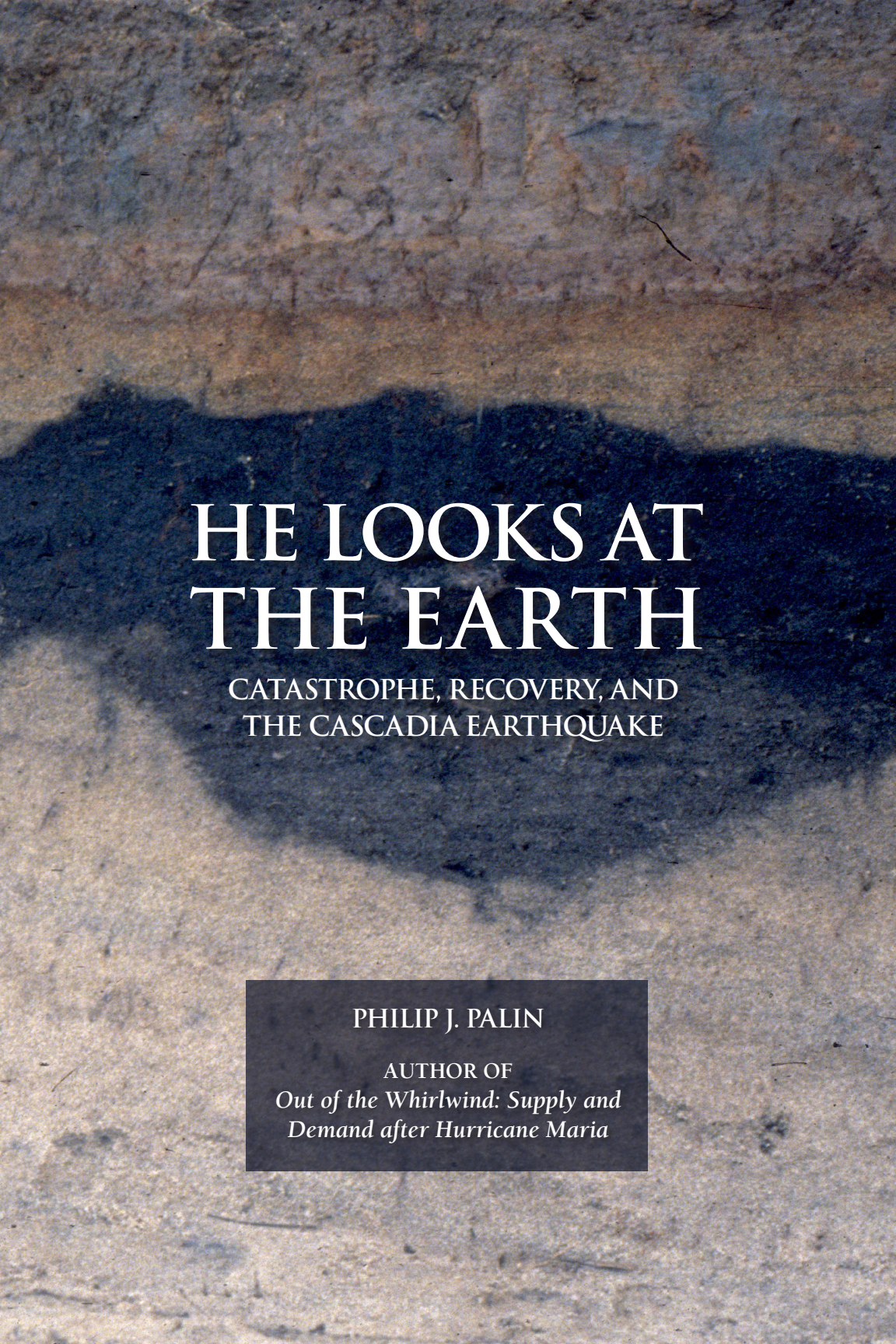


HE LOOKS AT THE EARTH

CATASTROPHE, RECOVERY, AND THE CASCADIA EARTHQUAKE

PHILIP J. PALIN

AUTHOR OF
Out of the Whirlwind: Supply and Demand after Hurricane Maria

Honoring the collaboration of Maxim Gorki, Russian author and playwright, with M. Wilhelm Meyer, German geophysicist and astronomer in describing consequences of the December 28, 1908 earthquake and tsunami at Messina, Italy. May art and science renew their relationship and affection.

HE LOOKS AT THE EARTH

CATASTROPHE, RECOVERY, AND THE CASCADIA EARTHQUAKE

PHILIP J. PALIN

On the Cover: Photograph of sand layer from the 1700 Cascadia tsunami *The orphan tsunami of 1700—Japanese clues to a parent earthquake in North America* (https://pubs.er.usgs.gov/publication/pp1707) page 20, and *Earthquake-Induced Subsidence and Burial of Late Holocene Archaeological Sites, Northern Oregon Coast* (http://www.jstor.org/stable/282017).

Design of cover and interior by Kristin Adolfson of Still Point Design Studio

He looks at the earth and it trembles;
he touches the mountains and they smoke.

Psalm 104:32

CONTENTS

PART I—INTER-SEISMIC: 2019-2022

Latin/Greek compound, *inter:* between; *seismos*: shaking.

That time and space extending between major earthquakes, generally understood as a sudden slip along a geologic fracture with related rebounding of surface and subsurface structures as experienced in the biological domain, especially by humans.

So-called ordinary—orderly—experience when conditions seem stable, but when coupling, creeping, subduction, and other stresses are subtly accumulating or being gradually released.

IT IS LOW TIDE. He steps cautiously from spongy marsh onto a slippery slope now exposed. Sliding two inches, he wedges the length of both boots into the tightly compacted pitch, awkwardly leaning sideways to examine the outcrop. It is about eight feet above water's ebb, slicing beneath the upper edge of brackish high-tide marsh.

He can count at least four buried soils. There are erratic lines that might signal one—perhaps two—more. Diagonally he scrapes low to high with a trenching hoe.

The lowest stratum is dark and peat-like, extending as a narrow ledge above the muddy stream bank. This is one-time forest floor. Many seasons of sticks, cones, and needles have been compacted by accumulation and centuries.

Abruptly above the bold stratum of peat are several inches of grey mud displaying lamination of recurring tides. Where there had been forest, mudflats arrived. Then a darker horizon above the mud: for a long time, no more tides. Centuries measured by centimeter.

Given the visible variegations, two to three-thousand years altogether here, he supposes.

Not far below tufts of this season's sea-arrow and hairgrass are parallel lines of sand. The lowest line, deposited upon another thick band of peat, consists of very fine sand. Each subsequent string of sand mixes with a bit more clay; the entire sandy interregnum less than three inches wide.

That's the tsunami, JP is certain. At least five pulses. Almost three-hundred twenty years ago.

On January 26, 1700 an earthquake violently shook the shore where JP now stands. Minutes later the ocean's surface, suddenly three to six feet higher, was flooding deep across meadows and forest. This opened channels for future tidal flooding—again, again, and again over many decades—transforming the landscape and leaving these lines of sand.

While JP mucks about in marshes near Willapa Bay, 120 miles northeast Kathy Juniper parks her rental at a restaurant close by the Edmonds ferry landing.

She is early. Seattle's traffic can be confounding. This is her first time finding Arnies. She hates being late.

A ferry is arriving. Juniper walks above the beach toward the pier. The huge vessel smoothly slides into place, dozens of cars are soon released and on their way. It takes thirty minutes to go fewer than seven miles across the Sound to Kingston. It takes at least two hours—often double that—to reach Kingston from Edmonds without the ferry.

The Puget Sound ferries have a certain Bauhaus elegance of straight lines and functional form. But it is the setting—cold blue water bounded on the west by snowcapped mountains—that give the big white boats an appearance of unlikely grace.

Her cell phone hums. The General has sent a text. He is on his way from the classified meeting she could not attend. Early in her career she briefly had a clearance. She found it intellectually corrupting and, perversely, limiting. Juniper wants to look wherever her questions take her and share widely whatever she finds.

They are seated at a window overlooking the Marina, the sound, and Olympic Mountains. They both order steelhead salmon with a Washington white wine. The General is a bit younger than Juniper, but not by much. Both are now in what he calls the subtle sixties.

The waitress has barely departed with their orders when Juniper launches her agenda.

"LA, San Francisco, New Madrid—all will be plenty bad. In each case long-term grid failure, communications down, road disruptions, demand and supply networks severely tested. But the more I look, the more potential Supply Chain Resilience I have found in each disaster zone. Until here. The deeper I look at Puget, the worse it gets."

She pauses. The General is listening. He does not take the opportunity to comment.

"For the first time in my professional life I have actually begun to consider mass evacuations. With a catastrophic no-notice involving millions, mass evacuation is usually proof some planner has a Napoleon or Jesus complex. But for these four million plus, I can't figure out how to feed them here."

"Where do they go? How do they go?" the General asks.

"Exactly. Maritime is just about the only way given context and numbers, but with the likely tsunami, the shore—like right here – will be totally torn up. And how do you manage a four-million-person queue? I know I can't feed or water the queue."

Her salad and his chowder arrive.

"Give me the thirty-thousand-foot view," he says. "What's missing that you were able to find in San Francisco and LA?"

"Velocity to start. Cascadia basically eliminates every grocery and most other food distribution centers. Then volume. There are a lot of food processors proximate to the population. But most of them are in the same places – on the same liquefiable soil – as the Distribution Centers. And those that survive won't have electricity to process anything."

She swallows more than tastes the Sauvignon Blanc. Another ferry arrives. They watch. Then she pulls from her black bag a Rand-McNally folded map of Puget Sound, 1-inch equals 4 miles, and unfolds it on the table. The couple at the next table stares as the ancient artifact expands to wider than the two-top.

"I-5 is essentially AWOL to Portland and probably well beyond. Maybe I-90 can be pieced together, but that's not where most of the freight travels today… and anyway the distribution centers are gone along with half the bridges. Even if we get enough groceries over Snoqualmie Pass, how do we deliver to actual survivors, if on the off-chance we can fuel our trucks?"

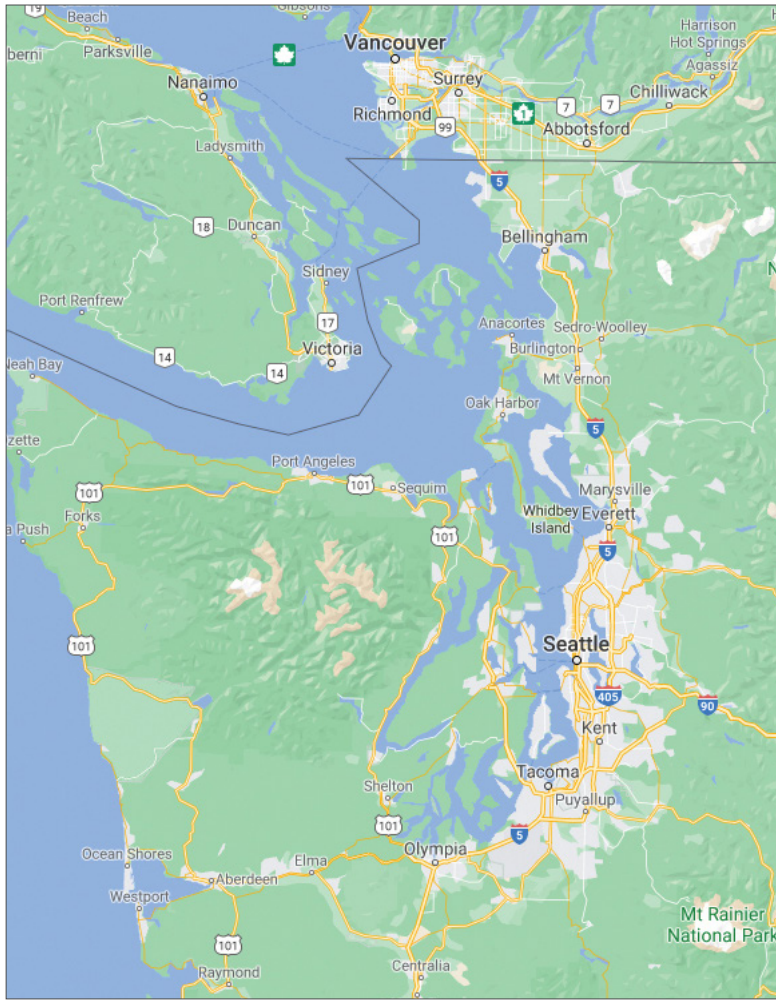
"So, regional planners," the general begins, mostly to give Juniper the chance to start her salad, "are looking at air drops. Moses Lake has enormous capacity to receive supplies and manage sorties. High velocity. A Chinook can fly from Moses to most of Puget in under an hour. Berlin Airlift stuff, constant flow…"

Juniper's eyebrows arch.

"Yes," he grins before she can finish chewing her lettuce. "There's a problem with volume. I have—FEMA has—enough shelf-stable to feed one million for about a week. Defense Logistics Agency has few million more MREs in emergency inventory. There are only about 2 million active duty and reserve military, worldwide. DLA is best prepared to feed those warfighters. Four million extra over-night is not in anyone's current inventory." The General is a West Point graduate, career Army, seven years into retirement.

"Any *government* inventories," she interjects.

"Yup. That's why we need to get up close and personal with the Big Five grocers" he replies. "They feed these folks every day."



"But their capacity won't survive a Cascadia event," she says. "Three of the distribution centers will be gone. One other might survive, but the road in between won't. The one sure survivor is the smallest of the top five and 150 miles on the east side. And… any idea how many Chinooks, Ospreys, maybe Sea Stallions you can cook up?"

The General smiles. "I've been told up to 500. But that will take time."

She responds, "I've been told more than a thousand big rigs are moving food into the Seattle metro region each day, not counting

exports. I seem to remember a 53-foot van can carry more than 4-times a Chinook's payload."

"Maritime is where we get our heaviest payloads."

"No doubt. But, what, at least six days one-way from San Francisco, eight from LA/Long Beach? Carrying what? See what I mean. Cascadia will probably take out Portland too. That puts Puget at the far end of a very long channel—by land or sea or air. Whatever calories are going to arrive will have to come a long, long way. Eventually volume can catch up, but after how many weeks. Velocity? I don't really see it recovering for months."

"And Anchorage depends on Tacoma," he adds.

The waitress arrives with their steelheads, mashed potatoes, and grilled green beans.

As Miriam's plane lifts from Fiumicino, she watches the Mediterranean disappear behind peach and citrus clouds. Autumn 2019 is moving through the pipeline: Insurance, import licenses, government approvals, air cargo, all the logistical details are flowing nicely. The team in Naples is happy. The funders in Seattle are happy. She is happy. It will be a great show.

She is not nearly as confident about Winter 2022. It is such a small set, just six paintings. But the complexities—political, financial, even empirical—are daunting. His largest works are quite fragile. She understands the hesitations. Despite being two years off, there's not much time left. She may have to forsake Antonello and shift to the Krakow option or, very reluctantly, the unwieldy circus being spun up by St. Petersburg, more of Moscow's soft power projection.

But not yet. She has the Benson, Sibiu, and London. If she can finalize Munich, surely, she can convince Syracuse and Messina. Besides, she has once-again fallen in love with the elusive, mysterious Antonello da Messina. Sudden ascent from no-where; acute psychological insight, transformative compositional skill; then as a meteor crossing the sky, he departs Venice returning home to an early demise. A Fifteenth Century James Dean with deathless hands.

Sophie is kneading dough. Her hands floury white, consciously focused entirely on the bread-to-be. But she also depends on her subconscious to covertly work the ongoing issue.

In the beginning, not so long ago, our online revolution offered a huge inventory of products at our fingertips, available by paying a modest premium. Another—originally secondary—feature was home delivery. For consumers these two features are experienced as time compression: We avoid multiple trips while increasing our options, we avoid the wait to check-out, we avoid any trip at all when the product comes to us.

The yeast has already begun to ferment starches into simple sugars. As Sophie's fingers compress the dough chemical processes accelerate, releasing carbon dioxide and ethyl alcohol. The gas emerges as bubbles in the dense dough.

Soon enough it was obvious (again) that quick gratification motivates more consumption. Speedy delivery accelerates consumer pull. With enough pull—at least in densely populated places—cost-per-unit of push plummets as the flow of units-pulled expands exponentially. Maximum velocity plus maximum volume can maximize profits.

As the starchy proteins begin to fuse, a gluten matrix forms. The fermenting bubbles of carbon dioxide are captured within this net, leavening the bread. Without kneading a few large bubbles will form. The best bread comes from more even distribution of action and reaction.

As types of products sold online have explosively diversified and as consumer expectations for one-day, same-day, even next-hour delivery increase, the cycle of velocity with volume is experiencing much more turbulence. Some product-offerings or whole companies have expanded quickly and collapsed as suddenly. A key challenge involves characterizing — and creating — connections in space that effectively — and sustainably— bend time toward consumer preferences, even individual customization. At least as a concept, mass customization is not an oxymoron. It continues to be the Holy Grail of ecommerce.

Leaven is derived from the Latin *levō*, meaning "I raise." Some etymologists, controversially, claim a relationship with *levamentum* suggesting mitigation, consolation, alleviation.

"We want a good baguette, not a croissant, and certainly not a souffle," Sophie's subconscious whispers.

His right hand reaches for the soil. It pours through his fingers. The aeolian sediments are very deep here. These fertile once-upon bottom deposits of a gigantic glacial lake cover most of Eastern Washington and Northeast Oregon, the gift delivered by two thousand years of recurrent flooding. Twelve millennia of winds have gathered this loess to bury remains of more ancient lava flows. Within the tectonic folds just east of the Cascades this wind-blown goodness accumulates. The same high ridges and narrow valleys moderate temperature extremes. Great for wine.

Josh feels his phone vibrate. Reaching with his left hand he answers a call from his father.

"Hey, hey. What's the special occasion?" Josh answers.

"Your Mom finally gets home tonight. Want to come over this weekend?"

"Sure, sure."

"How about Sunday brunch? Maybe Sophie too?"

"I'll check. That'll absolutely work for me. You sound far away."

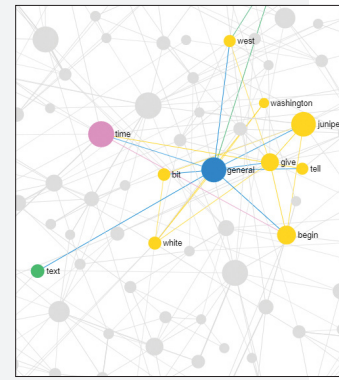
"Just off the Niawiakum. A one-step signal is great out here."

"Well, then, I'll bring wine, you bring oysters."

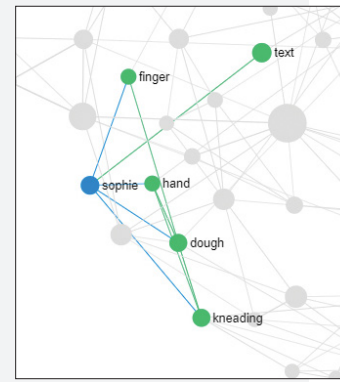
"That's a deal. Send me a text when you know about Sophie."

STARTING TO MAP THE NETWORK

Reality is both fractured and over-abundant, obscuring comprehension. But separate parts sometimes touch or mirror or echo other parts. Parts are more and less related. In any set of relationships, how do we identify strengths? How do we discern differences in influence? How about impediments?



JP and Miriam are married. Josh is their son. Sophie and Josh are a couple. Sometimes the four form one cluster, other times two clusters. Most of the time they are four separate nodes with multiple connections (or degrees). Juniper and the General are professional colleagues, at times forming a cluster, often separate, certainly connected. Juniper and the General are not yet directly connected to the others.



Above right is a network graph showing how the General co-occurs with other nodes inside the 2000 words so far. His link with Juniper is already obvious. Time will continue to be important. JP, Miriam and Josh are not yet sufficiently active to even be acknowledged by the visualization algorithm. Sophie is present, but only in terms of her bread-making (see lower graph).

In this book each word is a node. Each word-node is linked to other word-nodes. Some nodes are linked more intricately than others. In this way some nodes have more potential influence on the overall structure and flow of the network. By tracing and tracking nodes, links, and—where possible—flow across these nodes and links, it is possible to read networks, much as we read a book.

READING A TEXT

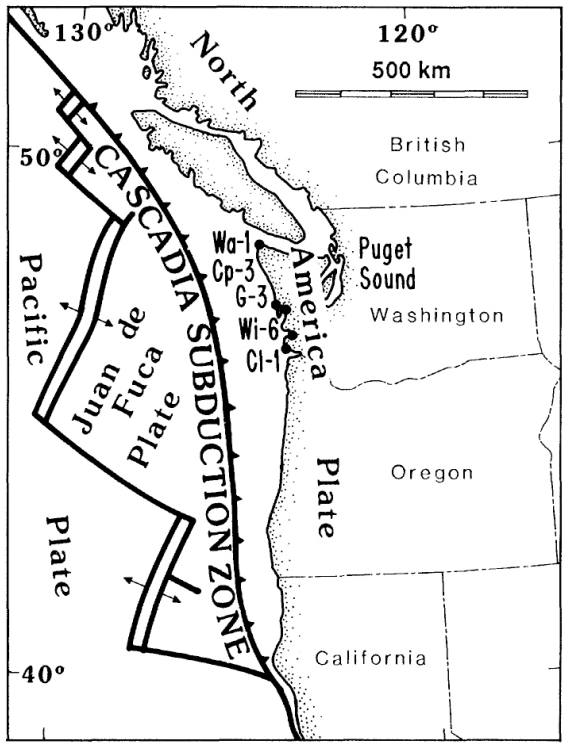
The comparative seismic quietude of the Pacific Northwest has obscured our threat. When the Cascadia megathrust does recur, it has the potential to be **thirty** times stronger than the worst **magnitude** predicted for California's San Andreas fault. This cataclysmic potential has, however, only been recognized over the last forty years. One of the pioneering geologists to see, recognize, confirm, clarify, and translate this evidence is Brian Atwater of the US Geological Survey and the University of Washington. In 1987 the journal Science published his brief Ur-text. Research has advanced since, but the original findings hold-up very well:

Intertidal mud has buried extensive, well-vegetated lowlands in westernmost Washington at least six times in the past 7000 years. Each burial was probably occasioned by rapid tectonic subsidence in the range of 0.5 to 2.0 meters. Anomalous sheets of sand atop at least three of the buried lowlands suggest that tsunamis resulted from the same events that caused the subsidence. These events may have been great earthquakes from the subduction zone between the Juan de Fuca and North America plates.

Geologic history could offer valuable constraints on the probability of a great (magnitude about 8 or 9) earthquake in the Pacific Northwest. Analogies with other subduction zones suggest that great earthquakes could emanate from the Cascadia subduction zone (map on next page), in which the Juan de Fuca plate has slipped beneath the North America plate at an average Quaternary rate of 3 to 4 cm per year. But no earthquake of the past 150 to 200 years in the states of Washington or Oregon has exceeded magnitude 7.5, and Indian legends seem too ambiguous to indicate whether great Northwest earthquakes occurred before that time . Only geologic evidence is likely to reveal whether great earthquakes from the Cascadia subduction zone have occurred and, if they did, whether enough time has elapsed since the last event for another to be expected soon.

In this report I consider Cascadia's seismic potential in light of geologic evidence for recurrent coastal subsidence. This approach, new to the Pacific Northwest and seldom used elsewhere, yields strong evidence that great earthquakes have occurred in the Cascadia subduction zone during the past 10,000 years (the Holocene). Coastal subsidence commonly

accompanies a great subduction earthquake. The coseismic subsidence, in a chiefly onshore belt flanked by a mostly offshore zone of coseismic uplift, apparently results from elastic extension within and behind the seaward-lurching part of the continental plate. Washington's outer coast conceivably could undergo either uplift or subsidence during a great Cascadia earthquake. But westernmost Washington apparently lacks Holocene marine terraces indicative of coseismic uplift. Therefore, any great Cascadia earthquake of Holocene age most likely entailed coseismic subsidence in the present vicinity of Washington's outer coast.



Subsidence during great subduction earthquakes in Chile (1960) and in Alaska (1964) changed vegetated coastal lowlands into barren estuarine flats, particularly where the subsidence was augmented by shaking-induced settlement. At the head of Cook Inlet near Portage, estuarine silt buried 18 km2 of pre-earthquake lowland that had subsided 1.6 m and settled an additional 0.8 m in 1964. Aggradation [1 to 2 m (10)] and uplift [0.2 to 0.3 m] after 1964 have allowed lowland shrubs and trees to

become reestablished in this area. A bed of estuarine mud that abruptly overlies a lowland soil and passes gradually upward into another lowland soil may thus indicate a cycle of coseismic submergence and postseismic shoaling. Accordingly, in Chile and Alaska, rhythmic alternation between estuarine mud and buried lowland soils has been cited as evidence of ancient subduction earthquakes.

Similar rhythmic bedding abounds in estuarine deposits of late Holocene age near Washington's outer coast. Peaty layers representing well-vegetated lowlands alternate rhythmically with muddy intertidal deposits at all of the estuaries that I studied, both large (Columbia River, Willapa Bay, and Grays Harbor) and small (Copalis River and Waatch River). The minimum number of buried lowlands per estuary ranges from one to six (noted on map, prior page), increasing with the depth to which Holocene intertidal deposits extend. Typically, the peaty layers are 0.05 to 0.20 m thick and the intervening intertidal deposits are 0.5 to 1.0 m thick. As exemplified at Willapa Bay, the typical peaty layer consists of peaty mud that resembles the A or 0 horizon of the soil on broad, rarely inundated parts of modern tidal marshes in the area. Conifer stumps rooted in buried peaty layers near uplands and streams confirm that the peaty layers represent nearly supratidal conditions. The bed above a typical peaty layer at Willapa Bay has an abrupt base but grades upward, from soft gray mud through firm mottled mud, into the succeeding peaty layer. The soft gray mud contains injected rhizomes (below ground plant stems) of only Triglochin maritima. At modern Willapa Bay this shallowly rooted plant is dominant only in salt-affected intertidal settings that are 0.5 to 2.0 m lower than the high-level tidal marsh represented by the typical peaty layer. The superposition of T. maritima mud over a peaty layer consequently indicates at least 0.5 m of submergence, and the sharpness of that contact indicates that the submergence was rapid. Conversely, the upward gradation from mud into a succeeding peaty layer implies at least 0.5 m of relatively gradual shoaling and the consequent building of a new high-level marsh. Thus Washington's outer coast has undergone submergence and shoaling in cycles that resemble, at least superficially, the known and inferred cycles of coseismic submergence and postseismic shoaling in great-earthquake regions of Alaska and Chile.

Three points tend to confirm that great subduction earthquakes triggered the cycles of submergence and shoaling in Washington.

1) Nothing other than rapid tectonic subsidence readily explains the burial of the peaty layers. Deposition during floods and storms should promote emergence of a coastal lowland, not submergence to the level of T. maritima salt marshes. Filled tidal creeks commonly produce bodies of sediment that are thicker and less conformable than the mud beds that buried the lowlands. Shaking-induced settlement, although consistent with the sagging of peaty layers and thickening of intertidal mud over the soft Holocene fill of a Pleistocene valley, does not explain why intertidal mud buries the peaty layers where they lap onto stiff Pleistocene deposits of the valley's sides. Purely isostatic and eustatic submergence during the late Holocene should have been sufficiently gradual to permit the high parts of tidal marshes to build apace with rising relative sea level, thereby producing homogeneous tidalmarsh peat many meters thick. Such peat is present on many mid-latitude coasts, Puget Sound included, but not at the sites that I studied within 20 km of Washington's outer coast. Late Holocene submergence along Washington's outer coast was punctuated by jerks of tectonic subsidence that prevented the continuous maintenance of high-level tidal marshes.

2) Tsunamis probably coincided with at least three of the episodes of rapid tectonic subsidence. A great subduction earthquake usually produces a great tsunami. The tsunami from the great 1960 Chile earthquake deposited sheets of sand on two or more Chilean lowlands in the belt of coseismic subsidence. Similarly, at Willapa Bay, a thin sandy interval mantles each of at least three buried lowlands among otherwise sand-free deposits. The most accessible of these sandy intervals forms a sheet (maximum thickness, 7 cm) that extends 3 km up the valley from the bayward edge of the buried marsh surface that it covers. This sheet disappears landward (Fig. 3B) and also becomes generally thinner and finer grained in that direction-a sign of a bayward source. Found only on buried lowlands, the sheet-like sandy intervals do not imply great storms or exotic tsunamis, for these events need not coincide with rapid tectonic subsidence at Willapa Bay. But approximate coincidence with Willapa Bay subsidence should be expected of tsunamis from great earthquakes in the Cascadia subduction zone.

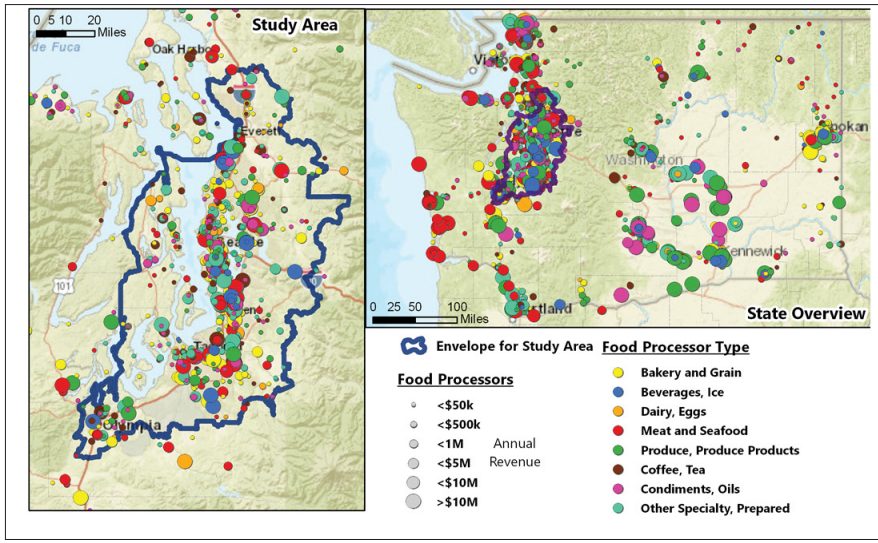
3) Tectonic subsidence during great subduction earthquakes could reconcile rates of short-term uplift with rates of long-term uplift in westernmost Washington. The uplift measured at tide gages and bench marks (2 to 3 mm per year average during the past 50 years) is much faster than that inferred from Pleistocene marine terraces (<0.5 mm per year average during the past -100,000 years). But these rates need not conflict if, as part of cyclic earthquake-related deformation, coseismic subsidence (like that inferred from the buried lowlands) has nearly negated cumulative interseismic uplift (of which tide-gage and bench-mark uplift would be a modern sample).

Jerky Holocene submergence at Washington estuaries thus strengthens the hypothesis that a future great earthquake could emanate from the Cascadia subduction zone. The number and shallow depth of buried lowlands at Willapa Bay may mean that at least six such earthquakes have occurred since sea level approached its present position on mid-latitude coasts, that is, since 7000 years ago. The earthquake ruptures, if really from events of magnitude 8 or greater, should have extended coastwise for at least 100 km. This corollary can be tested by determining the coastwise extent of individual episodes of coseismic subsidence. Another testable corollary is that shaking during the postulated earthquakes should have caused the liquefaction of Holocene coastal-lowland sand. If buried lowlands prove coeval for coastwise distances greater than 100 km, and if sand proves to have vented onto some of these lowlands at the start of burial, then the chronology of jerky submergence could be used to constrain the current probability of a great subduction earthquake in the Pacific Northwest.

Jerky submergence with shoaling, subsidence, rhythmic bedding, buried lowlands, sharp transitions from peat to mud, cyclic deformation, and sheet-forming thin sandy intervals is the text written in the earth. Earthquake and tsunami, our principal antagonists.

CONSIDERING CONTEXT

Juniper's current text is the list with addresses and fees-paid by licensed food processors from the Washington State Department of Agriculture. If the grocery distribution centers don't survive, maybe she can find enough volume upstream where food is packaged. Trying to address velocity, she has sent a request to the Washington State Department of Licensing for the number of Commercial Driver's Licenses (CDLs) in every zip code. Meanwhile she has a graduate assistant looking at public water systems and water-bottling facilities around Puget Sound.



