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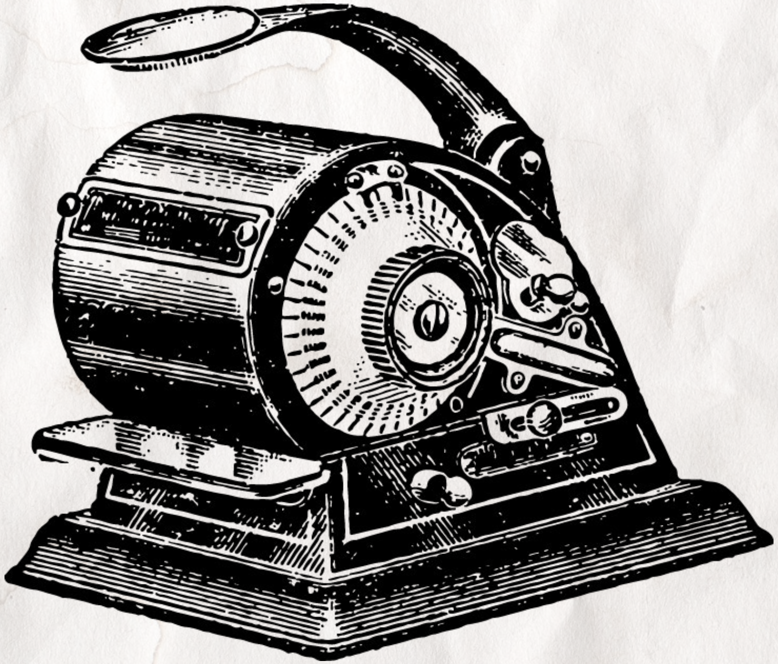

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Enlivening Data

Reassembling Life in Post-Fukushima Japan

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DASTS is the primary academic association for STS in Denmark. Its purpose is to develop the quality and breadth of STS research within Denmark, while generating and developing national and international collaboration.

Abstract

This article is based on ethnographic research conducted in the wake of the Fukushima nuclear disaster in Japan in 2011. The paper analyses how the interplay between the state, the citizenry, and particular radiation technologies defined the shifting boundaries of safety after the fallout and its disruptions. Drawing on James Scott's notion of legibility, I analyse the Japanese state's deployment of dosimeters, maps, and monitoring posts, which generated myriad data that were translated into the legibility of radiation, whereby the enactment of new boundaries of safety and the remaking of the Japanese state became feasible. Previous studies of the Chernobyl and Fukushima disasters indicated that ordinary people, if not precisely victimized, have limited capacities to make their claims and confront powerful authorities. In Iitate, I trace citizens' responses to incorporating accessible and affordable technologies that rendered the state's boundaries of safety leaky, immanent, and continually renegotiable, whereby ordinary people are empowered to enact alternative ways of seeing and perceiving radiation. I use the notion of 'enlivening' to differentiate citizens' data from those produced by the state and suggest how the environment has re-emerged as an experimental field generative of new relations between villagers' lives and a diversity of things and organisms.

Keywords: nuclear disaster, Fukushima, environmental governance, radiation, technology and citizen.

Setting the Scene

Everything was shaking, as if it were crumbling into fragments before Sugiyama-san's very eyes when the earthquake struck on March 11 2011. Experiencing the largest earthquake he had ever encountered, Sugiyama-san felt like the world was coming to an end. Finding themselves without electricity on the first night following the massive tremor, he and his family were in complete darkness, learning by listening to the radio of an evacuation announcement for anyone living within a 3km radius of the Fukushima Daiichi Nuclear Power Plant (FDNP1), which had been hit by the tsunami approximately an hour after the quake. Sugiyama-san learned too late that a 15m high tsunami had flooded four reactors, one of which had started a core meltdown by the time night fell.

After electricity was restored on the fourth day, Sugiyama-san was finally able to watch the live broadcast of the hydrogen explosion at Unit No. 3. He still had no clue, however, about the directional change in the wind that was bringing the radiation plume towards Iitate's mountainous northwest location. For villagers in Iitate,[1] the 'tsunami' did not come from the Pacific Ocean but, rather, from the sky above, to ravage the epicentre of the human-made infrastructure that they had been assured was '100% safe' (Jones et al. 2013; Dusinberre and Aldrich 2011).

The Japanese state disappeared in Sugiyama-san's hour of need. Can his grandchildren play outdoors? Should the family evacuate? When can his 90-year-old father touch the grass outside their home? In the unfolding of the nuclear crisis, mundane questions like these were left unanswered when the villagers confronted the official scientists parachuting in from cabinet-level ministries and the prefectural government. They told Sugiyama-san at the village office that it was safe only in Iitate, and that he should "learn to fear correctly (*tadashiku kowagareba ii*)". Yet, in less than three weeks, Iitate too was no longer safe; Sugiyama-san was ordered to leave his home, which by then was inside the Preparatory Evacuation Zone. This article addresses how the interplay of actors including the state, the citizenry, and dosimetric technologies defined the shifting boundaries of safety, leaving Sugiyama-san's home beyond the state's protection with his concerns—both known and perceived—ignored.

