

DRL Companion Report

# The Deep Chronology of Forestry Knowledge

*Four millennia of what was understood about forests, what was decided, and what was failing to be acted on*

<b>Document</b>	DRL Companion Report — Historical Chronology
<b>Series</b>	DRL Thesis Codex v4.3.3 supplement
<b>Scope</b>	Earliest surviving written record (c. 2100 BCE) through 2026.
<b>Posture</b>	Configuration described, intent not characterised. Primary-source citations only. The chronology shows the public record; the reader draws the implication.
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## Abstract

This companion document assembles a chronology of the published record on forest dynamics, harvest consequence, and sustained-yield management across the longest historical span for which written sources exist. The chronology runs from the Standard Babylonian recension of the Gilgamesh epic (c. 2100 BCE) through the twentieth-century scientific literature and into the modern policy apparatus 2014–2026. The DRL Codex's central claim — that biogenic carbon neutrality for commercial timber is not supported under full-boundary accounting — is a present-day finding. This document is its historical context.

The single observation the chronology produces, on the basis of the public record, is this: the knowledge required to identify the disclosure gap the DRL framework names has been on the record, in one form or another, for as long as the record exists. Each era contributed what its observational tools and institutional frameworks allowed. The Mesopotamian texts recorded the felling of cedar forests for civil construction. The classical writers recorded the consequences of Mediterranean deforestation. The pre-colonial Indigenous land-management traditions documented forest dynamics, fire regimes, and harvest rotation through accumulated practice. The eighteenth-century European foresters articulated sustained-yield management as a formal discipline. The nineteenth-century colonial forest services institutionalised the discipline. The twentieth-century scientific literature quantified the carbon stocks and fluxes. The twenty-first-century peer-reviewed record has documented the specific accounting gaps the DRL framework names.

What the chronology does not show is a moment of new discovery in 2026. The information has been accumulating for four millennia. What has not kept pace with the accumulation, on the basis of this review, is the action on the information. The disclosure boundary in current use for commercial timber omits liability categories that the underlying scientific and historical record would, on its own terms, ask to be counted. That is the recurring pattern this chronology documents.

The frame this document holds is auditor's voice. The historical actors named below are named only from their own published record. The eras are described, not characterised. The reader is trusted to draw the implication that the chronology supports.



## **Era 1 — Ancient Near East and the earliest written record (c. 2100 BCE – c. 500 BCE)**

The earliest surviving written texts that describe large-scale forest clearance for civil construction come from the Mesopotamian tradition. The chronology begins there because that is where the record begins.

### **The Gilgamesh material**

The Standard Babylonian recension of the Epic of Gilgamesh, compiled in the form modern scholarship reads c. 1300–1000 BCE from earlier Sumerian sources reaching back to c. 2100 BCE, records the journey of Gilgamesh and Enkidu to the cedar forest, the killing of the forest-guardian Humbaba, and the felling of the cedars for transport down the Euphrates as building material. The text is a literary work, not an audit document, but it is the earliest surviving written account of large-scale forest clearance for civil construction at scale, and it records the felling as a culturally noted act with consequences (George 2003; Dalley 1989). The forest is named, the cedars are named, the destination of the timber is named. The text does not endorse the felling; it describes it. What is on the record from the Mesopotamian tradition, taking the text on its own terms, is that the practice of felling large forests for civil construction was prominent enough to require literary treatment, and the literary treatment is not celebratory.

### **The biblical record**

The Hebrew Bible records forests and forest products with frequency and specificity. The cedars of Lebanon appear across the prophetic and historical books as the standard building material for monumental construction — the First Temple in Jerusalem (1 Kings 5:6–10) is built from cedar timber transported from the Lebanon range under treaty with King Hiram of Tyre. The cedars are named again in 2 Chronicles 2, in Ezra 3:7, in the Song of Solomon, in Isaiah 14:8 (“the fir-trees rejoice at thee, and the cedars of Lebanon, saying, since thou art laid down, no feller is come up against us” — the cedars register the cessation of felling as relief), and in the Psalms. The Lebanon range, which in the period covered by the texts carried the largest cedar forest in the Levant, is documented in the textual record as a source of building timber for at least seven centuries of construction across the eastern Mediterranean.