Hanson, Lars et al, CNA, 2019

The interlacing of processing facilities with population density is potentially encouraging. Very few are likely to have emergency power backup, but there should be raw and finished stock on hand. She needs to ask about licensed food warehouses.

Miriam's Italian is much better than her Latin, but St. Jerome's texts are clear enough. Whatever the Greek originals may imply (much less the Aramaic sources) the author of the Vulgate produced purposeful set pieces. An angel pronounces, Mary responds. An angel

pronounces, the shepherds depart to see this saying. Jesus cries out in a loud voice, creation responds in grief. Action-reaction pushes the narrative forward, specific shards of experience plucked from the flow of time. Intellectually the narrative is a tattered fabric with as many gaps as patterns. But there is an emotional sense—hope—that gaps can be filled; the puzzle might still be made whole.

Whenever she considers Giant Components, the image that appears in Sophie's minds-eye is the cover of her childhood copy of *James and the Giant Peach.* How did something so small—so luscious—become so big and solid enough to fly from London to New York?

Giant Components are also "connected components." Many kinds of networks demonstrate a tendency overtime for a large proportion of nodes to link together, concentrating a high proportion of total flows among a limited set of tightly tied nodes.

Famously, Vilfredo Pareto found that 80 percent of his peas came from 20 percent of his pea plants. Inspired by this insight Pareto proceeded to demonstrate that 80 percent of Italy's wealth was owned by 20 percent of Italians. In the 1940s, Joseph Juran found that 80 percent of confirmed product problems were caused by 20 percent of known production process defects. Two years ago, Sophie found that 78 percent of her texts were sent and received from 18 percent of her contacts. It seems to her that about 20 percent of her colleagues cause about 80 percent of the research team's problems. She has usually been part of that tightly tied team component that generates about 80 percent of overall value. But not recently. Over the last four- or five-months ambiguity and ambivalence have persisted. Part of the challenge is shifting from deciphering well-documented prior impediments to anticipating how emerging network flows will create new constraints.

Giant Components have been fundamental to the volume, velocity, and efficiency of flows achieved since the 1980s. Concentrating volume and reducing touches was a big part of how Walmart decimated Sears. As Amazon and Walmart fight over the future of 21st Century retail, consolidation, and concentration, with more and bigger Giant

Components, have been recurring weapons in the fight. Will they be as essential for the next forty years? Or… have the concentrations now become enormous risk-pools poised toward collapse?

Like his father, Josh did his degree in geology. The last five years he has mostly made and sold bread and wine. He sculpts, driftwood and basalt most often. Ten large pieces have sold in the last three years. He helps install geothermal heating and cooling systems. He has been on crews digging several water wells. Sophie perceives that Josh is a fox. She is a hedgehog. Miriam perceives her son is a bold blend of his parent's strengths sans hang-ups. It seems to Josh that too many peers are creatively and ethically myopic. Certainty is mostly self-delusion. Uncertainty is a practical virtue. There are myriad equally valid alternatives to achieve almost anything. Deciding what should be achieved is seldom better than a deniable hypothesis. Life is ongoing exploration.

It could be 250 years from now or this next second, but eventually the accumulated pressure will cause one or both structures to break. The depth, range, and displacement of the break will decide how dramatic our consequences.

A thin crust of rock floats above a dense deep churning cauldron of hot brimstone and pitch. Early in earth's formation some flow slowed, cooled, and congealed along the surface as basalt. Other flows slowed, cooled and solidified under the surface as granite.

Ocean crust is mostly three to five-mile deep deposits of basalt. Continental crust consists of five to twenty-five-mile ramps of granite. The Juan de Fuca ocean crust—orphan remnant of ocean-bottom off Pangea—is slowly slipping beneath the crust of North America. Roughly 175 million years ago, the ocean's basalt foundations began to collide with the continent's granite. Heavier basalts are subducted—moved beneath—the lighter, continental rock.

The dense flow beneath each crust is pliable. Basalt and granite can grind against each other while the earth's mantle serves as a superheated waterbed beneath. But pinched between the mantle's mass and the continent's heavy crust, basalt will finally fracture, granite will crack.

JP has been spending quality time with data spawned by the Cascadia Initiative. Since 2011 the National Science Foundation has funded more than sixty ocean bottom seismometers to monitor activity in the subduction zone off the coasts of Washington, Oregon, and Northern California.

What the amphibious array has heard, JP sees as reduced velocity of seismic waves at the boundary of crustal solids with the Mantle's flow. The data are not decisive, but what has captured his attention are shadows consistent with an upwelling of the mantle beneath the Olympic mountains.

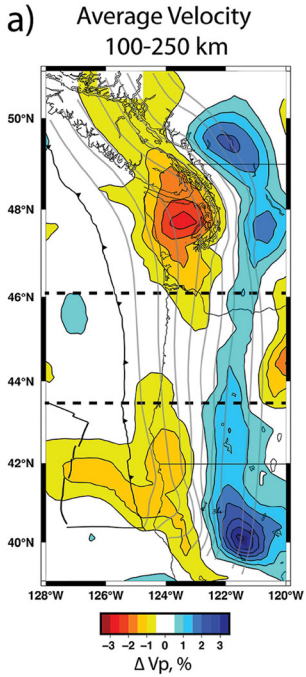
For JP this suggests that where the mantle's 1500-degree centigrade hot asphalt meets solid rock, a bit of water and/or carbon dioxide is now involved. This reduces the temperature needed to melt silica. Basalt may be restored to its lava-like origins. Beneath much of Eastern Washington, the basalt base of the Juan de Fuca plate could be melting.

If so, melt has accumulated since the 1700 megathrust. There is now—or seems to be—a bulge radiating from Mount Skokomish north to the Salish Sea, west to the Pacific, south to the Columbia River, extending to the granite ridges rising east of Puget Sound. A pulsing tumor has appeared in the waterbed. Melted rock is buoyant, but still heavy. Additional pressure is concentrated above the basalt with granite seam where the North American plate pushes above the Juan de Fuca. How much more will that seam hold?

If—well, when—the seam unravels it will find a much different place than January 1700. Mostly unchanged geological channels encompass very different content. People died then. According to oral traditions, whole villages were erased by tsunami and landslides. Now millions are gathered in those same and nearby places. These

millions also depend day-to-day on roads, bridges, ports, water systems, refineries, pipelines, dams, turbines, powerlines and many other links and nodes.

JP is especially concerned with how length and height of links and nodes may amplify seismic effects. The megathrust will be as a mallet striking a cymbal—or repeating mallet strikes on a set of different sized cymbals. Ground motion radiates outward in waves with specific amplitudes and frequency. Depending on the character of the wave, the ground through which the wave travels, and the mass, length and tension of the structure upon that ground, the result can be gentle swaying or violent shaking.



Bodmer, M., Toomey, D. R., Hooft, E. E. E., & Schmandt, B. (2018). Buoyant asthenosphere beneath Cascadia influences megathrust segmentation. Geophysical Research Letters, 45, 6954– 6962

Regions where seismic waves move more slowly, on average, are redder, while the areas where they move more quickly are bluer. The slower anomalous areas 150 km beneath the Earth's surface correspond to where colliding plates are more locked and tremor is more common.

WALKS VERSUS FLOWS

Another Text: "Round as an apple, deep as a cup and all the king's horses can't fill it up." What am I?

According to the nap-time rhymes read to Sophie by her mother's mother, the answer is "A well."

But before she was five years old, Sophie was unwilling to accept that answer. Grandma Vermillion had a well on her farm. It was much bigger than an apple and deeper than a cup. During a drought Sophie had seen her uncle digging the well deeper. That well could easily have been filled up.

When she was almost seven, Sophie spent most of that summer with her father's family in New Orleans. While jumping rope a cousin sang, "Round as a butter dish, deep as a cup, the Mississippi River can't fill it up."

Sophie, distracted (or the opposite), shouted, "What is it?"

"A sieve, silly," her cousin answered.

After disentangling from the Double Dutch ropes, Sophie asked, "What about round as an apple, deep as a cup and all the king's horses can't fill it up?"

"Nu uh," her cousin said, shaking her head. "That's wrong. Round as an apple, deep as a cup and all the king's horses cannot *pull* it up."

Years later Sophie credited that sweaty revelation of alternative rhymes for teaching her how to think.

Multiple observations of reality, different, dissonant, sometimes unreliable reports. Her first reaction: that answer is wrong. I need the right answer. But on reflection, Sophie found that while an initial report might be flawed, the flaw itself could be helpful. A well can be filled, but it cannot be pulled. Sieve and well describe two different relationships with water. Sieve and well describe different states of being with different but equally valid implications for absence.

Twenty years later Sophie's PhD dissertation would take on the role of absence in forming network topographies.

Nearly 300 years ago the mathematician Leonard Euler asked if a path exists to cross all seven bridges at Königsberg, but never cross any bridge more than once. Euler demonstrated this was impossible. He also discovered core characteristics of paths and walks as things-in-themselves.

For Euler only connections are relevant to deciphering the possible path. Only the existence or absence of a bridge (link or edge) between two riverbanks (nodes or vertices) are significant. The shapes or positions of any node or link are immaterial to the problem-solving. Euler observed that, except at the beginning and end of the walk, the number of times a node is entered is equal to the number of times it is exited (This number of links being the "degree" of the node.) As a result, to cross all bridges, but only cross each bridge once, depends on there either being zero nodes or exactly two nodes with an odd number—an odd degree—of links. At Königsberg all four nodes featured an odd number of links. Euler confirmed the null hypothesis.

For Sophie an equally interesting question is, where does a link's absence impede the walk's continuity? Where could placement of a link maximize—or optimize—potential flow? How can the walk become a circuit? How can a maze become a labyrinth?

For Sophie while Euler's links and nodes are fundamental, they are not sufficient. The number of links connected to a node—or its degree—says *something* about its importance or *potential* importance. But comparative value also depends on what and how much is moving across those links and through those nodes.

Sophie is increasingly persuaded that focusing on degree-distribution alone, regardless of position, is an unreliable indicator of network potential and network resilience. Giant components—giant peaches—come in many different forms: floating or flying, firm or squishy. Not every giant is friendly.

SOME SUBTEXT

Sunday, Josh picks up Sophie in his delivery van. She is vaguely anxious about brunch with JP and Miriam. They can be a challenging combination of head and heart, analysis and aesthetics, experience and exploration. They can surprise, suddenly reversing roles and expectations.

In many ways it is precisely their apposite differences that trouble Sophie. Long ago she rejected opposites-attract. In her experience, opposites conflict. Certainly, her mother and father did. In her early love affairs, the more he personified what she wanted—even needed—the more treacherous the relationship. Being together mostly amplified her deepest felt deficiencies.

JP and Miriam have been married nearly forty years. They knew each other for years before that. During one of the tough times a counselor offered, "You listen to each other. You do not interrupt. You ask questions. You are polite. I can assure you; this is not typical."

Josh claims his parents' relationship works well because one or the other is often gone. "They are perpetually getting reacquainted. Always learning something new."

Both have been seriously infatuated with others. "Jose Manuel Paloma is not my ideal type. Certainly, I am not his type," Miriam confesses. "I am not blond. I hate camping. The list continues. But we connect where it matters. We each look carefully. We take time to listen. We are slow—I am reluctant—to reach conclusions. We honor the mysteries, uncertainty… still-open possibilities of each other and life."

That mutual assessment reminds Sophie of connections she shares with Josh. This is another source of anxiety.

"Nervous?" he asks.

"A little, the usual"

"Today or last week?"

"Both."

They stop at Madison and Broadway. The First Hill Streetcar glides through the intersection.

"This week I probably made progress on Future Fulfillment, but everything is still very iffy… no clear formula yet."

"And today?"

"Your parents make me feel—well, being around your parents, triggers feeling… Philistine, transactional, sort of a sell-out."

"Because you work for a global name brand that makes billions and billions of dollars."

"Probably."

"Have you helped them make those billions?"

"Not really. Not yet."

"So right now," Josh is turning left. "You are being paid very nicely to indulge your curiosity in how networks behave."

"You've made this argument before."

"That's not Philistine. That's Michelangelo and the Medici. They could be mercenary. He was an artist."

Josh is once again surprised how something that looms so large can be so small. The 1908 white stucco one-story bungalow, snug between two-story neighbors, tightly hugging the top of the steep slope is where he lived until college. Still more than half his life.

JP and Miriam purchased the house in 1980 mostly because it was convenient and cheap. Now it would sell for more than $1 million. Boeing has gotten even bigger. Microsoft, Starbucks, Amazon, Costco, Fred Hutch and others have exploded. Ballooning demand. Constrained supply.

JP opens the wide-planked oak door to a sparsely furnished interior. Bright colors. One of their son's driftwood Poseidons is prominently displayed. A full, but fractured geode, indigo crystals sparkling, sits on a deep windowsill. The art changes; living, local artists are admired and encouraged. There is one 15th Century rendering of Christ seated on a stone bench with the woman caught in adultery. It is by an unknown artist who was clearly influenced by Fra Lippi. The woman's posture is fragile but regal. Long hair

falls over her right shoulder and barely covered breast. Jesus leans to draw on the earth. Miriam wants to believe—but does not insist—it might be an early Carnevale.

"Welcome, welcome," Miriam shouts from the dining room. She is arranging flowers cut ten minutes before from the narrow garden between front door and street.

Josh and JP hug. Sophie edges by to kiss Miriam.

"Still jet-lagged?" Sophie asks.

"Not bad," Miriam answers. "Dinner-time in Naples is lunch-time here. Let's see what happens after a second glass of wine."

Josh has brought two bottles of his second vintage. The oysters are already shucked, sitting on ice. JP will grill a salmon. Miriam has made risotto with fresh peas and mushrooms. Sophie has brought bread and salad.

"Cin-cin," JP raises his glass inviting others. "Welcome home Miriam and congratulations." The four glasses tinkle.

"Dad said everything is on its way?"

Miriam mugs and shrugs a tentative reply.

"She is walking on egg-shells," JP whispers.

"No missing pieces?" Sophie asks.

"So far everything we want is approved and prepared for shipment," Miriam answers.

"What's your favorite?"

"Probably Titian. We are leading with his Danae and cupid. Emotionally, Artemisia. I bet her Judith beheading Holofernes will get the most selfies. I have warmed to Ribera. I knew he was bloody. But there is tenderness I had missed before."

"The title will be flesh and blood, with lots of both," JP adds passing the risotto.

"This most recent trip, anything new, anything wonderful?" Sophie asks.

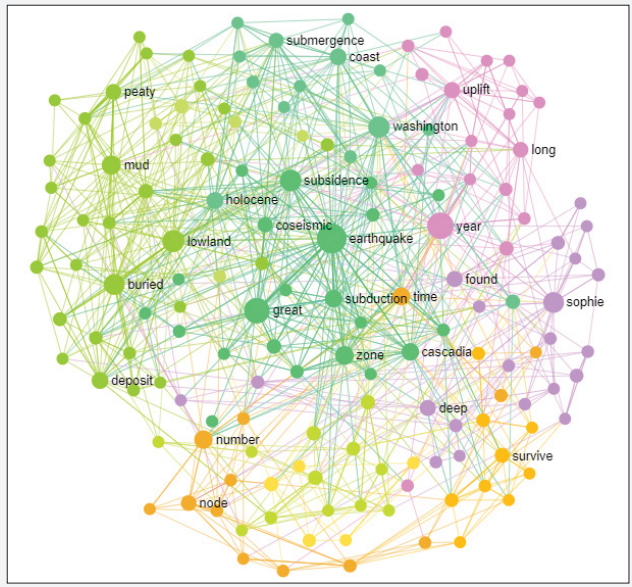
"A full week in Sicily, my longest there since Josh was born."

"Before Josh we went together. Even climbed Aetna," JP adds.

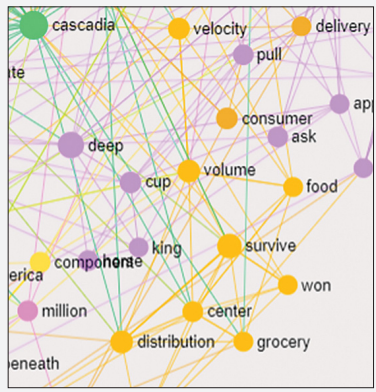
"Velasco and volcanos. An intersection of passions," Miriam laughs. She expects Josh was conceived at that inn on the beach at Naxos. Probably the morning after their ascent. Perhaps, she likes to think, just where the Greeks first made their home on Sicily.

In classical Greek, Aetna means "I burn."

NETWORK ANALYSIS: START TO PRIOR PAGE



So far network structure is diversified. There are clusters, contending or complementary? Moss-green is very earthy, dark-green is all things seismic (such as subsidence, subduction, and tectonic). Mauve involves many abstractions of time and space. Gold gives us functional—sometimes reciprocal—relationships: grocery with food, volume with velocity and then with distribution. Sophie, Josh, and Miriam are categorized as elements in time-and-space. But where is JP? How about Juniper and the General?



THE GROCERY SUMMIT

There are two dozen in the room, including Juniper, the General, the head of Washington State's emergency management agency, DHS and FEMA senior officials, several grocery distributors, retailers, and truckers.

Five grocery companies sell more than 80 percent of groceries consumed in Puget Sound. Intensely competitive, one or more will probably not survive the next ten years.

Most of the government officials in the room know each other. They meet often. None of the grocers have met before. Most of the grocers and truckers know one or two of the government officials in the room.

Jack is the warehouse manager for one of the big five grocers. He is glad to have been invited. He is also constantly scanning his phone for problems with morning outbound. He's got a good team, but he is usually there to keep the sluice slick. He also realized on the drive here, he doesn't want anyone to notice he might not be needed.

Here is a room near SeaTac. One big table. No windows. Coffee and bagels along the back wall.

Juniper introduces herself to Jack during the pre-meeting float. Once he describes his job, she asks whether Route 507 is viable for grocery transportation.

"Sure, we use it to deliver to Yelm."

"How about as an alternative to the Five?" she asks.

I-5? Did he hear her correctly? Shift what—inbound flow? -- from the Interstate to a two-lane wandering through small towns and countryside. Fortunately, just then they are asked to take their seats. He smiles as they separate.

All have been invited by a not-for-profit to talk together about feeding survivors of a Cascadia mega-thrust. The first thirty minutes consist of brief introductions from each invitee. "I am the planning chief for Snohomish County emergency management." "I am the warehouse manager for Fred Meyer/QFC." "I am the crisis manager for Albertsons." I am the new private sector liaison for Washington emergency management…"

Juniper is introduced by the not-for-profit's executive director. "She and her colleagues have just completed a flow map for groceries in the Puget Sound region."

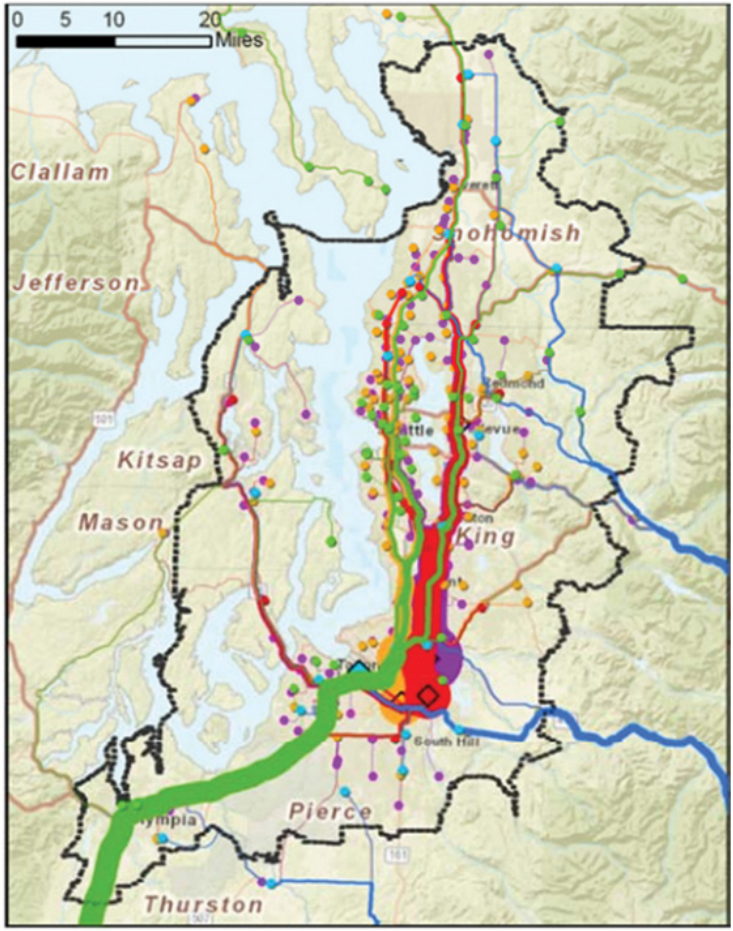
Juniper stands and walks toward the screen at the top of the table. But she stops behind Jack and across the table from most of the other grocers, self-positioned in a loose tribal cluster.

"I'm going to direct most of my presentation to the grocers who are with us," she says. "This is a data-driven picture of current grocery flows. The data is pretty clear. It could also be wrong. You know what really happens. Where does the data depart from reality? I want you to tell me anything that seems off to you. Ten percent off won't bother me. Twenty percent off is cause for concern. More than twenty suggests the data may be misleading."

She moves to the top of the table and punches up a map of population density in the Puget Sound region. "The goal is to give all of us a confident sense of Blue-Sky grocery flows. If we have a confirmed and shared understanding of these pre-event flows, we are going to be much better able to collaborate to serve survivors during Black-Sky."

Jack watches maps, tables, and statistics unfold in bright colors across the screen. Population and wealth pull food from across the continent. Southern California is an important source, Portland is almost as important, raw grains arrive by rail from the Dakotas, seafood and dairy are mostly local. I-5 carries more than double the freight of I-90. Puget Sound has less than 20 percent the road surface per person as Houston. Lots of truck drivers in Snohomish and Pierce counties. Tons of distribution centers, warehousing, and food processing along Route 167 in Kent Valley.

It's an interesting angle. Jack has a good sense of his inbound and outbound. He's never given much thought to his competitors' networks. Makes sense they would be similar. But he's still surprised how the five highly competitive grocery flows are from a distance almost the same. What was that Bette Midler song? The combined grocery flows remind him of a human heart and circulatory system.



Five competitive grocery flows (Hanson, Lars, et al, CNA, 2019)

It's a different angle on reality, but the flow maps mostly correspond to the same reality Jack has worked five or six days a week for the last twenty years. With one exception, according to the data, about half of the food consumed by people in Puget Sound is processed and packaged locally. This seems too high. What is locally processed and where it is processed seems about right, but how much seems off.

Jack looks at his competitors across the table. Do any of them seem skeptical? Are any of them about to say anything? He looks at government officials in the room. Is he the only one sensing something wrong?

For at least the third time Juniper asks, "Anything here seem significantly off? If the General makes a decision based on this information, can he depend on it being accurate or is he being misled?"

Jack bites his cheek, then raises his hand. "Your data says about half of groceries are processed locally. Half by what: weight, dollars, SKUs, cases, containers… what's the metric?"

"Both weight and dollar value are measured," Juniper answers. "In the case of Puget, the local proportion is not much different whether you look at weight or money."

"That seems high to me," Jack says.

"By how much," Juniper asks

"Maybe double."

"So, instead of half being locally processed, more like a quarter… in your experience?" Juniper is carefully watching the faces and posture of the other grocers. The crisis manager from Costco is nodding his head affirmatively. Others are not possible to read.

"By weight, locally sourced water would skew the results," Juniper suggests. "By dollars, locally sourced seafood and meat would add up quickly."

"How about wine?" an emergency management director asks.

"Excluded from this data-stream," Juniper responds.

Jack cocks his head thinking. "Still seems high. Most of what we push outbound comes long distances inbound. Lot of flow up the I-5."

All the other grocers are now nodding.

Each of the grocers have their own data sources that could size the local and non-local proportions with some specificity. But there are competitive implications of sharing that data. Juniper does not ask. She hopes that someday one or more of the grocers will offer. For now, there is a shared sense that the local proportion is probably somewhere between twenty and thirty percent. Still substantial.

The proportion of groceries having local origin ends up being the one open-question from the accumulated data-streams. All other

Blue-Sky flows derived from publicly available data cohere with the experience of the local grocers. Juniper is glad at least one data-outcome was questionable. It suggests the audience is paying attention.

There's a break. The participants are talking, not just texting and phoning. Another good sign.

Jack approaches Juniper, "Sorry to be the trouble-maker."

"Exactly the opposite."

"Really interesting question. If the I-5 is basically gone and we're trying to triple traffic over Snoqualmie, using all we've got close-at-hand is important."

"Any idea," she asks, "What the trucking capability of the processors might be. Is DSD (Direct Store Delivery) big in Puget?"

"Not really much volume. The bigger players deliver to a grocery or an institutional DC, you know, Sysco or US Foods, one of those. We can amortize the handling cost much better than any of the processors. They make. They deliver to us. We aggregate volume. We distribute and sell."

After the break, one of Juniper's colleagues presents what is projected to happen to Blue-Sky flows in case of three different seismic events. The Cascadia mega-thrust has the widest area impacts. It is expected to decimate the I-5 and most of the road network west of the mountains.

Four of the five Distribution Centers serving more than 80 percent of Puget Sound groceries are concentrated inside a ten-mile radius near Tacoma. It's a good place to receive flows up the I-5 and then truck into the urban matrix. Once upon a time the land was cheap. But all four are on liquefiable soils, unlikely to survive any of the three seismic projections. If any do survive, they will probably be cut-off by bridge failures and collapsed highways. Bye-bye velocity. If the grocers are right and a Pareto proportion of food products are processed outside the region: bye-bye volume as well. Not much left to feed millions of survivors who are not going anywhere anytime soon.

The prospect of losing each of their principal nodes and most of their links is mind-blowing to the grocers. Without the Distribution Centers it is very difficult to reestablish volume or velocity.

But the projected destruction of the grocery Distribution Centers seems to motivate government officials in the room. Two local emergency managers outline some prior planning they have done to deliver Meals-Ready-to-Eat (MREs) by boat. Could food be moved from Port of Oakland to some emergency dock to make up for lost roads?

How about moving resources south from Canada instead of north from Portland? Could a pop-up Distribution Center or expeditionary cross-docks be established to receive volume and begin to recover velocity? Another local points out that the area round Paine Field and the big Boeing plant at Everett is expected to survive Cascadia reasonably well. Could the Big Four Distribution Centers be relocated from Tacoma to Mukilteo?

Jack's mind is racing. Years before he worked at his company's San Francisco Bay Area Distribution Center. He pushed product to Port of Oakland for delivery to Hawaii. Jack knows the Oakland fleet is too small to supply Puget's population even if they stopped feeding Honolulu. If the navy could provide the vessels—his minds-eye sees dozens of D-Day landing craft dropping their bow ramps on the beach at Mukilteo—how would he get enough trucks with truckers onto the beach? How long would it take to load each van? Fork-lifts don't do well in sand. Anyway, his electric fork-lifts are out of juice and buried in the ruins of his DC, according to the projections.

The General notices the grocers have gone quiet. His government colleagues are talking about ideas that basically start from scratch to replace the prior network.

Another break.

The General approaches Jack. "Does that maritime delivery make any sense?"

"Not for my loads," Jack responds. "When do you begin pumping MREs?"

"Maybe by about day 6. Probably enough to feed 300,000 for, say, 20 days.

"But we're talking about 3 million."

"Two days then. That's why I'm glad you're at this table."

Coming back from break, the facilitator does a good job getting the grocers back into the discussion. They focus on trucks because that's the only way they can imagine moving enough volume. They ask about surviving warehouses not too far from their stricken Distribution Centers. They need docks as high as their truck-beds, floorspace, and a roof. Fuel for trucks. Some means of communications with the outside world will help with re-routing and reordering. Then they might be able to get a modicum of velocity going for shelf-stable products.

The old downtown hotel has a vintage oyster house. Juniper and the General meet for drinks and a shared appetizer, two east coasters already bleary late-afternoon Pacific time.

"Progress," he begins.

"Yes," she agrees.

"And a long way still to go," he adds.

She nods. "I want to believe we saw commitment emerging."

"Commitment?"

"To a shared problem. Your problem."

"Oh, that one: How do you water and feed millions of survivors without roads, power, or coms?"

A big platter of Oysters Rockefeller arrives, Romano Cheese still bubbling onto surrounding rock salt. The General asks for some sour dough bread.

Juniper steeples her hands over a half-finished glass of wine. "So, two recent thoughts. First, geologists suggest Cascadia recurs on a cycle of 300 to 500 years. We could still have a century or two to get ready. Second, while I can show why the entire network could cascade toward zero capacity, even when the proverbial sandpile collapses, not everything is flattened. Some connections persist. Networks can hold together beyond rational expectations."

A pause. The low hum of a restaurant before peak. Not silent, but quiet.

The General raises his glass, "Here's to irrational surprises."

PART II—CO-SEISMIC: LATE 2022

Latin/Greek compound, *co*: with, together, jointly; *seismos:* shaking.

That time and space when and where the geologic fault is shifting then rebounding, especially as experienced by humans.

An experience of disorder resulting from coupling, creeping, subduction, and other stresses being released, especially when the release is sudden and destructive.

THE MUNICH ANNUNCIATION IS THE LAST TO ARRIVE. Miriam takes light rail to meet the plane. The painting has traveled as carry-on with a curator from Alte Pinakothek. The twelve-inch by seventeen-inch Lindenwood panel is enclosed in a special case with its own first-class window seat. The curator sits protectively on the aisle. This is her first trip to Seattle.

Two museum security guards are already at international arrivals. Miriam and her German colleague will ride back to the museum in the cargo van. It has been a twelve-hour flight. Noon in Seattle is nine-at-night in Munich. Once the Antonello is safely inside the museum, the curator will be taken across the street to her hotel. Mary will be unpacked tomorrow morning.

The Syracuse annunciation is already hanging. A six-foot by six-foot fragile canvas, it was the last to be confirmed and most difficult to transport. It is now centered on the fourth-floor gallery's eastern wall. The Munich annunciation will be adjacent on the south wall.

On the other side of the wide doorway is the Benson Madonna. The West wall displays the large Messina Madonna. The two crucifixions share the North wall on either side of the doorway.

Anna, the Munich junior curator and courier, late-twenties or early-thirties, says she slept well on the plane and would appreciate help adjusting to local time, so Miriam joins her at the Four Seasons about three o'clock. They climb one block to Pike Place Market, watch salmon being thrown, then walk and talk their way ten blocks to the sculpture park.

"She is, I think, a very practical girl," Anna tells Miriam. "When I I first saw Greta Thunberg, I immediately added a full blue mantle."

Miriam laughs.

"No, truly." Anna continues, smiling. "So, that was—what?—almost three years ago now, just before the pandemic. Greta then, perhaps, fifteen. That is our Mary's age. Very young, but very self-possessed. Don't you think so too?"

"Perhaps, like Greta a bit prescient?" Miriam asks.

"Prescient?" the German asks

"Entshuldigen sie. Seeing the future. Knowing ahead."

"Ah, vorausschauend… More observant than prophetic probably. Women cannot afford *not* to see. We must find our nuts and berries through the leaves. Men must, I suppose, discount the risk they take hunting the beast."

Miriam does not reply.

They arrive at the sculpture garden with the sun low over the Sound. After the long walk they sit on orange chairs beneath Calder's huge orange Eagle.

"I am amazed Bellomo loaned you their Annunciazione," Anna changes topics.

"SAM was a lucky bystander. Uffizi wanted a Botticelli from the National Gallery. My DC colleagues were ready to agree if Florence pushed Syracuse. About eight chess moves later, I just arranged the logistics."

"All the hidden plumbing of the art world, rather sordid what we keep behind our beautiful brocade screens."

"Thank God for modern plumbing," Miriam rejoins. "Fifty years ago, Seattle would never have hosted these wonderful works. I might never have met your Quattrocento Greta."