Such fraught scenes articulate the fault lines between the Japanese

[1] Iitate is located in the Abukuma mountain range in Fukushima prefecture, northwest of FDNP1. Three-quarters of the village is forested land at an average altitude of 450m. It was home to a population of 6,000 people who were scattered over 250 square km of mountainous, forested terrain. For subsistence, villagers produced rice, vegetables, and flowers while raising cattle for beef and milk.

state and Iitate's villagers, underlying official responses to the fallout and associated policy decisions, which at first glance were not new. Adriana Petryna (2002), in her study of the Chernobyl accident, illustrates how the making of the Ukrainian state was intertwined with the containment of the fallout, which involved the incorporation of radiation data into the process of biologically monitoring and regulating at-risk populations (see also Beck 1992; 1999). While the state sought to conceal and shift its liability, limited access to data about personal doses forced the irradiated citizens to explore strategies through which to struggle with welfare and survival. Olga Kuchinskaya (2014) addresses how, in Belarus, state ministries produced authoritative representations of imperceptible radiation to manipulate public understanding of the health hazards and environmental risks. These studies highlight the victimization and incapacitation of citizens seeking to lay claim to knowledge about their irradiated bodies and polluted environments that have reinforced the dominance of the state over its citizenry.

In Japan, the failed promise of absolute safety and the chaotic emergency responses created widespread mistrust among citizens, and a crisis of legitimacy was imminent. As in Ukraine and Belarus, the state's compelling task was to restore its governance over the polluted environment in order to master the pressing social disorder (Agrawal 2005; Douglas 1966).[2] Yet the fallout pushed the limits of knowledge. Radiation released from a melted reactor core contains more than a hundred radioactive isotopes, of which only a few are found in nature. Iodine-131 sparked concern among mothers about the safety of children, whose thyroid glands were prone to absorb it (Kimura 2016; Slater et al. 2014). Tracing water-soluble cesium and bone-seeking strontium posed significant challenges to scientists and officials in assessing decontamination in the altered ecologies and new dynamics between carcinogenic radiation and citizens' bodies. Their

2 What makes the task more compelling is the Japanese conception of the environment, which is closely related to the notion of cultured and engineered nature, i.e., the aestheticization and exploitation that work together to allow nature to reach its full potential (Kalland and Asquith 1997; Kirby 2010; Walker 2010).

trajectories in the food system reopened debates over the current science regarding low-level radiation (Brown 2017; Morris-Suzuki 2014; Stawkowski 2017).

The fallout was vast, not only in terms of the variety and quantity of radioactivity unleashed but also in terms of the ecological, social, and political consequences, which had multiple and unbounded effects on the pre-disaster infrastructure of protection and boundaries of safety that the state had developed and maintained. Tracking the radiation unleashed was very much an open and urgent question. Contrary to Ukrainians or Belarusians, however, what made the difference here was the capacity of Japanese citizens, in the face of the inevitable disruption, to produce alternative representations of radiation that defined an inhabitable environment—that is, the conditions of life—through portable technologies. Following Sugiyama-san's concerns, I address how ordinary citizens generated their own data, which provided a basis for disputing the official science and the legibility of radiation enforced by the state. I argue that, in Iitate, in the deployment of novel technologies, radiation data have enlivened the persistence of life in a way that has entangled villagers with the decaying but ineradicable radiation and with other lives that arrived or remained and proliferated after the fallout.

To analyse this process, in the first part of this article, I describe the deployment of makeshift technologies in the state's immediate response as it sought to objectify the disaster and orient the distribution of vulnerabilities (Bond 2013; Fortun 2001). I then discuss the digitalization of the monitoring network that brought the assessment of radiation risks into close correspondence with the boundaries of safety enacted during the crisis. These technologies, with the underlying science, generated myriad data that were translated into the legibility of radiation, whereby the remaking of the Japanese state became feasible.

Drawing on James Scott's notion of legibility, I take the techno-political infrastructure to constitute a process of standardization and simplification designed to produce a grid-like vision of radiation that would provide the state with "the capacity for large-scale social engineering" (1998: 5; also see Jasanoff ed. 2004). To further illustrate the remaking of state authorities, I analyse the evolution of radiation maps, described by Kuchinskaya (2014) as 'formal representation[s]' that rendered imperceptible radiation pervasively visible not only in policy papers and science journals but also in social media and the daily news reports on people's everyday lives. Scott notes that these maps—as powerful representations that contributed to constituting the state's political power—"when allied with state power, would enable much of the reality they [state officials] depicted to be remade" (1998: 3; see also Anderson 1991).

Perhaps the official scientists whom Sugiyama-san met can offer us a glimpse of such a reality. "Learn to fear correctly" implied the presence of an authoritative way of 'seeing' radiation embroiled in perpetual uncertainty (Mathews 2011). During the unprecedented human-made disaster, citizens were asked to accept a new path to the persistence of life, envisioned by the radiation data and their effects: maps and other inscription devices (Latour and Woolgar 1986) that officials and scientists gradually obtained. In this sense, the legibility of radiation is the condition of a defendable environment, making a return to 'normal life' in a shared future possible. Yet the legibility of radiation was not implemented without resistance, as we shall see when citizens were forced to act using handheld dosimeters to gain knowledge about radiation exposure.

