

After the Fall: The Tapestry of Disturbance and Recovery

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Abstract: On July 3, 2015, Nalini Nadkarni, a world-renowned ecologist who had been studying the biologic processes of ecosystem disturbance and recovery, sustained a catastrophic 50-foot free-fall from the top of the rainforest canopy to the forest floor at her remote field research site. She lost consciousness in shock and sustained life-threatening injuries. Her accompanying students hiked out, radio-called 911, and the Harborview Medical Center (Seattle) Medivac team arrived 4 hours later to rescue her. Her prognosis was extremely grim; her family gathered in anticipation of her death as she underwent four operations during her 10 days in the ICU. As she emerged from coma, she spent weeks of hospital recovery and months of progressive mobility and physical therapy during medical leave from work. She experienced ICU psychosis and postintensive care syndrome, but slowly recovered nearly totally, to the point where she can solo hike up to 18 miles in a day, and has fully resumed her professional responsibilities as professor of biology, including climbing tall trees for her canopy research. She attributes her survival and remarkable recovery to both exquisite medical critical care and support she received, and also to incorporating lessons learned from her interdisciplinary study of how diverse natural systems commonly experience and recover from catastrophic disturbances (e.g., forest fires, traffic jams, orphaned children, and refugee survivors of war). Insights from her own encounter with critical illness and study of disturbance and recovery led her to reflect on the tapestry of disturbance and recovery that permeate all ecosystems, and with relevance to the evolving Society of Critical Care Medicine, post-intensive care syndrome, and THRIVE initiatives. (*Crit Care Med* 2017; 45:348–355)

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The tapestry of life's story is woven with the threads of life's ties ever breaking and joining...

—Rabindranath Tagore

The morning of my catastrophic fall, my trio of graduate students and I were excited to gather rare species of mosses that can only survive in the treetops of the temperate rainforest. We had tested and placed our ropes over strong branches and then ascended 50 feet into the tree crown with mountain-climbing equipment and harnesses, as I have done time and again over the 36 years of my canopy research. Without warning, my rope snapped, and I careened free-fall, like a silent sack of sand, to the earth below. Stunned and in shock, I lay shattered on the ground beneath the immobile trunk of the tree, unable to move. In the haze of memory during the hours that I waited for the helicopter, I remember gazing at the immense immobile trunk of that tree, and trying to decide if the shimmering movement of the leaves in the light breeze in the canopy above me was real or an artifact of my fading consciousness.

My next memory is of emerging from coma to consciousness several days later in the ICU, awakening to the cacophony of unfamiliar mechanical sounds that I would soon come to regard as the “new normal”: the buzz and beeps of the ventilator, monitors, smart pumps, and blast of TV that no one watched. I became aware of the presence of my husband, my two children, and my siblings, who had quickly assembled from afar, and whose exhausted faces reflected the fears and uncertainties that I, myself, was feeling inside (Fig. 1). My critical care and surgical team carried out four operations—which they called “damage control surgery”—to repair my many injuries: nine fractured ribs, lacerated lung, splenic rupture, T-3 to T-7 spine burst vertebrae, cracked C-2 vertebra, and multiple pelvic fractures (Fig. 2). My time in the ICU remains a disorienting blur of pain and confusion. I recall and am haunted by visions that seemed as real as life: I watched a soldier in a green uniform take aim with his rifle to



Figure 1. Nalini in the Harborview ICU with husband and son during the first week of treatment.



Figure 2. x-rays of pins in fractured pelvis and spinal fusion of T-3 to T-7.

shoot my son and me. I was convinced that the pills my nurse gave me were deadly poison. Because I was intubated, I could not speak, but was desperate to communicate. I tried unsuccessfully to use the deaf-mute alphabet sign language that I had as a child memorized from an biography of Helen Keller (1). The tapestry of my world had unraveled.

