A new spatially enabled geodatabase and interactive web-based map documenting rock falls in Yosemite National Park

Greg M. Stock *Division of Resources Management and Science, Yosemite National Park, El Portal CA, USA; greg_stock@nps.gov*

Autumn L. Helfrich *Geoscientists-in-the-Parks, Yosemite National Park, El Portal CA, USA; autumn_helfrich@partner.nps.gov*

Brian D. Collins *U.S. Geological Survey, Geology, Minerals, Energy, and Geophysics Science Center, Moffett Field CA, USA; bcollins@usgs.gov*

Background

Yosemite National Park in northern California experiences frequent rock falls and other slope movement events, posing hazard and risk to the 4-5 million visitors annually (Figure 1). These events are recorded in an inventory database that extends back to 1857. The database includes detailed information about each event, including date, time, location, event type, rock type, volume, triggering conditions, infrastructure impacts (Figure 2), and injuries and fatalities.

Figure 1. 28 September 2017 El Capitan rock fall, which caused injuries, vehicular damage, and a temporary road closure. Photo by Brian Degenhardt.

Figure 2. Examples of rock slides affecting park roadways. Left: 18 March 1943 rock slide onto the Big Oak Flat Road. Right: 7 January 2016 rock slide from a roadcut above the El Portal Road.

Previous work and general database characteristics

Three versions of the database have previously been published (Wieczorek et al., 1992; Wieczorek and Snyder, 2004), with the most recent released as a US Geological Survey Data Series report (Stock et al., 2013) containing event data through 2011. Since then, we have updated the database through 2020 and expanded it to include additional spatial data. The database now documents 1,489 events, predominantly rock falls (69%), but also rock slides (23%), debris flows (5%), and other slope movements. Most of these events occurred in Yosemite Valley. Event volumes span six orders of magnitude (0.02 to 200,000 m^3).

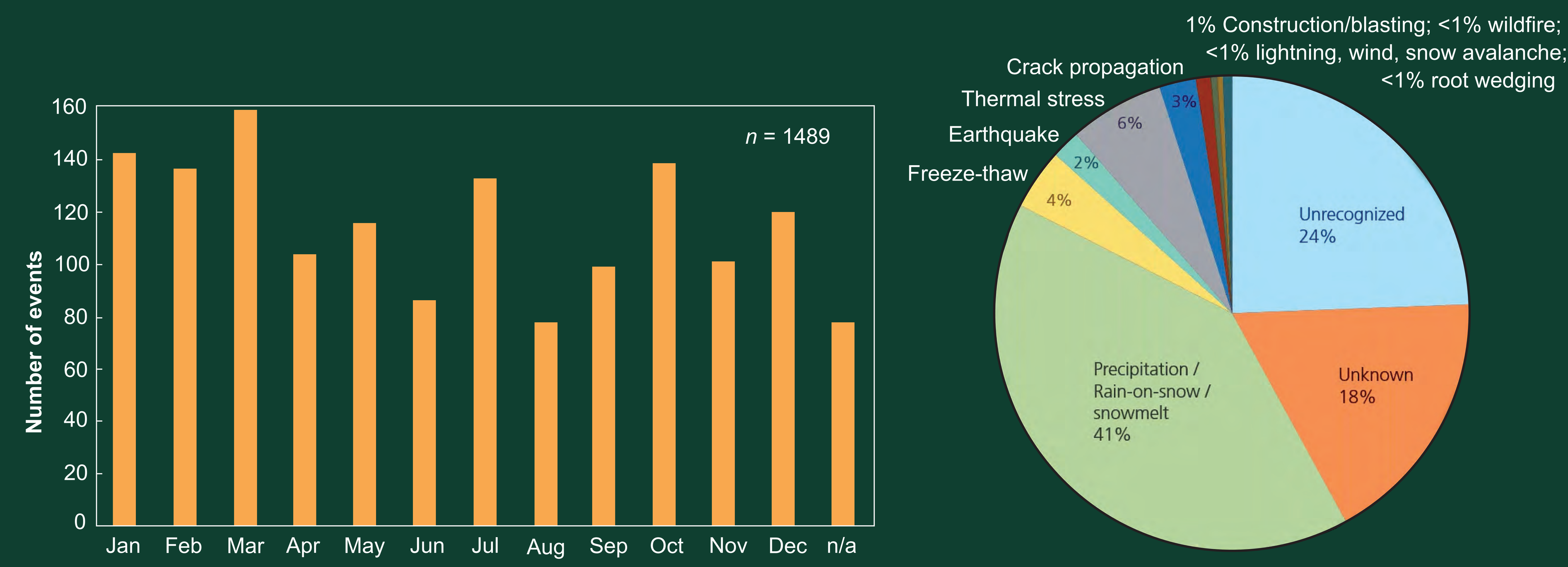

Figure 3. Examples of analyses of the Yosemite rock fall inventory database (1857-2020). Left: Rock falls by month. Right: Relative proportions of potential triggering mechanisms.