This article is based on uninterrupted ethnographic fieldwork conducted over 14 months from June 2016. After Iitate was reopened in April 2017, I stayed at Sugiyama-san's house, talking to would-be returnees and those already settled in other places, and driving around to talk with villagers who were struggling with new life circumstances shaped by radiation. Sugiyama-san was one of the earliest among the villagers to return and resume agricultural work in Iitate. During the six years of evacuation, he had joined a group of concerned citizens and scientists, mainly from Tokyo, to form a non-profit organization called Living Together with Fukushima (hereafter LiFu) to assist other villagers in the decontamination and monitoring of radiation as well as in experimenting with new ways to practice agriculture in a radioactive landscape.

This article makes two interventions. Firstly, it contributes to the discussion of the interplay between the state, citizens, and scientists/experts during the disruption of a disaster like nuclear fallout. Previous studies have depicted that ordinary people have little access to technologies to make their claims and confront powerful authorities. The incapacitation of civil society is the assumption of these scholars when studying the making of the state and its governance over the citizenry. I argue that, through flexible technologies like dosimeters, citizens' early involvement enables not only alternative representations and understandings of disaster but also collaboration in ways of rehabilitating the contaminated environment and livelihoods that are unthinkable to state officials and experts.

Secondly, I ask what the enduring salience of data carefully produced by citizens like Sugiyama-san and members of LiFu means for our understanding of datum itself. In Iitate, beyond a fact given, data become a platform for villagers, citizens, and experts to build rapport; meanwhile, in messy and complicated ways, data reconnect a diversity of things and organisms with the returning villagers' livelihoods. I use the notion of 'enlivening' to shed light on the emergence of generative relations embedded in the very possibilities of Iitate's altered ecology.

Official Science and Legibility of Radiation

Before the disaster occurred, the Japanese state had built radiation-monitoring infrastructure and put emergency response protocols in place to handle nuclear incidents. In light of the Three Mile Island incident and the Chernobyl disaster, the Japan Atomic Energy Agency (JAEA)[3] developed the System for Prediction of Environment Emergency Dose Information (SPEEDI) to keep the nation's operating nuclear power

[3] JAEA is a semi-government agency established in the 1950s to research the use of nuclear power (Aldrich 2008; Jones et al. 2013).

plants under constant surveillance. Radiation levels in the ambient environment, gaseous effluents emanating from plants' vent stacks, and waste heat water discharged into the ocean were monitored by detectors located around or on the periphery of all nuclear facilities. Risks of radioactive exposure were assessed by a dosimetric science with its root in the study of the health effects on people exposed to the radiation released in the explosion of two atomic bombs in Hiroshima and Nagasaki (Lindee 2016).

The SPEEDI[4] was designated to compile, during an accident, data received from the sensors and monitoring posts, as well as those transmitted from an emergency response system, to generate vital predictions regarding, for example, the movement of radioactive plumes and real-time dose assessments in radiological emergencies. Based on monitoring data and dose predictions, the radiation teams at offsite emergency centres were given the power to take charge of any nuclear emergency and make decisions to protect the citizenry (Chino et al. 1984; Misawa et al. 2008). Iitate was covered by one of the 22 emergency centres in the town of Ōkuma, located within a 5km radius of FDNP1. "Before the disaster, TEPCO [the operator of FDNP1] arranged two visits to the power plant, and all I had learned from them was that it was a safe facility; we weren't told what to do in case an accident happened," Sugiyama-san recalled. This safety myth was broken during the earthquake. On March 11, a power outage occurred at Ōkuma, resulting in the collapse of the entire system. The Ministry of Education, Culture, Sports, Science, and Technology (MEXT) tried to use the SPEEDI without data from the emergency response system to run simulations that resulted in unreliable dose assessments and trajectory predictions regarding the radioactive plume (Nakajima et al. 2019; Povinec et al. 2013: 84-90).

The effects of the triple disaster—the earthquake, the tsunami, and the meltdown—and the immense scale of the fallout surpassed the capacity of the legislated procedures and operations to manage the disaster. Disruptions in the SPEEDI and emergency response protocols created an urgent task for scientists, which was to estimate the size, scale, and movement of the invisible radioactive nuclides unleashed by the meltdown as quickly as possible: that is, to render radiation visible and thus legible.

The Nuclear Safety Commission (NSC), along with the JAEA, was assigned the task of revising the evacuation plan by Japan's Prime Minister. They deployed handheld dosimeters as a makeshift technology to produce radiation data they used to assess the fallout (MEXT 2011a). By March 25, the NSC had released the first map of cumulative radiation doses (Figure 3.1), building on two sources of data: the fragmented dataset recovered from the SPEEDI and those harvested by handheld dosimeters at sites where data points were determined by NSC and JAEA scientists. By citing and rendering these data points, a renewed bird's-eye view was articulated through the map that authorized the local emergency centres and officials to enact evacuation orders with apparently greater precision through redefining the boundaries of safety that had taken shape in April after dots (data points) on the map were connected to form contours (Figure 3.2 and 3.3).

Figure 3.1: The first map of cumulative radiation doses (NRA 2011a).

