‘A Great Aridness’

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Excerpt

Pages 22-27

THE GOOD NEWS, if you ask Richard Seager, an oceanographer at theLamont-Doherty Earth Observatory in Palisades, New York, is that the Northern Hemisphere Hadley cell is not expanding as fast as some recent analyses have warned. Those projections, he says, depend upon comprehensive satellite data, which have been available only since the late 1970s, a brief slice of time. He thinks the observed Hadley cell expansion is better attributed to a naturally occurring decadal shift in Pacific Ocean currents.

The bad news, however, is that, because of Hadley cell expansion andother factors, the Southwest is moving — and to some extent has alreadymoved — into a new set of climate conditions “unlike any climate state wehave seen in the instrumental record.” Seager thinks that the droughts of thepast, like the Dust Bowl drought of the 1930s and the 2000–2004 droughtthat killed millions of pinons and ponderosas in New Mexico and Arizona,will be the norm of the future. He is saying, in effect, that what we think ofas drought today will cease to be drought in the light of some not-toodistanttomorrow.

Drought is relative — and exceptional. One does not say that the Saharais experiencing drought. The Sahara is dry by nature, not by exception.According to Seager, the future Southwest will be much drier than the conditionsits present inhabitants consider "normal"; it will likely be as dry as itsdriest recent decades, and people will have to recalibrate their expectationsto a new idea of what "normal" stands for. Moreover, he says that the droughtsof the future will be superimposed on that dryness and that they will beunlike anything people in the region have known since late medieval times.