The Hebrew Bible also records the principle of sabbatical fallow in Leviticus 25 and Deuteronomy 15: “Six years thou shalt sow thy field... but in the seventh year shall be a sabbath of rest unto the land” (Leviticus 25:3–4). The principle is not a forestry doctrine. It is, however, the earliest articulation in the textual record of a duty of rest extended to the land itself, distinct from a duty owed to the land's owner. The conceptual move — that land productivity is not unlimited and that the rest period is a positive obligation rather than a discretionary practice — is established in writing in the canonical text by the time of the Second Temple period. The conceptual move predates the formal discipline of sustained-yield forestry by approximately twenty-three centuries.

### **Other ancient Near Eastern sources**

The Mesopotamian, Egyptian, and Phoenician records all document long-distance timber trade from the Lebanon range, the Amanus mountains, and the Zagros. The Egyptian Palermo Stone (Fifth Dynasty, c. 2400 BCE) records forty ships' worth of cedar imported from Byblos in a single year of the reign of Sneferu. The Phoenician city-states' economic prominence in the late Bronze Age and Iron Age rests on

the cedar trade. These are not contested historical claims. The textual and archaeological record establishes, by approximately 2000 BCE, that the major civil construction projects of the Near East depended on long-distance importation of forest products, because the timber resources accessible to the construction sites had already been depleted by earlier civil construction.

*The earliest surviving written record of large-scale forest clearance for civil construction also records that the resource was finite and the clearance had visible consequences. The information was on the record by 2100 BCE.*

## Era 2 — Classical antiquity (c. 500 BCE – c. 500 CE)

The Greek and Roman writers extended the record from observation of forest loss to explicit causal reasoning about hydrological, agricultural, and climatic consequence.

### Plato, Critias, c. 360 BCE

Plato's dialogue Critias contains the earliest surviving explicit account of post-deforestation landscape change. Describing the Attic peninsula, Plato writes that the land in his own day is “a mere skeleton of what it was” and attributes the change to the loss of the forest cover that had previously “received the water from the heavens and stored it up in the close clay soil... and so was able to discharge the drainage of the heights into the hollows in the form of springs and rivers with abundant volume and a wide territorial distribution” (Critias 111a–d, Bury translation). The text records (a) that forest cover had been lost over a known historical period, (b) that the loss had been caused by human action including building-timber harvest, (c) that the hydrology had changed as a consequence, and (d) that the agricultural productivity of the landscape had degraded along with the hydrological change. Each of these four claims is in the dialogue's own text. The causal chain Plato draws — forest → hydrology → agriculture → settlement viability — is the same causal chain that twentieth-century forest hydrology would later quantify in measured stream-flow terms (Bosch and Hewlett 1982; Brown et al. 2005).

### Roman writers

Roman agricultural writers from the late Republic and early Empire extended the record. Lucretius, in *De Rerum Natura* (c. 55 BCE), describes the progressive felling of the forests as agriculture pushed up into the hills (V.1370 ff.). Varro, in *Res Rusticae* (c. 37 BCE), gives explicit attention to the management of woodland as a productive asset, including rotation cycles and species selection. Columella's *De Re Rustica* (c. 65 CE) treats forest crops as a discipline of estate management, with attention to oak rotation, chestnut coppice, and the productivity loss from over-harvest. Pliny the Elder's *Natural History* (c. 77 CE) catalogues forest species, harvest practices, and the effects of forest loss on local climate, in language explicit enough that twentieth-century forest historians (Hughes 1983; Meiggs 1982) treat Pliny as a primary source for the state of Mediterranean forests at the height of imperial demand.

The classical record establishes by approximately the second century CE that (a) forest loss is causally connected to landscape change at a regional scale, (b) the connection is documented in writing and circulating in elite agricultural literature, and (c) the productive management of woodland under rotation is a recognised discipline. None of this is a twentieth-century insight. The information was on the classical record.

## **Era 3 — Pre-colonial Indigenous land-management traditions**

The chronology above describes the European-language written record. A second body of knowledge, accumulated independently and over comparably long timescales, sits in the Indigenous land-management traditions of North America, Australia, the Pacific, and other regions where pre-colonial practice was systematically documented by later ethnographic and ecological research. The DRL framework treats this layer as a parallel record, not as a contrast or a critique.

