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Perspectivs and challenges of phenology research on South America

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Detecting plant responses to environmental changes across the Southern Hemisphere is an important question in the global agenda, as there is still a shortage of studies addressing phenological trends related to global warming. Here I bring a fresh perspective on the current knowledge of South America‘s phenology, and discusss the challenges and future research agendas for one of the most diverse regions of the world. I will syntethize: (i) What is the current focus of contemporany phenological research in South America? (ii) Is phenology contributing to the detection of trends and shifts related to climate or antropogenic changes? (iii) How has phenology been integrated to conservation, restoration, and management of natural vegetation and endangered species? (iv) What would be the main challenges and new avenues for South American phenological research in the 21st century? (v) Can we move towards phenology monitoring networks, linked to citizen science and education? My perspective is based on recent reviews addressing the Southeastern Hemisphere, South America, and Neotropical phenology; and on reviews and essays on the contribution of phenological research to biodiversity conservation, management, and ecological restoration, emphasizing tropical, species-rich ecosystems. Phenological research has grown at an unprecedented rate in the last 20 years, surpassing 100 articles per year after 2010. There is still a predominance of short-term studies (2-3 years) describing patterns and drivers for reproduction and leaf exchange. Only 10 long-term studies were found, based on direct observations or plant traps, and this number did not add much to the previous surveys. Therefore, we remain in need of more long-term studies to enhance the contribution of phenology to climate change research in South America. It is also mandatory to bring conservation issues to phenology research. The effects of climatic and antropogenic changes on plant phenology have been addressed rarely, but the few published studies have shown the importance of taking phenology into account for forest managment, restoration planning, and to assess plant responses to land-use changes. The main challange remains to establish successfull monitoring programs, which could be partially achieved using near remote phenology digital cameras or phenocams. Phenocams are a relative low-cost tool for taking photographs from vegetation on a daily basis, reducing manual labor. Furthermore, cameras can monitor several sites simultaneously, therefore increasinfg the spatial coverage of phenological moitoring. Phenocams are successfuly detecting leaf changes, but reproductive phenology is still an issue. Networks of phenocams already exist in north America and we are starting the first phenocam network for South America, but consistent financial support and an effective collaboration with the existing networks are to be sought for the success of this endeavour. The integrations of local populations on phenology data collection and observations would be a effective strategy to fill that gap and enroll citzens on scientific activities linked to conservation and education. Still, citizen science is largelly unexplored across South America, and remains as one of the most important goal in penology research for the next decades.