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TREE RING DISTURBANCE-CLUSTERING FOR THE COLLAPSE OF LONG TREE-RING CHRONOLOGIES

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ABSTRACT

The Disturbance-Clustering hypothesis, first introduced here, posits that geographically-demarcated subtly-perturbed tree rings had induced the affected trees to crossmatch not in accordance with climatic signals, as is assumed in conventional dendrochronology. They instead crossmatch only within a geographic cluster of like-perturbed trees, and not with those of other clusters or with any of the remaining unaffected climatically-governed trees. During chronology-building, these clusters became connected with each other, into an artificially-long chronology, by means of rarely-occurring fortuitously-crossmatching "bridge" series. An experiment involving fifteen ostensibly heterochronous ancient trees graphically supports this hypothesis. Merely one-per-decade individual-ring perturbations induce all fifteen series to form a self-clustering, robust false master chronology (common variance), moreover to which each series crossmatches to an almost-entirely-convincing degree (nearly all featuring all the important statistics, and including segment-by-segment correspondence of the curves). Significantly, and as experimentally demonstrated in this paper, at least 3 of every 10 disturbances can be omitted in some series, and a robust master chronology still develops. What's more, the construction of the master chronology is not dependent upon the presence of *any* series that has the full complement of disturbances. Clearly, modestly-disturbed series could adequately have served as the "core" of a cluster of disturbed trees, just as required by the Disturbance-Clustering hypothesis.

Furthermore, the previously-introduced now-called Migrating-Disturbance Hypothesis does not require a literal repetition of events in time. A lateral movement of disturbances over centuries is sufficient, as is illustrated.

The Swedish and Finnish (Lapland) long Scots pine chronologies have a number of internal discontinuities. While not invalidating the chronologies, these discontinuities provide possible clues to their deconstruction.

KEY WORDS

Dendrochronology, multimillennial chronology, bristlecone pine, Scots pine, old-Earth challenges, carbon 14 dating, dendrogeomorphology, groundwater

GENERAL INTRODUCTION

Supra-long tree-ring chronologies, once an experimental curiosity, are now proliferating. There are two long chronologies from the Arctic of the Scandinavian peninsula, both consisting of Scots pine (*Pinus sylvestris*): The Finnish Lapland long chronology [hereafter FIN](1484 series*) and the Swedish Lapland Tornetrask long chronology [TRN] (945 series) [sometimes combined together: Larsson and Larsson 2018]. There is also the USA (California) MWK long chronology [MWK] (285 series) of bristlecone pine (*Pinus longaeva)*. All three chronologies are close to 8000 years long, according to conventional dendrochronology. Their ring-width measurements, being freely available, are examined in this study. [Those from the Alpine long chronology (Switzerland), the Hohenheim long chronology (Germany), and (in large part), the Belfast long chronology (Ireland), are still unavailable.]

Throughout this work, I benefitted from extensive discussions with a Swedish dendrochronologist. The technical matters discussed in this paper are often in response to the "iron sharpens iron" issues raised during these encounters.

There is no getting around the fact that dendrochronology is a very specialized subject, and it is impossible to teach it in one paper or speaking engagement. I strongly recommend that the interested reader visit *cybis.se* and familiarize himself/herself with modern dendrochronology and the CDendro program, in order to better understand my paper. Owing to the interlocking nature of the concepts presented in this work, it is not always possible to avoid using a term until it is specifically elaborated upon. For this reason, the terms pertaining to dendrochronological jargon (or to my informal shorthand), used in this paper, are marked with an asterisk(*) the first time they are used, and are defined in the Nomenclature section.

This paper builds on the author's earlier research on MWK (Woodmorappe 2003a, 2003b; 2009). It reaffirms the hypothesis developed by the author (Woodmorappe 2003a), which is now given a formal name—the Migrating-Disturbance Hypothesis. (Figure 1). In addition, it introduces a new hypothesis—the Disturbance-Clustering hypothesis (Figure 2). The latter depends on the demonstrated sensitivity of multiple perturbed tree-ring series to crossmatch, at high t-values, in a nonclimatic-dependent manner (Table 1); the ability of individual undisturbed series to crossmatch acceptably (Figure 3 and 4); and the ability of multiply-falsely-matched series to match at the same point even in the extreme case of failing nearly all other dendrochronological criteria (Figure 5). The latter inspired experiments that show the ability of falsely-crossmatched ensembles of series to match at the same point *and* to satisfy all other dendrochronological criteria (Table 2).

FIN itself is re-derived in order to get a sense of how far P2Aut* can go, in building the long chronology, before one-series-at-a time manual crossmatching becomes necessary (Figure 6). Finally, TRN/FIN, in a combined master chronology*, is "deconstructed" (Figure 7) in order to identify the 'weak spots" that likely (but

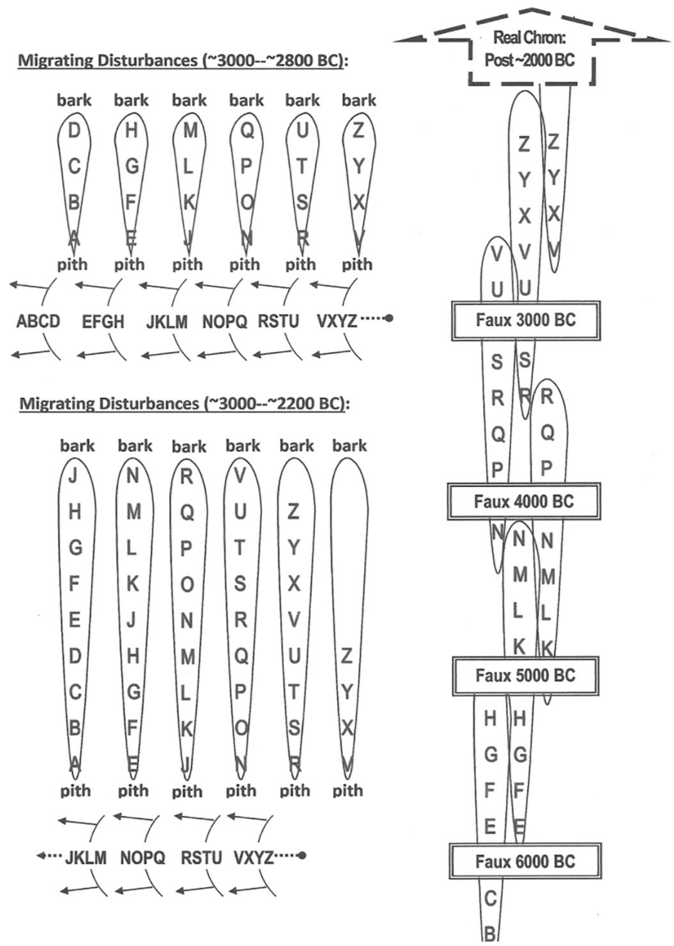


Figure 1. The Migrating-Disturbance Hypothesis (Woodmorappe 2003a). Slow-moving ring-altering events cause actually-contemporaneous trees to crossmatch in an age-staggered manner, ultimately creating an artificially-old chronology (far right).

not invariably) correspond to the discontinuities required by the Disturbance-Clustering hypothesis.

Dendrochronology consists of additive as well as interactive aspects, and I examine both. The former consists of individual-pair crossmatches, conveniently shown in a matrix*[including the data summarized in Table 2], while the latter recognizes the powerful common signal that emerges from the averaging-together of strongly-matched individual trees into a master chronology, as performed by P2Aut, and which is manifested as the master chronology effect*. Hoever, this effect is not limited to correctly-crossmatched trees. It also repeatedly shows up under various situations that involve falsely-crossmatched trees (Table 1 and 2; even poorly-matched ones: Figure 5). I have, in a sense, "put in reverse" for the correctly-matched series that comprise TRN/FIN in the experimental procedures leading to Figure 7.

This study is limited to the analysis of previously-archived tree-ring width measurements, and does not consider wood anatomy. However, it is unclear how important it is, in practice, to "look at the wood." Some dendrochronologists who built the long tree-ring chronologies have informed me (personal communications) that it is the reproducibility of crossmatches that is paramount, and that clues from wood anatomy only occasionally come into play. Evidently, this can be generalized. Thus, Torbenson et al. (2016, p. 64) quip, "The measurement of EW [earlywood] and LW [latewood] has not been a routine practiced within dendrochronology in the past…" Finally, as elaborated in the next section, CDendro can automatically make crossmatching decisions, moreover based solely on ring-width data, that are just as trusted as those of a trained dendrochronologist.

A comprehensive analysis of the relationship of C-14 dating, and the long tree-ring chronologies, is beyond the scope of this paper. However, I mention some seldom-recognized facts in this regard.

This work includes a number of internet-based citations. The concerned reader should realize that they are all from long-term, reputable, scholarly sources—moreover ones that have commonly been cited as authoritative in refereed, printed journal articles.

MATERIALS

The tree-ring width measurements from the first two mentioned chronologies, and the Scots pine assortment of collections from all over Eurasia, all used in this study, are part of ITRDB, the online international tree-ring archive (NOAA 2018). They involve MWK (*ca535.rwl*), elaborated earlier (Woodmorappe 2003a, 2003b, 2009); the TRN (*Swed334.rwl*) described by Grudd et al. (2002). In addition, I have used tree ring-width data for FIN (Lustia Dendrochronology 2018), which is described by Eronen et al. (2002) and Helama et al. (2008).

The tree-ring analysis software, used initially in this study, had been developed by the University of Arizona Tree Ring Laboratory. This includes programs for crossmatching and chronology development (COFECHA); the survey of tree-ring series in a file (SUR); the changing of the layout of tree-ring data (FMT); and the experimental alteration of individual listed tree rings (EDRM). CDENDRO, a commercial Swedish tree-ring program (Larsson 2003-2018) purchased by the author, was extensively used for the visual examination of tree-ring sequences prior to crossmatching, and for comparing tree-ring-matching statistical results from various programs used by dendrochronologists in Europe. It is invaluable for its graphical presentations of tree ring data, and especially for its automatic as well as interactive construction of master chronologies (mean value curves) of listed individual tree-ring series.

The editing of individual listed tree ring values was expeditiously conducted by importing the file into Word, changing the numerical figures, and saving it as a .txt file. Whenever they were large, the COFECHA and CDendro output files were imported into Excel for the purpose of sorting the data, as, for example, by the highest t-value false crossmatches. RANDBETWEEN, in Excel, was used whenever a set of random numbers was needed, for a preliminary experiment.

A word about computers to the skeptical. Dendrochronology is in no sense a "creation" of computers: It existed long before them. Unambiguous, reproducible ring-width patterns used to be identified and crossmatched visually, and statistical methods were generally eschewed owing to their labor intensiveness. Nowadays, we are blessed by computers that can display the visual patterns, and effortlessly quantify the unambiguously-distinctive crossmatched patterns of rings. In other words, these "number crunchers" merely mathematize, at great speed, the tasks that once had been performed manually, and usually qualitatively, by

dendrochronologists (such as the edge-wise juxtaposition of hand-written skeleton plots*, or the superimposition of graphed series over a light table). Computerized dendrochronology should not be conflated with the likes of computer climate change models and their complex, interactive, potentially assumption-based algorithms. The metrics used in computerized dendrochronology are in no sense "wooly": They are quite simple [see *cybis.se* for details], straightforwardly verifiable, and entirely practical. Had the computerized statistical methods failed to provide distinctively high t-values for valid crossmatches that had previously always been identified visually, and/or yielded nonsensical high t-values for trees known to have lived at great geographic distances or at different times, computerized dendrochronology would never have "caught on", let alone earned the widespread usage it now enjoys among dendrochronologists.

As a matter of fact, we are actually getting close to the point where machine can replace man in dendrochronology! Larsson and Larsson (2018) come close to saying this, as they discuss the semi-automatic chronology-building process [that is detailed in the next section under: *How Individual…*]. They comment, "The iterative procedure can be interactive (incremental) which means that CDendro suggests a candidate to add and the dendrochonologist manually accepts of rejects each sample after visual inspection of the match. But the procedure can also be fully automatical, which only makes sense with a relevant parameter setup (see above). If the criteria for acceptance are sufficiently high, the dendrochonologist most likely would accept the match also in incremental mode, *that means we do not think that the dendrochronologist will make better decisions than CDendro*." (p. 7; Emphasis added).

There is no concern about the somewhat different t-values, obtained for the same crossmatch, by the various older dendrochronological software programs. Consider an occasional difference in t-values of up to 2.0. While there could have been a potentially-valid controversy surrounding the significance of 6.5 and 8.5 for a crossmatch, in pre-CDendro software, there is no practical difference in, for example, the virtual certainty implied by, say, a crossmatch with a t-value of 12.6 or a value of 14.6.

TREE-RING CROSSMATCHING VALIDATED, WITH A SYNOPSIS OF MAJOR PROCEDURES

In this work, use of words such as "correct" or "valid" crossmatches refers to compellingly-visual and/or compellingly-statistical matches of trees, at their proper overlap, that are known to have lived at the same time in close proximity. It also refers to the crossmatches conventionally regarded as valid, for the long chronologies, based on visual and/or statistical criteria that is comparable to those found between compellingly-matched known-contemporaneous (living) trees.

Permit an example, of a correct crossmatch, involving currently or recently-living trees. We have a long-lived tree, designated as the reference, which was cut down right after the 1963 growing season. Another long-lived tree, which grew nearby, was cored right after the 2017 growing season. The series may not crossmatch strongly, if at all, but *if* they do, it is expected that the distinctively-high-t crossmatch point will be at the bark-ward (youngest) ring of the second tree offset -54 years relative to the bark-ward (youngest) ring of the reference tree, *and at no other position*. That is exactly what we find.

