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.

RMA Newsletter Fall 2021

Hybrid: in Leipzig, Germany & Online streaming

Important dates:

Abstract submission deadline:
February 28, 2022
Notification of acceptance:
March 31, 2022
Registration dealine:
April 30, 2022

more info to come at:
www. idiv.de/wcnrm2022

Keynote speakers:

Ingird van de Leemput
Wageningen University & Research, The Netherlands.

Martin Herold
GFZ German Research Center for Geoscience, Germany,

Simon Dellicour
Université Libre de Bruxelles, Belgium

contact:
wcnrm2022@wur.nl

Organizers:

Frank van Langevelde,
Fadia Al-Abbar, Martin Quaas

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PRESIDENT'S COLUMN

by Frank VAN LANGEVELDE

In my country, The Netherlands, we are entering now autumn with frequent rain and low temperatures, but also beautiful colours when trees are shedding their leaves, mushrooms growing everywhere, and birds grouping as preparation for their migration. This period also reminds us in Northwest Europe that Covid infections will remain in our societies for the coming years with so now and then peaks in the number of infections. Great scientific achievements of last year were the development of different vaccines and improved medications for treating Covid infections, for which I hope that vaccination worldwide will allow to go back to our lives as before the start of the pandemic. Next to these achievements, we gained better understanding to prevent such pandemics, especially the early detection of pathogen spill-over from wildlife to people and livestock. In these times, I hope that you and your family are all doing fine.

In June 2021, we enjoyed the annual World Conference on Natural Resource Modeling organized in Leipzig, Germany. The conference was fully online and perfectly organized in such a way that different sessions could be joined by participants in different parts of the world, and the recordings could be watched afterwards. Although we all missed meeting each other during coffee breaks, lunches and at the end of each day, the conference was very successful with many presentations from all around the world. Scientists from different disciplines were present and a nice mix of senior and junior scientists came together. The sessions were attended well, and I expect that many participants listened to the recordings. The theme of the conference was "Tipping ecological-economic systems towards sustainability" with well-known scientists giving the keynote lectures. During the conference, we discussed that ecosystems around the world are on the brink of collapse because many natural resources are being overexploited for short term economic benefits.

The next World Conference on Natural Resource Modeling will again be organized in Leipzig. I hope to meet all of you in person again after 2 years. For the ones that cannot attend the conference in person, we will organize online connections. I hope we can visit this beautiful old German city and experience the history and culture of Leipzig during the conference. The theme of the conference will be "Modelling natural resource management in a changing world" and the three keynote speakers will give their view. We are honoured to have three well-known scientists: Ingrid van de Leemput (Wageningen University & Research, The Netherlands), who works on theory of tipping points applied in many different systems (including resilience in health care), Martin Herold (GFZ German Research Centre for Geosciences, Germany), working on remote sensing and modelling changes in land use, and Simon Dellicour (Université Libre de Bruxelles, Belgium), who is an expert on species distribution modelling. These keynote speakers will set the stage for our thinking about modelling natural resources that are heavily exploited. I am looking forward to meet you all again and enjoy a wonderful conference.

Let's use communication of the RMA through social media such as ResearchGate, LinkedIn and Twitter, which are open for your input. We can use these media to circulate information in line with the objective of the RMA, such as new academic positions, conferences, workshops, books, papers. It would be great if these media can also be used for topics related to the focus of the RMA to be discussed among the members and others.

The objective of the RMA is to foster research and teaching at the interface of ecology, economics, mathematics and computer sciences and devote to the sustainable management of natural resources and ecosystems. As members of the RMA we have the possibility to promote the global interest in sustainability and environmental issues. I am convinced that the RMA can help society in these unprecedented times. I hope that the upcoming conference in Leipzig, the journal Natural Resource Modeling, the RMA newsletter and social media will help us with this.

I want to send my very best wishes to everyone in the RMA community!

