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Thoreau's River Seasons: A Phenological Baseline

Abstract: Thoreau's Journal entries from his decade of regular scientific sojourning (1850-1860) reveal a strong and continuous interest in the seasonal phenology of the Concord River system. Analysis of his descriptions over this ten-year period reveals an annual sequence of ten distinct river seasons of unequal length separated by specific thresholds. This narrative, which begins each year with ice breakup, provides a clearer and more detailed picture of the annual cycle of Thoreau's outdoor, climate-driven experiences than the continuous sine curve of solar radiation; the clock-like regularity of the four astronomical seasons; or the twelve months defined by lunar cycles. The range of dates for each season—beginnings, endings, and durations—provides a robust semi-quantitative baseline for assessing the phenological consequences of climate change since the 1850s.

Keywords: Phenology, Thoreau, climate change, Concord River, seasonality

Introduction

Thoreau country was river country.[1] The three main streams of his life—Assabet, Sudbury, and Concord—radiate west, south, and north from their confluence at Egg Rock, the *axis mundi* of indigenous lifeways, settler colonialism, and Thoreau's world. From that triple point, Thoreau regularly accessed ~33 miles of navigable water within easy reach of his "boat place," which lay across Main Street from his family home.

Thoreau's sojourns were river sojourns.[2] Quantitatively, for the ten consecutive years of near-daily journal entries between 1851 and 1860, he sojourned beyond the edge of Concord village an average of 212 days per year. Of these, 147 or 68.8 percent involved travel on one or more of his three rivers, whether by boat, skates, wading in shallow water, walking over snow-covered ice, or walking riparian trails. These river corridors also provided his main access to upland woods and fields.

Thoreau's year was a river year.[3] Not from January 1 to December 31, but from ice breakup to ice breakup. This was a yearly cycle of continuous change in water: *phase* (liquid, solid, vapor); *abundance* (discharge from precipitation, subsurface storm flow, groundwater); *temperature* (from the mid-30s to the mid-70s Fahrenheit); and *properties* (physical and chemical). These non-biological attributes drove a yearly cycle of riparian *ecology* for plants, animals, and humans *within* the water volume, on its *upper surface*, on its *channel bed and bank,* or on its *floodplain*. Within this spectrum of continuous change, he distinguished a series of phenological river seasons distinct from those of the land by writing sentences like: "A new season has come." [03.17.59][4] Within his seasons, he recognized stages; for example: "These are the stages in the river fall," differentiating them by diagnostic indicators such as the die-back of lily pads, the cooling and clarification of the water, and the effects of first frost on bank foliage. [09.24.54]

Earth's simplest and most regular seasons are astronomical. Technically, winter, spring, summer, and fall are inflection points on the annual sine curve of solar irradiance for every place on our tilted planet. The cold *minimum* of the winter solstice rises through the *mean* value of the spring equinox to the warm *maximum* of summer solstice before falling through the *mean* value of the fall equinox to the next minimum. On land, these four seasons lag astronomy owing to the thermal inertia of absorbed heat, are enhanced by feedbacks such as albedo and evapotranspiration, and exhibit great year-to-year variability owing to prevailing patterns of global circulation linked to the El Niño-Southern Oscillation and other cycles.

River seasons are in general sympathy with, but are more complex than, those of the adjacent land owing to the higher heat capacity of water relative to other terrestrial materials, the lag times of hydrologic fluxes in the Concord River relative to solar-driven inputs of the catchment (precipitation, snowmelt), and contrasts in evaporation between water and land. In short, the river has its own microclimates which lag those of the land, which lag those of solar radiation. Phenological interpretations of climate change based on the behaviors of plants and animals are compromised by the non-linear lag times of these physical complexities.[5]

Astronomically, each of the four solar seasons are further divided by lunar cycles into three months of variable length for a total of twelve months. Though these months come and go like astronomical

clockwork, January of one year may behave phenologically like February the next. Only through multivariable statistics can we characterize what the month of March "should" be like. Thoreau's Kalendar was a qualitative attempt to do just this, to find an average phenological signal beneath the statistical noise of year-to-year variation, and to identify statistical outliers.[6]

My methodology for defining Thoreau's river seasons is also qualitative. No artificial intelligence (AI) algorithms or statistical analysis were employed. Though qualitative, I was very objective in my categorical classification. I carefully examined the full range of Thoreau's phenological descriptions for all 1,466 days he spent sojourning the river in this decade (1850-1860). These ranged from the dangerous and destructive stampede of ice floes in a surging river during the annual freshet to the stagnant, unctuous trickle of late summer drought in a desiccating channel.

Next, I examined this range of Thoreau's described river behaviors for objective, physically-based thresholds that would partition the continuum into groups. The most clearly defined threshold was the irreversible, groundwater-driven breakup of slab ice on the frozen river. This threshold allowed the definition of a river year as the duration between successive break-ups. Within this year, other phenological thresholds allowed for partitioning the year into ten river seasons of unequal durations and times of onset. Finally, within each of these river seasons were trends of rising and falling conditions away from, and toward, the adjacent bracketing thresholds.

Thoreau's ten river seasons crudely follow, but lag behind, the twelve-month Julian calendar but are not defined by it. I do not assign dates for the seasons. Rather, we can only know the probabilities of them occurring at any given time of the calendar year. I consider this qualitative categorical analysis of seasonal phenology to be a first step toward quantification in subsequent studies.

Though I briefly described Thoreau's river seasons in *The Boatman*, I did not name them. And, to save space and to enhance readability, I paraphrased and aggregated Thoreau's descriptions far more than I quoted them, and did not explain the thresholds. This article names those seasons, identifies their thresholds, and, using ~300 Journal entries, shares his eye-witness descriptions. Each description is linked to a numerically formatted date in brackets using a six-digit format for month, day, and year, for example [02.12.54] for December 2, 1854. The

quotes I chose were drawn from lengthier and more detailed passages that greatly exceed those of Thoreau's Kalendar. For Thoreau's sketches of river phenology such as river ice, aquatic vegetation, and flow hydraulics, I refer to his original journal entries and recent compilations.[7] My categorical sequencing of ten seasons independent of the calendar year invites future quantitative studies of date-driven phenological comparisons between Thoreau's past and our present. The range of dates I give below each season heading is for the earliest and latest quotation I included in this article, rather than for the whole data set of 6,958 Journal entries. This date range is not an estimate of when that season will occur or its expected duration. For example, the most clearly defined season, *Break-up*, lasts no more than a few days, but Thoreau notes the phenomenon occurring anytime within the interval January 1 to April 7, a duration longer than three months.

Each river year begins with *Break-up*, the shortest season, a multi-day crescendo of lifting, cracking, splashing, crunching and grinding associated with ice floes being floated downriver by a channel swollen with snowmelt and cold spring rain.[8] Following each break-up was the season of the *Inland Sea* of the annual late-winter or early-spring freshet or flood. Though initially gray and stormy, clearing skies eventually create a chain of deep blue lakes lasting a week or more before draining away.

The next eight of Thoreau's river seasons also came in pairs. An *Aquatic Spring* defined by physical hydrology precedes a *Riparian Spring* defined by ecology. A *Summer* of low, tranquil, warm water precedes a likely annual *Drought* of fetid stagnancy and desiccated meadows. A turn toward fall brings the stronger, clearer, colder flows of an *Aquatic Autumn* before the colorful riot of a *Riparian Autumn* defined by foliage tints and a river clogged by fallen leaves. The turn toward winter brings *Freeze-up*—the incremental growth of crystalline ice to create a rigid ribbon of clear, skateable ice—before the *Winter White* of snow blankets land and stream alike and makes bridges unnecessary.

One complicating factor of my approach is that the second season, *Inland Sea*, can re-appear at any time of year in the aftermath of heavy rains during Nor'easters and tropical storms, usually during the mid-summer to early fall hurricane season. After storms, clearing skies left what Thoreau called an "undulating blue plain" [3.16.59] up to five miles across that was variously bordered by the lush green of summer, the arctic white of winter, and all the russet shades in between. In

contrast, the season *Drought* occurs most years, but not all. This analysis has no quoted descriptions for drought in 1852, 1855, and 1858.

My descriptions for river summer are much longer and more complete than those of other river seasons. I do so to illustrate just how much detail there is available for this and all other river seasons, and to show how change progresses within a single thresholded season. The other seasons could be similarly expanded.

In his funeral eulogy, Ralph Waldo Emerson spoke of Thoreau's effort to understand the river as a "lawful creature" (244).[9] The largest lawful aspect was the predictable progression of river phenological stages (seasons). Comparing Thoreau's seasonal descriptions from the mid-nineteenth century with modern conditions reveals just how much the New England climate has changed.[10] Qualitatively, break-up is less violent owing to thinner ice. Both springs arrive earlier, both falls arrive later, the intervening drought is more intense, and both winters are less icy and snowy. With continued regional warming, the river seasons Winter White and Break-up may disappear completely. These subjective interpretations invite a robust quantitative study beyond the scope of this article.