1. The "Floor" and the "Ceiling" for Recognizing Correct Crossmatches

Traditionally, dendrochronologists have been using a rough cutoff t≥3.5 before accepting a crossmatch as potentially valid (e. g, as in Figure 5). This may well serve as the minimum credible working value ("floor"), but a virtual-certainty ("ceiling") value is also needed for a prospective crossmatch, especially when one is dealing with prehistoric timbers for which little or no independent context (e. g, historical or archeological data) exists to back up

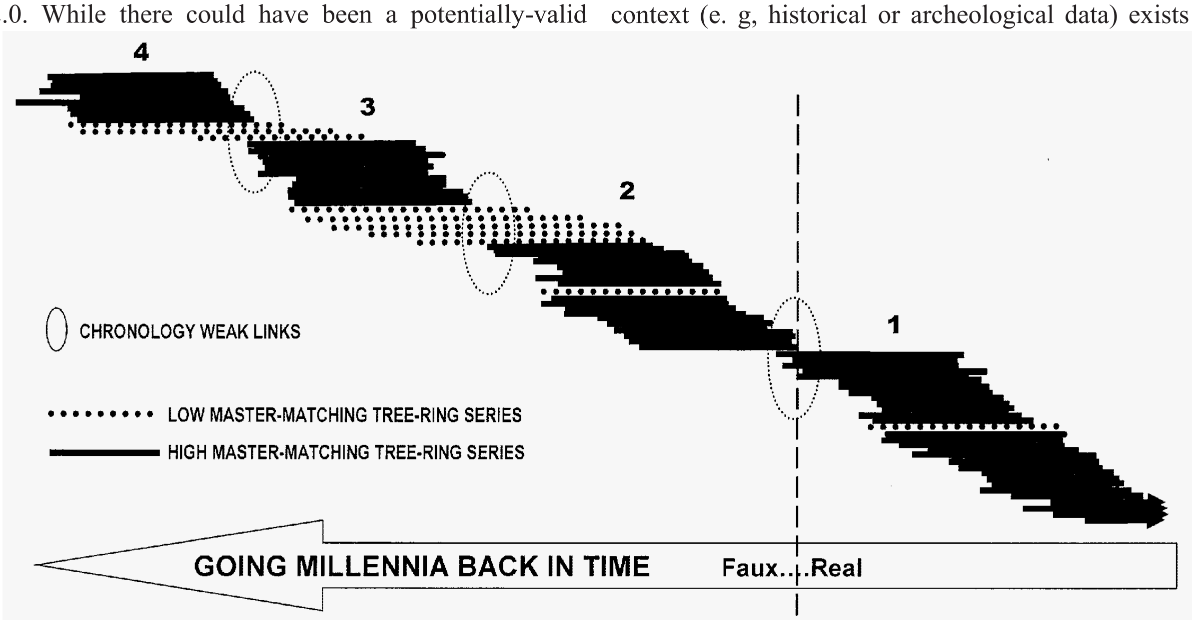


Figure 2. The Disturbance-Clustering Hypothesis. Actually-contemporaneous trees [the constituents of 1, 2, 3, and 4], now disturbance-induced to crossmatch only within their respective disturbance-imposed clusters (1)-(4), get staggered and assembled into an artificially-old long tree-ring chronology. "Bridge" series that connect the clusters may occur at sites of short overlaps [(1)-(2) junction], but more likely occur at zones where there are only "few6matchers"(*) and/or where (as illustrated) the series are relatively weakly "attached" to the master chronology [(2)-(3) and (3)-(4) junctions]. Both of the latter are suggestively identified in the actual TRN/FIN (Figure 7).

the crossmatches. Apropos to this, Larsson and Larsson (2018) suggest that the higher standard needed for the construction of prehistoric chronologies be realized by first using only individually-crossmatching series at P2YrsL* t≥7.0 (the "ceiling") for the first "building blocks" of prehistoric chronologies. Lesser-crossmatching series can then be added-in in conformity with the "superstructure" created by the t>7.0 crossmatches (via P2Aut*). One may make an analogy with a complex many-piece cardboard puzzle, for which no guiding "finished puzzle" picture exists. To avoid errors, it is best to first juxtapose the pieces that have very distinctive edge geometries, and then to fit-in the less-distinctively-edged pieces around the pattern created by the first-fitted pieces.

Is dendrochronology subjective? No and yes. We can think of dendrochronology as being objective at P2YrsL t≥7.0, increasingly somewhat subjective in the interval 7.0 down to 3.5, and likely intolerably subjective at t<3.5. As elaborated earlier (Woodmorappe 2003a, 2003b, 2009), the overall methodology behind dendrochronology, individual exceptions aside, is unassailable. This is easily illustrated once again. I have assembled a "motley" collection, consisting of 21 different Scots pine collections, each at least several hundred km away from its closest neighbor (916 series in total), from all over Eurasia (except Scandinavia), and allowed CDendro to freely pair-crossmatch all 916 series against each other. Many trees strongly crossmatched (for example, at P2YrsL t≥10.0) within their respective collections. Yet, out of all the 3,604 pair-crossmatches that occur at t≥6.0, only 26 were wrong (geographically impossible), and only 4 of these false crossmatches were at t≥7.0 [up to 7.3; never higher]. *Not once* did a high t-value (say, t>10.0) crossmatch occur at a position that is not synchronous with the time that the two trees lived, and *not once*, for example, did a tree from England have anywhere near a t>10.0 crossmatch with a tree from Mongolia. Were such instances to occur sporadically, individual dendrochronological results could legitimately be doubted. Were they (or their visual equivalents) to occur regularly, dendrochronology would have died in its infancy long ago.

I have conducted a comprehensive survey of TRN and FIN. Out of 22,684 FIN individual-pair crossmatches at P2YrsL t≥6.0, only 93 series pair-crossmatch others in the wrong place (Again, the correct place defined as the location in which they best crossmatch the master chronology.) Out of the 93, there are 43 having OVL*>99 years, and, of these, only 10 pass all the screening tests (the gateway statistics*: Skel-Chi2*, Besancon*, and wrstblk* 50 lag 10 r≥0.3). The corresponding figures for TRN are 17,110 individual-pair crossmatches, and 35, 10, and 3. As for false individual pair crossmatches at P2YrsL t≥7.0, I find the following: In FIN, 4 out of 11,937 total, and, in FIN/TRN combined, 8 out of 33,484 total.

The highest individual-pair false crossmatch I have ever seen, in the Scandinavian long chronologies, out of tens of thousands, is at P2YrsL t=8.2 at a modest 82-year overlap: TRN 0022027A (-916 -834) vs FIN FIL8839 (-3194 -3005). [This false pairing is part of the last false ensemble shown in Table 2.] To put this t-value, and all the foregoing others, in perspective, note that many individual pairs of trees, in all three long chronologies, crossmatch with each other at t=10, 15, and even more, and moreover often do so at

Table 1. Data of the Faux Master Chronology Made From Imperfectly Experimentally-Perturbed Subfossil Trees, Each of Which is Conventionally Dated in a Different Era of Time. In the 15 TRN Series, the 5th, 6th, 24th, etc., ring in each original series was reduced by 75% of its original width—except those marked with gray (X). For example, the 63rd ring in series Z022097A was left alone in its original width.

TORNETRASK NONCONTEMPORANEOUS SERIES:	# RING REDUCED BY 75%					X SKIPPED					P2YrsL SERIES XMATCH WITH:	
	5	16	24	35	47	54	63	73	86	94	BEST INDIVIDUAL	MASTER CHRONOLOGY
Z019005A (4157-4058 BC)											15.2	19.2
Z0TE0559 (3139-3040 BC)											13.9	17.8
Z022131A (2736-2637 BC)											14.3	19.7
Z022097A (2498-2399 BC)							X				14.3	16.0
Z022135A (2149-2049 BC)			X				X				13.6	12.4
Z0TE0649 (1788-1687 BC)	X		X				X				13.6	11.7
Z022035A (1234-1131 BC)	X		X						X		8.0	8.1
Z023158A (773-670 BC)		X			X					X	10.3	9.8
Z0TE0049 (250-151 BC)		X									12.1	14.5
Z022175A (102-201 AD)										X	15.2	18.3
Z0TB0029 (397-496 AD)					X			X			10.7	11.8
Z0TE0939 (735-834 AD)	X								X		10.0	12.4
Z0230830 (1280-1380 AD)		X			X					X	10.4	10.4
Z0260860 (1723-1824 AD)				X		X		X			7.1	7.1
Z0240072 (1878-1977 AD)				X		X					9.0	9.2

OVL>>100 years.

The conclusion is clear. Dendrochronology, given its premises, and particularly sufficiently-high t-values (especially t≥7.0), is a valid methodology. Thus, any chronology-compressing explanation must take the conventionally-accepted crossmatching results fully into account. What is disputed in this paper is not the *fact* and the distinctiveness of the high-t crossmatches, but the exclusive climatic *interpretation*, of such high crossmatches, as pertaining to ancient trees.

The fact that false crossmatches at P2YrsL t>6.0 (examples in Figures 3 and 4, and Table 2) and especially >7.0 (as those that are part of the next-to-last ensemble in Table 2) are exceedingly rare, is irrelevant to the Disturbance-Clustering hypothesis. When it comes to constructing the "bridges", we are no longer concerned with preponderance of evidence—to the contrary. We are engaging in what may well be an extremely "cherry picking" procedure—one that is perfectly natural to the attempted linking-together of prehistoric tree-ring subchronologies (Baillie 1995).

Let us briefly elaborate on the significance of the gateway statistics. Thus far, I have been emphasizing the P2YrsL test in CDendro. It must be stressed that the prospective crossmatch, against another series or against the master chronology, must "clear the hurdle" of not one but three crossdating algorithms [P2YrsL, Skel-Chi2 (t≥4.0), and Besancon (t≥5.0)](and do all that in addition to passing the block test*, though not as strictly)--a feat made more challenging by the fact that each algorithm has a different set of invulnerabilities to occasional, slightly-high artefactual crossmatches. My surveys of TRN and FIN indicates that the Skel-Chi2 and Besancon gateway statistics, while not absolute, are nearly so. That is, only 1%-2% of series had been included, by the original investigators, in TRN and FIN, respectively, in spite of failing Skel-Chi2, and only 6% and 3% (at OVL≥100 years), respectively, were included despite failing Besancon.

The need for the high standards, described above, is clear. In a few instances, errors had been made in the past, while piecing-together the long oak chronologies. This owed to the former adoption of too-low dendrochonological standards, which had misled dendrochronologists into erroneously connecting the subchronologies together. For a history of the numerous revisions of the German Hohenheim long chronology, and related problems in the Belfast long chronology, see Larsson (2003-2018).

2. Replication of Individual Crossmatches: Their Transitive Relationship

Correctly-crossmatched tree ring sequences do so transitively, as

Table 2. Assorted Experimental Crossmatched Ensembles of Correctly- and Falsely-Matched Individual Series. (These ensembles are examples of potential "bridges" between "cores", although they can also be considered small master chronologies in their own right). All series are Scots pine, and from TRN and FIN, except: BAL (Baloos, eastern Russia), GEO (Georgia), UN (Mongolia), and VEP (Slovakia). 1F3 denotes one series falsely added to three correctly-crossmatched series, 2F3 means two correctly-matched series falsely combined with three correctly-matched series, etc. The individual crossmatches (in the matrix) are compared with the interactive crossmatches with the master chronology. The least OVL of a series, with its master chronology, is provided in the rightmost column.

FALSE ENSEMBLE TYPE	CONSTITUENTS: SPECIFIED TREE-RING SERIES WITH CONVENTIONAL DATES	MAX SAMPLE DEPTH	"BRIDGE" LENGTH (YEARS)	MATRIX P2YrsL R-RANGE T-RANGE	MASTER CHRON P2YrsL R-RANGE T-RANGE	LEAST OVL WITH CHRON (YEARS)
1F3	FIL5943 (-2798 -2648) vs [BC00002Z, MEN0434, POM7240 [1779 2004]]	3	282	0.49-0.71 6.1-7.0	0.51-0.71 6.5-9.7	50
1F2	VEP24a (1756 2006) vs [LAN004L, LAN0080 [13th-Century BC]]	2	436	0.54-0.60 6.4-7.3	0.54-0.60 6.4-10.0	94
1F2	0022151A(-3672 -3580) vs [00TN0109, 00260340 [1801 1993]]	3	207	0.54-0.68 6.0-11.7	0.56-0.65 6.5-10.6	92
1F2	FIL3114(-1032 -861) vs [KOM5986, KOM6750 [-289 34]]	3	335	0.48-0.83 6.1-22.9	0.50-0.81 7.2-21.9	159
1F3	FIL5825(-1087 -915) vs [FIL8786, FIL8803, FIL8806 [-2872 -2649]]	4	263	0.38-0.67 4.4-9.8	0.48-0.68 6.2-11.0	97
2F3	[geo0101a, geo0102b [1770 2006]] vs [FIL3074,FIL7377,FIL9117 [-2693 -2463]]	5	391	0.35-0.59 3.2-9.6	0.52-0.64 8.1-10.4	139
1F1F3	FIL8836 (-2949 -2724) vs FIL6283X (123 359) vs [KAL0690, RIE0367, TSI7919 [1880 2004]]	5	334	0.31-0.68 3.1-9.6	0.42-0.75 5.0-11.6	104
2F3	[00231102, 00240140 [1530 1701]] vs [UN16NW, UN18W, UN25SW [1795 1996]]	5	292	0.31-0.74 3.4-14.1	0.54-0.76 7.9-14.8	155
1F4	PAR7319 (1789 2004) vs [BAL002A, BAL015B, BAL023A, BAL031B [1864 2007]]	5	275	0.39-0.59 4.0-8.6	0.54-0.65 6.7-10.3	109
1F2	00260710 (1493 1775) vs wrong-offset (27 years) 00TB0269, 00261120 [1443 1789]	3	346	0.46-0.59 5.9-13.3	0.55-0.61 8.8-13.9	179
1F8	0022027A (-916 -834) vs [FIL5895, FIL6728, FIL6902, FIL8712, FIL8807, FIL8829, FIL8839, FIL8921 [-3237 -2930]]	9	307	0.31-0.66 2.7-10.1	0.49-0.74 7.0-14.9	82

described by Baillie (2015, p. 95), "If two ring patterns A and B definitely matched (without doubt), then any third pattern C which matched A must also match B at a *unique position*. If it did not, then the implication had to be that C was incorrectly matched against A. As more trees were matched, each new example could be checked against A, B, C, etc." (Emphasis is in original). However, such reciprocity in crossmatching is not the sole property of correct crossmatches, and, moreover, can occur even among series that flout virtually all other dendrochronological criteria. [This is deliberately shown in Figure 5. The initial overlap (40 years) is much too short to start a chronology. The t-values are closer to the "floor" of 3.5 (one below it) than to the "ceiling" of 7.0, and, moreover, based as they are on Cofecha, some of the higher values may be inflated. The seven reciprocally-crossmatching series generally fail all the gateway statistics. Yet, despite all these fatal liabilities, all seven series, each assigned to very different ages in TRN, all reciprocally crossmatch at the same point.]

