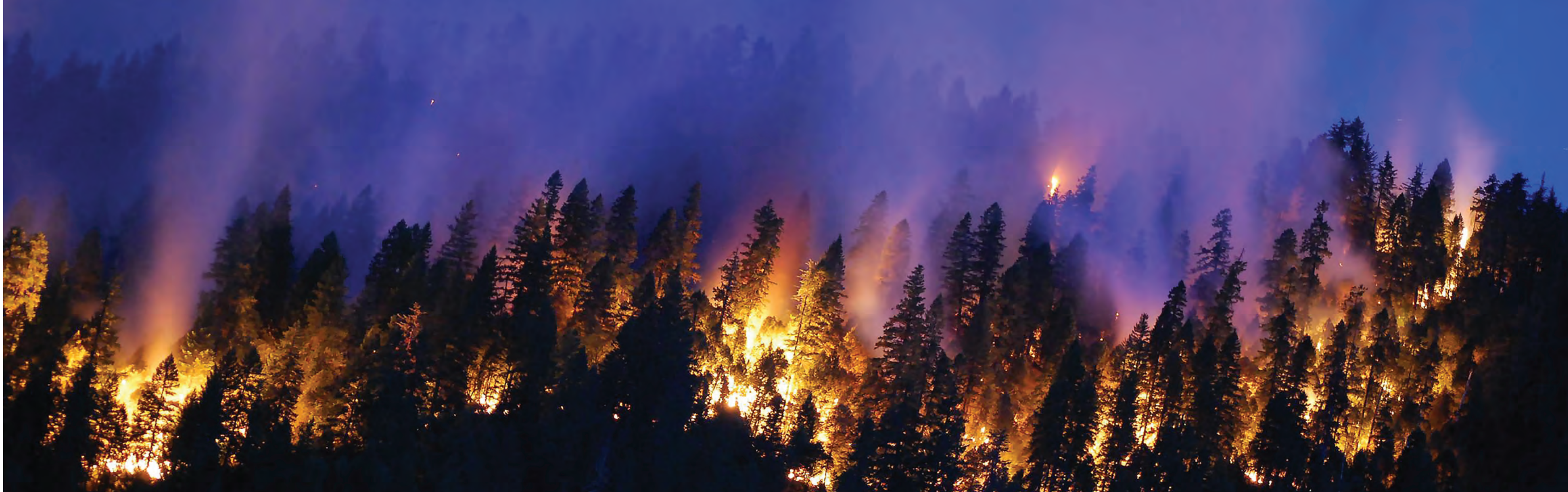
CONICYT

Chile & California: The Impact of Wildland Fires

By María del Carmen Thomsen, Pedro Reszka, Andrés Fuentes, and Carlos Fernandez-Pello



The Happy Camp Fire in northern California, 2014. (Photo courtesy of the U.S. Forest Service.)

It is often said that the country of Chile is "at the end of the world." In early 2017, parts of Chile indeed felt they were experiencing the end of the world as wildfires devastated hundreds of thousands of acres. These fires, the worst in Chilean history, destroyed 8 percent of the country's total forest area – more than a million acres – that may take 30 years to recover. Classified as a sixth-generation wildfire, the conflagration had the potential to impact the atmosphere at a continental level.

Chilean writer Ariel Dorfman wrote that "countless acres have been burned to cinders, killing people and livestock, leveling a whole town, destroying centenarian trees as well as newer woodlands meant for export." The damage went far beyond the raging flames. The Santiago air, "befouled with smoke and ash, became unbreathable for weeks."

This catastrophe gave an immediate relevance to a pilot research project involving UC Berkeley faculty, students, and researchers and their Chilean counterparts. They were among eight collaborative research groups that received UC Berkeley–Chile Seed Grants in 2014. The grant competition, organized by the Center for Latin American Studies (CLAS) at Berkeley, was funded by Chile's National Commission for Scientific and Technological Research (Conicyt).

These researchers, as well as many of the other groups benefitting from the UC Berkeley–Chile Seed Grants, point to the establishment of a continuing long-term effort of collaboration between Chile and California.