FEELINGS ELICITED BY DISTURBANCE

In my life before the fall, as a Professor of Biology at the University of Utah, I was routinely in control. I acted as the final authority in my classroom, in my laboratory, and on committees. Now, I was totally out of control, fully dependent on machines and strangers for every aspect of my life. Picturesque views of nature from my floor-to-ceiling office window of the Wasatch Mountains had been replaced by stark views from my bed in the ICU: dark curtains, white walls, unfamiliar machines, and a solitary wall clock that seemed to be frozen in eternity. Within a week, my doctors could say that I would not be paralyzed, but full neurologic recovery and mobility were uncertain, and chronic pain was likely. I remember the painful early mobility attempts and endless reminders to breathe into the incentive spirometer. Eventually, I was

supplied with a Miami J collar, a leg boot, and graduated to a walker (Fig. 3). I could sense that I still experienced the poor concentration and spotty memory loss that characterizes survival from critical illness. My university placed me on medical leave for an indeterminate length of time, never expecting me to return to work. Not only had my own life been profoundly disturbed, but also the fear, uncertainty of outcomes, and questions about my identity disrupted the warp and weft of my family and friends. Their fears shifted from my sudden death to transforming their lives and our home into a rehabilitation network that was focused on me. I felt guilty for distracting them from their own busy lives and life trajectories: it seemed as if everyone I cared about had disrupted and reorganized their lives around me.

My medical team was compassionate, but I was only one of their myriad patients. I grappled with fears, doubts, and questions, which coalesced into

three areas: 1) feeling of fears generated by pain and my surreal surroundings; 2) uncertainties of outcomes; and 3) questions about my identity. These areas—fear, uncertainty, and identity (FUI)—materialized in no particular progression, but rather, recurrently wove in and out of my tapestry of recovery.

THREADS OF RECOVERY

An unexpected set of responses to these FUIs came from sources originating outside the realm of medicine, coincidentally from an academic project that I spearheaded a year prior to my fall. It grew from my academic research in forest ecology, which concerns the processes of recovery of forests that are catastrophically disturbed by fire, deforestation, and climate change. I studied the roles that “relict” trees (the “last left standing” trees surviving a forest fire that sweeps through a landscape, and which continue to grow after the burn) play in converted landscapes (2, 3). These roles cannot be predicted based on prevailing ecological theory (4, 5). Thus, I opted to take a novel “Transdisciplinary Approach” (6), drawing upon disturbance and recovery theory and tools from diverse natural and human-created systems that experience disturbance sustain analogous relict structures.

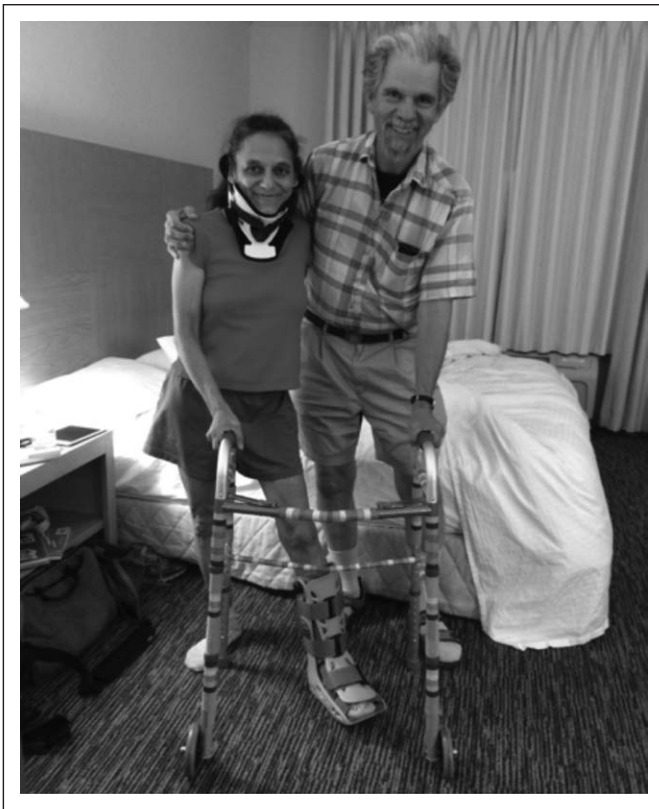


Figure 3. Nalini gaining mobility with walker decorated with the help of a family friend.