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In 2017, Donald T. Stevenson read my book, *The Boatman: Henry David Thoreau's River Years* (Harvard UP, 2017) and contacted me, asking if I would like to see some digital photos of the Sudbury River that he had taken from his apartment from the same spot with the same camera.[11] Stevenson sent me a series of seven dated photographs:

1. March 13, 2005–Aquatic Spring (snow)
2. May 4, 2005–Riparian Spring
3. June 11, 2006–Inland Sea (flood)
4. July 2, 2005–Summer (low water)
5. August 3, 2008–Summer (fog)
6. September 24, 2003–Riparian Autumn (early)
7. October 24, 2003–Riparian Autumn (late)

Stevenson offers excellent images of a consistent, elevated, sweeping view across the Sudbury. Though the hills are more forested today than in Thoreau's time, the river probably looks very much the same as it did

in Thoreau's day. This allows us to imagine what Thoreau's river seasons might have looked like during his river sojourning decade of 1851-1860. "August 3, 2008–Fog" is reproduced in black and white below (Figure 1). Readers may find Stevenson's photographs—stunning in color—on the Thoreau Society's website (https://thoreausociety.org/).

Figure 1. "August 3, 2008–Fog" (Courtesy of Donald T. Stevenson)

Ten Seasons

1. Break-up

January 1-April 7

Each year, the Concord River is reborn from below after the quasi-death of late winter. One or more warm days of snowmelt, perhaps with rain, initiates the process. On the white ribbon of the river, the water trickles downward and re-freezes, thereby increasing the mass and momentum of future floes. Elsewhere, water seeps downward through the soil and underlying sediment before reaching the water table and flowing sideways within aquifers to enter river channels from below the ice.

Thoreau recognized that, as the water pressure builds beneath the slab of river ice, it pushes upward on the dead weight. "Apparently–when the river freezes up thus tensely the ice compresses it." [02.12.54]

When the upward strain becomes too great, the ice cracks in the boundary rift zone between land-fast ice on the bank and rising ice in the channel. The over-pressured water "bursts out & overflows" [02.12.54] as a yellow-brown tea of dissolved organics leached from the meadows, marshes, swamps, and soils through which it drained.

Fracturing along the edges produced open leads into which Thoreau boated: "[W]e make our way with some difficulty–through a very narrow channel over the meadow & drawing our boat over the ice on the river . . . . By rocking our boat & using our paddles can make our way through the softened ice 6 inches or more in thickness." [04.07.56]

A reversal to cold can halt the snowmelt and relieve the upward pressure, leaving a "river-channel dark & rough with fragments of old ice–cemented togethe–not strong. polygons of various forms." [01.15.55] Meanwhile, warmer water flowing beneath the ice can melt it from below to produce irregular patterns of thinner, darker blue ice.

During break-up, a brittle sheet as wide as the river and up to two feet thick breaks up into floating slabs called floes: "white cakes of ice gliding swiftly down the stream–a novel sight." [02.27.60] "The tumult is exciting." [03.19.59] Floes travel together like cattle in a stampede that somersault and spin: tipping on edge, swirling in gyres, thrusting one above the other, battering bridge piers, bruising the bark of bankside trees, and colliding with the built environment of piers, docks and boathouses, crushing and tearing them apart.

Thoreau writes: "Examined where the white maple & the apple tree were tipped over by the ice . . . It struck them 7 or 8 feet from the ground–that being the height of the water–rubbed off the barke & then bent flat & broke them. They were about 10 inches in diameter . . . They have a hard time of it–When a cake half a dozen rods in diameter and nearly 2 feet thick is floated & blown against them." [02.28.55]

One afternoon, Henry and his frequent boating companion, Nathaniel Hawthorne, climbed aboard one of these floes in the Assabet and rode it downriver, towing their boat behind for safety's sake. "Great cakes of ice are wedged against the RR bridge there & still threaten its existence. They are about 20 feet in diameter & some 20 inches thick of greenish ice . . . They form a dam between & over which the water falls . . . One great cake as much as a dozen rods long is slowly whirling round just above the bridge." [02.17.55]

During a normal spring freshet, much of the ice action takes place above the channel because natural levees confine the drifting

floes. But if the water overtops the levees, the floes have access to the full width of the meadows up to a mile wide and several miles long. At bridges the floes are especially violent:

> It is very exciting to see where was so lately only ice & snow–dark wavy lakes–dashing in furious torrents . . . to hear only the rush & roar of waters. . . . What a tumult at the Stone Bridge–where cakes of ice a rod in diameter and a foot thick are carried rounded & round by the eddy in circles 8 or 10 rods in diameter, & rarely get a chance to go down stream–while others are seen coming up edgewise from below in the midst of the torrent. [01.22.55]

When the violence subsides, "broad sheets of dark blue water contrasting with the white patches of snow" remain. [01.14.54] When the water drains away, what's left is a "very wild and arctic scene . . . over what is usually dry land are scattered these great cakes of ice." [02.28.55] "[I]ce 8 or 10 feet across left 2 feet high or more above the banks," [02.01.59] some decorated red by cranberries washed up onto the ice. [02.27.60] Each shore is also lined with ice stuck fast to vegetation, a "continuous row–attached to alders maples swamp white oaks, &c." [02.01.59]

Ice is not all that is lifted up and floated away. The meadow surfaces consist of upright emergent vegetation growing above organic soils of low density. Water standing on the meadows can freeze deeply into these soils to create a rigid layer up three feet thick. When this condition is overflowed by water, the basal peat is broken off and floated upward to drift away until it becomes grounded somewhere, often near the channel. When the transporting ice melts, a clump of meadow up to several rods long and wide comes to rest like a stranded ship to produce a local hillock.

2. Inland Sea
January 27-April 22; May 6-May 11; October 27-December 4

In ancient times, the Concord River valley was filled to overflowing with a glacial lake with turbid, icy water averaging tens of feet deep. Its bottom was a thirty-mile-long ribbon of impermeable mud extending from North Billerica to Framingham that widened over what are now the meadows. Slow glacio-isostatic uplift of the bedrock outlet

to the north, combined with a northering wind during storms, retards the drainage and "keeps the water in the river." [04.19.52]

Each strong flood within the valley re-creates the map pattern of this ancient lake. Using Thoreau's terms, what had been a lazy river flanked by meadows became a "chain of lakes," [04.16.52] the largest of which lay over the Sudbury Meadows, which he dubbed a "smaller Lake Huron" in *A Week on the Concord and Merrimack Rivers*. The next largest lake, nearly two miles long and a half-mile wide submerged the Great Meadows of Concord.

"The world is not aware what an extensive navigation is now possible on our over flowed fresh meadows– It is more interesting & fuller of life than the sea-bays & permanent ponds." [04.22.57] "I think our overflowing river–far handsomer & more abounding in soft and beautiful contrasts–than a merely broad river would be– A succession of bays it is–a chain of lakes–an endlessly scolloped shore–rounding wood and field." [04.16.52] A chain that is initially stormy and gray before becoming blue and tranquil.

"There is the magic of lakes that come & go–the lake or bay is not an institution but a phenomenon." [03.16.59] "[T]he flood . . . looks like a *dark blue* liquid like indigo poured in amid the hills–with great bays making up between them . . .This dark blue water is the more interesting because it is not a permanent feature in the landscape." [05.06.54]

Under normal circumstances, "we are stiff & set in our geography–because the level of water is comparatively, or within short periods, unchangeable" But here in Concord, we can look forward to "more subtle & invisible & fluctuating floods–which island this or that part of the earth–whose geography has never been mapped." [03.17.59] "A new feature is being added to the landscape–and that is expanses & reaches of blue water." [03.12.54]

Thoreau describes the creation of one transient lake in April 1852:

> Of eight carriage roads leading into Concord, the water to my knowledge is now over six. . . . This may suggest how low Concord is situated. . . . All this has been occasioned by the repeated storms of snow & rain for a month or 6 weeks past, especially the melting of the deep snow of April 13 and added to this the steady rain from Sunday morning Ap 18 to this moment 8 Pm Ap 21st. The element of water is in the ascendant.

> . . . many new islands are made–of grassy & sometimes rocky knolls & clumps of trees and bushes where there is no dry land. [04.21.52]

"Green hills" rose "like islands" out of the blue lakes, to create "a thousand little vistas," an "intimate mingling of wood and water." [11.06.53] When flooded, the valleys of tributaries entering each lake of the chain become "deep and narrow 'fjords.'" [03.16.59]

During the spring freshet: "All sorts of lumber is afloat–rails–planks & timber &c which the unthrifty neglected to secure–now changes hands . . . . It blows so hard that you walk aslant against the wind." [03.19.59] Fall storms also released debris, a good time to "look out for your rails & other fencing-stuff & loose lumber lest it be floated off." [10.27.57]

These were high times for Henry the navigator, who seized every opportunity to go sailing. With high water and high winds came high excitement, whether during the spring freshet in March-April, or during the late-summer or early fall season of drenching subtropical storms, or winter extra-tropical cyclones called "Nor'easters." High stormy water surprised and delighted him at any time of year. The mood was one of angry dark waves, muddy whitecaps, bubbly streaks of dirty foam, and the rocking of his boat amidst the swells.

