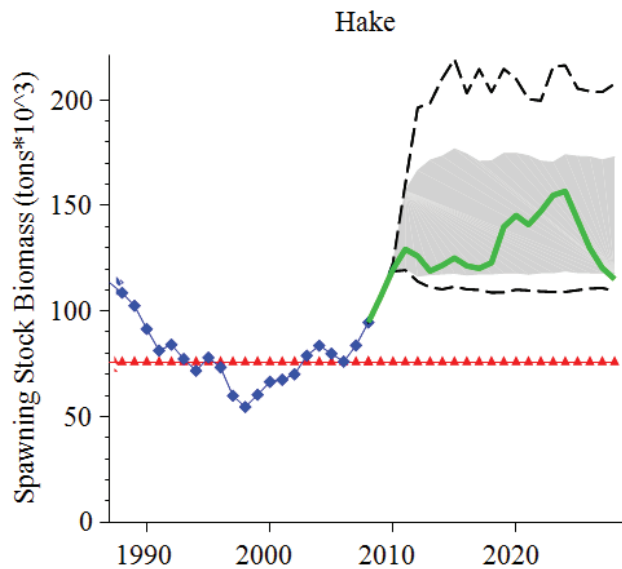


Figure 1. Bio-economic viability scenarios at the horizon $T = 2030$ of the Bay of Biscay demersal mixed fishery..

The viability kernel provides a solid and rigorous mathematical tool to address viability issues. In short, viability kernels are 'spaces' (states of the socio-ecosystem) from which starts at least one policy trajectory satisfying the whole set of constraints throughout time. The viability kernel is both a conceptual tool to represent sustainability and a computing tool for the applications relying on dynamic programming methods. Figure 2 illustrates the viability approach in a very

stylized and simplified bio-economic context inspired by hunting or fishing where a renewable resource is harvested to provide food security.

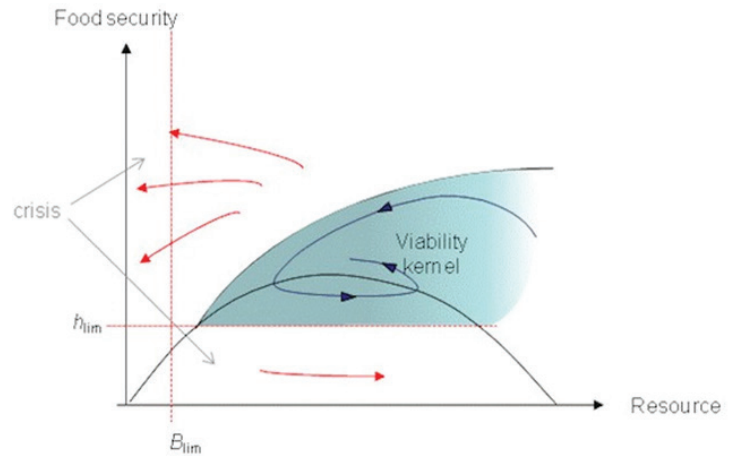


Figure 2. Bio-economic viability and viability kernel.

Assume that the initial viability constraints are lower bounds such as biodiversity minimal level B_{lim} and guaranteed consumption h_{lim} . Viability kernel as displayed in blue in the right-hand side of Figure 2 is characterized by an upper boundary related to harvesting quotas (the upper curve of the viability kernel) and a more demanding resource ceiling larger than the initial conservation threshold B_{lim} . This is explained in more mathematical terms in the Box A. The flexibility underlying the viability kernel and viable controls is fruitful in terms of adaptive management. In particular, the seminal MSY (Maximum Sustainable Yield) strategy and reference point emerge as a particular case of viability.

Box A: A stylized bio-economic model

A controlled dynamic system under constraints. We consider a simple controlled dynamic system under constraints including the following ingredients:

- A non linear population dynamics with harvest in discrete time: a stock (biomass, abundance of a species) $x(t)$ evolves according to renewable mechanisms f (typically Verhulst growth) and catches $c(t)$

$$x(t+1) = f(x(t)) - c(t), \quad t = 0, 1, \dots \quad (1)$$

The control of the system is the catch $c(t)$ while $x(t)$ stands for the state of the system.