"I love how she eyes Gabriel with such calm skepticism," Anna sits forward. "Not the half-lidded self-satisfaction of Syracuse."

"What is she saying?" Miriam asks.

"Wie kann das sein—How can this be—don't you think?"

Miriam senses her colleague's confidence. Younger than Josh, but already with her doctorate from Warburg. Youth, pedigree, brilliance? Perhaps some of each.

"Her arms suggest being threatened," Miriam offers.

"She is about to be raped. But I also think Antonello is showing off. He is such a master of hands, especially fingers, so he constructs the scene to display his strength."

Maria Annunciate (Maria der Verkündigung)
Antonello da Messina (1473) / Alte Pinakothek Munich

PUGET'S PULL AND PUSH

It is the second week in November 2022. Thanksgiving is Thursday, November 24, fourteen days to go. At 7 AM Juniper has brought a team of seven local, state, and federal emergency managers to a million square foot grocery distribution center near Tacoma to see how volume achieves velocity.

Dozens of pallet jacks whir past each other, emerging from long shadowy aisles. Selectors deliver five-foot high double pallets to the lineup behind each dock door, each pallet a Rubik's cube of various products, cases picked to match each store's order. Most selectors pick about a thousand cases per day. This Distribution Center averages 150,000 cases each day. So do, more or less, its four biggest competitors. Over the next seven weeks each will push 200,000 cases some days.

A Pareto Proportion—more than 80 percent—of groceries consumed by the population of Puget Sound flows from just five places. Three are within a few miles of each other near Tacoma. One is in Centralia, another hour south and the smallest contributor is way out on the other side of the mountains.

Three years ago, Juniper would never have asked to visit a grocery distribution center anytime in November or December. Earlier this year, after the second regional tabletop exercise, the grocers invited their public sector colleagues to watch the holiday surge underway.

Tom, the assistant warehouse manager, has guided Juniper and the seven others, all in orange safety-vests, to a safe-zone on the outbound staging dock.

"We've been picking and loading all night, "Tom shouts over the cacophonous din. "This shift of selectors started at 5:30. Most trucks that made over-night deliveries are already back in the yard and being topped off. The next shift of drivers will clock in soon. We'll roll out the next wave of deliveries between 8 and 9 o'clock. We shift focus to inbound 9 to 5."

"Most of our loads are 53' long vans, each just over 100" tall. We have to avoid going over 45,000 pounds. This means about 28 pallets

per van, fewer if we are loading something really heavy, like water. Each van is usually delivering to two stores. Getting the sequence right is critical."

In the nearest lineups, two men pull shrink wrap around side-by-side completed pallets. Almost running, they twist the glistening filament around the cardboard cartons. Behind them twenty more lines are being built, pallet jacks quickly enter and exit. Forklifts load vans. Other pallets are wrapped. Food for four million beginning to flow.

"It's really just math applied," Tom continues. "Today we have x number of vans, x number of trucks and x number of drivers. Everyday we have the same number of dock doors. The distance between these doors and our stores is always the same. Transport times are faster now than pre-pandemic, but not nearly as fast as during the pandemic, when the roads were empty. What is ordered and how much is ordered can shift quickly, especially this time of year, and we have very little control over shifts in demand. The only factor over which we do have some control is loading time and still there are only 24 hours in a day. But if we can speed up how quickly we pick a pallet and how quick we turn a truck; we can sometimes squeeze in more deliveries to a few more stores. Makes a big difference when your local store has had a sudden run on nutmeg. We usually have about three to five weeks supply available here, but that volume isn't worth much without the speed we can muster to deliver when and where it is needed."

Tom turns to Juniper, "Is that what you wanted me to say?" The visiting team laughs. Juniper smiles.

"Is it true?" she asks.

"True is a really big order," Tom replies. "Velocity is a big part of true. But there are lots of other parts. Every part is important."

"Would automation increase velocity?", one visitors asks.

"Automated picking? Robots building pallets? There are places doing that," Tom responds. "Seems to me the decision's still out on that one. For the reasons you're here, with the grid down after a big earthquake, I like what I've got. Three hundred human hands

connected to thinking minds are pretty good tools, especially on a really bad day."

They see the frozen turkeys being loaded. They encounter the steel wall of canned pumpkin, sweetcorn, gravy, and chicken broth neatly stacked. Tom explains that before the pandemic center-store products like canned goods had fallen sharply as a proportion of total grocery flows, but are now in higher demand, especially at Thanksgiving. At least twice each year, Juniper loves a quivering cylinder of cranberry sauce.

By 9 o'clock the visitors are on the opposite side of the distribution center from where they began. It is quieter here. Inbound is just starting to arrive. The flow is also much more concentrated. For inbound, pallets of the same product are unloaded and moved to an assigned place on the racks. The outbound pallets are aggregations of sometime single cases of many products. Inbound, Tom suggests, is more promising for automation than outbound.

"We run 100 to 120 trucks per day outbound." Tom says, his voice starting to sound scratchy. "We have received up to 150 trucks per day. About half are Full-Truck-Loads of a single SKU. But we also deal with several Less-Than-Truckload deliveries of more boutique or slow-moving products."

Jack joins the tour, bumping elbows and exchanging air hugs with the emergency management folks he has gotten to know over the last three years.

"Hey, let me add to Tom's welcome. Sorry I couldn't join you earlier. We lost two trucks overnight, missed four deliveries and there was a threat of more being missed today. Took us a while to redirect. As I'm sure Tom has explained, this time of year we need everything we've got to feed our stores."

Juniper offers a quick summary of lessons-learned so far: The Distribution Center is less a warehouse and much more a mixing bowl. The DC procures enough volume to leverage the best available price but not so much volume it can't move the product in good time, usually three to five weeks. So, volume available is tied tightly to velocity of demand. The more consumer pull, the more push. But there are limits. There are only so many trucks and drivers available.

There are only so many hours in the day. There are only so many miles of road. Velocity really depends on how quickly the DC can load and unload trucks. That's where flow is accelerated or not.

Jack furrows his brow and shakes his head. "O-k-a-y," he says slowly. The visiting team laughs again. "Wait, wait, I'm thinking." Jack raises both hands framing his chin at their intersection. "Tommy, we would never say it that way, but do you hear Dr. Juniper saying anything wrong?" Tom shakes his head.

Jack turns to the visitors. "I think over the last couple of years we have figured out that when Kathy summarizes something, she is testing for what we hear left out. "

Juniper stares at her shoes.

"So, if I am tasting a recipe, what Kathy has outlined covers the main ingredients. But there are a couple of herbs and spices important to getting it really right. Her summary can make it sound like a big pull just calls for a big push. One-hundred 18 wheelers unload single SKUs on one side; one-hundred 18 wheelers load up multiple SKUs on the other side. Then we move to the stores and stock shelves as quick as Seattle traffic allows."

Jack notices a supplier who just stepped onto the inbound staging dock. "Josh, hey Josh, you have some time?" Jack shouts and waves the man over.

"Let me introduce Josh Poloma one of our newest vendors. Josh, these folks are with local, state and federal emergency management or something related. They're here to help us be ready for a big earthquake. You answering some questions would help the cause, okay? So, how many cases of wine did you deliver to us today?"

"Fifty-two."

"When was the last time you delivered to us?"

"Last week. Forty-eight cases."

"And you started delivering to the DC in…?"

"Second week of August with 34 cases, one for each of your local stores."

Jack turns to the visitors, "Not an 18-wheeler. Not a Full-Truck-Load. Not huge volume. Not enormous velocity. Are you delivering to other retailer's DC's?"

"Not yet," Josh smiles.

"About what percentage of your total inventory are you moving with us?"

"I don't want to tell you," Josh laughs.

Jack smiles, "Smart guy. But while you don't want to be dependent on us, you're happy selling as much as possible through a single channel, right?"

"Sure. Costs me much less time, fuel, hassle to deliver fifty cases here than one case to fifty wine stores. My core value is wine-making—and I'm trying to get Jack's procurement guys to take on my bread and pastry too. Transport and delivery are really expensive for me. Jack can amortize his logistics costs over huge volume. I can't."

"Nearly sixty percent of our inbound gate calls are LTL—Less-Than-Truckload. Not efficient. Each time Josh shows up he costs me about 70 bucks. He delivers 52 cases. Unloading a full truckload—FTL—of, say, a thousand cases costs me about $200. Do the math. But I suffer the cost for Josh and many more local suppliers because they can differentiate our retail mix from competitors. Kathy's right, this is mostly a game of volume and velocity. You don't feed a million customers week-in-week-out without very efficiently moving volume at velocity. *And,* a significant element of our volume consists of lower velocity products. In fact, our ability to compete with our highest spending customers seems to increasingly depend on a collection of low-velocity products merchandised around the periphery of the store rather than the traditional products in the center of the store. The relationship between volume and velocity is shifting beneath our feet. We don't really know the answer yet, but it encourages us to take risks on good guys like Josh."

"So, to potentially state the obvious," Juniper adds. "These local low-velocity producers could be very important in the aftermath of a major event. If the FTLs are slowed or stopped by problems on the I-5 and I-90, Josh and many of his LTL peers are already inside the zone. Will this DC still be here? If not, is there a way to recreate

the opportunity for multiple smaller producers and processors to aggregate their products *somewhere* so that both volume and velocity can reemerge? How do we prepare Josh and his peers for sudden shifts in where and how they deliver? Josh alone is low volume and velocity. But when Josh and many others aggregate here, Jack can provide the volume and velocity needed to supply dense demand. We've got to get the FTLs back, unloaded, and into the mix ASAP too, but, as Jack and Tom have said, it's the whole combination that maximizes flow."

"Sounds like another good reason to begin aggregating my bread and pastry too," Josh adds.

Jack raises his hand into a traffic-cop-stop. "Convince procurement. Happy to have you on my dock."

More than an hour later Kathy Juniper walks back to her car. On the way she encounters Josh in the parking lot, just about to get into his delivery van.

"Thanks again for your help. I'm surprised you're still here," she offers.

"Had a meeting with procurement after I saw you and your crew. Good meeting. We've got a merchandising test for artisan cheese and crackers in three retail locations starting ASAP until January 1. Big opportunity."

"Congratulations. But no bread?"

"Not yet, crackers minimize potential losses for them—and us. Baby steps. Hey, if I can ask, are you looking at particular seismic events or earthquakes in general?"

"No particular fault, but only major events 7.0 and higher."

"Why just big ones?"

"From the supply chain angle smaller events can be worked-around with mostly standard measures. Tough job, but we know how to do it. The harder the hit, the wider the target, the longer

the grid and related is down, the more non-standard measures are needed to maintain flow."

"Gotcha…" Josh pauses. "I understand the nodes are important, but aren't the edges as or more important?"

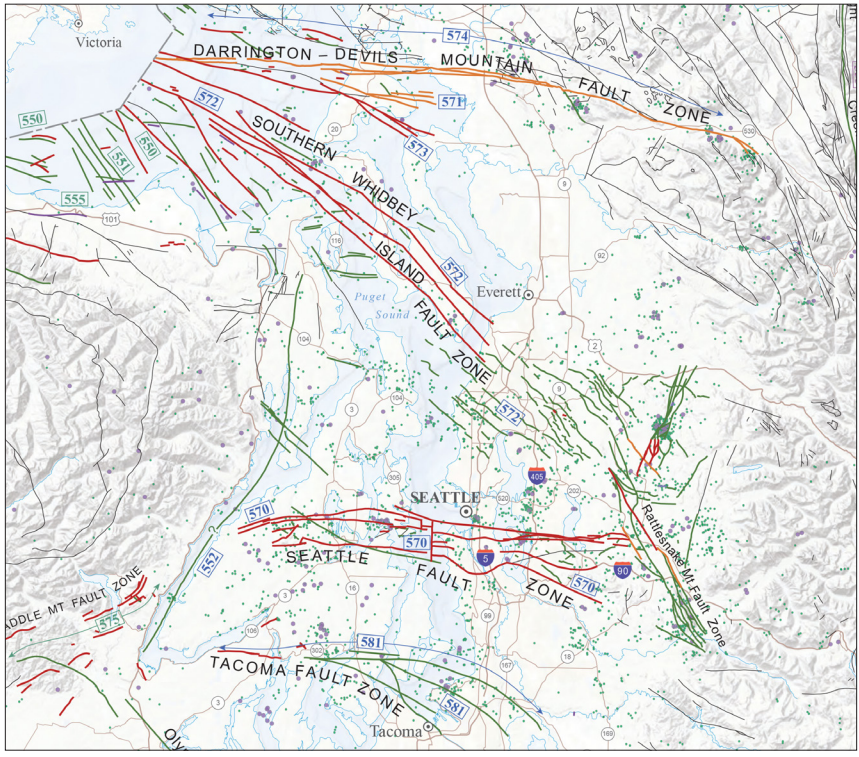
Juniper's head twitches slightly left and up. "Certainly, as important. What are you thinking?"

"Well, before I get here, l need to transit what's between where I am and here. So, just as a matter of sequence…"

"Yes, but the network can lose many vertices and edges and yet substantial capacity can persist if the Giant Component maintains integrity." She has shifted into jargon to test his reaction.

Josh does not hesitate. "So, you're depending on Centrality—high eigenvectors—to hold the network together?"

Kathy smiles, "Hoping against hope, more than depending. Do all wine makers make small-talk about eigenvector centrality?"



Seismic faults in the Puget Sound region

Josh laughs, "Only those who love a PhD in network science. But overheard and misunderstood or not, seems to me that in the kind of catastrophic events on which you are focusing, many of the key nodes will shatter. Hope will emerge, if anywhere, from the edges, from in-between, not from the center."

Origin implies movement. Destination requires movement. Nodes are usually intersections or, at least, once-upon intersections. A vertex of zero degree has no influence. An edge or arc is a boundary between, verging between, and usually both. A link is a connection, often one of many in a concatenation.

Classically an edge is an incident of a vertex. Edges emanate from vertices. Our path emerges from one place and concludes in another place. We start here, look there, *then* we consider connections. We tend to focus on places more than on lines.

But, *ex nihilo,* we move. Concentrations most often form from edges accumulated. Origin to destination is to suture steps between here and there. We close gaps between. The sometimes rough, random, ragged path that connects here to there is regularized with use. Over time suture swells into uterus prolific with aggregated edges.

Edges can grow in magnitude and assume a general direction becoming flow channeled and vectors measurable. Where many vectors meet, mathematicians speak of eigenvectors and eigenvector centrality.

The German *eigen* is most commonly translated by the English "own", but there is nuance in the German pointing beyond possession to being innate, essential, characteristic. Does the vertex own each vector or do converging vectors own their vertex?

Clearly there is interdependence, but Sophie has perceived a persistent deference to vertices that slightly skews her own observation and engagement. She wonders if this bias becomes an interpretive arc that obscures a more accurate view of underlying network realities.

A vertex without edges—a Distribution Center without road access—is absent from flow. Meanwhile the intersection of roads where a flattened Distribution Center once stood may still have very practical implications for flow. Which comes first, chicken or egg?

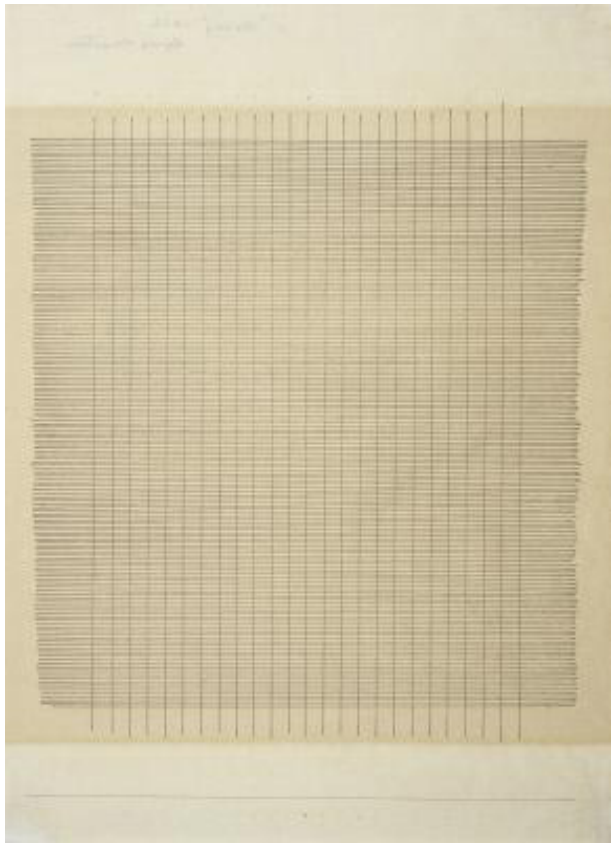
For Sophie, the edge—the path, line, arc, link—comes first. In 2018, partially based on Sophie's work, the ecommerce firm that employs her began investing in so-called micro-fulfillment centers. Near-equivalents had already begun to emerge in response to pragmatic requirements for rapid delivery. But initial deployments were opportunistic rather than strategic. Logistics managers were doing their best with what they could get. Sophie's research and recommendations suggested the possibility of principled siting that could optimize volume and velocity on a network-basis.

In most mature urban environments, nodes of wealth and population will shift overtime, but freight transportation pathways tend to persist. Even major improvements typically reinforce rather than displace preexisting channels. The edges increase in magnitude even as nodes can fluctuate. For velocity to keep pace, it helps for volume to be distributed across the network, rather than concentrated in larger and larger Giant Components.

Sophie's employers began quietly investing in network-centric siting of MFCs. Several formats were tested, including the so-called Star-System most closely associated with Sophie's work. She was not happy with the analytic reductionism. But her boss successfully sold the basic concept as disaggregating a single one-million square foot Distribution Center into five roughly 200,000 square foot MFCs, strategically located to reflect network dynamics. Early results have been promising. Procurement costs have not surged. Inventory costs have been just a bit lower. Distribution costs fell by almost five percent. Average delivery speed improved by nearly twenty percent. Sophie's pay has more than doubled.

With the additional income—and Miriam's help—Sophie has begun to explore her own interest in art. An early purchase is an auctioned set of ten Agnes Martin lithographs.

Miriam had introduced Sophie to a small set of works on paper the artist's sister had donated to SAM. Martin insisted, "There's no indication or hint about the material world in my painting. No, I don't paint about the world. Everybody else is painting about the world. That's enough." But Sophie disagrees. For Sophie, Martin's lines and intersections capture an essential characteristic of the universe.



The Cry
India ink on paper, 11 13/16 x 9 5/16 inches
Agnes Martin (1962)
Seattle Art Museum

RING OF FIRE

JP typically commits the last three weeks of his Intro class to the Pacific Ring of Fire, focusing on local faults and volcanoes.

"For more than 100 million years this section of ocean bottom has been squeezed between a much larger ocean bottom spreading east and the continental expanse of North America. This continent once met its Western ocean about where the Great Salt Lake sits. The 700-plus miles that now stretch between the Wasatch Range and an ocean view has accumulated from slow-motion—still-continuing—collision."

JP's PowerPoint clicks through shape-shifting maps leaping forward by tens-of-millions of years.

"Where two different velocities meet, there is friction. Where granite collides with granite, the Himalayas can emerge. When tight bonds of granite encounter the weaker olivine bonds of basalt, tight bends before and usually below what is loose. Where tectonic boundaries converge, after shoving, scraping and shuddering, one edge over-tops the other and the second—almost always granite—begins to sink. One edge is subducted—pulled under—the other. The descending crustal edge cools then knifes into hot mantle, expanding its disruptive reach. At this intersection of physical and thermal boundaries the rock becomes more friable, setting off further seismic movement. The sharper the angle, the greater potential movement."

The students are mostly sophomores, most somewhere in their early twenties. It is a night class. Geology 101 is an elective. It fulfills a distribution requirement, but most students take the intro physics or Bio 102 course instead.

"The longer the seam of subduction, the more energy is produced, accumulated, ready to be released. Where the oceanic encounters the continental between Vancouver Island and Mendocino Point is about 600 miles. Long enough to generate a magnitude nine earthquake."

"The moment magnitude scale now most commonly used for earthquakes is logarithmic," JP says. "Each whole number on the scale, 1.0 to 9.0., reflects a 32-fold increase in energy released. A 9.0 is 32,765-times as energetic as a 6.0."

JP is standing next to a dented blue cargo cart with twelve fifty-pound bags of sand neatly stacked. He reaches his hand into an open bag on top. "So, this handful is roughly 3000 grains of sand. Let's say this is equivalent to the energy released by a 6.0. Messy. Annoying. Thrown into a piece of equipment, it can do plenty of damage. Thrown into your eyes while you are driving, it is dangerous, even deadly. The 2014 Napa quake measured 6.0. One person died, about 300 were injured, up to $1 billion in damages were reported in a low-density location."

JP turns walks behind the blue cart. "These twelve bags hold more than 100,000,000 grains of sand. This reflects the energy released by a 9.0 earthquake. Almost 600 pounds. You don't want this falling on top of you."

Many years ago, JP referenced Hindu religious elements to characterize the merging of soft and hard, hot and cold, oceanic and continental. The cold steel of Shiva's sword breaks boundaries. The warm embrace of Parvarti raises mountains. The joining of Shiva and Parvarti unfolds in diversity, fertility, and all that humans know and love. First a Christian student complained of the Hindu aspect. Then another student heard implications of violent sex. When a non-Hindu complained this was an appropriation of Hindu culture, JP decided it was easier to dispense with poetic analogies.

He still argues that one of the assigned readings—*The Fragmented Death of the Farallon Plate*—does not describe disintegration, but integration. The Farallon plate is dynamic, not dying. Volcanic eruptions, strike-slips, and uplift are as easily understood as reformation as deformation. "Death," JP argues, "is characterized by stasis, what we thought was dead and buried is very much moving."

ANOTHER TEXT

One of the end-of-semester reading assignments for Geology 101 is *Effects of Simulated Magnitude 9 Earthquake Motions on Structures in the Pacific Northwest* by Marafi and Berman.

The Cascadia Subduction Zone (CSZ) produces long-duration, large-magnitude earthquakes that could severely affect structures in the Pacific Northwest (PNW). The long-period (1-7s) components of these ground motions from these earthquakes are amplified by deep sedimentary basins that underlie Seattle and several other cities around the Puget Sound. The effects of long duration and basin amplification are not well-studied for the CSZ because no recordings are available for M8-9 CSZ earthquakes. For these reasons, this study relies on an ensemble of simulated ground-motions to evaluate the impact of an M9 earthquake on structures in the PNW.

Ground Motion Intensity

The effects of deep basins are quantified using spectral acceleration. Figure 1 shows the maximum direction (RotD100) response spectra for the 30 simulated M9 scenarios for Seattle and for a location outside the Puget Lowland basin (La Grande, WA) that is located 80 km south of Seattle.

Both locations are ~100 km away from the rupture plane. In Seattle,

the median spectral acceleration (Fig. 1a, solid black line) is shown to be close to the MCER (red line) typically considered in building design. For La Grande, however, the median Sa values are much lower than the MCER (Fig 1b). Figure 1 also shows the 16th and 84th percentile Sa as dashed lines, which show that the variability in spectral acceleration is much larger inside the basin (Seattle) than the variability outside the basin (La Grande). These median Sa observed in these motions are similar to the MCER that is typically considered in design. However, the variability in Sa is larger than what is typically considered in non-linear analysis conducted in performance-based design.

An M9 earthquake on the Cascadia Subduction Zone has a recurrence interval of about ~500 years. The 475-year uniform hazard spectrum shown in Figure 1 (blue line) is much lower than the median M9 spectra. However, for a location outside the basin the median Sa values appear to be much closer to the 500-year UHS.

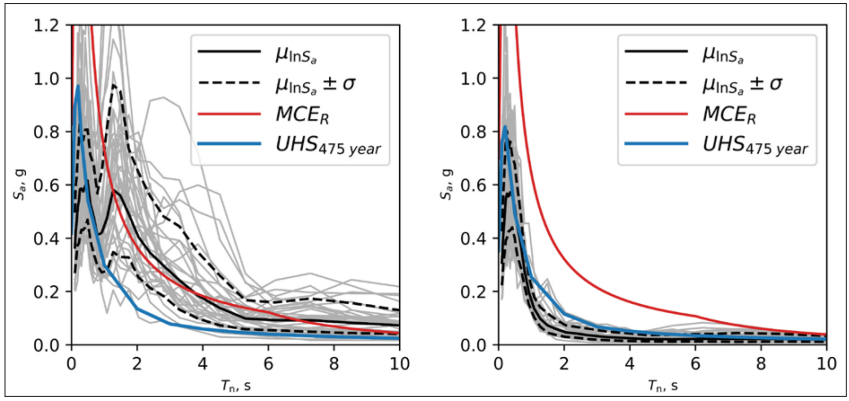


Figure 1. Response Spectra for motions in (a) Seattle, WA (inside basin) and (b) La Grande, WA (outside basin).

Subduction zone earthquakes are expected to be much longer than crustal earthquakes. Figure 2 shows the median 5-95% significant duration for the 30 realizations as a function of closest distance to rupture for the 30 realizations. A M9.0 CSZ earthquake is expected to produce motions that are around 110s long (in terms of Ds,5-95%) in Seattle ~100 km from the rupture plane. The deep Seattle basin was not found to significantly increase synthetic ground-motion durations.

Archetype Development

The effects of these simulated motions were evaluated for a set of archetypical reinforced concrete (RC) wall structures that were designed according to the current Seattle building code. These archetypal structures were designed to represent 4 to 40-story buildings. Figure 3 shows a typical floor plan for an RC wall archetype. Here, the impact of the M9 motions using 2-dimensional OpenSees models of the RC core in the uncoupled direction. Modeling of the cores was based on a methodology that has been previously validated using various quasi-static cyclic tests of RC structural walls.

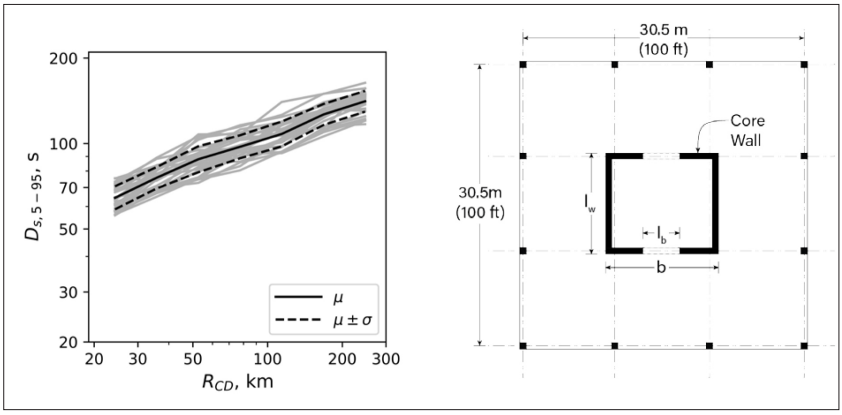


Figure 2. Significant duration (5-95%) with respect to closest distance for the 30 M9 realizations

Figure 3. Typical floor plan for an RC Wall Archetype

Impact on Structural Response

The deformation demands on the buildings were evaluated for 30 possible rupture realizations for a location in downtown Seattle and for La Grande (a location outside the basin). Figure 4 shows the maximum inter-story drifts in each story for the 24-story archetype. The median, 16th and 84th percentile maximum inter-story drifts are computed using ground-motions from all 30 realizations in Seattle (shown as black lines) and La Grande (shown as gray lines). Figure 4 and 5 shows that the inter-story drifts are much larger inside the basin (Seattle) as compared with a location outside the basin (La Grande). Additionally, the structure's deformation demands differed widely among the different scenarios as indicated by

the large variability (shown in Figure 4 and 5) in inter-story drift. For all archetypes, the deformation demands in terms of inter-story drifts is shown in Figure 5. The deformation demands due to the inside-basin motions (Seattle) exceeded those outside the basin (La Grande) by a factor of ~3-4. This increase in deformation demand is attributed to basin amplification of the long-period component of the motion causing higher spectral accelerations and damaging spectral shapes. These motions are also much longer (~100s) than those typically observed in crustal earthquakes and therefore may cause additional deformation once the structure yields. The peak inter-story drifts varied with period where the effects of the basin amplified spectral periods that greatly resonated with 12-story structures.

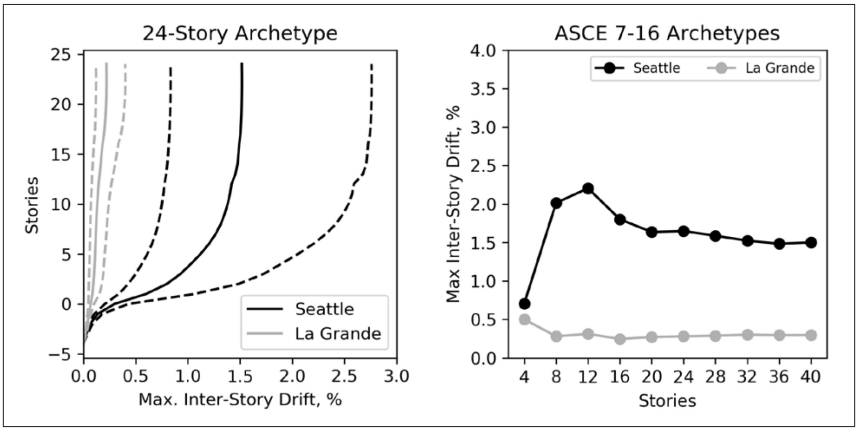


Figure 4. The maximum inter-story drift at each story for 30 M9 CSZ realizations in Seattle and in La Grande.

Figure 5. Maximum inter-story drifts with respect to number of stories in archetype.

Conclusions

Synthetic M9 earthquakes on the Cascadia Subduction Zone are shown to result in large deformation demands on RC wall archetypes in terms of the maximum inter-story drift. The maximum inter-story drifts demands were found to be ~3 times larger in Seattle, which overlies a deep sedimentary basin, than motions simulated outside the basin. This variability in deformation demand is attributed to amplifications in low-frequency waves that would increase the spectral accelerations at long periods. In addition, the variability in deformation demand is found to be much larger inside than outside the basin.

CONTEXT

The Westin Building in downtown Seattle is 34 stories, 409 feet tall. Originally built in 1981 as a hotel with offices (before the risk of Cascadia was widely recognized), it now hosts one of the world's largest communications exchanges. Miles of fiber optic, myriad telecomputing devices, and hundreds of racks digitally connecting Seattle to itself and with the planet. There are forty Seattle buildings as tall or taller than the Westin. Seventeen of these are hotels and/or residences. More are on the way.

SUBTERRANEAN SUBTEXT

We assume continuity. We anticipate current conditions persisting. We expect some change, some surprise, but mostly within a predictable range. We organize our individual and collective lives around what seem reasonable probabilities.

We also create change. We solve problems. We claim opportunities. We stumble into accidents. If our changes are intentional, success often depends on accurately understanding how current conditions will respond to our interventions.

Humans have changed Puget Sound. Only two centuries ago steep hills with tall Douglas Fir covered what is now Seattle. For over 5000 years the Puyallup River has followed the channels of volcanic lahars to feed rich tidal wetlands. Now Tahoma's port, fuel depots, and distribution centers sit atop sand and gravel that millennia of flooding carried from Mt. Rainer.

