

Oregon Resilience Hubs and Networks

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ABSTRACT

In this document, we describe the application of social network analysis and planning approaches drawn from military and United Nations doctrine to identify and develop community resilience hubs and networks to assist and sustain victims of disaster or crises in the harsh and remote Oregon areas until additional aid is provided. After assessing geographic conditions and infrastructure to identify “islands” of communities likely to be inaccessible after a disaster, planners used social network analysis and community resilience development grants provided by the Oregon Legislature to model mutually supporting resilience hubs and networks in preparation for disasters or crises. Resulting models may now be used to create pre-disaster direct relational ties to make networks more robust and responsive to crises in Oregon. This approach may be useful for emergency managers to increase resilience in remote and vulnerable communities in harsh terrain.

Keywords

Emergency management, remote areas, social network analysis, UN clusters, harsh environments.

INTRODUCTION

“Before, during, and after a disaster, people, agencies, and organizations help and hinder each other, alternatively opening up new possibilities and hamstringing others . . . our responses to disasters—emergency deployment, mitigation, coping, and adaptation—are all likewise facilitated and obstructed by variations in coordination and support between networks of actors.” Eric C. Jones and A.J. Faas

Oregon’s diverse geography offers something for everyone, from the mountainous Pacific Coast and temperate rain forest of the Valley of the Giants to the high desert between the Cascade Range and the Blue Mountains. While beautiful, the terrain also offers significant hazards to residents who live in remote areas. Geological experts forecast a 7-12% probability of a full margin rupture of the Cascadia Subduction Zone margin (a continental fault line off the western coast of the United States) over the next 50 years and an approximately 21% probability of a southern margin fault in the same period, with resulting earthquakes and tsunami (Goldfinger et al., 2012, p. 14). Rising temperatures and changes in rainfall patterns have caused wildfires that destroyed homes and infrastructure in recent summers. The rivers, marshes, mountains, and deserts that contribute to Oregon’s beauty also make responding to crises difficult. Emergency responders may be stymied by fallen bridges, landslides, and flooding, with no alternate routes to aid disaster victims—people who already face a dearth of public infrastructure. According to the Department of Land Conservation and Development, impacts from climate change are not expected to affect all regions and communities equally. Some populations and rural communities are likely to be impacted more than others (Department of Land Conservation and Development, 2021). Considering these challenges, how might emergency management professionals set conditions pre-crisis for more effective responses after disasters occur?

Emergency response professionals may reduce suffering and loss of life by making response networks more robust and communities more resilient by creating resilience networks before disasters occur. Immediately after a

disaster, information and resources are at their most limited, making optimal early use of limited resources most impactful during an initial crisis response. Social network analysis may assist emergency and resilience managers in developing mutually supporting resilience hubs and networks capable of addressing primary human needs early in crisis response. Emergency management planners, in this case, applied a framework for needs assessment derived from the United Nations High Commissioner for Refugees (UNHCR) clusters, which include camp coordination, early recovery, emergency communication, food security, health, logistics, protection, shelter, water, and sanitation (UNHCR, 2023) to supplement the Emergency Support Functions (ESF) outlined by the Federal Emergency Management Agency.

Drawing from operational planning techniques employed by US joint military forces and the United Nations Humanitarian Cluster System and supported by a resilience grant from the Oregon Legislature, Oregon's Office of Resilience and Emergency Management (OREM) has administratively divided Oregon into operational areas based on the "islands" where residents are likely to be made inaccessible by disasters. While not surrounded by water like real islands, these islands can be made inaccessible by bridge failure, landslides, traffic, liquefaction, debris, and other hazards resulting from earthquakes, tsunamis, and wildfires. Recognizing that providing humanitarian aid to remote areas by road, rail, or air may be delayed by months in some cases, planners are using social network analysis to guide the development of direct relational ties and create mutually supporting resilience hubs and networks that will sustain communities early in disaster response and aid in reconnecting vulnerable communities with aid resources as they are made available.

The benefits derived from network solutions are not without cost. Coordinated efforts require extensive stakeholder communication, consensus-building, process alignment, and operational coordination. Even with motivated network participants committed to the cause, management of highly complex or "wicked" problems (a complex social or cultural issue that is difficult or impossible to solve) may be "experienced as ambiguous, fluid, complex, political, and frustrating as hell" (Roberts, 2000). Social network analysis offers a method to create and manage complex networks more efficiently, as well as visualize and measure progress towards response preparedness objectives.

MATERIALS AND METHODS

In December of 2024, disaster response professionals from OREM and the U.S. Department of Health and Human Services Office of Human Services Emergency Preparedness and Response (OSEPR), supported by research associates from Naval Postgraduate School, explored the applicability of social network analysis to improve resilience network development in preparation for future crises. The team assessed the locations and operational reach of the newly awarded Oregon Resilience Hubs and Networks grant recipients, as well as that of professional emergency managers, law enforcement, and volunteer radio operators in sociocultural and geographic space throughout Oregon. Planners modeled courses of action to improve the network's robustness, resilience, and capabilities to support communities following a disaster.

The resilience network consists of two major components. Network actors in the first component were drawn from applications for grants under Oregon Legislature House Bill 3409 Section 86 "Resilience Hubs and Networks" and consists of community members who formally identified themselves as willing to provide support to their communities during and after a crisis. The second component is composed of law enforcement officers and volunteers from Oregon's Military Auxiliary Radio System (MARS) and Oregon's Amateur Radio Emergency Service (RACES), who have established responsibilities during disaster response and live and work within the communities they serve. This division of components during analysis is artificial, allowing the limited number of planners to task one planning cell to analyze grant recipients and their supporting community members and another cell to focus on ties between professional responders, law enforcement, and radio auxiliaries. Within the community, actors from both networks interact regularly as part of the same network.

Before this analysis began, Oregon grant program managers had selected grant recipients after assessing all applicants based on established criteria, each criterion resulting in a score for comparison. Application scores were weighted based on the applicant's geographic location and the U.S. Center for Disease Control and Prevention (CDC) Social Vulnerability Index and the Environmental Protection Agencies Justice Screening Mapping and Screening Tool to meet the legislature's stated intent of serving vulnerable and under-represented communities and combatting environmental justice issues (82nd Oregon Legislative Assembly 2023 Regular Session, 2023). Grant program managers had also considered applicant locations based on proximity to other applicants, balancing maximum coverage of grant resources to remote communities against mutually supporting networks when possible. Program managers also assessed grant applicants based on their existing ties to other relief organizations and resilience networks to maximize initial network reach and capacity.

