How Things Hold

A Diagram of Coordination in a Satoyama Forest

Elaine Gan and Anna Tsing

Abstract: This article experiments with combining three concepts—coordination, assemblage, diagram—to make vivid the composition of a satoyama forest in central Japan. The forest comes to life as a more-than-human assemblage that emerges through coordinations established by evolutionary and historical accommodations to life cycles, seasonal rhythms, and activity patterns. These coordinations are expressed through a diagram of intersecting temporalities of people, plants, and woodlands that condition the flourishing or decline of wild matsutake mushrooms. Working diagrammatically, we can better articulate how juxtapositions of humans and non-humans become assemblages that hold together through coordinations—without a unified purpose or design. We argue that understanding coordination is key to more livable multispecies worlds.

Keywords: assemblage, diagram, matsutake, more-than-human interdependencies, multispecies coordinations, satoyama forest

Satoyama is the characteristic village forest of central Japan. Although the word 'satoyama' is recent, adopted by those aiming to revitalize village forests, it refers to woodlands that emerged from a much older arrangement, in which farmers harvested wood for firewood and charcoal and gathered non-timber forest products ranging from dead leaves for green manure to the matsutake mushrooms that form the subject of this special issue. Matsutake grow in this

Social Analysis, Volume 62, Issue 4, Winter 2018, 102–145 © Berghahn Books
doi:10.3167/sa.2018.620406 • ISSN 0155-977X (Print) • ISSN 1558-5727 (Online)

area with Japanese red pines; Japanese red pines grow with satoyama woodlands; satoyama woodlands grow with disturbances created by farmers. This arrangement of more-than-human interdependencies intrigued us. Satoyama woodlands allowed us to think more generally about the concept of 'coordination' as a feature of 'how things hold'.

How has the question of 'how things hold' come to such importance? This question grows out of the turn to the concept of 'assemblage'. In earlier social theory in both ecology and anthropology, 'communities' were the focus of social cohesion. Worried that this concept overemphasized a taken-for-granted social solidarity, scholars in both fields have turned to assemblage, a more loosely imagined grouping. But this opens the question of how entities in an assemblage relate to each other. With growing evidence of symbiosis and interdependence from ecologists and evolutionary biologists (Gilbert and Epel 2015; Margulis 1981), theorists have reimagined the assemblage not as a static set of autonomous elements but as a dynamic process of 'becoming with' (Haraway 2008). The image of the knot has emerged as a way to imagine cohesion without a prior assumption of collective solidarity. Donna Haraway (2003: 6) has described the world as "a knot in motion." Deborah Bird Rose (2012: 136) writes of "embodied knots of multispecies time." Tim Ingold (2015) imagines knots as nodes in meshworks of lifelines. The word 'knots' offers a vivid image of interconnection within the assemblage. How do knots work? This article suggests that knots form through attunements in which humans and non-humans can align with each other through timing to make living in common possible. In this way, concepts of assemblage and of coordination require each other. Juxtapositions of beings gain force *as assemblages* when relations of coordination are thick within them.[1]

Coordinations, for us, are temporal rhythms across varied practices that together produce a new capacity or emergence. Many authors use the term to refer to modernist programs of top-down discipline. Glennie and Thrift (1996: 285), for example, define coordination as "the degree to which people's time-space paths are disciplined to smoothly connect with one another's." In contrast, our use of the term hones in on mutual attunements and accommodations. Like Born (2015), we stress improvisation and conjuncture. The coordinations we seek are created when an element of an assemblage finds openings in relations with another element in the assemblage, enabling interchanges where temporal alignment matters. We argue that temporal coordinations bring assemblages into overlapping trajectories of world building. Coordinations make assemblages historically consequential, even as they are made through the frictions and contingencies of assemblages.

Coordination is elusive. It cannot be grasped in a single impression. Because it works across different intervals and rhythms of time, no single snapshot can capture it. Questions of visual and narrative representation arise. How might

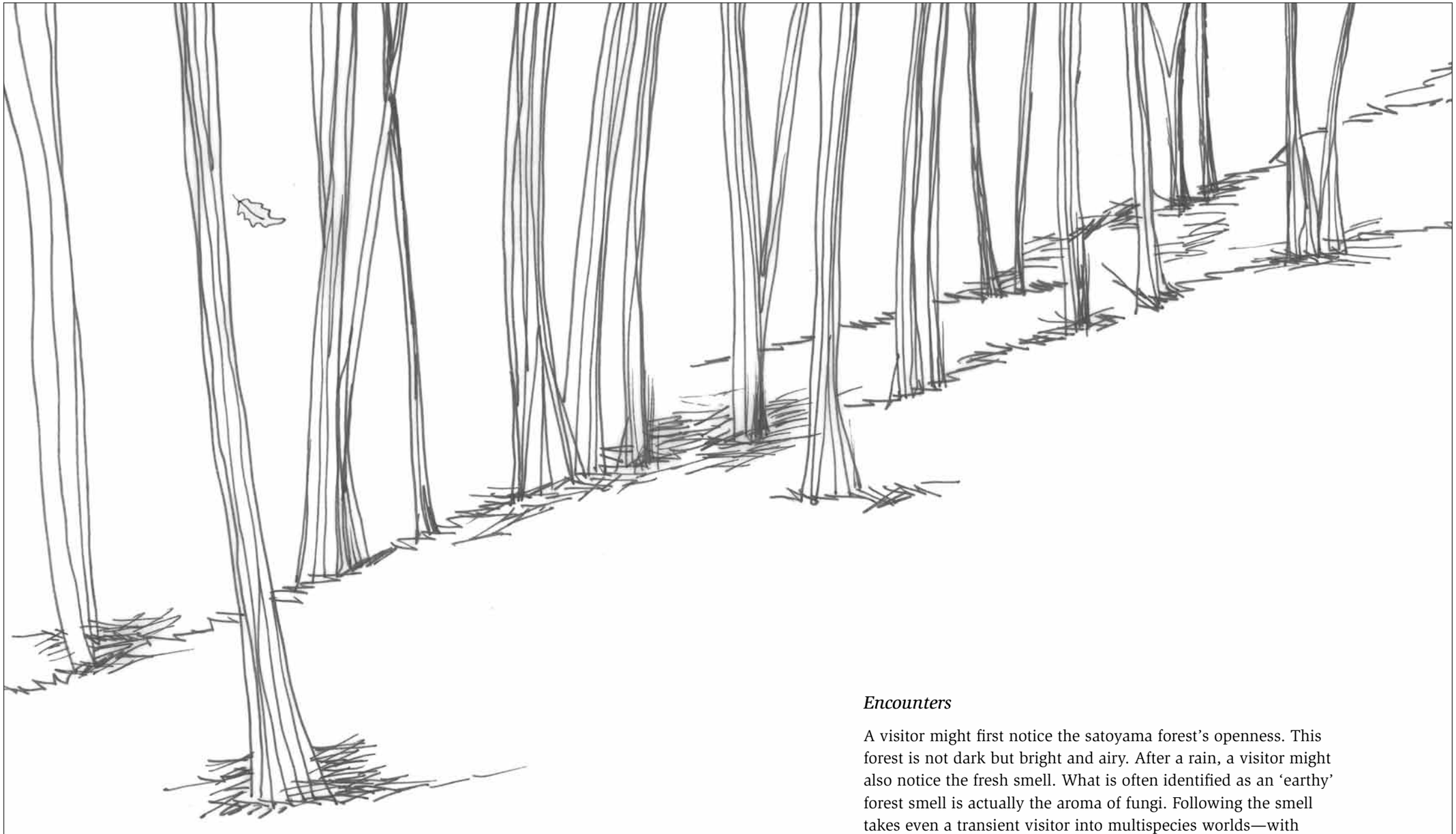
we parse temporal complexity and render interconnections more expressively? We turned to the diagram as a graphic form that might help us foreground coordination and multispecies assemblage rather than autonomous humans.

A diagram offers a critical description through selectivity and simplicity. Ours draws from a legacy of attempts to illuminate worlds in motion. Paleolithic cave paintings of Chauvet and Lascaux depict animals in superimposed and serial action. Byzantine clocks of al-Jazari used flows of water to mechanize durations. In the early twentieth century, Hermann Minkowski's spacetime diagrams offered a graphical description of four-dimensional relationships between things in motion. Richard Feynman's diagrams of the behavior of sub-atomic particles offered new formalisms for physicists. Anthropologists' kinship diagrams show the structure of social bonds. In Gilles Deleuze and Félix Guattari's (1987) *A Thousand Plateaus*, the diagram conceptualizes a manifold of socialities, an interplay of machinic assemblages and assemblages of discourse that constitutes a contemporary formation. More recently, Mullarkey (2006: 161) has theorized the diagram as a key tool for philosophies of immanence, an iterative method for outlining and exemplifying arrangements rather than explaining relations through transcendental concepts: "Our diagrams will replace conventional words and concepts with lines, arrows, shapes and spatial arrangements." Like Mullarkey's, our diagram works both theory and description. It informs our attempts to show how coordinations are not only critical to but immanent within how things hold.

Our diagram emerges from advocacy for satoyama woodlands. Until the late 1950s, satoyama woodlands were ubiquitous in central Japan. However, as villages were abandoned to the elderly and as village woodlands were converted to plantations or suburban developments, rural areas changed socially and ecologically. Since it began in the 1970s, a vigorous movement to revitalize satoyama has been growing (Tsing 2015). Satoyama advocates taught us how to see woodlands as a set of coordinations. Their guidance stimulated our attempt to theorize coordination through a diagram. We imagine the diagram, then, as neither Japanese nor Western, but rather as one entry into a set of interacting world-making projects crafted separately and together by plants and fungi, satoyama scientists and volunteers, and an anthropologist working with an artist.

