Riverine Landscape Modelling for the Management of Large River Floodplains

Modélisation des paysages fluviaux pour la gestion des plaines inondables des grands fleuves

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RÉSUMÉ

La gestion des zones riveraines des grands fleuves nécessite une approche à l'échelle du paysage. Dans de nombreux cas, les grands fleuves présentent une succession d'habitats très divers le long du fleuve, à la suite de processus géomorphologiques de la source à la côte, dans les grands bassins versants qui traversent des zones climatiques multiples et présentant plusieurs types d'utilisation des terres. La conservation des environnements uniques le long du fleuve, ainsi que la connectivité des habitats dans le sens longitudinal et latéral sont essentielles pour maintenir la résilience du milieu riverain soumis à des changements hydrologiques croissants. En ne gérant les zones humides et les zones riveraines que de façon individuelle et indépendante, on risque d'isoler les habitats et de porter atteinte à l'intégrité des écosystèmes. L'échelle spatiale et temporelle des processus de nombreux écosystèmes exige une approche englobant l'ensemble du système. La modélisation du paysage peut être utilisée pour prédire les changements qui surviendront dans l'écosystème riverain à cause des changements climatiques et pour établir les scénarios de gestion future. Elle peut aussi contribuer à la planification de la conservation en traitant la rivière comme un écosystème complet qui doit s'adapter aux changements des flux et du climat tout en conservant les services désirés pour l'écosystème. Cet article démontre la modélisation du paysage qui a été entreprise dans le bassin du Murray-Darling, en Australie du Sud-Est. L'article identifie également la recherche initiale sur la modélisation du paysage dans le bassin du Rhône, dans le Sud-Est de la France.

ABSTRACT

The management of riparian areas of large rivers requires a landscape scale approach. In many cases large rivers have a high diversity of habitats along the river length as a result of geomorphological processes from headwater to coast and the large catchment areas that cross multiple climatic zones and landuses. Conservation of unique environments along the river, as well as connectivity of habitats longitudinally and laterally are essential for maintaining the resilience of the riparian environment under increasing hydrological alteration. Managing only individual wetlands and riparian areas risks the isolation of habitats and the loss of ecosystem integrity. The spatial and temporal scale of many ecosystem processes requires a system wide approach. Landscape modelling can be used to predict changes in the riparian ecosystem under climate change and future management scenarios. It can also assist in conservation planning by treating the river as an entire ecosystem that needs to adapt to changing flows and climate while maintaining the desired ecosystem services. This paper demonstrates landscape modelling that has been undertaken in the Murray-Darling Basin in South-East Australia. The paper also identifies initial research on landscape modelling within the Rhône River Basin in South-East France.

KEYWORDS

Ecosystem response modelling, Flood modelling, Floodplains, Riparian, Vegetation.

1 INTRODUCTION

A landscape approach is required to best represent the riverine processes and habitats of large rivers. The key riparian processes are extent, frequency, duration and depth of flood inundation which influences geomorphological formation and the associated floodplain over storey and understory vegetation ecosystems. Large rivers often show a high diversity of riparian habitats from their headwaters to the coast. Longitudunal and lateral connectivity is essential for maintaining the ecosystem integrity of broad-scale environmental processes such as fish spawning and migration, seed dispersal and bird feeding and nesting locations. The diversity of habitats provides for the high biodiversity and productivity of riparian areas and also leads to high resilience of these systems. Landscape modelling can be used to predict changes in the riparian ecosystem under climate change and future management scenarios. It can also assist in conservation planning by treating the river as an entire ecosystem that needs to adapt to changing flows and climate while maintaining the desired ecosystem services. This paper demonstrates landscape modelling that has been undertaken in the Murray-Darling Basin in South-East Australia.

2 THE MURRAY-DARLING BASIN

2.1 Landscape Modelling

The Murray-Darling Basin occupies over 1,000,000 square kilometres and contributes to 70% of Australia's irrigated agriculture. Part of this Basin is the catchment for one of Australia's largest rivers, the River Murray. The River Murray is over 2,000 kilometres long and has a floodplain that covers an area in excess of 600,000 hectares. It is one of Australia's key environmental assets, as well as being a working river providing a vital water supply to Adelaide and other towns in the basin and providing irrigation for agriculture. River regulation has caused environmental degradation over the last century and the rate of loss of ecological function is increasing. Overton *et al.* (2009) used floodplain inundation modelling, vegetation remote sensing and digital elevation modelling to map the landscape scale habitats of the River Murray. In large low-land floodplain rivers there is a requirement for detailed understanding of channel flows and their connection with floodplain inundation to describe the ecological outcomes that might result from different environmental water allocations. To achieve this requires detailed floodplain elevation modelling, flood extent, vegetation mapping and condition assessment over the river floodplain. In large rivers, scale factors make such detailed data difficult to obtain and process and a costly exercise using traditional field based mapping and survey techniques. Large river floodplains are also highly complex environments with small elevation differences across the floodplain creating a multitude of different flooding regime habitats. Data is also lacking for good validation of hydrodynamic models. The need for better flood modelling and vegetation mapping dictate the use of a precise and detailed Digital Elevation Models (DEM) derived from LiDAR data. Existing vegetation maps of the River Murray were either at a scale that was too small to provide relationships between flood extent and vegetation condition, or provide sufficient detail for only a part of the system. These maps also used different methodologies making amalgamation difficult. Remote sensing provides an economical and repeatable method for vegetation assessment. However, traditional remote sensing using satellite imagery gives poor results due to changes in canopy density and understorey exposure, similar signals in major tree species and varying health of trees. The LiDAR data is again used to aid vegetation mapping by combining LiDAR derived vegetation canopy height and density with satellite imagery for classification of vegetation communities.