[4] Until 2011, the SPEEDI was operated and supervised by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) and local governments, monitoring 54 commercial reactors at 18 nuclear power stations (FEPC 2020).

Notably, the MEXT, the ministry responsible for constructing maps, attempted to build new versions by extrapolation to connect the dots and create a contour map that produced a topographic representation of radiation. As shown in Figure 3.3,[5] for the first time after the disaster, Japan was demarcated into two zones marked by the red line. Inside the red line was the zone that later became the Preparatory Evacuation Zone, whereas the rest of Japan would be deemed 'safe'. The newly mapped borders were not finalized until the release of the airborne radiation map that replaced this semi-accomplished version.

Figure 3.2: Dose rate map as of April 24, 2011 (MEXT 2012:1)

Figure 3.3: Integrated dose estimation map with a new border demarcating the forced evacuation zone (MEXT 2012:2)

The first airborne monitoring activity was launched in April, during which time the MEXT and the US Department of Energy joined forces to survey by aircraft an area within an 80km radius of the nuclear power plant. The technology involved the installation of highly sensitive

[5] Paradoxically, this map, which was supposed to indicate the correlation between geography and radiation risk, was the only map that combined geography with radiology. Landscape details were subsequently erased in later versions.

radiation detectors to measure gamma radiation from a height ranging from 150-300m; data collected were then used to estimate the air dose radiation 1m above the ground. By connecting an aircraft with dosimeters, this spatial modelling scheme equipped the MEXT with airborne maps capable of zooming into the surveyed zone. The map was filled with data points without actual on-the-ground measurements. This technology enacted scalability (Tsing 2015) that marked a watershed in the competition over radiation map production between the MEXT and the citizenry. Meanwhile, the map produced the radiation legibility that empowered the MEXT to form a new terrain of administrative mechanisms and policies.[6]

Such mechanisms and policies were grounded on new conditions of the living environment enacted by maps and later the network of monitoring posts. After the airborne map was overlaid with coloured patches, Fukushima's landscape was flattened, with the border that demarcated villages, towns, cities, and prefectures redrawn to articulate a new emerging fact: the nuclear crisis had been contained in a clearly marked zone, to which Iitate and Sugiyama-san's home were temporarily condemned.

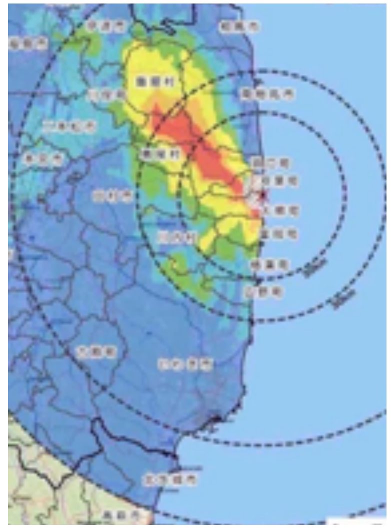

Figure 3.4: The first airborne radiation map (NRA 2011b).

[6] The first airborne radiation map was launched between April 6 and April 29 and finalized on May 6, nearly two months after the meltdown (see Figure 3.4). It covered the eastern half of Fukushima and, unlike the contour map, it encompassed the entire area within an 80 km radius, using the nuclear power plant as the centre. An early version was published on April 22 in national and local newspapers and other print media. Based on that version, the state declared on April 11 provisionally and April 22 officially that Iitate fell into the 'Planned Evacuation Zone', together with part of Minami Sōma City and the village of Kawamata. With the issuance of this order, villagers in Iitate had to move in accordance with the new orders from the state.

The airborne map has subsequently been widely circulated in official statements and policies, academic papers, and reports issued by discussion panels at international conferences and summits, as well as in the news, books in print, and video footage on social media; among Iitate villagers, the radiation map was taken as definitive and thus 'real'. Thus, the airborne map has become what Kuchinskaya (2014) calls a 'formal representation', serving further to stabilize the fallout as an object of environmental governance.

At the end of the nuclear emergency, the MEXT designed a new monitoring infrastructure to replace makeshift technologies, including the handheld dosimeters and car monitoring, to generate data for further analysis of the fallout (MEXT 2011b). Over 3,000 monitoring posts were installed Fukushima and 150 in Iitate; to enhance the transparency of information, not only were measurements displayed via LED panels attached to the monitoring posts, but data were also streamed to be compiled into new maps that would be accessible through the MEXT and Fukushima prefectural government websites.[7] Measurements in Sv/hr[8] are printed in local newspapers, reported on TV news programmes every day, and reviewed and studied regularly by experts at universities, state agencies, and official committees at the local and prefecture levels. These additional layers of inscription (Latour and Woolgar 1986) bolster the strength of the original inscriptions, producing a network that constitutes the continuing project of making radiation legible. Each datum was an index of the new radiation safety standard that bundled risk assessment and policy decisions concerning the nuclear fallout,

[7] Contrary to the high modernist regimes analysed by Scott, I suggest the Japanese state has enacted a more sophisticated kind of legibility. Alongside the technologies of simplification and standardization, public participation became constitutive of a new orderliness of the environment, and thus society, when data transparency was enforced through the internet and mass media.