For example, a healthy human being and a primary forest ecosystem are both systems with critical internal connections that are vulnerable to catastrophic disturbance, similarly, a crowded interstate highway, a city's downtown, human families in turmoil, professional dance troupes, and populations of refugees from war-torn environments. Catastrophic disturbances often disrupt these systems: a researcher falls out of a tree; a farmer converts forest to pasture; a jackknifed truck interrupts the flow of traffic; a parental separation orphans a small child; the rigors of intense physical training prevents a young dancer's integration into society; and political unrest creates forced human migrations to a foreign and unreceptive culture.

Before my "disturbing" fall, I had recruited two dozen faculty in wildly diverse departments at the University of Utah to participate in a "Transdisciplinary Colloquium." The idea was to exchange ideas from these "analogue" fields by sharing ideas, theory, and tools that we use to understand "relict structures" related to "disturbance and recovery." First, each individual shared the vocabulary and approaches of his or her field, which collectively revealed a tremendous range of tools and attitudes about system dynamics. We then extracted emerging concepts that went grew from common threads (<http://nalininadkarni.com/academic/transdisciplinary-colloquium/>). After my fall, as I recover from critical illness, I find myself weaving insights from the Colloquium into the tapestry of my own habilitation, addressing the FUIs that had threatened my progress.

Below, for each FUI, I: 1) describe its manifestation in my own recovery, 2) introduce insights from one or more of the analogue fields, and 3) extend this to the situation of a patient in critical care (Table 1).

THE "F" OF FUI: FEAR

Loss of Sanity and Reality

The most frightening and disorienting aspect of my recovery was experiencing vivid hallucinations in the ICU. Only after I was placed in a regular ward, I was able to take in what my doctors had informed me that those profound distortions in my perceptions of reality—the rifle-bearing soldier, the nurse with the poison pills—were manifestations of ICU psychosis that commonly appear in the ICU, with its constant lights, sensory deprivation, sedative medications, and sleep disturbances. That such visions are a recognized phenomenon eased the sharp fear I had sustained.

I recalled that in the Colloquium, the traffic engineer had related how the fear of catastrophic car accidents has prompted engineers to develop predictive theories about traffic flow. Although an individual car is a single unit, it functions in traffic as a dynamic flow—like water in rivers. Traffic engineering models and tools are based on the theory of fluid dynamics (7), and the collisions that result from disturbances in traffic flow can be reduced (8). Recalling that a horrific crash can be avoided because traffic managers have documented and understood patterns over the long term helped me understand that—in an analogous way—irrational experiences in the ICU have been documented and could be managed by medical professionals.

Pervasive Judgment That Disturbance Is Negative

As soon as I fell, I was barraged with expressions of horror, pity, and sympathy for being in my critically injured state. As with human recovery, people describe entities that experience disturbances in other fields with the perceptions and the language, nearly all with adverse and deleterious meanings: for example, ravaging forest fires; intractable traffic jams, catastrophic flooding of cities; and tragic uprooting of refugees; however, our Colloquium revealed examples of disturbed systems that provide positive outcomes. For example, some fire-adapted tree species require fire to open their "serotinous" cones, which allow them grow rapidly, using the high-light levels and the flush of nutrients that become available immediately after a fire (9). Refugee children from the South Sudan (especially young women) often obtain educational opportunities when they settle in their new country that did not exist in their home country (10). In addition, modern dance choreographers understand that a new form or approach of movement demands that the previous style must be upended or discarded; it is only in the wake of destruction that creativity can emerge.

