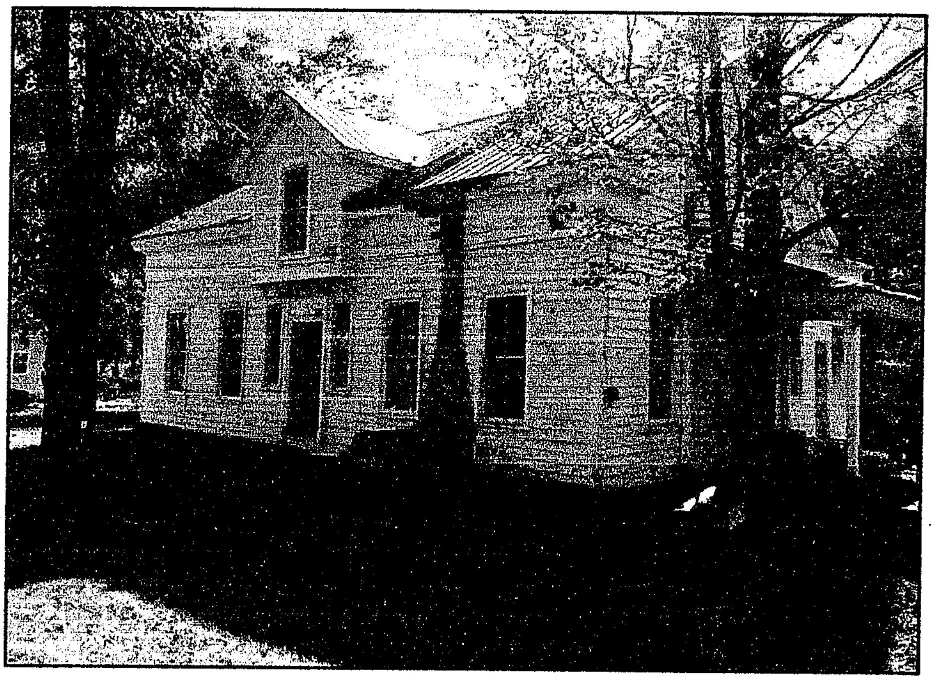
A Dendrochronology Study of Select Framing Timbers from the Woodworth House Preston Hollow, New York



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Introduction

On October 16th, 2018 a selection of framing timbers from the Woodworth house, located at 3053 Route 145 in Preston Hollow, NY, were sampled for the purposes of conducting a dendrochronology study. The samples were extracted, prepped and analyzed at Historic Deerfield by William Flynt, Architectural Conservator.

Background

Dendrochronology, or the study of tree ring growth patterns to date the age of archeological timbers, was initially developed in the 1920's by Andrew E. Douglass using long-lived Ponderosa pines in the Southwest United States. An astronomer by training, Douglass was interested in historical sun spot activity and its relationship to earth's climate. He surmised that by looking at yearly growth ring sequences in long-lived trees growing in an arid environment where moisture is key, he might be able to ascertain yearly variations in climate attributable to sunspot activity. (Baillie, 1982). To push the tree ring database back past the age of living trees, samples were taken from roof poles in Pueblo ruins which turned out to eventually overlap the living tree data. Besides fulfilling his research needs, this work revealed the feasibility of dating archeological structures.

In the 1980's the advent of computer programs to collate data, run comparative analyses, and compile master chronologies enabled unknown samples to be compared to known masters with a high degree of accuracy. Pioneering work in Eastern Massachusetts focusing on Oak (Krusic and Cook 2001, Miles, Worthington and Grady 2002, 2003, 2005) and in the Connecticut River valley initially concentrating on Pitch pine (Krusic 2001,Flynt 2004) and expanding into oak, chestnut, hemlock, and white pine, has revealed the suitability of using dendrochronology as a mainstream research tool for analyzing and establishing construction timber felling dates in the Northeast, a region heretofore considered too variable climatically to provide reliable results.

It should be remembered that trees were usually felled in the winter months with frame preparation occurring shortly thereafter, so the earliest a frame could be raised would be in the year following the felling date delineated in a dendrochronology study such as this.

Procedures

In procuring samples suitable for dendrochronology research, the analyst must be on the lookout for timbers, framing, and boards that exhibit several parameters. First, a bark, or waney, edge must be present if one wishes to establish with certainty the last year of growth. Second, there needs to be a sufficient number of rings in a sample to span several distinctive climactic variations that register as patterns of wide and narrow rings. Ideally, having 100 or more years of growth is best, but more often than not, samples will range from 50 to 100+ years. While it is feasible to get dates on young samples(50-60 rings), spurious results are possible and thus must be reviewed carefully both with longer-lived samples from the same structure as well as with what documentary and stylistic research uncovers. Third, enough samples need to be obtained (10-15 per building episode is usually reasonable) to allow for comparison and the fact that often some will not align for one reason or another. It is also critical that an assessment be made of the building frame to ascertain that the members from which samples are extracted were not reused or inserted at a later date, or, if so, are duly noted. Fourth, all samples must be labeled and entered into a log book that notes the position of each sampled timber within the structure, its species, whether or not it has wane, and any other information pertinent to the sample. In labeling the samples the following code was employed; PHW (Preston Hollow, Woodworth) with the numbers that follow simply referring to the sequence in which the samples were taken.