### **North American Indigenous fire and forest management**

M. Kat Anderson's *Tending the Wild* (University of California Press, 2005) compiles the documentary record of California Indigenous land-management practice into a single sustained treatment. The book draws on early-contact Spanish and Anglo accounts, ethnographic field records, and contemporary Indigenous practitioners to document the use of patch-burning, selective harvest, coppice management, and seed dispersal across the California landscape over a period the archaeological record extends across at least the last ten thousand years. The practices Anderson documents — fire regime management at landscape scale to maintain open oak savanna, deliberate disturbance to favour productive species, rotation-harvest of basketry materials over multi-year cycles — are functionally equivalent to the management regimes the European forestry tradition would later articulate as sustained-yield doctrine. They predate the European articulations by millennia.

Robin Wall Kimmerer's *Braiding Sweetgrass* (Milkweed Editions, 2013) extends the documentary treatment to Anishinaabe and broader Eastern Woodland practice. Kimmerer, a botanist and citizen of the Citizen Potawatomi Nation, writes from inside both the Western scientific tradition and the Indigenous knowledge tradition. The book documents harvest principles — the “Honorable Harvest” rules of asking, taking only what is needed, sharing the harvest, and using all of what is taken — as functioning rules of practice in the communities that hold them, supported by accumulated ecological observation over centuries.

What the parallel record establishes, taking both Anderson and Kimmerer on their own terms and on the terms of the field literature they synthesise, is that the principle of harvest-with-consequence-accounting is not a discovery of European institutional forestry. The principle is on the record across at least two continents in traditions that the modern scientific literature can document, reproduce, and learn from. The information was, by any reasonable accounting, available.

### **Australian and Pacific records**

Bill Gammage's *The Biggest Estate on Earth* (Allen and Unwin, 2011) compiles the equivalent record for Aboriginal Australian fire-stick farming, drawing on early-contact European observation and continuing ethnographic research. The Aboriginal practice of mosaic burning at landscape scale, applied across the continent over at least sixty thousand years, produced and maintained the forest and grassland configurations the first European settlers encountered and assumed to be wilderness. The same point: the management discipline was documented in the practice, accessible in the documentary record by the late nineteenth century, and not absent from the body of available knowledge by the time the colonial forest services were being established.

## **Era 4 — Early modern European institutional forestry (c. 1500 – c. 1900)**

The European institutional tradition gave the discipline its modern formal vocabulary. The chronology runs from late-medieval royal forest ordinances to the formalisation of sustained-yield doctrine in eighteenth-century Saxony to the institutionalisation of state forest services in the nineteenth century.

### **Hans Carl von Carlowitz, *Sylvicultura oeconomica*, 1713**

The locus classicus of formal sustained-yield doctrine is Hans Carl von Carlowitz's *Sylvicultura oeconomica*, oder haußwirthliche Nachricht und Naturmäßige Anweisung zur wilden Baum-Zucht, published in Leipzig in 1713. Carlowitz, the Royal Saxon Mining Administrator, wrote in response to a documented timber shortage in the Erzgebirge silver-mining region: the mines required pit-prop timber at a rate that exceeded the regrowth of the surrounding forests, and the consequence was rising timber prices and threatened mine closure. Carlowitz's response was the formulation of the principle of *Nachhaltigkeit* — variously translated as sustainability, sustained yield, or durability — as the rule that timber harvest should not exceed timber growth in any given forest district. The book articulates this as both an economic principle and an ethical one: “will ein Land sich erhalten, so muss seine Holz-Zucht nachhaltig sein” (“if a land is to sustain itself, its forestry must be enduring”).

The 1713 publication is the formal entry of sustained-yield doctrine into the European institutional record. Three observations follow from the publication date. First, the principle was published in a major European language, in a book that circulated across the German-speaking forestry profession, in 1713 — three centuries before the present. Second, the principle was published in response to a documented resource-depletion problem, with quantitative accounting of the depletion. Third, the principle was incorporated into Saxon, then Prussian, then broader German forest administration over the subsequent century, producing the *Forstwissenschaft* tradition that would in turn produce the institutional foresters of the nineteenth century.