Our diagram is a series of pen-and-ink sketches (our 'plates'). Each plate represents an interval of time and segregates particular axes of coordination, while also allowing the reader to watch how those separate axes layer together into structures of continuity and change. Our diagram allows us to visualize coordination as a series of connected events. Avoiding a hyperrealism that renders all details, as well as overgeneralized abstraction, we explore the concept through how it works in the satoyama. This means that we tell readers quite a bit about satoyama—as well as the satoyama revitalization movement that has instructed us in how to read satoyama. This article, however, is not an ethnography of the satoyama or the satoyama revitalization movement—a job better done elsewhere (e.g., Takeuchi et al. 2003). Our descriptions show the encounters through which the coordinations traced in our diagram arise.

Encounters across difference make and emerge from coordinations; the researcher is also a party to such encounters. In acknowledgement of our entanglements, we offer explanations of how we came to diagram coordination. Wedged between the nine plates, we offer instructions on how to read the diagram and notes on how it is made. We describe generative encounters: between matsutake and pine; between satoyama advocates and anthropologists; between critical landscape ecology, visual art, and feminist science studies. We call attention to ways in which incommensurable differences are sometimes able to encourage each other without homogenization. Taken together, we argue, the concepts of coordination, assemblage, and diagram articulate entangled temporalities and histories, showing how socialities emerge.



Encounters

A visitor might first notice the satoyama forest's openness. This forest is not dark but bright and airy. After a rain, a visitor might also notice the fresh smell. What is often identified as an 'earthy' forest smell is actually the aroma of fungi. Following the smell takes even a transient visitor into multispecies worlds—with their riddles of coordination.

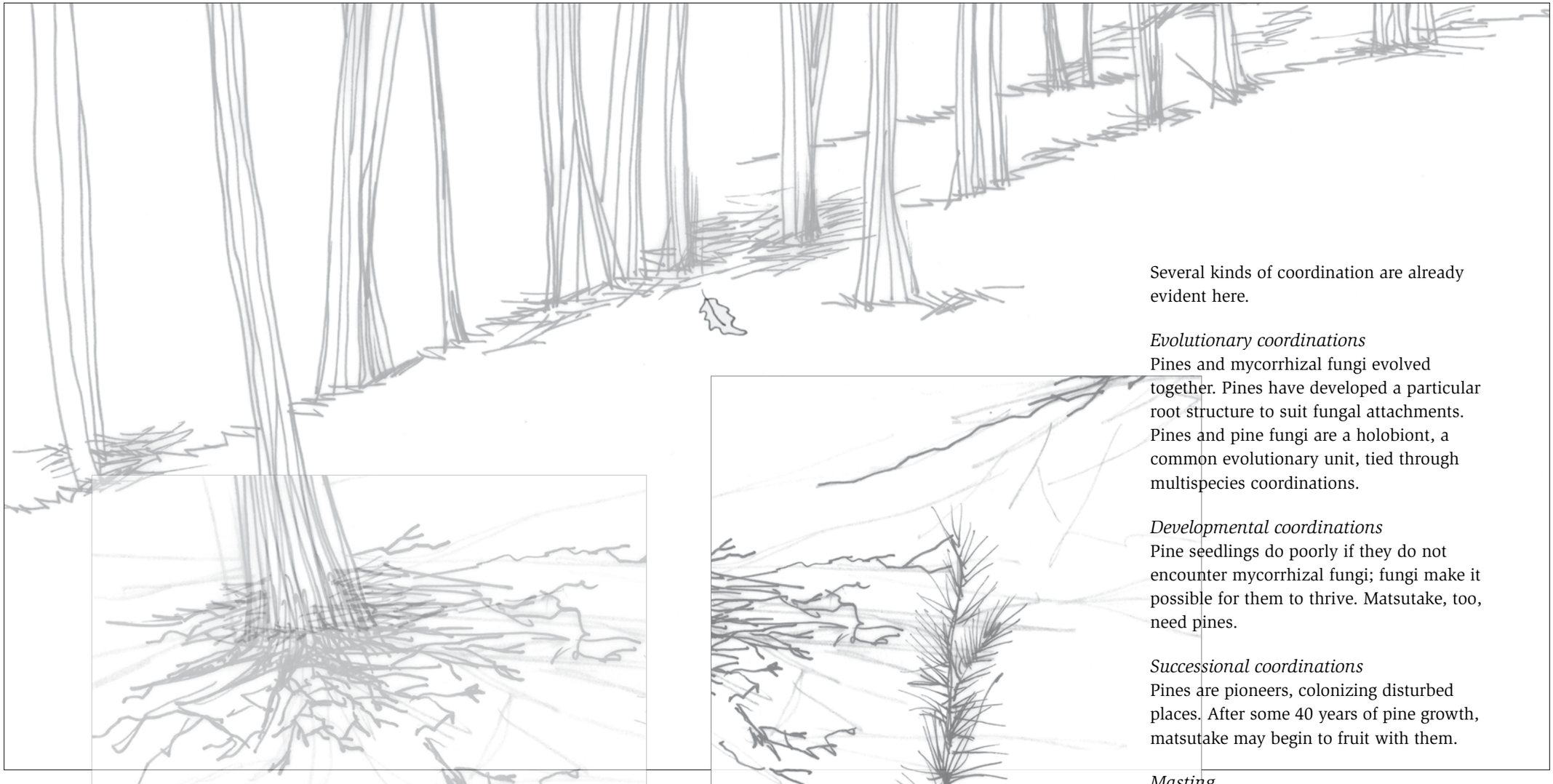
October 2005, Kyoto. A prefectural researcher is showing Satsuka, Hathaway, and Tsing how to smell matsutake in the satoyama forest: leaning forward and walking uphill, so that the ground, with its aromas, comes up before us. Our guide has worked hard to keep this forest open so that pine, the host of matsutake, can survive. He explains himself as only one of many makers working in this site, which is neither a garden nor a wild place. Tsing is excited by how much she can smell. Smell itself is a moment of encounter, the beginning of a coordination (see Choy, this issue). The aroma leads Tsing to ponder the combination of plants, fungi, and people that make this forest, which the prefectural researcher has shown her with so much love.

Tsing snaps a picture of the hillside. Later, as they discuss the interplay of oaks, pines, mushrooms, and people in making the forest, she shows the photograph to Gan.[2] It becomes the basis of a collaboration in which the forest itself comes alive as an effect of more-than-human coordination.

Tsing's photograph becomes Gan's window into the forest.

In order to focus on the red pines, Gan traced their outlines with pen and ink. Gan also included the forest floor and the slope of the hillside because they are the basis for the story that will unfold in the next few plates. The line drawing/tracing that you see is a visual guide to things growing in relation, rather than a portrait of autonomous subjects. The falling leaf on the upper left introduces the second type of tree: oak. Its position breaks the border of the plate to suggest that oak enacts yet another relational temporality beyond the human. The tracing maintains a fidelity to the original scene, while also simplifying it into just two characters—pine and oak—and two temporal qualities—endurance and ephemerality.

When Tsing visited satoyama forests with restoration participants and advocates, her guides showed her the two kinds of trees, pine and oak, that together structure the assemblage. Pollarded and coppiced broadleaf trees keep the forest open and active, while also providing firewood and charcoal. Pines, which grow in the open spaces of peasant use, are important for more extensive burning, for example, in making pottery, salt, and iron—as well as being hosts for matsutake mushrooms. To keep this species assemblage, undergrowth must be kept down and humus removed, originally for green manure, but now just to keep satoyama in place. If the forest floor is not cleared, evergreen broadleaf trees take over, changing the ecosystem. While each satoyama forest is different, every satoyama host pointed to these architectural features and then explained the many forms of creativity, human and non-human, that might emerge within this architecture: shiitake mushrooms can be raised on oak logs; children can be taught to love the outdoors; wildflowers and birds return to the open woodlands; biofuels can be produced; matsutake mushrooms emerge. All these are possible when the basic structure of the satoyama forest is maintained. Satoyama is a more-than-human architecture made through time.



Encounters allow forests to emerge

Deciduous oaks and red pines give the satoyama woodlands its character. Matsutake grows through encounters with pines, forming mycorrhiza—joint organs of fungus and root. The fungus lives off the plant's carbohydrates. The plant benefits from the water and nutrients made possible by the fungus. Forests emerge as assemblages through mycorrhizal connections; trees with mycorrhiza form forests (Curran 1994).

Several kinds of coordination are already evident here.

Evolutionary coordinations
Pines and mycorrhizal fungi evolved together. Pines have developed a particular root structure to suit fungal attachments. Pines and pine fungi are a holobiont, a common evolutionary unit, tied through multispecies coordinations.

Developmental coordinations
Pine seedlings do poorly if they do not encounter mycorrhizal fungi; fungi make it possible for them to thrive. Matsutake, too, need pines.

Successional coordinations
Pines are pioneers, colonizing disturbed places. After some 40 years of pine growth, matsutake may begin to fruit with them.

Masting
Trees and fungi coordinate irregular waves of fruiting.

The tracing of pine repeats in this plate, and the oak leaf, carried by wind, continues its journey. A third character appears: mycorrhizal fungi. Because they develop only when pine roots meet fungi underground, mycorrhiza, which are critical to the forest, mostly go unnoticed. Drawing performs an X-ray into the soil.