This research project began as OREM received the list of grant recipients and their associated applications. Planners first categorized the grant recipients based on the services recipients provided or proposed that they

would provide under several different frameworks, including the Federal Emergency Management Agency's (FEMA) Emergency Support Functions (ESF) framework, United Nations High Commissioner for Refugees (UNHCR) clusters framework, the 211 Human Services Indexing System, and an internal framework called Resilience Hubs Core Functions. Categorizing recipients for each system allowed planners to graph networks for visualization and planning based on the framework appropriate to the interagency partner or audience and present the data in the framework most familiar to the audience. FEMA directs the use of the ESF framework during incident management, but the UN clusters framework provides a greater degree of categorization to support planning and during intervention. For example, the UN clusters approach bins early recovery, food security, education, and shelter under the single FEMA ESF 6 Mass Care. Employing both frameworks simultaneously allowed planners to better model roles and identify support gaps. Planners created a list of grant recipients and their organizations, capturing these ESF and UN clusters service attributes, 211 service categories and subcategories, contextual information such as address, geospatial coordinates, and primary service groups (such as children, elderly, or low-income residents), as well as administrative categorization such as which county and service area they supported. Planners then created a list of relationships between network members and organizations. These relational ties included coordination, membership, financial support, and formal agreements. Each of these categories, relational ties, locations, roles, and other attributes were described in a code book to ensure consistent use of terms and descriptions.

For this analysis, planners had no requirement to select representative samples from the community because the grant recipients had identified themselves and their supporting networks during the grant application process and planners intended to visualize and model the network as identified. Planners did not establish statistical sampling criteria for probability as they did not intend to make inferences about the characteristics of the communities surrounding the resilience networks. Rather, the planners' intent was to turn the limited data available in the grant applications into a plan to identify and develop mutually supporting relationships between resilience network members. Planners needed to identify how grant recipients (and their self-reported supporting actors) were connected and communicated and to develop courses of action for how the resulting resilience network could be made more robust and resilient.

Simultaneously, a second planning cell identified and telephonically interviewed communicators from the Oregon County sheriff's offices, emergency managers, and Military Auxiliary Radio System (MARS) and Amateur Radio Emergency System auxiliaries and volunteers recorded steady-state and emergency radio contact networks, as well as contingency plans for communication when internet and cellular phone services are unavailable. As with the resilience grant network planners, the communication team focused on ties between specific responders, law enforcement, and radio operators without making inferences about the larger community. Planners created a table of these responders with contact information, areas of operation, and equipment types. Planners also created a table identifying relationships between community responders such as co-workers and friends, as well as communication types such as high frequency or handheld radios. Planners recorded descriptions of terms used in a code book to maintain consistency, such as specifying that a node capable of supporting "High Frequency" radio communication maintains a radio capable of receiving and transmitting on frequencies between 3 and 30 megahertz, a licensed operator, and a contact list and set of frequencies identified for use during crises.

Both planning teams analyzed data resulting from their code books using Gephi (Bastion, Heymann, & Jacomy, 2009) and the statnet package for R (Statnet Development Team (Krivitsky et al., 2003)). Network analysis employed several algorithms to measure and describe both the resilience hubs and networks component and the radio communication component. As this research was conducted in the initial phase of network development, planners focused primarily on network force-directed visualization algorithms such as Fruchterman-Reingold to assess the relative connectivity (or lack thereof) to supporting nodes by UN cluster within network subcomponents, and Force Atlas and Yifan Hu to assess relative distance between subcomponents.

DISCUSSION

During planning, military commanders assess the environment based on geography and other considerations to designate areas of operations where forces assigned to those areas can accomplish missions. Commanders use control measures to delegate responsibilities, coordinate movement and support, and manage operations between regions of operations (Joint Chiefs of Staff, 2022). Planners create and assign areas of operation based on environmental conditions, geography, unit capabilities, and mission requirements, resulting in limitations that rarely match existing administrative boundaries.

Mountains cover more than two-thirds of Oregon's land and more than 8,000 bridges span features that would otherwise prevent movement by passenger vehicles. Loss of even a few of the bridges along Highway 101 will render coastal communities inaccessible by road or rail from any direction, forming practical islands as the steep terrain to the east restricts access by response vehicles. Road obstructions are common to many mountainous states, such as landslides, causing cascading effects in areas with few routes of ingress and egress, turning what

would be a minor roadblock in a state with more roads into a major disruption in Oregon. Planners assessed the geography of Oregon and simulated several disaster scenarios, from earthquakes and tsunamis to wildfires and epidemics, and assessed the effects of crises on maneuver and area access. Analysis has revealed that the residents could be isolated into 31 geographic areas, potentially cut off from external support via road or rail for a period (Figure 1). Rarely do these areas align with administrative boundaries such as city limits or county lines. These areas often span city and county lines, requiring coordination between different agencies before and during emergencies. Planners chose the label “island” rather than an operational area to convey the potential isolation that these communities may face during crises.

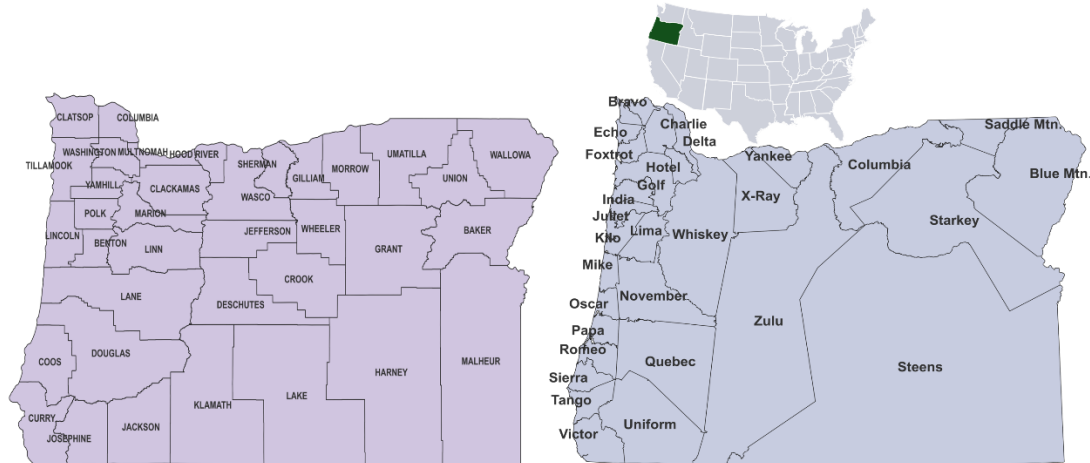


Figure 1. Oregon Counties (left) and Oregon “Islands” Vulnerable to Isolation in Crises (right) (QGIS Development Team, 2025)