### **Dietrich Brandis and the Indian Forest Service**

Dietrich Brandis, a German-trained botanist and forester, was appointed Inspector General of Forests to the Government of India in 1864 and served until 1883. Brandis brought the *Forstwissenschaft* tradition into the British Indian administration and produced the Indian Forest Act of 1865 (revised 1878), establishing what is, in the modern documentary record, the first large-scale state forest service on the European model. Brandis's own writings, in particular his *Indian Forestry* (1897) and his teaching at Cooper's Hill and later at the Indian Forest School at Dehra Dun, articulate sustained-yield doctrine for the tropical and subtropical forest types of South Asia. The Indian Forest Service trained foresters who would later staff the colonial forest services of Burma, Malaya, East Africa, and the British Caribbean, and who would influence the establishment of the United States Division of Forestry through Brandis's correspondence with Pinchot.

### **Gifford Pinchot and the United States Forest Service**

Gifford Pinchot studied under Brandis in the late 1880s and explicitly modelled his approach on the German and Indian institutional traditions. Pinchot's *Breaking New Ground* (1947, posthumous) records the intellectual lineage in his own words. Pinchot was appointed Chief of the Division of Forestry in 1898 and led the transformation of the Division into the United States Forest Service under the Transfer Act

of 1905. The doctrine the USFS was founded on — sustained yield in the management of federal forest reserves, with timber harvest set at or below growth rates — is a direct institutional descendant of Carlowitz 1713 via Brandis.

### **The 1889 New Zealand climatal reserves precedent**

The chronology includes one specific legislative precedent that, on the basis of this review, the modern New Zealand forestry and emissions-trading policy framework would benefit from re-engaging with. In 1889 the New Zealand colonial government, on the recommendation of the Surveyor-General Sir James Hector, established a system of climatal reserves — forest reserves designated specifically for the purpose of climate stabilisation, water-yield maintenance, and the preservation of indigenous forest. The 1889 reserves were created under the Land Act 1885 and the State Forests Act 1885, and explicitly identified the climatic function of forest cover as the basis for protection, predating by more than a century the modern climate-policy treatment of forests as carbon assets.

The 1889 New Zealand precedent is on the public legislative record. It is referenced in Roche (1990), Wynn (1977), and the New Zealand Department of Conservation's own historical materials. The principle the 1889 legislation established — that some categories of forest are protected for their atmospheric function rather than their timber yield — is in the New Zealand legal tradition before the twentieth century begins. The DRL framework's full-boundary accounting of forest carbon flows is, in this respect, an application of a category that the New Zealand colonial legislature had already named one hundred and thirty-seven years ago.

*By 1900, sustained-yield doctrine was in three written traditions across at least four continents, formally institutionalised in at least four national forest services, and on the legislative record in at least one jurisdiction as a climatic-function category. The information was on the record.*

## **Era 5 — Twentieth-century forest science (c. 1900 – c. 2000)**

The twentieth century quantified what the prior eras had described. The instrumentation of forest ecology — measured carbon flux, dendrochronology, eddy-covariance towers, satellite remote sensing — moved the discipline from observation and prescription to measurement and verification.

### **Stand-level carbon accounting**

The measured forest-carbon record begins with the dendrochronological work of A. E. Douglass and his Laboratory of Tree-Ring Research at the University of Arizona, founded 1937, which established that tree-ring widths preserve a quantifiable record of growth conditions over the life of the tree. The discipline extended through Schulman's millennial bristlecone-pine series in the 1950s and the subsequent international tree-ring data bank, providing the first instrumented multi-millennial record of forest growth response.

Stand-level carbon stock accounting was developed in the post-war period through the work of forest mensurationists (Husch, Beers, Kershaw) and applied at landscape scale by the U.S. Forest Service's Forest Inventory and Analysis program, which from 1928 onward has produced periodic state-level inventories of standing biomass. By the 1980s, the FIA data was being used as the basis for national-scale carbon stock estimation (Birdsey 1992; Heath et al. 1996). The carbon stocks of major U.S. forest types were quantified and published in the peer-reviewed literature by the mid-1990s.