The reciprocity of pair-crossmatches (e. g, Figure 5), especially large numbers of them, is best shown in a matrix. This is what is done by CDendro.

3. The Internals of Valid Crossmatches: The Block Test

Thus far, attention has been devoted exclusively to the *externals* of the prospective crossmatch (the overall t-value for the overlapping sequences). To be accepted as a valid, the *internals* of the prospective crossmatch must also be satisfactory: All components of the overlapping sequences should match acceptably. That is, individual segments (blocks), of one series against the other, or of one series against the master chronology, should not fall below a specified r-value. This is called the block test(*), which in practice is the wrstblk (worst block) test. In this paper, 50-year segments (blocks), successively lagged 10 years, should not fall below r=0.3. (However, some authors use less stringent criteria, such as 50 years lagged 25, while others use stricter ones, e. g, 30 years lagged 10.) It is reasoned that a false prospective crossmatch may fortuitously have an acceptably-high overall t-value, but it is less likely that its variance will also fortuitously be distributed sub-evenly within. I have examined 44 high (t≥6.0; OVL≥80 years) FIN false pair-crossmatches in CDendro, and have found that about two-thirds of them fail the 50 years lag 10 wrstblk of r≥0.3. An example of one that does is shown in Figure 3. So do nearly all the series in Table 2 (failures being slight ones).

A potentially-false crossmatch is not the only reason for preferring the exclusion of a series that fails the block test. An otherwise-qualifying series that has a poorly-matching internal segment is not a good choice for enhancing the common variance that is the main reason for building a master chronology in the first place.

However, the rejection of prospective crossmatches that contain low-matching segments is not hard-and-fast, as it is not unusual for a tree to go through decades of suboptimal response to the annual climatic signal. In fact, depending upon the judgment of the individual dendrochronologist, prospective crossmatches with even multiple low-matching segments can still be accepted as correct (e, g., Matheus 2017). The foregoing extends to low-matching-segment-containing series against the master chronology, which is further aggravated whenever the sample depth* is relatively low, and there is insufficient common variance to "iron out" some of the "misbehaving" segments.

But how often is the block test allowed to "slide" in the long chronologies? I used Cofecha quality control to identify series that contain flagged segments (defined as 50-years-lag-25-years

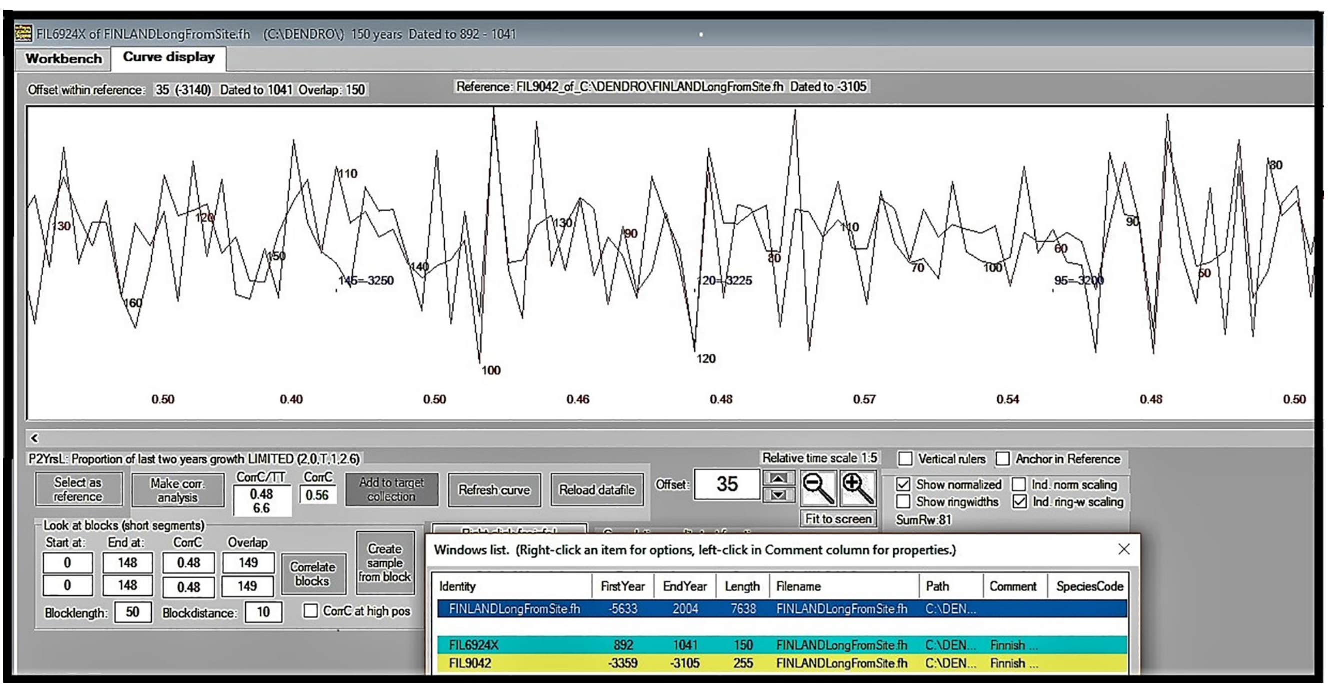


Figure 3. Screenshot of the CDendro Screen Displaying a Convincing But False Crossmatch of Two Series, From the Finnish Long Chronology (FIN), That, According to Their Placement in the Master Chronology, Had "Lived 3,997 Years Apart". The visual fit of the curves, especially at the all-important narrow rings, is good, and the internal consistency of the crossmatch is verified by the block test which shows consistently-acceptable r-values for each 50-year segment lagged 10 years: 0.50, 0.40, 0.50, 0.46, etc. The OVL is 149 years; the correlation of the two series according to P2YrsL is r=0.48 and t=6.6; the offset is 35 years.

correlating at r<0.3281 with the master chronology). With reference to MWK, FIN, and TRN, the percentages of their respective total series with at least one flag are: 9.5, 11.0, and 20.4. (CDendro does not readily lend itself to an after-the-fact examination, of a large collection, for wrstblk characteristics, so this was not attempted).

Actually, the number of identified flagged segments, based on the archived ring-width measurements I used, may be understated. Bearing in mind that very-young and very-old trees are more likely to respond poorly to the annual climatic signal, there is a tendency (personal communications) to clip off the early or late parts of a tree-width series in order to improve the overall statistical "fit", and especially to reduce the number of poorly-matching segments, of a given series, against another series or against the master chronology. It is also possible to take a sufficiently-long series, cut out a middle-situated "misbehaving" segment, and then treat the remaining "well behaved" segments as two separate series. While this procedure does not, of course, call the long chronologies into question, it does make the archived evidence for them somewhat more favorable than that in reality.

4. How Individual Tree-Ring-Series Coalesce to Form a Master Chronology

Dendrochronologists do not construct long chronologies by indiscriminately gathering thousands of subfossil samples and then determining if and how they crossmatch. They start with much smaller and locally-derived aggregations of samples, and perform the interactive procedure detailed in the ensuing few paragraphs (and executed in CDendro as P2Aut*). For example, consider the Belfast long chronology. Ten or twenty subfossil trees from a single location could make a site submaster(*) chronology that is 400-800 years length (Baillie 1995), and a single farm in Ireland could yield 50 subfossil trees that coalesce into a site submaster chronology that is 500-1,000 years long. (Baillie 2009). Eventually, such submaster chronologies became crossmatched with each other [as done, in preliminary fashion, in Figure 6], and then merged. This iterative process culminates in a single multi-millennial master chronology.

The modus operandi of building submaster chronologies is as follows (and is abbreviated P2Aut): An individual series is chosen from among the best "many6matchers"*, normally at or above the previously-stated "ceiling" P2YrsL t-value of at 7.0 (Larsson 2003-2018; Larsson and Larsson 2018). The chosen series, by virtue of the high frequency of its high-t pair-crossmatches against several other series, already contains a strong annual climatic signal, and is therefore designated the "seed"* or "kernel" of the impending submaster chronology. In CDendro, the "seed" is allowed to "choose" and "pick up" the highest-matching series to "join" it and be averaged with it (either one a time and checked by the dendrochronologist, or automatically). With the autoadd* function turned on, this averaged assembly then "chooses" and "picks up" a series that matches it well, averaging it in with the first two. And so the process "snowballs", owing to the "master chronology effect" (defined in next paragraph). Eventually, the process runs out of

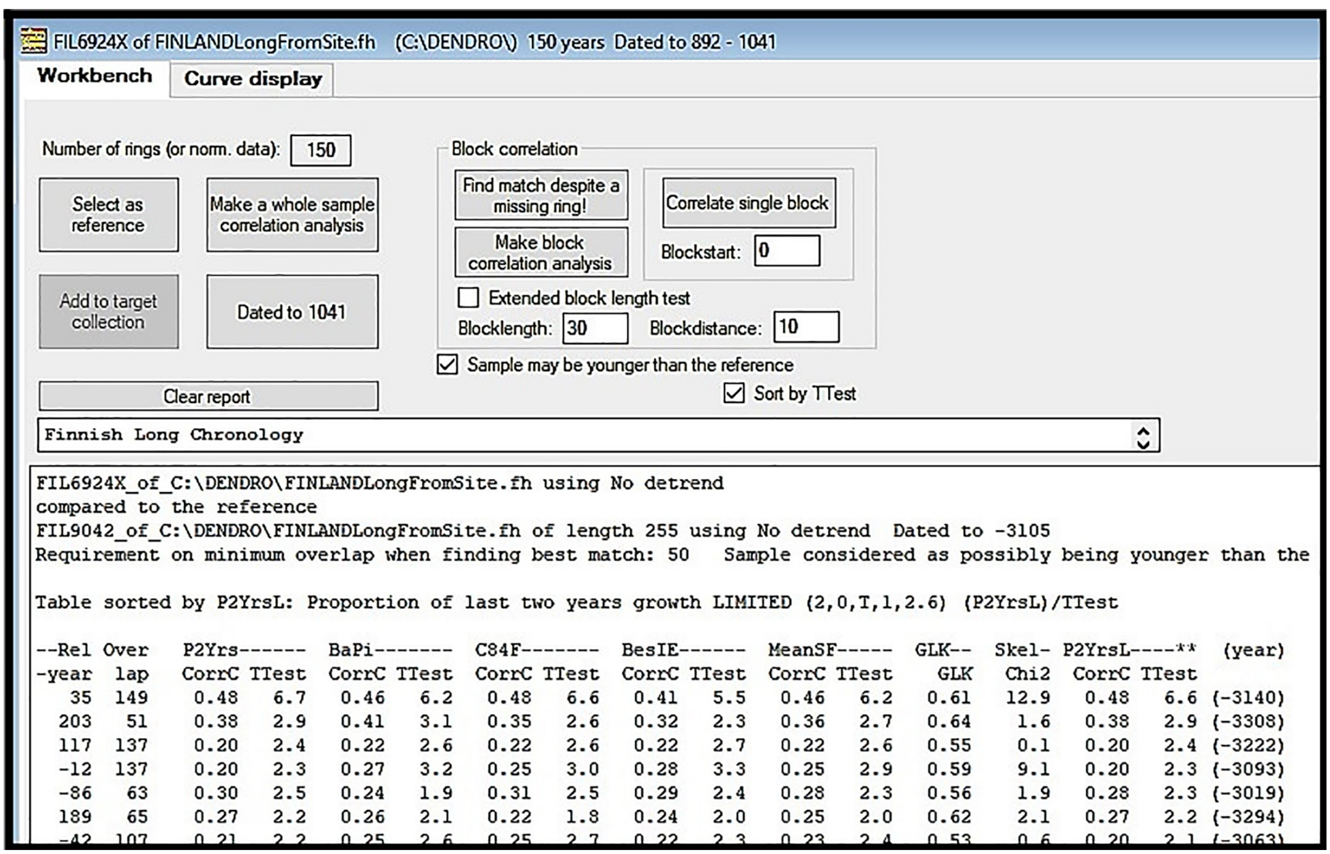


Figure 4. Screenshot Showing the CDendro Display of the Statistics Behind the FIL6924X/FIL9042 False Crossmatch in the Finnish Long Chronology (FIN) Illustrated in Figure 3. The most important numbers for the reader to follow are: The OVL, located at relative year 35, is 149 years long; the Besancon* is at r=0.41 and t=5.5; the skel-Chi2* is 12.9; the P2YrsL* is at r=0.48 and t=6.6. The gleichlaufigkeit* is a congenial 61%. Note the (observed and desirable) sharp discontinuity to the second-place (next best crossmatching position) finisher at P2YrsL t=2.9.

trees that match well with the ever-growing submaster chronology, and the dendrochronologist—if necessary--must manually add qualifying remaining series to it in order to fit them in.