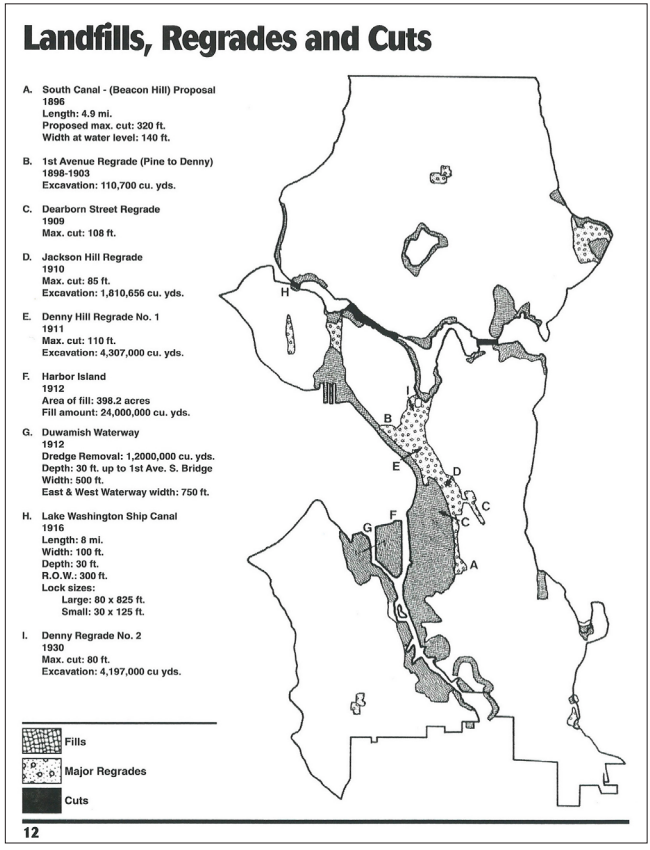
Seattle has been purposefully reshaped. Early in the Twentieth Century tall hills were flattened. Valleys were filled. Shoreline was created. When Harbor Island was finished in 1909 it was the largest artificial island in the world. It remains the heart of the port and home to important fuel infrastructure. Harbor Island sits where the Duwamish River empties into Elliott Bay. Roughly 85 feet of Beacon Hill was regraded to build the Island and what is now known as the SODO district.

Written history is short for this corner of the continent. We delayed and discounted too much to hear most of the oral tradition. Very few can read the story of soils like JP. When Seattle's hills were

being redistributed and the Puyallup was being put behind dikes, did anyone worry over liquefaction or "Ground Motion Intensity"?

As a result, three of the five most important grocery distribution centers serving Puget Sound are built on sand, gravel, and fill that a 7.0 plus earthquake will likely convert into something like oatmeal. The tallest buildings happen to have their foundations over the deepest most resonant portion of the basin, surrounded by glacial till rather recently deposited by human hands and ambition. The seismic waves spawned by Cascadia will be amplified within the basin prompting prolonged shuddering, shaking, displacement and potential failure of stiff structures, especially those taller and longer.

Tragedy requires heroes. In Sophocles and other classical dramatists, it is precisely admirable intentions and authentic strength that unveil the hero's fatal flaw. Unintended—unimagined, even unimaginable—consequences can unwind from honorable motivation.



Seattle Engineering Department Digest

THANKSGIVING 2022

Sophie will spend Thanksgiving with her mother, siblings, and extended family in Chicago. Josh is pushing wine, crackers, bread and pastry—and his dozen co-workers—until late Wednesday. He will be back at the bakery on Friday. Miriam is busy with final details; the Antonello exhibition's opening reception is December 1. JP wants to do something that will give both Josh and Miriam a break.

Thanksgiving had been JP's grandfather's favorite holiday. The Catalan refugee, agnostic, civil engineer was uncomfortable with the religious or commercial or jingoistic complexion of many holidays. But the original Jose Manuel Poloma was a disciplined, enthusiastic practitioner of giving thanks.

His older brother had been killed fighting Franco's Falange. JPs grandfather had intended to join another brother in Buenos Aires. A series of accidents brought him to Seattle instead. At first distraught, he flourished as the second world war revived the city's ports and factories. Argentina fractured and faltered as he watched. After the fall of Barcelona, his only sister fled into France where she was interned at Gurs. In 1941, with the help of Spanish Refugee Relief, Tia Maria was reunited in Seattle with her brother. For JP the grandson, Thanksgiving gathered a prosperous clan of first- and second-generation Americans at their matriarch's big house in Bellevue. It was not quite a prayer, but his grandfather opened each feast with the same words, "Ens reunim per donar gràcies per aquesta vida i els uns als alters" (We gather to give thanks for this life and each other). Later he might add, "When you have seen the alternatives up close, even your ankles crackle with gratitude."

JP calls his cousin Margaret in San Francisco, "Hola mi primo."

"Hola mi Pepe! How long it has been. Are you good?"

"Missing you and that huge gang at your grandmothers."

"It is like a dream. But fifty years now! Hard to believe."

They tell each other favorite stories.

"Well, I have called to get your help," JP says. "Do you have your grandmother's recipe for Mar i Muntanya?"

Margaret laughs, "Well, sort of, it changed every year depending on what she saw at the store and maybe her mood."

Sea-and-Mountains, at least in JPs memory, combines chicken and shrimp slow-cooked in tomatoes, onions, garlic, brandy and olive oil.

Margaret emails a detailed recipe, some more memories, and pictures of her grandchildren. Wednesday he braves the crowds at the huge Safeway on Madison.

The spot shrimp JP buys were caught four days before in the Hood Canal. Most of the fresh chicken sold in Seattle comes from Lewis County. But JP selects a whole chicken that claims to be free range, "Northwest" raised, and processed in Mt. Vernon. Yellow onions are on sale. Washington grows more onions than any other state. Garlic is grown commercially in Washington, but the cloves JP buys were trucked from California. His tomatoes ripened near Sacramento and were canned in Oakdale, California (in cans made in Reno by a company headquartered in Luxembourg). JP does not buy olive oil, there are two bottles in the kitchen cabinet. One is a can of Oleoestepa Arbequina from Spain, the other a bottle of California olives blended in West Seattle, a gift from Josh last Christmas. Almonds for the picada were grown in central California. Sophie always brings the bread. In her absence, should he buy from the deli or try to make his own? Do they have any flour at home? JP forgot to check. Josh can bring bread. Just in case, JP grabs a whole wheat baguette baked in South Seattle, with flour milled in Fairhaven from grain grown near Walla Walla. The bread had been delivered by bakery van—Direct Store Delivery—that morning.

The 737 from Seattle makes a wide U turn over Lake Michigan then descends for O'Hare, breaking through thick clouds above Foster Beach. The blue-green grid of nighttime Chicago extends into infinity. Gazing south, Sophie whispers into the window, "Under his ribs the heart of the people, Laughing!" She remembers the rest: "Laughing the stormy, husky, brawling laughter of Youth, half-naked, sweating, proud to be Hog Butcher, Tool Maker, Stacker of Wheat, Player with Railroads and Freight Handler to the Nation." Railways connected the town and made it a city. Chicago continues connecting, heart still pulsing.

JP does not consider himself a cook. But on Thursday morning while Miriam sleeps late, he begins cutting, boiling, mixing, and frying. He aims to have the menu mostly in the oven or simmering by eleven-thirty.

"Happy Thanksgiving," she says from the kitchen doorway, her voice still husky from sleep.

"Late night," JP responds with a peck to her cheek.

"Yes. Smells wonderful, reminds me of Naples."

JP was already asleep when Miriam returned on Wednesday night. He reports Josh should arrive between 12:30 and one. After some coffee, she fixes toast.

"I assume there are problems?" he asks.

"Katherine stopped by yesterday."

"Oh." Katherine is a member of the museum's board and a major donor. She and Miriam do not click.

"She's troubled by the Vulgate."

"She was surprised?"

"No evidence she had read any of the plans or updates. Obscurity of the Latin is a key curatorial point. But she called it 'another impediment'."

"Another?"

"As in one more typical example of old-school art-historical pretentions. Out-of-touch with where art lovers are going."

"Where are they going?" JP asks while braising onions.

"Apparently anywhere that makes them feel smart. Avoid anyplace that suggests they don't already know everything."

"And how does this...?"

"Each of the Antonellos relate to a specific Biblical text, originally Greek accounts of Aramaic, but his text was the Latin Vulgate. The *point* being he is translating what is already twice translated and we are translating his translation."

"'Revenge of the intellect upon art'?"

"Now you're just being cruel. No, Katherine wouldn't even recognize Susan Sontag's name. She's barely older than Josh."

"Anyway, Katherine finds your exegesis an impediment?"

"Katherine is into immediacy. Art is, she insists, about emotion. I tried to talk through our emotional encounter with mystery, the mystical, what we know we cannot fully know. The most explicit text still requires context and every context has subtle, sometimes hidden subtext. Our encounter with the not-fully-knowable is deeply emotional—two lovers still mysterious to each other… This was not a successful argument."

"So…?"

"So, I hope two or three visitors collapse in emotional conniption fits or full-on religious rapture. Otherwise the January Board meeting will be even more fraught than usual."

"This is why you were late?"

"Oh, not at all." Miriam retrieves a yogurt from the refrigerator. "We were re-hanging the fore-gallery. The first layout just wasn't working. Nathan had a brainstorm. He was right. We still have some more to do on Monday, but there's time. We may go in this weekend. He said he'll text me. After dealing with Katherine, it was good to use my hands and sweat."

JP, Miriam, and Josh hold hands around the kitchen table. The cook offers, "We gather to give thanks for this life and each other." He says the English, but JP hears his grandfather's Catalan.

The shrimp and chicken sit in a sizzling skillet in the middle of the table. There is also Samfaina—diced eggplant, zucchini, green and red peppers, glistening in olive oil—rice, bread and toast. Josh brought a loaf, his goat cheese, and wine.

It's raining. But the little house is bright, warm from cooking. Redman, Mehldau, McBride, and Blade riff on St. Thomas.

Happy memories mix with current complaints and absurdist stories that all three find hilarious. They have noticed Sophie does not share this taste. Her absence has turned a tap.

Miriam weeps with laughter. JP refills their wine glasses. Josh finishes the story, "…and she stalked away wrapped in shredded dignity." Brian Blade begins his drum solo.

Miriam recognizes Sophie's chime on Josh's phone. He glances and passes it screen-front to his parents. There is a selfie of Sophie with her mother, grandmother, and two other women. Aunts Nancy and Imani, the text says.

"Were you invited?" Miriam asks.

"Yes, but I think she was glad I stayed here."

"Giving quality time to bread-baking instead of grandma?" JP inserts from near the stove.

"Yes," Josh answers, "*and* choosing to invest quality time with co-workers, key customers, and each of you. Chicago is far away. Sophie's relationship with her family is plenty complicated. She has mixed feelings about adding yet another complication."

"Like you?" Miriam asks.

"Very much like me." Josh answers.

"Are you curious? About her context? About her origins?" JP asks.

"Sure. But I'm more interested in Sophie's internal narrative than any quick impressions I would pick up during a forty-eight-hour field trip. To Mom's point, Sophie's self-created subtext is more important than the explicit family ties."

"When did I say anything like that?" Miriam laughs.

"I think he's working up a pretext," JP offers.

"Okay, okay," Josh sighs. "I'm outnumbered and outclassed. But cohesion can be as valuable as connection."

"That's an audacious assertion, tell us more," his father responds.

No quick answer. Josh would welcome a diversion. But the request is not superseded.

"Well, the three of us… We cohere. Don't you think? We are physically and emotionally close. We like each other. We often communicate. We help each other. We want to please each other. In many ways we depend on each other. I am, after all, the result of your

intersection. As important—often more important—I am, maybe each of us are, an expression of shared energy. We are, it seems to me, *each* stronger because we are tightly linked. We are each more than the sum of our connections. Some sort of multiplier effect emerges from our cohesion. Our co-occurrence."

Miriam is still seated at the kitchen table. She reaches for her wine glass. JP is removing something from the oven.

"This is not Sophie's experience. She has many more connections than I do. Her family circle is much bigger and more widely scattered. Her workplace is frighteningly self-conscious about its far-flung network. But most of her connections are very loose. She is tight with her mother. Fairly tight with me. But otherwise there's not much push or pull. She floats just outside the flow. Excluded or self-excluding…"

"By choice or circumstance or the choice of others?" JP asks

"Each. Sometimes all." Josh answers.

"But tonight, she's with her family and sent you this text," Miriam objects.

"She can choose to join a flow. Floods can claim her too. But really, I'm trying to make a different point." Josh closes his eyes. "Maybe the real issue is not about connections or volume or velocity, but content of flow."

"I think you're a geologist trying hard to feel like a network scientist." JP smiles.

"Or at least sound like one," Miriam adds.

"Maybe," Josh sounds dissatisfied. "But the wine-maker knows it's not just a matter of bushels harvested, but the quality of the harvest and what happens next."

"GURRRRR," a grinding electronica emanates from JP.

"What on earth…" Miriam is startled.

JP checks his cell phone. "New Earthquake Early Warning signal. Looks like a less-than-five off the Oregon coast."

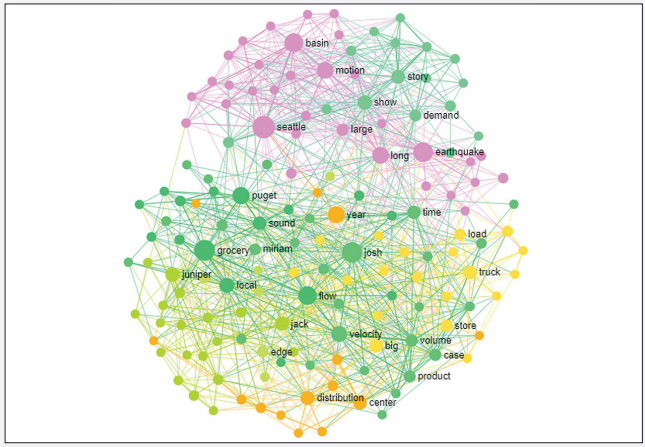
"That's the first time I've heard that growl," Miriam says. "I thought we were constantly creaking and creeping."

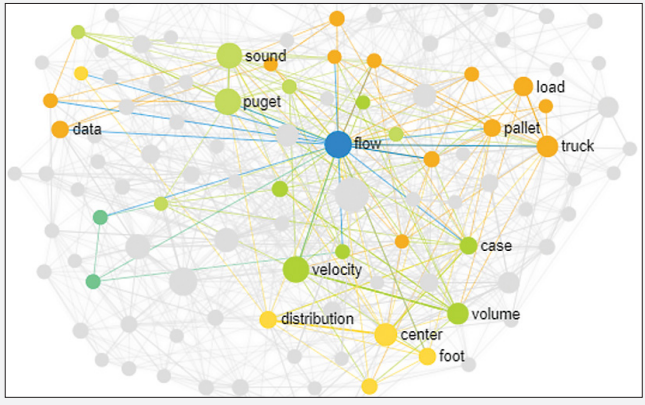
"I set an alert threshold for anything at 4.6 or above." Only the second one I've heard since I downloaded the app about three weeks ago."

At street level Chicago's blue-green linearity dissolves. From 5000 feet car-lights flow. At five feet they speed forward, stop suddenly, and swerve. Oncoming headlights blind. Sunday before dawn, Sophie's youngest half-sister drives her back to O'Hare. Real-time traffic to Sophie's phone allows them to avoid two bad back-ups on the I-90. The sister is eleven years younger. They barely know each other. They very seldom interact, but they share a persistent and powerful link with their mother. Their dense collection of shared connections can be graphed and measured. The quality—or absence—of content is much more difficult to capture.

NETWORK ANALYSIS OF PAGES 1 TO 67

The network structure of "He Looks at the Earth" continues to be diversified. There are more than five narrative clusters reflecting a balanced representation of several perspectives. Purple is now space, place, and structures. Lime green is time-as-experienced. The other clusters—principally Distribution Center operations (gold) and movement (bright green)—are much more interspersed. Nodes with the highest centrality (betweenness) are Seattle, earthquake, Josh, and grocery. There is an observable boundary between upper and lower, between purple with lime green and all the rest. Does this suggest a boundary between preconditions (upper) and active variables (lower)? Flow (below) is related to several aspects of Distribution Center operations and movement, especially velocity of grocery in Puget Sound.





ANTONELLO DA MESSINA

He was born in Messina. He died in Messina. He lived briefly at Naples and Venice, perhaps Rome and Milan. At least one biographer has him in Bruges and other Northern climes. The Bellini brothers and Mantegna were contemporaries. Two decades older than Leonardo, two generations before Michelangelo. Antonello's sources were Catalan, Burgundian, Provencal, Netherlandish, every hue of the Italian kaleidoscope, Classical, Medieval, and modern. Keith Christiansen, chairman of the Met's European Department, has written that "Antonello da Messina is, in a sense, the first European painter."

For Miriam, Antonello is the personification of ambivalence. Both his biography and his art suggest a decisive personality, but he is comfortable with—perhaps prefers –contending strengths. He explores. He combines. His choices are inclusive, iterative, often oblique.

The Munich Annunciation depicts a particular personality. Mary is alone. The open book and blue mantle are clues for some, but meaningless to many. Must this even be Mary? It is essentially a portrait, probably intended for private devotion.

The Syracuse Annunciation is social. Beyond the windows fishing, travel, commerce, and perhaps courtship can be discerned. Gabriel stands in pale brocaded beauty. The Holy Spirit is present as a dark double bird. This is one part of an altarpiece intended for communal worship.

Syracuse is profoundly wounded, a patchwork of fragments, including remains of a left ear, neck, and cheek of its patron. The large, roughly 6x6 foot work has—barely—survived earthquakes, misguided restorations, and extended neglect.

The Syracuse annunciation strikes many casual 21st Century observers as the more traditional religious form superseded by Munich's lonely modern Mary. But scholars date both to the mid-1470s, and several argue that Munich precedes Syracuse.

Antonello's oeuvre is no series of theses with antitheses unfolding into synthesis. Differences collide, coincide, cohere.

In the Seattle Art Museum's Fourth Floor Galleries the contending

annunciations are joined by four more of Antonello's Marys. The earliest, oil painted on wood from 1460, is a grief-stricken mother hands-clasped in agony standing rigidly at the foot of the cross. A second—later—crucifixion, also oil on wood, gives us Mary seated, soft, and contemplative. An austere Mother and child, rendered in old-fashioned tempera, is hung next to a brightly charismatic Madonna col bambino painted in oil.

Annuciazione
Antonello da Messina (1474)
Galleria Regionale di Palazzo Bellomo, Syracuse

The Friday evening reception is a preview for key donors, upper end museum members, and special guests. Senior staff have traveled from the lending museums in London, Munich, Sibiu, Messina, and Syracuse. Rome and Bucharest have sent two senior civil servants each. The Sicilian Regional government has sent three. There are two

curators and a development officer from the National Gallery of Art in Washington DC. NGA lent the Benson Madonna and will inherit the other five for its own Spring exhibition.

Miriam is wearing an indigo blue gown. JP found a matching blue tie that she vetoed as "too cute." For the first time Sophie has agreed to join Josh at one of these rituals. She notices conversational clusters of four to six, many more fours than sixes. She observes a few individuals—museum staff?—flitting between the clusters, sometimes shepherding two clusters together; all of which soon morph again into sub-sets of no more than six, more often four. Some masks, but not many.

Three hundred-twenty were invited. One-hundred eighty-three are now drinking, nibbling, and talking in the African galleries between the fourth-floor escalator and the rehung European galleries. An El Anatsui sculpture of discarded gold, mulberry, and phlox aluminum presides over a temporary wine-bar. It is hung to imply rippling kente cloth. Sophie notices the title: *Takpekpe,* meaning conference.

A one-foot riser and podium has been erected beneath a large banner featuring the Benson Madonna and announcing *Mother of God, December 2, 2022 to April 2, 2023.* Here the social cluster is larger, more than a dozen, but also more diffuse. Several stand shoulder-to-shoulder, but silently, neither listening nor talking.

"Good evening." Miriam's boss, the museum's CEO stands behind the podium. "Good evening," she repeats as the crowd quiets and weaves a bit tighter. "Thank you for joining us to open this important and gorgeous exhibition. Tonight, we celebrate the extraordinary skill of Antonello da Messina. We celebrate, again and always, the effervescence of Quattrocento Italy. Tonight, we also celebrate the life and legacy of, arguably, the most influential woman in Western civilization."

The CEO proceeds to acknowledge donors and lenders and assorted dignitaries. Miriam would have preferred for these formalities to end quickly, allowing the art—with her curatorial clues—to speak for themselves. But contracted conditions for lending the Syracuse annunciation require opening remarks by the director of the Palazzo Bellomo museum.

"Bueno sera," he begins. "Tonight, we also celebrate—interrogate—the mysteries of becoming and the secrets of surviving. In a few minutes you will stand before the Palazzo Bellomo's most important treasure. We seldom part with her. "

"Our annunciation is important because Antonello is important. It is a hinge work in a hinge career at the hinge between medieval and modern. A British friend tells me *pivotal* would be better here than hinge. But I stay with hinge, to point toward edges. Rome is a pivot. London is a pivot. Washington is a pivot." He points to each of his colleagues. "Syracuse, Messina, Sicily, we are on the edge. Antonello was on the edge. The Quattrocento miracle emerged from the edges."

"Antonello was on the edge between land and sea, cultures and dynasties, ancient methods and experimental techniques. From these liminal edges, from this being-between he saw and felt, we see and feel, realities that are difficult to discern from great centers, obscured by each pivot's constant spinning."

"My esteemed countryman Giovanni Battista Cavalcaselle wrote that Antonello's, 'first and last picture, and those of the Bellini, were, so to speak, the links of a perfect chain. The Italian nature of Antonello grew as he increased in years, his latest picture being the least Flemish, and the most like those of the Bellini… From that to the perfection of Giorgione and of Titian was but a step'. While Cavalcaselle is often brilliant, here he is wrong. Please do not persist in his error. Cavalcaselle was a man of the center, born into the self-conscious decadence of early 19th Century Venice, he adopted the imperial confidence of London ascendant, dominant. As a creature of the center, Cavalcasselle craves continuity, certainty, control. Antonello, from his lifetime on the edges, was the wiser—at least more realistic—man."

"The center does not hold. Eventually pivots pull too hard or other pivots pull away. Old is retrieved, new is forgotten. Layers accumulate then wash away. The whole fractures. Surviving fragments are too often mistaken for unrelated wholes. Rather they are parts still needing other parts. Centers collapse. Edges adapt. Tonight, you will see six aspects of one artist and a single subject. Antonello's subject is a woman on the verge. We are given alternate views of three essential, very human, inflections: opening, birthing, closing."

"Many have joined with Signor Cavalcasselle to rationalize Antonello, to make him one more link in their neat mechanical chain. But just as Antonello the man rejected the tyrannical Duke of Milan, Antonello's art resists these petty tyrants."

"When you consider my tattered annunciation, see her fighting for Antonello's liberty. If he had not signed that contract, the tyrants would surely claim the Syracuse annunciation to be closer in sequence to his early works. But the signed contract for future work," he emphasizes future and pauses, "is clearly dated August 1474. The next August, Antonello is at San Cassiano in the heart of Venice. The center of the center. With this the tyrants are overthrown. Within, you will see Munich's Annunciation, painted at Messina in 1473. From the very same year, we have the San Gregorio Madonna, still cherished at home in Messina. Then my annunciation from 1474 or later. Then London's somber even implosive Mary from, let us say, 1475 and, dramatically making my point, most now date our sultry blond Benson Madonna from the very same year. One subject. One artist. Reality shifting, surging, ebbing, flowing before our eyes."

Miriam is surprised and impressed. She had perceived the director to be more of a bureaucrat. Scanning the crowd, she notices Katherine standing with arms crossed. Deeply engaged or resisting, Miriam cannot decide.

"The tumbling, sometimes trickling current continues," his voice is gravelly. "In 1693 the church sheltering my annunciation was destroyed by earthquake. Badly damaged, during reconstruction the altarpiece was put aside and forgotten. For two centuries our Mary and Gabriel and all their busy friends almost disappear, finally retrieved and recognized in the late 19th Century. The convent in Messina that hosted our Christ-child and Mary with hovering crown and angels was seriously damaged by a series of earthquakes in 1783. Another massive earthquake in 1908 brought down the walls and left the entire ensemble in the rain for days. Similar stories could be told about most of Antonello's creations. Many have not survived. Yet here we are, almost six centuries from his birth celebrating the artist and his still quite edgy art."

"Tonight, as you encounter each of these six very particular forms, please notice how they differ. Please consider why Antonello has

deployed these differences. Please be motivated to learn more. Please allow Antonello to spur your emotion, imagination, curiosity, and thinking. But do not presume to divide what is whole. Do not presume one displaces another. Do not break apart but bring together."

"Another of my esteemed countrymen wrote," He slips into carefully enunciated Italian:

Tu stesso ti fai grosso
col falso imaginar, sì che non vedi
ciò che vedresti se l'avessi scosso.

You dull your own perceiving
with false fancies, failing to see
that visible but for preconceiving

"We are great-grandchildren of skeptical analysis and secular optimism. We have taken apart the natural world to remake it. We have placed ourselves at the center. We pull pivots of our own making. Can we step away from this center, just for this evening? Can we still join Antonello on the edge? Can we put aside our powerful preconceptions? Should we—can we—see in Antonello's exquisite, concurrent, cohering divergence a way to restore the whole? At the very least, tonight I invite you to open your eyes to this beguiling im-pro-ba-bi-li-ty."

There are at least two seconds of uncertain silence, then—mostly enthusiastic—applause. Even from Katherine, Miriam observes.

After exchanging words with his peers from London, Sibiu, Seattle and others, he stands in front of Miriam. Brushing her right cheek he whispers, "Mille grazie per l'aiuto con Dante."

JP knew about the subduction of the African plate along the Calabrian arc years before he was introduced to Cascadia's lap dance in his own backyard. That's why he and Miriam were in Sicily on his post-doc to study coastal subsidence and submarine landslides. His dissertation had focused on these factors for the 1964 Alaska earthquake.

Standing in front of the Messina Madonna he imagines December 28, 1908: thirty seconds or more of intense shaking, masonry and stone buildings releasing seams, beams and foundations, a twenty-foot tsunami, more than 100,000 fatalities, and 200-plus recorded aftershocks.

The baby Jesus chooses cherries—symbolizing his bloody martyrdom—from his mother's palm. Miriam's curatorial notes suggest this surviving panel was once surmounted by a pieta—dead Christ—that has now been lost. In 1908 all that remained was covered in rubble, then winter rains, then botched restorations.

In the 1980s it had long been decided that the 1908 tsunami was caused by the rupture of a North-to-Northeast-striking fault in the straits between Messina and Reggio de Calabria. Troubled by discrepancies in reported timing, JP had offered an alternative hypothesis involving displacement of undersea landforms in the Ionian Sea off the coast of Sicily. As a young post-doc, he did not have the time, funding, or credibility to do much more than speculate. But in the last ten years others have raised the same possibility with much more evidence.

"You look lost in thought," Josh and Sophie approach from behind JP.

"Oh… lost beauty, lost lives… and, I suppose, lost time," JP answers with a weak smile.

"Is Mom happy?" their son asks.

"We have not exchanged a single word, but if I know her body language, I would say she's thrilled."

Miriam is across the fore-gallery in lively conversation with two board members and their important others. Her hands are painting a scene.

"She should be," Sophie adds. "The rework of the permanent collection is amazing in itself."

"Be sure to tell her that," JP says.

"Helps me see what was already there," Josh agrees.

JP is distracted. His phone is vibrating again. Five throbs followed seconds later by five more, then again. All within three minutes. One 5.1, one 4.9, one 4.6, all within miles of the Mendocino Triple Junction. Higher magnitudes than most swarms. Unusual but not unprecedented. Worth a closer look when he gets back to a bigger screen.

DECEMBER 16

Juniper is with the General and three of his senior staff at FEMA Headquarters just off C Street in Washington DC, behind the Holiday Inn. It is late afternoon. They have been in discussion for nearly two hours.

On this day in 1575 an estimated 8.5 magnitude earthquake occurred in central Chile. On December 16, 1920 an earthquake of similar magnitude killed up to 200,000 in Gansu, China. Neither of these events are known by any of those in this conversation. At the start of the meeting, the General does mention December 16 is the day in 1811 that the New Madrid earthquakes started shaking the mid-Mississippi Valley. A similar quake today is expected to kill 3500, cause over 86,000 casualties, and displace more than 7 million people.

"What we seem to have are several credible engineering estimates telling us most of the transportation infrastructure will be gone," the General summarizes. "We also have a couple of new angles on Cascadia's specific seismicity that may suggest bridges and roads could do better than the consensus models. Right?"

Nods around the table.

"Sounds like we should prepare for the worst and hope for better," he says.

"Until we can look and actually see outcomes," his operations deputy adds.

"We have to be ready for whatever," his planning deputy says. "But once we get the rapid assessments, then we pivot to what we've got."

"Knowing where to look and recognize the implications of what we see or what is gone will decide what we do next," the private sector liaison adds.

"Okay…," the General looks out the window then across the table. "Dr. Juniper you have been unusually quiet the last hour or so. Anything to add?"

"I've heard well-informed people being smart about a tough problem. Not really," she replies.

"So, after my first Christmas party tonight, I can go to bed dreaming of sugar plums?" The General directs the question to Juniper.

"Pray for bridge abutments first," she answers, prompting laughter.

2.2 magnitude, 51 km depth
Bangor Trident Base, Washington, United States

2.7 magnitude, -1 km depth
Port Angeles East, Washington, United States

3.4 magnitude, 34 km depth
Ocean Shores, Washington, United States

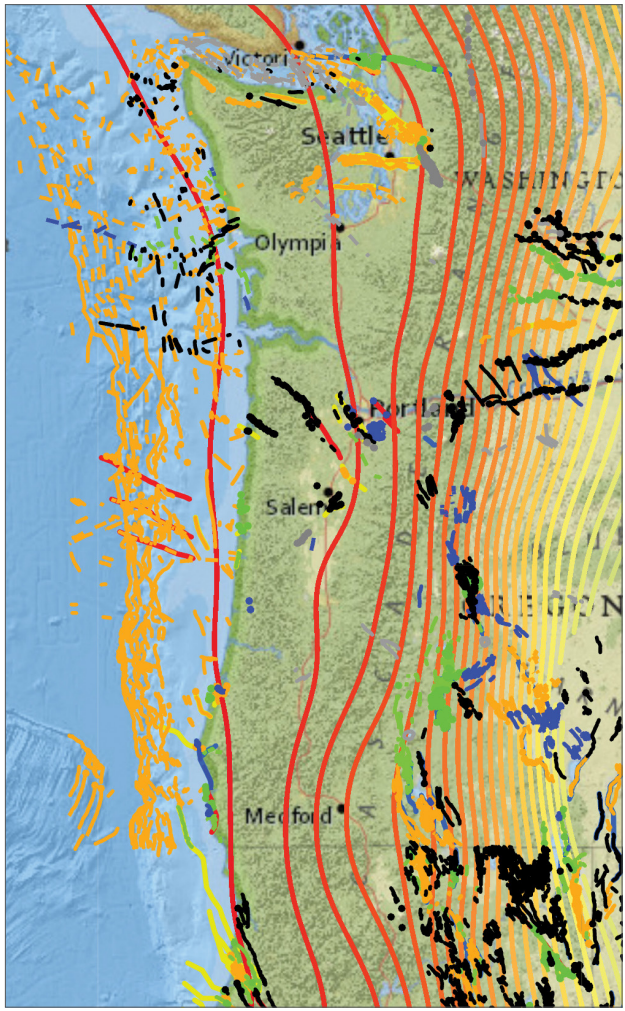
She adds, "We need the bridges to hold, at least most of the I-90. If we keep some portion of the 5, even just to Centralia, hallelujahs all around. If I had any real responsibility, I would invest most of my prep on the assumption that bridges and roads will survive just enough to find a path. Without this you won't be able to feed most of your survivors, no matter how much more planning you do. All the Sea Dragons, Blackhawks, amphibious landing craft, and C-130s in the US arsenal will not put Humpty-Dumpty together again."

"Sure, you do everything possible. But until the trucks can break through there will not be enough. So, I would lean into the barest possibility that key bridges will survive, we can fuel trucks, and trucks can deliver *somewhere*. Just doing that will be plenty tough and deserves all the attention we can possibly give it." Juniper pauses, then continues. "Otherwise, there will be a temptation to focus on the palliative care you mostly control, instead of the strategic capacity you do not control."

"Via est sumpta ex possibili et necessario," the General mutters, recalling his Summa Theologica. (The way emerges from possibility and necessity.)

DECEMBER 17

Today four small seismic events are recorded in the Cascadia Seismic Zone. All are less than 3.0. None are felt by any human. Jack has volume even higher than March 2020, which suggests next Friday or Saturday will pull even more. Why are jars of minced ginger sold out? Three different SKUs now have spiking backorders. Some Facebook recipe, he bets. Procurement is checking on getting a pallet from Tracy.