"[D]ark-blue & angry waves" contrasted "with the white but melting winter landscape." [03.08.53] Spring water was often muddy water, meaning boats "toss upon a sea of which one half is liquid clay–the other liquid indigo." [03.16.59] "Surging waves . . . rock you . . . and ever & anon break into your boat." [03.28.59] "[G]reat billows toss us–with their foaming yellowish crests." [04.22.57] "[B]lack backed waves–I judged to be at least 20 inches or 2 feet high . . . were crested with a dirty-white foam & were 10 or 12 feet from crest to crest." [05.08.54] Perpendicular to the waves were "long streaks of white foam 6 or 8 feet apart stretching north & south between Concord &Bedford– without end." [05.30.53]

In July, this stormy river mood included the economic devastation of a ruined hay crop. "I see much hay floating & 2 or 3 cocks quite black–carried round & round in a great eddy by the side of the stream–which will ere long be released & continue their voyage down stream." [08.22.56] A surprise October storm brought water-filled boats: "A half-dozen boats at the landing were full, and the waves

beating over them. It was hard work getting at and hauling up and emptying mine. It was a rod and a half from the water's edge," submerged by the rapid rise. "[S]chools of porpoises & of black fish are only more animated waves–& have acquired the gait and game of the sea itself." [10.27.57] In late fall, there was "quite a sea running . . . broad black waves with white crests" with a wave height between trough and crest of "15 inches." [11.9.53] Early winter brought back the ice: "Dark waves are chasing each other across the river from N. W. to SE. & breaking the edge of the snow ice," breaking it up into "what arctic voyagers call 'brash,' carry[ing] forward the undulation." [12.04.56]

Shorelines were highly variable. "My eyes are attracted to the level line where the water meets the hills now in time of flood. converting that place in to a virgin or temporary shore." [05.07.54] "No permanent shore gives you this pleasure." [04.24.52] "There is no strand–nothing worn . . . It does not beat but simply lave the hills." [05.07.54] In places, the shore is "so reddened with cranberries that I perceive them 15 rods off tinging it." [11.20.53] Like a meniscus, the water "kisses" the shore with a tremulous surface, creating a shore that is an "inexpressibly soft curving line" [03.23.59] that is "abrupt & surprising." [03.17.59]

Another pleasant oddity is a glass-bottom-boat view of "fields of potatoes and rye beneath still waters." [03.16.59] In Miles's swamp, they could "paddle right over . . . cow-slips in full bloom–their lustre dimmed they look up with tearful faces." [05.07.54]

When clarified of mud, the waters are "smooth and full of reflections" [04.15.55], and colored "with a far deeper & more exciting blue than the heavens." [04.09.56] Fair Haven Pond becomes "Fair Haven Lake undistinguishable from fallen sky." [06.11.51] In such a mood, the "great phenomenon these days is the sparkling blue water. A richer blue than the sky ever is. The flooded meadows are ripple lakes on a large scale . . . dashing, rippling, sparkling–living this windy–but clear day– Never smooth–but even, varying in its degree of motion & depth of blue as the wind is more or less strong–rising & falling." [03.02.60]

Each high water leaves a line of flotsam of whatever was floating, "an endless meandering light brown line further from or nearer to the river." [11.07.53] The residue of one season is left for another.

3. Aquatic Spring
February 25-May 21

Aquatic Spring commences when the inland sea of the annual freshet has subsided back into the river channel. Sheets of black ice may form at night and persist during cold snaps, melting away during the day. The water surface is clear, cold, vigorous, bright, and sparkling relative to the sluggish, weedy, oily, dusty, and iridescent water of summer yet to come.

The "clear placid silvery water" of the channel flows between banks of brown, gray, and russet that have not yet leafed out. [03.10.59] "These earth colors, methinks, are never so fair as in the spring . . . The earth lies out now like a leopard, drying her lichen & moss spotted skin in the sun–her sleek & variegated hide . . . Brown is the color for me, the color of our coats and our daily lives." [03.28.59] "Fishes now lie up abundantly in shallow water–in the sun–pickerel–& I see several *bream*. What was lately motionless & lifeless ice–is a transparent liquid in which the stately pickerel moves along. . . . the still brown river-bottom–where scarcely a weed has started. Water is yet only melted ice–or like that of November, which is ready to become ice." [04.07.60]

During Aquatic Spring, the river surface falls slowly through a vertical span of about 10 feet, though it can rise or stabilize during rains, a pattern very different from the stable level of steady aquifer drainage of late summer. On May 1, 1855, Thoreau reported: "The river is almost down to summer level . . . It has fallen about 8 feet since Feb. 17." Falling water left a brown-gray residue of "spray-like foam" where the waves dashed, and "a line of rubbish," wherever transiently rising water reversed direction. Such lines of flotsam "which in summer reminds me that the water has once stood over where I walk." [02.12.51] Falling water also leaves fresh, fine-textured mud to preserve the tracks of mink, birds, and squirrels which, given enough time, will "make tracks for the geologists." [04.29.59]

Thoreau's Aquatic Spring was a time of high winds driven by regional air masses. "This makes 22 days of windy weather in all reckoning only from the last still days." [04.10.59] The easterly or southerly winds came with rain, northerly and westerly with clearing, cold, and dryness. He watched "a remarkable whirlwind on a small scale–which carried up the oak leaves from that Island copse . . . no doubt 5 or 600 feet high at least." [05.01.59] On March 2, 1860 he watched "strong puffs . . . spread & diffuse itself in dark fan-shaped figures over the

surface of the water . . . as if so many invisible spirits were playing tag there."

This was a time of great contrasts, especially in heat. March 29, 1853 was "one of those days divided against itself when there is a cool wind but a warm sun." Given the strong thermal contrasts, "The wind has regularly gone down with the sun, & risen again with it. It has been so strong as to interfere with all outdoor occupations." [04.10.59] Some days are quite hot. And others, as late as May 21 in 1855 were cold enough to "Sit by fires–& *sometimes* wear a great coat and expect frosts."

This was a time of the "drying up the superabundant moisture" of mud season, when the water, trapped above the "hard pan" of frozen ground makes "a batter of the surface soil." [03.31.59] The persistence of cold, breezy, generally northerly and westerly air, is warmed by the strengthening sun, lowering its relative humidity to create a desiccating wind. The fire danger rises. "Air filled with dust blowing over the fields," making the ice gritty, though it remains "[p]retty good skating." [02.25.55]

4. Riparian Spring
February 27-May 25

At some point, these physical phenomena give way to the resurgence of organic life. This threshold is defined by the sudden greening of the riparian landscape, initially on south and west-facing banks. The river must warm before its submerged plants green up, so these seasons are definitely discrete. Though the bracketing dates for my chosen quotations for Riparian Spring only slightly postdate those for Aquatic Spring, this is due to my stretching the range of both for good description. But it is also due to the extreme variation in timing. In both cases, the quotations span nearly four months, giving plenty of time for two successive seasons.

Setting aside the phenology, the change from aquatic to riparian spring correlates with an annual shift in Thoreau's Journal. It swerves from his philosophical winter phase to the strong and steady rush of botanical and zoological inventories and phenologies.

Thoreau was overjoyed by the chorus of spring peepers announcing the arrival of Riparian Spring. "This is the R. halecina day–awakening of the meadow." [04.07.60] This annual orgy of spring peepers "is a singularly emphatic & ear-piercing proclamation of animal life, when with a very few & slight exceptions vegetation is yet dormant."

[03.31.57] "[T]hey express as it were, the very feelings of the earth or nature–They are perfect thermometers–hygrometers–& barometers." [05.06.58]

Aquatic plants begin their show. Those of the cress family are among the earliest arrivals, often appearing even before the ice is gone. [03.02.59] By mid-March, a "radical greenness" in the water begins "to correspond with that on the land." [03.19.55] "A myriad of polygonums, potamogetons, & pontederias are pushing up from the bottom but have not yet reached the surface." [05.14.53] Eventually, "yel. lily pads" reach the surface [05.07.53], followed by the white lily.

On the banks, "shade is being born . . . concealment will soon be afforded to the birds in which to build their nests." [05.12.53] Along with the shade comes a dusting of pollen on the water and a coating of airborne seeds, particularly "the down of the black willow," which whitens the river like snow that doesn't melt. [6.29.57]

Beyond the bank, the meadows follow their own sequence. Initially, a "strong–fresh marsh scent wafted from the meadows–much like the salt-marshes." [05.01.55] Then rapid plant growth produced "the greenest & rankest grass" [05.09.53] always being next to the river, beginning with the horsetails, which he called "pipes." [07.18.53] When the early grass of the broad meadows takes off with growth they "remind me of flame–as if it were a kind off green flame–allied to fire, as it is the product of the sun." [04.15.52]

Each year Thoreau catalogued the arrivals of animal life on the bank: the skunk cabbage blooming, tortoises moving about, alder catkins unfolding, white maple blossoming, and the earliest birds peeping. [03.03.51] "Hundreds of tortoises painted & wood, are heard hurrying through the dry leaves on the bank & seen tumbling into the water as my boat approaches." [05.07.53] Salamanders, which he called "lizards," could be seen swimming quickly beneath the clear water [03.11.54] with "tortoises on the bottom–a sternothaerus among them." [05.04.56] "It is evident that the date of the 1st general revival of the turtles . . . depends on the state of the river–whether it is high or low in the spring." [04.01.58]

A muskrat appears, "eating a clam . . . Even and anon he drops into the liquid mirror & soon reappears with another clam." [3.10.59] Honeybees are drawn to the smell of skunk cabbages [04.06.53] before seeking the sweet fragrance of bass trees. Crickets become background noise. [05.12.55]

The riverbanks were the richest places for bird life, the "general quire of spring." [03.12.54] On April 5, 1855, he noted that "Inland the groves are almost completely silent as yet." Birdsong, he noted "was the handle by which my thoughts took firmly hold on spring." [03.05.59] The "peep of a robin . . . so often heard in cheerless or else rainy weather So often heard first–borne on the cutting March wind–or through sleet or rain–as if its coming were premature." [02.27.57] Bluebirds and larks. [03.13.53] Blackbirds. [03.29.53] Song sparrows, blackbirds, robins, bluebirds, woodpeckers, and chickadees create quite a concert. [03.22.55] All their "warbling especially in the still sunny hour after sunrise–as rivers tinkle." [03.12.54] With them come the "marsh hawk[s]," an aerial case of predator migrating with their prey. [03.27.54]

Fish migration is part of Riparian Spring, when "the water running down meets the fishes running up." [03.20.58] It becomes "full of fishes, suckers–pouts–eels–trouts endeavoring to get up" streams of all sizes. [05.07.55] Taking advantage of high water, gravid fish and fish fry "are dispensing themselves through the fields and woods, imparting new life into them. They are taking their places under the shelving banks–& in the dark swamps." [03.20.58] Each spring, the eels build their stone heaps, the nests in which their young are protected from predators. [05.07.53] Each year, the sunfish, or bream, build their nests on the sandy bottoms and stand guard above them.