FEMA may pre-position supplies in readiness for humanitarian response. However, even with advance warning, these supplies are rarely sufficient for large-scale crises (**Office of Inspector General, 2006, p. 67**). Oregon’s geography will limit the ability of responders to move prepositioned materials between areas of need to match requirements. Emergency response planners have identified the requirement to enable remote communities to sustain themselves immediately after an emergency until state and federal responders can access their location.

Resilience Hubs and Networks Grants

In 2023, the Oregon Legislature allocated \$10 million to authorize Oregon’s Department of Human Services to award grants to establish resilience hubs, build resilience networks, and provide packages to non-state entities in Oregon to build community resilience and help communities support themselves during crisis. The bill defined a resilience hub as “a physical facility operated, managed, or supported by one or more residents, local governments, tribal governments, public schools, community-based organizations, nonprofit organizations or non-governmental organizations” (82nd Oregon Legislative Assembly 2023 Regular Session, 2023). The resilience hub must serve as a central point for gathering and resource distribution, operated and resourced daily to provide community resources, accessibility, climate control, and air filtration. House Bill 3409 (HB 3409) defines a resilience network as “an association of facilities, organizations, resource providers or service providers outside of a physical Resilience Hub facility that collectively serve the purposes of the Resilience Hub.” These partners with familiar faces actively work with the community daily. Resilience networks bridge resources and cultural gaps between government agencies and affected people. Planners considered several factors when writing resilience hub and grant network policy. Residents of remote communities often maintain fewer external ties than suburban area residents, which reduces resident knowledge of and access to government programs and resources (Faas A. J., Jones, Tobin, Whiteford, & Murphy, 2015). Planners wanted to avoid the frequent government policy of addressing economic capability without factoring in the “human” element or producing local resilience by fostering networked resident relationships. In their study of networks’ role after the Great East Japan earthquake in 2011, researchers noted that recovery policies often address physical infrastructure but typically do not focus on restoring human networks (Young-Jun Lee, 2017). Focusing on pre-disaster resilience hubs can mitigate remote community emigration with cost-effective approaches as opposed to post-disaster recovery efforts. Figure 2 depicts two maps with resilience islands indicated by blue boundaries. The red dots on the map on the left represent designated resilience hubs. The red dots on the map on the right indicate the resilience hubs and network grant recipients. Many grant recipients are already positioned to support a nearby resilience hub, while other recipients will support areas currently without access to identified resilience hubs.

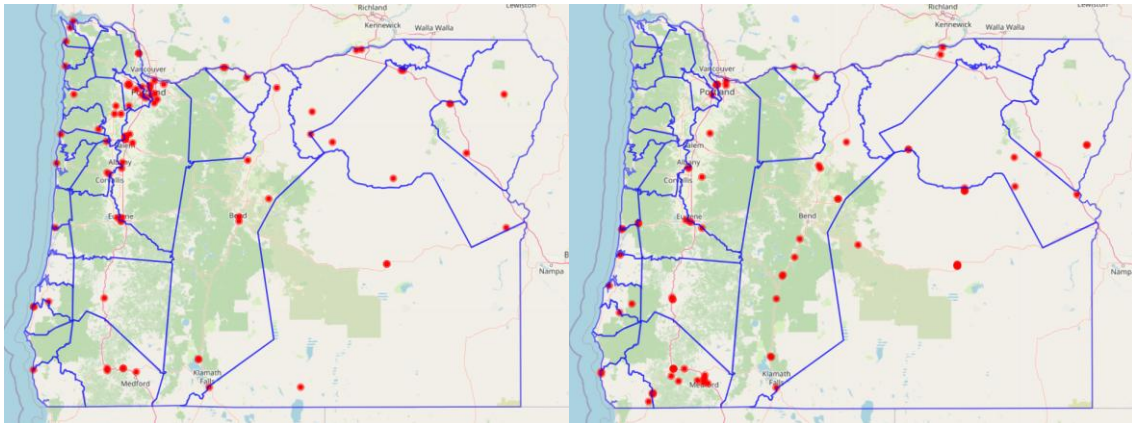


Figure 2. Oregon Resilience Hubs (left) and Grant Recipients (right) maps created using leaflet for R (Cheng, Schloerke, & Karambelkar, 2025), base map copyright OpenStreetMap® licensed under Open Data Commons Open Database License

Resilience hub grant applicants were encouraged to apply for items, activities, or staffing support. Requests included medical supplies, electronic charging stations, emergency plans, and training programs. Each applicant could also apply for a “typed package,” a set of resources to aid a community at a prepositioned location. Packages consist of a waterproof, air-tight container including shelving, locks, solar panels, tents, water, food, and other miscellaneous supplies. “Typed packages” are determined by the number of people the package may support, ranging from 50 to 250. Package costs vary from \$50,446 for a Type 5 (50 people) to \$122,032.90 for a Type 1 (250 people) (82nd Oregon Legislative Assembly 2023 Regular Session, 2023).

Emergency Support Functions and Humanitarian Cluster System

FEMA’s Emergency Support Functions (ESF) framework provides a structure for coordinating federal interagency support for both Stafford-Act declared disasters and non-Stafford Act incidents (Federal Emergency Management Agency, 2025). The support functions under this framework are often broad, binning several critical functions into the same category. ESF #6, for example, categorizes Mass Care, Emergency Assistance, Temporary Housing, and Human Services as a single function, as depicted in Table 1.