Samples were extracted using a custom coring bit, chucked into an 18 volt ½" Bosch battery-powered drill that creates a 9/16" hole out of which is obtained a 3/8" core. Core samples were glued into custom wood mounts and sanded using successively finer grit paper (150-600 grit) both on a bench top belt sander and by hand sanding to create a mirror-smooth finish. All samples were then viewed under a Unitron ZST 7.5-45X binocular microscope fitted with cross hairs in one eyepiece to ascertain and mark the number of rings per sample. This was followed with a careful visual review, again under magnification, in an attempt to determine if site-specific growth patterns could be ascertained in order to cross date the samples. Each sample was then placed under the microscope on a Velmex Acu-Rite Encoder sliding stage calibrated to read to the nearest micron (.001mm). Measuring begins at the outer, or last year of growth ring (LYOG), established as 1000, and proceeds to the center of the sample or first year of growth, as measured (FYOG). At the junction of each growth ring, the analyst registers the interface electronically which sends the measurement to the computer via a Quick-Chek Digital Readout. In all of the work in this study, the measuring program PJK16 was used to compile each sample's raw data files. The program transforms the ring widths into a series of indices that relate each ring's growth to its neighbors, thus standardizing the climate-related influences on a year-to-year basis (Krusic 2001). Thus trees from a similar location but growing at different rates should exhibit similar indices. With the raw data in hand, using the program COFECHA (Holmes, 1983) the samples from this site can be compared with each other to determine if all were cut at the same time or within the span of several years or more. The samples are also compared against one or more dated regional master chronologies or site masters of the same species to determine the exact year or years when the samples in question were felled. As strong samples are uncovered, these are added to a fledgling site master and the raw data is again run against this site master to see if additional samples align.

With COFECHA samples are broken down into ring groups of 50 years that are then compared to various dated masters. The 50-year ring groups in an individual sample are lagged a certain number of years (in this study a lag of 25 years was used) to provide an overlap of data within the groupings. The results are displayed in a series of ways with Part 8 "Date Adjustment for Best Fit Matches for Counted Unknown Series" composed of columns with the "best fit" being in column #1, the next "best fit" in column #2 and so on out 11 columns. The "add" number is the number to be added to the last year of growth (1000) to provide the year date of felling, while the "corr" number relates to how well the "add" meshes with the master. A correlation coefficient of .3281 is considered the threshold of significance. High correlation values (preferably over .40) accompanying consistent "add" numbers in the first column usually reveal reliable results. In the example below, consistent "add" numbers with strong correlations appearing in the first column for samples DLBH-07 and 08 reveal each samples true date of felling (1784 and 1782 respectively). Sample DLBH-09 does not show consistently strong correlation with any particular date. Note that the lag used in this example is 10 years.

SERIES	COUNTED SEGMENT	ADD	CORR # 1	ADD	CORR # 2	ADD	CORR # 3	ADD	CORR # 4	ADD	CORR # 5	ADD	CORR # 6	ADD	CORR # 7	ADD	CORR # 8	ADD	CORR # 9	ADD	CORR #10
DLBH-07	937- 986	784	.51	712	.47	729	.37	713	.37	847	.33	846	.31	728	.30	813	.29	800	.29	763	.28
DLBH-07	947- 996	784	.54	712	.45	760	.33	816	.31	729	.31	800	.29	713	.29	671	.29	847	.26	808	.25
DLBH-07	951-1000	784	.41	760	.35	712	.35	661	.31	787	.30	800	.29	774	.29	729	.27	808	.26	832	.25
DLBH-08	929- 978	782	.44	746	.42	793	.33	760	.32	705	.32	840	.31	858	.30	689	.30	824	.28	685	.26
DLBH-08	939- 988	782	.61	746	.37	689	.34	840	.30	725	.29	708	.27	723	.27	806	.27	684	.25	724	.25
DLBH-08	949- 998	782	.69	669	.47	840	.41	722	.32	806	.28	708	.27	700	.26	683	.25	723	.25	720	.24
DLBH-08	951-1000	782	.69	669	.38	840	.38	722	.34	757	.29	700	.28	730	.25	659	.24	838	.23	723	.23
DLBH-09	932- 981	713	.52	785	.35	848	.35	744	.35	729	.32	863	.31	846	.28	849	.26	693	.26	714	.25
DLBH-09	942- 991	846	.38	713	.36	785	.33	848	.33	729	.29	727	.29	790	.29	693	.28	761	.28	705	.27
DLBH-09	951-1000	799	.43	783	.39	731	.30	689	.30	808	.29	767	.27	756	.26	790	.25	814	.24	846	.24

Once samples from a site are firmly dated and grouped into a site master, Part 2 "Correlations with Master Series of all Segments as Dated and Measured" and Part 3 "Segments Correlating Low, or Higher, at other than Dated Position" of COFECHA can be viewed to see how well each sample correlates with the others in the group and where weak areas within the ring counts are located for further scrutiny.

Results (See Figure 1)

All samples turned out to be hemlock with a majority coming from long-lived trees. Hemlock has a good track record for aligning well with dated regional masters which bodes well for the study.