The dead sucker, often a mutilated one, is one of the surest signs of riparian spring: "I can remember now some 30 years, after a fashion–of life in Concord–and every spring–there are many dead suckers floating belly upward on the meadows." [03.26.57] This annual migration draws gulls up from the shore, and fishermen with spears coming out from their homes.

Flock after flock of Canadian geese and different species of ducks pass through, resting and feeding on wet meadows *en route* northward. Other birds use the river corridor as well, if only because it parallels the coast. On March 2, 1860, Thoreau saw "30 or more crows come flying in the usual irregular zigzag manner. in the strong wind . . . going N. E. The first migration of them–without cawing."

5. Summer
April 13-August 15

River summer announces itself with the last of the spring migrations, the flanking of the channel by emergent aquatic vegetation, the

crowding of the channel by lily pads, and water warmth. This is usually a long and stable season of groundwater flow into a channel that is pulsed by the rise and fall of rainstorm runoff.

The beginning of river summer had many markers. "Summer has suddenly come upon us," [05.08.57] Thoreau announced when final flock of migrating birds passed through. And, "does not the summer regime of the river begin . . . when the black willow is handsome–& the beds of front-rank polygonum are formed above water?" [07.02.60] And, "[N]ow that season begins when you see the see the river to be so regurarly divided longitudinally into [lily] pads, smooth-water, & sparkling ripples between–in a clear day." [06.30.60] And, when "the water begins to feel as warm or warmer than the air when cool." [05.05.56] Away from the water, summer is announced by "a tender green on the meadows & just leafing trees." [05.14.58]

After the onrush of spring, animals take a backseat to flowering plants in phenology. By May 1, 1858, Henry had noticed that the sound of the spring peepers was absent, asking "what has become of the thousands with which the meadows swarmed a month ago?" [05.01.58] Now they were replaced by a chorus of toads so loud that "some have to shut the windows" in order to sleep. [05.29.53] By mid-June, even the toads were drowned out by water that "resounds with the trump of the bull frog." "As we have 'frog ponds'" why should we not have Bullfrog Rivers, given that Musketaquid is but "one long frog pond." Alternatively, why not "*lily* river?" [06.18.53]

On June 2, 1854: "When we returned to our boat at 7 Pm–I noticed first to my surprise, that the river was all alive with leaping fish…Looking up I found that the whole atmosphere over the rive was full of shad flies. It was a *Great flight of Ephemerae* . . . It was like a dense snow storm, and all (with very few exceptions) flying . . . up the stream." [06.02.54] And "many of them coupled–even tripled & the fishes snap leap as before." [06.09.56] On June 5, 1857 they emerged in such numbers as to blacken "every cobweb," and "[a]ll freshly painted surfaces are covered with them."

This was the season when "the mosquitoes encircle my head–& torment me." [06.09.54] Thankfully, the bats and birds depend on them for food. A flock of bank swallows consisting of "over 100 birds" flew out of a bank on some river bend: "They continually circling about over the meadow & river in front–often in pairs one pursuing the other & filling the air with their twittering." [05.23.54]

Abundant "small dragon flies of different colors," were creatures of summer, "bright blue & lighter looped along the floating valisneria [eel grass], make a very lively & gay appearance." [08.03.56] Also, "the meadows full of lightning bugs to-night–first seeen the 14th." [06.16.60] By midsummer, he heard the "creak of crickets," "that fine serene undertone or earthsong . . . imparting its own serenity. . . . These rills that ripple from every hillside become at length a universal sea of sound, nourishing our ears when we are most unconscious." [06.04.57] By late summer, the "fine Zing of locusts" became "inspiriting."

As the sand hills warm up, the tortoises were out on every sandbank, leaving their trackways "2 parallel dotted lines 4 or 5 inches apart" [06.14.53] *en route* to depositing their eggs, which will soon be "robbed & the eggs devoured" by skunks [06.16.53]. Floating by like a submarine with its periscope up might be a "great snap turtle . . . reconnoitering us" in the boat. [07.11.56] Flying by might be a "green bittern . . . with heavy flapping flight its legs dangling . . . deep slate blue above–yellow legs–whitish streak along throat & breast, & slowly plows the air with its prominent breast bone, like the stake driver." [07.30.56]

Hatched young were everywhere. In the water, he watched "2 old pouts tending their countless young close to the shore . . . there must be a thousand of them at least–is incessantly moving, pushing forward & stretching out." [06.21.54] And "now is the time for young birds," on the riverbank. "You cannot go near any thicket but the old will scold at you." [06.22.53] In one encounter, a second "screech owl" "repeats the same warning sound" as the first. [07.10.56] Bitterns feasted on the rich meadows. [08.31.55] When boating, "young pickerel two or three inches long "flee before me" in shallow and weedy places."

By early summer, the water was sun-warmed to a temperature at or above what he called "bracing." [08.06.52] This invited boys everywhere to enter the waters for what they called bathing. Cattle followed the same schedule, beginning to stand in the water in late May. [05.24.60] Henry usually waited to swim until he'd seen that "some boys have bathed in the river." [05.08.57, 05.13.55]

"Thus we are baptised into nature." [05.25.57] Henry was one of the few adults who never abandoned the childhood joy of full-body immersion into the living waters, whether by wading in from the shore, or jumping off a bridge into the deep scour pool. Then, after bathing, to lie down on clean sands and bask, *au naturel* (we can assume) like a tortoise "under the oak. at Tarbell's first shore." [07.11.56]

By July, regular "bathing is an undescribed luxury." [07.09.52] "What a luxury to bathe now. It is gloriously hot. . . When you come out it is rapidly dried on you or absorbed into your body . . . I begin to inhabit the planet, and see how I may be naturalized at last." [07.03.54] On the river sand bars, the clams are thick: "I brought my feet together & lifted up between them . . . 3 clams." [07.03.54]

Never was the river more inviting for bathing than when the terrestrial realm was over-baked. "Furnace-like" [07.07.52] or "melting weather," with "[s]ultry mosquitoe nights." [08.15.53] "Thermometer 97 & 8 today." [07.26.56] The "hottest night" of the year. [07.22.54]

For a few years at least, Henry figured out a way to sojourn and swim simultaneously, taking what he called a "fluvial water walk." [07.10.52] Walking along, "now in water a foot or two deep now suddenly descending through valleys up to my neck–but all alike agreeable," [07.10.52] keeping company with the shiners and the curious bream. He stripped off all his clothes except for his shirt and hat, and then walked the center of the Assabet channel, feeling with his toes: "your feet expand on a smooth sandy bottom–now contract timidly on pebbles–now slump in genial fatty mud amid the pads," [07.12.52] "The luxury of walking in the river" [07.27.52] integrated the three sojourning activities of walking, fording, and swimming. [08.09.53]

The summer river was one of moderately low, smooth, stable, and quiet water "confined to the river for the most part." [05.05.56] Boating was often best done with a pole, rather than a paddle or by sail. In mornings and evenings "there is a sparkle on the river . . . as in fall & Spring." [07.01.54] But during mid-day and mid-night the air above the river is quiet because the locally generated air currents are quelled as the thermal contrast between water and air is reduced. With such stillness, sailing becomes impossible, for example: "my sail so idle that I count 10 devils needles resting along it at once." [06.13.54] For "a month or so we have had no *tumultuous* water–waves running with white caps." [06.16.54] Sometimes the slow downstream current of the stream and the gentle upstream breeze were "evenly matched," [05.17.54] keeping his boat at a standstill. Beyond the bank, "the air over the river meadows is saturated with sweetness." [06.06.54]

Late in the day, the wind can pick up. "Whole schools of fishes leap out of water at once with a loud plashing even many rods distant–scared by my sail." [05.28.54]

Midsummer is announced from the bottom up by the proliferation of aquatic plants: a "new era in the vegetation of the river–the commencement of its summer stage," being signaled when the potamogetons "have just reached the surface of the river & begun to spread out there." [05.28.60] "Then R. Purshii . . . ceratophyllum . . . perhaps the B. Beckii . . . then the Utric– vulgaris. . . & lesser Utricularias in many places." [07.18.56]