— Harley Shaiken

Convergent Environments, Convergent Research

Extreme weather, with high winds and very low humidity, along with human activities enhanced by the wildland–urban interface (WUI) clearly have increased the risk and the role of fires in forest ecosystems, both in Chile and the United States. Increased concern about the wildland fire problem has led to a veritable boom of related research activities in recent years, with notable efforts being made by research groups at Chile's Universidad Técnica Federico Santa María (USM) and the University of California at Berkeley.

The interest of both institutions in wildland fire research is no coincidence. On one hand, the vegetation of Mediterranean climatic areas of California and central Chile has long been cited as a classic example of convergence. In fact, the species native to both countries offer similar conditions for the initiation, spread, and control of wildland fires. And on the other hand, the bonds between the researchers are remarkably strong, and long-standing collaboration addresses different topics related to combustion and fires. Furthermore, joint efforts on wildland fire research have been facilitated by a grant from an agreement between Chile's Comisión Nacional de Investigación Científica y Tecnológica (Conicyt, National Commission for Scientific and Technological Research) and UC Berkeley.

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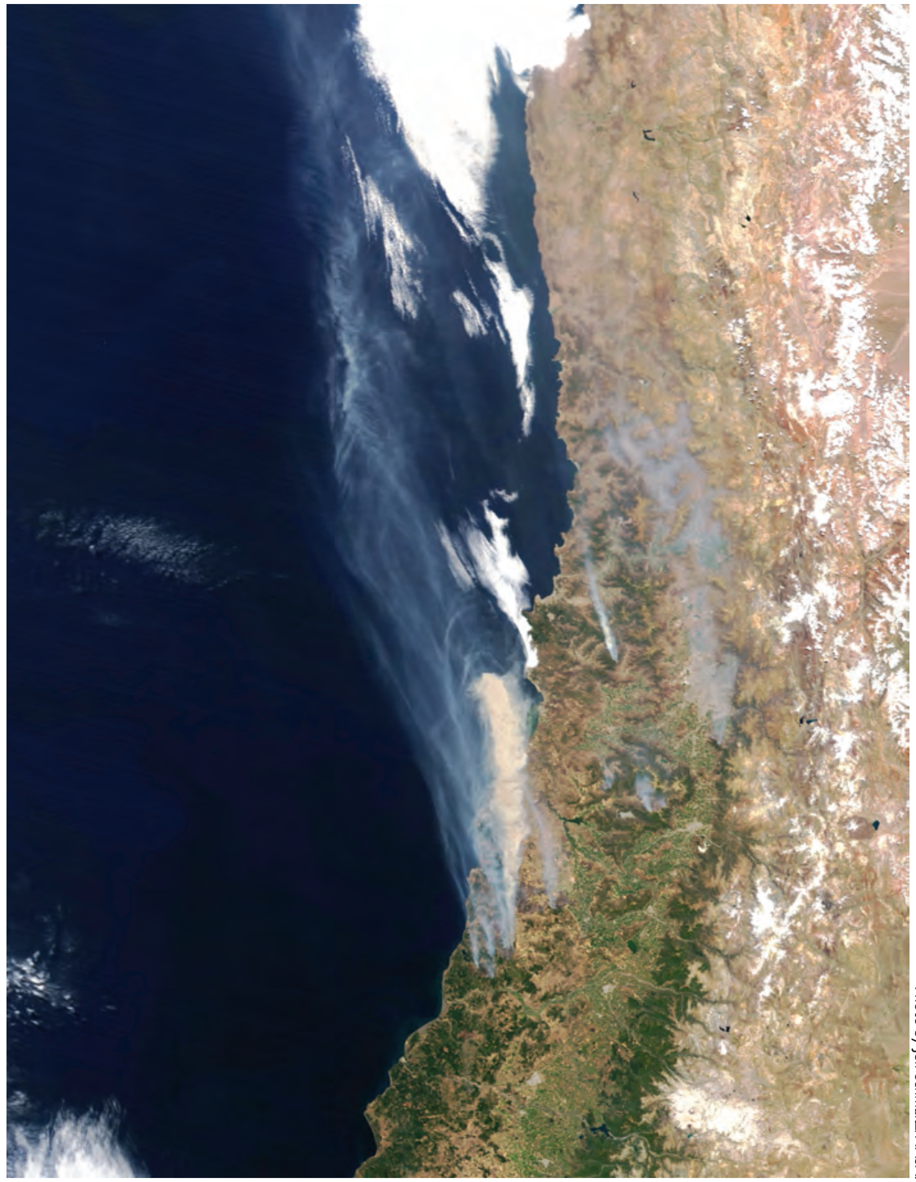

Photo by Jeff Schmaltz/NASA.