[8] The sievert (Sv) is the unit of measure for the biological effects of ionizing radiation. The *effective* dose measured in Sievert (Sv/hr) is defined as the *possible damage* to human tissue from a given absorbed dose. Before the disaster, Japan measured radiation in Gray (Gy/hr), defined as the energy *absorbed* by tissue over a specific duration of time. Early monitoring charts and tables could still be seen to report radiation in Gy/hr. This change hints at the shifting frame of reference that focuses on humans and the health risks to the population.

with the relationship between the affected people like Sugiyama-san, the state, and its citizenry.

First, these inscription devices make it possible to disseminate new safety standards and the borders that have resolutely isolated Iitate from the rest of Japan. During the crisis, the NSC had drawn up two new standards to demarcate the affected area. With an annual accumulated dose above 20 mSv, the area would be designated as the 'Difficult-to-Return' zone. Underpinned and made possible by radiation data, bordering practices situated Iitate on the new administrative-political grid as an evacuation zone. When the borderland was stabilized by new boundaries, so was the homeland for most Japanese citizens; hence, monitoring is both productive and also conducive to holding Japan—the state and its citizenry—together. In other words, radiation maps and monitoring posts are salient as they help to make Japan as much as they are made by the Japanese state (Latour 1991; also see de Laet and Mol 2000).

Serving as a reminder of radiation risk, therefore, the infrastructure envisioned a future of hope that people's homeland and livelihoods would eventually return to normal, as the readings of the posts show no fluctuation but a uniform decline. Moreover, as the official response to the nuclear disaster shifted to public health and radiation risk outside the evacuation zone, along with the technological mediation that it necessitated, it became increasingly difficult to induce state officials or scientists to answer Sugiyama-san's questions, as his home had been deemed unsafe within the designated borderland, and thus was to be abandoned.

Second, while the state implemented newly defined rules and policies concerning a governable environment, the legibility of radiation was mobilized to shape the meaning of effective decontamination and restoration. In Iitate, the entire village was divided into two zones: one consisted of forest and woodland areas that covered 75% of the village and was left untouched; the other zone consisted of farmlands, roads, and residential areas in which radiation levels were deemed reducible below 20 mSv of annual external exposure. The former zone was excluded from the risk calculus and official statistics of the Ministry of the Environment, thus rendering it 'twice invisible' (Kuchinkaya 2014).

In the restoration of farmlands, local knowledge of agriculture was also made invisible when the MoE assessed health risks primarily through radiation data produced by the monitoring infrastructure. Farmlands were decontaminated by stripping the topsoil using excavators, which was then loaded into flexible container bags, commonly known as 'black bags' (MoE 2013). Scrapped topsoil was replaced by infertile pit sand that villagers called 'guest soil', literally wiping out the web of relations that villagers had intimately cultivated through Iitate's ecology for decades. Ironically, as the environment was deemed governable, Sugiyama-san found it not habitable, saying, "No, this is not home, home is not yet ready."

'Doing Science Together': Contending With the State Through Citizens' Own Data

Sugiyama-san and Japanese citizens were as anxious as the ministry officials to obtain radiation data for the sake of their health and safety.[9] After the Prime Minister declared a Nuclear Emergency Situation on March 11, as Morita et al. noted (2013), citizens started spontaneously to measure and monitor the radioactivity in their communities. On March 13, a Tokyo-based video director used his Twitter account to call for assistance in constructing a Google map that incorporated individual measurements. He also downloaded data provided by the government-installed monitoring posts that were available on the MEXT's website and added those data to his map. This initiative quickly went viral as more citizens engaged in foraging hundreds of data points from multiple parties and some experts retooled skills (Miyazaki 2014; Riles 2013) that they had long since mastered, such as data visualization using Google maps, to produce citizen-sourced radiation maps (Abe 2014; Brown et al. 2016).

The complexity and multiplicity of the data and their sources stood in sharp contrast to the scarcity of available data on the MEXT's website. Morita et al. argued that the 'heterogeneity' of maps (Law 1987) facilitated the emergence of new standards of radiation monitoring,[10] as well as the co-production of what counted as valid data and the location of a safety/danger border. With their handheld dosimeters, citizens were empowered to evaluate the plausibility of official data and thereby their risk assessments. Yet the story did not end there. Other radiation-monitoring networks mushroomed in Japan, with some still operating today.

For example, Kimura (2016) and Sternsdorff-Cisterna (2018) discussed Japanese mothers across prefectures who mobilized to monitor food safety to protect their children. Traditionally playing the role of the caregiver, mothers gathered in their respective localities to practice a form of science that served their own understanding of risk and concern for their families, distinguished from the science endorsed by the state. Yet their efforts were considered peripheral to or marginalized by the state's stratagems to normalize radiation risks. Polleri (2019) surveyed three "citizen science" groups,[11] coining the term "conflictual collaboration" to diminish their data practices as "becoming part of the techniques of neoliberal governmentality designed to govern the conduct of populations amid a contaminated environment" (ibid.: 224).

At best, work from these authors reinforced the panoptic character of the state and the incapacitation of citizens; at worst, they represented

[9] In a climate of fear, handheld dosimeters were sold out within days, just as umbrellas were in Tokyo as citizens worried that black rain was about to fall again, decades after the atomic bombing of Hiroshima (Birmingham and McNeill 2012).