Looking shoreward from open water, are row after row of plants, each adapted to its proper zone. River life is but a series of parallel green lines. [07.07.52]

"Again I scent the white water-lily & a season I had waited for is arrived. How indispensable all these experiences to make up the summer." [06.16.54] "Now is the solstice in still waters. How pure its white petals–though its root is in the mud." [06.26.52] "The river at such an hour . . . perfectly smooth and lighter than the sky, reflecting the clouds, is a paradisaical scene" [06.22.53] The river becomes "[a] tender place in Nature–an exposed vein." [07.04.52] "The river–& shores with their pads & weeds are now in their midsummer–& hot-weather condition . . . The seething river is confined within two burnished borders of pads–gleaming in the sun for a mile." [07.03.54]

As summer aquatic growth continues, "[i]n shallow places the river is for long distances filled quite bridged over with the leaves of the potamogeton natans–the direction of whose stems at least may show which way the sluggish water is inclined." [07.01.52] "The weeds are now so thick in the river. Potamogetons–heart-leaf–R. Purshii–eel-grass &c &c as almost to conceal the stream & seriously to obstruct the passage of my boat." [07.04.53] Even when "the river was high we pushed through many beds of potamogeton–long leafy masses, slanting downward & waving steadily in the stream– 10 feet or more in length by a foot wide." [08.05.58] "They catch my oars & retard the boat." [07.12.54] "These cover the stream so densely in some places that a web-footed bird can almost walk across on them." [08.06.58] "The potomogetons are so thick some places in the main stream that a frog might hop quite across the river on them without getting in over his head." [08.08.59] "The water weeps or is strained through" the weeds. [08.05.54] "This might be called the potamogeton river" [07.01.52] "where you caught a crab at every stroke of the oar–& farmers drove their hay-carts across." [08.12.56] One so weedy that "I am now on foot." [06.20.53] Even the bottom can be paved with fleshy green: "I

believe it is the radical [basal] leaves of the heart-leaf" covering "the bottom of the river where 5 or 6 feet deep as with green paving stones." [07.13.53]

Summer is a time of early morning fogs, the "summers vapor bath. . . a great crescent over the course of the river from SW to NE." [07.22.51] Rowing in the fog could be like a dream, with "the dark dim out lines of the trees on the banks appear . . . & are soon concealed." [06.02.53] And of dog days and blue haze. "This is a perfect dog day," he wrote on July 30, 1856. "The atmosphere thick–mildewy–cloudy." Alternatively, he described the air as "sultry i.e. hot & cloudy–the air full of mist & here & there misty clouds–& you find yourself perspiring much before you are aware of it." [08.05.53] During sunrises and sunsets, the "sun's disk is seen round & red for a long distance above the horizon through the thick but cloudless atmosphere–threatening heat–hot, dry weather." [07.26.56] Looking westward, "I see sleeping & gleaming through the stagnant misty *glaucous* dog day air . . . the smooth silvery surface of Fair Haven Pond." [07.31.56] The soils seem parched, even as the air seems close to dripping wet. "Moisture reigns." [08.01.56] "It is sticky weather," [08.17.58] with a "blue haze. . . seen still with the earliest light" [08.25.54] except when cleared by a thunderstorm. [07.01.54]

A time of great thunderstorms. "I hear the low rumbling of the first thunder & now the summer is baptized & inaugurated in due form. Is not the 1st lightning the forerunner or warranty of Summer heat." [04.13.58] It can "rain with great violence . . . great drops patter on the river, each making a great bubble." [06.14.55]

Near the end of summer, stagnant water commonly "appears covered with an almost imperceptible blue film," [06.16.52] a smooth, almost "unctuous surface," [06.03.54] a "bluish scum . . . somewhat stagnant-looking," and "smooth & full of reflections here & there–as if there had been oil in those rains–which smoothed it." [07.17.54; also 07.20.54] "Methinks that about *this* time the waters begin to be more glassy dark & smooth." [07.17.54] By August the water surface can be a "purplish scum," or a "brown scum–somewhat gossamer like as it lies & browner still on your finger when you take it up." "What is it?" he asks. "The pollen of some plant?" [08.02.60] He likely knew what it really was: a thin oxidation precipitate on ultra-stagnant surface water.

In such water, bubbles persist on the surface. "[S]ometimes I can trace a boat that has passed half an hour before by the bubbles on

its surface, which have not burst." [08.03.56] These persistent bubbles signal the release of oils and surfactants as vegetation rots in the heat. [06.03.54] Thoreau said such water had "viscidity." [06.07.57]

Some days, the water was covered with "a kind of lint looking like dust at a little distance" and which "undulat[es] . . . with out breaking" [06.04.54], perhaps from "the young leaves & bud scales." [06.06.55] The stagnant looking surface "has the appearance of having been dusted over" [06.04.57] by what he sometimes identified as the "down of the black willow." [06.29.57] Mingled with the dust was "a minute plant abundantly spring from its midst & greening it . . . like grass growing in cotton in a tumbler." [06.29.57]

6. Drought
June 21-October 15

Drought arrives when *inputs* to the channel from groundwater drainage and precipitation fall far short of the *outputs* via drainage evaporation and evapotranspiration. The muddy flanks of a diminishing channel increase their exposure, making the air fetid with the smell of muck.

Henry spelled it *drougth*, noting dust, withered grass, drooping leaves, parched springs, and desiccated crops. Factories were shut down for lack of power. The deeper reaches of the Musketaquid never went dry because it is cupped in a bedrock basin. Instead, the river surface fell asymptotically to the base of its bedrock outlet at the Fordway, which today is near the Pollard Street Bridge in North Billerica. Flow might diminish to a trickle, but it never stopped.

"It is remarkably dry weather." Henry wrote on September 21, 1851. [09.21.51] "The neighbor's wells are failing– The watering places for cattle in pastures though they have been freshly scooped out are dry– People have to go far for water to drink–& then drink it warm. The river is so low that rocks which are rarely seen show their black heads heads in mid channel." [09.21.51]

Higher in the watershed, "silent are the watercourses," where "tinkling is normally heard." [08.31.54] Brooks flowing one day might be dry the next, as local water tables continued to fall. Even the outlets of ponds went dry, most notably at Flint's Pond, which trickles all year for all but the rarest years. [08.31.54] "Millers have not water enough to grind their grists." [10.15.57; 08.14.59]

The parching hot days are often windless. Sailing was pointless, even on wide reaches. Elsewhere, on shallow reaches, rowing became nearly impossible because channels narrowed, and the water shallowed. Pushing a boat with a pole became necessary around rocks, "snags and water-logged trunks," previously unseen. [10.11.57] Sometimes, even in the main stem of the river, Thoreau had no choice but to get out and pull his boat, whether over a mass of weeds or sharp-edged clams.

Dry meadows meant easy walking for humans but death for animals. Thoreau could "walk where in ordinary times I cannot go." [08.22.54] He noted that "we can walk across the Great Meadows now in any direction– They are quite dry . . . Even the pitcher plant leaves are empty." [08.18.54] Along the way, he noticed the thousands of small pools being dried up in places where patches of meadow had been lifted up by the ice and floated away. In such pools, the frogs could burrow downward, and the insects could estivate. But the fish had nowhere to go. "In one little muddy basin where there was hardly a quart of water caught half a dozen little breams and pickerel only an inch long . . . Hundreds if not thousands of fishes have here perished on account of the drought." [08.22.54]

Such creatures became easy pickings for the carnivorous waterfowl such as the herons, bitterns and stakedrivers who could stand in one place and eat their fill of wriggling fish. Gulls flew up from the ocean. Crows came down from the woods. "Saw a blue heron . . . Here was a rare chance for the herons to transfix the imprisoned fish. It is a wonder that any have escaped." [08.22.54] Dead fish begin to rot, adding the smell of aquatic carrion to that of the sulfurous, rotten-egg small of hydrogen sulfide being released from anaerobic bacterial decomposition. Sediment at the bottoms of countless small pools desiccated, becoming "cracked into a sort of regular crystals." [08.28.54] When liberated, light brown dust spreads widely throughout the valley.

Bream nests, normally on the river bottom, are left "high & dry." [07.29.59] The snails that crawled into pools were dying inside. "[T]he muddy shores are covered here & there with a sort of darkbrown paper–the dried filaments of confervae [filamentous green algae] which filled the water." [06.21.53] Any aquatic animal life that remained migrated inward and downward to deeper water, most notably the clams. [05.02.60]

With continuing drought, the entire surface of the meadows—not just the pools—became firm and hard enough for a "regimental

muster," [09.08.59] provided the grass was scythed low. With all that trampling, it was "fuller of dust & more uninhabitable than I ever knew it to be before," and the lily "pads in the river for half a mile from the village are white with it." [09.08.59]

In the culmination of drought, meadows would break up in vast polygons of vertical fissures, resembling in pattern those on the alkaline dry lakes of the hyper-arid west, caused by horizontal shrinkage. At greater depth the fissures would reach the ancient lakebed above which the marshes were perched, curling up layers of clay.