- A first viability constraint relates to ecological conservation with a safe stock threshold:

$$x(t) \geq x_{\text{LIM}}, \quad t = 0, 1, \dots \quad (2)$$

- A second constraint relates to food security with a basic need threshold:

$$c(t) \geq c_{\text{LIM}}, \quad t = 0, 1, \dots \quad (3)$$

Viability kernel. A more demanding space is provided by the following set of states from which starts at least one harvest trajectory $c(\cdot)$ avoiding crisis situations over time in the sense of constraints (2), (3):

$$\text{Viab} = \left\{ x_0 \mid \begin{array}{l} \exists c(t) \text{ and } x(t) \text{ starting from } x_0 \\ \text{satisfying dynamics (1) and constraints (2), (3) } \forall t \in \mathbb{N} \end{array} \right\}$$

Two contrasted cases. Assume that the population dynamics f satisfies the following conditions: $f_x > 0$; $f(0) = 0$; $f(K) = K$; $f_{xx} < 0$. We can distinguish between two contrasted configurations for the viability kernel as follows.

- **No viability:** the viability kernel is empty: $\text{Viab} = \emptyset$ if the basic need c_{LIM} is too demanding in the sense that $c_{\text{LIM}} > c_{\text{MSY}}$ where c_{MSY} is the Maximum Sustainable Yield defined by

$$c_{\text{MSY}} = \max_{x \geq 0} f(x) - x$$

- **Partial viability:** the viability kernel is nonempty when the basic need c_{LIM} is not too demanding in the sense that $0 \leq c_{\text{LIM}} \leq c_{\text{MSY}}$. In that case the viability kernel reads $\text{Viab} = [x_{\text{pa}}, +\infty[$ where the precautionary stock threshold x_{pa} is defined by

$$x_{\text{pa}} = \min \left(x, x \geq c_{\text{LIM}}, x \geq x_{\text{LIM}} f(x) - c_{\text{LIM}} = x \right)$$

Viable catches. Determining viable controls consists in maintaining the state x within the viability kernel Viab . For the previous model, this corresponds to the constraint

$$f(x) - c \geq x_{\text{pa}}.$$

Consequently, viable catches lie within the corridor

$$[c_{\text{LIM}}, c_{\text{pa}}(x)]$$

where the precautionary quota $c_{\text{pa}}(x)$ is defined by $c_{\text{pa}}(x) = f(x) - f(x_{\text{pa}}) + c_{\text{LIM}}$. Flexibility and adaptiveness emerges from this set of viable controls as several options can be selected among the interval $[c_{\text{LIM}}, c_{\text{pa}}(x)]$.

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Editor's Column

by Shandelle M. Henson

Editor-in-Chief of Natural Resource Modeling



Natural Resource Modeling, the journal of the Resource Modeling Association, covers all areas of natural resources, including renewable and exhaustible resources, terrestrial,

atmospheric and marine resources, energy, minerals and materials, land and soils, water resources, problems of pollution and residuals, managed biological populations, integrated pest management, agriculture and fisheries, rangeland and forest, wildlife and wilderness, preservation of endangered species and of genetic diversity, and others. We are interested in your expert insights, thoughts, and opinions! Do you have comments on some area of natural resources? Would you like to write a non-technical review of some aspect of management? Do you wish to comment on a paper in the Journal? Are you willing to put forth a controversial hypothesis to which others can respond? Can you write a survey of a particular need in resource management or about the effects of a recent natural disaster on a natural resource system?

The Journal is highly interdisciplinary; the common thread is the methodology of mathematical modeling. Even within the area of mathematical modeling, however, the journal is highly interdisciplinary. Methods include deterministic models such as classical differential and difference equations, stochastic

models, and statistical models. Analyses range from theorems and proofs to simulations.

Because of this wide variety of topics and methods, the associate editors on the Journal's Editorial Board often handle papers outside their own particular specialties. Clearly we cannot appoint an editor to deal with each possible topic and methodology. I greatly appreciate our associate editors because they are so good at locating expert referees in a variety of fields.

We do need some editors, however, who are comfortable handling papers in the following areas: agriculture, neural networks, hydrology, porous media, satellite landscape-level data, and minerals and materials.

If you know of a mathematical modeler who is an expert in one of these areas and would be a good associate editor, please send me the name and contact information.

Thank you !

Shandelle M Henson

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Where is WCNRM 2019 ?



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