Frank van Langevelde
President RMA,
Professor Wildlife Ecology and Conservation
Wageningen University The Netherlands

Optimal Harvesting and Taxation when Accounting for Marine Environmental Quality of the Fishery

by Ngo Van Long* Mabel Tidball† Georges Zaccour‡

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‡Chair in Game Theory and Management, GERAD, HEC Montreal

Laureates 2021 of the Lamberson Award

The literature on the management of the fisheries has emphasized the importance of the protection of their habitat (see, e.g., Barbier (2000), Fluharty (2000), Kaiser and de Groot (2000), Botsford et al. (1997)). The realization that management of the habitat must be an integral part of fishery management has been reflected in various Directives of the European Parliament.

There is a two-way relationship between commercial fishing and fish habitats. For instance, the use of destructive fishing gear can cause major deterioration of habitats, and the damage to habitats in turn leads to loss of spawning, resulting in a reduction in the growth rate of the fish stock. Habitat quality and habitat size can both influence the viability of the commercial fisheries (see e.g., Barbier et al. 2002, p. 344), and the rate of harvesting has a negative impact on the habitat. In this paper, we assume that the habitat can renew itself through a natural regeneration process, and suppose that the number of firms that exploit the fishing ground is fixed.

The purpose of our paper is to study the implications of essential habitat on public policies that ensure sustainable and efficient steady states. While in most fishery regulation cases the regulators use quantity instruments (quotas, transferable permits, etc.), it is well known that there is a one-to-one correspondence between quotas and taxes, as long as there is no uncertainty (Weitzman, 1974). We show that the tax policies considered in our paper correspond to a binding quota rule similar to the one considered in Nichols et al. (2018): the maximum allowable harvest is zero if the stock of fish is below a certain threshold, and is positive and increasing in the stock if the latter exceeds the threshold. The regulator solves an optimization problem taking into account the dynamics of the habitat and the fish stock. A major result of our paper is that there are many alternative tax rules that achieve the same golden rule steady-state stocks of fish and habitat. This result holds both for the case of a fixed number of firms and the case of open access. We show that the approach path to the steady state depends on the implemented tax scheme.

Evolution of stock and habitat: Foley et al. (2012) suggest the use of the following growth function

$$F(X,H) = r(H)X\left(1 - \frac{X}{K(H)}\right),$$

where X is the stock of fish and $H \geq 0$ is the habitat, $K(H) \geq 0$ is the carrying capacity, and $r(H)$ is the intrinsic growth rate. In any steady state, X cannot exceed $K(H)$, assuming $r(H) > 0$. They consider the linear formulations $r(H) = a + bH$ and $K(H) = f + gH$. If $a = 0$ and $b > 0$, then Foley et al. (2012) say that the habitat is "essential" in the sense that $H = 0$ implies that the intrinsic growth rate is zero. Alternatively, if $f = 0$ and $g > 0$, then the habitat is also "essential" in the sense that the steady-state fish stock cannot exceed gH (the carrying capacity), and thus when $H = 0$, the steady-state fishstock cannot be positive. We use this kind of growth function for the evolution of the stock but in our model the habitat will follow its own evolution, given by a differential equation.

We consider a fishery described at any instant of time $t \in [0, \infty)$ by the available stock of fish $x(t)$ and an index measuring its marine environmental quality (MEQ), given by M (t). Denote by $e_i(t)$ the fishing effort of fisher i at time t, and let the corresponding harvest be denoted by $h_i(t)$. We assume that the harvest is proportional to fishing effort and to the fish stock, $h_i(t) = qe_i(t)\,x(t)$, where q is a constant called the catchability coefficient. Let $h(t) = \sum h_i(t)$. The following differential equations describe the evolution of the state variables:

$$\dot{x}(t) = bM(t)\,x(t)\left(1 - \frac{x(t)}{gM(t)}\right) - h(t), \quad x(0) = x_0, \tag{1}$$

$$\dot{M}(t) = M(t)\,(1 - M(t)) - \beta h(t), \quad M(0) = M_0, \tag{2}$$

where b and g are strictly positive parameters, β is a non-negative parameter, and x_0 and M_0 are the initial values of the stock of fish and the MEQ, respectively.