Table 1. Federal Emergency Management Agency Emergency Support Functions

ESF #1: Transportation	ESF #9: Search and Rescue
ESF #2: Communications	ESF #10: Oil and Hazardous Materials Response
	ESF #11: Agriculture and Natural Resources Annex
ESF #3: Public Works and Engineering	ESF #12: Energy
ESF #4: Firefighting	ESF #13: Public Safety and Security
ESF #5: Information and Planning	ESF #14: Cross-Sector Business and Infrastructure
ESF #6: Mass Care, Emergency Assistance, Temporary Housing, and Human Services	
ESF #7: Logistics	ESF #15: External Affairs
ESF #8: Public Health and Medical Services	

The United Nations High Commissioner for Refugees (UNHCR) outlines an approach for organizing disaster response resources by cluster, a method slightly different from FEMA’s ESF. The cluster model “is used for coordinating non-refugee humanitarian emergencies . . . often co-led with government and/or co-chaired with NGO partners” (UNHCR, 2023). Clusters are based on categories of essential service categories that can be networked into systems connected by personal relationships, communications, and predetermined working relationships. These clusters are camp coordination and camp management, early recovery, education, emergency telecommunications, food security, health, logistics, nutrition, protection, shelter, and water, sanitation, and hygiene (WASH), as depicted in Figure 3. The cluster system does not replace FEMA’s Emergency Support Functions, National Response Framework, or National Disaster Recovery Framework. Rather, it nests under these frameworks to subcategorize broad ESFs like ESF #6. The use of the cluster system will also enable easier integration with international aid organizations in the event of a catastrophe resulting from a disaster, such as the projected magnitude-9 earthquake and resulting tsunami associated with a seismic shift in the Cascadia

Subduction Zone.

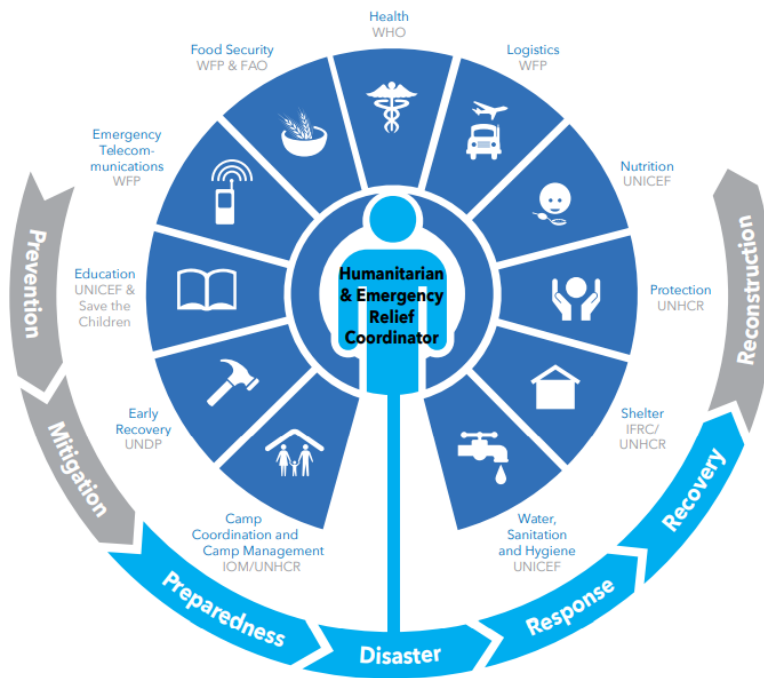


Figure 3. The United Nations High Commissioner for Refugees Cluster System

Planners assessed past events such as the 2015 Nepal Earthquake, Sulawesi Earthquake and Tsunami, and Typhoon Rai to identify which emergency services responding agencies provided. In addition, they assessed the percentage of services for each emergency required to forecast a model of resource requirements to respond to an emergency of a similar scale. Planners selected these disaster responses based on similarity in scale to an earthquake and tsunami resulting from a shift in the Cascadia Subduction Zone. Table 2 indicates the distribution of relief cluster resources for a resilience network that case studies suggest may be suitable for a response to such an earthquake. The percentages depicted here suggest a baseline from which field staff will adjust based on factors within the response network island. Creating networks with a high degree of direct relational ties and standing processes for collaboration through the UN cluster system is the next step in producing resilient crisis response capabilities.

Table 2. Proposed United Nations HCR Cluster Prioritization

20-30%	15-25%	10-20%	5-15%	5-10%	1-5%
Health	Food Security	Early Recovery	Education	Logistics	Camp Coordination
	WASH		Shelter		Emergency Telecom
					Nutrition
					Protection

Social Network Analysis in Crisis Response Planning

Social network analysis holds as a fundamental tenet "that positions in a social structure have consequences for the people occupying them" (Borgatti, 2010). It "assumes that the behavior of actors is profoundly affected by their ties to others" (Everton, 2012). When applied to an emergency management context, SNA can identify and model structure, thus allowing practitioners to improve their understanding of a network, forecast how individual actors may operate within an emergency context, or simulate network disruptions. While the applications are many, the benefits of applying SNA to emergency response networks potentially result in force-multiplicative outcomes. These potentially manifest in increased resilience and robustness, denser communication ties,

facilitated autonomous decision-making, and improved knowledge-sharing between decision-makers and policymakers.

Fass and Jones present in *Social Network Analysis of Disaster Response, Recovery, and Adaptation*, a series of case studies assessing the importance of pre-existing relational ties in early response, social capital, and network topography effects upon victims' access to aid resources (2017). The application of SNA in these case studies was intended to contribute to the science of SNA and social theory rather than to demonstrate an approach to improve network response effectiveness pre-crisis, but identifies several lessons learned that may be applied to response network development. Case studies of disaster response show that response networks tend to be emergent rather than planned (Kapucu & Demiroz, 2017), but this need not be the case. During this effort, response professionals and researchers applied Jones and Faas's emphasis on the importance of direct pre-existing relational ties to model networks for future crisis response.

Emergency response planners developed a model for resilience network development drawing from U.S. Army Techniques Publication (ATP) 3-57.30 *Civil Network Development and Engagement* (2023). This publication describes a process for network development with eight phases: Preparation, Design, Establish, Assess Capabilities and Resources, Vetting, Protection, Expansion, and Culmination.