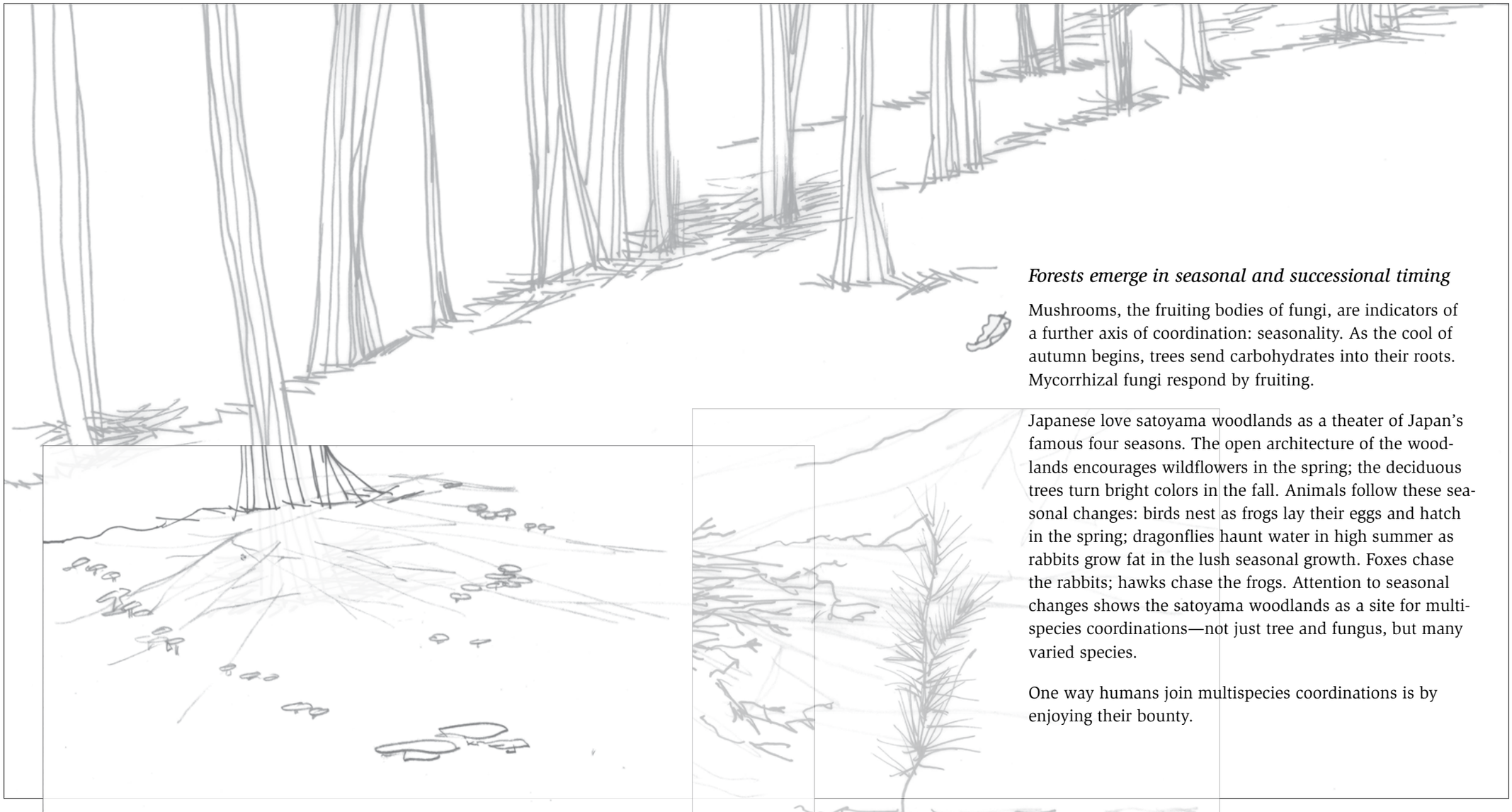
Here is what matsutake do to make a satoyama forest: they join with pines to colonize open ground and make nutrients available for pines in soils without organic humus. Pines create a forest environment that encourages other plants and animals to move in. Farmers cut back vegetation that might compete with pines; they rake needles and duff, exposing the bare mineral soils pines prefer. Farmers also cut back broadleaf trees, especially oaks, which grow back readily despite the cuts. Regrowing oaks hold hillsides for forests, keeping them from succession to brush or grasslands, despite human disturbance. Each organism offers its own set of temporal cycles and sequences; these temporalities connect in coordinations.

In the plates, we highlight the multiplicity of temporalities by using montage: a filmmaking technique of editing, piecing together, recombining, and overlaying separate shots to convey a novel composition that is based on—and yet analytically distinct from—raw footage from the field (Eisenstein [1949] 1977; MacDougall 1978). Each image is intended to portray its own time as it co-exists with others. Going against graphics software aesthetics of layering different images together and then erasing their seams, our diagram stays close to our observations in order to map and clarify the distinctions between various temporalities.

This plate is one of nine, which together show how a landscape assembles in ways that exceed human management and intention. We use a variety of media: text, field photographs, pen and pencil tracings, and fragmented overlays. We show temporal coordination in four ways that push beyond the limits of written text and digital imagery. First, each of the plates is an act of standing still. It situates a moment from a discrete vantage point. This works like a snapshot, but it does not show just any random moment. Each plate frames an event or an encounter that matters for multispecies livability. Second, across plates, some images repeat to show continuity or change. This works like a flipbook or a film reel, to show how and which encounters come to matter. Encounters socialize place through contingency and emergence. Enduring rhythms are shown through layering, shifts in scale, and changes in transparency. Third, a few plates show discontinuity or a radical change in pattern. Layers are cleared or a landscape altered to show intrusions or indeterminacies that break a sequence. Fourth, each plate opens with a phrase or a sentence that gradually forms a relay across all the plates. Text signals a particular mode of temporality in every scene and shows how they come together historically.

Creating this diagrammatic set of drawings based on hundreds of digital images taken during fieldwork experiments was a method of analysis. Field photographs and videos capture a slice of time, an image of light, an unfolding sequence of actions as they become sensible to a camera or electronic sensor. Multi-dimensional life is flattened into pixels that may be recomposed on a computer at a later date. But our goal was not endless recomposition, the false promise of digital media. We wanted to render particular coordinations and assemblages that unfold differentially and so are not always visible together at the time and place of documentary capture.

As explained above, Tsing was taught to read satoyama for the architectural features that shone through already-ruined versions and now called out for restoration. Satoyama forests might be ideal subjects for a diagrammatic analysis of coordination because satoyama, as enacted in restoration, has the generalized simplicity of a diagram. Its elusiveness is not abolished but rather rendered in a few skillful conceptual strokes, as in an ink brush painting.



Forests emerge in seasonal and successional timing

Mushrooms, the fruiting bodies of fungi, are indicators of a further axis of coordination: seasonality. As the cool of autumn begins, trees send carbohydrates into their roots. Mycorrhizal fungi respond by fruiting.

Japanese love satoyama woodlands as a theater of Japan's famous four seasons. The open architecture of the woodlands encourages wildflowers in the spring; the deciduous trees turn bright colors in the fall. Animals follow these seasonal changes: birds nest as frogs lay their eggs and hatch in the spring; dragonflies haunt water in high summer as rabbits grow fat in the lush seasonal growth. Foxes chase the rabbits; hawks chase the frogs. Attention to seasonal changes shows the satoyama woodlands as a site for multispecies coordinations—not just tree and fungus, but many varied species.

One way humans join multispecies coordinations is by enjoying their bounty.

Seasons begin to appear. While mushrooms are seasonal, they do not reappear like clockwork. We convey variations within seasonal cycles by drawing the mushrooms in soft clusters, different opacities, and penciled shades. The forest floor is simultaneously changing, and we convey this with a ghosted layering of two of the pine trees. We invite you to find these small variations, which we trace from one plate to the next.