These examples helped me to contradict the assumption that disturbance was wholly negative. When I expressed my fears of the dark aspects of my life to a friend, her response was this: "You've been stopped - stopped from your work,

TABLE 1. Fears, Uncertainties, and Identity Questions Addressed With Transdisciplinary Approach

Fears, Uncertainties, and Identity	Manifestation	Other Field	Solution	Relationship to Critical Care Medicine
Feelings of fear	Loss of sanity—ICU hallucinations	Traffic engineering—fluid dynamics helps explain dynamics of disturbance	Knowledge is antidote to fixing traffic jams	Give information to patient, e.g., ICU psychosis exists
	Negative judgment of disturbance	Refugees get education, dancers and other artists gain new aesthetic frontiers by disturbing old regimes	Examples from other fields can shift attitudes to provide promise for positive outcomes	Provide examples from other fields where positive outcomes result from disturbance
	Nature-deficit environment, stark surroundings fosters anxiety, and stress	Ecopsychology provides basis for healthful effects of nature; nature videos in correction venues provide evidence of reduced anxiety in extreme nature-deficit locale	Nature imagery at bedside can be restorative	Build nature imagery into extreme hospital environments, e.g., ICU and windowless rooms
Uncertainty of outcomes	Immobility and slow temporal scale of recovery may prompt overcompensation in physical therapy regime	Refugee populations overcompensate for lack of food through deleterious hoarding	Understand that recovery will be slow, and overdoing prescribed regime can be deleterious	Advise the patient to “be the tortoise, not the hare,” and reinforce negative aspects of overcompensation
	Isolation from family, friends, work, and play	Forest ecology documents that single isolated trees resulting from disturbance can maintain connections with primary forests. Older dancers return to childhood links after the “disturbance” of training	Web of relationships must be reinforced	Advise the patient to participate in blog or electronic communication; connect with resources of THRIVE
Identity questions	Who will carry out my functions?	Psychology and human development draw on attachment theory to document that if a parental bond is broken, others can function in the capacity of maintaining trust for the child	Other members of the patient world have the capacity to take on essential functions during recovery	Provide examples that show that functions can continue
	Who am I after this trauma?	Disturbance often changes our lives and capacities	Need to accept “third state”	Provide positive examples

your hikes, the way you go about your life. You must now live through a period of boredom and patience, and then you will perhaps be ready to experience a time of creativity and spirituality.” For the first time, I was able to see the portal of potentially positive outcomes from my treefall disturbance.

Agitation Comes From Nature-Deficit Surroundings

As an individual who works and plays in wild places, I found the stark surroundings of the hospital interior to be oppressive and agitating. The views from the windows I gazed from hobbling the hallways with my walker and foot boot were of the

urban landscape. Nature was nowhere. My graduate students hung bright, tissue-paper flowers over my bed, which travelled with me each time I changed wards. Without fail, nurses, doctors, and visitors commented on those and the array of flowers that friends had sent.

These responses evoked lessons I had learned in another interdisciplinary endeavor, a program I initiated in 2003 to bring science and nature to the incarcerated. I brought nature imagery videos to men in solitary confinement cellblocks of Supermax prisons, the most isolated and nature-deprived parts of prisons. This research was based on studies in hospital settings, which showed more rapid recovery and reduced stress for patients who viewed trees rather than concrete walls from their windows. Subsequent research in dementia wards showed that aggressive incidents were reduced, and so we tried this in the venue most vulnerable to stress and violence. In my study, after a year of showing nature videos to inmates in solitary confinement, staff and inmates reported lower stress and anxiety, and violent infractions of inmates were reduced by 26% (11). Thinking of men in their tiny concrete cells, and looking at my stark hospital surroundings, I brainstormed how hospital administrators might facilitate painting or projecting images of nature upon walls, floors, and ceiling surfaces, or printed images of pastoral nature scenes on nurses' scrubs and patients' gowns. This seems a rich area for exploration at the interface of ecopsychology, architecture, fashion, and medicine.