### **Old-growth net carbon-sink finding (Luyssaert 2008)**

Luyssaert et al., “Old-growth forests as global carbon sinks,” *Nature* 455:213–215 (2008), synthesised the global eddy-covariance dataset to establish that approximately 75 percent of forest stands older than 180 years remain net carbon sinks — that is, they continue to accumulate carbon at significant rates rather than reaching the carbon-neutral equilibrium that the prior textbook treatment had assumed. The finding was published in *Nature*, the highest-impact venue in the natural sciences, in 2008. The implication is direct: the prevailing accounting convention that treated old-growth forests as carbon-neutral was, by the publication of Luyssaert, contradicted by the measured eddy-covariance record. The information was on the published peer-reviewed record from 2008 forward.

### **Continuous large-tree accumulation (Stephenson 2014)**

Stephenson et al., “Rate of tree carbon accumulation increases continuously with tree size,” *Nature* 507:90–93 (2014), assembled the measured growth record of 403 tree species across temperate, subtropical, and tropical biomes and established that for the great majority of species, the rate of carbon accumulation per individual tree continues to increase with tree size — older, larger trees accumulate carbon more rapidly than smaller, younger trees in the same stand. The finding overturned the prior assumption that growth rates decline with age. The implication for harvest-replacement accounting is direct: the substitution of young plantation regrowth for harvested mature trees does not, on a carbon-flux basis, replace the harvested carbon-accumulation function. The Stephenson finding has been replicated in subsequent peer-reviewed work and stands in the published record.

### **Soil organic carbon under harvest disturbance**

Meta-analyses of soil organic carbon response to forest harvest disturbance have been published in the peer-reviewed literature since the 1990s. Johnson and Curtis (2001) synthesised 73 prior studies of

forest soil response to disturbance. James and Harrison (*Forests* 7(12):308, 2016) and Achat et al. (*Forest Ecology and Management* 348:124–141, 2015) updated the synthesis with measured field datasets. The conclusion across the meta-analytic literature is that whole-tree harvest and intensive site preparation produce a measurable loss of soil organic carbon in the upper soil profile over the first decade post-harvest, with the magnitude depending on soil type, harvest intensity, and climatic regime. The DRL framework's full-boundary accounting of SOC efflux is, in this respect, an application of measurements that have been in the soils literature for two decades.

## End-of-life methane from wood in landfill

Ximenes et al., “Greenhouse gas balance of native forests in New South Wales, Australia,” *Carbon Balance and Management* 3(1):1–13 (2008), measured the methane release from wood in landfill conditions and established that a substantial fraction of the biogenic carbon stored in wood that enters anaerobic landfill is re-released to the atmosphere as methane rather than as carbon dioxide. The IPCC AR6 (2021) Working Group I, Chapter 7, Table 7.15 establishes methane's 100-year global warming potential at 27.9. The combination — measured methane release fraction times the GWP100 — is the basis for the end-of-life liability the DRL framework names. Both inputs are in the peer-reviewed and intergovernmental record.

## The biogenic-neutrality convention

The biogenic-neutrality convention itself was articulated in the international LCA standards during the development of ISO 14040 (1997) and ISO 14044 (2006). The convention treats biogenic carbon emissions as offset by biogenic carbon uptake on a per-cycle basis, producing a net-zero accounting for biogenic flows in the standard LCA boundary. The convention is not, on its own terms, a scientific finding about atmospheric carbon residence; it is a methodological choice about boundary definition. The ISO standards' own documentation acknowledges the methodological character of the choice. The U.S. EPA's April 23, 2018 Statement of Policy applying biogenic neutrality to forest-biomass combustion at stationary sources for regulatory purposes describes itself, in its own text, as “not a scientific determination.”

*By 2014, the peer-reviewed Nature literature had established (1) that old-growth forests are net carbon sinks at 180+ years (Luyssaert 2008), (2) that large trees accumulate carbon at accelerating rates with size (Stephenson 2014), (3) that soil organic carbon is measurably released under harvest disturbance (meta-analyses 2015–2016), and (4) that end-of-life methane release from wood in landfill is non-trivial under measured field conditions (Ximenes 2008). The four findings, taken together, are the four pillars of the DRL framework's full-boundary accounting. All four were on the peer-reviewed record before the modern mass-timber policy apparatus assembled in 2014–2026.*

## **Era 6 — The modern apparatus and the contested record (2014 – 2026)**

The period from 2014 forward is documented in detail in the DRL Codex and in the Reagan Forestry Legacy companion paper. The chronology here notes only the points at which the historical record intersects with the modern apparatus.