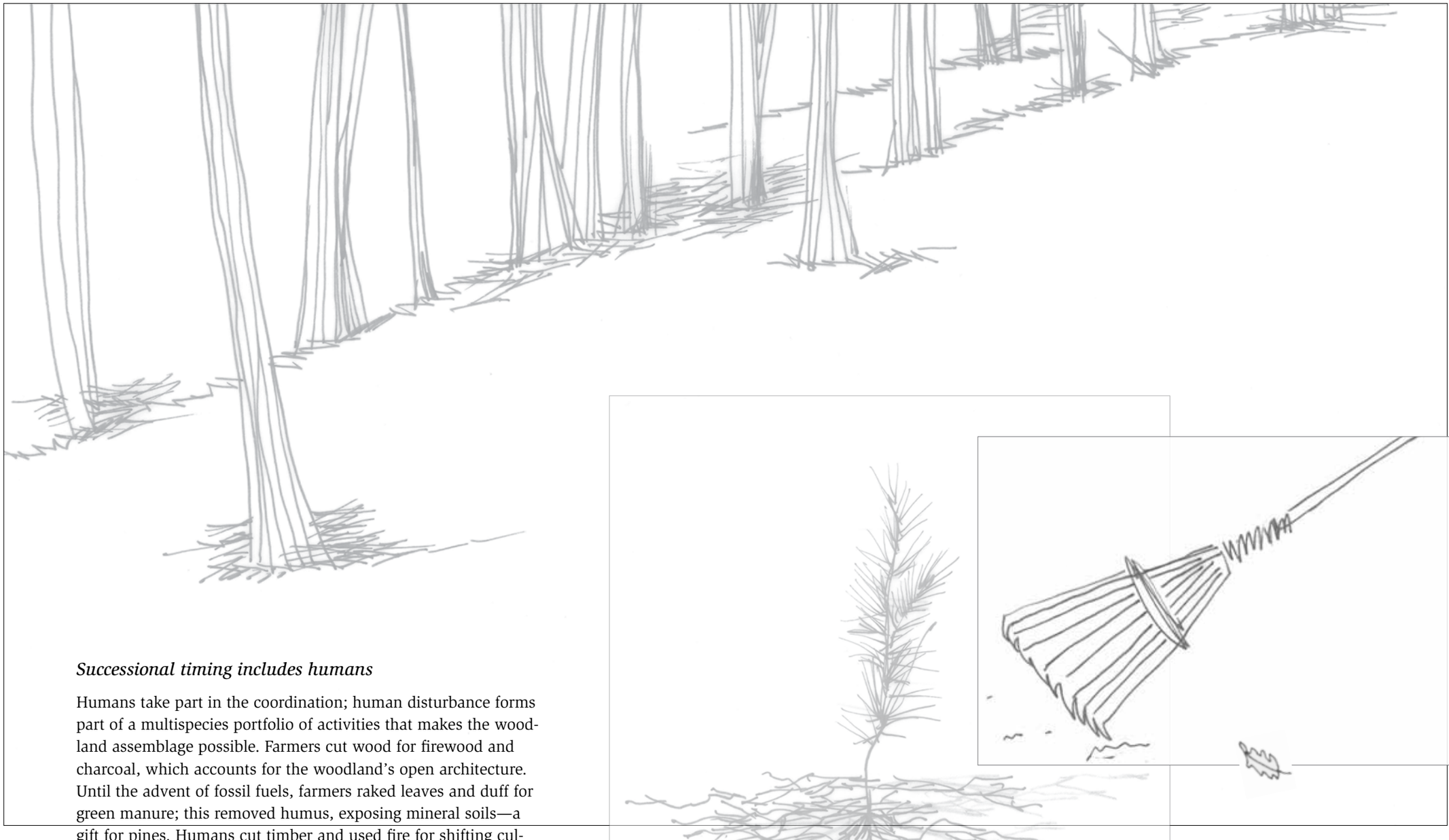
In contrast to diagrams that show how to make a product, our diagram focuses on the temporalities of an assemblage, an open-ended gathering of ways of being. We ask when things meet and start to work together. But just as this redefines the diagram, it also redefines coordination. How might our usage of coordination sit within others' uses of the term?

One well-known treatment of coordination is the actor-network theory of Bruno Latour (2005) and John Law (2008). Actor-network theory reminds us that action emerges from interconnection, which is one kind of coordination. Yet to make the point of emergence clear, Latour purifies his conception of the network from what he calls 'context', that is, those multiple scales of space and time that enter as well as emerge from a chain of associations. Sticking to emergence as it arises within the network, his diagrams are self-consciously 'flat'. As Annemarie Mol (2003: 66) explains it, for Latour "coordination is established or not. There are no distinctive *forms* of coordination." A consideration of temporal coordination requires a richer conceptualization of encounter.

Mol refuses Latourian flatness to ask about coordination within the practices that make up human bodies. How is it, she asks, that medical diagnoses, which differ from a patient's experience of illness, manage to inhabit the patient's body? Mol watches coherence emerge as certain practices are given more authority than others and as ways of enacting bodies are translated into each other's frames. Coordination is not a chain of associations but rather cohabiting ontologies. Still, there are connections: Mol, like Latour, watches coordination to show processes where modernity sees units. And because those modern units are imagined outside the play of time, so too are their processual reworkings. For Mol, like Latour, timing is not the basis of coordination.

What if instead we began with bodies in motion? This is the perspective advanced by Tim Ingold (1993: 159–160), who shows us how a "taskscape" brings temporality into social life "because people, in the performance of their tasks, *also attend to one another*." We might interpret 'people' in its widest, animist sense as beings; attending is a good place to begin when thinking about temporal coordination. Ingold likens the sociality of taskscapes to orchestral music, in which each musician attends to the conductor and the other musicians. This metaphor opens doors to asking about less perfectly aligned tasks and unruly temporalities. For this, we might turn from a classical orchestra to a baroque fugue in which each instrument maintains a separate melody line. The listener must attend to each line separately as well as to moments of harmony and dissonance as the separate lines cross each other. Separate-and-together listening is required to notice what we call coordination.

In contrast to Ingold's taskscape, our problem of coordination arises in the turbulence and indeterminacy of the assemblage, where specificity and commonality are always taking shape. In contrast to Mol's multiply-enacted body, for which incommensurabilities must be negotiated so that a patient's body can live, our focus on the contingently attuned scene of elusive living turns us toward evanescent coordinations that hold together precisely because of incommensurabilities. Coherence flickers. Temporality is relational, situating livability for many and diverse bodies. In the multispecies landscape, no single Latourian actor-network shows us enough. Connections both thwart and enable each other in a fugue-like play of life where no resonance ever remains the same. We draw from these scholarly allies to unflatten sociality, even as we follow our own path.



Successional timing includes humans

Humans take part in the coordination; human disturbance forms part of a multispecies portfolio of activities that makes the woodland assemblage possible. Farmers cut wood for firewood and charcoal, which accounts for the woodland's open architecture. Until the advent of fossil fuels, farmers raked leaves and duff for green manure; this removed humus, exposing mineral soils—a gift for pines. Humans cut timber and used fire for shifting cultivation; pines, specialists in disturbed areas, came back. Pines flourished because fungi made it possible for them to find nutrients despite the removal of nutrient-rich humus. Pines and fungi remade human-disturbed places as forests.

December 2009. Satsuka and Tsing meet with landowners who are trying to revive satoyama. Two partners have taken us to their hillside for the day, where they show us the practices through which they open the forest. Raking is one: the removal of leaves, branches, and duff on the forest floor, once a practice necessary to farming (for the green manure collected), but now a labor of love for the forest. For the moment, they have piled up the plant matter. One partner is hoping they might sell it for biofuel, but they have yet to figure out the business connections. Even without the money, they are committed. This forest was once an active satoyama and a great source for matsutake, and they are determined to restore it.

Raking is a repetitive disturbance that is necessary for the maintenance of satoyama. Gan traced the rake to represent a specific human contribution to forest making. The rake embodies a particular arrangement of local materials: it is not just any rake, nor is it a single rake. The rake, with its own histories and temporalities, merits its own box in this plate. Not all disturbances are acts of destruction. Raking is related to other acts of cultivation—pollarding (cutting branches) and coppicing (cutting trunks)—which appear in the next plate.

But how can we, or the satoyama advocates we follow, claim to know the rhythms of trees and fungi? The key, for us, is to respect the situated nature of knowledge without reducing knowledge to its situatedness. We observe trees and fungi, rather than stopping with advocates' ideas about nature. We also pay attention to the conditions of knowledge production. Three features struck Tsing.

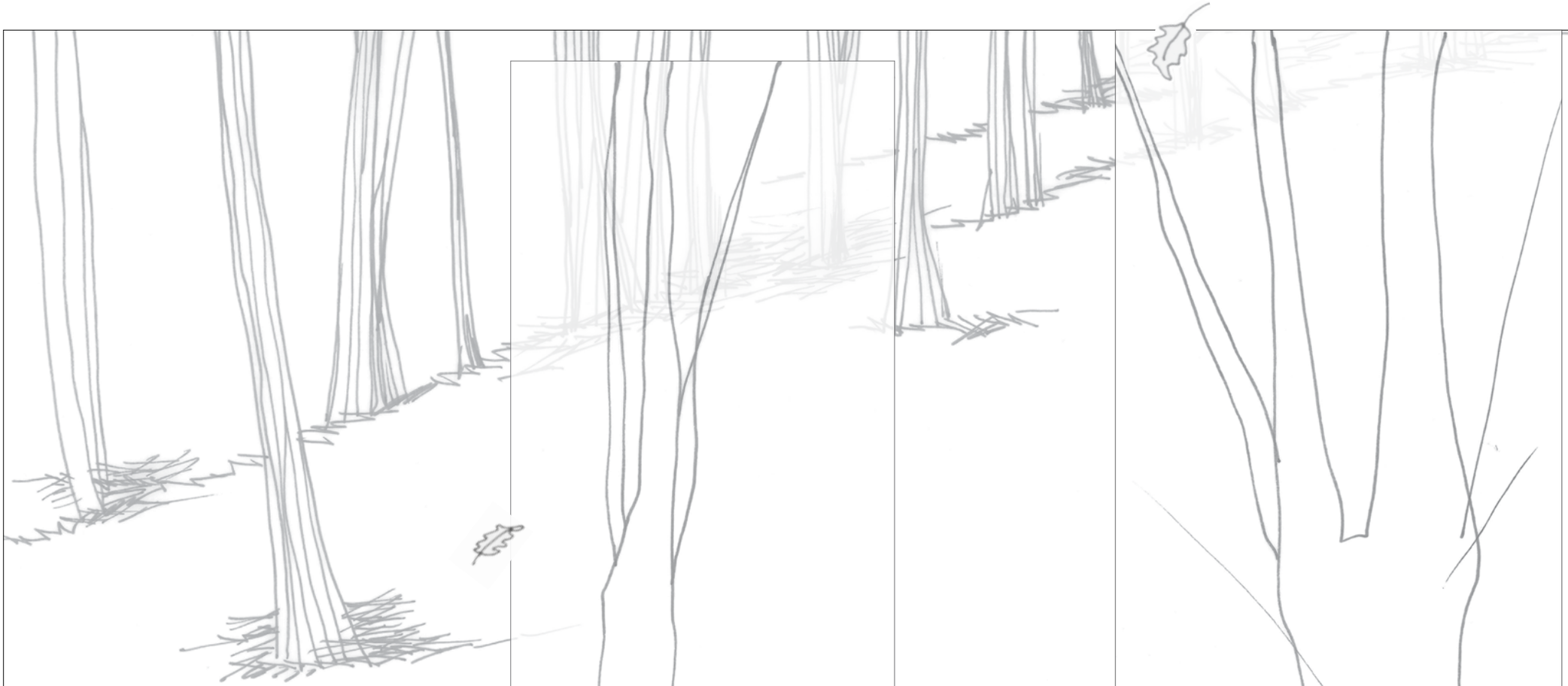
First, description and advocacy of satoyama are part of the same complex of practices. The term 'satoyama' was brought into general use by advocates, whose research defines its characteristics. Our ability to notice the features of satoyama follows advocates as they reassemble relations between city and countryside and between traditional farming and modern conservation. Satoyama advocacy first emerged in central Japan in the 1970s as advocates noted the abandonment of peasant management and the spread of noxious weeds. Young people had moved to the city, and farming had been left to the elderly. As the children of urban migrants grew up, they rediscovered the countryside as a site of advocacy. One early group called itself the Kusakari Jujigun (Grass-Cutting Crusaders), and this name offers a sense of both local challenges and cosmopolitan sources of the movement's appeal. By the twenty-first century, most parts of central Japan had satoyama advocacy groups and rural revitalization projects. Satoyama are not discovered but constituted by these practices. They are simultaneously modern and traditional, and both rural-inspired and urban-inspired.