The first series of tests were aimed at determining how each sample related to the others in terms their felling dates. By comparing the entire group of samples to one or more of the longer-lived samples, it is often possible to determine if all were felled in a single year, or over a period of several years. This effort was met with success as noted on Chart 1. Part 8 of Chart 1 shows most samples were felled the same year (as denoted by the 0's in column 1) with the exception of sample 4 and 10. It is possible that what was thought to be wane was not, or it could be that one or more of these members were reused. Part 2 of Chart 1 reveals very high correlation coefficients between the samples where their 50-year ring groups overlap. Clearly the trees from which these samples were fabricated grew in close proximity to each other. It could very well be that several timbers came from the same tree.

The next test compared the Woodworth house samples to a dated regional hemlock master. When compared to an eastern New York hemlock master compiled by Edward Cook of the Lamont Doherty Tree-Ring Laboratory, with some data added by the author, strong alignments with specific dates are revealed. Chart 2 displays robust correlations with the date 1821 for those samples aligning with 0 on Chart 1 while sample PHW-04 aligns with 1788 and PHW-10 aligns with 1745 throughout most of its growth, in agreement with the offsets displayed on Chart 1. A bit of weakness for 1821 is noted in the results for samples PHW-02,06,07, and 08, but this is inconsequential. With the strong correlation coefficients noted throughout the chart it is clear that these dates are correct. As a result, there was no need for further tests against more distant hemlock masters. Figure 2 graphically depicts the relationship between the house site master and the eastern New York hemlock master

Discussion

While it was a bit of a challenge to locate an adequate number of sound timbers with waney edges to sample, thankfully the species used throughout the structure was hemlock which often dates well against regional masters. As is seen in the various tests, the samples aligned well with themselves and with a regional master from the area, a relative rarity. Normally the results are not so clear cut and additional testing needs to occur in order to make sense of the data. The two samples that indicate earlier 18th century dates could be reworked timbers, or what was thought to be wane was not. The fact that a majority of the samples from both the main floor and basement date to a single year strengthens the case for this to be the main felling event for the construction of this building. From an inspection of all samples' last year of growth it is clear felling occurred after the growing season ended. With a majority of samples indicating a felling date of 1821 (winter of 1821/22), the earliest the house frame could have been erected was the spring of 1822. A search of the local documentary record (tax records, account books of owners and merchants, inventories, etc.) around this time period should provide further evidence of the structures construction.

Acknowledgments

The author would like to thank Anastasia and Kent Woodworth for their interest in having this study undertaken, and Kent for helping to obtain cut offs from several decayed framing members that had been wisely retained rather than tossed in the trash.

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FIGURE 1

WOODWORTH HOUSE, PRESTON HOLLOW, NY

SAMPLE	AGE	FYOG	LYOG	WANE	SPECIES	LOCATION
PHW-01	128	1694	1821	Y	TCSA	NW CORNER POST
PHW-02	142	1680	1821	Y	TCSA	1ST POST S.OF NW CORNER
PHW-03	132	1690	1821	Y	TCSA	2ND POST S.OF NW CORNER
PHW-04	150	1639	1788	Y*	TCSA	4TH POST S.OF NW CORNER
BASEMENT:						
PHW-05	TOO MANY BREAKS			Y	TCSA	3RD JOIST FROM E.SILL AT S.CHIMNEY BASE
PHW-06	159	1663	1821	Y	TCSA	WEST SILL
PHW-07	188	1634	1821	Y	TCSA	NORTH SILL
PHW-08	75	1747	1821	Y	TCSA	FRAMING SCRAP
PHW-09	92	1730	1821	Y	TCSA	FRAMING SCRAP
PHW-10	130	1616	1745	Y*	TCSA	FRAMING SCRAP

FYOG = FIRST YEAR OF GROWTH (AS MEASURED)
LYOG = LAST YEAR OF GROWTH
TCSA = HEMLOCK
Y* = WANE THOUGHT TO HAVE BEEN PRESENT, BUT POSSIBLY NOT.

CHART 1

PART 2: CORRELATIONS WITH MASTER SERIES OF ALL SEGMENTS AS DATED AND MEASURED   Tucson-Mendoza-Hamburg-Lamont ProgLib

32-YEAR CUBIC SPLINE FILTER; CORRELATIONS OF 50-YEAR SEGMENTS LAGGED 25 YEARS
PHW HEMLOCK FLOATING SITE MASTER
FLAGS: __A = CORRELATION UNDER 0.3281; __B = CORRELATION HIGHER AT OTHER POSITION

SEQ	SERIES	INTERVAL	775 824	800 849	825 874	850 899	875 924	900 949	925 974	950 999	975 1024	1000 1049	1025 1074	1050 1099	1075 1124	1100 1149	1125 1174	1150 1199	1175 1224	1200 1249	1225 1274	1250 1299	FLAGS/ TOTAL
1	PHW-01	873-1000	-	-	-	.62	.62	.72	.74	.69	.68												
+																							
2	PHW-02	859-1000	-	-	-	.84	.79	.77	.81	.72	.71												0/ 6
+																							
3	PHW-03	869-1000	-	-	-	.81	.81	.87	.88	.83	.80												0/ 6
+																							
4	PHW-04	818- 967	-	.46	.49	.52	.62	.67	.70	-	-												0/ 6
+																							
5	PHW-06	842-1000	-	-	.65	.61	.67	.74	.73	.52	.51												0/ 6
+																							
6	PHW-07	813-1000	-	.34 __B	.30 __A	.57	.50	.60	.75	.67	.66												0/ 7
+																							
7	PHW-08	926-1000	-	-	-	-	-	-	.70	.60	.60												2/ 8
+																							
8	PHW-09	909-1000	-	-	-	-	-	.68	.77	.57	.58												0/ 3
+																							
9	PHW-10	813- 924	-	.51	.55	.62	.49	-	-	-	-												0/ 4
+																							
																							0/ 4

