CLIMATE SCIENCE

The challenge of hot drought

An analysis of North American drought variability over the past millennium shows that it is not unusual for widespread drought to persist for years, prompting fresh thinking about our ability to deal with such climate conditions.

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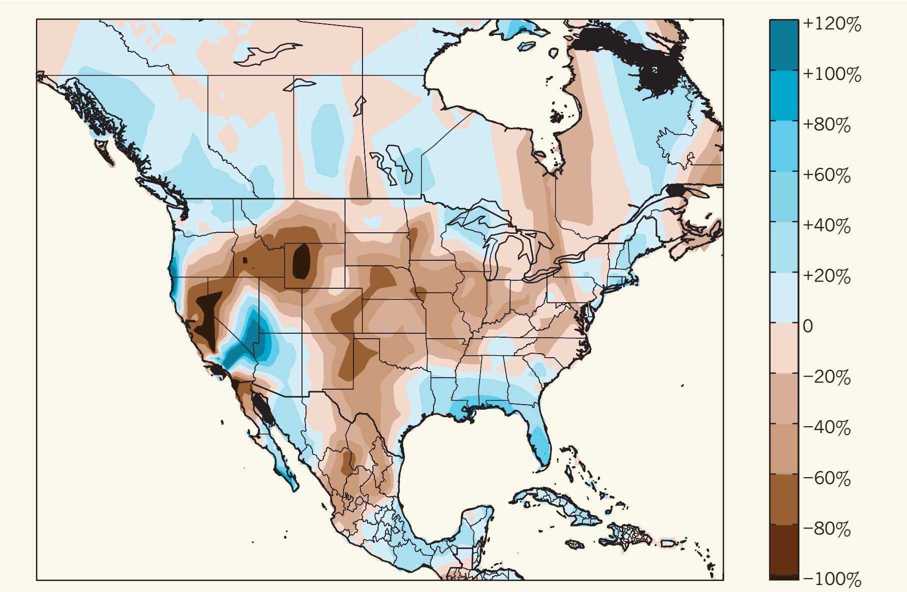
Drought is heating up around the warming world. Particularly hot drought has cost more than US$40 billion and claimed 218 human lives since 2010 in the United States alone[1]. These hot and dry conditions have also contributed to unusually widespread and devastating wildfires[1], fuelled by wide expanses of weakened and dead trees that were unable to deal with heat stress and subsequent insect attack[2]. Yet, to get a real sense of how this recent change in drought severity might shape the future, one has to look to the past. An analysis of regional and pan-continental North American drought over the past 1,000 years, reported by Cook *et al.*[3] in the *Journal of Climate*, makes it clear that recent droughts, as costly as they have been, are only a taste of what might lie ahead, independently of any big climate change.

Drought conditions, including the two most severe categories — extreme and exceptional — covered more than half of the continental United States in 2012[4]. This drought affected several regions of North America (Fig. 1), earning it the distinction of being a pan-continental drought rather than the more common regional drought[3]. Cook *et al.* tap a continental array of 1,000-year drought records based on tree rings to show how the 2012 pan-continental drought pattern has occurred in 12% of years since the tenth century. More importantly, the authors' study highlights how no major US region is immune to such drought, and that we understand quite a lot about how sea surface temperatures drive the differing patterns of drought.

Cook and colleagues' most relevant lesson for the future, however, may be that the one-year pan-continental drought of 2012 was but a glimpse of drought compared with the multi-decadal pan-continental megadroughts that were most common during the twelfth and thirteenth centuries. The complexity of these megadroughts still defies complete explanation and yet it implies that unusually persistent anomalies of sea surface temperature can combine with amplifying changes in vegetation and soil to drive droughts that — if they happened today — would outstrip many of our institutional capacities to deal with such aridity. For example, another tree-ring study[5] highlighted a 50-year drought, with only one normal year of precipitation, in the headwaters of both the Colorado River and the Rio Grande during Roman times. It is hard to imagine how such a drought would play out today, but it would surely prove a much greater challenge to regional water resources and forests than any drought of the past 120 years.



MAP: BENJAMIN COOK; DATA SOURCE: CLIMATIC RESEARCH UNIT/UNIV. EAST ANGLIA

Figure 1 | The 2012 North American drought. The map shows the per cent precipitation anomaly for June–August 2012, relative to the mean for 1961–90, and illustrates (in brown colours) the widespread nature of the 2012 drought. Although this three-month period was wetter than normal in parts of the southwest United States, this region has also been in drought more often than not since 1999. Palaeoclimatic records[3] indicate that droughts experienced over the past 100 years, including the costly 2012 drought, have been modest compared with the often much longer and equally widespread droughts of the past millennium.