The maximization problem of agent i: We suppose that the fishers behave myopically, i.e., they do not account for the state dynamics in their profit-maximization problem. Denote by p the exogenous price of fish and by $C(e_i) = c/2\ e_i^2$, $c > 0$, the convex increasing fishing effort cost. The maximization problem of agent i is given by

$$\max_{e_i} \pi(e_i) = (p - \tau(x))\,qe_i x - \frac{c}{2}e_i^2, \tag{3}$$

where $\tau(x)$ is the per-unit tax collected by the regulator, satisfying $\tau^{l}(x) \leq 0$. We let the tax function be given by $\tau(x) = \tau_0 + \tau_1/x$, where $\tau_i, i = 1, 2$ are non negative constants.

The optimal taxes: We adopt the Golden Rule approach, and assume that the regulator aims at maximiz-

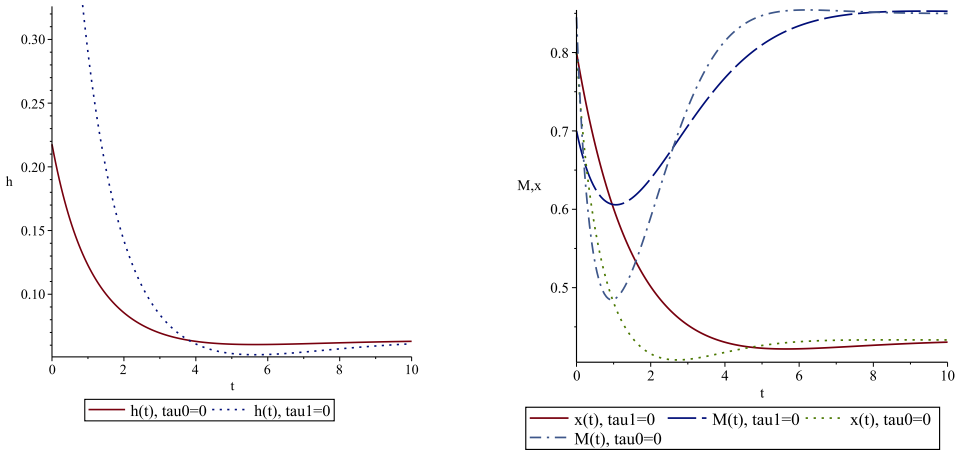

Figure 1: Harvest (left), stock and habitat (right).

ing the steady-state welfare and solve the following problem:

$$\max_{x^\infty, h^\infty, M^\infty} W = ph^\infty - \frac{c}{2}\left(\frac{h^\infty}{qx^\infty}\right)^2, \tag{4}$$

$$\dot{M} = M^\infty(1 - M^\infty) - \beta h^\infty = 0, \dot{x} = bM^\infty x^\infty - \frac{b}{g}(x^\infty)^2 - h^\infty = 0. \tag{5}$$

The main result of the paper is that a social optimum exists and the regulator can implement it through an infinite number of taxes. Among other things, this implies that the regulator can reach the same social optimum using either a constant tax ($\tau_0 > 0$; $\tau_1 = 0$) or an inversely proportional tax to the stock of fish ($\tau_0 = 0$, $\tau_1 > 0$). Whatever the regulator chooses, the steady state of the system will be the same. However, the transient phase will differ depending on the implemented tax. Figure 1 (left) shows the two harvesting trajectories and Figure 1 (right) exhibits the evolution of the two state variables in the two taxation scenarios. We observe that when the tax is constant, the representative fisher harvests less in the short term than when the tax is stock dependent, and consequently depletes less the stock of fish and the MEQ. The intuition behind this result is that the stock is abundant in the beginning and the stock-dependent tax is not sufficiently high to deter overfishing, and consequently the resource decreases faster.

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Catching-up with former RMA awardees: Vanessa Trijoulet

Researcher at DTU Aqua(Denmark)

In this column, dedicated to a former recipient of the Best Student Presentation, Vanessa Trijoulet, kindly accepted to answer few questions.