Here is what I informally call the "master chronology effect*": Individual trees crossmatch more strongly (often considerably so) against a submaster or master chronology, in terms of both externals and internals, than they do against any individual tree in the collection. Brown and Baillie (2015, p. 204) explain why, "A submaster should always contain more matching signal than an individual ring pattern." (p. 204). This occurs because the averaging of tree-ring indices* tends to accentuate the common variance (climatic signal) while averaging-out the uncommon variance (noise—the individualism of constituent trees). For example, if the r-value rises from 0.6 to 0.7, it means that the noise has declined from 0.4 to 0.3. [However, the "master chronology effect" does not always hold. Series sometimes crossmatch more strongly, when paired, than either of them does with the master chronology. This happens, for example, if the trees grew close together and were crossmatched against a master chronology that was composed of trees that grew over a wide geographic area. Owing to the fact that the master chronology effect is not absolute, the fact that some of the trees, identified in Table 1 and 2, "go against" the master chronology effect, is not a matter of concern.]

Finally, it is important to realize that the "master chronology effect" implies the accentuation of *a* common signal, but not necessarily that of a *climatic* common signal. In fact, it does not even necessarily imply a passable-quality series of crossmatches (See Figure 5). Series 240760 crossmatches with the modest false master chronology that is made of the three circled falsely-matched series, at Cofecha t=7.2. This is more than it does individually with any of the three constituent series (t=5.1, 5.4, 6.4). The "master chronology" effect here is very tepid. A far more pronounced "master chronology effect" shows up in my experimental false master chronology (Table 1) and experimental false-crossmatch ensembles (Table 2), described later.

NON-CLIMATIC EXPLANATIONS OF LONG TREE-RING CHRONOLOGIES

This section reviews previous hypotheses for the compression of multi-millennial tree-ring chronologies before introducing my new one.

1. Multiple Annual Rings?

Although this idea keeps being revived (e. g, Matthews 2006), there remains no evidence that bristlecone pines can grow more than one ring per year, except when very young, as noted by Woodmorappe (2003a,b; Woodmorappe 2009). The reason is simple: If the genetics does not allow for mid-season cambial* dormancy and subsequent mid-season re-activation in non-juvenile trees, there can be no plural annual rings, regardless of the climate! In fact, we now realize that xylogenesis (the process of ring formation), determined by the start and end of cambial growth, is, in bristlecones, governed primarily by genetics, and secondarily by photoperiod (Hallman and Arnott 2015).

With C-14 factored, annual multiple-ring formation, were it to occur, would have to do so on a staggering scale. Note that the Eastern Alpine Conifer Chronology (EACC) is now over 10,000 years old (Nicolussi et al. 2015), and several other long chronologies are not much shorter. So, as a working hypothesis, given the Noachian Deluge at 3,000 BC and time-accurate C-14 dates beginning no later than 2,000 BC (as presumably governed by archeological and historical constraints), this means that at least 6,000 rings had to form in just 1,000 years, and then in a near-perfect lockstep manner. This appears extreme. A more-realistic

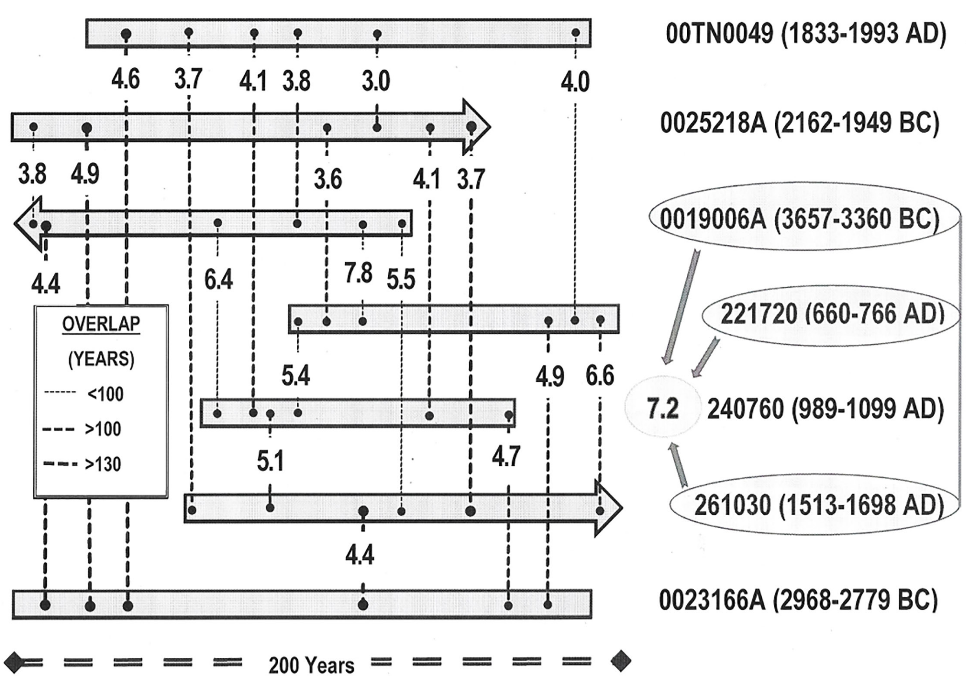


Figure 5. Seven All-Falsely-Placed Yet Reciprocally-Crossmatching TRN Series, According to Cofecha: All But One Crossmatch Occurs at the Traditional Minimal Threshold of t≥3.5. A modest "master chronology effect" develops (Series 240760, at 7.2, against the average of the three series in ovals). All this exists despite the fact that the seven-member ensemble flouts nearly all other dendrochronological criteria!

chronology-compressing welter of multiple annual rings, if it could occur, would require their deployment in specific patterns that cause repeated "collapsing antenna" series-sliding crossmatches of tree ring sequences with each other. This, too, is uncharted territory.

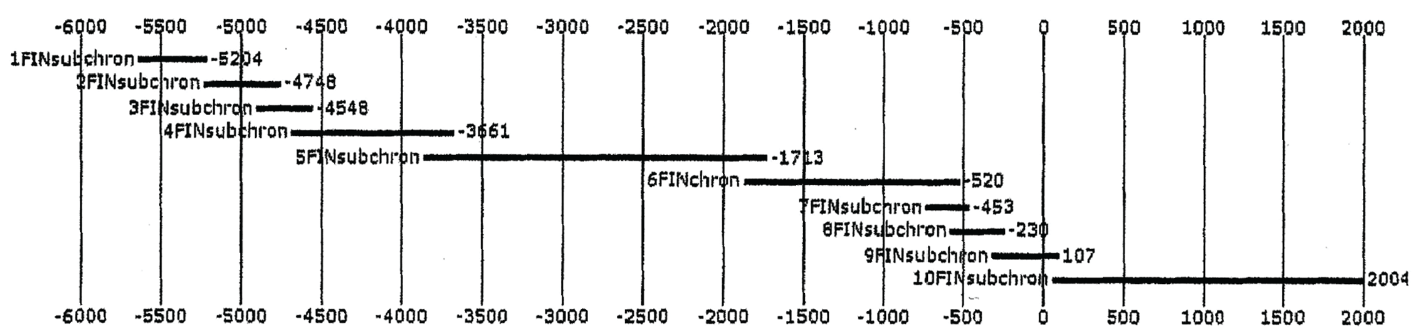
Multiple annual rings, moreover those occurring on a sustained , extensive scale, have no chance of realization unless the genetics of bristlecone pines, and that of all the other long-chronology-forming trees, was very different after the Flood from what it is now. Interestingly, the oldest bristlecone pines tend to show larger rings than all but the most recent ones (Salzer et al. 2009), and the latter is interpreted in terms of (what else?) climate change. Could it, instead, mean that older bristlecone pines were governed by a different set of genetic "rules" from their more recent counterparts?

Unfortunately, it appears that virtually nothing is known about the genetics that govern multiple-annual-ring-formation, much less about how any such genetics could potentially change over time scales limited to a few thousand years. Until this at least begins to happen, it behooves us to work with more productive hypotheses that do not depend upon multiple annual rings, and that is what I have been doing.

2. Disturbance-Caused Narrowings and Widenings of Individual Tree Rings

Many different environmental influences (for example, waterlogging or chemical poison: Baillie 1995) can cause the ring growing a particular year to be either narrower or wider than it would have been if determined primarily by the growing season's climatic signal. This, by itself, is unremarkable. Such alterations are normally too episodic in time and too discordant, from tree to tree, to overprint the climatic signal that governs the crossmatching of trees, much less to create convincing alternative crossmatches. My research focuses on what happens if they did.

But how difficult would it be for a physical process to "overrule" the annual climatic signal? Not difficult at all, as I once found out. (One can be heartened by the fact that some of the greatest scientific discoveries have come about by accident.) When I had begun my studies of dendrochronology decades ago, I had incorrectly saved a tree-ring-width file as Word (.doc) instead of .txt. Cofecha "forgave" my mistake, read the file, and performed the crossmatches—but only after mutilating the data. The results were astonishing. The highest crossmatch was an obviously-false one—but at an extraordinarily-high t>13.0. It turned out that Cofecha had arbitrarily changed every tenth ring to a zero-value before performing the crossmatching operations. The cyclicity in the data was apparent: Each next-best crossmatching point was offset ten years from the previous one, and, instead of one clearly-demarcated high crossmatching value [as illustrated in Figure 4], there was an obviously-cyclic descending "staircase" of high t-values (13, 9, etc.). All this, of course, was dendrochronologically nonsensical, and so it disqualified this specific mechanism from being considered further. Yet this salient fact remained: Impressively-high but totally-false crossmatches could be generated from relatively infrequent changes in tree ring series that ordinarily would never plausibly, much less strongly, crossmatch with each other. This inadvertent finding established a "probable cause" for the tree-ring disturbance alternative, and became the



10 checked members, Collection dated to -5633 2004			
Member Id	**Rings**	**Start Year**	**End Year**
1FINsubchron	430	-5633	-5204
2FINsubchron	479	-5226	-4748
3FINsubchron	342	-4889	-4548
4FINsubchron	1016	-4676	-3661
5FINsubchron	2142	-3854	-1713
6FINsubchron	1333	-1852	-520
7FINsubchron	269	-721	-453
8FINsubchron	350	-579	-230
9FINsubchron	420	-312	107
z10FINsubchron	1935	70	2004

Figure 6. My Reconstruction of the Entire Finnish Long Chronology in Terms of Submaster Chronologies That Are Created by P2Aut* Entirely at t≥7.0. A few subchronologies (#3-#4 and #6-#7) already crossmatch adequately with each other, and so are ready to be merged. But some have OVL* too short for crossmatches (#1-#2 and #9-#10). The remainder (#2-#3, #4-#5, #5-#6, #7-#8, and #8-#9) have correctly-located crossmatches that flunk one or more gateway statistics*. Thus, seven of the nine junctures are in need of additional (manually-added) series before their crossmatches become adequate so that all ten subchronologies can be merged into a single near-8,000 year chronology. [The "z" is not a typo: It serves an alphanumeric-sorting purpose.]

inspiration for my experiments and hypotheses in this and earlier works (Woodmorappe 2003a, 2003b, 2009).

To test my finding, I attempted to evaluate the crossmatching characteristics of a handful of privately-acquired tree ring measurements from obviously-disturbed trees. It was encouraging to see some of them adequately crossmatch with each other in an obviously climatically-nonconformist manner. Unfortunately, however, ring sequences from disturbed trees are not archived for general usage, and hence my pilot study could not be expanded to any meaningful decree. I also learned, from personal communications with dendrogeomorphologists, that no studies had ever been conducted on non-climatic tree-ring crossmatches caused by subtle disturbances (or even by obvious disturbances). This is not surprising, as research in general tends to be paradigm-driven, and nothing in uniformitarianism prompts curiosity in such crossmatches.

Owing to this disappointing lack of basic research on the relevant phenomenon, my dendrochronology works are necessarily theoretical. However, a lack of direct evidence for the mechanism behind a suspected process should not tempt one to discount the process itself. Gregor Mendel is instructive. He discovered the laws of genetics even though the specific modus operandi had to await the emergence of cytological and molecular genetics nearly a century later.

An important clarification is in order. The kind of geomorphic disturbances envisioned in this, and my earlier papers, should not be confused with the usually-severe ones normally utilized in dendrogeomorphic studies. The latter features tree deaths, multiple-year suppressions followed by many-year recoveries in the obviously-injured trees, wood-vessel anomalies, tilted tree-trunks and ensuing growth-ring asymmetries, the formation of reaction wood, etc. None of these severe "insults" usually apply here. In contrast, and according to the classification scheme of dendrogeomorphologists Stoffel and Corona (2014, p. 10), we are dealing with what they call "weak GD (growth disturbances)." These are defined as disturbances that are limited to decreases in ring width <60%, growth-release increases in ring-width <50%, and growth suppressions and releases limited to only a few years each. Such mild disturbances are "under the radar": That is, they usually are subsumed under the guise of the normal climate-governed tree-ring formation, and hence normally go unnoticed in conventional dendrochronology. Also for this reason, they are of no interest to dendrogeomorphologists. Yet they are at the heart of the two hypotheses discussed here.