Preparation includes activities to establish systems and study existing data while considering mission objectives. Planners establish milestones for data collection, analysis, and dissemination. Several OREM planners have studied applications of social network analysis, but many field staff have not. OREM assists field staff not trained in data collection through the fielding of data collection products formatted to guide field staff through information requirements facilitated by a mobile application. Figure 4 depicts the recipients of Oregon's Resilience Hubs and Networks Grants and their connections to their reported supporting community resilience partners immediately after grant awards. In the graph, grant recipients are depicted as circles or nodes, colored by the UN cluster they support, such as light green for early recovery services and dark blue for water, sanitation, and hygiene. The gray nodes indicate non-recipient community resilience partners reported by grant recipients whose support has not yet been categorized. The lines between nodes represent relational ties or connections between the grant recipients and the resilience partners that the recipients identified during the application process. The size of each node in this graph represents relative centrality, meaning the number of ties a node has with other nodes as a percentage of all ties available. In this graph, the nodes are sized by degree centrality, meaning that larger nodes denote a resilience network member who maintains more connections to other network members than the members represented by smaller nodes. In addition to assisting planners in rapidly identifying the most well-connected resilience network members, planners immediately identified that many grant recipients had no connections to supporting subnetworks or other recipients. Few people or organizations boast the ability to support all types of humanitarian services alone, so connecting these isolated recipients to the larger resilience network became an immediate priority. Planners were able to use this list to identify which resilience hubs lacked support from the established desired ratio of 20-30% health, 15-25% food security and water, sanitation, and health, 10-20% early recovery, 5-15% education and shelter, and 1-5% for camp coordination, emergency telecommunication, nutrition, and protection. In Figure 4, a resilience node that meets the desired response status would be represented as a central node with a minimum of one each red, lavender, orange, and dark blue nodes, one or two light green nodes, and either a dark green, purple, or light blue node (based on comparison with capabilities of nearby network subcomponents). Nodes with more ties relative to other nodes in the network are larger. Once gaps in support were identified, planners could begin developing courses of action to create direct relational ties between hubs and resource providers, such as selecting a home improvement store for pre-disaster contract provision of material to be maintained in reserve and delivered upon request.

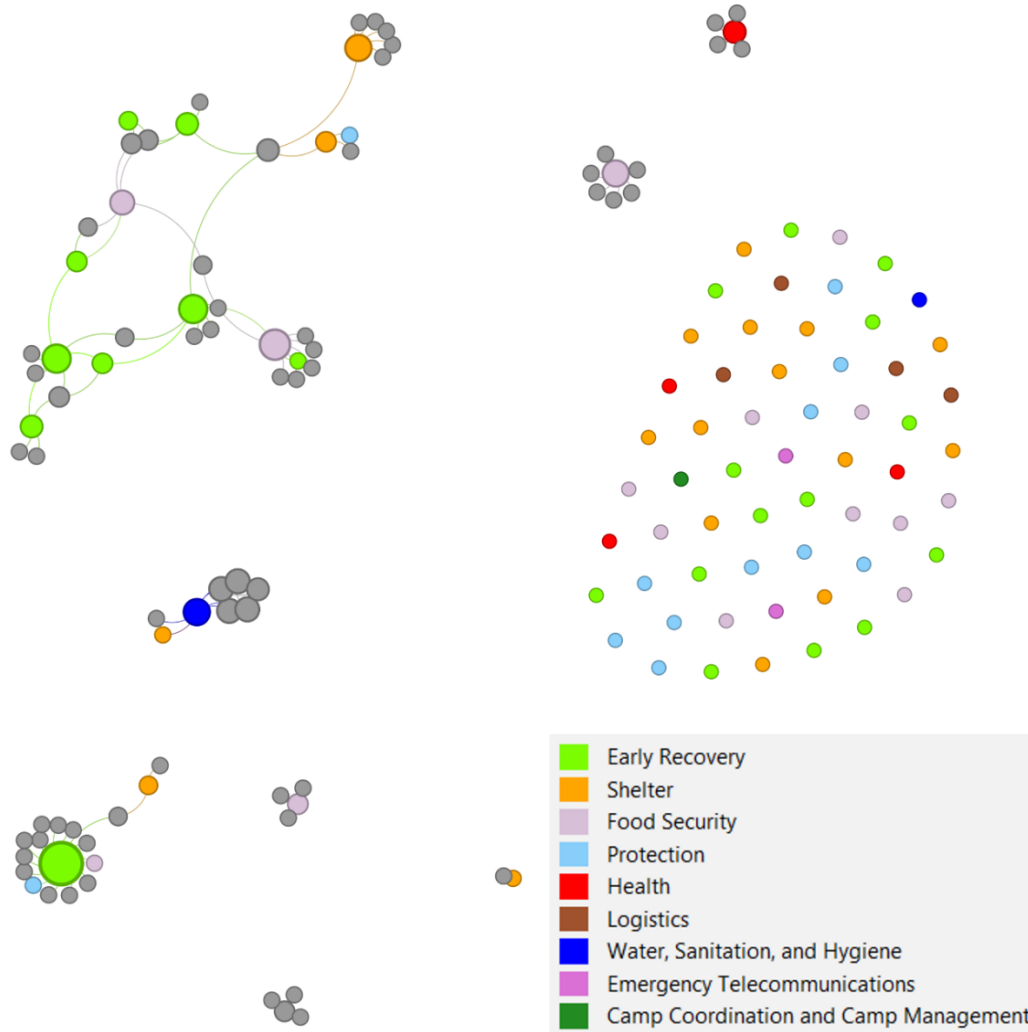


Figure 4. Oregon Resilience Networks Relational Ties (all network graphs created using Gephi, unless stated otherwise (Bastion, Heymann, & Jacomy, 2009))

Communication

Communication within networks is critical during disaster and crisis management, especially in uncertain environments. Difficulty in communication and transmission of information from those having specific knowledge of the crisis in the field to those managing resources and response teams outside the response area is compounded in remote, harsh environments. Terrain masking of radio emanations and vulnerable cellular towers dependent upon power lines whose length increases exposure to hazards associated with disaster conditions reduce the ability of field staff to coordinate with higher echelons, either to coordinate aid or report sufficiently stable conditions to allow aid to be fielded to areas of greater need.

Many response organizations' worst-case scenario involves the complete loss of internet and cell phone infrastructure in conjunction with a disaster. Standard operating processes and daily routes are constructed around reliable real-time communication systems without requiring specialized equipment. The map on the left in Figure 5 depicts the emergency response network of field agents, country emergency managers, and county law enforcement without cell phone or internet communication. The translucent blue borders indicate a 5km radius or maximum line of sight range (assuming no blocking terrain features) of fielded very high frequency (VHF) and ultra-high frequency (UHF) radios. Without additional support and capabilities, loss of telephonic or internet communication would significantly fragment this network.