Second, satoyama advocacy self-consciously mixes science, vernacular enthusiasm, and old farmer knowledge. Elderly farmers are often consultants, but most leaders are urbanites. Some group leaders are scholars and scientists who had begun to worry about the deterioration of the countryside. Other leaders have histories of community organizing. Government foresters play a role in some areas. There are also landowners, some of whom bought land while others inherited family tracts. But their work would not be possible without large groups of volunteers: housewives, students, retired people, and even salaried employees who join in on weekends.

Through this mix of participants, satoyama revitalization brings goals of personal and social revitalization together with scientific inquiry and pedagogy. Some volunteers speak of biodiversity, and some of vitality. Some want rural people to have better incomes. Many are concerned that urban people have lost connection with the countryside and, as a result, have lost something important in themselves. Most have pedagogical goals involving building better relations between people and the countryside around them. Together, these combine what social scientists often imagine as alternative forms of knowledge and practice.

Third, these are both Japanese and not-just Japanese forms of knowledge and practice. They incorporate science, but also aesthetics and philosophy (see Satsuka, this issue). They make connections, extending ties to interlocutors as various as shifting cultivators in Laos and historical ecologists in Sweden. Satoyama advocates build Japanese cultural landscapes, but they do so in conversations that reach across continents.

Taken together, these three characteristics form a basis for an engaged citizen practice that reaches both into and beyond science, Japan, and traditional farming. As much as anthropologists might like this to be true, satoyama advocates are not spokespeople for an autonomous Japanese cosmology. Instead, their agility in moving in and out of these categories, mobilizing translations across varied forms of knowledge and practice, informs their commitments to noticing how pines and oaks and fungi and farmers (as well as scientists and anthropologists) might get along. When living well with difference is taken seriously, the critical role of coordination becomes apparent.



Humans are unintentional actors in the longue durée

Migration opens further axes of coordination. Japan sits in the tracks of two post-glacial migrations: deciduous oaks and pines resemble the flora of the northeast Asian mainland, while evergreen oaks and laurels come from southeast Asia. Peasant disturbance advantaged the former set (Tabata 2001).

Through pollarding and coppicing, farmers helped deciduous oaks in an indirect way. Oaks grew back, remaining stable fixtures in the forest. Meanwhile, farmers removed young evergreens for green manure. Deciduous oaks—with their characteristic companion species, including matsutake—maintained the open architecture of the satoyama woodlands.

The role of human activities became clear when rural Japanese abandoned their farms and woodlands in the 1950s. As soon as pollarding, coppicing, and raking stopped, other species moved into the woodlands, including evergreen oaks and laurels. These species, which remain green all year, produce a dense and dark forest. They create a thick layer of humus, covering mineral soils. Pines fester in the shade and cannot regenerate. Wildflowers disappear, and no leaves change in the fall. Multispecies coordinations change. By the late 1970s, matsutake had become rare.

Thus, too, anthropogenic climate change will be felt through its interruption of multispecies coordinations.

December 2009. Satsuka and Tsing are visiting other satoyama landowners, in this case a husband and wife who are proud to show us the work they have done to make the forest lively. But here we entered a place of old oak pollards, still holding the hillside forest landscape as their own. When encountered in person, the trees' pollarding scars were evident, as was the fact that all the oaks branched at the same height, convenient for humans. Farmers cut back these trees, and they grew into the shapes you see in the sketch.

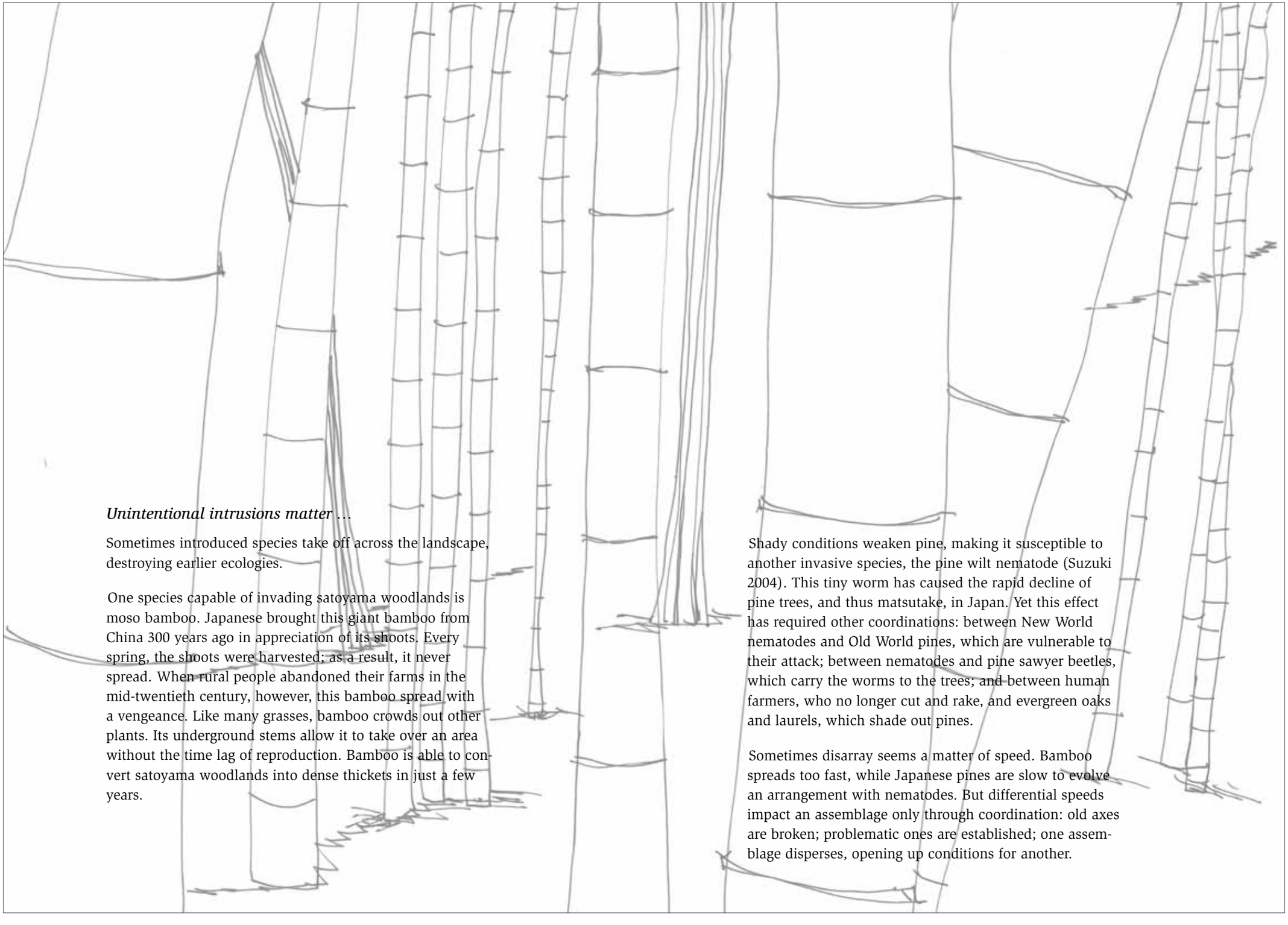
The shapes of trees are temporal traces. One trace is in the branching itself: in forks and scars we see the results of peasant wood gathering. Another trace follows light. In the sketch, the branches aim upward at steep angles, suggesting that there was no open field around these trees when the branches grew back, but rather shade. A third trace is the mark of time passing. The branches that grew back from the last pollard are now thick and strong, indicating that the pollard was a long time ago. These traces weave a record of the satoyama—and its abandonment.

The trees offer a striking pose, a testimony to relations between people and trees that has lasted many years. In contrast to the appearance of mushrooms, which shows seasonality and indeterminacy, pollarded trees tell a story that lasts the lifetime of the trees (Mathews 2018).

