

The Cascadia Region Earthquake Science Center (CRESCENT): Regional Science in a Resilience Context

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Abstract

The Cascadia subduction zone poses significant risks to the Pacific Northwest, from shaking, tsunami inundation, and cascading hazards. Among the challenges to improving resilience are the effects of a less mature “earthquake culture” than other seismically active regions (in science and preparedness) and gaps in the workforce (in community representation and technical training). The Cascadia Region Earthquake Science Center (CRESCENT) has been established to address these challenges through research, education, and community engagement. By integrating scientific studies, fostering collaboration, and leveraging new technologies, CRESCENT seeks to improve hazard assessment and resilience in the region. This article outlines the novel regional framework for how the center’s structure provides science-to-practice approaches for equitable and inclusive workforce development, societal preparedness, and seismic resilience. This framework draws on existing models of codesigned research to propose an academic-regional partnership model that may be applicable to future endeavors.

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Introduction: The Cascadia Subduction Zone

A large convergent margin spanning three states and two countries, the Cascadia subduction zone (CSZ) produces some of the largest earthquakes globally (Wirth et al., 2022). A very high likelihood of strong (modified Mercalli intensity [MMI] > 6) shaking throughout the CSZ (Fig. 1), specifically at population centers (Kolaj et al., 2023; Petersen et al., 2024), presents significant risk to resilience, including life safety and infrastructure (Nako et al., 2009). Considering impacts from tsunamis (significant in coastal communities, Fig. 1), ~\$300 billion in losses and decades of societal disruption during a prolonged recovery period are predicted (Belenky et al., 2014; OSSPAC, 2013; Fig. 2).

Part of the region’s vulnerability stems from the relatively recent “rediscovery” of earthquakes. Oral histories among Indigenous peoples reflect long-standing awareness (e.g., McMillan and Hutchinson, 2002; Ludwin et al., 2005, 2007; Harmon and Borrows, 2012), which was disregarded during colonization (e.g., Lewis, 1995; Spirling, 2012). With long recurrence intervals of great CSZ earthquakes and few historical earthquake records, the earthquake potential of the CSZ was only acknowledged by western U.S. science in the 1980s (Heaton and Kanamori, 1984; Atwater et al., 1991; Savage et al., 1991; Satake et al., 1996; Yamaguchi et al., 1997; Clague, 1997).