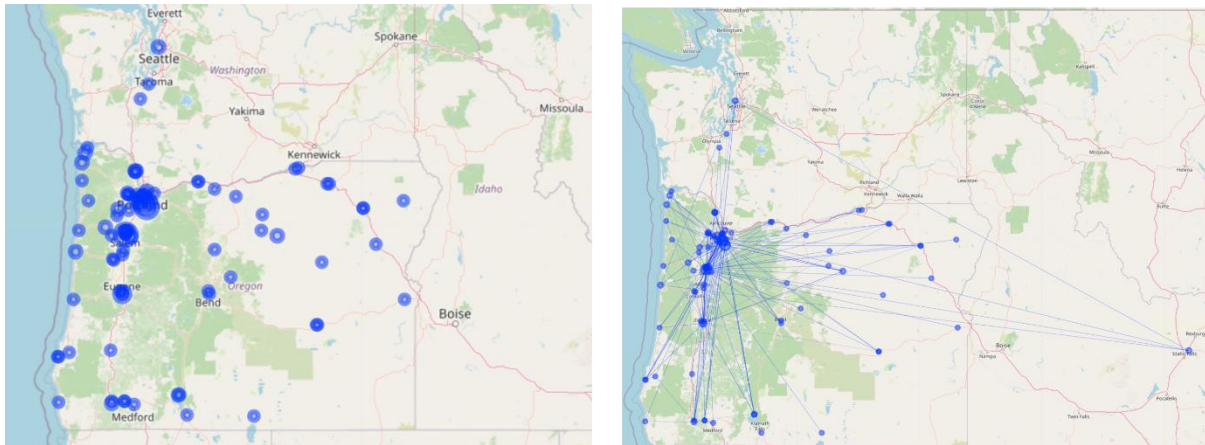


Figure 5. A Map of OREM UHF/VHF Radio Network (left) and HF/UHF/VHF Radio Network (right)

Understanding that severe power outages may reduce cell network and internet access, Oregon’s disaster plans include support from the Oregon Military Auxiliary Radio System (MARS) and the Oregon Amateur Radio Emergency Service (ARES) to law enforcement and responding agencies. These volunteer communication experts employ high-frequency (HF) radio systems and practice radio net control procedures to provide communication support during emergencies. MARS and ARES radios have far greater range than handheld communications equipment, and the established communication ties between these nodes is depicted in Figure 5 on the right. They are also compatible with military forces that may be deployed to support a crisis of sufficient scale to be declared an emergency under the Stafford Act, enabling civilian and military forces to share information and coordinate response.

RESULTS

Emergency response planners modeled a course of action for network development beginning with Island Uniform in southwestern Oregon due to its mountainous and heavily forested terrain, large rivers, remote communities, and grant recipients with relationships with other resilience providers (illustrated in Figure 6).

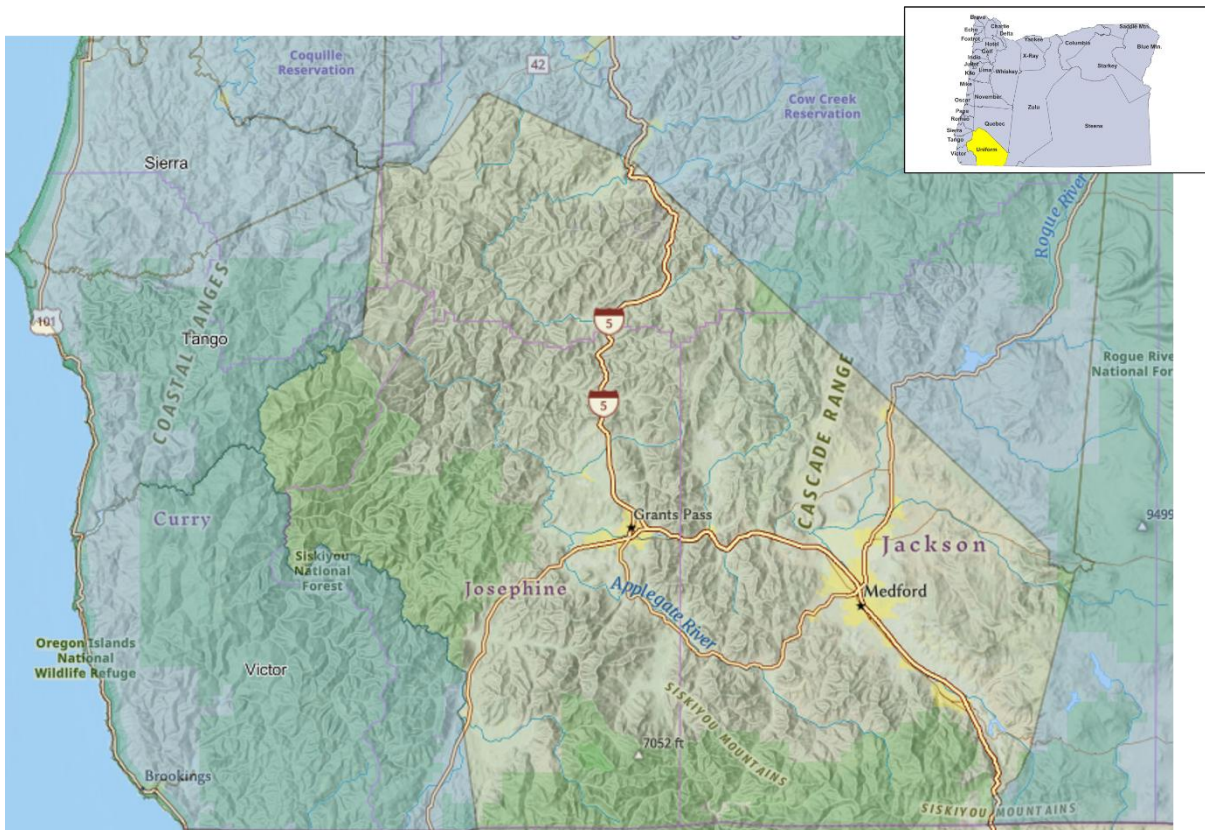


Figure 6. Oregon Island Uniform (Esri, 2025)