Seager holds an endowed position at Lamont-Doherty, a research armof Columbia University. He's a Brit who came to the United States for educationand stayed. I visited him at his Morningside Heights apartment on aday when the lab was closed and his son Angus was home from school,contending with homework at the dining table. The humid smell of laundrywas in the air. We had plenty of time to talk, but not an unlimited amount — an important football game (real football, played with the feet) would betelevised from England that afternoon. Seager lives close to Columbia, onlya block from the diner made famous by the sitcom "Seinfeld." He takes anamused pride in this link to American pop culture, marveling at the touristsposing for snapshots and the occasional celebrity guiding a tour. Seager is abit of a cultural sponge. As we talked, he alluded frequently to the intricaciesof Colorado River politics and to Dust Bowl histories and books onwestern water. Except for his accent, he could have been a good-old-boyinsider.Seager calls himself an oceanographer and meteorologist, avoiding the term climatologist , which suggests, to him, a duffer "with a cloth cap and a rain gauge in his garden." He came to the study of the Southwest "by purechance, which is the way science goes, you know?" He and his team hadbeen looking at Asian monsoon variability in the nineteenth century, goingback to 1856, the year the British and American navies began recording airand sea surface temperatures and winds from all their ships. Other naviesand merchant marines eventually followed suit, making it possible to compilea nearly global century-and-a-half record of oceanic weather. Seagerand his team drew upon that data to model relationships between sea surfacetemperature and changes in atmospheric circulation. In 2004, SiegfriedSchubert, a scientist at the nearby NASA Goddard Institute for SpaceStudies, a leading center for climate science, wrote a paper that linked theDust Bowl drought to small temperature changes in surface waters of thetropical Pacific. 5 Seager had access to an advance copy. "When Schubertpublished that paper, and actually before it came out," says Seager, "I justlooked in the model that day and said, well, does our model produce a DustBowl drought? And sure enough, it produced a Dust Bowl drought."Further investigation showed it "made a nice big drought in theSouthwest in the 1950s," which Schubert's simulation had missed, and italso showed the Southwest turning dry in 1998, the approximate onset ofthe drought that produced widespread tree die-off s in 2002–2003. Thingswere getting interesting. Seager checked the model against a new droughtatlas that Lamont-Doherty's tree-ring researchers had just produced andfound that they jibed: the model tracked the wet and dry periods recordedin the tree rings for the mid- to late nineteenth century with high fidelity."So we just sort of dropped stuff , whatever we had been doing, and misusedgovernment funds to fund this research instead of what the governmenthad actually given us funds to do." His program managers didn't complain,because they understood the importance and opportunities of the newwork. "So we pushed it forward."The forwardness was in two dimensions: forward in terms of refiningan understanding of historical drought records and forward also in time,projecting climate for the Southwest into the twenty-first century. TheIntergovernmental Panel on Climate Change (IPCC), which the UnitedNations established in 1988, had also done this. Modelers contributing tothe IPCC's "Fourth Assessment Report," which appeared in 2007, concludedthat the North American Southwest would grow appreciably drierin the twenty-first century, but their predictions focused far in the future,past 2080. They also concerned themselves solely with precipitation, notthe finer-grained interaction of precipitation less evaporation, which betterdescribes the moisture available to nourish soil and discharge into streamsand rivers. “So there’s a bit more to the story than the precipitation” — andSeager and his team set out to tell it.Their simulations showed that the Southwest would not have to waituntil 2080, or even 2050, to experience drier times; greater aridity wasalready on its doorstep — hence the considered use of the word imminent inthe title of their paper, “Imminent transition to a more arid climate insouthwestern North America,” which appeared in the journal Science in2007, attracting considerable attention. Their research also told them thatthe increase in aridity would not result from the same forces that triggeredthe droughts of the past. Those droughts, possibly including the extendeddroughts of medieval times, appear to have occurred when the currents ofthe tropical Pacific, for whatever reasons, carried relatively cool surfacewaters far to the east, toward the Americas. This pattern, commonly calledLa Nina, seems to give a northward push to the winter storm track thatbrings moisture to western North America.The opposite pattern, El Nino, pulls the storm track southward, bringingwinter rain to U.S. deserts and snow to the southern Rockies. (Mexico isnot so lucky; it depends principally on summer monsoons.) Together ElNino, named for the Christmastime arrival of warm waters off the coast ofPeru, and La Nina, its contrary sister, are known as the El Nino SouthernOscillation (ENSO). The mnemonic for this relationship, from asouthwestern point of view, is sexist: the boy child brings welcome winterprecipitation, filling the reservoirs crucial to both cities and agriculture, butthe girl brings drought.Or so it has been in the past. The model simulations analyzed by Seagerand his team showed the Southwest to be drying out “for a different reason,and that different reason is just a simple consequence of warming up.”Seager explains that when Earth’s surface and its atmosphere warm up, twothings happen. One is the intensification of the hydrologic cycle: warmerair holds more water vapor; more vapor converges in wet regions, and itrains more there. “The pattern of water vapor transport intensifies. Thatmakes dry regions drier and wet regions wetter. So that’s part of why theSouthwest dries, because it’s already in one of these places where importantparts of the atmosphere circulation take moisture away.” The other reasonSeager cites is the expansion of the subtropical subsidence zone, where thedry, downwelling air of the Hadley cell returns to the surface of the land.“And that’s not the same as what causes the natural droughts,” he concludes.“The cycle of natural dry periods and wet periods will continue, butthey continue around a mean that gets drier. So the depths — the dry partsof the naturally occurring droughts — will be drier than we’re used to, andthe wet parts won’t be as wet as we’re used to, because they’re both happeningaround a mean state that gets drier and drier.” That new “mean state” iswhat he calls the new climatology of the Southwest, something similar tothe Dust Bowl or the 1950s — a far cry from the anomalously wet period thatran from the late '70s into the '90s, which forms many people's notion ofwhat is "normal" for the region.Not everyone agrees with Seager's message, and certainly not with theblunt, alarming language in which he delivers it. There are always cries formore data and improved models, for further analysis at a finer spatial scale,and for the consideration of other possible explanations. There are alsocritics who say that even if he is right, he should be more careful: predictionsas strident as his risk undermining the public's faith in the scientificcommunity. What if the Southwest enjoys a string of generously wet years?Every system exhibits variation, and all long droughts include wet episodes.What if the new climatology arrives late, or not at all? Perhaps then theurgency he has tried to engender will turn to cynicism, commitment turnto inaction, and the public's grudging acceptance of the reality of climatechange degrade into disbelief. Perhaps, in the end, his startling warningmight have an effect opposite to the one he intended.Seager shrugs: "It's because of things like that that the Bureau ofReclamation and their like can sort of throw their hands in the air and say,'Well, what do we do with these climate model projections? They don'thave information at the spatial scale we need to predict what the ColoradoRiver is going to do.' And they're right, strictly speaking — that's correct, butthat's not a good excuse for not doing anything, because the chances are,once you get a model with all the right spatial scales to have all thetopography, it's probably not going to change the sign of the result." Thesign, plus or minus, would still be a minus in terms of water availability — things will be getting drier. "So if you just do nothing and wait for that,you're just wasting time. . . . It could be ten, fifteen years before you get themodels at the resolution you need, by which time you're probably deep intothis drying trend."Pages 121-124LEOPOLD'S PREDICTION WAS correct, except for the prophecy of a touristroad. The integrity of the Gavilan did not last long after his 1936 visit. Hecame back for a second hunt at the close of 1937, bringing his brother Carland eldest son Starker, and this experience was as enchanting as the first.He also urged in various quarters that the area be preserved as "an internationalexperiment station" to serve "as a norm for sick land on both sides ofthe border." 