LETTERS

People cross an international border bridge from Mexico to the United States.

PHOTO: REUTERS/ALAMY STOCK PHOTO

Edited by **Jennifer Sills**

Mexican and U.S. scientists: Partners

SOME OF THE staunchest challenges to President Trump's new immigration policies have come from U.S. researchers and academic organizations determined to ensure unfettered scientific pursuit [e.g., (*1*, *2*)]. Given the administration's negative portrayal of Mexicans, we appreciate the commitment of our American colleagues to defend academic freedom in the United States and beyond.

Mexican scientists value the opportunities for education and collaboration with scientists in the United States. Of the 27,286 Mexican scholars registered in the National System of Researchers (SNI), 2218 of them obtained their Ph.D. from U.S. universities (*3*). Judging by collaborative work, many of these U.S.-trained scholars continue to reinforce their academic bonds with U.S. universities after they return home. Since the 1940s, Mexican researchers have published 104,664 papers with foreign colleagues, and of these, more than one-third (36,057 articles) have been coauthored with U.S. scientists (*4*).

The long-term social and academic consequences of the current political climate could be dire. Ethnic, religious, and racial profiling are unacceptable, and Mexicans are not unwanted enemy aliens. Rather than deportations and travel bans, which only promote anti-Americanism, we require constructive solutions to protect our joint scientific efforts. Part of the answer may lie in developing an extended binational community of science students, researchers, and teachers on both sides of the border by reinforcing and diversifying existing exchange programs, setting up science festivals and other outreach activities, and organizing extended visits for U.S. students to Latin American universities. As demonstrated by the success of the European Erasmus program (*5*), exposing future researchers to different cultures and lifestyles can substantially improve international academic networks.

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REFERENCES

1. J. Berger-Sweeney *et al.*, "A message to the president," *The New York Review of Books* (9 March 2017).
2. J. G. Merino, A. Jha, E. Loder, K. Abbasi, *Brit. Med. J.* **356**, 775 (2017).
3. Government of Mexico, Conacyt, Sistema Nacional de Investigadores (http://conacyt.gob.mx/index.php/el-conacyt/sistema-nacional-de-investigadores) [in Spanish].
4. O. Ortega Adriana, S. Armendáriz, "Miradas multidisciplinarias a la producción científica mexicana con perspectiva de género: el caso de la UNAM" (UNAM, México, 2017) [in Spanish].
5. E. Pain, "25 years of Erasmus," *Science* Careers blog (2012); http://blogs.sciencemag.org/sciencecareers/2012/01/25-years-of-era.html.

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Lessons from the Oroville dam

CALIFORNIA HAS EXPERIENCED tremendous amounts of precipitation in the past few months, leading to the wettest year on record (as of mid-rainy season) immediately after a 5-year record-setting drought over the region. On 7 February 2017, the Oroville dam, the tallest dam in North America (*1*), suffered damage when extreme water flows created a massive hole in the primary spillway and then excessive erosion in the emergency spillway. The rapidly developing situation prompted an emergency evacuation of about 190,000 people living downstream of the dam. A few days later, a levee breach occurred near Manteca, leading to evacuation of about 500 people. These incidents clearly demonstrate how extreme events, land-cover and land-use changes, and the emerging climatic changes can threaten the integrity of our aging dams and levees (*2*).

Structural repairs to the Oroville dam and the Manteca levee are in progress. There are, however, still active threats to dams and levees due to excessive sediment and debris flow, exacerbated by wildfires during the drought. The large swaths of flood-induced flowing sediments are observable even from space (*3*). Such a large volume of unexpected sediments, intensified by floods in a drought-stricken area, can substantially affect the operation of hundreds of dams and levees in California. Large volumes of sediment and debris can shorten the service life of these dams, which are already not far from the end of their design life. Furthermore, a wet year leads to a lot of fuel for future fires. If a dry year follows a wet year, the fire risk (and hence debris flow) will be higher than average. A classic example is the infamous Devil's Gate dam in southern California, which has turned into a large debris basin because of a series of post-fire flood events (*4*).

Compounding effects of a number of factors unfolded in the Oroville dam incident. We need to reevaluate failure probability of all major dams and levees under multi-hazard scenarios. Ignoring the underlying relationships between multiple events can lead to underestimation of extreme events and their impacts. We need a new paradigm for describing extreme events based on their impacts and not just occurrence probability of climatic conditions. The Oroville experience showed that even a moderate extreme precipitation event (a 7-day event likely to happen about once every 2 years) (*5*) could lead to a potentially hazardous situation given the antecedent conditions [i.e., the second-most-extreme runoff observed in the Oroville basin since 1995 (*6*)]. Furthermore, the majority of critical infrastructure elements are interdependent. Resilience dependency between flood protection systems (such as levees and dams) and other critical infrastructures (such as energy infrastructures) needs to be better understood.

The average age of the dams and levees in the United States is well above 50 years. Nearly 15,500 dams were classified as "high hazard" in 2016, and the number continues to increase (*7*). Their design did not account for changes in the statistics of extremes over time. However, the past hydrologic events, emerging patterns, and projected climatic conditions all point to a future with more extreme events (*8*). Oroville dam is a portent of the risks that our aging dams and levees face from compounding events in a changing climate. The existing infrastructure needs to be reevaluated with a vision toward "climate-adapted" infrastructure that the United States can rely on in the face of new climate realities.

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REFERENCES

1. R. G. Lin II, R. Ranoa, C. Megerian, "Here's the nightmare scenario at Oroville dam that officials are fighting to prevent," *Los Angeles Times*, 13 February 2017.
2. N. S. Diffenbaugh, "What California's dam crisis says about the changing climate," *The New York Times*, 14 February 2017.
3. A. Voiland, "From an atmospheric river to a river of sediment" (NASA Earth Observatory, 2017); http://earthobservatory.nasa.gov/blogs/earthmatters/2017/02/21/from-an-atmospheric-river-to-a-river-of-a-sediment/.
4. S. Karlamangla, "L.A. County supervisors OK debris clearance for Devil's Gate dam," *Los Angeles Times*, 12 November 2014.
5. NOAA Atlas 14 Point Precipitation Frequency Estimates: CA (http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=ca).
6. T. Di Liberto, "Flooding concerns at Oroville dam as water levels reach capacity" (2017); www.climate.gov/news-features/event-tracker/flooding-concerns-oroville-dam-water-levels-reach-capacity.
7. American Society of Civil Engineers (ASCE), "2017 Report Card for America's Infrastructures" (2017); www.infrastructurereportcard.org/wp-content/uploads/2017/01/Dams-Final.pdf.
8. S. I. Seneviratne *et al.*, in "Managing the risks of extreme events and disasters to advance climate change adaptation: A special report of the Intergovernmental Panel on Climate Change," C. B. Field *et al.*, Eds. (Cambridge Univ. Press, 2012), pp. 109–230.

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