The updated database allows for a variety of analyses, including rockfall timing and potential triggering (Figure 3). Just under half (45%) of all reported events have an unknown or unrecognized trigger, indicating either incomplete information on the environmental conditions present, or that obvious triggering conditions were lacking, suggesting subtle and previously unrecognized factors such as thermal stress. For those events with recognized triggers, precipitation in various forms is the primary trigger (80%).

A spatially enabled geodatabase

Earlier versions of the inventory database included only general rock fall locations in spreadsheet text format. We converted the updated database to a spatially enabled database by deriving NAD83 UTM coordinates and NAVD88 elevations, along with inferred uncertainties, for every event in the database. The precision of location information in the updated database varies from relatively low, when inferred from written descriptions of early events, to very high, when determined by lidar or Structure-from-Motion photogrammetry.

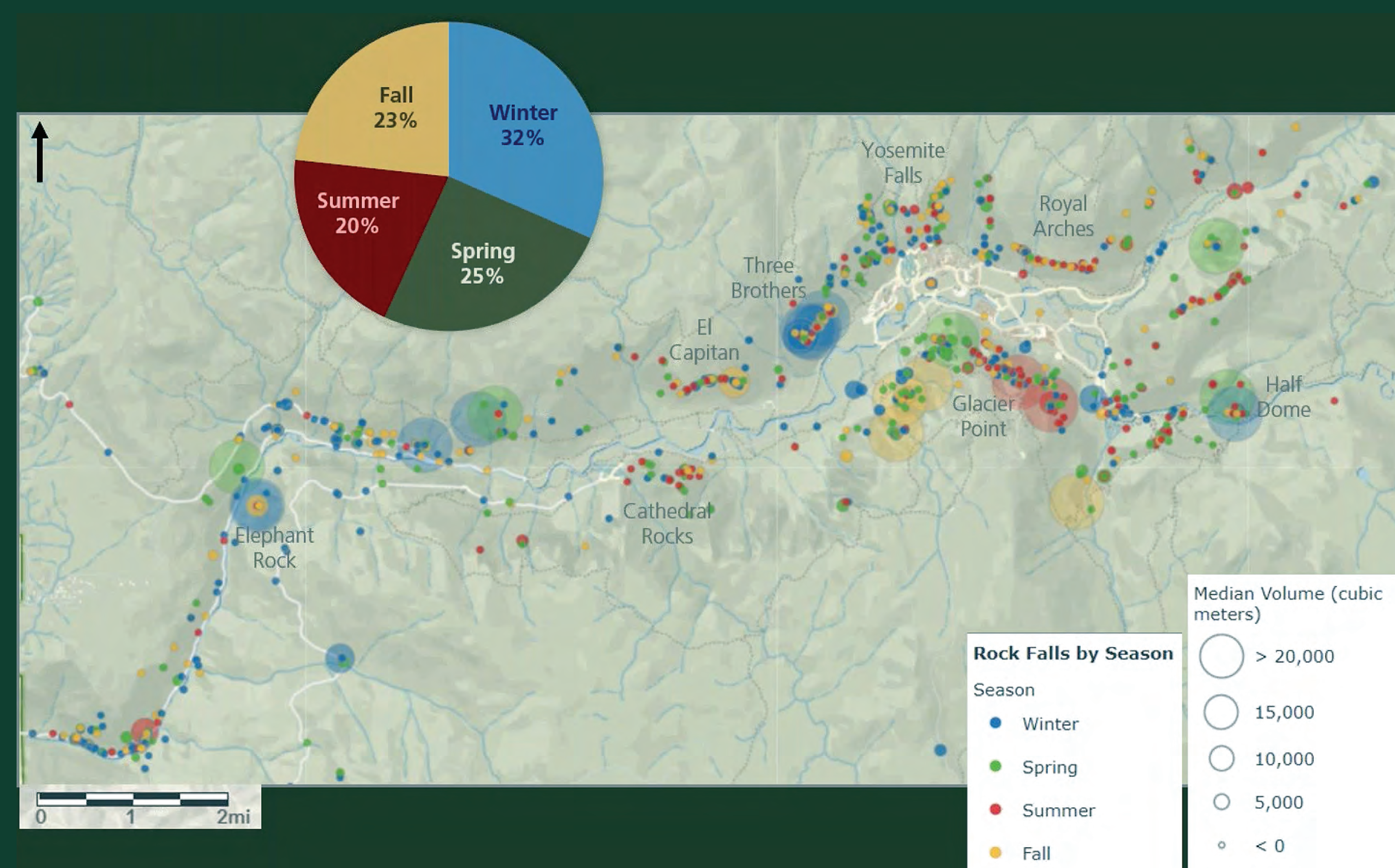

Figure 4. Locations (with uncertainties represented as shaded circles) and seasonality of rock falls and other slope movement events in Yosemite Valley.