Tree populations also move, and tree migration stories are written in the landscape. Satoyama privileges northeast Asian tree species. When satoyama is abandoned, deciduous oaks are replaced by evergreen oaks and laurels. Amazingly, this is not just a matter of trees: the landscape encouraged by trees draws a selective set of other creatures. Here is Tabata (2001) writing about satoyama ants:

> In Kyoto, *satoyama* woodlands are very rich in ant species because of the mosaic structure of the environment. It is remarkable that rare ant species, especially submerged species, are found in *satoyama* woodlands. They are represented by *Discothyrea sauteri*, *Monomorium triiale*, *Pentastruma canina*, *Epitritus hermerus* and *E. hirashimai*. Boreal species like *Dilchoderus sibiricus* inhabit oak woodlands whereas tropical or subtropical species such as *Epitrutus hexamerus* and *E. hirashimai* are found in bamboo forests. Evergreen broad-leaved forests are also inhabited by tropical or subtropical ant species … Just as the association between fungi and the host plants has been roughly maintained, so has the biological association between particular ant species and vegetation. This association has been maintained at least since the last ice age.

We can only begin to know our many oft-overlooked companions when we learn to think across temporal scales.



Unintentional intrusions matter …

Sometimes introduced species take off across the landscape, destroying earlier ecologies.

One species capable of invading satoyama woodlands is moso bamboo. Japanese brought this giant bamboo from China 300 years ago in appreciation of its shoots. Every spring, the shoots were harvested; as a result, it never spread. When rural people abandoned their farms in the mid-twentieth century, however, this bamboo spread with a vengeance. Like many grasses, bamboo crowds out other plants. Its underground stems allow it to take over an area without the time lag of reproduction. Bamboo is able to convert satoyama woodlands into dense thickets in just a few years.

Shady conditions weaken pine, making it susceptible to another invasive species, the pine wilt nematode (Suzuki 2004). This tiny worm has caused the rapid decline of pine trees, and thus matsutake, in Japan. Yet this effect has required other coordinations: between New World nematodes and Old World pines, which are vulnerable to their attack; between nematodes and pine sawyer beetles, which carry the worms to the trees; and between human farmers, who no longer cut and rake, and evergreen oaks and laurels, which shade out pines.

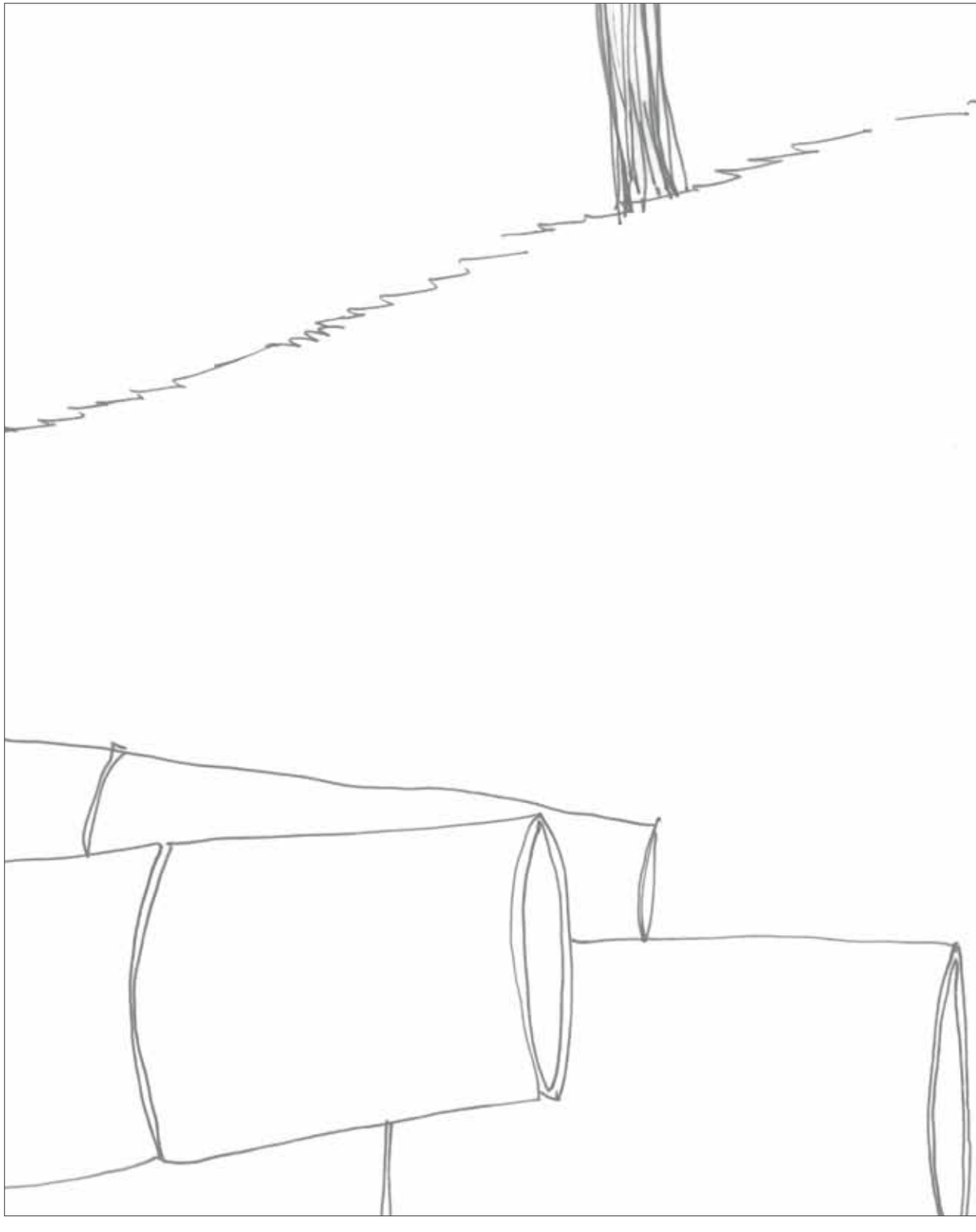
Sometimes disarray seems a matter of speed. Bamboo spreads too fast, while Japanese pines are slow to evolve an arrangement with nematodes. But differential speeds impact an assemblage only through coordination: old axes are broken; problematic ones are established; one assemblage disperses, opening up conditions for another.

December 2008. A professor has taken Tsing to the satoyama revitalization project he started at his university. To emphasize the urgency of opening up the forest, he shows her the moso bamboo stands, which have spread wildly. They have grown so thick that other trees cannot survive in their midst. Later, Gan and Tsing chose moso bamboo to make the point about challenges to satoyama because it is so visually dramatic. In the drawing, bamboos form a curtain, blocking everything else.

Here is a photograph of the more ordinary situation, which Tsing took at a different satoyama revitalization project in June 2006. The project leader took Tsing here, too, to show the problem: a forest in which people are no longer participants. The pines are crowded by a host of evergreen broadleaf saplings. There is so much going on that it is difficult to sketch.

Crowding and shading have encouraged the work of pine wilt nematodes, which have killed pines across Japan, changing the landscape. Pine nematodes can wreak destruction only through a finely honed system of coordinations. Consider their transportation: the nematodes are incapable of making their way to trees by themselves. But American nematodes have been able to synchronize their travels with the life cycles of Japanese pine sawyer beetles. They travel by crawling into the breathing tubes of the beetles—but only when the (American) nematodes are in their last larval stage and as the (Asian) beetles become fully adult. The beetle crawls to a new tree and makes a wound to lay its eggs; only then does the nematode safely emerge to eat wood. What careful timing all this requires (Zhao et al. 2013). The delicacy and variety of what we are calling temporalities is illustrated here.

In many satoyama forests across Japan, one sees only dead remnants of pines. The possibilities for matsutake's growth are cut off. But there is more: a long-standing coordination between human and non-human life has been precluded. Livable coordinations can no longer be taken for granted.



… yet memory is not extinguished

Sometimes assemblages that have been dispersed are able to reassemble. Before the late twentieth century, Japan had many episodes of rapid deforestation, followed by the reappearance of satoyama woodlands. Pine seedlings colonized open ground; oaks followed. This history of satoyama re-establishment has given hope to satoyama advocates, who work to reintroduce human disturbance into Japan's forests to make satoyama woodlands possible again. They clear shady species and remove humus, advantaging pine. They relearn arts of coppice for deciduous oaks.

The word 'satoyama' is more than a descriptive term. Advocates use it to speak of hope for the restoration of particular interspecies arrangements. This is not the same as gardening; it retreats from dreams of mastery. Satoyama advocates do not imagine that they control the assemblage. All they can do is to resume their part in making appropriate disturbances, hoping other species coordinations will follow.

December 2016. Tsing revisits a site for satoyama revitalization. Volunteers have removed the thick brush, allowing red pines to flourish. Amazingly, and for the first time this year, matsutake have emerged. A flag marks one matsutake location. (In the photograph, we focus your attention on the flag and make the rest of the forest recede visually.)

The appearance of matsutake is a small success. It could not be planned. Interactions between matsutake mycelia and red pine roots produce mushrooms; human planning does not. The volunteers make the hillside a good place for pines—and hope and wait. Satoyama advocates take part without expectations of modernist control. Shedding such expectations is key to appreciating both the elusiveness of the mushroom (see Faier, this issue) and the modes of social analysis we see necessary to notice different kinds of coordination.