Smoke in this satellite photo of Chile shows the extent of the January 2017 wildfires.

Vegetation in California and Chile is also surprisingly similar. Shrubland covers the dryer areas of southern California and central Chile. Agriculture is concentrated in the fertile Central Valleys of both California and Chile. And as in southern Chile, temperate rainforests spread over the U.S. Pacific Northwest, including the northern reaches of California.

The landscapes and vegetation of California and Chile likewise present unique challenges in terms of wildland fires. Fires in shrublands tend to propagate rapidly. Under certain conditions related to topography, wind, and the state of the vegetation, these fires display sudden, very fast, "eruptive" behavior. Eruptive fires are particularly hazardous for fire crews because of their unexpected intensity, and as a result, they have claimed many casualties. Dry vegetation, due to the combination of a long drought and a severe heat wave, encourages the phenomenon. Severe fires in wildland cover large areas, posing logistical, firefighting, and population evacuation challenges.

The wildfire problem in Chile is mostly limited to the central and southern parts of the country, where a sizeable forestry industry relies on plantations of non-native species to produce cellulose, wood chips, timber, and engineered timber products. The greatest industrial capacity of related production is located around the cities of Talca, Concepción, and Temuco. Most of the tree plantations are Monterey pine (*Pinus radiata*), covering 60 percent of the planted surface, and eucalyptus (*Eucalyptus globulus* and *E. nitens*), accounting for 35 percent.

Weather, Land, and Vegetation

California and Chile share very similar weather patterns, geological features, and types of vegetation. The Golden State enjoys a type of Mediterranean weather similar to what we encounter in north-central Chile, specifically between the cities of La Serena and Valdivia. Likewise, Santiago presents characteristics reminiscent of Los Angeles, with warmer temperatures in the summer and short winters. Weather in northern California is quite like that of southern Chile.

The presence of noticeable mountain chains in both Chile and California — the Andes and the Sierra Nevada, respectively — adds further parallels to the general landscape of both regions and influence temperature changes and wind patterns. Experience has shown that the incidence of wildland fires is directly related to weather conditions and variations in atmospheric air patterns that affect temperature and precipitation.

Ignition and Fire Spread

Sources of wildland fire ignition vary. Major sources are human activities, such as campfires, waste burning, industrial work, etc. There are, however, important natural sources, including lightening, sun radiation concentration by natural rock formation or glassy surfaces, and bird interaction with power lines. These sources result in what is called "spot wildfire ignition" because they usually occur as a localized ignition area. There have also been cases where a "prescribed burn" — used to decrease the vegetation load and, in turn, reduce the risk of a fire — has gotten out of control and started large wildfires.

Spot wildfire ignition by hot metal fragments/sparks and firebrands (flaming or glowing embers) is an important fire ignition pathway by which wildfires and WUI fires are started and may propagate. Hot metal fragments and sparks can be generated by power line interactions, hot work (friction, grinding, welding), and overheated incandescent particles. The particles generated by these events can fly from the source of origin by initial momentum or be carried by wind. Depending on the energetic characteristics of these particles and the target fuel bed on which they land, the particles are potentially an ignition source.

According to published data, hot metal particles and sparks from power lines, equipment, and railroads cause about 28,000 natural fuel fires of the approximately 80,000 wildfires that occur annually in the United States. Although most fires are put out shortly after they start, some spread with disastrous consequences. An example of a catastrophic spot-ignited fire is the 2007 southern California firestorm known as the Witch Creek and Guejito Fires, which eventually burned almost 200,000 acres and destroyed more than 1,100 homes. The California Department of Forestry and Fire Protection (Cal Fire) report for these fires alleges they were ignited by hot particles generated by clashing power lines.