U.S. Quaternary Faults
United States Geological Survey

HANUKKAH BEGINS

Juniper is late sending her holiday message. She spends Sunday afternoon finalizing the cover note. Her email includes, "Most of my professional relationships are tied to Supply Chain Resilience. This can be a geeky, nerdy, rather dense, and ambiguous context. But our common purpose is to save lives, reduce human suffering, and strengthen the shared connections on which all of our lives depend. Without you, this work would have been diminished. With you, progress has accelerated and widened. It has been wonderful to work with you."

But what was the miracle of the first night? The light that should have lasted one day lasted eight. But that means there was something miraculous about days 2 to 8; nothing miraculous about the first day...

Perhaps the miracle was this, that the Maccabees found one cruse of oil with its seal intact, undefiled. There was no reason to suppose that anything would have survived the systematic desecration the Greeks and their supporters did to the Temple. Yet the Maccabees searched and found that one jar. Why did they search? Because they had faith that from the worst tragedy something would survive. The miracle of the first night was that of faith itself, the faith that something would remain with which to begin again.

—Rabbi Jonathan Sacks (2013)

"Enclosed is a thank you gift. The original poem in Spanish is by Federico Garcia Lorca. I am confident that Lorca was not thinking about supply chains as he wrote this. But when I read this, demand and supply networks rush into view. The Supply Chain is surely *our garden of the possible*. This reflects fundamental characteristics of our essential networks: organic and engineered, random, clustered, and scale-free, simple and complex. Humanity emerges from such connections. Best wishes for this season of preparation, expectation, connection, and becoming. Best wishes tending your garden."

There are more than three hundred recipients. In the Puget Sound region Jack and Josh are among about a dozen that each receive the message. Both are still at work, Jack at the Distribution Center, Josh at the bakery. Tis the season. After reading, Josh forwards to Sophie and asks her to join him for dinner at a place around the corner from her apartment. They haven't seen each other all week. She agrees.

El jardín
by Federico Garcia Lorca

Jamás naciò, ¡jamás!
Pero pudo brotar.

Cada segundo se
profundiza y renueva.

Cada segundo abre
nuevas sendas distintas.

¡Por aquí! ¡Por allí!
Va mi cuerpo multiplicado.

Atravesando pueblos
o dormido en el mar.

¡Todo está abierto! Existen
llaves para todas las puertas.

Pero el sol y la luna
nos pierden y nos alejan.

y bajo nuestros pies
se enmarañan los caminos.

Aquí contemplo todo
lo que pude haber sido.

Dios o mendigo,
agua o vieja margarita.

Mis múltiples senderos
teñidos levemente

hacen una gran rosa
alrededor de mi cuerpo.

Como un mapa imposible,
el jardín de lo posible.

The Garden

Never born, never!
But bursting into life.

Every moment is
deepened, renewed.

Every moment it opens
New diverse pathways.

Over here! Over there!
See my many bodies.

Passing through cities
or asleep in the sea.

Everything open! Keys
to fit every lock.

But the sun and moon
lose and delude us.

And under our feet
the highways are tangled.

Here I mull over all
I once could have been.

God or beggar,
water or old marguerite.

My multiple paths
barely stained.

Form this enormous rose
encircling my body.

Like an impossible map
the garden of the possible

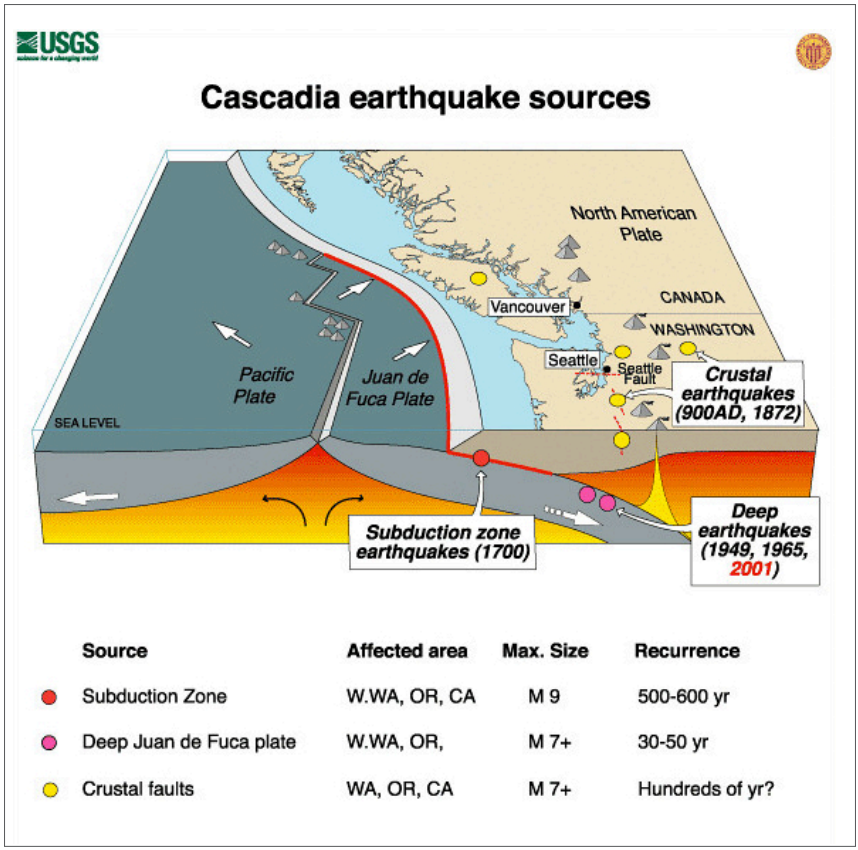
Every moment is
deepened, renewed.

Never born, never!
but bursting into life.

DECEMBER 19

At four in the morning a double arrives from Tracy, California, 788 miles south on the I-5. The team of drivers left about three o'clock Sunday afternoon. A half-pallet of minced ginger is included in the load. There may be more by Thursday, but demand is sky high everywhere north of San Diego and west of Denver.

The last Monday before Christmas is a good day to see demand and supply networks operating at very close to full capacity. This is



Cascadia Subduction Zone
Pacific Northwest Seismic Network

also the first holiday shopping season with the full complement of five Micro-Fulfillment Centers in place. In the Puget Sound region, Sophie's employer has now deployed two large-scale Fulfillment Centers—one for grocery, the other for non-grocery—five MFCs, and twenty Velocity Support Centers—including an experimental mobile unit. This is their first urban area—and first holiday season—fully optimized.

Sophie's work focuses on demand-driven volumes, velocity requirements, and placement of the MFCs. For technology inside the nodes, she mostly plugs other people's projections into her formulae. Occasionally she asks skeptical questions. But the automation engineering team is world-class. They work the system's endogenous attributes. She tries to reduce—or even use—friction where the system encounters the rest of the world.

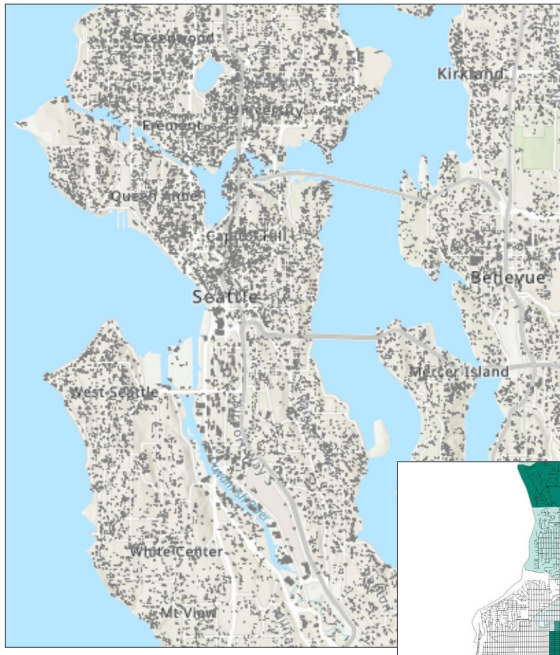
Today endogenous and exogenous are making a joint field trip to see what happens when all their data-crunching encounters peak demand. They start in Georgetown, south of downtown, north of Boeing Field. Good access to both the I-5 and Marginal Way. The multistory structure stands out among its low-rise neighbors. This MFC, completed in 2019, predates Sophie's data-driven process. It was a speculative build reflecting smart practitioner intuitions (and real-estate realities). Its unexpected construction increased confidence in Sophie's theoretical approach. Leasing reduced the risk for Sophie's employers. Pandemic demand confirmed the potential.

The site earns a 7.2 on her ten-point index. An east-west link with sufficient capacity is missing. There are too many bridge dependencies. It is in a flood plain. But these are common constraints—more common than not, in the Seattle metro area. Proximities to wealth, residential construction, and population densities are all strong.

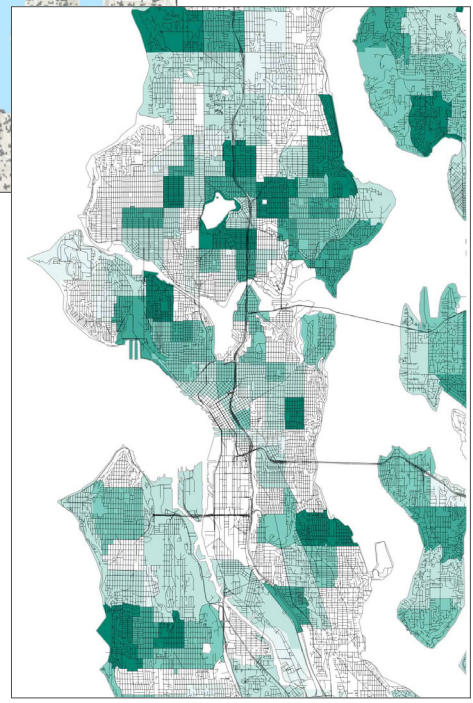
Her Lyft driver cruises south on 15th Avenue, crossing over the I-5 and railway tracks on Albro. The interstate is backed up and barely moving either way. A freight train slowly heads away from the port pulling more than two-hundred containers.

In her minds-eye Sophie is a water molecule bending across the flow just below the neck of Seattle's hourglass. North of the neck,

wealth pulls. South of the neck, products and people push. When all is right, the neck's various functions facilitate flow. But where the neck narrows, flow will slow. If the neck breaks, there is dispersal instead of flow.



Microsoft Building Footprints



DECEMBER 20

Monday's observed outcomes are okay. Flows direct to MFCs, between MFCs, and between the full-service Fulfillment Centers and the MFCs are at or above projections. But flows to the Velocity Support Centers and direct to demand are not showing the expected acceleration. VSCs are meant to behave like high-speed cross-docks, instead there is congestion. The data does not immediately expose cause. Sophie guesses increased case handling has introduced additional network segmentation. VSC managers might be buffering high-demand SKUs. But more likely, she expects, is time or space mis-calibration between inbound and outbound loads. How much this might be an issue of volume or cycle speed or another aspect of velocity is not yet clear.

Harmony in the Small-World

Massimo Marchiori[1,2] and Vito Latora[3]

In this paper we propose a general theory of small-world networks. We start by considering a generic metrical graph G, that in principle can be also non connected. N is the number of vertices (or nodes) in the graph and K is the total number of edges (or arcs). Each two nodes i and j of the graph are at a certain *physical distance* $\ell_{i,j}$, which can be for example the real distance between the two nodes or a measure of the strength of their possible interaction. The *distance on the graph* $d_{i,j}$ is instead defined by the shortest sum of the physical distances throughout all the possible paths in the graph from i to j.

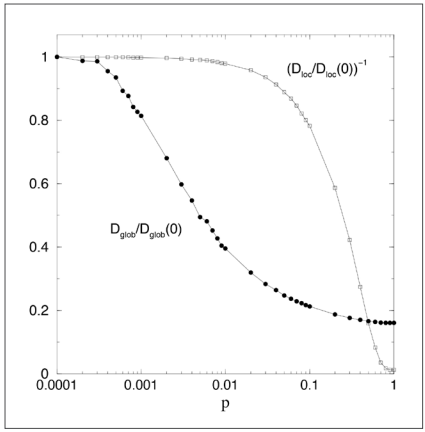
Sophie wonders if she has been too focused on eigenvector centrality. There are aspects of betweenness and harmonic that certainly apply.

Given current and anticipated pull, where will new edges—new bridges at Konigsberg—most likely increase velocity of flow?

Interestingly enough, the connectivity length of the graph is *not the arithmetic mean* but the *harmonic mean* of all the distances:

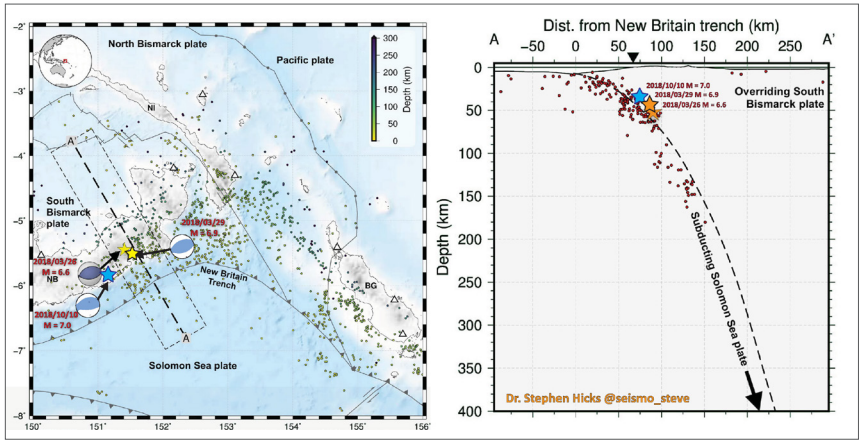
$$D(G) = H(\{d_{i,j}\}_{i,j\in G}) = \frac{N(N-1)}{\sum_{i,j\in G} 1/d_{i,j}} \tag{2}$$

The harmonic mean has been known since the time of Pythagoras and Plato[7] as the mean expressing "harmonious and tuneful ratios", and later has been employed by musicians to formalize the diatonic scale, and by architects[8] as paradigm for beautiful proportions[9]. Nowadays, it finds extensive applications in a variety of different fields, like traffic[10], information retrieval[11], visibility systems[12], water control[13] and many others. In particular, the harmonic



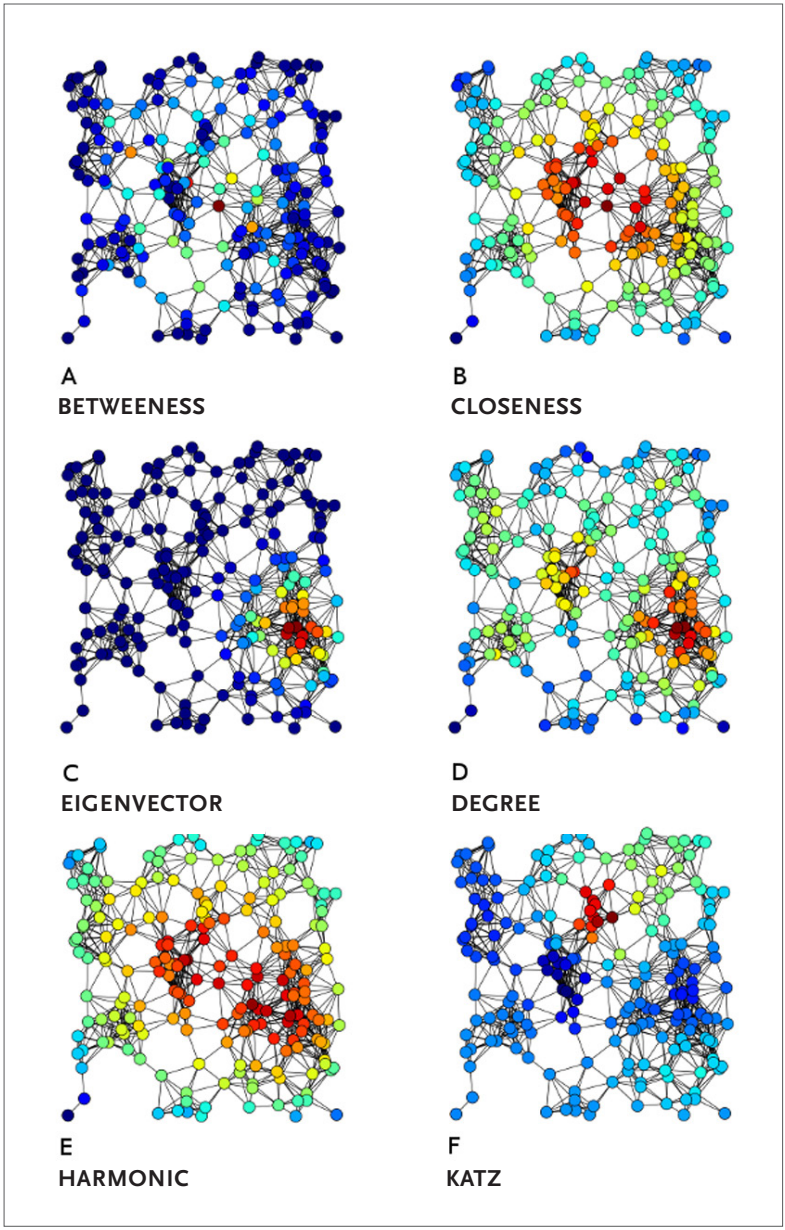
For Sophie's current purposes the places that matter most are where demand is concentrated. Every big city includes affluent Islands that pull disproportional value or volume or velocity. To increase speed in densely populated environments requires bridging the actual physical distance between supply and demand.

The Velocity Task Force is meeting at 1:00. Sophie wants to generate six different network characterizations from inventory, sales, and delivery data for between noon on Friday and noon on Monday. Just seeing how, where, and when congestion emerged may help them ask better questions.



Seismicity map and cross section (modified from Dr. Hicks, 2018). Epicenters are shown on the map, with the earthquakes selected for the cross section is outlined as a dashed rectangle labelled A-A'. Hypocenters along cross section A-A' are shown relative to distance from the trench axis.

VARIATION OF CENTRALITY MEASURES
IN THE SAME GRAPH



Tapiocozzo (2015)

WINTER SOLSTICE

The sun rises at 7:55 local time.

Jack has been at the DC for over two hours. Two drivers have called in sick. One truck has gone off the road and tipped. Their last case of minced ginger was just loaded. There are now twenty-three current-demand SKUs on backorder. He has already complained to the head of procurement. He is not happy with her. The feeling is mutual.

JP is finishing his morning walk, just about to arrive back home. It is cloudy and 34 degrees.

Miriam has just poured her first cup of coffee.

Josh is helping load the bakery and wine delivery trucks.

Sophie has arrived at her office on the 26th floor. The sun has not quite edged above Capitol Hill. But the snow on Mount Constance is a rosy glow.

Juniper is at Boston-Logan about to board a plane for nearly three weeks in Puerto Rico. There is an icy rain.

The General is at his office behind the C Street Holiday Inn. He has an 1100 meeting on the ninth floor to discuss the 2024 budget request.

On this day in 1946 an 8.2 Mw killed over 1300 in Japan. More than 38,000 homes were destroyed by the quake and subsequent 16-to-20-foot tsunami. The rupture was caused by the Philippine plate subducting beneath the Eurasian.

The sun sets in Seattle at 4:20.

DECEMBER 22

The Pacific Northwest Seismic Network is convening the Zoom call to provide an update on recent seismic and geodetic activity. Start is scheduled for 2:00. JP clicks in at 1:58. The proliferation of participant tiles accelerates until after 2:01, at which point the host announces they will wait two more minutes. He asks everyone to put their connections on mute. Several do not. The line fills with papers rustling, multiple conversations, Christmas music, traffic noise, and airport announcements. The brief gets seriously underway after 2:10.

"There has been an increase in the number of events. Magnitudes remain modest. The number of events is not surging, but the shift is statistically significant. Our friends at the University of Oregon will give us the headlines and then take questions. Please hold comments and suggestions for later."

"Just in case there are new folks or students on the call, a quick bit of context," an unidentified male voice begins. "We now have a catalogue of more than 1.4 million CSZ soundings since 2008. Analysis has demonstrated that there are tremor patterns—foreshocks—correlated with larger seismic events. But, at least so far, each pattern has been unique to each event. While these behaviors are rather obvious post-hoc, we have not yet recognized behavior that can confidently support prediction."

"Real-time data from the sensor array suggests spatial and temporal relationships, referenced as event patches or families or fragments. PNSN has given particular attention to Episodic Tremor and Slip or ETS events. Today's presentation and discussion is prompted by the recent increase in tremors and low-frequency events. We want to highlight the data and support research and analysis. We are not intending to raise an alarm."

The call doesn't tell JP anything data-specific that he does not already know. He scans real-time feeds almost daily and gives sustained attention to sensor-outputs for the Olympic peninsula.

The call does confirm there is nervousness in several of the social networks accessing the data. He is not alone. But there is nothing obvious in the data to reinforce or alleviate the anxiety. That's not the sort of stress being measured by this array.

The earth is moving thorough space. The earth's inner core rotates fast in an eastward direction. The outer core rotates west somewhat slower. Larger and smaller fragments of mantle float over these viscous currents. Fragments are constantly slipping by or grinding against each other. Where one fragment is subducting another, contending movements produce push and pull, tension, compression and shear. Where forward movement is long-constrained and flexibility finally exhausted, stress will be released in some sort of fracturing: slow or quick, short or long, gently or not. The earth will, in any case, continue to move.

Jack finishes Thursday with all deliveries made and only seven active SKUs on backorder. Procurement even found a local boutique processor to fill the gap in minced ginger. Today, push has fulfilled pull. He is so ready for Christmas to be over.

DECEMBER 23

Josh has twelve full-time-employees, nine at the bakery, and many seasonal employees, especially during harvest at the vineyard. Pete and Johnny are full-time. They drive the delivery trucks, with Josh pitch hitting. Josh tried to hire a third driver for this holiday season or even full-time, but he couldn't find someone with the right attitude and skills. Because they regularly see customers face-to-face, the drivers are crucial to marketing, selling, and troubleshooting as well as delivery. Just after Thanksgiving Josh hired two work-release prisoners to help Pete and Johnny with loading and unloading, So far, so good.

The bakery and warehouse occupy the one-time Bedrock Baptist church—originally St. Paul's Lutheran—far south on Rainier Avenue. Josh appreciates that the structure actually sits on a small spit of Blakeley Formation bedrock. The parking lot is crumbly sandstone that unveils occasional fossilized mollusks. Josh played around with the Bedrock Bakery brand, but Sophie suggested that rock-hard is not a positive differentiator for his products.

The matriarch and manager of the bakery is Connie Atwater. She learned to bake in the Bedrock Baptist church-kitchen, then in

the basement where the wine is now kept. With many hesitations, three years ago she helped Josh build the new kitchen in the once-upon sanctuary. She was glad to expand. The pews had long been gone. But it still felt strange. "Feed my sheep," became her mantra. This Christmas she has often repeated those words to manage the stress that success can bring. They sell eight times the product as pre-pandemic.

Dao Thi Lam is Connie's right-hand for mixing, fermentation, and makeup. Her left-hand for scoring, baking and bagging is Solomon Senai. Half the bakery team can walk to work. All the part-time workers are local and most have become seasonal regulars.

Today where the altar once stood there are three tables overflowing with big plates of bakery goods. This is the annual Christmas exchange. All the bakers, wine-makers, and many vendors bring family favorites. Vietnamese, Ethiopian, Chinese, Mexican, Ukrainian, Turkish, Iraqi and more pastries. Connie's raisin cookies are always popular. Some of the bakery's most successful commercial products have emerged from the Christmas exchange.

Todd and Mike, who deliver the biodiesel, show up with double-chocolate brownies. Harry scheduled his weekly flour delivery to bring his grandmother's oatmeal cookies. Sophie arrives with raw New Orleans beignets that she bakes fresh onsite. There are dozens of delights. But the most luscious gift is undoubtedly Margherita's Pio el quinto, the rum drenched custard cake of her childhood. Not yet twelve, on this day in 1972, she was staying overnight with her grandparents in the old center of Managua. As was tradition they were going to make Pio V together the next day. The earthquake struck at half-past midnight killing her grandmother and two cousins. Ten thousand died. Three-hundred thousand, including Margherita, were left homeless. Three years later she was in Los Angeles. Ten years later she arrived in South Seattle. Five years ago, for the second Christmas exchange at the bakery, she made Pio V for the first time since 1971. She needed three tries.

About 3:00 Josh raises his coffee cup and quiets the crowd by saying three times, "We gather to give thanks for this life and each other." Each time more respond in kind, often in heavily accented English and one other language.

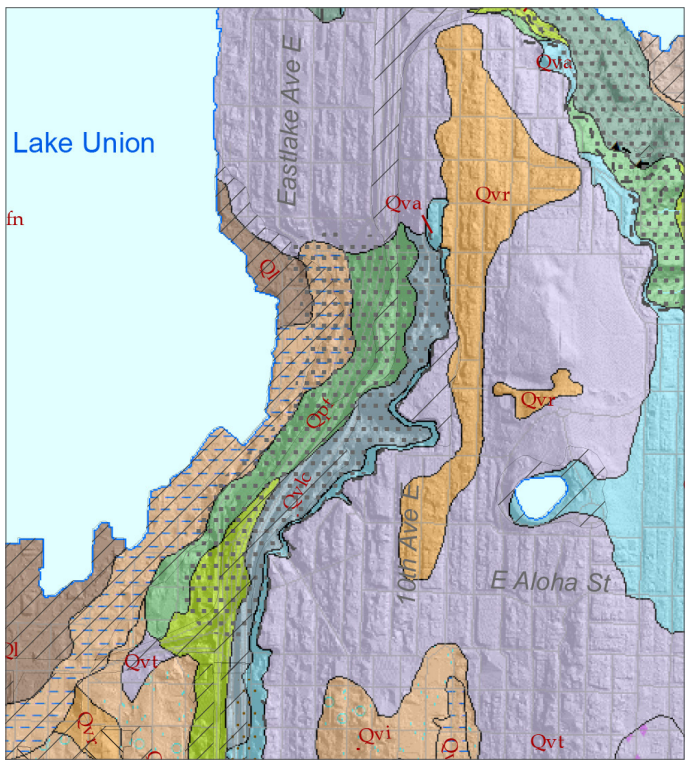
"Njtamie litaqdim alshukr ealaa hadhih alhayat wabaedna albaeda."

“My zbyrayemos' podyakuvaty za tse zhyttya ta odne odnomu"

"Nos reunimos para dar gracias por esta vida y entre nosotros," Marguerite says as she wipes away a tear.

CHRISTMAS EVE

St. Mark’s Episcopal Cathedral is massive, unfinished, and raw. Its poured-in-place concrete slabs were originally meant to be disguised behind wood and stone. Instead, unexpected Romanesque and Byzantine arcs emerge from proto-brutalist volumes. The not-yet century old structure sits on the edge of a sharp 360-foot incline of glacial deposits above Lake Union, including outwash, subglacial debris and melt-out till. Prehistoric landslides have left additional

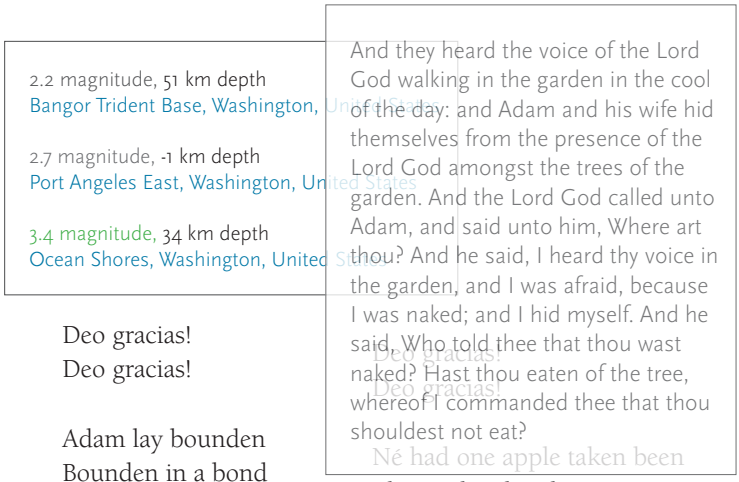


Troost, Booth Wisher, and Shimel, The Geologic Map of Seattle, United States Geological Survey.2019

folds. Various human modifications contribute further laminations up, down, along, and into the ridge.

For three decades now, since Josh was still in a stroller, Miriam—usually, but not always—joined by JP, has walked from the house to the Cathedral on Christmas Eve. It is about one and a half miles each way. She goes through the park, taking the path between the Asian Art Museum and the reservoir.

Lessons in Carols begins at seven. As always, the first reading is one Miriam despises. It is followed by one of her favorite carols. Push and pull persists.



Deo gracias!
Deo gracias!

Adam lay bounden
Bounden in a bond
Four thousand winter
Thought he not too long;

Deo gracias!
Deo gracias!

And all was for an apple
An apple that he took
As clerkës finden
Written in their book

Né had one apple taken been
The apple taken been
Né had never Our Lady
A been Heaven's Queen

Blessèd be the time
That apple taken was
Therefore we moun singen:

Deo gracias!
Deo gracias!
Deo gracias!
Deo gracias!

The liturgy shifts between said and sung, scripture and song. Familiar words, ancient hymns punctuated by something entirely new. This year the choir sings a contemporary carol adapting a Bertolt Brecht poem:

> The night when she first gave birth
> Had been cold. But in later years
> She quite forgot
> The frost in the dingy beams and the smoking stove
> And the spasms of the afterbirth towards morning.
> But above all she forgot the bitter shame
> Common among the poor
> Of having no privacy.
> That was the main reason
> Why in later years it became a holiday for all
> To partake in.
> The shepherds' coarse chatter fell silent.
> They later turned into the Kings of the story.
> The wind, which was very cold
> Turned into the singing of angels.
> Of that hole in the roof letting in frost nothing remained
> But the star that peered through it.
> All this was due to the vision of her son, who was easy
> Fond of singing
> Surrounded himself with poor folk
> In the habit of mixing it up with kings
> And of seeing a star above his head at night-time.

Miriam is glad the poem's translation is printed in the worship booklet. She is not thrilled with the dissonant sound but appreciates the liminal—numinous?—mood it induces. As the sixth lesson is read from Luke—"And it came to pass in those days…"—she leans to kiss JP on the cheek, he turns and their lips join, his left hand holding tight her right.

CHRISTMAS

From time to time JP explains he believes in the God of Spinoza. This typically prompts his discussion partner to change topics. On rare occasions—such as his second date with Miriam—when the obvious follow-on question is posed, JP has translated Spinoza as saying God is "that substance having infinite variables, each expressing essentials beyond negation."

"So," Miriam then asked, "Whatever is both essential and infinite is God?" Not infinite, not God. Then, for Spinoza—or you—what is essential?"

The twenty-four-year-old JP had never been asked this question. He answered rather tentatively, "The Latin Spinoza uses is 'infinitam essentiam exprimit', so, maybe… active expression of infinite being."

JP was the first boy to quote Latin to her. More than four decades later, he remains the only American she knows who inserts the occasional Latin epigram into conversation. Still, if this instance had only involved "infinite being," Miriam would not have been much interested. But the addition of "active expression" got her attention. This is what she had already experienced with Rembrandt, Leonardo, and Titian. The specific work of art is fragile, far from infinite. But each of these artists has sometimes achieved an active expression of infinite being. This ineffable rendering is what great artists—across genres—share and what stubbornly eludes the not-quite-great.

He had just been groping to answer a cute girl's question. But thereafter *active expression* took on more meaning for JP. Geology can still betray a Saussurian preoccupation with beginnings and endings: Particular structures at particular times minutely measured. But in his teaching and research, JP gave increasing emphasis to active expressions of geological behavior that suggest essential attributes, modalities, relationships, movement, and system-of-system characteristics.

In subsequent years, JP has self-critiqued his too-quick translation of Spinoza in the throes of youthful courtship. But regardless of what Spinoza might have meant, JP and Miriam have become, each in their own way, avid collectors of active expressions of infinite being.

In December 1675 Spinoza wrote, in Latin, to a friend in London, "with regard to the eternal son of God, that is, God's eternal wisdom, which has manifested itself in all things and chiefly in the human mind, and most of all in Jesus Christ... without this, no one can attain to a state of blessedness, since this alone teaches what is true and false, good and evil."