Smoke was added to that dust, when farmers burned their meadows, which they did to "burn out the moss" or the shrubs, hoping that grass would come back in its place. [09.19.51] Once started, these fires would often burn out of control, turning the peat to ash, lowering the surface, and thereby increasing later wetness: "Saw a meadow said to be still on fire after 3 weeks–fire had burned holes 1½ deep–was burning along slowly at a considerable depth." [08.31.54]

Below the meadows, the water kept falling in the main channel. Miles of lily pads bordering both sides of the rivers slowly fell to the bottom of bars and banks where they rotted in place. Theirs was a "fall" not of leaves, but of whole plants. Mud on the exposed bars would then crinkle and crack into miniature polygons like their counterparts in the meadow pools. Filamentous green algae growing on the banks became pasted against them: "muddy shores are covered here & there with a sort of dark brown paper–the dried filaments of confervae which filled the water. Now is their fall." [06.21.53]

7. Aquatic Autumn
July 28-September 26

As the summer season wanes, the air cools, evapotranspiration slows, fall rains commence, and more water finds its way into brooks and streams. After a month or more of declining stage, the flow begins to rise and water begins to clarify, even if there's little change on land.

"The season has now arrived when I begin to see further into the water–see the bottom–the weeds–& fishes–more than before [08.28.59. . . familiar bream with the dusty light reflected from its fins––the vigorous-looking perch– (tiger like among fishes) . . . motionless pickerel–with reticulated back & sides . . . The weeds are as indispensable to the fishes–as woods & shrubbery to us." [08.08.59]

"The water is suddenly clear, as if clarified by the white of an egg or lime. . . . All the secrets of the river bottom are revealed. I look down into sunny depths which before were dark." [07.30.56] The water became "so clear & sunny" that it was "better than any aquarium." [08.08.59] On October 6, 1851 he wrote: "I never saw any water look celestial," a superlative that included Walden Pond. Wondering why, he asked: "Has this clarity anything to do with the greater sluggishness of the water when low? Perhaps you can see furthest into the most sluggish water" [07.28.59] because transparency depends on "the particles are in rapid motion." [07.30.59] Alternately, the clarity of the water was due to its nutrients being sopped up by the demands of summer plants, thereby stunting algal growth.

"Mill-wheels that have rested for want of water begin to revolve again." [08.26.59] The surface of the water is changed as well, becoming less unctuous. Bubbles do not "readily form on the water–& soon burst forth on account of the late rains which have changed its quality. There is prob. less stagnation & scum– It is less adhesive." [09.04.54]

The wind regime changes. With cooler surface water and warmer banks, the wind now rises "in the middle of the day–blowing hardest at noon–quite hard–but went down toward night." [08.16.54]

At the surface, "1st the 2 vars of yel– lily-pads beg. to decay & blacken." [09.24.54] "2nd the first fall rains come after dog days & raise & cool the river & winds wash the decaying" weeds "to the shores & clear the channel more or less." [09.24.54; 09.05.54] By mid-September, "the weeds in mid stream" have generally disappeared, washed away or drowned. [09.14.54]

By later September, there is a chill in the air, especially above the water, especially during mid-day, and "the river is getting to be too cold for bathing." [09.25.52] Sensing this, the clams are "now moving into deep water" leaving furrows to show their direction. [09.27.55] The water temperature drops, even when there is no rain, perhaps because there is proportionately more flow from deeper groundwater. [08.14.54]

8. Riparian Autumn
September 27-November 1

Thoreau's Riparian Autumn is defined by a parade of change in autumnal pigmentation, from green to the gray-brown and russet colors of marcescent oaks and shrubs. On the bank, a spectrum of color is

reflected by the silvery mirror of the clear, cold water. The fluttering fall of leaves blankets the surface. Usually, they float downstream as did fragments of ice during breakup, gathering into concentrations, forming temporary dams, sinking to the bed, and dispersing to the distant sea. Cruising the river on successive days was like watching a slow-motion kaleidoscope of color.

"Methinks the reflections are never purer & more distinct– than now at the season of the fall of the leaf." [10.17.58] "The squirrels & musquash make haste to shelter & conceal themselves by constructing nests and cabins." [10.18.58]

The red maples, "touched by the earliest frosts, are memorable features in the scenery of the stream" [after 09.19.50] This species is the first to raise its "scarlet flag" above the water [09.27.57]. A "single tree becomes the crowning beauty of some meadowy vale." [09.25.57]

The willows blazed yellow over Thoreau's boat place; he had to empty his boat of their leaves before paddling away. Combining the yellows of willow and the reds of maples painted the banks the variable color of flames. Meanwhile, the buttonbush went from green to dull brown to naked twigs.

Under dry conditions, "countless leafy skiffs are floating on pools & lakes & rivers and in the swamps and meadows often concealing the water." [10.17.56] Some leaves are "driven out to sea," but "most are drifted toward the shore which is converted into one long crowded haven where the water is concealed." [10.17.56] This action created the fifth pair of flanking corridors for the year: the tea-colored slush of late winter, white landfast ice after breakup, green lily pads in summer, the mosaic of leaves in the fall, and the edge ice of freeze-up to come.

Leaves fallen on the river go with the flow. Some spiral along on the surface. Others are blocked by upstream winds, forming "a broad & dense crescent quite across the river." [10.21.58] Where waxy oak leaves float away, "acorns . . . strew the ground & the bottom of the river thickly." [10.28.58] Those leaves that "were floating before" a rain "have sunk to the bottom being wetted above as well as below." [10.16.57] On November 5, 1858, Thoreau reported that a "great fleet of leaves" from the "21st of October is now sunk to the bottom . . . paving it thickly."

The larger overhanging trees of the riparian woodland—white maples, walnuts, oaks, and other bankside species—dropped their waxy,

curled leaves on the water where they became "rude boats" [11.01.52] that floated and sailed about by the billions.

Riparian Autumn ends when the color fades and all the fallen leaves have been transported to their final destinations.

9. Freeze-up
November 11-January 4

Freeze-up was Thoreau's second shift in focus from biology to physicality. Beginning with the first crystals, the channel is gradually covered in ice to its culmination: a slab of ice up to two feet thick covering the river everywhere except for constrictions where the streamflow is too rapid, or springs where the groundwater discharge is too warm.

The mood is one of anticipation, of "waiting for ice." [11.11.58] Waiting for that first freeze, which always took place on the stillest water, and always to Henry's surprise. A mood of clean cold beauty to offset memories of dog days and the suffocating, panting heat of summer. "The waters look cold and empty of fish and most other inhabitants." [11.11.58]

Freeze-up strikes along the edge of the bank. Thin sheets of clear, a.k.a. black, ice grow inward toward the channel center. A "remarkably coarse crystallization." [12.09.56] In one place he finds "crystals of ice 6 feet long like very narrow & sharp spears." [11.01.53] In another, a "surface being starred with great raised rays as thick as you thumb and several feet long, as it were the beginning of a bony system." [12.09.56] Crystals "oftenest that of low flattish–3 sided pyramids," within which were "small & perfect pyramids–the largest with bases = to 2 or 3 inches." [12.10.53]

These were "shooting crystals," because they shoot inwards from the edges toward the centers, so thin that they can be seen only under certain light conditions. Once solid, they give "the appearance of broad fern leaves or ostrich-plumes or flat fir trees with branches bent down." [12.10.53] Rosettes. Sometimes the crystals formed tesselated mosaics like that of a tile floor. When skating with the sun low, Henry saw them "reflected from the surface of the ice flakes of rain bow somewhat like cob webs." [02.12.54]

"Virgin ice." "Transparent" [12.13.57] "Black ice." [12.13.59] A superficial "glaze." [01.01.53] When laden with suspended sediment,

the color of ice changed to translucent gray-brown. When bubbly, it is white. When frozen from saturated snow, it is gray.

Sometimes a watery slush of crystals floated downstream, "looking like dark ripples in the twilight–& grating against the edges of the firm ice" [12.08.53] before coming to rest and freezing in place. Sometimes this slush had precipitated from within the water as frazil ice. Elsewhere it was slush composed of snow, perhaps floated off by rising water. Or snow falling on super-cooled water. "When I crossed the river on the roughish white ice," in early December, "there were coarse ripple-marks 2 or 3 feet apart & convex to the south" presumably blown that direction by the wind before the stiff slush froze in place. [12.06.56]

Freeze-up is a season of back and forth. Ice froze by night and melted by day, as did frost on leaves. "Each day at present the wriggling river nibbles off the edges of the trap which have advanced in the night. It is a close contest between day & night–heat & cold." [12.04.56] Freezing and thawing also occur in alternate weeks as one weather system replaced another. Freeze-up commences with small patches of "ice by the side of the brooks" [11.23.50] clinging to the edges, a delicate fringe of shelf ice, marbled by bubbles. "On the meadow" where the water "stands virtually still," it freezes to "a whitish light like a sliver plating." [11.25.53] Or, when stained by the organic tea of drained meadow, frozen overflows create "a discolored yellowish & soft ice." [12.17.56] Thick pure ice when settled of all its sediment, and drained of all its life, freezes to an "indigo blue," as with deep snow. [12.31.54]

Wide spots on the river froze first because the current was slackest. "These expansions of the river skim over before the river itself takes on its icy fetters." [11.25.50] "There is a thin ice for half a rod in width along the shore," he wrote in late November, "which shivers & breaks in the undulations of my boat": a black river with a fringe of black ice. [11.25.59] From the bank, the freezing front moves inward to close the channel. There, a tug of war commences between atmospheric cold pulling inward and aqueous heat pushing outward, with the atmosphere fated to win every time.