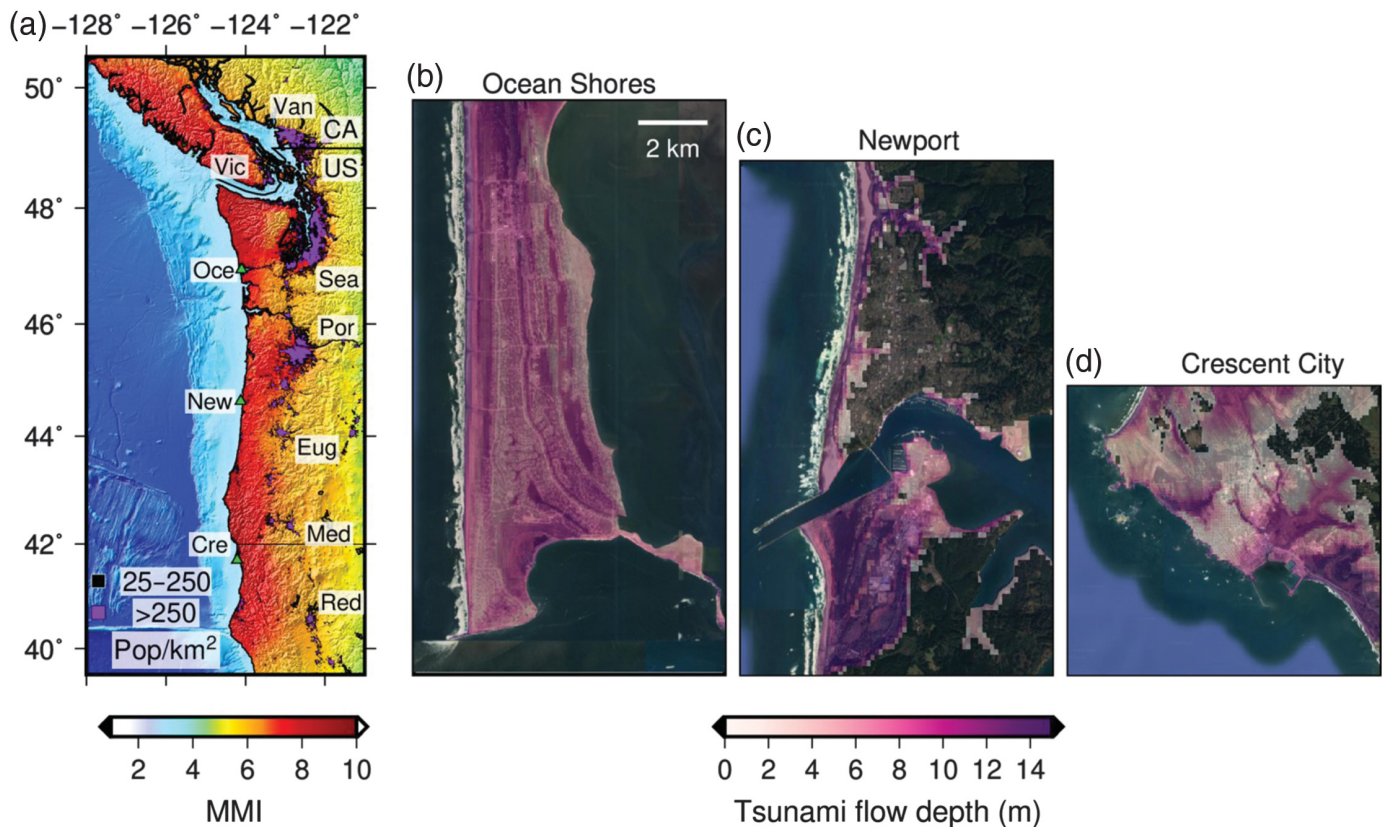
Attitudes toward earthquake risk have evolved toward a growing culture of resilience (e.g., Dunn et al., 2016; Ahn et al., 2021; MacPherson-Krutky et al., 2022). Coastal communities have advanced tsunami preparedness (Wood and Good, 2005; Buylova et al., 2020), and inland cities recognized the risks posed by older, code-deficient buildings (Raghunandan et al., 2015). However, much of Cascadia’s population remains underprepared. Vulnerability is a function of not only immediate life safety, but in the amount of time it takes to recover after the event. Reduced levels of pre-event preparedness prolong recovery times, demonstrated by the resilience triangle in Figure 2 (Yu et al., 2014).

The intersection of science, engineering, and policy presents complex challenges to urban planning and risk mitigation (e.g., Chang et al., 2019). For example, in the city of Portland, policies regarding signage on unreinforced masonry structures hold significant implications in a city with pervasive racism and disparity in equitable access to housing (Semuels, 2016; Dukes et al., 2022). Addressing these issues requires

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coordinated policy solutions and sustained investment (Tong *et al.*, 2022).

Many solutions require advancements in earthquake science research; yet, research is often conducted in a disparate environment from those impacted by the hazards, motivated solely by knowledge production and siloed in academic publications. To support resilience in the CSZ, the National Science Foundation funded Cascadia Region Earthquake Science Center (CRESCENT) to perform earthquake science and hazards research in partnership with regional hazard and risk organizations and offer programs that address workforce training needs.

CRESCENT

CRESCENT has three interconnected “pillars,” existing within an ecosystem and rich history of regional resilience work:

1. Science: foundational research on science underpinning Cascadia’s seismic hazards (Melgar *et al.*, 2026).
2. Partnerships and Applications (P&A): building regional, bidirectional research collaborations between academics, practitioners, policymakers, and the public.
3. Geoscience Education and Inclusion (GEI): equitable research training opportunities to broaden representation of affected communities and equip emerging professionals with the necessary knowledge, skills, and perspective.

