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Scale dependence in the feedbacks between woody plant encroachment and microclimate in desert grasslands

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Woody plant encroachment into grasslands is a global phenomenon that results from a variety of drivers. In the southwestern deserts of North America, changes in vegetation composition and structure due to shrub encroachment are major drivers of land degradation, loss of rangeland productivity, and soil erosion. The relatively abrupt character of grassland-to-shrubland transitions suggests that arid and semiarid rangelands may be bistable systems, with stable states characterized by either grass or shrub dominance. Thus, even small changes in environmental drivers may cause abrupt state transitions from grassland to shrubland. Bistable dynamics are often induced by positive feedbacks between external drivers and the current state of the system. Here we show that positive feedbacks between land cover change and microclimate may contribute to shrub encroachment. To this end, we investigate changes in surface energy balance and near surface temperature resulting from grass-to-shrub transitions in the northern Chiuhuahuan desert. We find that the encroachment of native shrubs into desert grasslands modifies the surface energy balance with the overall net effect of increasing nighttime air temperatures, thereby favoring the establishment and growth of freeze-sensitive shrubs. We investigate the scale dependence of this feedback and determine the minimum size at which shrub patches can effectively modify their microclimate.