The foregoing statements do not mean that the postulated disturbances left no independent evident of their occurrence. Far from it. For instance, the oaks comprising the European long chronologies regularly display a striking pattern of normal growth interspersed with prolonged growth depression (reviewed by Scharnweber et al. 2015). The root death that commonly initiates the bark-stripping modes of growth in bristlecone pine is often associated with soil disturbances (Boyce and Lubbers 2011). At other times, the "collateral damage" from the postulated disturbances, though of course not conventionally recognized as such, is even more extreme. Prehistoric tree samples in chronology-building routinely have a rejection rate of 10-25% and even 40-45% (Brown and Baillie 2015; Edvardssson et al. 2012; Eronen et al. 2002; Krapiec and Szychowska-Krapiec 2016; Woodmorappe 2003b). Even if visually normal, they had evidently been so traumatized that they are not cross-datable at all.

Significantly, disturbances that perturb tree ring growth are quite variegated. For example, Malik et al. (2016) showed that slow-moving time-transgressive landslides can proceed as little as 1 cm a year, and cause surface displacements so inconspicuous that they show no geomorphic evidence of their existence, and show up only in the tree rings. The disturbances themselves can be shallow or deep-rooted, mediated or not mediated by external factors (rainfall, pore-water pressure, height of the water table, etc.), and take place in regoliths of widely divergent compositions. For these reasons alone, the postulated disturbances, in my two hypotheses, are broadly applicable.

3. Demystifying the Migrating-Disturbance Hypothesis

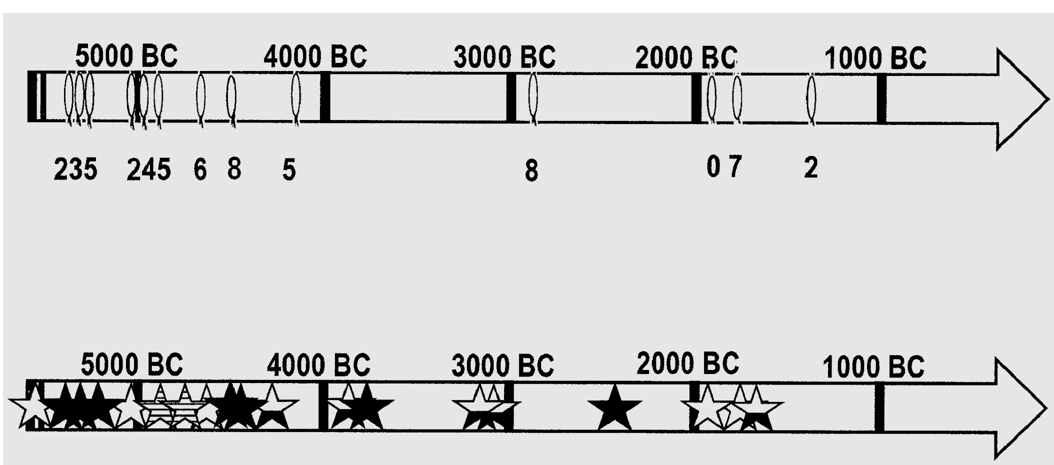


Figure 7. "Weak Links" in the 5633BC—1000BC Interval of the combined TRN and FIN (790 Series Total; Each At Least 100 Years Long). Top: Lacunae in the chronology that appear upon the successive removal of the worst "Few6Matchers"—that is, series having only (0, 1, 2, … and then 8) crossmatches, with other series, at P2YrsL t>6.0. Bottom: Lacunae in the chronology that appear upon the iterative removal of series with relatively low crossmatches with the master chronology; that is, at P2YrsL t<=10.0 (white star), <=11.0 (striped star), <=12.0 (half-black star), and <=13.0 (black star).

This hypothesis, described earlier (Woodmorappe et al. 2003a), has led to misconceived over-reliance on the notion that sequences of disturbances, affecting tree rings, had necessarily repeated *in time*. While events that recur at quite-regular intervals do occur in nature (e. g, Hurwitz et al. 2014), and theoretically remain a viable possibility in terms of a complex series of tree-ring-altering events literally-repeating and geographically-migrating on a time scale measured in centuries, they are distracting by virtue of their complexity, and are totally unnecessary to achieve the required outcome. For this reason, they are not considered further in this paper.

A time-transgressive set of the *same* sequence of events, sustained over centuries and covering appreciable geographical distances (Figure 1; explained below), suffices. Examples of known time-transgressive ring-perturbing events are those of rising floods causing narrowed rings in different trees at different times (Ballesteros-Canovas et al. 2015), and that of narrowed rings caused by slowly-moving landslides impacting the roots of trees at different times (Stoffel and Corona 2014).

The migrating disturbances can be entirely subterranean, as in the case of groundwater. Although groundwater acting in "staccato" manner has apparently not been investigated, the effects of groundwater, on tree-ring growth, are known to be quite diverse. Thus, for example, tree growth is inhibited by both a "too dry" and "too wet" substrate (Scharnweber et al. 2015). The widths of individual tree rings can correlate with yearly levels of groundwater, as well as rainfall, whenever the water table fluctuates between just-within and just-beyond the reach of tree roots. (Gholami et al. 2015). Now, if groundwater level could be decoupled from annual rainfall, and "pumped" by underground forces whose loci of action migrate over centuries, it could lead to centuries-paced pulses of growth-reducing and/or growth-enhancing groundwater that are reflected by a time-transgressive pattern of ring alterations.

The foregoing hardly exhausts the possibilities of time-transgressive individual-ring-altering sequences of events. For instance, they could be biological in origin (See *Future Research*).

The Migrating-Disturbance Hypothesis is most applicable to MWK. There the trees all grew close to each other, and the crossmatched series, with some exceptions (Woodmorappe 2003a), feature very long (sometimes >1,000-year) OVL with each other.

Here is a necessarily-simplified description of the Migrating-Disturbance Hypothesis in action (Figure 1):

A series of six bark-to-pith cores, from trees, are shown being "over-written" by migrating disturbances in the first few centuries after the Flood of 3000 BC (first row, left and center). Then the same six are shown in the later centuries after the Flood (second row, left and center). As shown in top-left, a series of disturbances (ABCD…EFGH…, etc.) had formed between the trees, and are migrating leftward. The leftmost tree's core has just been marked by ABCD and the second-left one with EFGH. And so on.

This process continues over the centuries. With reference to the second row, the tree originally shown affected only by ABCD (at top-left) is now marked with ABCDEFGHJ (bottom left). It will soon additionally be marked with KLM. And so on. Some trees (bottom row, second one from the right) had not been entirely overwritten by disturbances. The unaffected parts can still crossmatch in accordance with the normal annual climate signal. The unaffected ends crossmatch with the younger climate-governed trees, and serve to "root" the disturbance-crossmatching trees with the entirely climate-governed trees starting at about 2000 BC (topmost right).

The end result (far right) is a long tree ring chronology that seems to begin before 6000 BC even though none of its constituents are any older than some date between about 2000 BC and 3000 BC (the Flood). Had the forgoing-described migrating-disturbance process not taken place, all of the cores/series shown in Figure 1 would have crossmatched with each other, in accordance with the annual climatic signal, at 2000-3000 BC (top far-right).

4. An Introduction to the New Disturbance-Clustering Hypothesis

The Disturbance-Clustering hypothesis dispenses with the temporally- or geographically-repetitive disturbances of the Migrating-Disturbance Hypothesis. Instead, a series of geographically-static, geography-demarcated sets of disturbances are the ones that erase the conventionally-expected climatically-induced crossmatches. The affected trees themselves now crossmatch only within their respective "bundles", and these "bundles" can get connected in a chain that comprises the artificial pre-3000 BC part of the long chronology.

Here are the details (Figure 2). Some trees had undergone distinct disturbances in what (not shown) can be called the geographically-demarcated regions [2], [3], and [4]. Because of this, the respectively-overprinted trees, shown as constituents of clusters [2], [3], and [4], now strongly crossmatch with each other, but not with trees of any other cluster, or with the remaining unaffected climatically-crossmatching cluster [1]. During conventional dendrochronology, the "clusters" ([1]-[4]) become the nuclei of the submaster chronologies. In time, these clusters become "bridged" into a chain. The "bridges" consist of a combination of fortuitously-crossmatching individual series, small ensembles of validly-and invalidly-crossmatching series, and by fortuitously-crossmatching randomly-disturbed tree ring series that do likewise. The "bridges" are illustrated by ovals in Figure 2. The clusters ([1], [2], [3], [4]), heretofore disjointed, became connected together in an artificially-long chronology. This faux chronology ostensibly began anywhere from a few to several thousand years—potentially more--before 3000 BC, but is actually composed of trees that had grown at or about the same time (and after ~3000 BC).

TREE-RING CHRONOLOGY-BUILDING IN THE LIGHT OF THE DISTURBANCE-CLUSTERING HYPOTHESIS

This section describes the modus operandi and workability of my new hypothesis.

1. The Experimental Construction of a Perturbed-Tree False Master Chronology

Earlier work (Woodmorappe 2003a) had shown that decadally-spaced ring alterations are sufficient to force two individual bristlecone pines to anomalously crossmatch with each other. Would this also occur in other trees? More important, how difficult would it be for disturbances to so profoundly transform

the crossmatching characteristics of *numerous* tree ring series such that they would all decisively "come together" into a strong master chronology (the clusters/ "cores" of the Disturbance-Clustering hypothesis), all the while satisfying all of the other dendrochonological criteria (gateway statistics) for correctness? To help answer these questions, fifteen TRN series were selected that supposedly lived at very different times (Table 1). Each was limited to about 100 years in length in order to alleviate the labor-intensiveness of the experimental procedure. Roughly one ring per decade was perturbed (the 5th, 16th, 24th, etc., of each respective series). The intervals between perturbations were eyeball-chosen so that no obvious repetition (cyclicity) be introduced in the ensuing crossmatches (later verified by the absence of obvious stepwise-recurrent patterns of the OVL, of successively weaker potential crossmatching points, as identified by CDendro). The first letter or number of the series identification, for the experimentally-altered trees, was changed to "Z" in order to distinguish it from the original series in the TRN collection.

The ring widths chosen for experimental perturbation ring were arbitrarily but consistently reduced to 25% of their respective original values. (Greater reductions of original ring width, which probably would have yielded more distinctive results, were avoided in order to avoid potentially-skewed results—a lack of skewing later verified anyway by the results of the small-ring-insensitive P2YrsL and Besancon algorithms in CDendro.)
In order to evaluate the robustness of the Disturbance-Clustering hypothesis, in the face of disturbances that potentially fail to materialize, several of the series had intentionally-omitted disturbances, at a rate of 1 in 10, 2 in 10, and then 3 in 10. (More than 3 in 10 was not attempted). All fifteen of the series were first crossmatched individually.

Fifteen trials were conducted using the CDendro P2Aut at t≥7.0, with all 15 series allowed, in turn, to serve as the "seed". This was done in order to unmask any dependence upon the order of added series. In order to further test the sensitivity of the master chronology—this time in terms of fully-disturbed constituents (or lack thereof)--this experiment was repeated with the involvement of only those twelve series that contain omitted disturbances. The "seed" was Z022135A, which lacks 2 of the 10 experimentally-inflicted disturbances.

2. Results and Implications of the Experimental False Master Chronology

Without the experimental alterations, the fifteen ostensibly-noncontemporaneous series, at the attempted single-pair trial crossmatching at the full-length 99 or 100-year overlaps, are nonexistent (with (r) usually far less than 0.3 and (t) usually far less than 3.0) as conventionally expected. Now, thanks to the alterations, most of the pair-crossmatches are more than satisfactory (P2YrsL t>7.0 and often >>7.0). This significantly extends my earlier preliminary results from bristlecone pine.

The experimental outcome of the false master chronology (Table 1) surpassed my wildest expectations. Merely one 75%-reduced ring-width, consistently spaced per decade from tree to tree, is all that it took to induce all fifteen series to coalesce into a robust but false master chronology. Moreover, all the altered series now crossmatch, usually at high-t levels, with the faux master chronology they have created, and with nearly all in full accordance with the multiple CDendro crossdating algorithms. [The last listed series fails Skel-Ch2, and the last two listed series fail Besancon, though not by much (4.5 and 4.7).] What's more, the average r-value (not shown), for the individual series' crossmatches (excluding itself) with the master chronology, is an impressive 0.77.

The internals of the series/master crossmatches (not shown) are also outstanding. Virtually all 50-year-lag-10 segments correspond to their opposites at the block test (50 years lag 10, r≥0.30).

The series that comprise the faux master chronology clearly "belong" with each other. Any of the fifteen series can be chosen as the "seed", and the results are identical. In fact, the same 13 of the 15 series are always "attracted" to the "snowballing" master chronology, at the highest default settings, regardless of the chosen "seed". This indicates that at least 13 of the 15 constitute a "natural" assemblage, whose members instantly "recognize" each other. Note that this instant "self-recognition" is a characteristic of the "cores" of actual submaster chronologies, and that this process maps perfectly unto the "cores"/clusters of Figure 2.

Most fascinating of all, both the individual-crossmatching and P2Aut master-chronology self-construction function even when (at least) 3 out of 10 of the experimental ring-width reductions were omitted! That is, the "seed" successively picked up all the series. (Table 1). In fact, the "seed" picked up one of the three the 3-of-10-omitted series even while at the highest-standard P2Aut default setting (P2YrsL t≥7.0). The significance of this missing-disturbances-irrelevance is vividly evident: The postulated disturbances required by the Disturbance-Clustering hypothesis could be quite inexact and yet be fully effective!