The scientific framework for the Science pillar, described in detail in Melgar *et al.* (2026), features nine groups working toward key science questions and foundational products.

Figure 1. (a) Ensemble ShakeMap showing expected intensities as modified Mercalli intensity (MMI) for a Cascadia subduction zone (CSZ) M9 event, adapted from U.S. Geological Survey data (Wirth *et al.*, 2021). Population density is from LandScan (Weber *et al.*, 2022). Population centers are labeled as (Van)couver, (Vic)toria, (Sea)ttle, (Por)tland, (Eug)ene, (Med)ford, and (Red)dington. Coastal towns where inundation was computed are labeled as (Oce)an Shores, (New)port, and (Cre)scent City. (b) Computed tsunami inundation for Ocean Shores, Washington, using the XL1 “t-shirt” rupture frequently used as a representative scenario for tsunami hazards planning (Witter *et al.*, 2011). (c) Same as (b) for Newport, Oregon. (d) Same as (b) for Crescent City, California (CA).

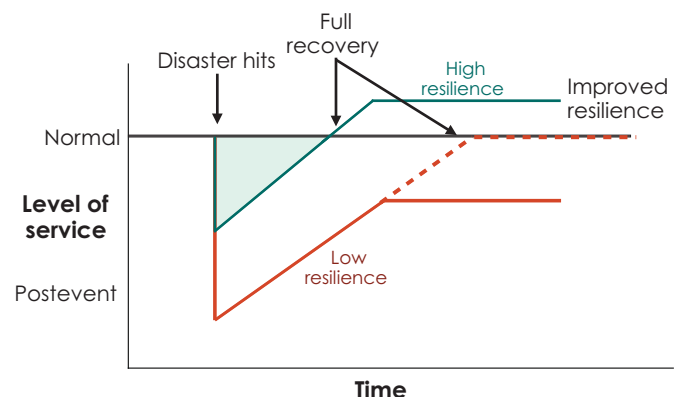


Figure 2. “Resilience triangle,” demonstrating the reduction in “levels of service” or community functionality after an earthquake, for a high-resilience (prepared) versus low-resilience society.

Highlighted here are the framework and goals of the P&A and GEI pillars.

Partnerships and Applications: Science for a Resilient Pacific Northwest Framework

Persistent vulnerabilities in infrastructure, communications, and lifelines combined with impossibly long tsunami evacuation times continue to challenge resilience and limit the region's ability to recover post event, illustrated by the resilience triangle (e.g., Burns *et al.*, 2021; Chen *et al.*, 2021; Mayer *et al.*, 2021; Allgeyer and Goldbloom-Helznerr, 2024; Fig. 2). Overcoming these vulnerabilities requires coordinated, cross-sector collaboration among agencies, utilities, first responders, private industry, tribal governments, scientific research, and community organizations. Community engagement is indispensable to meaningful preparedness (Ryan *et al.*, 2020; Bostrom *et al.*, 2024). Local input allows scientific research to be directed by and toward community-specific needs that might otherwise be overlooked in a purely academic setting, and prevents scientific insights from being inaccessible outside the academic community. Building and sustaining relationships between academic and community partners with bidirectional feedback and trust require thoughtful planning and consideration (Frerichs *et al.*, 2017). Sustained impact also depends on public understanding. Awareness grounded in scientific literacy and cultural familiarity with seismic hazards enables more effective response and recovery.

CRESCENT's P&A pillar aims to bridge these often siloed sectors, emphasizing shared learning and coproduction of knowledge through strong, strategic partnerships between scientists, practitioners, and communities—making research actionable. There are other examples of academic centers organized around this ethos. The Northwest Climate Adaptation Science Center motivates and conducts climate science based on tribes' and regional agencies' priorities toward conservation (NW CASC, 2017). The Cascadia Coastlines and People Hub focuses on coproduced science toward coastal hazards (Bostrom *et al.*, 2024). However, this framework to cultivate a shared ownership of knowledge generation in research and preparedness is novel within the earthquake hazards context.