Several grant recipients and response providers in Uniform report the ability to support early recovery services in response to crises. A network with several well-connected nodes dedicated to early recovery can likely provide early recovery even after a significant shock, as the strong ties increase network robustness. However, this single-function network component can only support early recovery. The community around this node may lack resources such as access to water and sanitation, medical care, and food. To increase the capability of this network component to respond to crises, planners must prioritize creating direct relational ties between resilience network members and providers of other resources from each cluster. Figure 7 depicts the planners’ model for the initial development of the resilience hubs and network in Island Uniform. Network hubs should be supported by network components capable of supporting health, logistics, protection, shelter, camp management, early recovery, education, emergency telecommunication, food security, and water, sanitation, and hygiene. The minimum number of ties between network components required depends on the assessment of the hazards to which the community may be exposed. After identifying which resilience hubs and network components lack the support functions required to address area hazards, field staff may work with grant recipients to increase supporting relationships and to coordinate emergency support pre-crisis through relationship building, grants, and pre-disaster support contracts. Field staff may, for example, contract a lumber store associated with a resilience hub to provide a predetermined stock of material to a predesignated distribution point immediately following a crisis. As network development efforts continue, the graph will transition from the sparsely connected network in Figure 4 to the more robust network in Figure 7. Figure 7 represents a network in early development. The colors of the nodes indicate the UN clusters framework service provided by that node, such as red represents health support. The colors of the ties indicate the type of support provided to the network, also colored by UN cluster service. A robust hub, likely ready to provide support to the community during or after a crisis, might be identified by its “rainbow” of connecting ties. This graph demonstrates that several resource providers have been connected to hubs through field staff direct engagements. However, the presence of several disconnected nodes indicates that many potential resources remain to be incorporated into the network. The resilience grant recipient labeled A in Figure 7 has ties to resilience network members 1, 2, 3, and 4. All these network members specialize in supporting health without reported ties to other network members for other services.

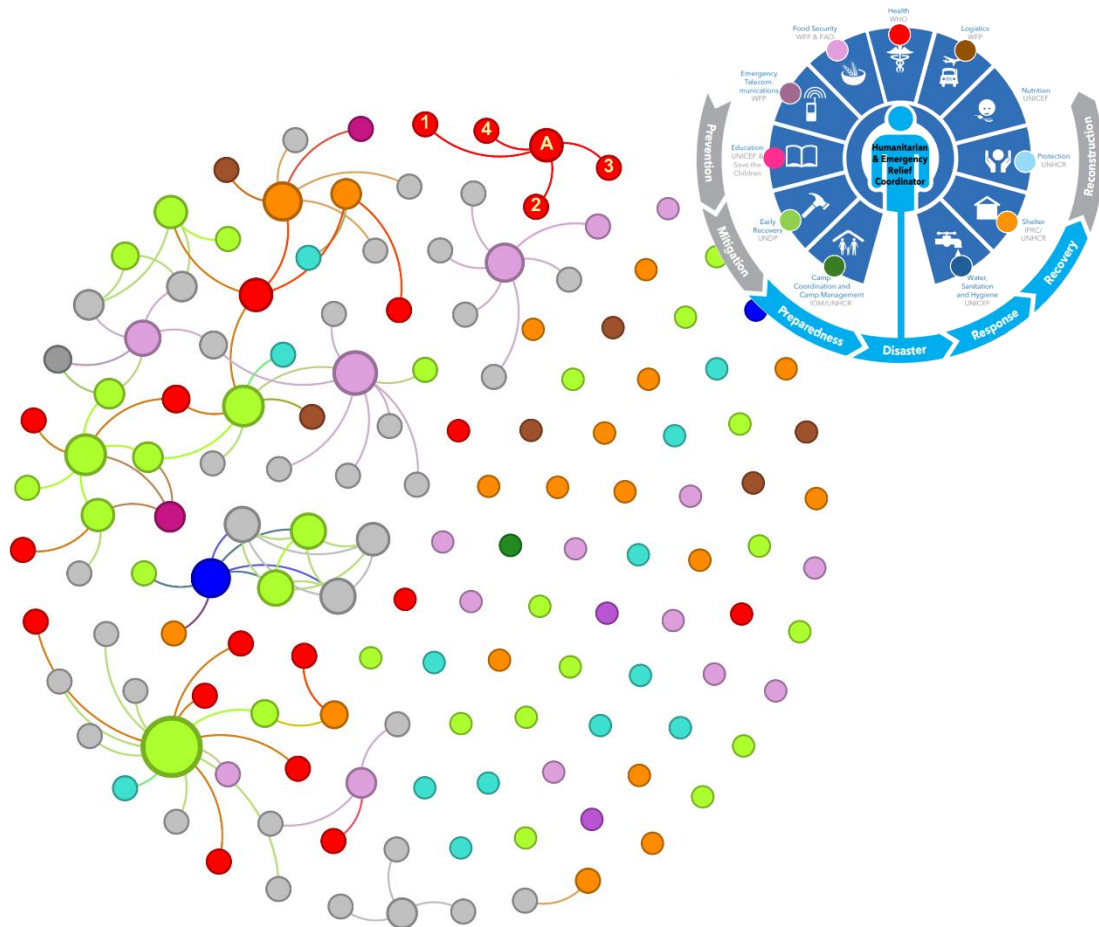


Figure 7. Resilience Hubs and Network Members in Island Uniform Depicting Ties by UN Resource Cluster

Cultivating trust, coordinating actions, and collaborating for system change drive resilience hub and network development. Trust may not easily extend from field staff working directly with community members to the sponsoring governmental agency represented, and high degrees of bonding capital among residents in remote communities may inhibit coping adaptation and disaster preparation by normative pressure on agents of change if residents view proposed change as counter to norms (Faas & Jones, 2017, p. 15). While working with resilience networks, field staff must remain self-aware regarding community members' perceptions. Faas, Tobin, et al. warn that cooperation may be seen as a sign of deservingness by state and non-governmental organizations, potentially leading to the abandonment of those who do not cooperate (2015). All inter-organizational networks require time to build trust, interoperability, and compatible processes, which require patience from both field staff and program managers.