Most scholars read this letter as Spinoza rejecting the incarnation of God in Christ, rejecting that God was born in human form. This is not JP's reading. Rather, he understands that for Spinoza, Jesus was God made flesh, and so are all things born and made. Such ephemera are not God, but they are modes, attributes and variables of God: active expressions of infinite being, at least this is their essence and potential.

All of which are notions bouncing about JPs mind as he and Miriam finish their Christmas morning walk. Madison Street is quiet. Josh and Sophie should arrive about 1:00. The tree is trimmed. The presents are wrapped. The standing rib roast is another word made flesh.

ZOT HANUKKAH

The bakery is closed today. Saturday morning deliveries topped off every customer. All customers were closed on Sunday, Christmas Day. Many are also closed today. Dao Thi Lam and her prep team will return at 3 AM on Tuesday.

Amit, the engineer-of-all-things for Josh, has calendared today for electrical contractors to install a new battery pack for the convection ovens. Six times since August the bakery has pulled electricity from the grid instead of the solar collectors pushing power to the grid.

The higher-capacity batteries will provide enough of a buffer for full night-time shifts and the most serious Seattle cloudbanks.

The work will also keep Amit busy on a day when he welcomes distraction. In 2004 he and Josh were classmates. When he first heard of the 9.0 plus megathrust off Sumatra, any risk to Sri Lanka, more than one-thousand miles distant, did not occur to him. Two days later he heard from his older brother that their parents, uncle and aunt had been on the train between Maradana and Matana when

the tsunami crashed ashore, overturning the engines and drowning the cars under ten feet of water, a second even higher wave followed. The bodies were never recovered, four of more than 220,000 killed eighteen years ago today.

For the next three weeks Amit lived with Josh, Miriam and JP. After college Josh helped Amit with his geothermal installation business. He still helps on some big projects. Amit is a salaried part-timer at the vineyard and bakery.

Shortly after noon Josh and Sophie show up at the bakery with a packed lunch of Christmas leftovers. The batteries are being installed where there had once been a full-immersion baptismal tub behind the altar. The three of them retreat to what had once been the choir robing room, now used to store pallet tubs.

Amit's then girlfriend introduced Sophie to both men. They had already been best friends for more than a decade. But other than a shared affection for Monty Python, she has never heard them discuss anything but the most instrumental issues: power access, irrigation systems, heat extraction, convection ovens, and other applications of Newtonian physics; less often interest rates, health insurance, and taxes. She knows that Josh has a wider range, she expects Amit does as well. But then, other than Josh, with whom does she really talk… other than about giant components, centrality, volume, velocity, and flow?

After receiving Kathy Juniper's holiday message from Josh, Sophie asked for an introduction. Only three hours later Juniper had replied with an email that combined personal warmth with professional curiosity. Even amid holiday and semester-ending distractions the two women's correspondence quickly goes deep. Juniper is especially interested in better understanding Sophie's theory of capacity embedded within network edges. They exchange academic papers, several equations, and even more poetry. Sophie had never heard of Lorca, but she finds another of his poems that resonates with her even more than what Juniper had sent on Hanukkah.

Oh what a crush of people
invisible and reborn
making their way into this garden
for their eternal rest

Each step we take on earth
bringing us into a new world
Each foot supported
on this floating bridge

I know there is no
straight road
only a giant labyrinth
of manifold crossroads

Constantly created
while our feet walk
as enormous blades
these roads in embryo

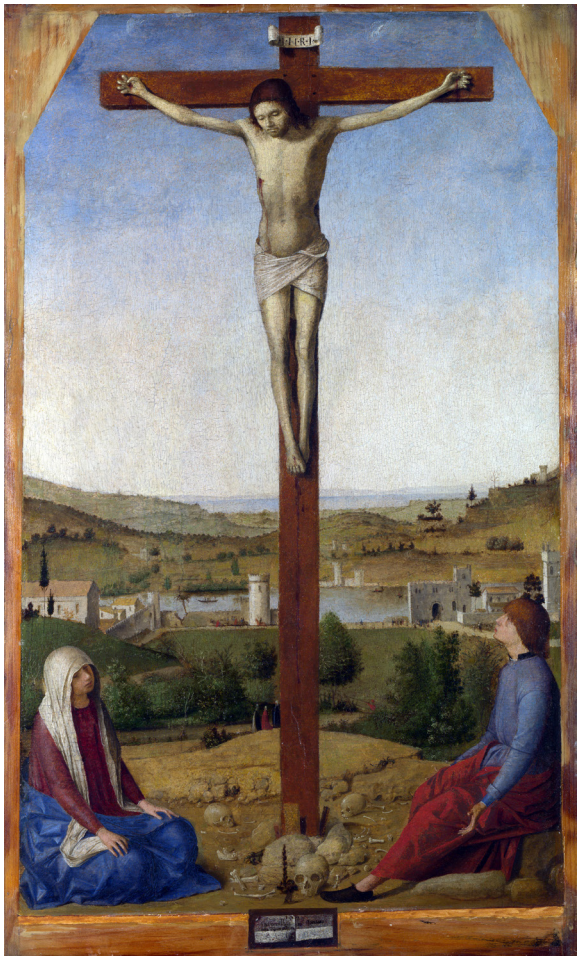
Oh garden of white
theories! Oh garden
of all I am not, all
I could and should have been!

Responding to a Christmas Day note from Juniper, Sophie writes, "Euler was preoccupied with static bridges. I imagine floating bridges and wonder—given all the preexisting pathways, people, and possible destinations—where might we best place such floating bridges? Euler was preoccupied by the principal routes that were, of course, connected to his static bridge, all artifacts of accumulated preferential attachment. What if our network topography is less constrained? What if our core context is "only a giant labyrinth of manifold crossroads?" If this reality is valid, then each Giant Peach is but a temporary expediency and entirely appropriate for eating before it spoils, freeing its denizens to become "rich and successful in the new country," according to Mr. Dahl. Our new country—and fundamental reality—being the persistent pliancy of floating edges that turn, touch, intersect, aggregate, and separate."

Juniper scans the spreadsheets and related maps that Sophie encloses. It is a layered approach. Sophie accepts static bridges and principal routes as much as Euler. But she also incorporates the push and pull of ecommerce, changing demographics, variations in household wealth, and dozens of other network dynamics. Many of her most important intersections reflect transient volumes at high velocity rather than fixed facilities or typical definitions of inventory. Juniper needs more time and thought to be sure, but it seems that Sophie has developed an approach to characterizing networks that integrates betweenness and closeness, finding the shortest path among the whole set of intersections and the specific sub-set of these intersections that has the best potential for maximizing high-velocity flow. Juniper recalls a trip years ago from LAX to downtown. The freeways were even more crowded than usual. Her driver took streets and turns Juniper could never quite duplicate, showing her edges of the city she has never seen again, delivering her faster than ever before or since. Sophie has systematized that driver's experience and networked intuition.

DECEMBER 27

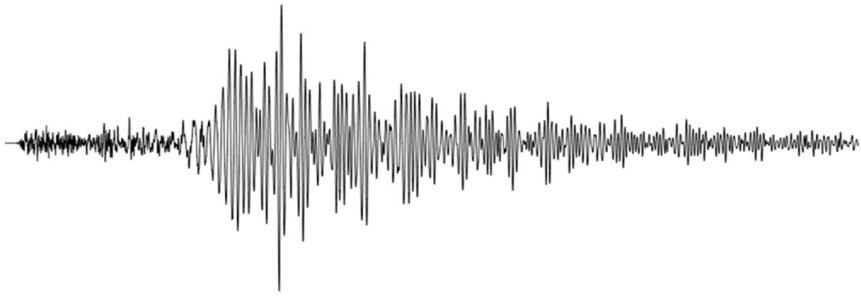
At lunch Miriam visits the quiet galleries. A newly placed poster tells visitors that today is the Feast Day of Saint John. From the cross Jesus directed John, "the beloved," to care for Mary. The figures in the Sibiu crucifixion are a bit generic. But the mother, son, and friend in London's later version are each unique personalities. John's upturned eyes are swollen from tears.



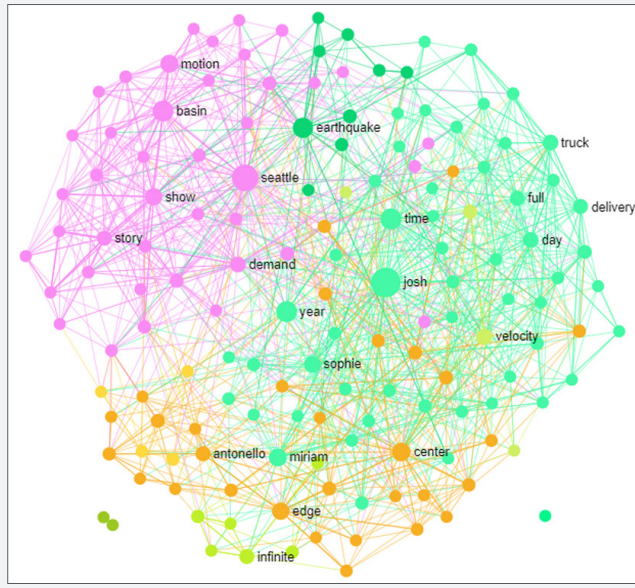
Crucifixion
Antonello da Messina (1475)
National Gallery, London

DECEMBER 28

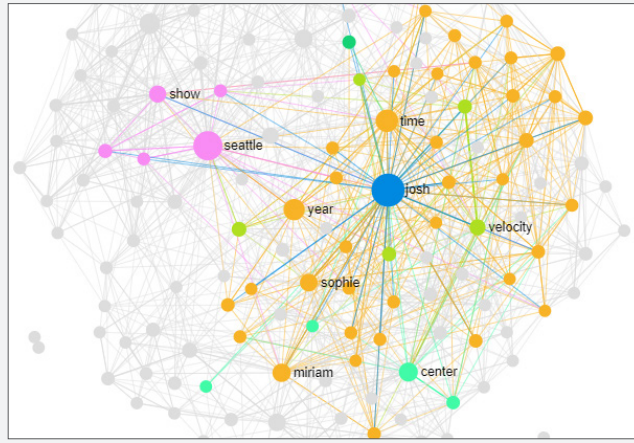
0520 Pacific Time

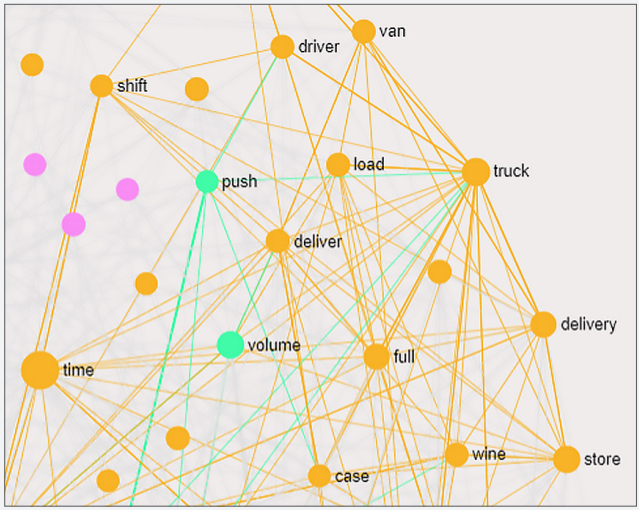


NETWORK ANALYSIS FOR PAGES 69 TO 100

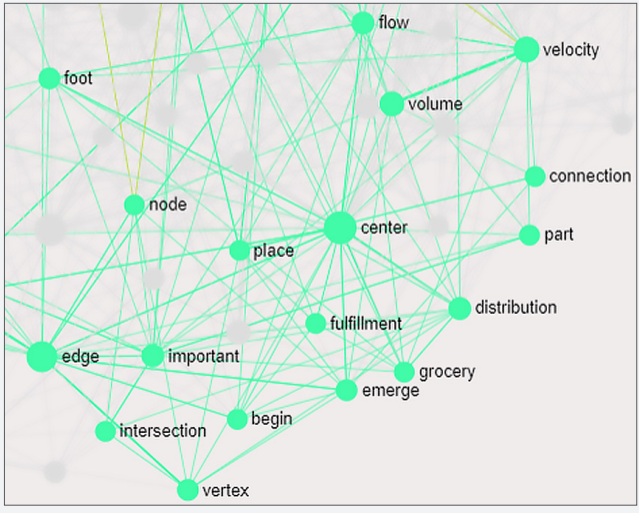


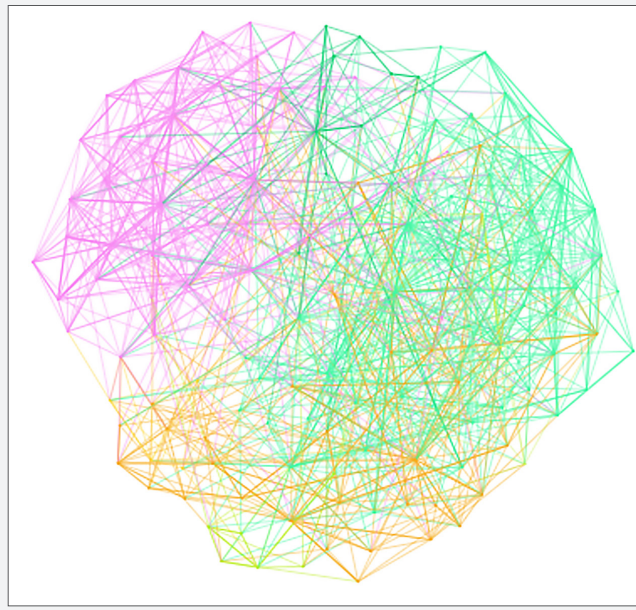
The network spawned since page 69 is much more place-bound than prior network analyses (see pages 32 and 68). The museum galleries and the bakery are most prominent. Key people associated with these places (even dead, such as Antonello) stand-out. Josh is increasingly central to the whole graph. The Josh-Sophie dyad is strengthening. Distribution Centers and their activity remain prominent.



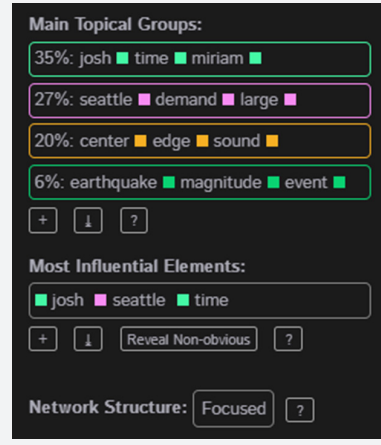


The network detail above (for pages 69 to 100) discloses the structure for physical distribution as described in the text. The network detail below displays textual relationships of what can be characterized as concepts-of-distribution. Considering the nodes and links highlighted, according to the text, grocery flow can be conceived as an outcome of volume flowing at velocity through Distribution Centers to edges. The algorithm displays mostly what is conceived.





Above is a bit more three-dimensional view of the graph at the top of page 101. While the color-differentiated topic clusters are still apparent, this visualization also suggests significant connectedness and density of relationships. The network analysis algorithm being applied assesses the 150 words that are most co-occurring in the text. This is a "focused" network structure, based on co-occurring nodes and links that expose many different topic clusters, each of which feature a robust set of nodes and multiple links between distinct, but simultaneous topic clusters. Analogous to reality's co-occurring complexity?



PART III—POST-SEISMIC: EARLY 2023

Latin/Greek compound, *post*: after; *seismos*: shaking.

That time and space following the release of accumulated geologic stress, often involving settling and after-shocks.

Encountering and engaging the consequences of disruption and destruction caused by permanent changes in surface and subsurface structures.

JOSH IS WITH SOPHIE. JP AND MIRIAM ARE AT HOME. The bungalow on 22nd Avenue shimmies sharply. The ninth-floor apartment sways. The General is just arriving at FEMA headquarters. Kathy Juniper walks the beach below her condominium in Puerto Rico. Jack is at his Pierce County grocery Distribution Center.

As vibrations persist seams pull apart, corners crack, glass smatters, anything brittle breaks. Six minutes later broken bits are pulverized, whatever started wet is now diffused. Hillsides slide. Towers tumble.

The initial USGS estimation is 8.9. There are trans-Pacific tsunami warnings. The grid is gone from Vancouver BC to well south of Portland, Oregon. Automatic breakers protect power for most of Eastern Washington and Oregon by shutting down dark.

The General tells his team to assume the worst and start pushing toward Moses Lake. "This is the maximum-of-maximums. Progress-report in 90 minutes." He can't call Costco, but he can call Kroger

and Albertsons with quick reach-outs to connect and encourage. His deputy calls personal contacts for four regional refineries, US headquarters executives, not the Puget Sound contacts. It will be awhile before anyone knows impacts to production and pipelines. Fuel flow will be essential to food flow. The General tries to call his buddy at Fort Lewis. Nothing but a manic electronic claxon.

Dawn in Seattle is still nearly two hours away. With the sun, satellite and drone images will deliver a more accurate picture. There are specific bridges, interchanges, and distribution clusters that the General wants to see. But with force-on-target reported, the strategic challenge is already clear enough: search and rescue, emergency medical care, water, food, shelter—the lower bands of Maslow's pyramid.

But until then the General is pushing his team and network toward Maslow's apex: self-actualization, fulfilling individual potential, and creativity. He calls the Alaska Adjutant-General. They served together in Iraq.

JP is in his first-floor office when the seismic signal sounds from both phone and desktop. He starts for the stairs, shouting for Miriam, but the first jolt throws him down. The most that Miriam can do is pull the pillows over her head, while her brain sorts between a dream of a Fifteenth Century Neapolitan plague and this sudden convulsion.

The first seismic wave pushes Josh off the bed onto the floor. One of his sculptures falls beside him. He grabs for Sophie and pulls her and the comforter under the table-desk spanning the west wall. Stiff wave action continues for a terrifying two minutes. It is dark. The steel and concrete building groans, creaks, and screams. They hold tight, each heart racing, both breathing deep. There is an acrid smell of metal grinding hot.

The FEMA transportation chief asks, "Did rail survive to Cle Elum?"

"Pretty sure to Ellensburg. Sensors aren't reliable further up the slope given debris and potential liquefaction. We have teams out to eyeball." The reply comes from a BNSF emergency coordinator out

of Salt Lake City.

"What about the dams? Keechelus? Kachess?" someone else asks.

Another voice, originating in Spokane, "So, don't know for sure, but no downstream evidence. The PEs on the reconnaissance teams have four dams on their checklist."

"Any other questions?" the General asks. It is now almost four hours since the initial earthquake.

Silence. "Any other questions from those not in the room?" The room has nine FEMA logistics leads. On the video conference link there are another twenty-two.

"Okay, hearing none, let me try out an over-simplification of where we're at right now: We won't know several essential elements for another 24 hours, if then. But… at the waterline from Cannon Beach to Ozette we can assume the worst. Portland is badly wounded, but conscious, communicating, and connected to California. If we can get enough fuel flowing, Oregon should be okay. We know the I-5 is broken in too many places between Portland and Seattle to help anytime soon. I-90 and US-97 are being reconnoitered as we speak. Moses Lake is fine, ready to receive. We should have a convoy rolling from Tracy within a couple of hours. DLA is releasing inventories to us. This afternoon Pacific Time we should have more pallets loaded on more trucks rolling toward Puget. Third Fleet assets will steam north tonight or early tomorrow, ETA sometime Friday. We need to decide if the Navy road clearing mission is better deployed to Portland, coastal Washington, Seattle metro or where. What's the right center for gravity… Tom, you've got that tasker, right?

"Yes sir."

"Air transport components have been identified," the General continues. "Assets are being vectored into Moses. Sue, you're going to work up some key targets and sequences for the sorties." Another yes sir. "We would prefer to establish our close-in ISB at Cle Elum, but we're not sure yet if we can push enough flow up the Yakima River gap, so we may fall back to Ellensburg. Jim, you're going to interface with WSDOT and BNSF to see what's possible now and, if not now, when it will be possible."

Then the General takes a five-count pause. “We don’t have enough trucks. We won’t have enough trucks. Fuel will be tight at best. Road networks are fractured, we don’t know yet how bad. So… my core take-away is that we continue pushing everything we’ve got toward Moses Lake. We don’t know how complicated it will be to push into the metro area. We don’t know if water, grocery, and fuel supply chains have survived. We do know that whatever volume we can get as close as possible will eventually increase potential delivery velocity. We do all we can with what we’ve got.” He scans the room making eye-contact with each of the nine in the room. “Anyone on the call hear me get something seriously wrong.”

Another long pause. “Okay, keep it moving. We’ll aim to get together again at 1700 Eastern. Look for a confirmation invitation.”

Sophie insists that she will walk with Josh to check on his parents, about two miles away. Roads and sidewalks are cracked and covered in debris. Streetcar cables and other overhead wires litter the ground. Masonry buildings have crumbled. But Central Coop has generator power and a line has already formed outside the now missing windows. At the top of Madison Street one of the broadcast towers is crumpled over the Shell Station, all four lanes, and then across the entrance to Trader Joes. A team from the neighborhood fire station is helping evacuate residents of a retirement home to a nearby school playground. At least the cacophony of car alarms is done. From the ridge where Madison begins to fall toward Lake Washington the sun is edging above Glacier Peak into the indigo sky of a clear winter morning.

A note is taped to the front door. Josh recognizes his father’s handwriting: “We are OK. Relocating to Volunteer Park (or nearby). Don’t like the look of the back yard. Will be back once aftershocks settle. Don’t worry about us. Stay safe.”

The door is unlocked. Josh and Sophie go in. The kitchen cupboards’ contents are mostly on the floor. Furniture is out of place. The brick fireplace is seriously fractured. Portions of ceiling have

fallen and wallboards have buckled. Dust coats everything. But roof and walls have, so far, stayed connected.

On the dining room table is a back-pack. Another note in his mother's hand: "For you."

"When I was a kid, we always refreshed the go-bags on New Year's Day. So, I guess this is from last January." Inside there is water, a water filtration straw, energy bars, a poncho, thermal underwear, washable N95 mask, flashlight, extra batteries, first aid kit, hand-crank radio, matches, flint, three pairs of socks, a notepad, and three pens.

The big Sitka spruce behind the house is leaning precariously over the apartment houses at the base of the hill that separates 22nd Avenue from 23rd. Half the always shallow backyard is now pressing against the first floor of apartments. The next serious aftershock could take the house too.

Josh shakes his head. "We're not going to find them. We should head for the bakery." He writes a note on the back of the paper Miriam left for him and leaves it on the dusty table.

From her living room overlooking the Atlantic, Kathy Juniper has recruited three of her graduate students to take on post-Cascadia. They have already loaded several data-sources to a mapping software package. The data feeds include elements from Sophie's spreadsheets received just two days earlier, near real-time seismic data from the United States Geological Survey, and an instance of the University of Washington's M9 simulation package. This had been set up in November, but with all the demands of semester's end, Kathy has not seriously worked with the M9 engine until now.

Data formats are inconsistent. APIs are stubborn. Outputs can look fabulous, but then unravel with closer examination. Juniper and her team are self-aware they are engaging a model of reality, not reality itself. But by the end of the second day they are feeling more confident the model is giving them some meaningful signals worth testing against actual reality. They also know that actual reality can be tough to discern, especially by those embedded in mayhem. Some

of what is emerging could help expose opportunities that might otherwise not be seen.

Before dawn on December 30, Juniper writes to the General and two other federal officials:

> Enclosed is a map. This reflects our best effort to characterize the current demand and supply network for the Seattle Metropolitan Statistical Area. This is based on pre-Cascadia population data and retail flows plus post-Cascadia damage indicators with estimations for likely impact on food flows. We are working on a similar water-system assessment that is taking longer. Some quick take-aways:
>
> - Based on public sources available to us, we estimate near-term volumes of demand to be essentially unchanged.
> - Immediately available supply volume been slashed, potentially up to 80 percent depending on what is counted. Velocity is disrupted as much or more.
> - Given the disconnect to Portland and distance of Seattle to other population centers, supply capacity is radically reduced.
>
> None of this is news to you. But the data models also reveal at least two potentially important surviving sources of volume and potential velocity:
>
> 1. Up to seventy percent of local food processing facilities may have survived. Loss of grid will reduce functional capacity, but early cross-tabulation with installed solar and other non-grid power sources suggests this could be a non-trivial source of food flow.
> 2. Three of the five highest volume grocery distribution centers have, almost certainly, not survived this event, but mapping suggests several Micro-Fulfillment

> Centers (MFCs) have survived and could serve as a nascent network to enhance volume-at-velocity for serving survivors.
>
> If available transportation links and assets are able to aggregate both local and external food flows at the MFCs, a much higher capacity demand and supply network is possible. On the second page after the map more detail is provided. If this is in any way helpful, we welcome your questions and will be doing follow-on work. I will send you what we've got as it emerges to benefit from your questions and inputs. Many thanks.

JP stretches a tarp between the graves of Princess Angeline, the Henry Yesler clan, and the austere alabaster obelisk of Philip H. Lewis, all waiting out aftershocks in Lake View Cemetery. Others have also arrived with tents, blankets, and sundry. Without the headstones it would have seemed festive. The ruined nearby conservatory is also disconcerting. It is a crystal-clear day, the sky cloudless except for several columns of ascending smoke. By 2 o'clock the temperature has broken fifty degrees.

It takes nearly five hours for Josh and Sophie to walk the seven miles to the bakery. South on 23rd Avenue is quick enough until the bridge over the I-90 is not entirely there. But the sometime fresh produce market at the intersection with Rainier is selling. Even more surprising, Borracchini's bakery has a line. Still, Rainier Avenue has been hit hard. In Mt. Baker Lowe's long, thin wall has peeled off into the street scattering bricks and construction panels and chunks of roof. But the big dairy a bit farther south seems to be fine. Given the noise, Darigold must have installed back-up generators. Josh notices reefers are still backed-up to the docks. Looks like the earthquake hit before the morning milk run had left. A wide variety of tents and their equally varied inhabitants have taken over the Columbia playing fields and parks. The doors of the fire station south of Kenny are

open. The fire equipment is gone and a first aid station set up in one of the empty bays has attracted a crowd.

Café Avole is open. In early 2020 Avole was one of three bakery customers that joined Josh to purchase solar panels. While finally less than ten blocks from the bakery, Josh cannot just walk by without checking with Amari. The two men embrace without a word. The tall, thin Ethiopian reaches out to bring Sophie into the hug.

"We survive again," Amari smiles.

"So far…," Josh responds, to which Amari laughs.

As if on cue another low aftershock rumbles through. Amari steadies himself. The metal furniture jingles against the brick patio. "So far," he repeats with less of a smile.

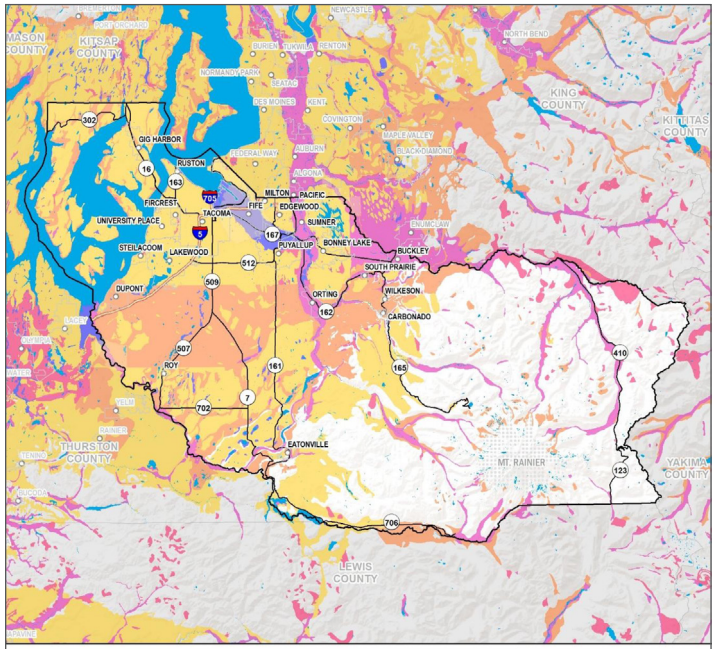
Jack's wife and kids stay with her parents in Yakima. He returns late on Tuesday to be at the Distribution Center for the shift change. The morning shift—especially between Christmas and New Years—can be spotty. Jack wants to personally see and feel what's happening and not.

Turn-out is fine, every trucker and most selectors. The third-shift set-up is, if anything, better than usual. Front of the flow is ready to go, final outbound cases are being loaded.

The seismic concussions hit hard from the start. After about ten seconds Jack feels further acceleration when his mind very much wants deceleration. Screeching, grinding growls surround and swell. Large objects are heard and felt falling hard. Lights sway, some fall, then all fail. Red exits glow. Emergency spotlights lend dust-filled air the semblance of smoke. Neat lines of well-wrapped pallets rattle across the dock spilling their contents. Jack is on his knees, then curled into himself on the concrete floor that has become as a trembling shore. Odors of agitation, friction, industrial solvents, cranberry juice, vinegar, and his own fear assault Jack's nose.

On the dock there is no cover. Between the racks it is even worse. At velocity, a case of canned goods is a very efficient killer. In the freezer everything is hard. Very cold steel shelves snap. Sections of

LIQUEFACTION RISKS IN PIERCE COUNTY (ABOVE) AND SEATTLE (BELOW)



roof collapse. Rigid walls are torn to shreds. Glass shatters, shards scatter. It is a high-speed car crash that continues for over four minutes. Force equals mass times acceleration. A portion of the planet is a powerful multiplier.

Light snow swirls over the black tarmac at Moses Lake. Another C-17 roars off empty. Trembling glints circling above show the sequence of packed cargo planes waiting to land. Pallets from a dozen fixed-wing aircraft are being cross-docked to helicopters and trucks. The dark edge of a winter squall is falling past Mission Peak, racing over the river, approaching fast.

In the seven days since subsidence Grant County International Airport—once-upon Larson Air Force Base—has been transformed. Over the last three days it has averaged five cargo landings per hour, plus take-offs. The mostly tented cross-docks are handling almost as much weight as the Memphis Matrix or Louisville's Worldport. Mostly food. Not enough. But an amazing achievement.

For the last three days volume arriving at Moses Lake is double to triple volume delivered over the mountains to Puget Sound. Big belly planes are unloading into tiny belly helicopters.

Nearly 90 percent of the helicopter airlift is vectored to SeaTac Airport, south of Seattle; Paine Field, south of Everett; and Thun Field, south of Tacoma. If not for aftershocks, SeaTac and/or McChord and/or Paine would be receiving cargo planes directly, but not yet. In the last two days California Air National Guard and Air Force Reserve C-130 aircraft have started cycling in and out of Thun. At each of these landing fields trucks of various kinds arrive, refuel, and are dispatched to both intermediate nodes and a few final destinations.

Final destinations range from cul-de-sacs to elementary schools to fire stations to the far side of fractured bridges, places from which people cannot or should not travel. The intermediate nodes are also diverse: gymnasiums, recently empty retail, tented playgrounds, surviving warehouses, two huge Boeing airplane hangars, and several repurposed micro-fulfillment centers. Where a wide mix of

electronics, tools, books, and Christmas presents recently moved, there are now flows—well, spurts—of shelf-stable-calories.

The flights landing at Moses Lake consist of large quantities of a few products: MREs or ramen or cereal or soup or energy bars and similar neatly stacked cases arriving from Boston, Harrisburg, Atlanta, Lakeland, Memphis, Cincinnati, Chicago, Minneapolis, Los Angeles and many places in between. From Moses Lake the single product pallets are ferried to SeaTac, Paine, or Thun. To feed a few final destinations some pallets are broken up at these three depots. But most pallets stay tightly wrapped until they are received at the intermediate nodes. There are now nine nodes operating between Everett, Redman, and central Pierce County. Again, not enough. Neither volume nor velocity are enough to feed current, much less long-term demand. But, after only seven days, an amazing achievement.