Specific activities

With the above framework in mind, CRESCENT's P&A pillar engages in five main activities (Fig. 3).

1. Annual Partnerships and Applications Workshops (Sahakian *et al.*, 2025) bring together representatives from communities concerned with Cascadia earthquake resilience and research (including local, state and federal agencies, tribal governments and organizations, emergency managers, utilities, industry, nonprofits, and educational institutions). Participants identify complementary initiatives and opportunities for collaboration

between each other and with CRESCENT to effectively engage existing earthquake hazards research, and plan for future community-driven research projects.

2. In collaboration with the Cascadia Lifelines Program (CLiP, Olsen, n.d.), CRESCENT hosts monthly webinars aimed at engineering practitioners. The webinars translate cutting-edge earthquake research into practical insights that inform engineering design and risk mitigation strategies. Featuring leading scientists and case studies, the series fosters a collaborative environment where practitioners engage directly with researchers.
3. Social media and a dedicated newsletter, *The Seismic Moment*, are key outreach tools for CRESCENT. The social media strategy leverages platforms (Bluesky, LinkedIn, Facebook, and Instagram) to share quick updates, highlight events, and disseminate key findings. Complementing this, *The Seismic Moment* provides more in-depth communication, delivering curated quarterly updates directly to subscribers.
4. Community events centered around notable seismic events provide a powerful platform for public engagement to raise awareness about earthquake science, preparedness, and resilience. Collaborating with partner organizations such as museums, science centers, and disaster preparedness agencies amplifies the impact of these events. Interactive exhibits, expert panels, storytelling sessions, and hands-on workshops are tailored to make complex seismic concepts accessible and relatable to diverse audiences.
5. Regular one-on-one meetings and correspondence with partner organizations allows CRESCENT to learn about the agencies' work, who they serve, how science contributes, and discuss strategies for collaboration. These meetings seek to codesign research agendas and enable bidirectional communication between agencies and CRESCENT working groups (Melgar *et al.*, 2026).

Geoscience Education and Inclusion: Building the Workforce of the Future Framework

A gap exists between those most adversely affected by natural hazards and those conducting the research and resilience work. Geohazards disproportionately impact communities of color and economically marginalized populations (Scarlett, 2022; Nam *et al.*, 2023), yet these groups remain underrepresented in geoscience fields (Bernard and Cooperdock, 2018). Addressing risk mitigation in the CSZ requires a workforce that reflects diverse lived experiences and cultural insights—equipped with diverse technical and interdisciplinary expertise—which has been shown to enhance creativity, innovation, and problem-solving capacity to meet community needs (Hofstra *et al.*, 2020).

A representative workforce strengthens trust and connections with affected communities. When geoscience researchers share



Figure 3. Examples of activities from the Partnerships and Applications (P&A) pillar. Clockwise from top left: P&A 2024 workshop table discussion; 2024 workshop; social media posts; local ShakeOut outreach event collaboration; Seismic Moment newsletter; and CLiP webinars.

cultural backgrounds, languages, or experiences of the communities they serve, science is motivated by these community values and needs, increasing relevance and impact. This alignment fosters greater buy-in for preparedness initiatives, as residents see their values and concerns reflected in research, and increases the likelihood that future science agendas address social inequities and power imbalances (Javanparast *et al.*, 2022; Brooks *et al.*, 2023; Kliskey *et al.*, 2023; Shen *et al.*, 2023). CRESCENT's commitment to building this inclusive workforce is both a matter of social justice and a strategic approach to building community resilience.