[10] For example, it was at this juncture that the MEXT standardized the unit of measurement as Sieverts per hour (Sv/hr) and set the measuring height at the 1m level. Moreover, data transparency was a valued new standard that many advocated; citizens uploaded their data with a range of details such as the type of dosimeter used, the date and time of measurement, the surroundings where the measurement was taken, and other conditions that might influence the readings.

[11] From Polleri's descriptions, I believe LiFu was one of the groups that he had observed.

the data practices of the citizenry as weak versions of science that were eventually ignored or co-opted by the state, downplaying the potential of the more flexible and technology-backed participation that prevailed after the disaster. I saw something different during my fieldwork: I met individuals[12] who used dosimeters to create their own 'monitoring systems' to challenge expert rationality (Jasanoff 2012; Morris-Suzuki 2015), and groups that contended with the state over representations of the fallout, rendering the official science of radiation more temporary and fragile.

Sugiyama-san was also driven to act after the official experts failed to answer his questions. Like most Japanese citizens, Sugiyama-san had been a novice to the dosimeter and its science, yet the salience of that data was the most important lesson he learned when the radioactive plume was precipitated, with the snow, onto his home: "the enemy is invisible". After he decided to return to Iitate, he joined a group of citizens and scientists to form LiFu in 2011. Alongside contending with the legibility of radiation imposed by the state, he and LiFu produced perceptible traces and markings of radiation through their keen awareness of the altered ecologies in Iitate. Their practices produced data that official scientists were not tasked with providing, with the purpose of enabling villagers to thrive again, enlivening their livelihoods by re-connecting them with other organisms, creatures, and landscapes that were as alive as they were.

Before Iitate's reopening in 2017, LiFu organized a series of experiential learning activities and regular weekend visits to bring together people with diverse personal trajectories who sought to retool

[12] For example, Yoshida-san, the father of two sons from Koriyama city, resisted 'seeing like the state' when he measured the neighbourhood using a Google-map-powered iPad connected to a dosimeter. In contrast to the 1m above-the-ground standard authorized by the state, he measured radiation at just a few centimetres above the ground. He argued that the NRC standard was arbitrary and did not take the health risk to children and pregnant women into account. Fujino-san, one of the very few villagers who refused to evacuate, measured his daily accumulated radiation exposure and posted those readings every day on his Twitter blog, at times criticizing the MoE's leaky decontamination in Iitate. "My body is the evidence of contamination here", he said. These individuals deliberately challenged the borders and boundaries demarcating safety areas legitimized by the state's monitoring infrastructure.

themselves in the nuclear disaster, a group that eventually assembled in Sugiyama-san's living room: retirees from Japanese multinational corporations, experienced mountaineers, a gardener, a playwright, a self-employed IT professional, university and graduate school students, teachers, a horticulturist, small entrepreneurs, scholars with specializations ranging from high energy physics to social science, and grandmothers who were student activists in the 1960s. They were more than the typical volunteers that we saw in mass media or government propaganda; rather, they became "citizen scientists" who "have gifted technostruggle to the world", as Weston portrayed them (2017: 101), who wanted to challenge Iitate's isolation from the public and the boundaries of safety set forth by the state.[13]

Since 2011, LiFu has experimented with multiple methods of decontaminating Sugiyama-san's rice paddies while preserving nutritious topsoil and monitoring the surrounding environment; they have also explored the cultivation of new crops and alternative ways to regenerate the forest. LiFu engaged villagers and would-be returnees, as well as concerned people more broadly from Japan and overseas, to deploy dosimeters to monitor lingering radiation along major roads and forest trails; they also joined university researchers in collecting samples of air, water, soil, food, crops, and wildlife (such as mushrooms and boars) to study the transference of radioactivity in the local ecology. Differing from the MoE's fixed-point monitoring, LiFu demonstrated a more flexible, thus more creative, use of dosimetric technologies to generate myriad data to accommodate the penetration of radiation and meticulously negotiate the state-enacted safety boundaries. Let me use LiFu's radiation household monitoring survey as an example to

[13] LiFu had an 'arsenal' of dosimeters to forage data for different purposes. The most sophisticated was that borrowed from the High Energy Accelerator Research Organization (KEK), Japan's most renowned research organization for high-energy physics, which was located in Tsukuba (Traweek 1988). Its detector tube could catch random radiation bouncing around in the ambient environment, which could be seen from the readings flickering at 5-second intervals on the display panel. Radiation seemed alive as readings jumped up and down in an unpredictable way. Other portable devices, including wearable and handheld gadgets and GPS-enabled dosimeters, were used for average-over-time readings of ambient radiation.

illustrate how they collaborated with villagers to unlearn the legibility of radiation imposed by the state in order to explore a new persistence of life. Villagers usually participated in this survey before moving back, a time when they felt most uncertain about their livelihoods in a radioactive landscape.