RMA: *You've been awarded during WCNRM 2015 held in Bordeaux, could you tell us a little bit more about you at that time and some memories about the conference ?*

Vanessa: . When I presented at the WCNRM2015, I was in my 3rd year of PhD at the University of Strathclyde in Glasgow, working on developing fisheries models to estimate the bioeconomic impact of grey seal predation on West of Scotland fisheries. I had already participated in many conferences, from marine mammal conferences to more fisheries oriented ones, but it was my first time participating in the WCNRM. One of my friends had participated in WCNRM before and advised me to participate given the relevance with my PhD work. I was always happy meeting new people and collaborations at conferences and I was looking forward to some sun in Bordeaux, which actually went far beyond my expectations given that it was in fact more than 40 degrees the entire week! I remember that I really appreciated the icebreaker evening before the conference. I arrived there not knowing anyone, but by the end of the evening, I had met many people. It was then easier to talk to people during the conference week.

RMA: *What happened since then ? What is your current position, and your research fields and interests ?*

Vanessa: After graduating from my PhD, I moved to Cape Cod in the US to work as postdoc in NOAA on developing a state-space fisheries ecosystem model. I stayed there for 2 years and then moved to Copenhagen for another postdoc at the Danish Technical University (DTU Aqua). In October 2020, I became a tenure track researcher at DTU. I am still working on fisheries modelling and my work involves stock assessment for western Baltic herring, general model developments as well as work on mixed fisheries and multispecies projects.

RMA: *Are you a member of Resource Modeling Association and/or are you still in touch with present RMA members ? Had RMA somehow helped you in a particular way ?*

Vanessa: At WCNRM2015, I accepted to become part of the leadership support team of the RMA, which involved at that time mainly helping with posting jobs and opportunities on the RMA website. I then became Director of communication in the RMA board in 2017. With the help of the leadership support, we developed RMA social networks on Facebook, Twitter, Research Gate and Linked In. I have therefore kept close contact to the RMA members. My term as Director of communication is soon ending but I am hoping that it will not be the end of my collaboration with the RMA community.

RMA: *Have you attended other WCNRM and will you recommend it to young researchers ? Could you give some advice to young students to improve their presentations or posters ?*

Vanessa: Given my involvement in RMA since Bordeaux, I have of course participated in other WCNRMs. I would definitely recommend young researchers to attend the conference. The WCNRM feels intimate. The number of participants is moderate and lunches are organized as part of the conference, as well as a social day or afternoon. These really help feeling at ease speaking to other researchers and students, things that can be difficult in other big international conferences.
If I had some advice for students presenting at conferences, I would say, first relax and enjoy the experience. Having a student enthusiastic about his/her work is often enough to capture the audience. Also, do not underestimate the power of nice looking slides or posters. Finally, be clear and simple about your objectives and conclusions. I know it is tempting to present all the hard work done but you do not need to present your entire PhD or Master's work, the questions and social dinner will give you enough time for in depth discussions with people that are interested in learning more about your work.

Best Student Presentation Leipzig 2021

A composite model of bistable stochastic ecosystems

by Michael Stecher and Stefan Baumgärtner

Chair of environmental economics and resource management, University of Freiburg.

Many ecosystems exhibit abrupt shifts between alternative locally stable states, which often occur in a catastrophic manner and may be difficult or impossible to reverse (Scheffer et al., 2001). The existing literature on theoretical modelling of multi-stable ecosystems largely remains deterministic or limited to the use of a hazard rate (e.g. Polasky et al., 2011), although stochastic perturbations may significantly influence ecosystem dynamics. We contribute to this literature by constructing a generic model of bistable ecosystems that combines several aspects of the existing literature in a novel way. In particular, our model combines the deterministic ecological processes behind multi-stable behaviour with two different kinds of stochastic perturbations: continuous diffusion and discrete jumps. This is important since omitting or oversimplifying stochastic dynamics may cause inaccurate model outcomes and poor system understanding.