What's more, the P2Aut process is not dependent on the presence of *any* series having a complete set of disturbances. The twelve series containing omitted disturbances alone freely "come together" into a robust master chronology. Furthermore, their respective crossmatches towards this 12-member false master chronology differ only slightly (usually ~0.5-1.0 less) from those of the entire fifteen-series-ensemble, against its master chronology (as shown in Table 1).

Finally, whether a series has 3 of 10 disturbances omitted (3/10), as opposed to 2 of 10 omitted (2/10), does not, by itself, predict its falling short of the gateway statistics. Thus the last-listed series, Z0240072, the only one that fails both Besancon and the crucial Skel-Chi2, is at 2/10, in contrast to the remaining three 2/10 series that pass with flying colors. At the same time, series Z023158A, despite being 3/10, does also. In fact, out of the 15 series, it ranks 11th highest in terms of average t-value, against all the other series, in the matrix. All of this suggests that the success of series with many omissions (3/10, perhaps even more), in crossmatching, is as much governed by the vagaries of the remaining undisturbed rings as it is by the magnitude of the omitted disturbed rings.

Of course, it is not expected that crude one-per-decade perturbations, for the series involved, shall satisfy every single characteristic of a good master chronology, and they do not. CDendro displays the FIN and TRN master chronologies at annual resolution, showing the mean, upper standard deviation, and lower standard deviation,

of all the indices for every single year. A narrow channel between the upper, mean, and lower curves indicates that the indices agree well, with each other, for that year: A wide channel indicates that they are quite discordant. Not surprisingly, the master chronology for the perturbed series (Table 1) exhibits wide channels, except for the experimentally narrowed rings. However, my examination of the TRN and FIN master chronologies shows that wide channels do occur naturally (albeit sporadically and on a few-decades scale), notably at 5076-5086 BC in the combined TRN/FIN master chronology (not shown).

3. Individual Series, in Various Combinations, and Their Role as "Bridges" Between "Clusters"

The ability of convincing but fortuitous <100 year and especially <50 year OVL crossmatches to arise is unremarkable: It is called the "segment-length curse" in dendrochronology. Yet convincing false crossmatches are not limited to short overlaps, and I have identified a number of them. For example, there is one with considerable overlap (149 years), of a pair of trees, in FIN, that had ostensibly lived thousands of years apart (Figure 3 and 4 screenshots), and this pair-crossmatch satisfies all the gateway statistics, including the block test. Interestingly, both the P2Yr and P2YrL are nearly the same as the T-statistic from COFECHA--6.8, the latter of which, as noted earlier, is suspected of sometimes giving inflated t-values. Additionally, the gleichlaufigkeit*, though not usually important in the acceptance of crossmatches as valid, is above the minimally-informative 60%.

The success at identifying credible but false pair crossmatches inspired me to expand the research to ensembles consisting of more than two falsely-crossmatched series and/or assortments of correctly- and incorrectly-crossmatched series. The results (simulated "bridges") are summarized in Table 2, and discussed later.

Of course, dendrochronologists would not have accepted the mistaken crossmatch, shown in Figure 3 and 4, as valid, because of the elementary fact that the two involved series each match the master chronology better, as placed and dated, than they do each other in the shown pairing-crossmatch. However, were it not for the existence of TRN/FIN chronologies, the crossmatch shown in Figure 3 and 4 would likely be accepted as valid.

Let us look more closely at the existent/nonexistent concept raised in the previous paragraph in order to appreciate its importance in the Disturbance-Clustering hypothesis—specifically to the generation of "bridge" series. Initially, most if not all trees growing in the first millennium after the Flood (3000 BC to 2000 BC) likely crossmatched with each other according to the usual common climatic signal. After the "clusters" formed as specified, some individual trees likely escaped this process, and thus continued crossmatching with the few remaining unaffected climate-controlled trees, just as before. However, in the case of time intervals in which virtually all series were disturbed, the few undisturbed "survivor" series no longer had a chronology to match towards. They had thus been "released" from their "obligation" of "fitting-in" with a chronology. That is, they could now freely crossmatch towards each other (as illustrated in Figure 3 and 4), or to become part of crossmatching ensembles as illustrated in Table 2. Some of these ensembles encountered particular spots of satisfactorily crossmatching with some "cluster" of disturbed series. Depending upon the location of the crossmatching point, they either became "padding" that merely added to the local sample depth, or they became the crucial "bridges" that connected two "clusters" together. To pursue the analogy with the cardboard crossword puzzle, imagine someone taking scissors and cutting the pieces, thereby destroying their edge-matching characteristics. Thus, any and all previous fits of the puzzle pieces are now irrelevant: The pieces now fit in accordance with how they had been cut [disturbed: Table1]. Any stray pieces that had escaped the cutting no longer have to "fit-in" with the better-fitting pieces: They can now freely fit amongst themselves [Table 2] and to fit with the newly-cut edges of the new-fitting mutilated puzzle pieces [as "padding"], even connecting [as "bridges"] these mutilated assemblies together, eventually forming a long chronology.

One of the challenges in constructing the false ensembles (Table 2) had involved the choosing of series that would not incur the "warning low-outlier effect*" upon their inclusion. An even bigger challenge was to avoid series with conspicuously-poor pair-crossmatching tendencies, in the matrix, against other series. This extended to the avoidance of obviously bifurcated* collections in the matrix. All of series involved, in each matrix summarized in Table 2, had to crossmatch at r≥0.3, at OVL≥50 years, in order to be included. To keep this challenge in perspective, note that many series in the respective matrices consisting of all series of TRN, FIN, or TRN/FIN combination, are below r=0.3, and quite a few of them are flagged by CDendro (as "Bad Dating") by falling below r=0.2. As for bifurcated collections, these, although preferentially avoided, are not necessarily indicative of false assemblages. They can occur naturally whenever two sets of trees grew at significant distances from each other. For instance, the combining of TRN and FIN, done in order to complement the intervals of low sample depth in each (Larsson and Larsson 2018), is actually a double-edged sword. The geographic distances between TRN and FIN cause a bifurcated collection: TRN series have many high pair-crossmatches amongst themselves, and the same is true of FIN series amongst themselves, but few individual TRN series and individual FIN series pair-crossmatch strongly with each other. Furthermore, quite a few TRN series glaringly "stand out" in the matrix owing to their row-after-row asterisk-marked "Bad Dating" against many FIN series. Bifurcated collections can also result amongst the constituents of P2Aut. Consider "seed" FIL KOM6750 (-289 34), which, incidentally, forms Subchron 9 (Figure 6). The 19 series involved, when displayed in the matrix, include series FIL6236X and PIT5494, which form almost-opposite tendencies of crossmatching strongly with one set of series but not the remainder of them.

Let us now focus on the 11 false master chronologies (potential "bridges") in Table 2. The ensembles include those with large (>150 year) OVL's with their respective master chronologies. Sample depths equal or greater to 5 are readily achieved. The largest master chronology effect observed, despite the fact that they all are small collections, was an improvement of 4.8 (last entry). The first three listed ensembles have constituents that all crossmatch individually, within each respective ensemble, at P2YrsL≥6.0. Although my

self-imposed lower limit for inclusion, in Table 2, was r≥0.3, some of the ensembles have a minimum matrix pair-crossmatch at r≥0.4 or even 0.5.

REVERSE-ENGINEERING THE PRE-1000 BC PART OF THE SCANDINAVIAN LONG CHRONOLOGIES

The conventional presentation of a long chronology, as a fait accompli, can create the mistaken impression that the evidence behind it is equally sound in all parts of it. It is not. This section deconstructs the TRN and FIN. It then necessarily-tentatively relates this to the "clusters" and "bridges" of the Disturbance-Clustering hypothesis.

1. A Re-Derivation of the Entire Finnish Long Chronology

Larsson and Larsson (2018) claim that the entire FIN can be reconstructed almost entirely by the P2YrsL t≥7.0 P2Aut alone. That is, submaster chronologies are created, overlapped, and then merged. This creates three large submaster chronologies that cover the youngest 6,500 (that is, all but the first few centuries) of FIN. Only some manual adding of series, at P2YrsL<7.0, is then needed to "suture" all these together.

Owing to the fact that Larsson and Larsson (2018) did not publish any details on this, I have attempted my own P2Aut t≥7.0 reconstruction of the entire FIN, and have evidently obtained at least roughly comparable results (Figure 6). The PAut process generated 10 submasters of varying length, having "picked up" a given series only once. Some of the submasters edge-crossmatch at P2YrL ≥7.0, while satisfying all other criteria, and do so at their expected points. These can straightforwardly be merged together. Others have crossmatches at the expected points, but the crossmatch cannot be accepted because one or more of the gateway statistics is too low. Finally, a few of the junctures between submasters have too short an OVL to even attempt a crossmatching. In summary, most of the nine junctures need manually-added-on series, at increasingly lower-standards, before the crossmatches can be sufficiently high to justify a merging of all the subchronologies into one grand near-8,000-year long master chronology.

Now consider what happens when this entire exercise is repeated, this time allowing TRN as well as FIN series to be "available" to the same "seeds" as formed the subchronologies shown in Figure 6. Moreover, this time I allow for each series to remain eligible for "picking up" by more than one "seed". The subchronologies become noticeably longer, eliminating the junctures of insufficient OVL for crossmatching, except for the 5226 BC 5204 BC junction (again, possibly to be filled with a new collection).

Although the ability of P2Aut to re-create nearly the entire FIN at first seems impressive, it actually encompasses a good deal of "hollowness" in TRN and FIN. This "hollowness" is identified in the remainder of this chapter. Again, this does not call into question the validity of the long chronologies, but it does "lower the bar" for the Disturbance-Clustering hypothesis to account for them.

Let us first focus on P2aut itself. Larsson (2003-2018) states that, as long as t≥7.0, autoadd never "picks up" a wrong TRN or FIN series to attach to the emerging master chronology. I have made many "runs" of P2Aut using different "seeds", and, based on my own experience, tentatively agree. However, such an outcome is far from absolute. As elaborated earlier regarding Table 1, perturbed series readily get "picked up" at P2Aut t≥7.0, moreover regardless of which disturbed series serves as the "seed". Moreover, as it turns out, this "false recruitment", at t≥7.0, is not limited to known-disturbed series. Let us temporarily consider the entries in Table 2 not as prospective "bridges" but as embryonic master chronologies in their own right. I have found that, in the last entry of Table 2, all eight remaining series are "picked up" by the autoadd process, of P2YrsL≥7.0 and OVL≥70 years (P2Aut), provided that "interloper" TRN series 0022027A is allowed to serve as the "seed". In the fourth listed series, both remaining series will be "picked up" if the "seed" is either KOM5986 or KOM6750. Finally, in the next-to-last entry, both remaining series are "picked up" regardless of which of the three series is chosen as the "seed".

Next, we must ask how P2Aut relates to the pair-crossmatching capabilities of the "picked up" series. It has been suggested that it does not matter if many of the series in the matrix pair-crossmatch at low levels (P2YrsL t<6.0), as is the case with TRN and FIN, as long as the assembly found in the matrix had arisen entirely from a P2Aut at t≥7.0. However, apart from dubiously treating P2Aut as an absolute (which, as we have just seen, is not so), such an approach glosses over the poor pairwise-crossmatching quality of many "picked up" series, as is obvious by looking at the TRN and FIN matrices. Note that, in a number of modern large Scots pine collections I have surveyed (those of Baloos eastern Russia, Mongolia, Georgia, etc.), most of the series, "picked up" by P2Aut t≥7.0, pair-crossmatch in the matrix at P2YrsL t>6.0. However, this is not the case for the series in the older parts of TRN and FIN. That is, for the 790 TRN/FIN (L*≥100 years) pre1000 BC series, the P2YrsL t>6.0 matrix crossmatches (those at OVL≥50 years), pertaining respectively to TRN, FIN, and combined TRN/FIN, are relatively few, and as follows: 26%, 46%, and 32%. For P2YrsL t>7.0, the respective figures are only: 13%, 30%, and 19%.

Thus far, I have considered TRN and FIN, in terms of relative numbers of "few6matchers*" and "many6matchers*" only in an overall sense. However, it turns out that that the same liability holds for the "strong" subchronologies that are created solely by the P2Aut t≥7.0 process. To make the strong-subchronology exercise even more challenging, I focused on just the most robust part of the pre-1000BC FIN/TRN chronology—that is, the interval from about 2000 BC to about 4000 BC (identified as such by Larsson and Larsson 2018, and also so identified by my own experimentation, which is later discussed in conjunction with Figure 7). I chose as the "seed" FIL6741 (-3503 -3204), and performed P2Aut, under the restrictive chronology-starting condition of each candidate series crossmatching with the emerging master chronology at P2YrsL t≥7.0, and OVL≥90 and then ≥70. This CDendro procedure "picked up" and averaged 305 series, into a master chronology, before running out of qualifying series. It thus constructed a 2,142-year-long submaster chronology (-3854 to -1713), which is shown in Figure 6 as Subchron 5.

Let us consider the matrix with its individual-pair crossmatches of the 305 "picked up" series. I had CDendro rank them (left to right, in descending order, recognizing only OVL≥50 years) as follows: The best "many6matcher" (with 52 of them) down to the worst "few6matcher" (with 0). The descending order showed an exponential decline not only in the numbers of "many6matchers",

but also in the numbers of total crossmatches. In terms of details, the highest ranking series (FIL1402) enjoys 52 crossmatches at P2YrsL t>6.0 out of a total of 71 crossmatches. The series located at the first quartile (the 76th one: FIL8855) has 23 of 53 total. The second-quartile (median) series (the 153rd one: FIL5303) shows 15 of 53 total. The third-quartile series (the 229th one: FIL8880) is down to 9 of 40 total. Finally, the last 16 series have only 3 or fewer t>6.0 crossmatches per series. As for the P2YrsL t>7.0 in this 305-member subcollection, these decline even more steeply: 29/71, 14/53, 9/53, and 4/40. In the last 16 of the total of 305 "picked up" series, there are *collectively* only 13 total t>7.0 crossmatches.