PART 8: DATE ADJUSTMENT FOR BEST MATCHES FOR COUNTED OR UNKNOWN SERIES   Tucson-Mendoza-Hamburg-Lamont ProgLib

PHW HEMLOCK VS PHW HEMLOCK FLOATING SITE MASTER
50-YEAR SEGMENTS LAGGED 25 YEARS

SERIES	COUNTED SEGMENT	ADD	CORR # 1	ADD	CORR # 2	ADD	CORR # 3	ADD	CORR # 4	ADD	CORR # 5	ADD	CORR # 6	ADD	CORR # 7	ADD	CORR # 8	ADD	CORR # 9	ADD	CORR #10	ADD	CORR #11
PHW-01	873- 922	0	.71	34	.46	-69	.39	19	.30	42	.27	-32	.26	-54	.25	53	.25	-47	.25	-13	.24	32	.22
PHW-01	898- 947	0	.77	34	.32	26	.28	-34	.28	-53	.27	-88	.27	-89	.27	-97	.26	42	.23	44	.22	-45	.22
PHW-01	923- 972	0	.80	-122	.37	-34	.35	-26	.33	-42	.31	26	.30	-68	.27	-86	.26	-85	.24	21	.23	-107	.22
PHW-01	948- 997	0	.77	-94	.37	-26	.35	-61	.30	-46	.28	-122	.27	-113	.27	-43	.25	-75	.23	-150	.20	-144	.20
PHW-01	951-1000	0	.78	-26	.37	-94	.32	-46	.28	-122	.24	-61	.24	-150	.23	-113	.23	-43	.22	-28	.21	-75	.21
PHW-02	859- 908	0	.89	19	.48	-19	.39	86	.26	23	.25	66	.24	39	.21	-37	.21	-55	.19	18	.18	76	.18
PHW-02	884- 933	0	.79	-19	.42	-89	.38	-20	.35	-1	.33	-39	.30	-33	.30	34	.30	55	.30	43	.27	-18	.25
PHW-02	909- 958	0	.84	-87	.27	-66	.27	8	.27	-85	.27	-89	.25	-24	.21	-72	.21	34	.21	-34	.20	5	.20
PHW-02	934- 983	0	.86	-122	.39	-43	.37	-87	.25	-61	.25	-113	.23	-35	.22	-8	.22	-30	.21	8	.21	13	.21
PHW-02	951-1000	0	.79	-122	.35	-152	.28	-68	.28	-49	.27	-94	.26	-54	.24	-28	.24	-75	.23	-131	.22	-83	.22
PHW-03	869- 918	0	.87	-19	.51	19	.38	-5	.29	-18	.28	74	.26	14	.24	34	.24	67	.22	-39	.22	66	.22
PHW-03	894- 943	0	.89	-19	.41	5	.31	-5	.30	-79	.30	-24	.28	43	.27	-53	.27	-97	.24	56	.24	13	.24
PHW-03	919- 968	0	.91	-122	.42	-34	.42	-66	.31	-53	.30	-42	.27	-24	.24	-79	.22	-87	.21	26	.21	-5	.21
PHW-03	944- 993	0	.87	-92	.34	-113	.32	-74	.30	-26	.29	-66	.22	-55	.22	-94	.22	-122	.22	-32	.22	-119	.21
PHW-03	951-1000	0	.86	-26	.33	-94	.27	-61	.24	-54	.24	-56	.24	-49	.24	-75	.23	-28	.21	-134	.20	-152	.20
PHW-04	851- 900	-33	.68	-20	.34	-42	.34	19	.29	98	.29	46	.28	97	.28	5	.25	43	.24	3	.23	86	.22
PHW-04	876- 925	-33	.68	-18	.26	-14	.25	-69	.24	-48	.22	19	.22	61	.21	-54	.20	73	.20	-20	.19	46	.18
PHW-04	901- 950	-33	.72	-52	.38	15	.31	-70	.30	-92	.27	-22	.27	-72	.27	-85	.25	-3	.22	-8	.22	10	.21
PHW-04	926- 975	-33	.68	-3	.41	-70	.34	23	.33	10	.29	-38	.28	-52	.28	-28	.25	-131	.25	-112	.22	-47	.21
PHW-04	951-1000	-33	.76	-89	.31	-99	.27	-141	.27	-55	.26	-118	.26	-65	.24	-28	.24	-63	.23	-107	.23	-131	.22