CRESCENT's GEI pillar seeks to bridge this gap with education and training opportunities spanning high school to early career. The programs are designed to attract and encourage participation from the range of people impacted by earthquake hazards. Through partnerships with minority-serving institutions and community-based organizations specifically, CRESCENT builds a pipeline of diverse talent and a more accessible and equitable discipline. Finally, these efforts must be comprehensive and sustained to reduce attrition and foster long-term success.

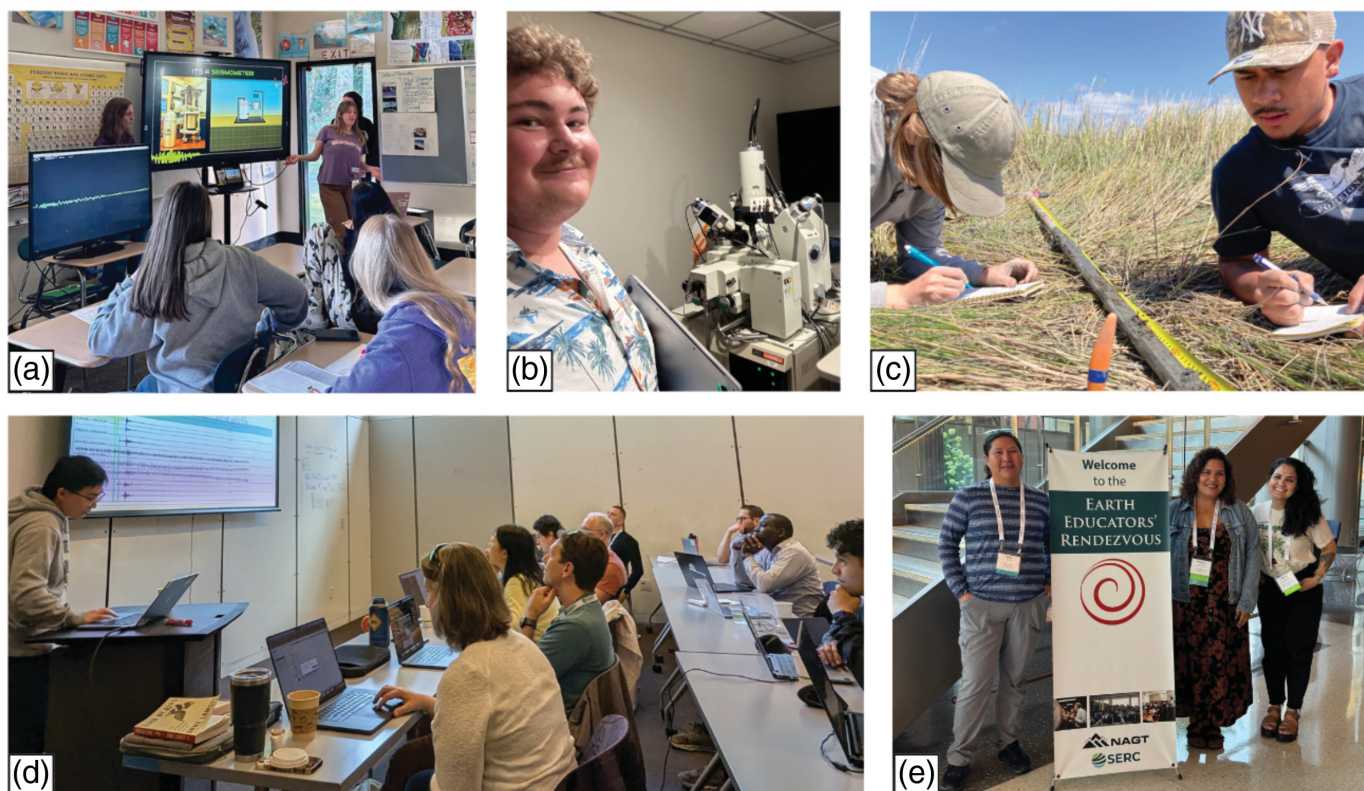
Specific activities

GEI develops and engages in activities designed to span geoscience levels (Fig. 4) with five programs:

1. High school: CRESCENT partners with University of Washington's (UW) Riverways Education Partnerships program and the Cascadia Culture and GeoScience Exchange

(CCASE) Program, a graduate student-directed program seeking to augment community resilience through culturally rooted education. CCASE has built strong relationships with Quileute Tribal School and Neah Bay High School, emphasizing place-based programming and cultural exchange that intertwines geoscience and Indigenous Knowledge. CCASE teaches an annual week-long geohazards curriculum at each high school, hosts high schoolers for UW visits, mentors high schoolers on geohazard projects that impact their local community, and participates in cultural activities.

2. Undergraduate twinning program: a paid, year-long, research experience with a dual mentorship and institution model and peer cohort. Undergraduates work at their home institution during the academic year with both mentors, and spend time at the other institution over the summer. Students experience a complete cycle of research: conceptualizing a problem, data collection and interpretation, preparing a final report, and delivering an oral presentation. Unlike typical summer internships, the program funds students for a full academic year and summer enabling students to focus entirely on research.



3. Cores to code (C2C): an undergraduate program combining lessons in field data collection with computational earthquake process modeling. Combining hands-on marsh coring fieldwork and lab analyses with practical JupyterHub applications to rupture and tsunami models, the program demystifies advanced geoscience research. Students meet with community and regional hazard specialists to learn how their work informs resilience efforts and about professional pathways. This alignment of practical, place-based learning with advanced technical applications makes geoscience more accessible.
4. Technical short courses: hands-on experiences to build early career scientists' technical skills by offering hands-on experience, fostering collaboration, and providing exposure to tools and methodologies. Participants develop specific competencies and cutting-edge methods (i.e., data science and machine learning) for advanced research and professional practice. The courses create networking opportunities by connecting students with experts, mentors, and peers and foster a culture of continuous learning and adaptability. Community building benefits individual students and elevates the overall research output of institutions.
5. Geoscience professional development fellowship: a biannual call for stipends for students to attend professional development opportunities to emphasize training beyond technical capacity to prepare for the job market. This helps students build versatile skill sets that prepare them for diverse career paths, fostering a holistic approach to professional growth. This complements the technical short courses.

Figure 4. CRESCENT's Geoscience Education and Inclusion (GEI) programs. (a) Cascadia Culture and Geoscience Exchange Program (CCASE) at Neah Bay High School. (b) Undergraduate Twinning Program student collecting detailed electron microscopy and geochronology data. (c) Cores-to-code (C2C) students describing a sediment core. (d) Technical short course on using machine learning to build earthquake catalogs. (e) Professional Development Fellowship recipients attending the 2024 Earth Educators' Rendezvous.

Integration

In large efforts similar to CRESCENT, what is often most challenging is building a culture that nurtures a holistic framework toward regional and community priorities. The framework we have described here attempts to do so and remains an iterative process. We have found that the siloed nature of academic and regional applied hazards research poses large barriers. We have attempted to break these down by increasing contact time between groups by featuring partners as keynote and closing presenters at CRESCENT science meetings; dedicating time at smaller workshops and meetings; supporting quarterly working group meetings for partners, such as the regular Community Fault Model meetings that solicit feedback and needs from partner agencies; and working collaboratively with partners to develop briefing documents and media talking points for new CRESCENT research (Dura *et al.*, 2025). The GEI pillar provides mentoring and professional development opportunities and organizes technical short courses to build a community focused on the needs for the next

generation. We evaluate our progress toward our goals by direct feedback from partners in individual meetings as well as feedback surveys after every CRESCENT event. We use this feedback to generate responsive agendas for workshops and meetings. These efforts seek to direct regional earthquake science toward societal and community need and make the resulting knowledge production informed by, and accessible to, more than just the academic research communities.

Data and Resources

There are no new data or resources to report for this article.

Declaration of Competing Interests

The authors acknowledge that there are no conflicts of interest recorded.

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