Now, it is normal for P2Aut to first "pick up" series that exhibit superior t-value pair-crossmatching characteristics, but, sooner or later, P2Aut runs out of them, and has to "settle" for series that are inferior in this respect. Using this conceptualization, one can realize that P2Aut has to "settle" for inferior series, in the case of TRN and FIN, a lot more than it does for many extant-tree Scots pine chronologies. This, in turn, means that both the "cluster" and "bridging" processes, of the Disturbance-Clustering hypothesis, are relieved of the burden of producing or involving series that generally have high pair-crossmatching characteristics with each other.

I now consider the relative "strength" of the 5634 BC-1000 BC TRN/FIN chronology interval. This is based on both the additive (Part 2, below) as well as the interactive (Part 3) aspects of tree-ring chronology-building.

2. Interlocking Strongly-Crossmatching Paired Series: Implications of Their Uneven Distribution

The total number of trees crossmatching with each other, at a given point in the chronology (sample depth), may not be as significant as the number of series, at that point, which pair-crossmatch strongly with each other. Thus, for example, a sample depth of 5, where all the series reciprocally pair-crossmatch strongly with each other, may actually be more robust than a sample depth of 10, where few if any of the series reciprocally pair-crossmatch strongly with each other. [In Figure 2, the reader sees the illustration in terms of a local set of series that match weakly with the master chronology (which is discussed in the next section). However, the same concept can be extended to a local set of series that pair-crossmatch weakly with each other (which is the subject of this section).]

To further illustrate the latter, the reader is asked to imagine a floating island held together by the entwined roots of plants. It turns out that only a relatively few plants have many long roots, while most of the plants have few or no long roots. So only a relatively few plants do all the work: Most plants contribute little or nothing to the cohesiveness to the island. Moreover, what is the most important is not the total number of plants per unit area of the island, but the even-ness of the distribution of the relatively-uncommon many-long-rooted plants. Therefore, areal zones having few or no many-long-rooted plants are zones of weakness at which the island is likely to break apart. In this analogy, the island is the long chronology; the long roots are the strong individual-pair crossmatches (P2Yrsl t>6.0); the many-long-rooted plants are the "many6matchers", the plants having few if any long roots are the "few6matchers". Clearly, the local abundance of reciprocally-crossmatching series (sample depth) is not as important as the local abundance of "many6matchers". Consequently, "links" in the chronology which consist only of "few6matchers" are relatively weak ones at which the chronology can more readily be breached. My survey of the pre-1000 BC part of TRN/FIN identifies a huge range of "many6matchers" and "few6matchers". Some series are endowed with 50-60 pair-crossmatches, with the available overlapping series, at P2YrsL t>6.0, while, at the other extreme, quite a few have few or none. In order to determine if aggregations of "few6matchers" cause local weaknesses in the chronology (Figure 7, top), I successively removed all the "few6matchers" having 0, then 1, then 2…then finally 8 pair-crossmatches at P2YrsL t>6.0, and noted whenever the TRN/FIN sequence of overlapping series was breached (narrow ovals, top of Figure 7). Recall that, when submaster chronologies are being compared with each other, a minimum OVL of 70 years is required before the sufficiently-high-t crossmatch is considered credible (Larsson and Larsson 2018). In this exercise, I was more lenient: I reckoned the chronology breached whenever the last-standing local two series' crossmatching OVL fell to <=60 years. (However, many of the breaches were absolute, that is, no OVL remaining).

The results (Figure 7, top) show that the chronology becomes breached, at just the removal of the worst "few6matchers" (those with zero), and more "holes" appear as "few6matchers" with up to 8 pairwise P2YrsL t>6.0 crossmatches are removed. The 2nd, 5th, and 6th millennia BC are the most susceptible to "holing" by the removal of few6matchers. What's more, the schematic nature of Figure 7, top, does not tell the full story. The removal of successive "few6matchers" (0, 1, 2,…8) not only introduces "holes" at new locations in the chronology, as is shown: It also frequently expands the previously-made "holes", often considerably. In fact, some of the "holes" in the 5th- and 6th millennia BC grow into multi-century "chasms" as the (0, 1, 2…8) removal process proceeds. However, the severity of these "chasms" is tentative, as this early part of the chronology will be reinforced, and at least potentially extended back in time, through the soon-to-be addition of new series, according to a Finnish dendrochronologist (personal communication).

3. The Iterative "Peeling Away" of the Constituents of the TRN/FIN Master Chronology

How well do the TRN/FIN series "bond" to the common variance? To help answer this question, I describe, in this section, my experimental removal of the series that crossmatch relatively weakly with the master chronology (Figure 7, bottom). I variously define "weak" as t<=10, 11, 12, and 13. This definition of "weakness" is based on the fact that master chronology effect values in the 10-13 range are commonly achieved even by small but false master chronologies (Table 2).

In order to proceed, we need first to consider how TRN and FIN series crossmatch not as pairs, but as individuals against their respective master chronologies. [I did not perform this experiment for TRN/FIN in combination, because of the difficulty of transferring so many results to Notepad and then Excel]. I constructed both master chronologies, and then employed the "Test Towards Rest of Collection" function of CDendro to show the t-value of each series against its master chronology (without itself). Here is the results: TRN series, against the TRN master chronology, show a range of

P2YrsL t-values of 4.4-32.4, with: 1st quartile 8.7, median 11.1, and 3rd quartile 14.3. For FIN series, crossmatched against the FIN master chronology, the corresponding values are: 3.4-25.0, 8.6, 10.4, and 12.8. Thus, my experimental iterative removal of t-value crossmatches, in the 10-13 range (Figure 7, bottom), albeit against the combined TRN/FIN master chronology, corresponds to the disqualification of roughly the lowest 50%-75% master-matching series.

4. Obvious and Subtle Candidate Locations of "Bridges"

As is the case with the progressive removal of the worst "few6matchers" (Figure 7, top), it is the 2nd, 5th, and 6th millennia BC that are the most susceptible to "holing" by the progressive removal of series with relatively low crossmatches to the master chronology (Figure 7, bottom). Moreover, as this process continues, "holes" also appear in the 3rd and 4th millennia BC. In addition (not shown), lacunae also appear in the very early 1st millennium BC.

It is not surprising both sets of relative weakness (top and bottom, Figure 7) largely coincide: Intervals of the master chronology only consisting of "few6matchers" have relatively little common variance that can "reverberate" into a large (here t>13.0) master chronology effect. Those with "many6matchers", by the very fact of being "many6matchers", have a good deal of common variance "stored" amongst them that can do so. However, owing to the vagaries inherent in the expression of the common variance that constitutes the master chronology, this is not always the case.

The junctures of the subchronologies (Figure 6) do not necessarily correspond to "bridges", as these apparent zones of weakness need not remain so. They eventually become reinforced by the averaging-together of the overlapping edges of the subchronologies, by the manual addition of individual series done in order to create effective crossmatches between the subchronologies, and, finally, by the "mopping up" of the remaining series that are added to the chronology once it has been fully assembled together. [At time of the early stage shown as Figure 6, there still are 238 unclaimed FIN series that will eventually be fitted-in!]

The results of Figure 7 (top and bottom) are not meant to imply that the "strong spots" necessarily correspond only to the "cores" and the "weak spots" only to the "bridges" specified by the Disturbance-Clustering hypothesis. However, it stands to reason that a largely-fortuitous process ("bridge" building) is more likely to account for a "weak spot" than a "strong spot".

What about potential locations of "bridges" that are not intuitively obvious? To help answer this, let us now consider the Disturbance-Clustering hypothesis in the light of the P2Aut process. As just noted, the reader should not suppose that "bridges" are potentially limited to those parts of the chronology that have to be produced though the manual, one-at-a-time addition of qualifying series (Figure 6) or to the sites of conspicuous "weak spots" (Figure 7, top and bottom) in the finished master chronology. "Bridges" can also automatically be created *within* a subchronology created by P2Aut t≥7.0 itself. One potential indicator of this occurs during the execution of P2Aut, and as displayed on the onscreen CDendro printout situated the bottom of the computer screen. The onscreen printout generates a running list of the series that are being "picked up", along with the t-value of their respective crossmatches with the emerging master chronology. One may observe several series autoadd at, say, t>12, then a series autoadds though barely qualifying at t=7.0, and then more series autoadd at, say, t>12. The barely-qualifying series may be the "bridge" that enables the second group to "join with" the first. If P2Aut is re-run with the barely-qualifying series unchecked (omitted), and one finds that the second-group series fail to be "picked up" by P2Aut, this suggests a "bridge" role of the omitted barely-qualifying series. If, furthermore, no substitute series can be found that will induce P2Aut to "pick up" the second-group series, this conclusion is greatly strengthened.

Unfortunately, owing to the fact that series in the long chronology number in the thousands, it is not feasible to manually search for potential "bridges" within P2Aut t≥7.0 subchronologies according to the criteria described in the last paragraph. It is hoped that one day a computer program will be developed that could automatically do so. For more on the search for "bridge" sites, see "*Future Research*" on "*Automated Creation*…" Finally, it is possible that some "bridges" is entirely "seamless", and hence not apparent during the P2Aut process, if at all.

DISCUSSION: THE "MISFIRING" OF TREE-RING DISTURBANCES

As noted earlier, tree ring sequences, in terms of crossmatching characteristics, are typically distinctive. Given normal (i. e, climatic) circumstances, they either crossmatch with a geographically close, contemporary tree at a unique crossmatching point, or they do not convincingly crossmatch at all. However, if the sequences are shorter than 70 and especially 50 years, they can fortuitously crossmatch, to a convincing degree, in wrong places.

1. Subsuming Non-Ideal Behavior Within the Repetitive Aspects of Tree-Ring Chronologies

Since erroneous short-series crossmatchings are ubiquitous, they cannot qualify as evidence for the actual-contemporaneity of many of the trees that comprise the long tree-ring chronologies. However, by their very presence, they can serve as "camouflage" for non-ideal behavior in the hypothesized tree-ring-perturbing processes shown in the Figures 1 and 2. That is, some 50 years (often more, and occasionally substantially more) of tree rings could be "skipped" entirely by the perturbing processes, and the resulting contemporaneity-betraying short-to-medium crossmatches could be hidden amongst all the short-to-medium-segment fortuitous crossmatchings that normally occur in any case.

Now consider what I informally call mosaic-segment crossmatching: That is, for example, the first 50 years (sometimes more) of a 100-year old tree can convincingly crossmatch against a tree that had ostensibly lived at one time, while the remaining 50 years (sometimes more) of the same 100-year old tree convincingly can crossmatch against a tree that had ostensibly lived at a very different time. As an example of mosaic crossmatching, consider the 120 year-long TRN series of 0022115A (5168-5049 BC). The "Create sample from block" [make a segment cut out of the original series] function of CDendro shows that, besides matching the TRN master chronology at the correct location, the older half of that series (5168-5110 BC) crossmatches with the master at the (2884-2826 BC) interval at r=0.52 and t=4.3; while the younger half of that series (5109-5049 BC) manages to crossmatch with the master

at a very different interval (483-423 BC), at r=0.48 and t=4.2.

Mosaic crossmatching could subsume any instances where two sets of perturbations (Figure 2) each happened to "mark" the opposing ends of the same individual tree. In addition, whenever the two sets of perturbations overlapped, the resulting multiply-"overprinted" segments often became those commonly-seen intervals of non-matching (wrstblk test failure) that occur within otherwise-cross-datable trees. Taking this reasoning further, the earlier-discussed 10-45% dendrochronologically-"illegible" trees probably include those that are oddly (multiply) disturbed not over part but over practically *all* of their lengths.

2. A Much-Needed Perspective: Long Tree-Ring Chronologies Arise Only Under Atypical Conditions

For every continuous multi-millennial tree-ring chronology "rooted" to the present, there are several "stillborn" ones that consist only of one or more floating chronologies*. This is conventionally understood in terms of the vagaries of climate and preservation, but can also be explained, at least as well, in the light of the two hypotheses. That is, when migrating disturbances take place (Figure 1), they usually only generate floating chronologies, as they fail to operate over sufficient time-distance intervals to create several thousand continuous years of staggered-crossmatching trees ultimately connected to the ~2000 BC climate-governed trees. The clustered disturbances (Figure 2) also need only exceptionally create long chronologies. Usually, the disturbance-created clusters (designated [2], [3], [4]) remain too far apart, in terms of reconnaissance C-14 dates, for anyone to attempt to connect them, with suitable "bridging" series, to each other, and/or to the climatically-determined cluster that starts around 2000-3000 BC [1]. We are thus usually left with one anchored chronology, beginning 3000 BC or later [1], along with 1-3 floating chronologies ([2] connected or not to [3] connected or not to [4]).

Whenever one or more of the "clusters" entirely fails to develop, this alone prevents the construction of single multimillennial chronology linked to the present. For instance, with reference to Figure 2, if disturbance set [2] failed to materialize, then all of the constituent trees would remain climatically governed and indistinguishable from those in set [1]. Nothing would exist to connect ([3]-[4]) with [1] into a single long chronology.