PHW-06	842- 891	0	.80	19	.37	15	.33	-19	.30	79	.28	94	.28	-21	.26	-37	.24	26	.22	-6	.22	102	.22
PHW-06	867- 916	0	.79	-19	.43	19	.36	74	.34	-70	.31	-39	.28	60	.26	18	.24	26	.24	-38	.22	-1	.22
PHW-06	892- 941	0	.80	-19	.46	-66	.34	34	.33	-84	.31	-97	.30	-45	.30	-60	.30	-34	.26	-79	.26	48	.25
PHW-06	917- 966	0	.77	-34	.40	-66	.37	-60	.35	-5	.34	-79	.33	-26	.31	23	.27	-18	.26	-122	.25	-85	.24
PHW-06	942- 991	0	.76	-53	.44	-26	.27	-94	.26	-113	.24	-43	.23	-86	.22	-140	.22	-34	.22	-42	.21	-131	.21
PHW-06	951-1000	0	.68	-53	.36	-115	.34	-26	.34	-94	.30	-148	.27	-144	.27	-131	.23	-13	.22	-87	.21	-134	.21
PHW-07	813- 862	0	.70	122	.42	89	.40	66	.27	6	.26	36	.25	-13	.22	84	.21	-15	.20	47	.20	55	.20
PHW-07	838- 887	0	.72	-30	.33	45	.32	26	.31	68	.29	66	.28	29	.26	8	.25	-29	.25	53	.24	85	.24
PHW-07	863- 912	0	.67	66	.45	-19	.40	53	.36	50	.32	19	.29	45	.26	-13	.25	11	.23	29	.22	74	.22
PHW-07	888- 937	0	.63	-19	.33	53	.33	50	.33	-78	.32	29	.30	-42	.27	16	.27	-8	.25	21	.24	26	.20
PHW-07	913- 962	0	.75	-63	.37	-42	.31	-37	.28	-89	.27	-34	.27	26	.24	24	.22	-24	.21	-13	.20	37	.18
PHW-07	938- 987	0	.79	-122	.33	-34	.26	-63	.23	-98	.21	-102	.21	-83	.21	-121	.20	-26	.19	11	.19	-17	.18
PHW-07	951-1000	0	.73	-61	.27	-83	.27	-121	.27	-94	.27	-122	.25	-26	.25	-75	.24	-119	.20	-67	.20	-4	.18
PHW-08	926- 975	0	.78	-122	.34	-85	.28	-64	.27	22	.26	-17	.23	-130	.22	-50	.21	-92	.20	-109	.20	-32	.19
PHW-08	951-1000	0	.73	-152	.30	-74	.29	-61	.27	-87	.24	-20	.23	-54	.22	-22	.20	-130	.19	-118	.19	-49	.18
PHW-09	909- 958	0	.78	-34	.38	-79	.36	17	.30	-26	.29	5	.29	-8	.28	-66	.28	-40	.23	-29	.23	-100	.22
PHW-09	934- 983	0	.79	-122	.41	-79	.36	-34	.31	-66	.30	-53	.28	-131	.27	-29	.26	-85	.25	-132	.24	-8	.24
PHW-09	951-1000	0	.70	-61	.38	-56	.34	-140	.30	-94	.25	-98	.25	-130	.24	-131	.24	-75	.23	-12	.22	-51	.22
PHW-10	871- 920	-76	.87	2	.42	-39	.34	54	.32	46	.31	27	.31	76	.27	12	.27	28	.22	55	.21	21	.20
PHW-10	896- 945	-76	.81	-91	.30	-55	.29	41	.29	-13	.26	-82	.26	-38	.25	-97	.22	-72	.22	37	.21	-94	.21
PHW-10	921- 970	-76	.79	-10	.40	-112	.37	-57	.35	9	.30	-113	.30	-18	.27	-34	.27	-91	.25	11	.24	-97	.23
PHW-10	946- 995	-76	.71	-34	.38	-39	.36	-42	.35	-58	.27	-102	.26	-50	.26	-95	.25	-68	.23	-105	.22	-57	.20
PHW-10	951-1000	-76	.67	-39	.37	-42	.37	-34	.36	-102	.28	-58	.25	-95	.24	-105	.23	-50	.22	-135	.20	-99	.20