The Assabet, flowing more quickly, freezes long after the Sudbury to become "a beautifully smooth mirror within an icy frame." [12.14.54] Looking inward from the shore, "your eye slides first over a plane surface of smooth ice of one color–to a water surface of silvery smoothness like a gem set in ice." [12.14.54]

Continued Freeze-up takes place in a series of bands on opposite sides that one might say resemble the growth pattern of tree rings, with "each successive strip of ice {drawing} leaving so many parallel ridges." [02.15.60] The snow ice of the edge, the yellowish ice of the overflow, the "new dark smooth ice" of the middle, and over the widest spots in the lake-like reaches, "a thick fine gray ice–marbled." [12.19.54] Sometimes the river freezes as foam, creating a "rough flowing scaly mass . . . frozen into a kind of batter, like mortar, or bread that has spewed out in the river," typically "where water has oozed out at the sides." [01.04.57]

When Freeze-up is complete, however, some patches remain open year after year, perhaps where the flow was accelerated by a bridge, or "where a brook comes in." [12.30.55] Other openings defy explanation. Heat from below? Lack of shade from above? An unseen current? Access to the wind? All of the above?

Thin sheets of ice bonded to the margins flex with the waves Henry sent outward by rocking his boat, cracking to produce the "sound of the undulations" that were otherwise silent. [12.03.53] Thin sheets are also rapidly cracked by heating and cooling and frequently covered with hoar. When thin ice breaks, it splinters and fractures into particles that re-freeze into a mosaic of beauty [11.11.53] or into a hash of irregular fragments. Sleet makes the ice "hobbly like a coat of mail or thickly bossed shield," ruining the skating. [12.08.54]

Black ice is clear and therefore dangerous for the skater because there's no way to determine its thickness, and therefore its strength. Fortunately, it is quickly cracked, allowing the walker or skater to judge its thickness. Three inches will confidently support the walker, even over the deepest water. When thin but walkable, it flexes up and down beneath a person's weight to give a rubbery feeling known as "kittly benders." Thicker ice becomes a rigid sheet ready to catch and hold the snow. On such ice, dazzling crystal forms can develop: "richly marked . . . large whitish figures–suggesting rosettes of ostrich-features or coral . . . a sheaf of feathered arrows 5 or 6 feet long" a "black floor . . . divided into polygonal segments." [12.13.59]

Thoreau so loved to skate that he monitored the ice carefully for good conditions. One day he skated nearly sixty miles in three segments: up the river from Concord to near Framingham, down the river from there to Billerica, and then back up to Concord. [02.03.55]

10. Winter White
December 8-March 27

The final river season is defined by its covering of snow. When falling on thin black ice, the snow resembles a crystalline white powder. Walking over this "dust of diamonds" [02.13.59] Thoreau noted great rays the color of rainbows separated from one another by an angle of about sixty degrees. As the snow thickens, it accumulates as it would on adjacent land or a sandbar, except that it is much smoother, giving rise to an unbroken ribbon of pure white.

After the river surface is frozen, the contest is no longer from the edge inward, but from the top down. Each snowfall adds weight, which sinks the ice down, which saturates the snow, which freezes to produce "snow ice." A subsequent rise of the river can flood that translucent snow ice and freeze above it as a clear pane. Thus, the slab ice becomes complexly layered from two directions, upward as snow-and-ice sandwiches, and downward into the channel as a balance between the conduction of atmospheric cold and the viscous heat of flowing water.

"It is surprising how much room there is in nature," Henry famously wrote. "I enjoy the retirement and solitude of an early settler." [01.26.53] This well-known quotation came after a long, mid-winter river sojourn when the entire landscape was buried beneath a blanket of drifted snow, with land and river hard to distinguish from one another. "The river is now so concealed that a common eye would not suspect its existence." [01.21.57] "I cannot tell when I am on it." [02.09.55]

"Not till winter do we take possession of the whole of our territory. I have 3 great highways raying out from one centre–which is near my door–I may walk down the main river–or up either of its two branches. Could any avenues be contrived more convenient?" [02.13.59]

Once solidly frozen, one was "not compelled to walk in the tracks of horses" [02.13.59] because it was the road not taken. [01.05.56] "It is invaluable to the walker–being . . . the only practicable route. The snow never lies so deep over it as elsewhere–& if deep it sinks the ice & is soon converted into snow ice to a great extent . . . Neither is it drifted here . . . Here where you cannot walk at all in the summer is better walking than elsewhere in the winter." [01.20.56] Additionally, this was a world without the need for bridges. [02.09.51]

Meadows that were lush green just a few months ago now present "a very wild & arctic scene . . . a sea of white waves of nearly uniform shape & size," meaning snow drifts. These "oval hollows" with a "regular reticulation," resemble waves on the sea, but stand cold and still. [02.02.60] The Great Meadows have become "a broad level plain roughened only by snowy waves–about 2 miles long & nearly half as wide." [02.07.54] "How glorious the perfect stillness & peace of the winter landscape!" [12.31.54]

Thick winter ice is multi-colored. It may appear clear or black when transparent, "white like polished marble" when refrozen snow, yellow when overflowed, and "quite green, a vitreous green, as if seen through a junk bottle," becoming "greenest when the sun is 20 or 30 minutes *above* the horizon." [01.31.59; 12.30.55; 12.29.59] Reflections and absorptions can give rise to a "pink light" here, and a "dark indigo blue" there. [01.02.55]

"We do not commonly distinguish more than one kind of water in the river–but what various kinds of ice there are!" [01.31.59] The river ice stratigraphy on February 8, 1856 was "7 inches of snow, 9 inches of snow ice & 8 of water ice . . . .The water rises to within 1/2 inch of the top of the ice." [02.08.56] What Thoreau called "Graphic ice" is a mosaic of crystal faces and fractures. [01.26.59] Marble ice is snow, saturated from above by rain, and then refrozen with a capping glaze. [01.31.59] At Barrett's Pond, Henry identified ten different downward freezings from cold nights in about fifteen inches of ice. [01.10.59]

Ice forms thickest and fastest when the temperature plummets. On the night of February 6, 1855, the mercury in the Thoreau house thermometer plunged into the bulb, and the neighbor Smith's thermometer fell to twenty-six below zero on the Fahrenheit scale. [02.07.55] The following year on January 25 was "the hardest day to bear," with "a strong N.W. wind." [01.25.56] On January 24, 1857, Smith's thermometer fell even lower, to "-30° - at 9 1/4 Am." [01.24.57]

At times like these, the surface of the Concord River literally becomes dry land composed of the mineral ice, even as the thalweg of the river flowed invisibly below it as a liquid. "What a solid winter we have had! –no thaw of any consequence–no bare ground since Dec 25th." [03.18.56] "Frozen solidly for seven weeks." [02.27.56] "Elijah Wood Sen. about 70 tells me he does not remember that the river was ever frozen so long–nor that so much snow lay on the ground so long." [03.27.56]

In some years, however, winter never seemed to come; for example, in 1852-53. "The ground has been bare almost all the time–& the river has been open about as much. I got but one chance to take a turn on skates over ½ an acre . . . I doubt if there has been one day when it was decidedly better sleighing than wheeling." [03.24.53]

Ice, being a mineral, responds to physical stress very much the same way our silicate crust does. Like the crust of the earth, the slab ruptures with the audible seismicity of belches, booms, and roars whenever the expansion, contraction, shearing, and flexing stresses become too great. [12.20.54]

"The ice cracks suddenly–with a shivering jar–like crockery . . . And I notice as I sit here at this open edge–that each time the ice cracks–though it may be a good distance off toward the middle, the water here is very much agitated." [12.28.58] Those agitations result from seismic waves traveling through the ice to its edge, or to pressure waves traveling through the water from the site of rupture. Both are likely.

"Who would have suspected that so large and cold and thick-skinned a thing to be so sensitive?" [302] This famous line from *Walden* may lead us to believe that this observation was made there. Instead, its source was the river at Fair Haven Pond, where the seismic waves, felt or unfelt, can travel through many miles of continuous ice upstream or downstream. [02.12.54]

Once the slab ice is strong, the river can lift or lower it depending on the height of the denser water flowing below. On the way up, the main body of ice is lifted above the channel, but the edge ice anchored to the bank can't rise, creating a rift parallel to the shore, and allowing some of the yellow water to bleed out and re-freeze. On the way down, the main body of ice can become a low valley as the ice sags deeper into the channel than where it was created, making the bank appear higher than normal. Attached to the bank is "a shelf of ice–what arctic voyagers call the Ice-belt or Ice Foot . . . adhering to the walls & banks–at various heights . . . It is often 2 or 3 feet wide & now 6 inches thick." [01.01.57]

Even during the coldest winter, there are ice openings and great variations in thickness. Thoreau writes of a "black artery here and there concealed under a pellicle of ice." [12.08.54] Thin ice or open water were often present at constrictions such as bridges [12.19.54] or where the flow, being shallow, was too swift to freeze. [01.24.56] Ice may also be thin "where perchance warmer springs come in." [12.14.51]

Or perhaps where the flow, turning a corner and rising up from the bottom in a helix, melts the ice from below. [12.28.59] In late December of 1859, Henry identified persistent openings as part of a systematic investigation of river ice. [12.28.59]

The winter white river season was a time of hibernation. "I do not this moment hear an insect hum–nor see a bird, –nor a flower," Thoreau wrote during the winter of 1856. [01.20.56] The Great Meadow, that "museum of animal and vegitable life . . . is now reduced to uniform level of white snow–with only half a dozen kinds of shrubs & weeds rising here and there above it." [01.20.56] There is aquatic life beneath the ice, but it's a tenuous life spent waiting for the oxygen supply to diminish. Winter fish kills from anoxia float up each spring.