Flows of similar pallets from Stockton, Reno, Salt Lake City, Boise, and Spokane are trucked to various staging areas in and around Ellensburg, Washington. A small number of trucks carrying medical supplies have made the now many hours-long but only hundred-mile trip into Seattle. Landslides are still recurring and at three places Interstate-90 westbound is being stitched into the eastbound lanes to bypass major structural failures. WSDOT is targeting Friday, January 6 to allow the first major convoy over Snoqualmie Pass. If weather cooperates.

Just west of Thun Field three grocery retailers have repurposed preexisting stores into pop-up distribution centers. Products are shuttled from the landing field to parking lots where the homogenous pallets are broken into mixed pallets. What had been a trickle is finally a real flow with the C-130 payloads. For the first time since subsidence Jack has more inbound volume than he has outbound volume. He has six trucks running

Jack is about ten miles south from where the seismic waves had thrown him hard to the ground. That was as the river bottom beneath the building dissolved into mud. Two hours later he had helped place six bludgeoned bodies in the giant meat freezer. One of his assistant managers, a lay preacher, said some prayers. Friday morning they had found a way up and out of the river bottom, bringing trucks and loaded reefers with them. Now he is standing five hundred feet

higher where glaciers once scraped. Much more stable. Jack is still moving food, including about three vans per day evacuated from the ruins in the river bottom. He had passed a note and number to a helicopter pilot who had called his wife in Yakima. Jack now knew that she knew that he was still alive. Tired, but very much alive.

On December 28, Dao Thi Lam and Jane Thisdale, as usual, arrive at the bakery at 3AM. Solomon Senai and his nephew arrive at 3:45. Breads, pastries, cakes and cookies are already baking at 4AM. At 4:30 Avery and Marguerite arrive to help with bagging. Connie Atwater, Pete and Johnny are there at 5AM to fill the trucks with still warm products. Minutes later Amit wanders in for coffee after sleeping on the couch in Josh's office. He is still fine-tuning the new battery array for the solar panels.

When the earthquake strikes at 5:20 Johnny has just clicked his seatbelt, about to start his delivery route. There is a jolt and then two more. To Johnny it feels like an at-speed collision. Inside several full metal bakery racks topple over. A big industrial bowl of chocolate filling pours across the floor. Bags of sugar spill. Open flour bags explode into white clouds. The building's once-upon stucco bell tower spawns a long, ragged crack. But, while the 30-million-year-old compressed ocean bottom fused into primeval basalt rattles it does not shatter.

As the shaking slows, most of the morning crew races for the parking lot. Connie stays prone under the stainless-steel prep table. Amit emerges from the long-ago baptistry, eyes wide, exhaling a breath held too long. The still-swinging ladles, spoons, knifes, and stirrers are now singing instead of screeching.

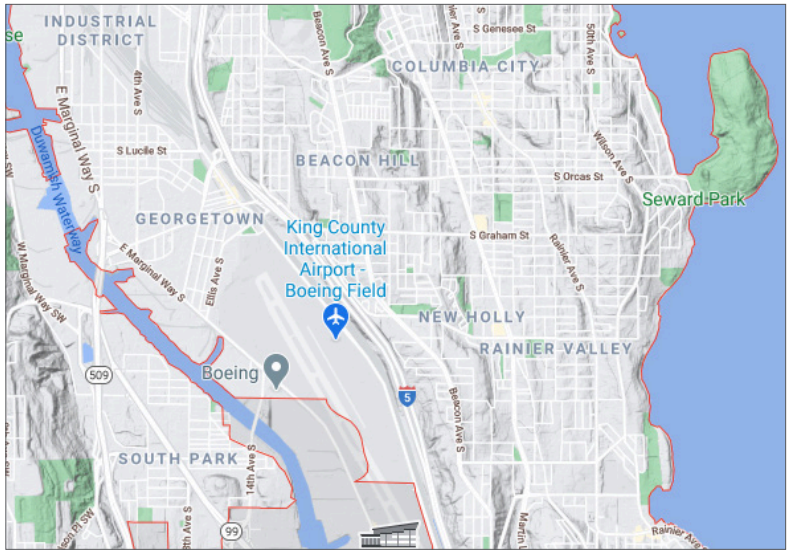
Connie remembers, "It did not fall because it had its foundation on the rock."

When Josh and Sophie arrive late afternoon, the bakery is even busier than usual. Several workers' families are now helping. As the early dusk of a Seattle winter descends, the lights from cracked, now taped, windows seem especially bright on an otherwise powerless street. Two men stop Josh and Sophie from walking into the parking lot until Johnny vouches for them.

The morning's disarray has been replaced by evidence of continuous cooking since. Connie, Amit, Pete, and Johnny gather round Josh to fill him in. One of the big refrigerators has rejected every fix Amit has tried. Connie redistributed the perishables. What cannot be kept is now baking in pies and turnovers. To save power the ventilators have been turned off. The big room is very warm. Amit wants to doublecheck the roof, but the solar panels did their job all day and the batteries are working too.

The big problem is lack of running water. But Amit and the neigh-borhood guys have serpentined **a thousand feet of hose** to Lake Washington. The water is pumped to a commercial coffee maker, now set to boiling, just behind the bakery. Pete and Johnny ended up delivering most of what was baked today. The Dunlap and Othello Safeways stayed open. They found customers open as far north as Beacon Hill and as far south as Kubota Garden. MLK Way survived much better than Rainier Avenue. The I-5 beside Boeing Field looks really torn up, with edges of Beacon Hill now covering several lanes.

They have supplies to bake most of their regular products through at least Saturday. There is enough teff flour for two or three weeks of injera, the bakery's bestselling flatbread. Connie's not sure how long the cardamom seeds will last, but ambasha can also be



Seattle's Southern Edge

raisins, cinnamon, and sesame seeds. On Tuesday they topped off inventories for Coptic Christmas. Unless they can buy more butter and eggs, brioche will disappear first, followed by croissants. Baguettes can be baked for several days, especially if brioche, croissants, and Kaiser rolls cannot.

Blue tarps now cover the ruptured ridge behind the house on 22nd Avenue. Typically distributed to repair roofs lost to hurricanes, JP and his neighbors have deployed several to reduce the chance of rain-washed foundation failures. He packs dirt excavated for the latrine to close the overlapping edges of two tarps extending over most of his backyard. On Friday hundreds of tarps had been delivered with thousands of MREs by a Marine helicopter landing in the drained wading pool at Volunteer Park.

There were two serious aftershocks on Wednesday, but nothing knee-buckling since. The temperature falls on Friday. Rain and some snow threaten Saturday. The crowd at the cemetery self-organizes surprisingly well. Sufficient inputs of water, food, and shelter are available and shared. But by the third day human outputs—especially perspiration, urination, and defecation—are over-concentrated. JP and Miriam decide to risk sleeping at home.

Broken glass is swept away, the refrigerator emptied and cleaned, scattered plaster gathered, and missing windows covered with custom cuts of blue tarp stapled to crooked frames. In the faint light of late afternoon the cerulean hue reminds Miriam of Chartres.

Sunday afternoon JP is on the roof repairing and reinforcing the northwest corner. Miriam is standing at the dining room table. On its surface are assorted objects retrieved from the exorcism of cleaning. Her mother's china teacup, now missing its handle. Honeymoon photos drenched when a water pipe broke. Chipped Christmas decorations from when the tree fell and rolled into the cold fireplace. Much more.

Miriam's right index finger flattens the note Josh had left behind: "Sophie and I are OK too. Heading for the bakery. See you soon. Però, se 'l mondo presente disvia, in voi è la cagione, in voi si cheggia." She smiles again.

Twelve-year-old Josh did not cooperate in learning Italian. After several months of tutoring, she gave way and let him join the rocket club instead. But a decade later he discovered Dante. Wonderful conversations soon unfolded.

The verse is from Purgatorio Canto 16, the monologue on free will: "So, if the present world should go astray, the cause is in you, it will be wrested from you," is a possible translation. Dante's use of si cheggia is unusual. Depending on source and context it might be heard as fight or struggle or play or seek. Josh knows it is one of his mother's favorite lines. As Buddhist as Sufi as Tao as Catholic, Miriam has observed.

Yet after so many readings, today she notices something new. Scheggia is a common Italian word meaning a small piece that has broken off, a chip, a splinter, a sliver, a fragment… scheggia della croce: a sliver of the true cross. Might there be a relationship? If the present world should go astray, the cause is in you, the continuing fragment is you?

Miriam wonders.

PAYDAY

Another bakery is operating in Columbia City. A wood-fired pizza place in Othello is adapting its menu. A pasteleria in Beacon Hill has a solar oven. None of them make injera or ambasha. Josh and Connie decide to discontinue anything needing butter or milk and while baguettes are usually a top seller, they decide to focus on items with a longer shelf-life. The Columbia City bakery and the pizza place probably make a better focaccia, no need to duplicate.

Starting on Friday, December 30, the bakery makes mostly crackers (flour, water, oil, salt, and varied herbs), simple rolls (flour, water, yeast, sugar, and oil) some with honey, injera (flour, water, yeast, and salt) and ambasha (flour, water, yeast, sugar, olive oil, salt, and various spices). Baking more of fewer products increases overall volumes about twenty percent. Because most other suppliers are not delivering into Seattle's southside, demand is much more concentrated and much higher than usual.

Johnny and Pete are delivering fewer products to fewer places, none more than three miles from the bakery. Before subsidence, each day's delivery followed roughly circular routes often fifty miles roundtrip. With the biodiesel already in the gravity-flow tank, their suddenly shorter delivery routes can be served for at least thirty days. Salt and yeast might last that long too. But not flour or oil or sugar, at least not at Thursday's demand pull. Yesterday Johnny made three trips across the twenty blocks between the bakery and three customers in Othello. At the last stop he was glad two of Solomon's bigger nephews were riding with him. The crowd outside the Safeway was clearly nervous.

Connie really can't know how long her current supplies will last. No one has anyway of predicting volume or velocity of demand.

Friday late afternoon Josh gathers his co-workers in the open space where each morning the loaded bread-trays are stacked for Johnny and Pete to roll to their vans. He raises both hands, conversation stops.

"Thank you. I want to give you my sense of where we're at and where we're going. Since Wednesday we have used as much wheat flour as we usually use in seven baking days. We have used as much teff flour as in ten days. Many thanks for your amazing work. You have been creative, diligent, and wonderful."

There are smiles on faces in front of Josh. Also, more male facial hair than usual. Clothes are atypically stained and wrinkled. A few are obviously exhausted. There are also three, make that four faces that Josh does not recognize. He has tried to meet all the nieces and nephews and children and neighbors who have arrived to help. But there are still more.

"The solar panels and batteries are doing well. Our own waterworks is an amazing accomplishment." Enthusiastic applause. "We will continue baking as long as we can." More applause. "Starting Monday, we will, however, limit each day's baking to no more than double our pre-earthquake daily average of flour and oil. By taking this step, we should be able to continue baking at double-daily average volume through at least the end of next week. Meanwhile,

Pete and I are going to try to find a way through to BakeMark. If the building is still standing maybe we can buy or glean more flour and oil. We have delivered blueberry muffins to Fire Station 33." Laughter. "They know we are here and open. They tell us that food is being delivered to SeaTac and a few other places. Pete and I will deliver a care package to the police precinct on our way to BakeMark. We will also ask them to help us get re-supplied. So, we hope to continue baking and feeding beyond next week." Josh pauses, looking over the room. It has only been seven days since the energy and laughter of the Christmas exchange. There is still energy, but of a different sort.

"If we are not re-supplied it is likely that we will have to shut down the ovens sometime between, maybe, January 7 to 10." He pauses again, a deep breath then a slow exhale.

"Today is payday. Payroll would usually have been transferred into your accounts yesterday. That did not happen. Mary-Alice can write a check for anyone who wants one. But there is nowhere for you to cash or process the check. We don't have enough actual cash on hand to pay even one of you for the full two weeks. I am so sorry."

"What we can do is give you bakery products for your own use or that you can barter. We also have about three-hundred cases of wine in the basement. I am not suggesting this as payment in-kind. Providing you with daily bread has nothing to do with paying you what you have earned as soon as the banks reopen. But given our situation, including my inability to pay you now, I want to support your immediate needs as best I can. Trouble is, I can't quite figure out how many rolls or ambasha or injera you can actually use or in what proportion. I hope you will tell me. We will start some sort of distribution on Monday. Today Connie has bread pudding to send home with everyone. We will have a regular Saturday schedule tomorrow. We will not bake on Sunday. What else? What questions can I answer?

A long silence. Then Claire Maxwell asks, "When are you going to marry Sophie?" Laughter. Smiling, Josh glances toward Sophie, standing next to Amit near the doors. Her right hand covering her eyes.

Marguerite stands from her chair near the front. The laughter subsides. She says "Josh…" stops, swallows hard, inhales, then very clearly says, "We give thanks for this life and each other." Quiet. Then Solomon says the same. Then Connie. Others join, "We give thanks for this life and each other."

NEW YEAR'S DAY, 2023

Most Sunday mornings Seattle's Beacon Hill neighborhood is quiet. Especially on New Year's Day morning. Especially when it is cloudy and thirty-four degrees Fahrenheit at eight AM, quiet is not surprising. But fallen traffic lights are still disconcerting. Snapped electrical poles and powerlines coiling across streets startle. The number of windows with no glass still surprises even four days after subsidence.

For long stretches Rainier Avenue is an ancient stream bed, often less than 100 feet above sea level. Martin Luther King Way, just a few blocks west, is consistently higher. Less than one mile farther west, Beacon Avenue can be 300 feet above a sharp slope that descends to the Duwamish River that soon flows into the Sound. Damage and debris along Rainier are undeniable. But as Pete and Josh drive the delivery van north on Beacon Avenue, with the sun just below the mountain ridges, for a few blocks the shadowed streetscape could, without too much willful neglect, suggest the last four days had not happened.

Then the west end of Graham is gone and Swift Avenue is buried. They backtrack and take Orca but have to turn back. The farther downhill on Lucile they go, the more houses have lost more bricks. The street is wavy, then lumpy but, amazingly, the passage is clear beneath the I-5. Then a few yards farther, the viaduct has collapsed onto the rail tracks below. Pete pulls the van tight to the right.

"Whaddya say?" he asks.

"Let's see if we can walk it, at least see if it's still there," Josh answers.

They stumble down the rocky slope to the train tracks. Exit ramps from the I-5 have collapsed blocking the street, but they find an alley that takes them to a perpendicular. Plenty of cracks, some fallen facades, corners toppled.

The industrial area, built on 20th Century fill over a wetland, was seriously shaken, but not as decimated as Pete had imagined. The street is still a street. Structures are, mostly, still standing. He heard there had been fires on Harbor Island, but not here about one mile south.

In grad school, Josh studied the 1995 Kobe quake. Here he has a sense of déjà vu. There is a mix of total failures next to many still standing fine. Most of the larger structures are tilt-ups consisting of concrete panels anchored to concrete floor slabs and steel roof supports. Rigid anchors have been displaced by shaking and liquefaction. Ductile anchors have tended to hold. Strapped roofs have mostly stayed connected. Roofs nailed to wooden ledgers have splintered and separated. Some have collapsed. Once a tilt-up roof detaches, walls tend to follow.

They walk by a wholesaler of granite kitchen counters, the display frames cracked, raw slabs thrown into each other, broken and scattered across the ground. At Essential Baking one reefer has lost a forward chassis strut, another has lost both, each now kneeling. The building is dark.

Near the corner of First Avenue and Marginal there's a US Army ISV in the middle of the road. One uniformed guy with an M4 carbine is standing talking to another guy who is probably one of the neighborhood's homeless contingent.

"Morning," Josh offers as they approach. The guy with wild hair smiles. The soldier responds with a curt "mornin."

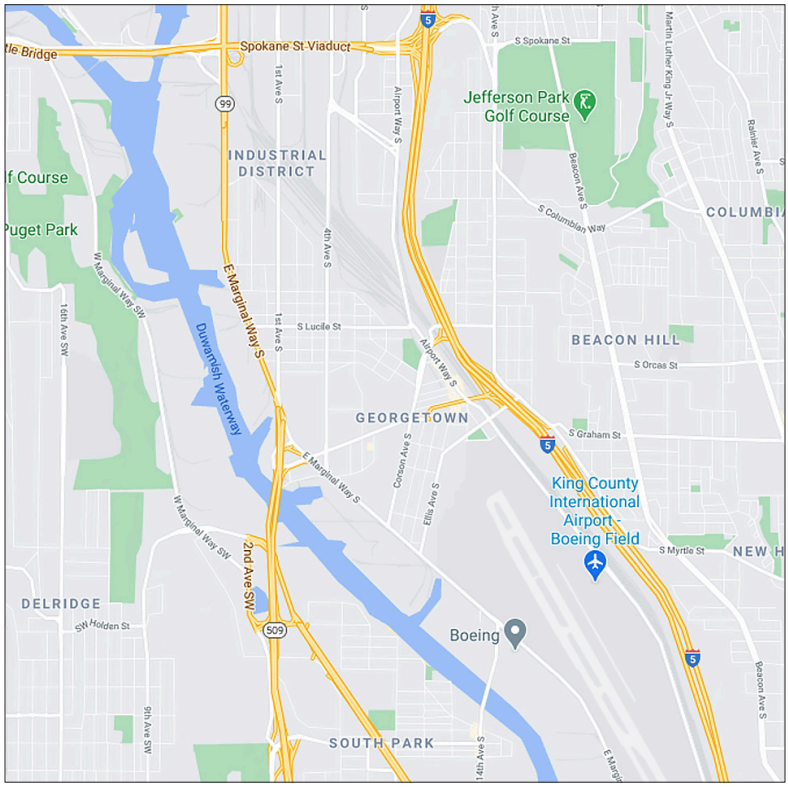
"We're heading for BakeMark, still good?" Josh asks.

"Don't know, sir," the soldier replies, "my team is inside the medical warehouse." He nods toward the low grey building immediately opposite.

"Outside looks good," the smiling man offers. "But I bet the inside is all shook up. It was like a bouncy castle, man."

"How'd you drive in?" Pete asks. "We couldn't get across the train tracks."

"We deployed to Boeing Field at dawn by chopper. Lieutenant says we're going to check all access points across the I-5. But we just started, our second stop. So, can't help you."



South Central Seattle

Three exit the medical warehouse, two in uniform, one a civilian.

The Lieutenant reaches out with a fist bump to Josh, "Adam Adelman, US Army."

"Josh Poloma, Seattle baker. This is Pete Ritzinger." Another fist bump and more introductions. Josh explains what they want to find. Lieutenant Adelman says BakeMark is next on their list. They walk south together.

"What's your list?" Josh asks the lieutenant.

"We're a Supply Chain Surveillance Team. We assess what's still working, what's recoverable. We have a list of warehouses, distribution centers, food processors, fuel depots stuff like that. Mostly prechecked by drone. But we've been sent in to doublecheck this area, looking where the drone cannot see. Mostly inside."

At BakeMark there are fifteen dock-doors. Five on the north end are inaccessible behind a collapsed canopy and wall. Three others farther along have lost their rolling doors, exposing the fallen racks and inventory within. Josh can see pallets and pallets of flour just waiting. The soldier takes photographs with her rugged looking tablet.

The female civilian from King County Emergency Management climbs a naked chassis to look inside. "Total mess," she says, "but looks like most of the product could still be used."

"This is our regular supplier," Josh says. "I don't think they would've had anyone here at 0520 on a Wednesday morning and doesn't look like anyone has been here since."

"Hard to get here," the civilian SupSurt member responds. "No known road access from west or east. Big chunks of the Spokane Street Viaduct block access from the north. It's even worse from the south. Can't get close. We're looking for an eye-of-the-needle to thread."

A second soldier with another tablet asks Josh, "What's the name of your bakery?"

"Rainier Valley on Rainier Avenue South."

The soldier scrolls and looks up, "You're on the list. You're supposed to have solar power."

"Good list," Pete comments.

"We're still baking. But won't be for much longer without more flour and oil. That's why we're here," Josh adds.

The lieutenant says, "We can help with that."

JANUARY 3, 2023

Tuesday, shortly after 2PM, a Seattle fire department SUV arrives at the bakery. Josh is requested by name. Sophie has just finished formulating yeast for the overnight, so he asks her to climb in for the unexpected ride to the Rainier Beach High School football field (home of the Vikings).

A Washington National Guard soldier stops the SUV at the

entrance to the high school parking lot. The firefighter explains what he knows. Another soldier asks Josh and Sophie to walk with him. A large, insulated tent has been erected behind the Eastern goal posts. Just about the fifty-yard line a US Navy Seahawk is about to drop a cabled pallet into the deck of an Oshkosh MTV. Three more trucks are standing by.

Inside the tent the helicopter's wump-wump is surprisingly softened. The soldier hands over the visitors to another soldier who leads Josh and Sophie to a table at the south end of the tent.

A civilian wearing a bright orange insulated vest and a tattered red pocket cap looks up, smiles, and says, "You must be Josh Paloma. I'm Nick Peake FEMA ESF-14." Instead of offering a fist-bump, the man bows slightly. "I understand you need some baking flour."

The next ten minutes are as surreal as any scene from Kafka's *Amerika*. The friendly guy from "cross-sector operations" deploys several PDFs on his digital tablet. Josh gets lost, but Sophie thinks she follows. Basically, the federal government will sell Josh flour, oil, and other supplies. The government will also loan Josh the funds to buy the flour. If Josh demonstrates that he sells or donates goods made with the supplies inside the zip codes listed (Western Washington) then the government will forgive the loans. Several digital pages are dedicated to how Josh can prove that the goods are sold at fair market prices or donated as required. More screens are dedicated to financial and criminal penalties for not complying as required.

"If you sign here, here, and here—and here—sorry, my first time too—then I will send you back to the bakery in a truck with your first load. I expect to be able to make deliveries most days, weather cooperating."

Josh, wide-eyed, looks at Sophie.

"Yes, it's all sort-of crazy," Nick says. "But basically, the lawyers have put together a way for us to get you what you need, if you sign. As far as I can tell, unless you stop baking or charge exorbitant prices, you get free flour and whatever else we can vector in. Teff flour is not easy for us to get right now."

Sophie nods affirmatively.

"While you think about it," Nick says. "I have someone else who wants to talk to you." The FEMA guy punches in a number on a satellite phone and repeats another number to whoever answers on the other end, then says, "Kathy, Nick here. I found him. Stand by for Josh Paloma." And he hands the boxy device to Josh.

"Hello?" his voice is scratchy.

"Josh, great to find you. This is Kathy Juniper. I hear you're still baking. I hope we can help keep you baking." She pauses, but Josh does not fill the steely echo, so, she continues, "Nick can give you any answers you need. He's a good man. But I'm trying to find your friend Sophie, can you help me find her?"

"She's standing right here."

"Great. Can I answer anything? Nick really knows more than me. Otherwise, can I talk to Sophie?"

Josh extends the satellite phone to Sophie. "It's for you. It's Kathy Juniper. The professor who sent us the poem."

Accepting the fat orange curved rectangle with a black phallic extension she holds it in front of her face. "This is Sophie."

"Oh, thank goodness we connected before Christmas. Your floating bridges have been enormously helpful. But we need you. Please join us in Ellensburg?"

"Ellensburg?"

"Kittias County, just over the mountains. We're staging a big push into Puget, probably next week. We really need your help choosing and placing our active edges."

Human speech is often full of details that have five-second lifespans but when interwoven approach the infinite. Meaning emerges mostly from emotional connections made between so-called content.

Forty minutes later Sophie is boarding a Navy helicopter, barely 24 hours out from Guam, returning to Bowers Field, about 100 miles east of Rainier Valley.

Josh and Nick wave as Sophie lifts above the football field.

Nick yells above the rotor wash, "This chopper squadron calls themselves the Archangels."

ORTHODOX CHRISTMAS EVE (JANUARY 6)

Jack now has a storage yard with twelve-reefers and twenty vans in what was the west-side parking lot. He has relocated six electric forklifts and two propane units from the ruined Distribution Center. Almost all the retail store-shelves have been removed to allow for palletized storage and loading line ups. On the east and west walls full size racks are going up, cannibalized from the river-bottom. The once-upon large retail store has three efficient dock doors. There are now two more (less efficient). The fuel center is for delivery trucks only.

Pre-subsidence Jack supplied forty-two stores. Now there is recurring, sputtering flow for fourteen. Three more should be reopened in another week. He has eight trucks on regular routes. He has already gone through twenty ruined tires. New tires have been even tougher to find than fuel. The airlift into Thun was focused on food and water for most of the first week. This week Jack has been able to finagle other missing pieces. Not enough. But both inbound and outbound are now much more than catch-as-catch-can. There is sustained volume and intentional velocity. It is a network again not just a random walk.

About noon Jack is in the back meeting with the Pierce County Emergency Management private sector liaison. She has been working with each of four grocery distributors on retail locations to reopen based on population, distance to other grocery stores, the comparative physical condition of each structure, and current abilities of each distributor to supply. The idea is to maximize the limits of each distributor to serve the most people.

They are interrupted by the lead selector, "Boss, better come front. We got company."

Jack assumes it is the National Guard or maybe a crowd of neighborhood customers. Retail is still available out of the one-time tenant spaces on the southeast corner of the building.

Instead, diesel engines idling, there are five full-size 18 wheelers, accompanied by two National Guard ISVs, all packed with groceries ready to be unloaded. Each van carries about 50,000 pounds. A Blackhawk carries about 9000. Jack has seen Sea Dragons drop

about 32,000 pounds. The C-130s deliver about 50,000 pounds per sortie. This is more inbound than he has received on any single day since subsidence.

"Shit," Jack whispers. "The cavalry's arrived."

On eighty miles of I-90 between North Bend and Ellensburg there were five landslides and three major structural failures. Over the nine days since subsidence—and with every aftershock since—the Washington Department of Transportation, joined by US Army Corps of Engineers, Third Fleet Seabees, and construction crews from as far away as Salt Lake City have dug dirt, constructed road ramps, and reconnected Puget Sound to the continent east of Issaquah. Between the I-90's intersection with Route 18 at Tiger Mountain and the White River, engineers and construction teams have cleared more landslides, repaired three bridges, including installation of a 2000-foot-long Bailey Bridge. These needs were anticipated, preparations put-in-place.

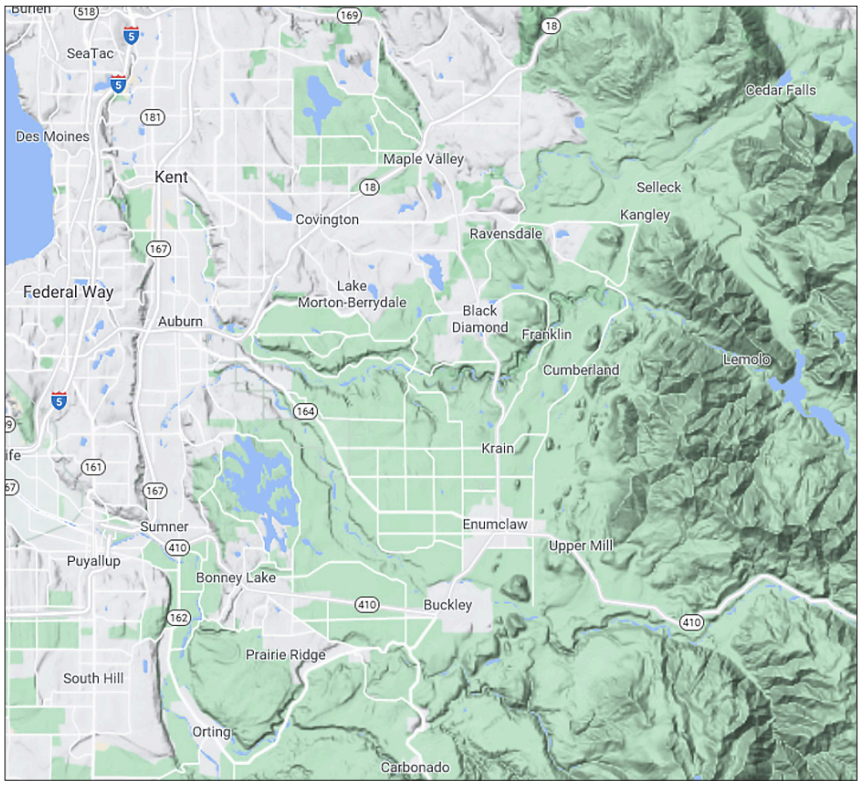
At dawn on January 6, one-hundred twelve trucks pulling fully loaded grocery vans, accompanied by twenty-one Idaho, Washington, and Utah National Guard ISVs, roll out of their staging areas at the Loves and Pilot Truck Stops just west of Ellensburg. At North Bend seventy-two trucks with escorts head north on the 202. Four miles farther the rest of the convoy heads south on State Route 18. Winds gust to 25 miles per hour. Snow flurries with an occasional squall keep the wipers sweeping.

The trucks roll south eventually taking route 169 out of Maple Valley, shedding one or two along the way. There are only twelve in the convoy departing Enumclaw on the 410. The entire route has been chosen to edge around the Seattle Basin avoiding the worst liquefaction. Out of Orting the convoy is on country roads. After turning right on route 161, five find Jack. Another of the Thun Field pop-up DCs gets four. The third gets three vans, mostly reflecting pre-subsidence market share.

Jack's five include two Kroger-branded vans, one Walmart, one Albertsons, and one Estes. The calorie contents of each van come from even more diverse sources. FEMA has done deals with grocery manufacturers and distributors that are mostly bigger, more surreal

versions of what Josh signed-up for the bakery. Ellensburg has become a huge mixing bowl to convert converging volumes of single item pallets into mixed-item van loads that can maximize available velocity. Not enough… yet. But, still, after barely ten days, an amazing achievement.

Two hours past sundown, Tadros and his cousin Ashraf arrive at the bakery. They are now the night watch, allowing Josh and Amit sound sleep. At the far-end of the kitchen they light a candle, turn off the lights, then sing together in Arabic, "According to Your mercy, I enter Your house. Before the angels, I sing to You and bow down before Your Sanctuary. To the Holy Maiden Mary: We praise you, with Gabriel the archangel, saying; Hail to you, O full of grace. The Lord is with You."



Tiger Mountain to Thun Field

JANUARY 12, 2023

Hammering Man still stands outside the museum, but his arm no longer hammers. *Middle Fork,* John Grade's 105-foot life-size tree sculpture in the lobby has lost one of its sections and three of its limbs. Yet the ductile anchors and flexible cables mostly held.

The galleries are dark, cold, and layered in dust. Emergency lights are long drained. But Miriam and five other curators and carpenters are back with flashlights and hand-tools. In the third-floor contemporary spaces, a quick inspection suggests a couple of crumples, but no fatalities. Seismic mitigation measures have kept their promises.

The fourth-floor African galleries are almost pristine, even dust is obscured by lack of light. The windowless room opening into the European collection, reconceived for the Antonello exhibit, is almost as well-preserved. Tempera on Monaco's *Christ on the Cross* sparkles as the narrow beam sweeps the gallery walls. Jan Swart's *Miracle* has fallen to the floor, but Miriam does not immediately recognize serious damage.

Both of Antonello's crucifixions are exactly as Miriam last saw them. But the gypsum wall behind London has fractured. The contrasting Madonnas with child are fine, but a ceiling corner above the Benson is missing. Serious cleaning will be required. Munich's Mary still asks, "How can this be?" It is a question Miriam has been asking herself, recalling that in the Quran when Gabriel appears before the soon-to-conceive mother of Jesus, she tells the archangel to "leave me alone." The young girl knows enough to realize encounters with divinity are usually catastrophic, previous narratives dramatically shifted: positive or negative or often both.

The Syracuse Annunciation, almost 6x6 feet, has already survived the 1693 earthquake and others since. The earthquake, colluding with newly popular Baroque preferences, caused the Annunciation to be relocated from the altar to an obscure rather damp arcade wall. Several patches without any painted elements mostly result from two centuries of mold. The depth and pattern of crettatura implicates age more than seismicity. Before and after photos indicate the 1906 restoration caused further cracking. Human choice and neglect have done more damage than geologic convulsions.