At any point in time $t \in [0,\infty)$ the state of the ecosystem is characterised by the value of a continuous state variable $X_t \geq 0$, such as the spawning stock biomass of a fish stock in a marine ecosystem or an index of the ecosystem state. The evolution of the state variable over time is given by:

$$(1)\quad \frac{dX_t}{dt} = \theta(\mu(c_t) - X_t)dt + \sigma dW_t + y dN_t \,.$$

Specifically, this equation describes an Ornstein-Uhlenbeck process (used by Mäler et al., 2007 to model bistable groundwater table dynamics) with an additional jump process. The composite process belongs to the class of jump-diffusion processes commonly used in the finance literature. The first term represents negative ecological feedbacks: the process is attracted by its deterministic equilibrium $\mu(c_t)$ with rate determined by θ. The second term captures continuous fluctuations of X_t. It consists of a Wiener increment $dW_t = W_{t+dt} - W_t \sim N(0,dt)$ and the diffusion coefficient σ which measures the relative contribution of the Wiener process to X_t.
The last term denotes the infinitesimal increment of a compound Poisson process which captures discrete jumps in the value of X_t that arrive with probability λdt in the interval dt. The size of jumps is a normally distributed random variable with mean k

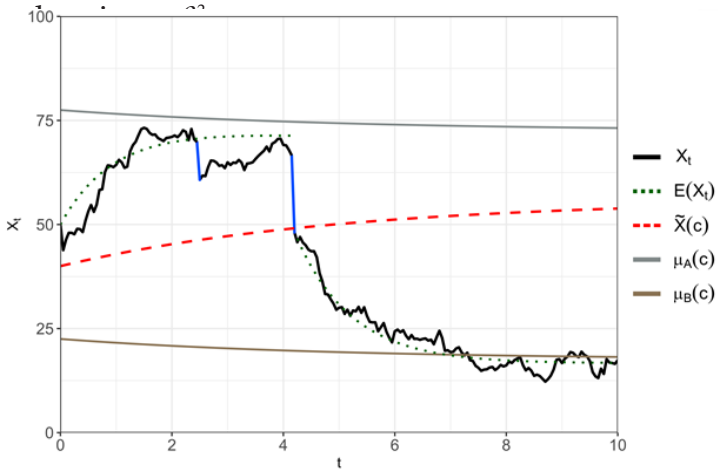

Figure 1: Random realisation of the stochastic process X_t exhibiting a regime shift

Equation (1) describes an ecosystem with multiple stable states when $\mu(c_t)$ may take on more than one value for a given level of conditions $c_t \in [0,1]$. In particular, the bistable case depicted in simple heuristic devices (Figure 2) is obtained when there are three possible values of $\mu(c_t)$ for a given value of c_t across the range of conditions between the bifurcation points F_1 and F_2:

$$(2)\quad \mu(c_t) = \begin{cases} \mu_A(c_t) \text{ for } 0 \leq c_t \leq F_1 \\ \mu_A(c_t) \text{ for } F_1 \leq c_t \leq F_2 \wedge X_t > \tilde{X}(c_t) \\ \mu_B(c_t) \text{ for } F_1 \leq c_t \leq F_2 \wedge X_t < \tilde{X}(c_t) \\ \mu_B(c_t) \text{ for } F_2 \leq c_t \leq 1 \end{cases}.$$

With this, we define a basin of attraction $b[\mu(c_t)]$ as the set of all values of X_t for which it holds that:

(3) $$\lim_{t \to \infty} X_t = \mu(c_t) \text{ for } \sigma = y = 0 \text{ for all } t.$$

Additionally, we define dynamic regimes – collections of qualitatively similar equilibrium states of the ecosystem across a range of environmental conditions – as the set of all basins of attraction corresponding to equilibria with subscript A or B, respectively, over the entire range of conditions:

(4) $$r_A = \{b[\mu_A(c_t)]\}_{c=0}^{F_1}, \quad r_B = \{b[\mu_B(c_t)]\}_{c=F_2}^{1}.$$

This enables the possibility of regime shifts via two mechanisms. Firstly, crossing the boundary between the basins of attraction at the corresponding threshold value of the state variable $X\,(c_t)$ ("pushing the ball over the ridge"). Secondly, conditions changing beyond either one of the bifurcation points and the current basin of attraction suddenly ceasing to exist ("transforming the landscape to a single valley"). Both mechanisms may be triggered by a combination of external drivers, stochastic perturbations and deliberate management actions.
The simplicity of the model enables a number of applications, such as studying decision problems of ecosystem managers.