### **Searchinger and Peng, Nature 2023**

Peng, Searchinger, Zions, and Waite, “The carbon costs of global wood harvests,” *Nature* 620:110–115 (2023), estimated that conventional carbon-accounting approaches systematically undercount global wood-harvest emissions by 3.5 to 4.2 gigatonnes of CO<sub>2</sub>-equivalent per year over the coming decades. The *Nature* paper extends the peer-reviewed challenge to the biogenic-neutrality convention into a quantified global figure, situated in the highest-impact venue in the natural sciences. The challenge is, in the journal's own terms, currently being debated — Sohngen, Baker, Favero and colleagues published a *Matters Arising* critique in *Nature* 646:E18–E19 (October 2025), with a reply from Searchinger, Berry, and Peng in *Nature* 646:E20–E23. The exchange is ongoing in the peer-reviewed record. What is settled is that the question is, on the basis of the public record, an open scientific question in the highest-impact peer-reviewed forum, not a closed convention.

### **The 2018 EPA policy statement, in its own words**

The U.S. Environmental Protection Agency's April 23, 2018 Statement of Policy on the Treatment of Biogenic CO<sub>2</sub> Emissions from Stationary Sources opens with the text: “This statement of agency policy is not a scientific determination and does not revise or amend any scientific determinations that EPA has previously made.” The opening sentence of the policy that grounds the U.S. domestic biogenic-neutrality convention disclaims being a scientific finding. The text is in the EPA archived record. The American Forest and Paper Association's same-day press release characterised the policy as reflecting “long-standing scientific principles.” Both statements are on the public record from the same date.

### **Where the modern apparatus stands relative to the chronology**

The modern mass-timber policy apparatus assembled between 2014 and 2026 — the IBC 2021 tall mass-timber provisions, the USDA Wood Innovations Grant Program, the WoodWorks specifier-conversion infrastructure, the LIMBER Timber Act tax credits expiring December 31 2030 — operates within an accounting boundary that, on the basis of this review, excludes liability categories that the four-millennium chronology above had on the record by the time the apparatus was assembled. The chronology does not, in itself, characterise the assembly. It records what was, on the public record, available to be considered.

## Closing observation

The single observation this chronology supports, taken on its own terms and on the terms of the sources it cites, is the following:

*The information required to identify the disclosure gap the DRL framework names has been on the public record, in one form or another, for as long as the public record exists. The action on the information has not kept pace with the accumulation of the information.*

Each era contributed within its observational and institutional limits. The Mesopotamian texts contributed a literary record of large-scale clearance and its consequences. The classical writers contributed the explicit causal connection between forest cover, hydrology, and agricultural productivity. The pre-colonial Indigenous land-management traditions contributed accumulated practical knowledge of forest dynamics, fire regime, and rotation, documented over centuries to millennia. The early-modern European institutional foresters contributed the formal articulation of sustained-yield doctrine. The nineteenth-century colonial forest services contributed the institutional architecture. The twentieth-century forest sciences contributed the measurements. The twenty-first-century peer-reviewed literature has contributed the specific identification of the gaps the DRL framework names.

The contribution this chronology makes is none of those. It is the observation that, taken together, the prior contributions were enough. The chronology does not claim that a new discovery is required to close the disclosure gap. It records that the discoveries required are already in the record, and that the lag is in the application.

The DRL framework's full-boundary accounting is, in this light, not the introduction of new science. It is the application to current accounting of measurements and principles that the underlying record has held for periods ranging from decades to millennia. The framework asks only that the disclosure boundary be drawn at the location the underlying record would, on its own terms, ask it to be drawn. The question for present-day policy, taking the four-millennium chronology on the basis of the public record, is not whether the information is available. It is whether action will follow.

*This document is a supplement to the DRL Thesis Codex v4.3.3. It documents the four-millennium record. Its companion, *The Curtain*, documents the modern period from 1969 forward during which the formal accounting framework was assembled; *Tree of Many Sales* documents the present-day configuration in which the same physical carbon is counted as a benefit across multiple accounting systems. The three are intended to be read together.*

## Source register

*Every claim in this chronology traces to a public-record source. The following register lists the principal sources, in the order they appear in the text.*

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