Training events and exercises, from tabletop exercises to large-scale scenario-driven crisis simulations, do not just test systems and processes. They are instrumental in forming the direct relational ties upon which response personnel will rely during crisis response. Simulations and performance evaluations also allow planners to test network effectiveness through the three methods recommended by Turrini, Cristofoli, Frosini, and Nasi for measuring network performance: client-level effectiveness (are clients content with results?), community-level effectiveness (does the community benefit from the network?), and network-level effectiveness (does the network achieve its established goals?) (2010). Training events and exercises also allow crisis managers to identify and address common factors that hinder collaboration during disaster response—formal missions, cultural conflicts, role ambiguity, disagreements between agencies and strategists, and lack of communication guides (Kapucu & Demiroz, 2017). Complex training scenarios with multiple actors may reveal potential hindrances while time remains to address them before crises occur. In the field, training exercises that include resilience hubs and networks may improve social fabric, creating non-emergency-related social capital among residents in remote communities.

Vetting tests the network, supports effectiveness assessment, and builds relational ties between network members. Vetting is an ongoing process of assessing capabilities and resources that increase integration and trust with governmental agencies. Vetting exercises the network to identify gaps not anticipated in preparation and design. For OREM, exercising includes monitoring the completion of projects identified in coordinating actions as part of the establishment, integrating island networks into OREM or Oregon Emergency Management (OEM) exercises, codifying best practices, and integrating the statewide network system into an OREM or OEM exercise. Exercises and projects provide an opportunity to catalog formal after-action reviews on network functionality. These reviews are then used to improve network functionality by researching additional nodes and engaging the network. As vulnerabilities are addressed, the network is expanded to increase robustness and resilience and to add extra capability until a balance of effectiveness and sustainable maintenance cost is achieved.

The network (and its resources) must be protected from both physical harm and the dissolution of the network through fragmentation. All supply caches and typed packages must have physical protection measures meeting established standards to deter theft, damage, and spoilage. Packages and resource caches must be maintained for serviceability of items and rotation of perishable items. Funding to refresh expired and expended supplies must be programmed and protected. Resilience hub staff should report quarterly to the sponsoring governmental agency on any conflicts among organizations in their network and proposed solutions incorporating input from affected parties. Networks undergo regular leadership and organizational changes, and the network's health is critical to its functionality. Social network analysis may assist in maintaining relationships and continuity during member transition.

Connecting resilience hubs and networks requires more than establishing a policy that MARS and ARES will support emergency responders during a crisis. These systems need to be codified, rehearsed, tested, and maintained. After identifying the extent of communication gaps, communication network planners may now contact the Oregon county emergency manager to identify which MARS or ARES communicators that the office intends to contact during a crisis and may do the same with county law enforcement. The graph in Figure 8 depicts the communication ties between responding levels of government and supporting communication assets using fielded equipment and supported by MARS and ARES. Notice the large number of isolates (nodes with no communication ties) and dyads (nodes with only a single tie). These fragmented network components represent actors unable to communicate with the larger network without the use of internet or cellular communication. Planners should prioritize the development of communication plans and purchase of equipment to maintain connection between nodes throughout the emergency response. Early efforts may be connecting isolated actors to the ARES volunteers in their counties. These volunteers are represented by the red, well-connected nodes in the bottom right of the graph.

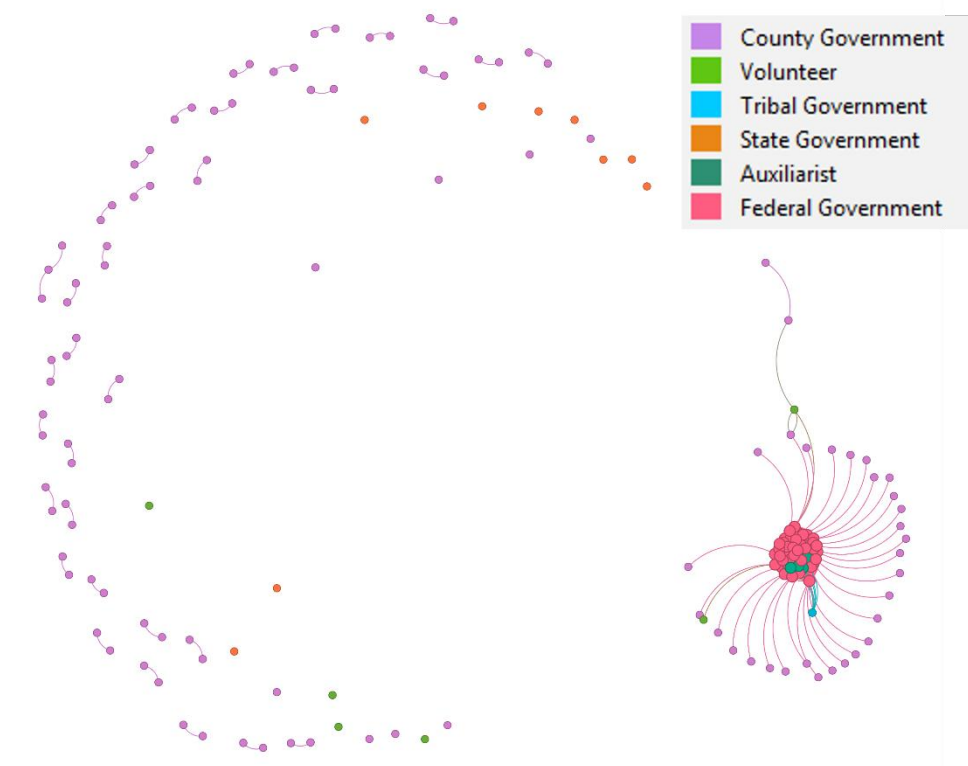


Figure 8. A Graph of Radio Communication Nodes Supporting Disaster Response in Oregon

CONCLUSION

Climate change will not impact all communities equally, and remote communities in harsh environments already face increased risk. Oregon's hazards, such as earthquakes, tsunamis, wildfires, and other crises, are not unique. These hazards and more threaten many remote communities. A social network approach during pre-disaster network development may assist emergency response planners in measuring risk and mitigating hazards. Emergency response professionals may reduce suffering and loss of life by making response networks more robust and communities more resilient by creating resilience networks before disasters occur. Identifying hazards and vulnerable areas, creating networks of resource providers connected by direct relational ties before emergencies, and maintaining and developing networks through training and exercises will create mutually supporting resilience hubs and networks. These networks may sustain communities early in disaster response and aid in reconnecting vulnerable communities with aid resources as they are made available. While not without cost, the coordinated effort to communicate to stakeholders, build public awareness of community action plans, and test response systems will increase community social fabric and may help communities manage more common problems than disasters.

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