Flame-like lacunae consume much of the lower third of the Annunciation, Clyfford Still silhouettes emerging from Fifteenth Century allegory. The warp and woof of naked canvas expose Antonello's complex scene as fingernail thin. The angel, the girl, Talmud, well-known narrative, unknown merchants, fisherman, miniature patron, likely lovers, intrusive divisions, and infinite horizon reside on the shallow edge of assorted pigments mixed with linseed oil, layered to entice human eyes and fire our imaginations. Beneath this edge was decayed walnut, replaced in the early 20th Century with tightly woven linen and glue.

Detail of Mary's hands from the Syracuse Annunciation

Much to Miriam's dismay Palazzo Bellomo had required that the Annunciation remain in an air-tight, gas-filled, threat-resistant glass envelope. This casement had then been attached to a three-part custom-made device using springs, ball bearings, and sliding parts to keep the painting stable if it needed to surf seismic movements (or clumsy visitors). It is this mechanical isolator that is bolted to the building's frame.

Apparently, it worked. Miriam cannot find even an errant flake inside the transparent armor.

Miriam is glad harm has been avoided. The value of the protective device is clear. Its costs are complicated, involving loss of intimacy, immediacy, and—the illusion of?—symbiosis. Rather than mysteries

revealed, she perceives a shroud: separating, even deadening. Active expression of infinite being requires self-aware openness to risk. She loves the Munich Annunciation because the subject is so obviously vulnerable. How much, Miriam wonders, does her affection for Syracuse depend on what it has obviously suffered. Wouldn't this maiden's smile seem smug without all the surrounding distress? Even with two fingers missing, the Syracuse Mary has deft, not defensive, hands. Her surviving fingers relay courage and competence in response to Gabriel's audacious claims.

Miriam departs Antonello dreading what she will find in the Porcelain Room.

[On this day in 2010 a 7.0 Mw earthquake decimated Port-au-Prince, Haiti, killing a quarter of a million people.]

DECEMBER 7, 2023

Standing before a large group at the SeaTac conference space, Kathy Juniper summarizes what happened—and had not happened—almost one year before focusing on Puget Sound. Charts and maps begin to blur in the most organized minds.

Real demand—actual need—was largely static. Given the earthquake's predawn timing most people were at home. More than ninety-seven percent of the population survived. Those with preexisting vulnerabilities encountered seriously amplified risk and hundreds of thousands were newly vulnerable. Tens of thousands were suddenly homeless. Still, most residential structures remained habitable. Most preexisting pantry stocks survived. Given the 2020-2021 pandemic, many pantries were better stocked than had been the case two years before. Given the holiday season, many pantries were better stocked than two weeks before.

The ability of demand to pull new supply was, however, profoundly disrupted. The water network experienced thousands of ruptures. Many grocery retail facilities were wrecked, most losing both power and communications connections. The ability of consumers to express demand evaporated in the failure of digital connections at homes and stores.

Many flow channels were destroyed by the earthquake. Cell towers, communications cables, switching stations, electrical transformers, substations, bridges, roadways, pipelines, docks, and runways were missing, unreliable, or blocked by debris. The population was physically separated from stores and functionally separated from e-commerce. Stores were separated from suppliers and unable to communicate demand. Demand—from wherever—could not be heard. Sending supplies was confusing, uncertain, complicated, and in some places impossible.

Distribution centers collapsed. Fuel could not be pumped. Most truck drivers were not yet at their trucks. Interstate-5 at Tacoma and farther south was shattered. Interstate 90 was fractured from Seattle to Snoqualmie and a few places farther east. Even where volume survived, potential velocity for moving volume was slashed.

Large proportions of production, processing, and packaging suddenly stopped. The grid was severed. Natural gas lines were mangled. Equipment toppled. Roofs fell in. Walls fell over. Running water was scarce.

For at least sixty hours after the tremendous initial jolt, demand was silenced, supply was suppressed. There were two serious aftershocks and dozens more that, while less serious, delayed and complicated recovery.

And…while much was destroyed, much remained with which to begin again. Most of Washington's September potato harvest—three billion pounds—remained nearby. Close to one hundred million boxes of Washington apples were just over the mountain passes. The huge flour mills in Spokane County still stood. Cairnspring and Fairhaven mills at Burlington, survived the shaking and the sixty miles of I-5 south to Seattle survived much better than the I-5 south of Olympia to Portland.

Many Puget Sound food processors were functionally demolished. But about as many survived. Even where food processing capabilities were mangled, substantial inventories of foodstuffs could be salvaged. Farther east, beyond that ominously beautiful line of ancient volcanoes, the farm-to-factory network continued to operate (minus a few bridges).

Within ten days the I-90 was sort-of stitched together again. Various round-about routes were figured out. Straight lines were lost, but other links from here to there were found. Pilot and Flying J Travel Centers in Winnemucca, Nevada became surprisingly important to Seattle. The twenty-eight miles of State Route 18 in King County, Washington saw truck counts surge. Tiger Mountain truckers are high on the long list of heroes that Puget Sound history will honor.

Most important—almost miraculously—velocity was rescued from the wreckage by a smart restart of demand signaling and the recent diversification of the distribution network. Demand facing functions were rescued. Demand-oriented decisions were supported. Preexisting demand was used to inform the targeting and pulling of post-disaster supply. High volumes from many places were able to be disaggregated into what was really needed and pushed there. The emergent network generated a fraction of prior velocity, but it was enough to move enough volume toward enough demand when it really mattered.

The major reorganization of grocery and other retail distribution prompted by the Pandemic had transformed many hub-and-spoke supply chains into something closer to rhizomes. An even higher capacity system was constructed of widely distributed nodes. Puget Sound was at the forefront of this transformation. Huge high-volume distribution centers—Giant Components—are still involved, but so are many other nodes that were able to partially compensate for the loss of the network's biggest pumps.

It was hit and miss and very hard for the first forty days, but as the aftershocks weakened and recurred less often, adaptation was able to establish a new equilibrium. No place anywhere close to Puget Sound was back to normal after six weeks or six months. But there was more anxiety than actual hunger. Because of the Pandemic, the people of Puget Sound were much better fed in 2023 than they would have been fed if the Cascadia Seismic Event had happened on December 28, 2019.

PART IV—TEXT, CONTEXT, SUBTEXT

REALITY IS FRAGMENTED. Reality is layered. Reality extends in time and space. We seldom, perhaps never, comprehend the whole. But our fractures can cohere. We are influenced by what emerged long-ago and far away. We can also exert influence with understanding and intention—or too often not.

Text was once the weave of a fabric, that look and feel emerging from threads entwined over and under each other. Text became words woven with particular purpose or in a specific style. For awhile text was synonymous with scripture. Recently text has become both verb and noun for quick messages exchanged by mobile telephones.

This text is fragmented. This text is layered. This story is incomplete, it excludes much more than it includes. Reality is much more densely detailed than these pages. Yet even from these fragments, a reader can quickly discern much more than most of us know about our typical day.

This text places a set of fragments in context. Several threads are interwoven. Separate pieces are connected. Intersection in time and space clarifies both differences and similarities. Continuities can be traced, perhaps even coherent potential.

Out of context our experiences can seem especially fractured and fracturing. With an awareness of context, creative possibilities can be unveiled. Standing under (or over) the complex weave we can understand, at least in part. By recognizing connections and consciously making connections we are much more likely to achieve a strong, long-lasting, continuous fabric… or deploy purposeful discontinuity.

In context we recognize how separate pieces are related: competitive or compassionate, independent or interdependent or dependent, contrasting or coinciding. The purpose of this text is, in many ways, to encourage enhanced attention to context.

Contemporary complexities, professional specializations, perpetual mobility, and post-Enlightenment habits have diminished our sense of shared context. We use definitions—boundary setting devices—to explicitly detach functions, variables, and even purposes from context. Many approach life as a series of randomized controlled trials, with more emphasis on what can be controlled than what is random. Along the way, subjects are rigorously separated. We treat each group differently to accurately observe what differences then emerge. If we can, we voluntarily blind ourselves to reduce the chance that expectations or purposes or affections might influence outcomes.

It is a great way to test for medical efficacy. In other contexts, such controls can wound and contaminate.

Rather than exclude bias we could consciously cultivate bias. Another etymological excursion: bias was once the diagonal line between the warp and weft of a woven fabric. It is the professed oblique, as when Alexander chose his angle of attack or as in the Second Law when two motions obliquely joined create a new motion or as in Picasso's cubist inflections. When an oblique is deployed, is there a purpose? Purpose or not, what is the outcome? Is the oblique constructive? Is the oblique justifiable?

This brings us to motivation or intention or unintended consequences. To what extent are we complicit? Is choice implicated or a delusion? Do we decide or mostly react? Are our choices explicitly targeted or randomly experienced?

In this text, a Fifteenth Century artist and his creations are used to explore a range of potentially persistent subtexts: surprise, suffering, survival, coincidence, edgy creativity, conflating contradictions, peripherals unfolding into crux and core, death, destruction, and resurrection. How will these be encountered in our next catastrophe?

"What, after all, of the remain(s), today, for us, here, now..."

> "For us, here, now, from now on..."
>
> "The incalculable of *what remains* calculates itself, elaborates all the coups [strokes, blows, etc.], twists or scaffolds them in silence, you would wear yourself out even faster by counting them. Each little square is delimited, each column rises with an impressive self-sufficiency, and yet there is an element of contagion, the infinite circulation of general equivalence..."
>
> Jacques Derrida **GLAS**

[M. Wilhelm Meyer and Maxim Gorki arrived in Messina four days after the December 28, 1908 earthquake and tsunami. The following pages 140-141 excerpt, translate and paraphrase what they were told, observed, and reported in the original German.]

On the eve of the catastrophe and all that night, the wind had been blowing. The sea had angrily pushed massive waves against the shore, and residents locked their doors and windows tight to protect from unusual cold. At 5:20 that morning the earth trembled, the first quake lasting almost ten seconds: crackling and cracking of window frames and door jambs, shattering glass, and collapsing stairs awoke those sleeping. Leaping up, they felt an unceasing series of subterranean throbs all through their bodies, rational thought promptly displaced by paralyzing fear.

Some ran about their rooms in distress, trying to find light in the dark, gathering women and children around them even while walls swayed, shelves, vessels, pictures, and mirrors detaching and falling to the floor, even as the floor itself was warping. Furniture was shaken back and forth, the cupboards dancing then falling prostrate, tables still bouncing. Each slack thing panicked and hostile to humans, all inert things threatening death to any living thing.

As if it were made of paper, the ceiling tore, stucco fell, lumber splintered, bricks and stone scattered. Children were sobbing, cries of fear, groaning in pain. Hurrying through the dark, survivors bumped into each other, finding no way out of the sudden cyclone that converted their houses into shifting barges, rummaging the earth beneath them like the waves of the sea.

Am Vorabend der Katastrophe und während der ganzen Nacht hatte der Wind geweht, das Meer hatte seine hohen Wellen wütend gegen die Ufer geschleudert, und die Bewohner Messinas und der kalabrischen Uferstädte hatten, um sich vor der ungewohnten Kälte zu schützen, Türen und Fenster fest verschlossen und lagen in festem Morgenschlummer. Um 5 Uhr 20 Minuten erzitterte die Erde, ihr erstes Beben dauerte fast zehn Sekunden: das Knistern und Krachen der Fensterrahmen und Türpfosten, das Klirren der Scheiben, das Gepolter der einstürzenden Treppen weckte die Schlafen- den, und sie sprangen auf, an ihrem ganzen Körper diese unterirdischen Stöße fühlend, die ihnen plötzlich das Bewußtsein raubten und sie mit jäher, geistlähmen- der Furcht erfüllten. Die einen liefen verstört im Zimmer umher, suchten im Finstern Licht zu machen und scharten Frau und Kinder um sich, während rings um sie die Wände prasselnd schwankten, die Konsolen, Gefäße, Bilder, Spiegel sich von den Wänden lösten und auf den Boden fielen, der Boden selbst sich verbog, die Möbel hin und her gerüttelt wurden, die Schränke durch die Zimmer tanzten und umfielen, die Tische umherhüpften und alles von Panik erfüllt, alles den Menschen feindlich gesinnt war und sie mit dem Tode bedrohte. Wie wenn sie von Papier wäre, so zerbarst die Decke, der Stuck fiel herab—überall das Knistern und Krachen des Holzes und das Rollen der Steine, das Weinen der Kinder, Angstgeschrei, schmerz- liches Stöhnen. Menschen eilten durch das Dunkel, stießen gegeneinander und fanden keinen. Ausweg aus diesem Wirbelsturm, der plötzlich ihre Häuser in schwankende Barken verwandelte und in der Erde unter ihnen wühlte wie in den Wogen des Meeres.

MEYER-GORKI TEXT CONTINUES

Everything trembled and tumbled in darkness, crashing into the abyss now opened. Wherever stairs had descended there were now black pits from which dust devils of destruction whirled. The terrified jumped, children in their arms, hoping for solid ground.

Their limbs broke, skulls smashed, crawling over piles of rubble, each surviving stained with blood. All things rolled from repeated aftershocks. Screaming and moaning arose from tens of thousands of human throats. In the pre-dawn darkness, houses collapsed one by one, masonry flew. Mortar fell and buried mutilated bodies of half-naked survivors, shivering with cold and horror.

Dust rose with the whirling wind into staring eyes, sprinkling open wounds, covering bloody faces with hideous masks. No sooner had one cloud of dust dispersed when, with a new collapse, another gray vortex would rise as a cloud pelting people in the street with small stones. The earth booming and groaning, bending and making deep crevices—as if a gigantic worm slumbering since ancient times had awakened and crawled, its tensing muscles breaking the bark of earth, pulling buildings down on heads of living things.

Water pipes were broken, geysers erupting from cracks in the earth, splashing all passing with freezing water. The feet of those fleeing were tripped by sudden holes. With each new earthquake more were torn from life. Those who still had strength to walk (or crawl) moved for the shore or one of the city parks, stumbling all the way over messes of fallen wires that had once connected them to modern life.

Houses swayed and shook, crevices and cracks zigzagged over white walls, then collapsed, blocking narrow streets, entombing residents within huge masses of broken stone and splintered beams. The limbs of women and children broke, disfiguring their bodies in horrific ways.

The deep subsurface rolling, the rumbling of stones, the cracking of beams, all these were drowned out by cries for help, groans of the

wounded, insane calls of despair. Fresh gray dust swirled up into the sky, suppressing breath and obscuring sight. It was impossible to see where the danger is less, where one might escape…

The earth ebbs and swells like the sea, shaking palaces, shacks, houses of worship, barracks, prisons, schools… Cascading again and again, it destroys hundreds and thousands of women and children, rich and poor, educated and uneducated, believers and deniers of God. Survivors nestle close to the earth—wanting to sink up to their necks, gaining a moment of stability, peace and rest… They want to drink; the dust excites thirst. But the fountains have spilled out, so they greedily sip inky water from puddles.

Small, yellow flames are already flickering in the rubble, like those eternal lamps that burn before images of the Madonna. It is the dry wood of the beams that ignites, the underlaid ceilings, smashed furniture, doors, yesterday's laundry—everything is on fire. The smoke mixed with mortar, debris, and dust is dense and acrid... There is thunder and another crash. A bright pillar of fire blazes up. Gas has exploded and this row of houses, spared by the earthquake, collapse from the blast…

Death is awakened, rising up against man and triumphs over us in blind, blunt strength, taking revenge for all those civilized, latter day humane victories. Death seeks to intimidate and humiliate our insubordinate spirit…

The sea foams with anger, the horizon entirely obscured by spray. Thousands of waves crash, throwing up white crests against each other in the narrow strait. The shore dweller, intimate with the sea, sees something unusual and ominous in this dance: the green mass of water has no rhythm. The sea does not show its ordinary shared upswing nor harmonic descent. This morning the dance of the waves is strange, wild, incomprehensible, as if a giant of irrepressible strength had tossed the water up and immediately pulled every wave down by gripping their dangling roots.

Yawning gorges replace watery mountains. Everywhere the eye can see, waves form scarps of high, dark hills that shake their ridges then

disappear, disintegrating into snowy white, sliding down into the depths of a roaring inchoate mass, the whole shaken by constant fluctuations from hidden fire blazing below. The sea undulates like a huge bowl that will pour its contents over the remains of the city.

The sea itself is in despair, pale with almost human terror… The sea had always been like a poem to this city, keeping its rhythm in every storm: that regular punctuation against the rocks making its own grand melody, even the most impetuous songs sounding somehow harmonious as an organ under the sky's dome. But now the high waves shake with wild roaring fear, grabbing at the rubble of houses as if these waves do not want to return to their depths, where hostile blows press and crush, finally propelling their liquid bodies over the edge of the shore. In mad leaps, the waves crash onto land, one over the other, destroying buildings, pulling corpses, loosing lumber, extracting stones and hauling all back to the beach, where each is pulverized on the hard edge of rocks.

Then looking out at sea, people back away, and scream. A wave of immeasurable height has risen—its white crest covering half the sky plunging the beach, burying houses and rubble. It crushes and strangles the living and then loses its grip on the shore, sliding back into the depths carrying away debris from boats, doors, furniture, women and children, priests, workers, soldiers, students… Now, again, returning, farther into the city. Then hitting the rocks once more, this time with weaker strength, giving rest to those still alive.

Dawn is finished, sun instead of sea climbing. The ruins of the city smoking, fire snaking across heaps of rubble, now and then flames forming triumphant pillars. Buildings still collapsing—continual collapse lasting for six full hours—through clouds of dust and acrid smoke that smelled of burnt flesh and fat…There are no words to paint the pain, no colors to capture the catastrophe…

How could this terrible thing happen? Is not this earth the foundation on which we all build our hopes? Cannot the same horrible fate hit any of us at this very moment? Such thinking would plunge us into dull, inactive despair if we did not feel a deep urge to triumph over the horrors of death.

A newly vivacious life blossomed over the rubble of Lisbon, San Francisco, and Valparaiso. Messina will also be resurrected—perhaps more beautifully—certainly on a more confident basis. In the face of the terror, the people have forgotten all their petty struggles and join hands with the unfortunate to raise up again…

Oh! How does misery always unite us? In view of these elemental catastrophes, do we now perceive how little the individual—indeed, the individual nation—means? Essential nature leads humankind towards common goals, mutual joy, and shared suffering. Everything would be more beautiful and blossom more brightly if we always joined hands as on this horrible day.

Nature is not as cruel as these horrors seem to tell us. It is we ourselves who mostly cause these wounds. When on November 1, 1755 Lisbon, the richest city of that time, fell into ruins, 32,000 were buried and humankind wanted to despair of benevolent providence.

But Rousseau, who always called people back to their essential selves, said that the victims would not have been buried so deep, if they had not built their palaces so high. The same must said today. All these horrors are telling us: It is we ourselves that cause these wounds.

For much more than a century now, since the city was last shattered by a violent earthquake, residents have been warned of the constant threat and advised to build earthquake-proof buildings. Science and technology, which have been fully domesticated in Japan (almost constantly shaking) have long set strong standards… Today, science can with a high degree of probability indicate where there is a greater, lesser or no earthquake hazard, so that we can choose accordingly.

This catastrophe ought to be recognized as a necessary, foreseeable consequence of the processes that have shaped our globe for millions of years and will continue doing so. If such insight cannot reduce the misfortune itself, it should eliminate our temptation to denial and paralysis…

RESEARCH BIBLIOGRAPHY

Geology and Seismicity

Atwater, Brian F. "Evidence for Great Holocene Earthquakes along the Outer Coast of Washington State." Science, vol. 236, no. 4804, (1987)

Atwater, Brian F. and Hemphill-Haley, Eileen, Recurrence Intervals for Great Earthquakes Of the Past 3,500 Years at Northeastern Willapa Bay, Washington, United States Geological Survey (1997)

Atwater, B.F., Musumi-Rokkaku, S., Satake, K., Tsuji, Y., Ueda, K., and Yamaguchi, D.K., The orphan tsunami of 1700—Japanese clues to a parent earthquake in North America, 2nd ed.: Seattle, University of Washington Press, U.S. Geological Survey Professional Paper 1707 (2015)

Robert A. Morton, Noreen A. Purcell , and Russell L. Peterson, Large-Scale Cycles Of Holocene Deposition and Erosion at the Entrance to Willapa Bay, Washington Implications For Future Land Loss and Coastal Change, United States Geological Survey (2018)

Bodmer, Miles and Toomey, Doug, Parts of the Pacific Northwest's Cascadia fault are more seismically active than others—imaging data suggests why, The Conversation (August 2018)

Pogue, Kevin R., Folds, floods, and fine wine: Geologic influences on the terroir of the Columbia Basin, Geological Society of America (2009)

Oregon Statue University, Volcano World, The Earth's Layers (2020)

Toomey, Doug, Hooft, Emilie E. El, Schmandt, Brandon, Buoyant Asthenosphere Beneath Cascadia Influences Megathrust Segmentation, Geophysical Research Letters (2018)

Tripathy-Lang, Alka, A subduction zone in pieces: the segmented Cascadia megathrust, Incorporated Research Institutions for Seismology (2019) *based on Toomey et al immediate prior*

University of Oregon, Cascadia Initiative Expedition Team (CIET: Cascadia Amphibious Array), Collected Data 2011-2014

Dhakal, Y.P., Suzuki, W., Kimura, T. et al. Evidence of strong long-period ground motions of engineering importance for Nankai Trough plate boundary earthquakes: comparison of ground motions of two moderate-magnitude earthquakes. Earth Planets Space (2018)

M. Kano , H. Nagao , K. Nagata , S. Ito , S. Sakai , S. Nakagawa, M. Hori , N. Hirata, Seismic wavefield imaging of long-period ground motion in the Tokyo metropolitan area, Japan, JGR: Solid Earth (2017)

Smart, Ashley, Artificial Intelligence takes on earthquake prediction, Quanta (2019)

Kermanshah, A. and Derrible, S, A geographical and multi-criteria vulnerability assessment of transportation networks against extreme earthquakes, Reliability Engineering and System Safety (2016)

Hawley, William B. and Allen, Richard M., The Fragmented Death of the Farallon Plate, Geophysical Research Letters (2019)

Rumble, Amanda, Why does basalt weather faster than granite? Sciencing (2017)

Haas, Ryan and Rosman, John, How powerful is a 9.0 earthquake? Oregon Public Broadcasting (2015)

Wang, Y., Forsyth, D., Savage, B., Fossil slabs attached to unsubducted fragments of the Farallon plate, Proceedings of the National Academies of Sciences (2013)

Hickey, Hannah, Fifty simulations of the "Really Big One" show how a 9.0 Cascadia earthquake could play out, University of Washington News (2017) video and text.

Marafi, Nasset et alia, Effects of Simulated Magnitude 9.0 Earthquake Motions on Structures in the Pacific Northwest, Eleventh U.S. National Conference on Earthquake Engineering (2018)

Seismological Society of America, 3-D models of Cascadia megathrust events match coastal changes from 1700 earthquake, Phys.org (October 2019)

Risk Management Solutions, The 1908 Messina Earthquake: 100-Year Retrospective, RMS Special Report (2008)

Billi, Andrea et alia, On the cause of the 1908 Messina tsunami, Geophysical Research Letters (2008)

Howard, Jenny, Groundbreaking earthquake catalogue may have just solved a seismic mystery, National Geographic, (August 2019)

Royer, A.A. and Bostock, M.G. A comparative study of low frequency earthquake templates in Northern Cascadia, Earth and Planetary Science (2013)

Livermore, P.W., Hollerbach R., Jackson, A, Electromagnetically driven westward drift and inner-core superrotation in Earth's core, Proceedings of the National Academy of Sciences (2013)

Thomas, Amanda and Bostock, Michael G. Identifying low-frequency earthquakes in central Cascadia using cross-station correlation, Tectonophysics (2015)

The Washington and Oregon Whole Community Exercise Design Committee, Cascadia Rising (Exercise Scenario Document) (2015)

Demand and Supply Networks

Leonard Matt, Warehouse supply rises but still cannot match urban demand, SupplyChainDive (February 2019)

Goodchild, Anne V. and Ukraincyzk, Luka, Food distribution supply chain data collection: Supply chain firm interviews and truck counts, Washington Department of Transportation, University of Washington Transportation Center (2016)

Abel, Carol, The small, but mighty micro-fulfillment center, FMI Blog (August 2019)

Long, Katherine. K. and Romano, Benjamin, Amazon leases new multi-story warehouse in South Seattle, Seattle Times (October 2019)

Rattner, Nate and Palmer Annie, This map shows how Amazon warehouses are rapidly expanding across the country, CNBC (January 2020)

Levy, Nat, Amazon expands same-day delivery with new network of mini warehouses, GeekWire (March 2020)

Jones, Sasha, Amazon doubles-down on fulfillment centers, TheRealDeal (July 2020)

Bloomberg, Amazon plans to put 1000 warehouses in neighborhoods (September 2020)

National Academies of Sciences, Engineering and Medicine, A Framework for Assessing Effects of the Food System (2015)

National Academies of Sciences, Engineering and Medicine, Transportation Research Board, Freight Transportation Resilience in Response to Supply Chain Disruptions (2019)

National Academies of Sciences, Engineering and Medicine, Building Adaptable and Resilient Supply Chains after Hurricanes Harvey, Irma, and Maria (2020)

Euler, Leonhard, Solutio problematis ad geometriam situs pertinentis, Commentarii academiae scientiarum Petropolitanae (1736)

Sabrin, Kaeser M. and Dovrolis, Constantine, The Hourglass Effect in Hierarchical Dependency Networks, Network Science (2017)

Albino, Vito, Izzo, Carmen, Kuhtz, Silvana, Input-output models for the analysis of a local/global supply chain, International Journal of Production Economics (2004)

Beer, Jakob Emanuel, Analysis and Management of Bottlenecks in Supply Networks, University of Stavanger (2015)

Bimpkis, Kostas, Candogan, Ozan, Ehasani, Shayan, Supply Disruptions and Optimal Network Structures, Social Science Research Network (2017)

Battison, Pietro, Constrained Network Formation, Italian Economic Journal (2016)

Barabasi, Albert-Laszlo, Random Networks, Network Science, Cambridge University Press (2015)

Lewis, Ted, Bak's Sandpile: Strategies for a Catastrophic World, Agile Press (2011)

Shore, Jesse, Chu, Catherine J., Bianchi, Matt T., Power laws and fragility in flow networks, Social Networks, (2015)

Marchiori, Massimo and Latora, Vito, Harmony in the Small-World, Physica A: Statistical Mechanics and Its Applications (2000)

Wills, J.M., Polyhedral manifolds with properties of the Platonic solids, Annals of the New York Academy of Sciences (1985)

Boldi, Paolo and Vigna, Sebastiano, Axioms for Centrality, Internet Mathematics Journal (2013)

Pareto, Vilfredo, Manuel d'economie politique, Reprint by Oxford University Press (1909)

Paranyushkin, Dmitry, InfraNodus: Generating Insight Using Text Network Analysis, WWW'19 Conference Presentation, May 2019

Palin, Philip J., Out of the Whirlwind: Supply and Demand after Hurricane Maria, Rowman & Littlefield (2019)

Palin, Philip J., Seven Steps for Countering Catastrophe, Supply Chain Quarterly (2020)

Palin, Philip J., Food and other flows in case of catastrophe, Journal of Critical Infrastructure Policy (2020)

Antonello da Messina and related

Mauro, Lucco, Antonello da Messina: L'Opera Completa, Biblioteca di Babele (2006)

Cardona, Caterina and Villa, Giovanni Carlo Federico, Antonello da Messina, Skira (2019)

Gioacchino, Barbera et alia, Antonello da Messina: Sicily's Renaissance Master, Metropolitan Museum of Art (2005)

Christiansen, Keith, Antonello da Messina, Heilbrunn Timeline of Art History, Metropolitan Museum of Art (2010)

Kwakkelstein, Michael W. and Talvacchia, Bette, Around Antonello da Messina: Reintegrating Quattrocento Culture, Instituto Universitario Olandese di Storia dell'Arte (2014)

Brandi, Cesare, Restoration Theory and Practice, AISAR (2015)

Podany, Jerry, An overview of seismic damage mitigation for museums, International Symposium on Advances of Protection Devices for Museum Exhibits (2015)

Timmons, Traci, Protecting art in an earthquake, Seattle Art Museum blog (2010)

Other

White, Blanche Fisher (illustrator), The Real Mother Goose, Rand McNally, Chicago 1916

Perkins, A.E., Riddles from Negro School Children in New Orleans, Louisiana, Journal of American Folk-Lore (1922)

Dahl, Roald, James and the Giant Peach, Alfred A. Knopf (1961)

Midler, Bette, From a Distance, song written by Julie Gold (1990)

Peckenpaugh, Daniel J., The organic and artisan ingenuity of The Essential Bakery, Snack and Food Wholesale Bakery (2018)

Joshua Redman Quartet, St. Thomas, Munich (2017) YouTube

Sontag, Susan, Against Interpretation, Shifter Magazine (1965)

Sandberg, Carl, Chicago, Poetry (March 1914)

Sacks, Jonathan, Eight short thoughts for eight Chanukah nights, rabbisacks.org (2013)

Brecht, Berthold, The night when she first gave birth, music by Muldowney, Dominic, Hyperion (2010)

Melamed, Yitzhak Y., Christus secundum spiritum: Spinoza, Jesus, and the infinite intellect, History of Philosophy (2011)

Sleman, Abraam, Saint Basil Liturgy, Copticchurch.net (2007)

Derrida, Jacques, GLAS, University of Nebraska Press (1986)

Meyer, M. Wilhelm and Gorki, Maxim, Im Zerstörten Messina (1909) (translated and paraphrased by Philip J. Palin)

Gadamer, Hans-Georg, Truth and Method, Bloomsbury Academic (2004)

Dante, Paradiso, Canto 33, DigitalDante, Petrrocchi Edition, (translated and paraphrased by Philip J. Palin)

Network analysis of text was completed with Infranodus developed by Dimitry Paranyushkin 3, Am Flutgraben 12435, Berlin, Germany

Many of the maps were generated using Google Maps

ABOUT THE AUTHOR

Philip J. Palin is the son and grandson of grocers, a former college president, and serial entrepreneur who has served as a Supply Chain Resilience subject-matter-expert with the National Academies of Sciences, Engineering, and Medicine, Institute for Public Research at CNA, Department of Homeland Security, FEMA, and with several states and cities. He has researched and engaged in a wide range of extreme events including the 2011 Triple Disaster in Japan, Superstorm Sandy in 2012, Hurricane Haiyan (Yolanda) in 2013, Hurricanes Harvey, Irma, and Maria during 2017, and most named storms during the 2018 and 2019 hurricane seasons. In 2020 he was involved in pandemic response and preparedness, especially focused on flows of food and medical goods. He works with federal, state, local and private sector leaders to prepare for and respond to complex wide-area catastrophic events involving dense populations. He is the author of several books and articles, including *Out of the Whirlwind: Supply and Demand After Hurricane Maria* and now *He Looks at the Earth: Catastrophe, Recovery, and the Cascadia Earthquake.*

The first two sections of *He Looks at the Earth,* Inter-Seismic and Co-Seismic, were completed in late 2019, prior to widespread awareness of the Pandemic. Post-Seismic was written in the late summer and autumn of 2020 when pandemic-related edits were also made to the earlier sections.

Other publications by Philip J. Palin can be found at
supplychainresilience.org

(DANTE, THE FINAL LINES OF PARADISO)

Qual è 'l geomètra che tutto s'affige
per misurar lo cerchio, e non ritrova,
pensando, quel principio ond' elli indige,

tal era io a quella vista nova:
veder voleva come si convenne
l'imago al cerchio e come vi s'indova;

ma non eran da ciò le proprie penne:
se non che la mia mente fu percossa
da un fulgore in che sua voglia venne.

A l'alta fantasia qui mancò possa;
ma già volgeva il mio disio e 'l velle,
sì come rota ch'igualmente è mossa,

l'amor che move il sole e l'altre stelle.

As the geometer intently seeks
to square the circle, but cannot reach,
through thought, the principle needed,

so I searched that strange sight:
Desiring to see our human form
well-fitted for that circle;

though my wings are far too weak:
yet my mind was splendor-struck
to receive what it had requested.

Here high fantasies fail;
but my desire was already turning
as a wheel steadily propelled by

love that moves both sun and other stars.

FEBRUARY 2021