Mathematical model explains how complex societies emerge, collapse

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The instability of large, complex societies is a predictable phenomenon, according to a new mathematical model that explores the emergence of early human societies via warfare. Capturing hundreds of years of human history, the model reveals the dynamical nature of societies, which can be difficult to uncover in archaeological data.

The research, led Sergey Gavrilets, associate director for scientific activities at the National Institute for Mathematical and Biological Synthesis and a professor at the University of Tennessee-Knoxville, is published in the first issue of the new journal Cliodynamics: The Journal of Theoretical and Mathematical History, the first academic journal dedicated to research from the emerging science of theoretical history and mathematics.

The numerical model focuses on both size and complexity of emerging "polities" or states as well as their longevity and settlement patterns as a result of warfare. A number of factors were measured, but unexpectedly, the largest effect on the results was due to just two factors – the scaling of a state's power to the probability of winning a conflict and a leader's average time in power. According to the model, the stability of large, complex polities is strongly promoted if the outcomes of conflicts are mostly determined by the polities' wealth or power, if there exist well-defined and accepted means of succession, and if control mechanisms within polities are internally specialized. The results also showed that polities experience what the authors call "chiefly cycles" or rapid cycles of growth and collapse due to warfare.

The wealthiest of polities does not necessarily win a conflict, however. There are many other factors besides wealth that can affect the outcome of a conflict, the authors write. The model also suggests that the rapid collapse of a polity can occur even without environmental disturbances, such as drought or overpopulation.

By using a mathematical model, the researchers were able to capture the dynamical processes that cause chiefdoms, states and empires to emerge, persist and collapse at the scale of decades to centuries.

"In the last several decades, mathematical models have been traditionally important in the physical, life and economic sciences, but now they are also becoming important for explaining historical data," said Gavrilets. "Our model provides theoretical support for the view that cultural, demographic and ecological conditions can predict the emergence and dynamics of complex societies."

More information: Gavrilets S, Anderson D, Turchin P. 2010. Cycling in the complexity of early societies. Cliodynamics: *The Journal of Theoretical and Mathematical History*. 1:1 escholarship.org/uc/irows_clio … ics?volume=1;issue=1

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