Modernist dreams have focused attention on only one kind of coordination: disciplined control. Here, elusiveness is banished; every party to the coordination should act predictably. Twentieth-century scholars came to define the term 'coordination' exclusively this way, forgetting that this small subset of coordinations is hardly the only form coordination can take. With only this one meaning in mind, scholars showed that industrialization, urbanization, and the spread of capitalist enterprises required coordinating temporalities. E. P. Thompson's (1967) classic article on industrial time showed the way: workers came to embody the time of the factory. Despite the occurrence of multiple rhythms (Glennie and Thrift 1996), scholars focused on industrial time. Eating changed to fit the factory schedule (Mintz 1986) as human metabolisms were increasingly tethered to the factory. Under this regime, coordination was standardization, and it did not seem elusive—only another instance of discipline.

As our diagram suggests, however, there are other forms of coordination that underlie social life even as their importance is denied by modernist planners. The ecological coordinations of the satoyama are unplanned. Through working with and around each other over a long period of time, pines, matsutake, oaks, and farmers have developed the temporal synchronies that produce the satoyama forest. If we are interested in the dynamics of livability—rather than efficient resource use—coordination in this sense is key: it keeps livable assemblages alive.

Pests and pathogens can be part of an ecological assemblage without destroying it (see Hathaway, this issue). The pine wilt nematode has been successful in killing only so many pines, according to satoyama advocates, because of multiple stresses on pine trees. Furthermore, one disease follows closely on another. The speed and scale of the industrial transfer of pests and pathogens in the last hundred years has been unique. Trees cannot keep up. This is one way that industrial coordinations get in the way of ecological coordinations: the very efficiency of long-distance transfer, along with the scale of industrial plans, has thrown so many pathogens at trees that one species after another has succumbed. Another way that industrial coordinations interfere with forests is to turn them into plantations, that is, monocrops in which planners imagine that only one species is necessary. Tree plantations are an attempt to grow forests without unplanned coordinations. Their gaps in ecological function—and their proclivity to encourage pests and pathogens—make them a poor model for life on earth. Our attention to those coordinations that are unrecognized by plantation planning suggests alternatives.

Encounters layer landscapes

Landscapes are made with multiple projects, human and non-human. Our landscapes are layered with satoyama dreams, mycorrhizal explorations, nematode invasions, autumn matsutake outings, and much more. In coordinations across these enactments, landscapes and assemblages achieve moments of coherence.

In this part of our diagram, we shift from a drawing to a black-and-white photograph. We zoom out from the forest assemblage in previous plates to a wider landscape view.

Satoyama is a landscape that is made over time, through multiple encounters and embodied temporalities. Representations of landscapes too often turn them into backgrounds for human actions. Attending to satoyama enables us to trace landscape's structural features as multiple synchronies, accidental encounters, and indeterminacies.

Although anthropological discussions have not focused on coordinations of this sort, coordinations make it into many ethnographies. In Eduardo Kohn's (2013) *How Forests Think*, for example, an astonishing coordination involving the flight of winged leafcutter ants finds its way into a section on interspecies semiosis. Kohn writes: "The precise moment at which the flight will take place on that day is a response, sedimented over evolutionary time, to what it is that potential predators might, or might not, notice" (ibid.: 80). Once winged ants take off, they become easy prey for bats and birds. Mating ants fly from just before daybreak, when bats are out for only a few more minutes, until right after sunrise, when birds take flight. Bats and birds are least likely to notice the ants within this small yet crucial window in time. Runa, and others interested in ants as food, learn to wait and watch for signs of this elusive event.

Or consider E. E. Evans-Pritchard's (1940) *The Nuer*, which takes us into cascades of coordination. There are daily and seasonal changes, which transform cattle and grass as well as human activities. In the evening, after the day's work is done, a song sung by girls tells of wind blowing *wirawira*, which Evans-Pritchard translates as "the north wind which blows at the time of rich pasture when the cows give plenty of milk" (ibid.: 46–47). Early rains are considered a "season of fatness, for then the grasses germinate, or renew their growth after the long drought, and the cattle can graze on the young shoots to their content" (ibid.: 59). Within routines and rhythms, too, another kind of time arises—fortuitous coincidence: "Nuer, spurred by hunger, leave camp after the first heavy showers to look for giraffe tracks and pursue these animals relentlessly till they overtake them. This is only possible at the time of the first rains when the animals still have to approach camps to drink while their large hooves stick in the moist earth and slow down their movements" (ibid.: 74). Through such coordinations, landscapes are made.

We use the term 'landscape' to refer to material enactments of space and place by many historical actors—human and non-human. The anthropology of landscape was caught for many years in anxieties about the etymology of the word as a European style of painting (Cosgrove 1985); anthropologists could only rehearse differences between these Western ideas of landscape and the ideas of non-Western people (Hirsch and O'Hanlon 1995). More recently, however, there has been a turn to the materiality of landscapes and the enactment of landscape by human and non-human actors (Tilley and Cameron-Daum 2017; Tsing 2015). This turn to materiality opens up a host of new research trajectories, including the search for coordinations.

Sometimes everything changes

Temporal coordinations snap into place and then unravel all the time. Assemblages come and go. Landscapes are made and unmade. Yet ruptures are also possible.

In March 2011, the explosion of the Fukushima Daiichi Nuclear Power Plant changed the satoyama woodlands of northeastern Japan and beyond. Water and wind carried radioactivity away from the site after the explosion. Just how far one should map sites of rupture is unknown.

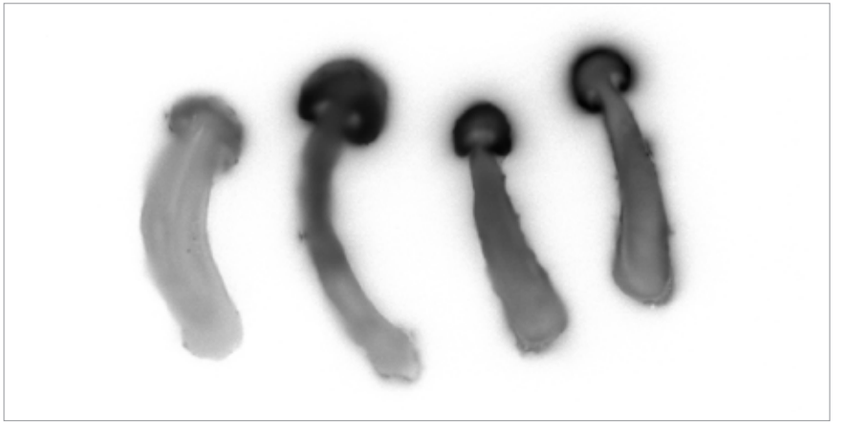
As expensive gourmet mushrooms, matsutake have been an icon of satoyama revitalization. Yet mushrooms absorb radiocesium, drawing it into their metabolism. They are a particularly dangerous food in a radioactive landscape. This is one kind of rupture at the heart of the assemblage.

How to represent time out of joint? The black-and-white photograph from the previous plate appears as its inverse and cut apart. The sky turns black; everything is different.

We wrote this article in the shadow of the Fukushima disaster. It changed how we imagined how things hold. The disaster was simultaneously biological, geological, and chemical; its effects were immediate and yet will last for many years. It offered a glimpse of a catastrophic coordination, that is, one that abruptly destroyed coordinations that are necessary for livability.

Satoyama, and thus too matsutake, have become more and less common many times in Japanese history. When forests are allowed to grow back without human disturbance, satoyama disappears. When logging creates 'bald mountains' and farmers' practices keep regrowing forests active, satoyama reappears. In these histories, satoyama shows the force of resurgence, the ability of the forest to come back after disturbance, human or otherwise (Tsing 2017). Resurgence is a basic principle of livability. But it is possible to block resurgence—especially within a civilizational matrix in which livability is seen as unimportant in comparison to power and profit. Fukushima radiation is an example of this problem. Fukushima radiation blocks the resurgence of satoyama by the simple fact of making mushrooms toxic, thus undermining satoyama revitalization and the human and non-human coordinations it supports.

A collaboration between photographer Masamichi Kagaya and researcher Satoshi Mori aims to make radioactivity visible through a series of autoradiographs. Below are their images of matsutake from a village 35 kilometers from the Fukushima Daiichi reactor.[3] The irradiated mushrooms in the autoradiograph show contaminated caps and gills.



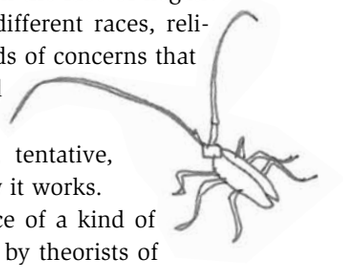
As mushrooms absorb radiocesium, animals (including humans) eat them, transferring radioactivity. Or else the mushrooms decompose, and the radioactivity remains for other life forms to absorb. The coordinations of radioactivity are multiple; it is impossible to measure its temporality as a single line.[4] Still, toxic landscapes will outlast us.

How Things Hold in Precarious Times

Satoyama forests, we argue, show us coordinations, a mode of sociality that does not depend on communication, a common goal, or human-driven webs of significance. Too much popular and scholarly thinking begins with consciousness and communication as the anthropogenic standard with which to rank all living beings. Instead, we show how *timing* can matter to making social lives in common. Through attunements across species difference, as when tree roots and mycorrhizal fungi meet, varied temporalities are brought into coordination, materializing as historically consequential assemblages. Rhythms of life resonate and harness each other, making affordances, too, for others.