Once ignited, a wildland fire can spread through two different mechanisms. One is related to the heat transfer from the fire front by convection and/or radiation towards the unburned vegetation bed located ahead of the flame. Vegetation materials are then raised to a sufficiently high temperature to release combustible gases that combine with air to form a flammable mixture eventually ignited to attain fire propagation. The second mechanism is related to fire propagation by mass transfer and occurs mainly when bushes and trees are involved. Flaming or glowing vegetation particles, called firebrands, are commonly lofted by the fire plume and transported by the prevailing wind ahead of the fire front. If these firebrands reach the ground with sufficient energy, they can lead to the smoldering and/or flaming ignition of the receptive fuel bed. Firebrand spotting leads to more rapid fire spread than flame-front propagation because firebrands generated by burning vegetation or structures are transported downwind to ignite secondary fires or structures remote from the flame front.

The modeling of trajectories and combustion of flying firebrands has received a considerable amount of attention, but fewer experimental and theoretical works have studied

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Firefighters with Chile's National Forestry Corporation battle the 2017 blazes near Valparaiso.

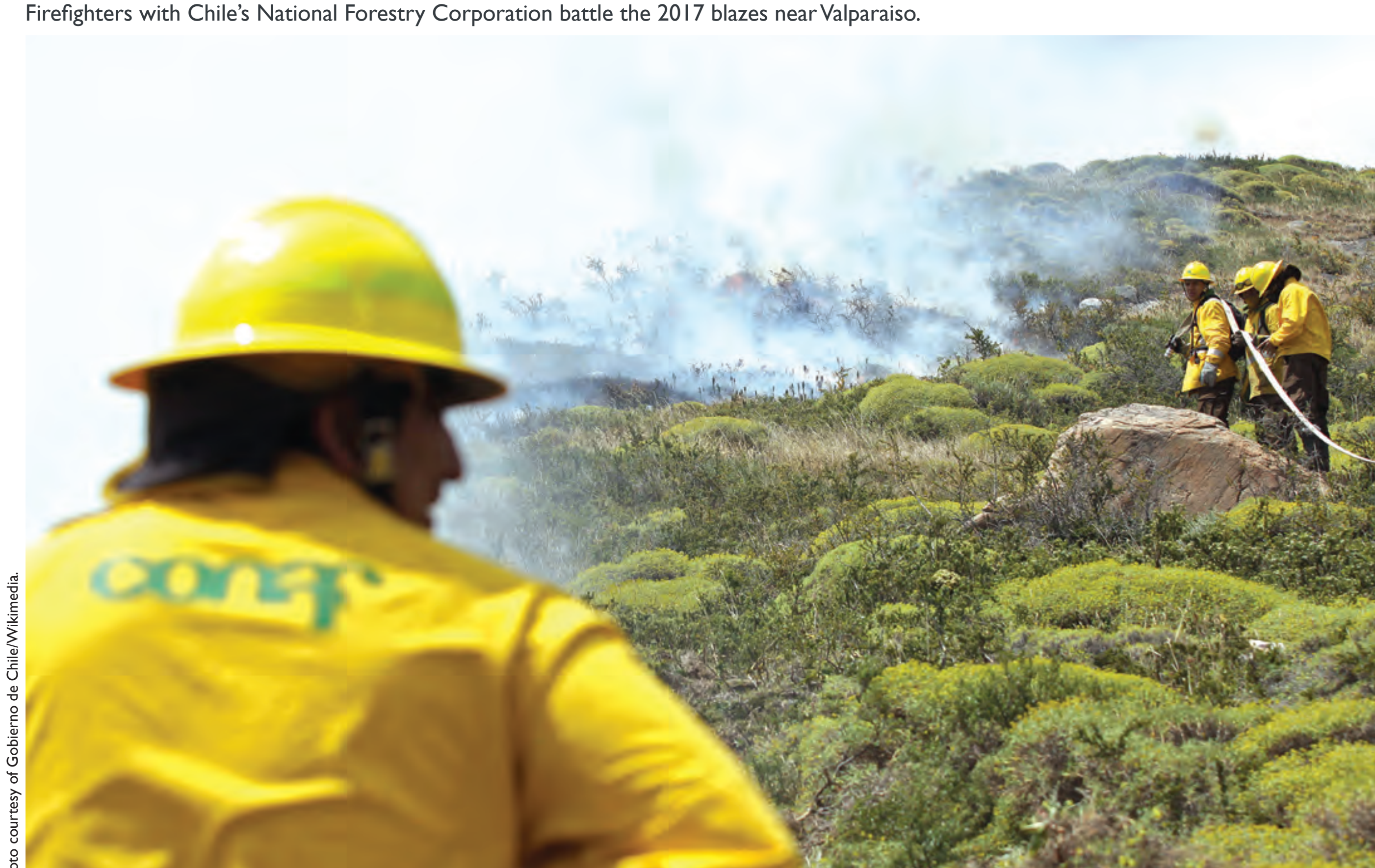

Photo courtesy of Gobierno de Chile/Wikimedia.