CHART 2

PART 8: DATE ADJUSTMENT FOR BEST MATCHES FOR COUNTED OR UNKNOWN SERIES

Tucson-Mendoza-Hamburg-Lamont ProgLib

PHW VS EASTERN NEW YORK STATE HEMLOCK MASTER- E.COOK,W.FLYNT
50-YEAR SEGMENTS LAGGED 25 YEARS

SERIES	COUNTED SEGMENT	ADD CORR # 1	ADD CORR # 2	ADD CORR # 3	ADD CORR # 4	ADD CORR # 5	ADD CORR # 6	ADD CORR # 7	ADD CORR # 8	ADD CORR # 9	ADD CORR #10	ADD CORR #11
PHW-01	873- 922	821 .68	1000 .39	1016 .37	1039 .35	1024 .33	789 .32	696 .31	752 .29	889 .28	855 .27	874 .26
PHW-01	898- 947	821 .62	712 .35	733 .35	768 .31	958 .30	738 .28	834 .27	1024 .27	889 .26	966 .26	680 .26
PHW-01	923- 972	821 .62	712 .40	677 .34	641 .32	963 .31	691 .30	900 .30	971 .29	833 .29	745 .29	699 .28
PHW-01	948- 997	821 .65	898 .42	886 .34	937 .33	965 .32	562 .31	817 .31	900 .29	867 .29	765 .29	760 .29
PHW-01	951-1000	821 .65	937 .38	886 .36	898 .36	600 .35	562 .33	866 .32	900 .30	560 .28	750 .27	793 .27
PHW-02	859- 908	821 .63	802 .42	934 .37	1021 .35	685 .34	654 .34	907 .33	954 .33	694 .32	844 .32	839 .30
PHW-02	884- 933	820 .59	821 .54	997 .43	878 .39	795 .37	934 .37	1030 .35	654 .34	788 .31	1020 .30	723 .30
PHW-02	909- 958	821 .68	990 .43	998 .42	949 .41	691 .33	699 .30	891 .30	755 .29	758 .29	763 .27	832 .27
PHW-02	934- 983	821 .58	791 .40	758 .36	721 .35	613 .33	691 .32	587 .32	712 .31	892 .30	656 .30	990 .29
PHW-02	951-1000	821 .53	841 .41	898 .39	733 .36	613 .36	562 .36	619 .36	900 .36	640 .34	691 .33	684 .29
PHW-03	869- 918	821 .61	654 .47	802 .43	935 .37	934 .37	752 .35	953 .34	1016 .31	864 .30	734 .29	694 .28
PHW-03	894- 943	821 .65	947 .38	768 .36	997 .34	826 .32	738 .31	1006 .31	915 .30	949 .30	675 .29	834 .28
PHW-03	919- 968	821 .74	998 .41	699 .39	949 .39	721 .37	677 .34	990 .32	691 .32	662 .32	712 .31	747 .31
PHW-03	944- 993	821 .56	619 .43	900 .41	841 .38	898 .36	613 .35	789 .35	708 .33	867 .33	733 .32	835 .31
PHW-03	951-1000	821 .61	898 .44	900 .39	886 .38	809 .33	937 .32	619 .32	888 .32	562 .31	841 .31	733 .31
PHW-04	851- 900	788 .54	784 .50	801 .46	907 .36	930 .33	805 .32	699 .31	731 .30	1058 .29	939 .28	1051 .28
PHW-04	876- 925	788 .47	907 .40	959 .36	836 .34	649 .33	736 .33	908 .32	988 .32	850 .32	909 .30	699 .29
PHW-04	901- 950	788 .54	769 .47	621 .41	907 .39	836 .33	647 .31	678 .31	632 .31	855 .30	983 .30	1008 .30
PHW-04	926- 975	788 .60	774 .38	946 .35	730 .34	751 .34	818 .31	860 .31	1000 .31	700 .30	714 .30	601 .29
PHW-04	951-1000	788 .67	916 .42	957 .42	965 .39	799 .35	688 .34	634 .32	714 .29	932 .27	636 .27	903 .26
PHW-06	842- 891	821 .57	840 .35	728 .34	700 .33	732 .31	815 .30	711 .29	802 .29	786 .28	1050 .27	769 .26
PHW-06	867- 916	821 .60	1016 .49	802 .41	711 .41	681 .39	1015 .37	1039 .34	839 .31	840 .29	974 .28	960 .28
PHW-06	892- 941	821 .49	915 .39	733 .37	997 .36	755 .36	825 .31	914 .31	882 .30	675 .30	840 .28	963 .28
PHW-06*	917- 966	821 .50	812 .38	949 .38	998 .38	742 .37	915 .37	892 .36	963 .35	691 .34	787 .34	840 .32
PHW-06	942- 991	588 .50	821 .43	892 .43	929 .38	646 .37	906 .34	937 .34	715 .32	867 .32	599 .31	690 .31
PHW-06	951-1000	821 .45	677 .36	937 .34	599 .34	848 .34	840 .33	929 .33	588 .32	715 .31	750 .29	874 .29
PHW-07	813- 862	1100 .38	910 .36	999 .35	769 .34	778 .33	1036 .33	777 .31	899 .30	943 .30	1018 .28	1099 .28
PHW-07	838- 887	821 .39	1034 .36	1021 .35	700 .34	693 .33	741 .31	869 .29	728 .28	978 .28	1064 .27	913 .27
PHW-07	863- 912	821 .49	992 .44	1064 .39	813 .38	802 .37	915 .33	654 .33	911 .33	1015 .32	1031 .31	827 .31
PHW-07	888- 937	821 .36	911 .35	1031 .32	941 .31	733 .29	850 .28	813 .26	802 .26	1006 .25	639 .25	757 .25
PHW-07	913- 962	821 .53	699 .41	832 .34	998 .33	721 .33	949 .31	667 .31	941 .30	758 .29	662 .28	802 .28
PHW-07	938- 987	821 .63	858 .37	619 .36	704 .35	613 .31	591 .31	617 .30	758 .30	833 .29	721 .28	892 .28
PHW-07	951-1000	821 .54	833 .35	888 .33	562 .33	660 .31	721 .30	613 .30	619 .30	680 .29	640 .28	858 .27
PHW-08	926- 975	821 .62	990 .43	833 .37	965 .36	936 .36	712 .33	747 .32	789 .32	845 .31	791 .29	691 .29
PHW-08	951-1000	847 .41	646 .38	821 .36	691 .35	656 .32	813 .32	620 .30	959 .30	660 .30	965 .30	861 .30
PHW-09	909- 958	821 .62	755 .46	721 .36	998 .32	968 .32	863 .32	792 .32	990 .31	712 .31	686 .28	634 .27
PHW-09	934- 983	821 .49	792 .37	704 .35	646 .34	755 .31	588 .30	990 .30	699 .29	892 .28	686 .28	977 .27
PHW-09	951-1000	821 .39	809 .38	914 .38	765 .37	898 .34	888 .33	634 .33	646 .30	656 .29	677 .29	937 .29
PHW-10	871- 920	745 .62	1017 .39	867 .37	674 .34	708 .32	833 .31	1024 .30	702 .29	917 .29	687 .28	683 .27
PHW-10	896- 945	745 .60	656 .40	1017 .36	920 .35	902 .35	766 .33	935 .32	899 .32	749 .31	783 .30	858 .29
PHW-10	921- 970	745 .69	652 .44	828 .44	624 .38	658 .36	902 .33	931 .32	811 .31	854 .30	656 .30	972 .29
PHW-10	946- 995	745 .51	940 .47	858 .47	828 .42	782 .37	980 .34	824 .34	956 .31	657 .30	609 .30	604 .30
PHW-10	951-1000	940 .48	858 .48	745 .43	828 .40	782 .38	609 .34	824 .32	876 .30	703 .30	647 .29	959 .29