2.2 Ecosystem Changes and Future Predictions

Landscape modelling of floodplain inundation was used by Overton and Doody (2008) to map the last 100 years of floodplain inundation on the River Murray. The relationship between pre-regulation flooding frequency and vegetation communities was used to build a flood response index. The modelling was then used to show how the frequency of flooding (flood index) can be used to predict the health of riparian vegetation. Using a range of global climate models, the health of the floodplain was predicted for a 50 year period (Figure 1).

2.3 Conservation under Changing Environments

A landscape approach to conservation in riparian habitats would require the diversity of habitats to occur in the riverine corridor as per natural conditions. Higgins *et al.* (2011) used landscape modelling to prioritise conservation strategies to conserve current areas of habitat as well as allow adaption to change habitat types while maintaining the diversity of riparian environments. Figure 2 shows the areal distribution of wetlands across a range of flooding frequencies. Current river regulation has reduced the flooding frequency of many wetlands while increasing the number permanently inundated. Flooding frequency drives the ecosystem type and a conservation strategy was developed for maintaining the diversity of these types not necessarily in the same locations as historic conditions.

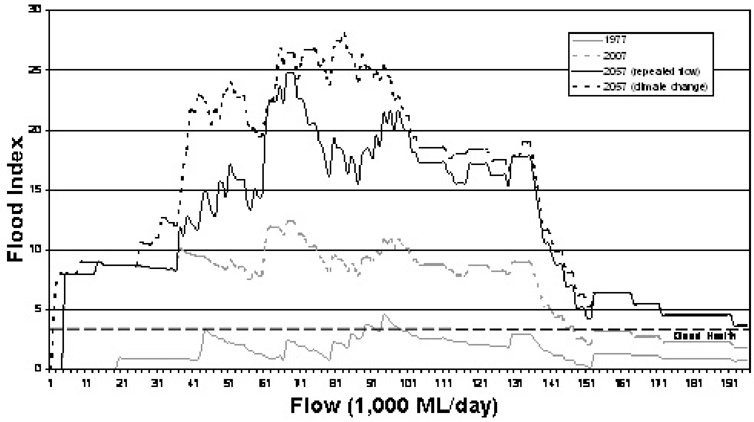

Figure 1. Flood index for different river flows for Zone 16 at Chowilla in the Lower River Murray.

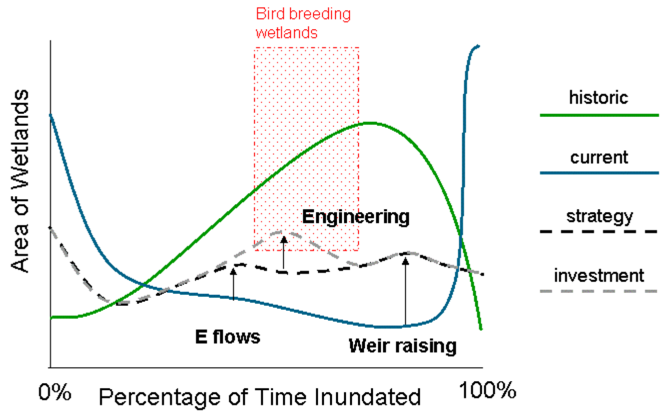

Figure 2. Area of wetlands over a range of percentage of time inundated. Green represents pre-regulation natural conditions. Blue; current distribution. Black; a management strategy and grey a specific engineering investment to meet the required hydrological habitat for successful bird breeding indicated by the red area.

3 DISCUSSION

Managing large rivers is a highly complex undertaking. In the past many actions have focussed on individual wetlands or riparian areas. There is a need, however, to consider the river as a whole as many ecosystem processes occur on large longitudinal or lateral scales above those of the typical management reserve. Large scale flood inundation modelling and vegetation mapping can be undertaken using remote sensing. These two layers form the basis for landscape modelling which can be used for mapping past environments and predicting future conditions under climate change and management scenarios. The Water Framework Directive is driving conservation strategies within the Rhône River Basin in France. Landscape modelling is currently being applied to this river to test the transferability of the approaches taken in the River Murray.

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