It is worth reflecting for a moment on the fact that the question we ask—how things hold—is a significant shift from the classical concerns of both ecology and social science from the last century, when holding together was taken for granted and the important research questions addressed why things fall apart. Ecological disturbance was considered the exception, not the norm, and ties of place and community were imagined as foundational features of the human condition. Today, in comparison, both human and non-human assemblages seem precarious, and the question of whether anything will hold asserts

itself with new mystery. Does it make a difference if our landscapes fill up with invasive species and human-disturbance ecologies? In the face of negative pronouncements by ideologues, can neighbors of different races, religions, and nationalities get along? These are the kinds of concerns that have moved social theory to work with open-ended concepts of landscape and assemblage, and to consider how things hold. 'Holding' has become fragile, tentative, and contested. Social theorists suddenly wonder how it works.



In this article, we have argued for the importance of a kind of temporal coordination that was for too long ignored by theorists of modernity: coordination without top-down discipline. We have shown how assemblages emerge through coordination and how coordinations emerge through assemblages. This recursivity happens without common cause or higher authority.

As Gan (2017) argues elsewhere, mapping temporal complexity is key to understanding the Anthropocene. Both the power and terror of industrial civilization can be understood in relation to its more-than-human temporal routines. Coordination is an important tool for this kind of analysis. In tracing coordination in a Holocene ecology, the satoyama forest, this article develops a tool for understanding both stability and precarity in the multispecies knots that hold together social assemblages.

Acknowledgments

This article is based on the collaborative research of the Matsutake Worlds Research Group, and especially Tsing's joint research with Shiho Satsuka and Michael Hathaway. We are indebted to Fumihiko Yoshimura, Noboru Ishikawa, Daisuke Naito, Heather Swanson, and many others with whom Tsing discussed satoyama. Karen Barad and Michelle Bastian were important interlocutors on multispecies temporalities. This article joins many creative experiments between the authors that have taken place from 2012 to 2017. It grew out of a browser-based storytelling project titled "A Fungal Clock: Experiments in Representations of Time," which was initially presented at the annual meeting of the American Anthropological Association in November 2012. The project may be viewed at http://fungalclock.com.

Elaine Gan is an artist-scholar who plays at the intersection of feminist science studies, environmental anthropology, and digital arts and humanities. She teaches at the Center for Experimental Humanities & Social Engagement at New York University. She is a co-editor of *Arts of Living on a Damaged Planet* (2017) and a co-author of "Using Natural History in the Study of Industrial Ruins" (*Journal of Ethnobiology*, 2018). E-mail: elaine.gan@nyu.edu

Anna Tsing is a Professor of Anthropology at the University of California, Santa Cruz, and a Niels Bohr Professor at Aarhus University, where she co-directs Aarhus University Research on the Anthropocene. She is a co-editor of *Arts of Living on a Damaged Planet* (2017) and a co-author of "Using Natural History in the Study of Industrial Ruins" (*Journal of Ethnobiology*, 2018). E-mail: atsing@ucsc.edu

Notes

1. For Ingold (2015), correspondence is an alternative to assemblage, which Ingold believes includes too much incoherence. In this, he takes on the question of the best translation for Deleuze and Guattari's (1987) *agencement*. For us, assemblage is a good term because we remain in conversation with its use in landscape ecology. Verran's (2009) discussion of assemblage as an unfolding of heterogeneous agencies with world-making effects also informs our conception.
2. In this article, the photographs are by Anna Tsing, and the drawings by Elaine Gan. The autoradiographs were created by Masamichi Kagaya and Satoshi Mori, all rights reserved.
3. See Mori and Kagaya's "Autoradiograph" at http://www.autoradiograph.org.
4. The temporality of radiocesium depends on coordinations. In the laboratory, cesium-137 has a half-life of about 30 years; in the field, however, its ecological half-life is indeterminate. In 2009, Chernobyl's radiocesium level had not changed since the 1986 accident (Madrigal 2009). This is thought to be an effect of mineral flows across layers of soil and organic life.

References

Born, Georgina. 2015. "Making Time: Temporality, History, and the Cultural Object." *New Literary History* 46 (3): 361–386.

Cosgrove, Denis. 1985. "Prospect, Perspective and the Evolution of the Landscape Idea." *Transactions of the Institute of British Geographers* 10 (1): 45–62.

Curran, Lisa. 1994. "The Ecology and Evolution of Mast-Fruiting in Bornean Dipterocaraceae: A General Ectomycorrhizal Theory." PhD diss., Princeton University.

Deleuze, Gilles, and Félix Guattari. 1987. *A Thousand Plateaus: Capitalism and Schizophrenia*. Trans. Brian Massumi. Minneapolis: University of Minnesota Press.

Eisenstein, Sergei. (1949) 1977. "A Dialectic Approach to Film Form." In *Film Form: Essays in Film Theory*, ed. and trans. Jay Leyda, 45–63. New York: Harcourt Publishing.

Evans-Pritchard, E. E. 1940. *The Nuer: A Description of the Modes of Livelihood and Political Institutions of a Nilotic People.* Oxford: Clarendon Press.

Gan, Elaine. 2017. "Timing Rice: An Inquiry into More-Than-Human Temporalities of the Anthropocene." *New Formations* 92: 87–101.

Gilbert, Scott F., and David Epel. 2015. *Ecological Developmental Biology: The Environmental Regulation of Development, Health, and Evolution*. 2nd ed. Sunderland, MA: Sinauer Associates.

Glennie, Paul, and Nigel Thrift. 1996. "Reworking E. P. Thompson's 'Time, Work-Discipline and Industrial Capitalism.'" *Time & Society* 5 (3): 275–299.

Haraway, Donna. 2003. *The Companion Species Manifesto: Dogs, People, and Significant Otherness.* Chicago: Prickly Paradigm Press.

Haraway, Donna. 2008. *When Species Meet*. Minneapolis: University of Minnesota Press.

Hirsch, Eric, and Michael O'Hanlon, eds. 1995. *The Anthropology of Landscape: Perspectives on Place and Space*. Oxford: Oxford University Press.

Ingold, Tim. 1993. "The Temporality of the Landscape." *World Archaeology* 25 (2): 152–174.

Ingold, Tim. 2015. *The Life of Lines.* London: Routledge.

Kohn, Eduardo. 2013. *How Forests Think: Toward an Anthropology Beyond the Human*. Berkeley: University of California Press.

Latour, Bruno. 2005. *Reassembling the Social: An Introduction to Actor-Network-Theory*. Oxford: Oxford University Press.

Law, John. 2008. "Actor Network Theory and Material Semiotics." In *The New Blackwell Companion to Social Theory, Third Edition*, ed. Bryan S. Turner, 141–158. Oxford: Blackwell.

MacDougall, David. 1978. "Ethnographic Film: Failure and Promise." *Annual Review of Anthropology* 7: 405–425.

Madrigal, Alexis. 2009. "Chernobyl Exclusion Zone Radioactive Longer Than Expected." *Wired*, 15 December. https://www.wired.com/2009/12/chernobyl-soil/.

Margulis, Lynn. 1981. *Symbiosis in Cell Evolution: Life and Its Environment on the Early Earth.* San Francisco: W. H. Freeman.

Mathews, Andrew S. 2018. "Landscapes and Throughscapes in Italian Forest Worlds: Thinking Dramatically about the Anthropocene." *Cultural Anthropology* 33 (3): 386–414.

Mintz, Sidney W. 1986. *Sweetness and Power: The Place of Sugar in Modern History*. New York: Penguin Books.

Mol, Annemarie. 2003. *The Body Multiple: Ontology in Medical Practice*. Durham, NC: Duke University Press.

Mullarkey, John. 2006. *Post-Continental Philosophy: An Outline.* London: Continuum.

Rose, Deborah Bird. 2012. "Multispecies Knots of Ethical Time." *Environmental Philosophy* 9 (1): 127–140.

Suzuki, Kazuo. 2004. "Pine Wilt and the Pine Wilt Nematode." In *Encyclopedia of Forest Sciences*, ed. Jeffery Burley, 773–777. Cambridge, MA: Elsevier Press.

Tabata, Hideo. 2001. "The Future Role of *Satoyama* Woodlands in Japanese Society." In *Forest and Civilisations*, ed. Yoshinori Yasuda. New Delhi: Roli Books. http://www001.upp.so-net.ne.jp/ito-hi/satoyama/docs/future.html.

Takeuchi, Kazuhiko, Robert D. Brown, Izumi Washitani, Atsushi Tsunekawa, and Makoto Yokohari, eds. 2003. *Satoyama: the Traditional Rural Landscape of Japan*. Tokyo: Springer-Verlag.

Thompson, E. P. 1967. "Time, Work-Discipline, and Industrial Capitalism." *Past & Present* 38: 56–97.

Tilley, Christopher, and Kate Cameron-Daum. 2017. *An Anthropology of Landscape: The Extraordinary in the Ordinary*. London: UCL Press.

Tsing, Anna. 2015. *The Mushroom at the End of the World: On the Possibility of Life in Capitalist Ruins*. Princeton, NJ: Princeton University Press.

Tsing, Anna. 2017. "A Threat to Holocene Resurgence Is a Threat to Livability." In *The Anthropology of Sustainability: Beyond Development and Progress*, ed. Marc Brightman and Jerome Lewis, 51–65. New York: Palgrave Macmillan.

Verran, Helen. 2009. "On Assemblage." *Journal of Cultural Economy* 2: 1–2, 169–182.

Zhao, Lilin, Shuai Zhang, Wei Wei, Haijun Hao, Bin Zhang, Rebecca Butcher, and Jianghua Sun. 2013. "Chemical Signals Synchronize the Life Cycles of a Plant-Parasitic Nematode and Its Vector Beetle." *Current Biology* 23 (20): 2038–2043.