CHART 3

PART 2: CORRELATIONS WITH MASTER SERIES OF ALL SEGMENTS AS DATED AND MEASURED Tucson-Mendoza-Hamburg-Lamont ProgLib

32-YEAR CUBIC SPLINE FILTER; CORRELATIONS OF 50-YEAR SEGMENTS LAGGED 25 YEARS
PHW DATED HEMLOCK SITE MASTER
FLAGS: __A = CORRELATION UNDER 0.3281; __B = CORRELATION HIGHER AT OTHER POSITION

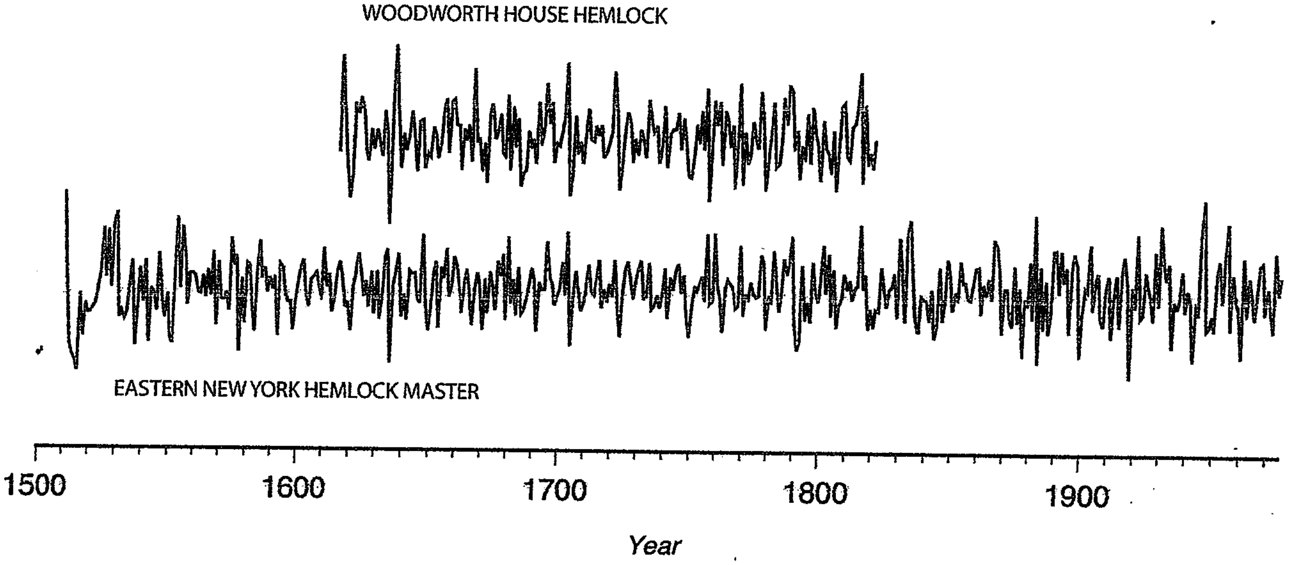
0SEQ	SERIES	INTERVAL	1600 1649	1625 1674	1650 1699	1675 1724	1700 1749	1725 1774	1750 1799	1775 1824	1800 1849	1825 1874	1850 1899	1875 1924	1900 1949	1925 1974	1950 1999	1975 2024	2000 2049	2025 2074	2050 2099	2075 2124	FLAGS/ TOTAL
1	PHW-01	1694-1821	=	=	=	.62	.65	.68	.71	.68	=												
2	PHW-02	1680-1821	=	=	=	.84	.76	.75	.81	.71	=												0/ 5
3	PHW-03	1690-1821	=	=	=	.81	.80	.85	.89	.80	=												0/ 5
4	PHW-04	1639-1788	=	.46	.52	.63	.61	.62	.70	=	=												0/ 5
5	PHW-06	1663-1821	=	=	.65	.67	.69	.65	.72	.51	=												0/ 6
6	PHW-07	1634-1821	=	.34 ___B	.31 ___B	.58	.49	.58	.77	.66	=												0/ 6
7	PHW-08	1747-1821	=	=	=	=	=	.70	.68	.60	=												2/ 7
8	PHW-09	1730-1821	=	=	=	=	=	.68	.71	.58	=												0/ 3
9	PHW-10	1634-1745	=	.51	.55	.68	.49	=	=	=	=												0/ 3
																							0/ 4