Digitial database records allow for GIS analyses of rock fall dependence on variables such as slope, aspect, elevation , rock type, and glacial extent. As one example, nearly two-thirds of rock falls originate from above the Last Glacial Maximum trimline, likely because glaciated scoured loose, decomposed rock from below the trimline. By coupling spatial and nonspatial attribute data in this new geodatabase, we created a robust single interface for interacting with rock slope information.

Web-based GIS application

The new web-based GIS application of the inventory database provide visualization capabilities to symbolize rock falls by attribute selection. The map interace has customized pop-up content for each event, including written narratives, select photos or videos if available, and links to additional information such as scientific publications and media (Figure 5).

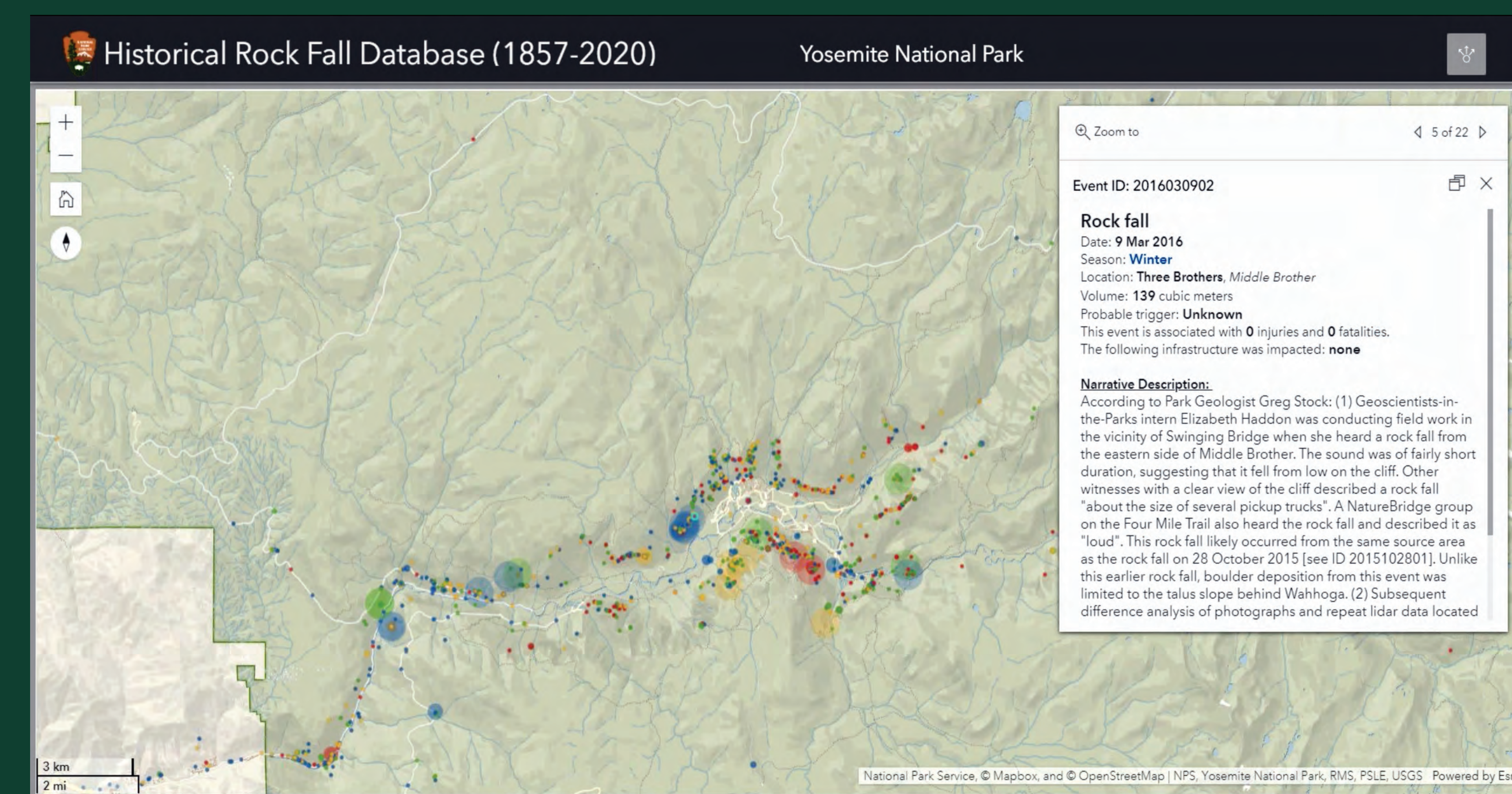

Figure 5. Example of pop-up content for a specific rock fall. Clicking on a symbol on the map brings up a window showing key metrics of that event, a narrative description, and relevant photos, videos, and/or published references.

The shift from a spreadsheet-based inventory database to a geodatabase and interactive web-based map increases accessibility to the data and enhances the data viewing experience for scientific researchers and the general public alike. Further analyses of this inventory database will be critical for understanding potential triggering mechanisms, identifying areas of rock fall susceptibility, and assessing rock fall frequency, all of which will help lead to better quantitative characterization of rock fall hazard and risk in one of the world's most iconic parks.

References

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