THE "U" OF FUI: UNCERTAINTY OF OUTCOMES

Increments of Progress Are Not to be Rushed

In my life before the fall, I was accustomed to the rapid pace of the academic year. But my progress in gaining mobility, restoring my ability to concentrate, or weaning myself from pain medications seemed agonizingly slow, and filled me with uncertainty about my future. The urge to do too much too fast was seductive. But I had learned from the Colloquium that overdoing things are counterproductive. For example, many refugees who have lived in an environment of scarcity hoard food and shoes when they arrive in the United States (12). They fill their homes with canned goods to the point of dysfunction. From that knowledge, I reluctantly accepted the message of my rehabilitation doctor, whose mantra was: be the tortoise, not the hare.

Isolation and the Web of Relationships

Among so many, I have never felt lonelier than in the ICU and hospital. Even though I had the companionship of my family and friends for much of the time, the uncertainty of how I would stay connected with others was disquieting. I often felt akin to the single trees that stand in pastures in the landscapes I studied. How can a tree that has been isolated by the disturbance of deforestation remain as part of the fabric of its former forest surroundings? Will birds be able to fly across the "ocean" of pasture to pollinate flowers and disburse the fruits of the relict tree? These questions corresponded to the

uncertainty about my web of relationships with my professional colleagues, my neighbors, and my friends.

In analogue fields, the importance of the web of connections is clear. Dance training in many cultures—such as Balinese dance of Indonesia and Kathakali dance of India—requires that young people commit exclusively to their training. They must often live apart from their families and friends although they hone the complex knowledge of the moves and supple strength of body, and equanimity needed for the emotional highs and lows of performance. But as adults, when their career is over, usually at an age when there are decades left to live, they must rely upon the web of relationships that they formed when they were children. The "relict friends and relatives" formed decades earlier and sustained through long absences to reconnect and reweave decades later. This pattern reassured me that although I often felt isolated during parts of my recovery, my connections might reweave when the time was right. I observed that both my loved ones and I could take an active part in fostering this web of relationships. One of my friends put out the word that he was creating a "Recovertree," a branch with leaves of cloth with messages that friends sent to assemble as a mobile of connections that could hang over my bed (Fig. 4). He collected dozens of "leaves," and throughout my recovery, it was a reminder that the spirits of even my distant friends were close by.

The weekly blog I wrote for the "CaringBridge" website—an e-site designed for patients and their loved ones to communicate (<https://www.caringbridge.org/>) was invaluable in sustaining the shuttle of information on our tapestry of recovery. Below is an example of the writing I shared with the over 400 participants; we registered over 7,000 exchanges in 4 months.

The calendars of our human lives, like the rings of trees, mark the time through which we move. For me, 2015 will be a year with an exclamation point: the year I fell from a tree. This situation engendered both negative and positive aspects intertwining, the positive not possible without the negative. The obvious negative aspects of the fall were my physical pain and the emotional worry of my family and friends. But there were many positive aspects that revealed themselves slowly and subtly as my recovery progressed. First, I learned that everyone takes a fall of some kind. How human it makes us to listen to



Figure 4. The "Recovertree" mobile, composed of leaves with messages assembled by a family friend.

and to speak about such things. Compassion and empathy now take up a bigger part of my spirit.

Second, I see that many of my activities are more about obligation and expectation than a sincere sense of participation or passion. I thought that during recovery, with all the time I had to reflect on my life that I might come up with scintillating new activities to add into my work and play. What I have found, however, is not that I have added anything new but rather that I have been subtracting things: saying no to committees, turning down invitations to give presentations, and deciding not to jump into new projects. I worried that I might zero myself out of everything and become a total slug. But the pattern that has emerged is that of slowing down and opening space for reflection, for sitting quietly, for observing instead of doing. For being home. For being happy.