Household Monitoring Survey and a New Persistence of Life

Residing in Miyauchi hamlet, Miyakawa-san and his wife, Kyoko-san, maintained a family of four and had refurbished their house just before the disaster. At first sight, their house was clean and spacious, as if it were newly built, with a broad view of deserted rice paddies in front and of forest to the rear. Large tree stumps were left on the forested side in the 20m clearance zone, or satoyama, between forest and land that was inhabitable by humans.

Led by Nitta-san, we arrived at their house with two other LiFu members. After a typical Japanese welcome, Nitta-san began explaining household radiation-monitoring procedures to the attentive couple. He also asked to see the floor plan of the two-storey house, its radiation-monitoring records, and those of the surrounding environment. He sketched the floorplan on A4 paper and confirmed its accuracy with Kyoko-san. We then divided into two groups, Nitta-san and I forming one and the others forming the second group, to measure radiation in the house and the surrounding environment, respectively. The second group walked from the door of the house to the rice paddies and the forest, carrying a handheld dosimeter that was connected to a GPS-enabled data logger, while Nitta-san and I started from the centre of the first floor—defined as the reference point for the entire survey—and I pointed the Geiger tube of another dosimeter at the door at 1m above ground level. We measured the living room, the kitchen, and the bathroom, one by one.

Sometimes we saw a noticeably high measurement, for example, rising from a level of 0.2 μSv/hr in a sudden increase to 0.4 μSv/hr (which translated to 3.5mSv/yr). Nitta-san remained calm but could not hide

his surprise as he tried to find some possible explanations to soothe Kyoko-san, who looked alarmed. "Perhaps it is because the room is close to the forest", he suggested. He did not comment on whether 0.2 or 0.4 μSv/h was safe or not, and the MoE's safety standards were not even mentioned; however, we found more fluctuations in readings both inside and outside their house, revealing that regressions seemed inescapable.

Nitta-san, who joined LiFu in 2013, shared with Kyoko-san what he knew and what could be done according to the experience and knowledge he had gained in conversations and debates among LiFu members. He told Kyoko-san that, according to the MoE's policy, a second round of decontamination would be conducted only if a hotspot of at least 3 μSv/h were found. For the relatively high-level radiation that we detected along the side of the house close to the forest, he suggested performing a second decontamination that LiFu had tested in the satoyama surrounding another villager's house. The conversation was informative and addressed Kyoko-san's concerns.

The couple was forced to recognize the illegibility of radiation, and re-learn the messy reality that differed from the one promised by the MoE. Nitta-san used the dosimeter deliberately to render those things that were 'out of place' (Douglas 1966) as visible as they could be—not only radiation but also the chopped tree stumps, the graveyard, the children's bedrooms, the forest, a crack near the rainwater drain, the drainage inside the house. His actions and utterances were not fear-mongering tactics, as can often be the case with some anti-nuclear activists (c.f. Zonabend 2007); instead, it was an effort to bring villagers on board with collecting data together to make radiation not only visible but also knowable and actionable, provoking questions about and memories of radiation from the villagers.

This 'doing science together' approach stressed the need for participation in the production of knowledge in a time of high uncertainty that was making things complicated and less predictable at the local level (Jasanoff 2012; Kelty 2017). It also convinced the couple to refute the MoE's restoration masterplan in accordance with which they had been 'put back' into their unevenly decontaminated home. Within the state-enacted borders, there was no assurance that one would have a home that was anything more than temporary and unstable. Thus, LiFu invited villagers to get their hands as dirty as Nitta-san and engage with the illegibility of radiation, which was not inscribed in the maps and charts of the MoE's policy documents and data analysis.

Like many villagers, Miyakawa-san and Kyoko-san were struggling over whether they would restart farming, as many consumers had lost confidence in Fukushima produce. Nitta-san suggested that LiFu could sample the soil in their rice paddies, and shared the findings of experiments that had been undertaken in Sugiyama-san's farmland and greenhouses. Apart from exploring new possibilities for subsistence, we also followed the couple's everyday habits, looking for hotspots that would be most concerning, measuring radiation levels in the warehouse, the nearby graveyard, farmlands, and forests. LiFu's data traced the course of radiation in the messy environment and ecologies of villagers' homes, reflecting everyday life and its vulnerabilities, which MoE officials ignored with their acting-at-a-distance approach (Agrawal 2005; Latour 1987).

Dosimeter readings are inextricably intertwined with villagers' lives and their families in a unique way as the data produced amount to more than technical knowledge. LiFu takes radiation not so much as separable and containable but as relational and penetrating, thereby enlivening data through the collaboration with villagers and scientists to generate localized knowledge about radiation. This is what Ingold depicts as "acts of dwelling", whereby reality emerges from home-related activities and "the specific relational contexts of their practical engagement with their surroundings…. Only because they already dwell there can they think the thoughts they do" (Ingold 2000: 186).

Re-centring life at a returnee's home, LiFu repairs or maintains the web of relations embedded in the very possibility of Iitate's ecology. LiFu's data—essentially many kinds of data regarding radiation risk and safety embedded in the air, soil, food, and freshwater that are vital to life—are being used to enfold the new givens with radiation—black bags, monitoring posts, bodily permeability, and its illegibility—into everyday realities that are embedded in juxtaposition and competition with the state's restoration programs. Data, not the legibility of radiation, become the condition of an animated environment to enliven another form of persistence, a life that I call 'contaminated but safe'.