29 But nothing came of his proposal. Game began to decline in themountains in subsequent years, and the outfitting business in ColoniaPacheco was all but dead by 1941. 30 Shortly after Leopold's death in 1948, hisson Starker returned to the Rio Gavilan hoping to initiate some of the ecologicalstudies his father had dreamed of, but the paradise he remembered froma decade earlier was gone. Logging roads threaded through the headwatersand livestock had followed. Many stretches of the formerly moss-hung riverhad become a scour of cobbles.The downward ecological spiral of the Rio Gavilan continues to the present.31 In the all-too-familiar cycle that Leopold in his early days documentedthroughout Arizona and New Mexico, logging and overgrazingbared the land to the violence of storms. Deprived of its defense of grass,litter, and living roots, the soils of the slopes yielded to the force of downpours,and floods tore every soft thing from the rivers and creeks, leavingrocky gutters in their place. The damage was a kind of sin against the land,which Leopold captured in one of his best metaphors: “Somehow thewatercourse is to dry country what the face is to human beauty. Mutilate itand the whole is gone.” 32MANY ARE THE accounts of southwestern watersheds that unraveled. In oneof his essays on Mexico, Leopold cites Will Barnes’s telling of the destruction of valley lands along the San Simon River in Arizona. In “Pioneers andGullies” (1924) Leopold himself describes the loss of 90 percent of the cultivatedland along the Blue River in Arizona’s White Mountains. Elmer OtisWooton, in a seminal 1908 monograph, The Range Problem in New Mexico,recounts how deepening arroyos cut the life out of the Mangas Valley in theBurro Mountains. These and other reports point unmistakably to humanagency as a trigger for widespread erosion, if not through logging and grazingthen as a result of roads, trails, and other disturbances that gutteredrunoff and initiated the formation of arroyos. Just before his first trip to theGavilan, Leopold drafted an extensive discussion on this topic, which hetitled “The Erosion Cycle in the Southwest.” Dutifully, he sent the essay outfor review, including a copy to the eminent Harvard geologist Kirk Bryan, anative of New Mexico who had closely studied arroyos in Chaco Canyonand other southwestern locations. Bryan and many of his colleagues maintainedthat climate, not human activity, governed arroyo formation and that,independent of human influence, the Southwest had repeatedly undergonealternating periods of degradation — arroyo cutting and stream entrenchment — on the one hand, and aggradation — the building up of alluviallands — on the other.Bryan's critique evidently prevented Leopold from settling his mindon the subject of arroyo formation, and "The Erosion Cycle in theSouthwest" was never published. But he did not let the matter rest. Heurged his son Luna to go to Harvard to study with Bryan and get to thebottom of the issue. 33 Not many families pass intellectual conundrumsfrom one generation to the next, but the Leopold family was in a class byitself. All five of Leopold's children became accomplished naturalists, andthree, Starker, Luna, and Estella, achieved election to the NationalAcademy of Sciences. 34 Luna's dissertation, "The Erosion Problem ofSouthwestern United States," was not completed until after his father'sdeath, but the conclusion he reached neatly bridged the points of view ofhis father and his mentor. Near the end of his own life, he restated it in abook, A View of the River, that sums up his life's work as a hydrologist:"The deep gullies cut by erosion in pre-Columbian time took less than200 years to evacuate a large part of the early Holocene fill. In the period1880–1920, overgrazing and climate change repeated the events of A.D.1200–1400 in a period of less than 50 years." 35 Luna Leopold had concluded that climate and geology control cycles of large-scale erosion, butalso that human activity, like an enzyme in a biological reaction, acceleratedthe process markedly.The relative weights accorded to climatic and human causes of arroyoformation are important. If climate is the sole cause, then clear-cutting a watershedor grazing it to the point that it can’t hide a golf ball might alter its biotaand ruin its productivity, but the gullies that subsequently take form wouldhave formed anyway. Such a view is nonsense, as both Leopolds well knew, andthe Rio Gavilan was their proof. The watershed of the Gavilan did not unravelduring the arroyo-cutting heyday of 1880–1920. It came apart later, after itstimber was cut, its grass removed, and its slopes braided with roads and trailsthat concentrated the energy of storm runoff on newly exposed targets. Themost reasonable conclusion, in fact, might be stated less conservatively thanthe restrained scientist Luna Leopold was willing to do: namely, that the waypeople treat the land influences arroyo-cutting considerably, and that theinfluence is especially great when climatic factors favor downcutting anddegradation.Two key factors are important to understand: effective aridity and stormenergy. In the period 1880–1920, when most of the valley arroyos in the westernstates were cut, total precipitation did not differ markedly from otherperiods of similar length, but more precipitation appears to have come fromheavy storms, and less as light rain.A light rain — what some Pueblos call a female rain — falls slowly andgently. It soaks the ground, and a large proportion of its water becomes availableto plants. Under a regime of abundant light rain, which would normallymean many mild storms, the vegetative cover of the land tends to increase. Bycontrast, heavy rains — male rains — quickly saturate the topmost layer of thesoil. During the downpours, the water falls so fast that it soon exceeds theabsorptive capacity of the soil, and most of it runs off , sometimes in violentflash floods. Only a small portion remains behind to nurture plant growth.As a result, a period with many violent thunderstorms and few light rains iseffectively more arid than a period in which light rains produce the same totalamount of moisture. As aridity increases, the protective clothing of the land — in the form of vegetation, leaf litter, and other organic matter — decreases,making the soil more vulnerable to the increased energy of those big, wild,violent male rains.If all this sounds familiar, it should. The prospect of bigger, more violentstorms coupled with increased effective aridity is part of the bundle of effectspredicted for the Southwest as a result of climate change. In the early 1990s,Luna Leopold put the matter bluntly: "The climatic changes of the past suggestthat if the trend toward a warmer and more arid climate actually continuesin the coming decades, the erosion of alluvial valleys seen in thethirteenth century, and again in the nineteenth, will be repeated in many ofthe semiarid areas of the planet where the rainfall is primarily of the thunderstormtype."3 6

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