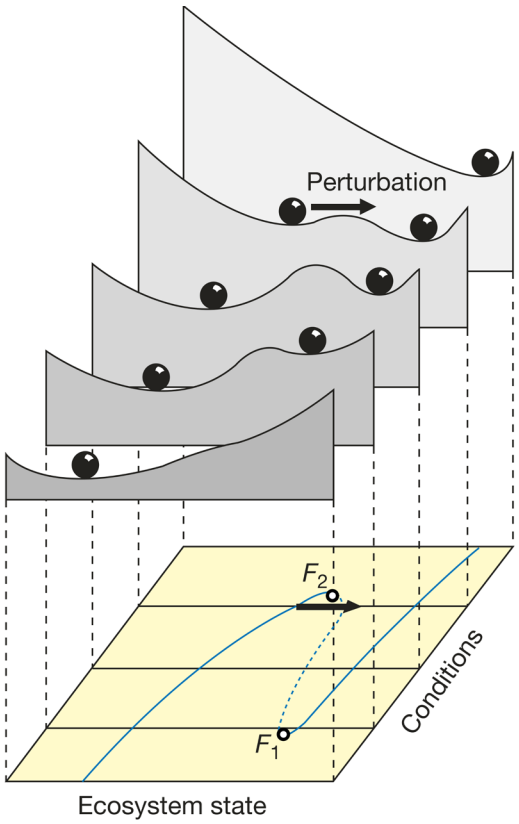

Figure 2: Heuristic Illustration (Scheffer et al., 2001)

For instance, the model permits finding economically optimal management strategies or identifying criteria for sustainable ecosystem management in a stochastic viability framework. Other applications include deriving the probability of a regime shift or, when calibrating the model to a specific system, identifying the factors which are responsible for causing a regime shift

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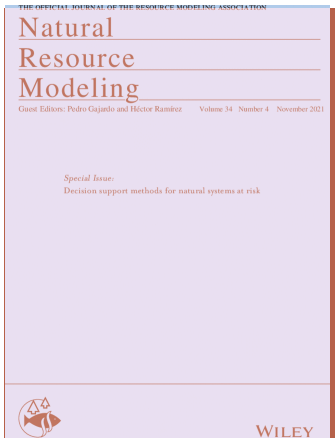
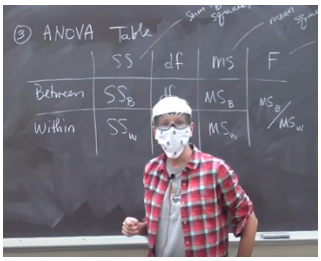


NRM Editor's Column

Special Issue : Decision Support Methods for Natural Systems at Risk

by Shandelle M. Henson, Editor-in-Chief



Volume 34, Issue 4 of Natural Resource Modeling (NRM), published November 2021, is a special issue devoted to the 2020 annual meeting of the Resource Modeling Association (RMA), known as the World Conference on Natural Resource Modeling (WCNRM). The January 2020 meeting, held in Valparaíso, Chile, and organized by the Universidad Técnica Federico Santa María and the Universidad de Chile, focused on decision support methods for natural systems at risk. This special issue is edited by conference organizers Pedro Gajardo and Héctor Ramírez.

I greatly appreciate editors Pedro Gajardo and Héctor Ramírez, as well as the authors who submitted papers and the anonymous referees, for their excellent work and focus during the trying and frightening circumstances that followed WCNRM 2020. For almost immediately after the conference, the world began to shut down due to the pandemic. On March 11, my university sent the students home and I became an online professor almost overnight. In the following semester, when students returned, I found myself struggling to teach a hybrid (in-person and online) classroom in a mask and safety goggles, streaming and recording lectures while trying to connect with the students directly in front of me. It was difficult to get much of anything else done, and yet during this time the special issue took shape under the leadership of Pedro and Héctor. To you, I say a heartfelt, "Thank you!"