A home is not merely the sum of a roof, a driveway, satoyama, and farmland, as the MoE seems to have assumed. That agency deploys decontamination and monitoring technologies in an ostensibly organized and uniform manner to build the 'pipes and wires' (Law and Singleton 2013) with which to pull together an environment that has become unruly. LiFu's data prompt temporal moments that question, slow down, and re-orient the intensified rhythm of restoration enacted by these technologies. For many villagers, this homely insight prompts them to opt for local knowledge to establish their boundaries in homes built to be comfortable and persistent as they move on slowly.

From the household monitoring survey, Miyakawa-san and Kyoko-san barely embarked on a new persistence of life, with more challenges to follow. A year after my fieldwork, I returned to Iitate to visit Sugiyama-san. He showed me a new greenhouse and the crops he was growing. He also gave me a gift, a bottle of Japanese sake made from the rice grown in his paddies that had passed the state's food inspection. His father could touch the grass in the garden again as he knew the level of radiation around the house.

Conclusion

Disasters, as Charles Perrow (1984) notes, have become 'normal events' in the post-industrial era. In Japan, a country historically prone to earthquakes and tsunamis, disaster is both immanent and constitutive of social life and political institutions. Yet a disaster as multiple and unbounded as nuclear fallout has shockingly revealed the neglected embeddedness of technological risks within social, cultural, and political domains, which largely go unnoticed in ordinary times. Official and expert attention alike have focused on pre-disaster techno-political infrastructure and its inadequacy; less attention is paid, however, to the state's efforts to re-inscribe itself through makeshift technologies after the disaster and the disruption it caused, which initially overwhelmed the emergency response instruments and protocols.

I have traced the formation of the legibility of radiation through the dosimeters, maps, and monitoring posts that were assembled to make the techno-political infrastructure more robust and productive. Unlike the high modernist legibility that Scott analysed, such legibility was also achieved through co-production with the spontaneous efforts of the citizenry, who used portable devices and retooled their expertise to detect the fallout and thereby attain a sense of safety in times of uncertainty. 'Seeing like a state' in a digitalized world, therefore, is no longer a top-down or panoptic act as citizens' presence becomes indispensable in data production and representation. Nevertheless, in this case, these contingent interactions and practices also gave the state opportunities to remake itself through the enactment of new boundaries of safety. Yet even the most productive infrastructure cannot compensate for the failure of a '100% safety' promise. When the next human-made disaster happens—whether climate change, wildfires, or a pandemic—the question, then, will not necessarily be about the readiness of the state. Instead, the capacity of citizens will be *the* matter of concern.

The citizens' responses that I have analysed remind us of their capacity to become entangled with the state's representation of a disaster and its remedies. Accessible and affordable technologies rendered the state's boundaries of safety leaky, immanent, and continually renegotiable, empowering ordinary people to enact alternative ways of seeing and perceiving radiation. In Iitate, the notion of 'enlivening' helps us to differentiate these approaches from data produced by the state to show how the environment has re-emerged as an experimental field generative of new relations between villagers' lives and a diversity of things and organisms.

In the Chernobyl accident, affected communities and irradiated bodies lacked the means to initiate their technostruggle to lay claim to

their rights or confront powerful figures and institutions. Dosimeters and maps, following Petryna and Kuchinskaya, are inscription devices whereby dominant and circulable realities are produced in power-laden sites such as hospitals and government bureaus. Yet, when citizens use them to generate their own data, it becomes possible not only to understand a disaster in more than one way but also to create a diversity of collaboration to explore the pursuit of livelihoods that are unthinkable to the state. It is in this sense that disaster becomes productive, because it triggers creativity.

When we push past the incapacitation of victims and move towards an appreciation of spontaneity and creativity at play in making sense of invisible radiation, data begin to look less like something incomprehensible to people and more like a platform that is open even to the least powerful groups. Data also engage experts or scientists who want to become amateurs, as 'scientist-citizens' (Riles 2013; Weston 2017), in times of uncertainty. Citizens' practices have illustrated that data are heterogeneous, messy, and political. Sometimes, they are used to collaborate with the state to fulfil shared goals or interests; at other times, they are used to reject claims or proposals that hinder the protection of citizens' homes.

If we stay close to how data are collected on the ground, the question of returning to normalcy is not always about the remaking of the state and its imposition of an apparently radiation-free future; it can be about the availability and intensity of technologies with which to challenge the very notion of normalcy itself. In Iitate, while not in any standardized or simplified form, data are used to connect a diversity of things and organisms with the returning villagers' livelihoods. As I have shown, the dosimeter articulated traces and markings of radiation in villagers' homes to redefine the boundary of safety in an altered ecology; data enliven an inhabitable environment for villagers who persist in what I call a 'contaminated but safe' life.

It is not my intention to overstate the capacity of ordinary people to respond to a disaster like nuclear fallout. Iitate is also nowhere close to a desirable place for most villagers. Even Sugiyama-san's family was split, with his grandsons moving to another town. Nevertheless, we might take a cue from Iitate about how people tackle big problems by 'doing science together' when they are forced by circumstance to try.

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