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A regime shift of an ecological network induced by hydrologic dynamics in a wetland complex

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Wetlands distributed in a large landscape play a critical role in providing various ecosystem services including the provision of ecological habitats, hydrologic controls, and biogeochemical processes. These services are, however, also controlled by regional hydro-climatic and geological conditions by forming a certain pattern of wetland area distribution and spatial organization in the landscape with a dynamic influence on hydrologic regime of each wetland. Its large-scale pattern also varies over time as this wetland complex is subject to stochastic hydro-climatic forcing in various temporal scales. Consequently, dispersal pattern of inhabiting species affected by the hydrologic status and spatial distribution of wetlands modifies dynamics and persistence of populations. Therefore, it is necessary to analyze the effect of temporal variation in the spatial structure of wetlands that affects the dispersal ability of habitat species. Here, we numerically show (1) the temporal change of the wetland area distribution over seasons and (2) characteristics of the corresponding ecological networks which are formed either deterministically (e.g., threshold distance) or stochastically (e.g., exponential dispersal kernel and heavy-tailed dispersal model). The results indicate that the wetland area distribution changes by seasonal climatic condition and occasionally recovers to the initial state in wetter season. The corresponding ecological networks, which the structure and function change by the change of distances between wetlands, and measured by mean degree and network efficiency, decrease during the seasons with a high seasonal dryness index. Especially, when the change of large wetland is significant, the ecological network showed completely different characteristics implying a regime shift. Moreover, during the recovery phase, the network recovered through a new pathway that was not observed in the previous state. The similar trends in the results were observed in all dispersal mechanisms tested in this study. Our analysis indicates that observed spatial characteristics of wetlands are vulnerable to drought, and the resilience of a wetlandcape can be low in a dry season causing the fragmentation of habitats. Implications of these results for modeling ecological networks depending on hydrologic systems will provide a new decision-making process, especially for conservation purposes.