All contents of the issue are open access :

Editorial, by Pedro Gajardo and Héctor Ramírez

A Bayesian model identifying locations at risk from human-transported exotic pathogens, by Steven C. McKelvey, Frank H. Koch, William D. Smith, Kelly R. Hawley.

Model analyses show how biodiversity conservation could reduce infectious diseases in an ecosystem, by Kevin J. Duffy, Obiora C. Collins.

The effective sample size for multivariate spatial processes with an application to soil contamination, by Ronny Vallejos, Jonathan Acosta.

Potential economic impacts of groundwater conservation in the Mississippi River Alluvial Aquifer (MRAA), Louisiana, USA, by Dependra Bhatta, Krishna P. Paudel, Bin Li.

Fish catch management strategies: Evaluating the interplay between body size and global warming, by William Campillay-Llanos, Victor Saldaña-Núñez, Fernado Córdova-Lepe, Felipe N. Moreno-Gómez.

Current forecast of HIV/AIDS using Bayesian inference, by Kernel Prieto, Jhoana P. Romero–Leiton

On the set of robust sustainable thresholds, by Pedro Gajardo, Cristopher Hermosilla, Athena Picarelli.

In closing, let me remind you that NRM is now a full Gold Open Access journal. Papers published in NRM are immediately freely available to read, download and share. Open Access increases the visibility of your research, leading to more downloads and citations. Many funding agencies now require Open Access and we are pleased to have made this transition.

I look forward to receiving your submissions to NRM. Also, if you are interested in guest editing a special issue, please contact me.

Peace,

Shandelle M. Henson
Editor-in-Chief
Natural Resource Modeling

Call for the Rollie Lamberson Award 2022

The RMA board invites all readers of the newsletter to nominate papers on natural resource modeling for the Rollie Lamberson Award published or in press in the period January 1 2020 until December 31 2021. We are looking for nominations published in other journals than the journal of Natural Resource Modeling.

The Rollie Lamberson Award celebrates the contribution of Professor Rollie Lamberson to the field of natural resource modeling and the growth of the Resource Modeling Association by recognizing each year the most outstanding paper in natural resource modeling in the previous two years.

The award will be given to the paper most in keeping with the society's and journal's overarching goals, namely:
"the development and analysis of mathematical models as tools for resource management and policy development," reflecting "the conceptual and methodological core that is common to model building throughout disciplines including such fields as forestry, fisheries, economics and ecology," particularly those "concerned with the sustainable utilization of renewable resources and their vulnerability to anthropogenic and other disturbances," serving "as an antidote to disciplinary fragmentation."

Mail your nomination and a short argumentation before December 31 2021 to :

frank.vanlangevelde@wur.nl

Recent Medal Recipients:

2017

The 2017 Lamberson Medal was awarded to RMA members Guillermo Herrera , Holly Mueller and Michael Neubert for their paper "High seas fish wars generate marine reserves'.

2018

The 2018 Medal rewarded a paper in the field of to Agroecological transition: "A viability model to assess soil restoration" by Marie-Hélène Durand, Anna Desilles, Patrick Saint-Pierre, Valérie Angeon and Harry Ozier-Lafontaine

2019

The joint laureates of the Rollie Lamberson prize for 2019 are:

– "Assessing the economic trade-offs between prevention and suppression of forest fires" by Betsy Heines, Suzanne Lenhart, Charles Sims
– "Sensitivity analysis of the recovery time for a population under the impact of an environmental disturbance" by A. S. Ackleh, H. Caswell, R. A. Chiquet, T. Tang, A. Veprauskas

The official newsletter of the
Resource Modeling Association

Editors : Anne-Sophie Masure, Julie Vissaguet,
Sébastien Lavaud, Luc Doyen.