Third, and most importantly, I have learned how deeply powerful are the concern and love of family and friends and strangers in bringing about recovery. The words and letters, e-mail messages and books, and walks and calls have helped to turn the negative to positive, despair to hope, fear to bravery, and loneliness to laughter.

From a Herman Hesse essay, "On Trees":

Trees have longer thoughts, long-breathing and restful, just as they have longer lives than ours. When we have learned how to listen to trees, then the brevity and the quickness and the childlike hastiness of our thoughts achieve an incomparable joy. Whoever has learned how to listen to trees no longer wants to be a tree. He wants to be nothing except what he is. That is home. That is happiness.

More recently, Society of Critical Care Medicine's initiative called "THRIVE functions" to foster connections at a macro scale. THRIVE has created support and focus groups that implement face-to-face or virtual contact between critical care survivors after they leave the hospital. This program reinforces the web of relationships with nonfamily and friends, opening up the possibility of new and stronger relationships that share a common bond.

THE "I" OF FUI: IDENTITY QUESTIONS

Need to Shift From Previous Critical Functions

In my life before the fall, I was a stabilizing anchor in my family life, my community, and my work. A tremendous fear was that the many tasks for which I felt responsible would also fall. In the Colloquium, I learned about "Attachment Theory" from my colleague in the field of human development, which states that if the critical parent-child bond is broken early in the life of a child due to the death of disappearance of a parent, the child will have great difficulty in creating and maintaining trustful, loving bonds later in life (13). However, if another adult—such as an uncle or grandfather—steps into that role, then such damage can be averted. As my recovery progressed, I learned that others in my life were willing to step into those functions. My husband carried out the domestic chores I had habitually done; my graduate students were able to shoulder many of the tasks in my research projects that they had previously counted on

me to do. Thus, I learned that there is a plasticity of roles that can alleviate the fear that home life and work life will collapse as we recover.

Who Am I Now?

The unremitting questions that wove throughout my recovery like a weaver's shuttle within a loom were as follows: who will I be, compared with who I was before? What effects will this disturbance have on my family, my work, my place in the world? Although there is a general sense that "recovery" implies a full return to the original state or relationship results from the recovery process can generate states and interactions that differ from both the original and the disturbed state. The Colloquium group termed this a "third reality," ...not better, not worse, just different from the prior state. For example, in urban settings after major damage from a hurricane—such as New Orleans after Katrina, reconstruction resulted in changes in architecture, infrastructure, human community dynamics of neighborhoods, and the city as a whole (14). These changes created new relationships and communities that were different from the original, not better, not worse, just different.

A year after my fall, my doctors document that I have very nearly returned to my previous state. However, my broken fibula never healed, and will remain a "nonunion" fracture. But that has not hindered my ability to move through the wilderness; on the anniversary of my fall, I solo backpacked up and over the Olympic Mountains, walking 38 miles in 2 days. However, I can no longer run more than three miles without pain, and so have placed my running of half marathons into my past. That has prompted me toward a "third state" of exercise. I have taken up swimming and fitness classes, which are both enjoyable and better for my overall health than running on my 6-decade-old legs and spine. My relationships have also shifted into a third state; even though I am capable of scrambling eggs and making coffee, my morning routines now frequently feature breakfast created by my husband, a welcome carryover from my time in early recovery.

AFTERTHOUGHTS

Disturbance is everywhere. Although we tend to view natural and human systems as static, every system is subject to catastrophic disturbance. The exterior manifestation of disturbance such as physical trauma makes these conditions apparent to others. When I wore my Miami J collar, foot boot, and navigated with a walker, friends and strangers could see evidence of my critical illness. Many felt free to comment with surprise, sympathy, empathy, or dread about my condition. In the same breath, they often described their own recent "disturbance": experience with a health issue, divorce, or operation. Although unnerving at first, it led me to understand that nearly every human has had a significant and transformative encounter with disturbance and recovery, but that there is a tendency to reveal this only when there is some externally recognizable evidence of disturbance, which perpetrates the impression that critical illness is rare and unusual.