A single long chronology also fails to materialize whenever no acceptable "bridges" can be found to adequately connect otherwise-suitably-deployed clusters ("cores"). This means that at least some "weaker elements" are real, and not simply artefacts of insufficient or misguided sampling procedures. As an example, parts of the Belfast long chronology have still not been directly- and locally-bridged despite 25 years of quasi-random sampling (Brown and Baillie 2012), and must continue to rely on circuitous long-distance crossmatching with other chronologies. Worse yet, in quite a few other cases, no suitable "bridge" series—whether local/direct or distant/circuitous--are found at all, and all that exists are several floating chronologies instead of a single long chronology. It can be particularly frustrating when C-14 dates suggest a temporal overlap between "clusters", but no suitable "bridge" trees can be found. It is then suggested that the trees did grow at the same time but under different climatic regimes (e. g, Edvardsson et al. 2012), or that the expected "bridge" series are too uncommon to be found because of a then-unfavorable episode of tree growth (e. g., Krapiec and Szychowska-Krapiec 2016).

CONCLUSION

Dendrochronological methods, including those applied to long chronologies, appear to be generally sound. However, climatically-caused crossmatches are not the only possible ones, though usually treated as such.

Tree ring series are very sensitive to perturbations that can convincingly "over-write" the climatic signal (in terms of both the externals and internals of the crossmatch), and cause them to coalesce into robust submaster chronologies. These, in turn, can be connected into fictitiously-long multi-millennial chronologies by "bridges", that is, suitable ensembles of correctly and incorrectly-matched series.

The Disturbance-Clustering hypothesis, unlike other ones, has virtually no limits in terms of the compression of apparent time, and could "fold" a tree-ring chronology that is multiples of 10,000 years long. All that is needed is an adequate number and diversity of C-14 dated "clusters", and enough suitable "bridge" series to interconnect them.

Clearly, the field is wide open, in dendrochronology, to creationist research. It is my hope that there soon emerges a cadre of dendrochonologically-practicing creationist scientists that could systematically examine the matters raised in this paper.

AVENUES FOR FUTURE RESEARCH

Hopefully, numerous tree-ring-width measurements of actually-disturbed trees will become generally available for study, thereby allowing a direct testing of my hypotheses. For now, and as elaborated below, theoretical experiments on perturbed tree rings should be greatly expanded. Dendrochronological information should also systematically be related to other evidences in a creationist context.

1. Automated Production of Vast Numbers of Randomly-Disturbed Tree-Ring Series

The most limiting—and sometimes frustrating—aspect of this investigation has been its extreme labor-intensiveness, as elaborated in the next paragraphs. A major step forward would involve the development of a computer program that could systematically perturb thousands of tree-ring series in accordance with various experimentally-prescribed perturbations, and—better yet--automatically crossmatch them according to both external and internal "fit".

The emergence of suitable "bridge" series is, to a considerable extent, a numbers game, moreover further driven by the fact that the number of candidate crossmatches increases exponentially (second-power function) with the number of candidate series. For instance, if there are 50 oddly-disturbed series, then there are 1,225 potentially-suitable paired-series combinations for crossmatching. With 100 such series, this explodes to 4,950. And these are only the candidate crossmatches amongst the oddly-disturbed series themselves, which ignores those that occur between them and the many different candidate locations in the long master chronology.

It would therefore be desirable to determine how oddly-disturbed

trees would function in terms of crossmatching. Unfortunately, an attempted experiment, involving the removal or addition of one or more rings, at random places, had to be abandoned, because of inordinate time-consumption, after 20 contemporary bristlecone pine series had thus been altered at a rate 20-50 rings apart. While the crude perturbations did not, by themselves, completely erase the earlier (correct) crossmatchings, or enable the resulting crossmatches to pass all the gateway statistics, they did add to the absolute numbers of plausibly-high-t candidate-"bridge" series.

2. Enhancing the Sophistication of Experimental Tree-Ring Disturbances

The ring-width alterations, whose positions are shown in Table 1, have been rather primitive. My faux master chronology was based on monotonic 75% ring-width reductions and, in my discontinued experiment, on random perturbations that had been limited to the insertions and deletions of 1-3 consecutive rings. The experiments should be extended to more modest prescribed disturbances that occur over several consecutive rings. For instance, with respect to the original widths, the first ring could be reduced 75%, the second 50%, the third 25%, and the fourth increased 50% (a simulated "rebound" effect).

Trees, by virtue of differential survivorship, could themselves skew the record of disturbances, and this should be tested experimentally. For instance, what if trees cannot survive two disturbances within, say, two years of each other? What if a tree usually dies whenever a disturbance takes place during an already-bad growth year (impending narrow ring)? This would mean that the longest surviving subfossil tree-ring series—the ones most desirable for crossmatching attempts—would be the very ones most likely to have initially-random disturbances recorded at decidedly nonrandom intervals.

Instead of just random-linear, ring-disturbances should also be of other distributions (e. g, log-normal). So should Markovian and non-Markovian ones. The occurrence of disturbances themselves, in nonrandom patterns, should especially be evaluated experimentally. For example, what happens if the introduction of a disturbance increases (or decreases) the likelihood of another disturbance several prescribed years "downstream" in the tree-ring sequence?

The potential "stickiness" of disturbances should, most of all, be factored. What happens, for instance, if a disturbance that lands on the 7th value in a decade induces the next disturbance to occur within rings 6-8 (in the next decade) at an 80% probability, and for the next disturbance to occur, in the successive decade, at a 60% probability, within rings 6-8? How long could such a "chain" of disturbances proceed before it would introduce telltale cyclicity into the data? What, furthermore, happens when one, more than one, or all ten places, per decade, are "sticky", moreover in either the same or different way from the other "sticky" sites?

All of these sophisticated large-scale experiments would probably lead to a proliferation of "bridge" series that are endowed with longer overlap, higher-t with and without the longer overlap, greater sample depths, and (especially) a greater tendency to "self-add" (at the standard P2Aut t≥70 and OVL≥70 years.) How far could this go? As an extreme, could it dispense with clusters ("cores") entirely, so that the "bridge" series become an end in themselves—a faux long chronology consisting of "bridge" series alone?

3. Evaluating Biological Agents of Convincing Climate-Independent Tree-Ring Crossmatches

The agencies causing sets of disturbances in ring widths (Figs. 1 and 2) need not be entirely physical, or even physical at all. Consider cockchafer* infestations. They have been found to introduce previously-unsuspected false crossmatches, in both ancient and modern oak trees, until their 3-5 year cyclicity, and effects on wood anatomy, gave them away (Kolar et al. 2013, and works cited therein). But if there are, or were, species of insects that could systematically alter tree ring widths without collateral traces, and moreover do so with ever-changing periodicities as they move from tree to tree over a time span of many centuries, they could have realized the Migrating-Disturbance Hypothesis (Figure 1). On the other hand, if there were differing subspecies of the same insect, each of which infects trees at predictable (but not cyclic) intervals, and each of which operated only on its own geographic territory, this would have generated geographically-demarcated sets of reciprocally-crossmatching perturbed trees, satisfying the Disturbance-Clustering Hypothesis (Figure 2). Finally, in the most conservative situation, if insect infected-trees were numerous, but were not imprinted by any kind of consistent disturbance, this alone would be useful. It would increase the numbers and diversity of candidate tree ring series for the "bridging" of the clusters that arise by other means (Figure 2).

Now consider ants. The proximity of ant nests to trees can reduce their tree ring widths (Frouz et al. 2008). If edaphic* factors, governed by subsurface chemistry, could cause "bands" of ant nests to migrate over centuries, or to self-consistently "mark" tree growth within distinctive geographic territories, this would respectively fulfill both hypotheses (Figure 1 and 2). Additionally or alternatively, mildly ant-distorted tree ring series could supply candidate series for "bridging" (Figure 2).

4. Automated Creation of "Bridges", Overhangs, and "Bridged" Submaster Chronologies

The production of possible "bridges" (ensembles in Table 2) is very time-consuming. It is also for this reason that the contents of Table 2 are largely, but not entirely, limited to simple combinations (1F2, 1F3…1Fn). In order to overcome this labor-intensiveness, a computer program should be developed that could automatically generate and "look at" vast numbers of ensembles, of varying sophistication, and identify those that have good crossmatching characteristics within the matrix (including little or no bifurcation), ones that produce a large master chronology effect without any hint of a "warning low outlier effect", etc.

The next step would involve the automated trial additions, of all the many different satisfactory ensembles, as overhangs*, at every physically-possible point in FIN. The latter could be realized by having the computer chop-up the FIN master chronology into several thousand successively-lagged 100-year segments (5633 BC—5534 BC, 5632 BC—5533 BC, 5631 BC—5532 BC,… 1994—2003, 1995—2004), and then trial-attach each ensemble at both ends of each 100-year segment. The computer would then

identify the most convincing segment/overhang results, in terms of the gateway statistics and in terms of the numbers of high-level pair-crossmatches in the resulting matrix.

As a final step, the computer would take these convincing segment/overhang results, trial-attach them to all possible remaining segments, and then identify the best final results, again in terms of the gateway statistics and in terms of the numbers of high-level pair-crossmatches in the resulting matrix. As a hypothetical illustrative example, imagine one segment (4463 BC—4364 BC) satisfactorily connected by a "bridge" to another segment (2135 BC—2036 BC), thereby forming a robust but faux submaster chronology.

As an extension, the computer could take an even more broad-based approach. It could forego the FIN segments and try to satisfactorily "bridge" the many variously-sophisticated previously-discussed disturbed series that the computer had made earlier.

5. Factoring Carbon-14 Dating and the Supra-Long Tree-Ring Chronologies

Consider, first of all, the construction of the long chronologies themselves. C-14 dating typically was used first to place the subfossil trees in approximate chronological sequence before the attempt was made to crossmatch their tree rings (Baillie 1995, Brown and Baillie 2015, Eronen et al. 2002, Stambaugh and Guyette 2009). The ability of tree ring chronologies to "stand alone" on the merits of dendrochonological procedures, argues that this was not an exercise in circular reasoning.

Carbon 14 dates much older than the 3000 BC Noachian Deluge are common, and this implies, from a Biblical perspective, that C-14 dates older than about 3000 BC have fictitious "built-in" years. Explanations for this have centered upon the buildup of C-14 in the atmosphere after the Flood (see Sanders 2018 for review). An additional, albeit neglected mechanism, is that of "infinitely old" carbon dioxide percolating from the depths, and becoming admixed with the atmospheric carbon dioxide that was breathed-in by trees that had lived soon after the Flood. (Woodmorappe 2003a).

Clearly, both C-14 and dendrologically-based dates had been inflated in the post-Flood world. But just how closely in "lockstep" must the two systems have been during this epoch of fictitiously-long time? Carbon-14 dates on dendrologically-dated samples frequently have inexplicable outliers (e. g, Kuzmin et al. 2004). Their inclusion in the C-14 dating calibration curve, while of course not invalidating the C-14/dendrochronological progression, makes it "looser", thereby reducing the "lockstep". If parts of the Belfast long chronology, on which a large part of IntCal* is directly and indirectly based, have been misdated by several years as proposed by Larsson (2003-2018), the "lockstep" becomes even more inexact.

In terms of overall detail, IntCal13 (Reimer et al. 2013) contains some segments with low slope ("plateaus"), wherein a significant spread of dendrochronological dates correspond to a relatively small range of values for C-14, and other segments with just the opposite--high slope ("cliffs"), in which a relatively small range of dendrochronological dates correspond to a relatively large range of C-14 dates. Both sets of sites have an especially-unimpressive "lockstep" of the two systems.

Now consider the fine detail in C-14 dates ("Suess wiggles"), reproducible in various long tree-ring chronologies from all over the northern hemisphere. Some have argued that the "wiggles" are of such diagnostic specificity (precise "lockstep") that they compel the acceptance of the C-14/dendrochronological system. Do they? Considering the C-14 "wiggle" record as a whole, one must, as a start, ask about the presumed uniqueness of each set of wiggles. I asked the following of a world-class C-14 expert and statistician, "I have wondered about the potential repetitiveness of patterns of wiggles over long periods of time. Suppose that one were to take the entire dendrologically-constructed 14C curve from today back to 12,000 years BP. If one were to disregard the ages, so that one set of wiggles could be allowed to potentially match with another set centuries or millennia earlier, based solely on Bayesian or other statistics, how often would patterns of wiggles repeat (based on different intervals of time, numbers of measurements, etc.)? Has anyone written a paper on this?"

This expert, who has considerable experience working with the "wiggles", answered very supportively as follows, "I am not aware of any such paper and I think that something of the sort could be really interesting. However, such an experiment would not be exactly analogues to the conventional use of wiggle matching since the master curves are index(*) averages of long sequences and are thus not quite like the raw tree-ring indices. To do a statistically thorough and really interesting job, I think one would need to collaborate direct with the tree-ring lab that put the master sequence together in order to get access to the raw data as well as the preprocessed and smoothed averages."

6. Integrating Dendrochronology and Evidence From Frost-Damaged Rings, Ice Cores, etc.

There have been claims of long-distance "greater-than-chance" correspondences of such things as MWK frost-damaged rings, atypically narrow rings, and volcanogenic acidities in ice cores. (Salzer and Hughes 2007). The latter, to begin with, is fraught with pitfalls and conflicting interpretations (Baillie and McAnney 2015). In addition, statistical tests of significance assume the complete independence of occurrences as the null hypothesis. This implies, for example, that, given sufficiently cold spring temperatures, frost damage can "strike" with equal likelihood during the formation of *any* tree ring. This is far from reality. For instance, a tree infected by a fungus is more vulnerable to frost damage (Cherubini et al. 2002). Among healthy trees, young and smaller-diameter trees in general (Kidd 2015) are more likely to experience visible frost damage. Most significant of all, the susceptibility of a tree ring to impending frost damage, even within a given tree, is *not* independent of the impending tree-ring width of that year. (Kidd 2015).

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