firebrand ignition of the receptive vegetation bed. To address this need, the research groups in Chile and California have worked on spot ignition by firebrands using an original, simplified version of a "fully physical model" to predict the minimum-size firebrand capable of igniting a typical sample of Mediterranean vegetation litter.

Forest and Wildland Management

To minimize the risk of ignition and consequently of fire propagation, the management of wildland becomes fundamental. In this regard, California boasts vast experience and abundant technical resources, and the Chilean researchers who visited California acquired an interesting knowledge base that could eventually be applied in Chile. Indeed, forest management can truly alter the state and conditions of the wildland. Multiple techniques, ranging in effectiveness, can be used to prevent wildland fires or make the environment less prone to and more prepared for them.

For example, ecosystem restoration can prevent wildland fires. Healthy, thriving ecosystems are less vulnerable to extreme fires that can destroy wildlife habitat, damage private property, and risk lives. Restoration of natural ecosystems can be achieved through mechanical treatments (such as thinning crowded forests) or controlled burns, which can prevent the buildup of flammable vegetation that promotes extreme fires.

In Chile, the Corporación Nacional Forestal (Conaf, National Forestry Corporation) manages the country's forest resources, and one of the institution's main objectives is the prevention of wildland fires. Conaf collaborates with California permanently through the Cal Fire agency, mostly for professional exchange focused on community-based fire prevention. Because almost all forest fires originate in human activities, whether through carelessness, intention, or accident, most of Conaf's efforts are focused on educating people and eradicating common behavior that can end up generating a wildland fire. As part of its strategies to prevent wildland fires, the institution devotes resources to keeping roads near the forest in good condition for better access in case of emergencies, building fire breaks, clearing the areas under power lines and other constructions, etc. These fire mitigation methods are discussed with Cal Fire to compare the practices used to protect homes and other private property, especially in WUI zones, and to study how these techniques might apply to areas such as Valparaíso in Chile.

Shared Challenges, Shared Opportunities

Different climate change projections agree that in the next century, central and southern Chile will face scarcer

Photo by Vladimir Rodas/EU/ECHO.

The 2017 fires in Chile killed 11 people and burned nearly 1.5 million acres.

rainfall, with increased drought events and increased extreme weather events, like high temperature and high wind, similar to the conditions during the 2016–2017 fire season. At the same time, the growth of the Chilean population will be concentrated in urban areas, which means that WUI areas will be increasingly populated. Similar concerns can be observed in California. As a result, wildfire problems will become more severe, both in the occurrence of extreme fire events and an increased number of people exposed to wildfires. This prognosis presents many challenges related to Chile's management of its forests, wildlands, and wildland–urban interfaces, the country's efforts to combat forest fires, and the design and construction of a built environment that is more resilient to future wildfires.

Wildland management requires a better fundamental understanding of the burning behavior of different forest fuels and how external conditions (e.g., weather patterns, water availability, interaction with other species) affect that fire behavior. This information impacts decisions regarding which species should be favored in both native and agricultural forest environments. Clearly, the response to wildland fires requires risk-informed decisions, which in turn require sound predictive capabilities. Therefore, the current computer fire models often used in the U.S. will need to be adapted to Chilean fuels, or new models will have to be developed.

The strong similarities between the western U.S. and Chile present great opportunities for technical, operational, and scientific collaboration between Californian and Chilean universities and government institutions. Chile can learn much from the California experience, particularly in wildland management, community fire safety, and building code improvements. Operationally, Chile offers different firefighting tactics, including experience in the use of computer modeling in major fires and management of private forests. Finally, the recent project on spontaneous ignition by firebrands funded by the UC Berkeley–Chile Seed Grants program is an example of successful scientific collaboration that offers opportunities for both fundamental and applied research, another high-water mark in the long tradition of joint efforts between California and Chile.

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