Recovery is pervasive. The slow and hidden worlds of my recovering body were both mysterious and fascinating. Each time I saw a new set of x-rays of my nine fractured ribs, I traced the progress of the rib nubbins that had coalesced through the space of my thorax to heal. So does recovery happen in other disturbed systems. Relict trees bear fruit from the visits of forest birds. Traffic jams become unsnarled through the understanding of fluid dynamics. Orphans find their way into new families. Older dancers reunite with their childhood friends.

Neighborhoods of post-Katrina New Orleans become revitalized. My fibula remains unhealed, but that leg takes me hiking with my husband into the mountains. These recovered systems may differ from the original entities, but they achieve function by alternative pathways. Even tapestries can have multiple outcomes, created by the incorporation of an unexpected thread.

My last observation draws from those first difficult FUI moments after my fall, when I was laying on the ground in shock awaiting rescue below the maple tree, as silent and immobile as the tree trunk, but noting the tiny swirling movements of individual leaves in response to the breeze. Months later, when I had returned to tree-climbing, I wished to explore this apparent contrast of stillness and movement. I climbed into another maple tree, tied tiny paintbrushes onto the tips of twigs, and held up a canvas to capture the movement of the branches and allow the twig to “paint” a picture in the wind. Over the course of 2 minutes, the twig had created brushstrokes, making an image that was remarkably compelling (Fig. 5). I then scientifically measured all of the line segments created by that twig in 2 minutes, added them up, multiplied them by the number of twigs per branch and the number of branches per tree, and then extrapolated that number to the length of a whole year. The collective distance of all of the twigs on that single maple tree was 186,780 miles in 1 year, equivalent to seven times around the circumference of the Earth. That piece of tree art told me that when I look at an entity in one way—at the massive trunk—I see only immobility. But if I shift my gaze upward to see trees with a different perspective, I can experience the hope that comes with small, incremental movements to create a third state—a new reality—different from the original, which is not better, not worse, but different from the original.

Someone I loved once gave me a box full of darkness. It took me years to understand that this too, was a gift.

—Mary Oliver

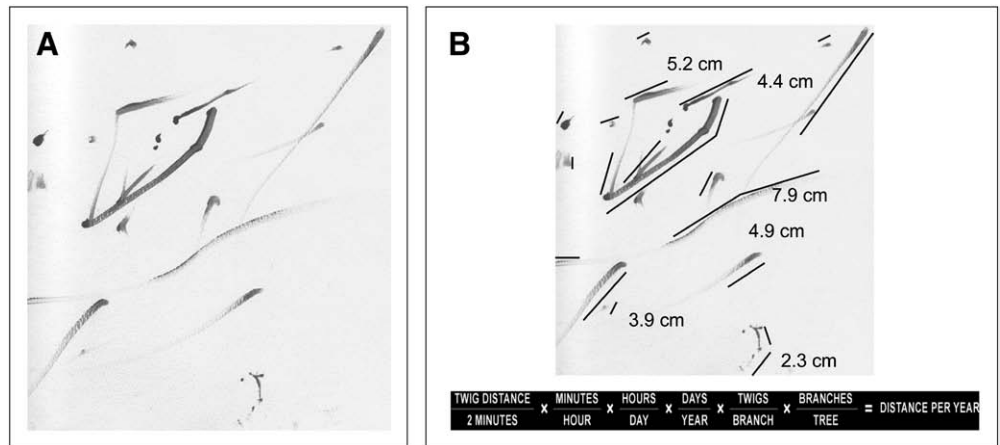


Figure 5. A, “Tree art” created by tying paintbrushes to tips of tree twigs, and holding up canvas to capture the movement of a seemingly immobile system. B, Segments marked and measured to calculate the total distance moved by the entire tree over time.

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