Tree-ring records are just one invaluable source of palaeoclimatic information. Proxy climate records from lake sediments and cave formations also help to show how drought has varied over timescales that are too long to be understood from the short record provided by thermometers and rain gauges alone. Moreover, palaeoclimatic data provide long records of climate variability against which state-of-the-art models can be tested. For example, the climate models used in the ongoing Fifth Assessment of the Intergovernmental Panel on Climate Change (IPCC) seem to underestimate the strong multi-decadal drought variability that is evident in the multi-proxy palaeoclimatic record[6]. This implies that, although well validated in many ways, these models underestimate the risk of future multi-decadal megadroughts of the type that plagued medieval and earlier times in the southwest United States. There are many potential reasons for this shortcoming, including perhaps inadequate representation of tropical Pacific variability in the models[6,7].

Cook and colleagues end their new work with a warning that global warming has the potential to increase the severity and extent of future droughts. This seems clear in some regions, such as the southwest United States, for which researchers have coined the term "global-change-type drought"[8], which might more appropriately be called global-warming-type drought. Warming seems already to be altering the duration and frequency of drought in some regions of the globe, a trend that will probably become clearer as global warming proceeds[9]. In addition, warming is likely to reduce flows in snow-fed rivers such as those of the western United States[10,11], and will intensify vegetation stress during drought[12].

The bottom line on drought seems evident. Cook *et al.* highlight the rich diversity of droughts that can occur naturally. Droughts can be short, and they can persist for decades. Moreover, they can be intensely regional or be pan-continental. Without doubt, the situation calls for the public, policy-makers and all types of resource managers to consider 'no-regrets options' (activities that yield benefits no matter what) for dealing with long and potentially extensive drought that will inevitably happen

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again in the future. Choices include saving groundwater for when it is really needed; injecting extra water into the ground during wet periods for storage; making water use more efficient; perfecting the inexpensive reuse of water; and maintaining water use in activities (such as farming) whose users can sell their water when less-flexible users (including urban populations) need help in dealing with extended drought. These strategies might prove more feasible than massive efforts to transfer water between regions, especially given that, as Cook *et al.* show, many regions can be hit by drought simultaneously. At the same time, work is urgently needed to understand all the ways in which global climate change will exacerbate the types of drought that have occurred before.

Could we thrive in the face of a pan-continental megadrought? Probably yes, but only if we develop the appropriate buffering strategies in advance of the drought, and if we think more seriously about reducing emissions of greenhouse gases to the atmosphere as a way of keeping future droughts from becoming so hot and dry that they are beyond our buffering capacity. ■

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HUMAN EVOLUTION

Group size determines cultural complexity

Many animals use culture, the ability to learn from others, but only humans create complex culture. A laboratory experiment tests which characteristics of our social networks give us this capacity. SEE LETTER P.389

PETER RICHERSON

Isaac Newton famously said that he saw further by standing on the shoulders of giants. A more apt image for most human culture is that we see further because we stand on the shoulders of a vast pyramid of mini-Newtons. Only a few people have invented even one word of the language they speak, for example, yet a native speaker of English knows tens of thousands of words. As early as the Stone Age, people spoke complex languages, interacted in diverse social systems and built exquisite and functional tools. So how do we create the wonderfully diverse cultural systems that sustain us in almost every terrestrial habitat in the world? Studies of cultural evolution point to two factors — accurate imitation[1] and large social networks[2]. Mathematical modelling suggests[3] that these two properties will support the fast, cumulative evolution of cultural systems. On page 389 of this issue, Derex *et al.*[4] present results from a laboratory experiment that support the role of network size (Fig. 1).

Accurate imitation allows humans, but not chimpanzees, to learn complex skills and ideas from others — much more complex ones than they can learn for themselves. Large social networks allow human learners to tap the knowledge of mentors skilled in any cultural domain, thereby rapidly spreading the best ideas throughout a society. Studies to test the effect of network size on cultural evolution have mainly used observations of small, isolated populations compared with larger neighbouring groups[5]. But such natural experiments are controversial: not all studies find the effect, perhaps because other factors also influence cultural complexity. Therefore, Derex *et al.* turned to the laboratory to investigate the issue.

Theory suggests[2] that if a too-small group attempts to make a too-complex tool, over time the tool will become simplified: small groups will often lack a tool-maker of sufficient skill to make the complex version of the tool and a simpler form will evolve. To study the effects of varying task complexity and the number of members in groups of learners, Derex *et al.* asked participants to draw either a stylized arrowhead or a fishing net on a computer screen. These designs were then used to earn the participants money from simulated hunting or fishing expeditions. The monetary yield of an arrowhead was a simple function of its shape, whereas that for nets was a complex function of net shape, the size of cord used in different parts of the net and

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Figure 1 | Net gain. Derex *et al.*[4] show that interacting in large groups helps people to maintain the ability to perform complex tasks, such as building nets.

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