Thoreau's river year ends in the nick of time before Break-up begins.

Conclusions

Using Thoreau's words to the extent possible, I have categorized the totality of Thoreau's river observations into ten discrete seasons. They are: Break-up, Inland Sea, Aquatic Spring, Riparian Spring, Summer, Drought, Aquatic Autumn, Riparian Autumn, Freeze-up, and Winter White. All of Thoreau's seasons remain today, though they have changed in intensity and have been time-shifted owing to climate change. This qualitative conclusion invites a quantitative phenological comparison between his seasons from the mid-nineteenth century and those of today.

The first two seasons—Break-up and Inland Sea—are governed less by solar radiation than by the hydrologic regimes of the Concord River Valley. The subsequent doublets of spring, summer, and autumn are more closely linked to the calendar year but are complicated by time-lagged physical changes in the river that force the subsequent ecological changes. The final two seasons of Freeze-up and Winter White are most closely linked to the annual sine curve of solar radiation.

The great overlap of beginning and ending dates for discrete river seasons is due to the strong, year-to-year variability in Concord's four-season climate, rendering phenological interpretations of climate change complex. In spite of this challenge, Thoreau's river phenology provides an unparalleled opportunity to render the abstractions of climate change into tangible realities.

Notes

[1] For the geographic and hydrologic setting of Thoreau's river country, see Thorson's *The Boatman*, especially pages 38-45. For the geological history, see Thorson's *Walden's Shore*, especially pages 21-168.
[2] This analysis is based on a total of 3,563 continuous days described on pages 131-133 of Thorson's *The Boatman.* The raw data is available on request.
[3] The duration of a river year must average 365 days, but will vary as the duration between river break-ups. The seasons are also of variable durations, some being days long, and others months long. Quantification is in progress.
[4] To de-clutter the text, I cite by date using brackets and the standard six-digit code of xx.xx.xx for month, day, and year: for example [03.17.59] for March 17, 1859.
[5] See Primack, *Warming*, Dimick, "Disordered," Miller, "Comparing," and other sources accessed through Primack's lab website.
[6] See Kristen Case's *Keeping Time* and "Knowing," which provide a recent published update of the Kalendar project (www.thoreauskalendar.org). Thoreau's narrative descriptions of his river seasons in his Journal provided the basis for entries in his Kalendar matrix, but they are brief and often anecdotal.
[7] See Kelly, et al., "An Inexhaustible."
[8] Phenological patterns of break-up and freeze-up are documented in the Global Lake and River Ice Phenology Database of Benson et al. (2000).
[9] See Emerson's eulogy for Thoreau for remarks on Thoreau's scientific aptitudes and engagement with the river.
[10] The U.S. Global Change Research Program (2018) provides an overview. For a 165-year-long record of changing ice conditions on lakes see Hampton, "Environmental." Regular measurements on the daily discharge of the Concord River by the U.S. Geological Survey from 1937-present can be compared to Thoreau's river years of the mid-nineteenth century.
[11] I am grateful to D.T. Stevenson for contacting me, sharing his photography, and giving me permission to share it. I am also grateful to the staff person at Newbury Court who worked with me to track

down additional details. Finally, thanks to Kathleen Coyne Kelly for her encouragement and support of this project.

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What follows is a supplement to Robert M Thorson's essay, "Thoreau's River Seasons: A Phenological Baseline," in *The Concord Saunterer*, n.s. 32 (2024).

ROBERT M. THORSON

Thoreau's River Seasons in Photographs by Donald T. Stevenson

In 2017, Donald T. Stevenson read my book, *The Boatman: Henry David Thoreau's River Years* (Harvard UP, 2017). He reached out to ask if I would like to see some digital photos of the Sudbury River he had taken from his apartment. Of course, I responded gratefully. When I asked if I could share the photos with credit, he gave me written permission to do so.[1]

Stevenson sent me a series of seven dated photographs to which I gave titles that match what I call Thoreau's river seasons, listed in phenological order:

1. March 13, 2005–Aquatic Spring (snow)
2. May 4, 2005–Riparian Spring
3. June 11, 2006–Inland Sea (flood)
4. July 2, 2005–Summer (low water)
5. August 3, 2008–Summer (fog)
6. September 24, 2003–Riparian Autumn (early)
7. October 24, 2003–Riparian Autumn (late)

Several years later, I asked Kathleen Kelly, editor of the *Concord Saunterer*, if she would be interested in reviewing for publication an article about Thoreau's river phenology. In my inquiry, I sent her the Stevenson photographs for a possible pairing between the proposed article and the Thoreau Society website. I was hoping to obtain more photographs and information from Stevenson and to talk over a project with him. However, I had lost his email address. Using the photographs he had sent me, I approximated the line of sight and field of view by comparing the edges and center line of the photographs with images from Google Earth Satellite View. The photographs could only have been taken from the vicinity of Newbury Court, an assisted living property in West Concord. The images reveal a fairly close view of the channel and floodplain of the Sudbury River and its bracketing upland hills. Below are two Google Earth images with my reconstructions in yellow arrows. All photographs show a slightly different field of view. (Figures 1 and 2.)

I contacted the facility. They confirmed that Stevenson had been a resident and was now deceased. He would have been approximately eighty years old when he took the photographs and ninety-four years old when we corresponded. He died at age ninety-eight on October 31, 2021.

Figure 1. Google Earth satellite image showing camera origin and approximate line of direction for series of seven photos taken by D.T. Stevenson from September 24, 2003 to Aug 3, 2008. Camera type and lens unknown. Southeasterly view centers on the crest of Fairhaven Hill (end of yellow arrow) between Walden Pond and Fair Haven Bay; the Sudbury Road Bridge is barely visible in several of the photos.

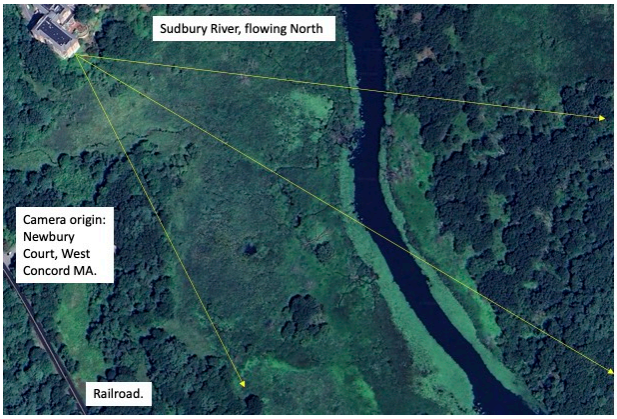

Figure 2. Closeup of Google Earth satellite view of Sudbury River showing with yellow lines the approximate foreground coverage of terrain photographed in 2003-2008 by D.T. Stevenson from Newbury Court, located where the lines converge.

The chief value of the photographs is historic and aesthetic: Stevenson offers excellent images of a consistent, elevated, sweeping view across the Sudbury in an undeveloped part of Concord. It amazes me that such an expanse would seem so undeveloped in this millennia. The photographs depict a common background containing Fairhaven Hill above Walden Pond and the vicinity of Fairhaven Cliffs above Fairhaven Bay.

The line of sight and field of view are generally the same, but they vary slightly with each photograph, suggesting that the camera was hand-held, and that the zoom was somewhat different each time. Critically, the series shows a single physical place for seven different times of the phenological year within a fairly narrow time interval from 2003-2008, predating the most recent two decades of intense climate warming.

Beyond the constancy of the topographic landscape, the images capture the variability of meteorological-hydrological conditions of the river from low stage with flanking ice (March 13) to a summer flood (June 11) and summer low stage (July 2). The only visible ecologic phenology involves the different stages of foliage from completely bare with clinging snow (March 13) to leafed out (June 11) to turning (Sep 24) to post-peak color (Oct 24).

Though the hills are more forested today than in Thoreau's time, the river probably looks very much the same as it did in Thoreau's day. This allows us to imagine what Thoreau's river seasons might have looked like during his river sojourning decade of 1851-1860.

Donald T. Stevenson's Photographs

March 13, 2005–Aquatic Spring (snow)

May 4, 2005–Riparian Spring

June 11, 2006–Inland Sea (flood)

July 2, 2005–Summer (low water)

August 3, 2008–Summer (fog)

September 24, 2003–Riparian Autumn (early)

October 24, 2003–Riparian Autumn (late)

Notes

[1] I am grateful to Donald T. Stevenson for contacting me, sharing his photography, and giving me written permission to share it. I am also grateful to the staff person at Newbury Court who worked with me to track down additional details. Finally, thanks to Kathleen Coyne Kelly for her encouragement and support of this project.