PART 8: DATE ADJUSTMENT FOR BEST MATCHES FOR COUNTED OR UNKNOWN SERIES Tucson-Mendoza-Hamburg-Lamont ProgLib

PHW HEMLOCK VS PHW HEMLOCK DATED SITE MASTER
50-YEAR SEGMENTS LAGGED 25 YEARS

SERIES	COUNTED SEGMENT	ADD CORR # 1	ADD CORR # 2	ADD CORR # 3	ADD CORR # 4	ADD CORR # 5	ADD CORR # 6	ADD CORR # 7	ADD CORR # 8	ADD CORR # 9	ADD CORR #10	ADD CORR #11
PHW-01	873- 922	821 .71	855 .46	752 .39	840 .30	863 .27	789 .26	767 .25	874 .25	774 .25	808 .24	853 .22
PHW-01	898- 947	821 .77	855 .32	847 .28	787 .28	768 .27	733 .27	732 .27	724 .26	863 .23	865 .22	776 .22
PHW-01	923- 972	821 .80	699 .37	787 .35	795 .33	779 .31	847 .30	753 .27	735 .26	736 .24	842 .23	714 .22
PHW-01	948- 997	821 .77	727 .37	795 .35	760 .30	775 .28	699 .27	708 .27	778 .25	746 .23	671 .20	677 .20
PHW-01	951-1000	821 .78	795 .37	727 .32	775 .28	699 .24	760 .24	708 .23	671 .23	778 .22	793 .22	746 .21
PHW-02	859- 908	821 .89	840 .48	802 .39	907 .26	844 .25	887 .24	860 .21	784 .21	766 .19	839 .18	897 .18
PHW-02	884- 933	821 .79	802 .42	732 .38	801 .35	820 .33	782 .30	788 .30	855 .30	876 .30	864 .27	803 .25
PHW-02	909- 958	821 .84	734 .28	755 .27	829 .27	736 .27	732 .25	797 .21	749 .21	855 .21	787 .20	826 .20
PHW-02	934- 983	821 .86	699 .39	778 .37	734 .25	760 .25	708 .23	786 .22	813 .22	791 .21	829 .21	834 .21
PHW-02	951-1000	821 .79	699 .35	669 .28	753 .28	772 .27	727 .26	767 .24	793 .24	746 .23	690 .22	738 .22
PHW-03	869- 918	821 .87	802 .51	840 .38	816 .29	803 .28	895 .26	835 .25	855 .24	888 .22	782 .22	887 .22
PHW-03	894- 943	821 .89	802 .41	826 .31	816 .30	742 .30	797 .28	864 .27	768 .27	724 .24	834 .24	877 .24
PHW-03	919- 968	821 .91	699 .42	787 .42	755 .31	768 .30	779 .26	797 .24	742 .22	734 .21	847 .21	816 .21
PHW-03	944- 993	821 .87	729 .34	708 .32	747 .30	795 .29	755 .22	766 .22	727 .22	699 .22	789 .22	702 .21
PHW-03	951-1000	821 .86	795 .33	727 .27	760 .24	767 .24	765 .24	772 .24	746 .23	793 .21	687 .20	669 .20
PHW-04	851- 900	788 .68	801 .34	779 .34	840 .29	919 .29	867 .28	918 .28	826 .25	864 .24	824 .23	907 .22
PHW-04	876- 925	788 .68	803 .26	807 .25	752 .24	773 .22	840 .22	882 .21	767 .20	894 .20	801 .19	867 .18
PHW-04	901- 950	788 .72	769 .38	836 .31	751 .30	729 .27	799 .27	749 .27	736 .25	818 .22	813 .22	831 .21
PHW-04	926- 975	788 .68	818 .41	751 .34	844 .33	831 .29	783 .28	769 .28	793 .25	690 .25	709 .22	774 .21
PHW-04	951-1000	788 .76	732 .31	722 .27	680 .27	766 .26	703 .26	756 .24	793 .24	758 .23	714 .23	690 .22
PHW-06	842- 891	821 .80	840 .37	836 .33	802 .30	900 .28	915 .28	800 .26	784 .24	847 .22	815 .22	923 .22
PHW-06	867- 916	821 .79	802 .43	840 .36	895 .34	751 .31	782 .28	881 .26	839 .24	847 .24	783 .22	820 .22
PHW-06	892- 941	821 .80	802 .46	755 .34	855 .33	737 .31	724 .30	776 .30	761 .30	787 .26	742 .26	869 .25
PHW-06	917- 966	821 .77	787 .40	755 .37	761 .35	816 .34	742 .33	795 .31	844 .27	803 .26	699 .25	736 .24
PHW-06	942- 991	821 .76	768 .44	795 .27	727 .26	708 .24	778 .23	735 .22	681 .22	787 .22	779 .21	690 .21
PHW-06	951-1000	821 .68	768 .36	706 .34	795 .34	727 .30	673 .27	677 .27	690 .23	808 .22	734 .21	687 .21
PHW-07	813- 862	821 .70	943 .42	910 .40	887 .27	827 .26	857 .25	808 .22	905 .21	806 .20	868 .20	876 .20
PHW-07	838- 887	821 .72	791 .33	866 .32	847 .31	889 .29	887 .28	850 .26	829 .25	792 .25	874 .24	906 .24
PHW-07	863- 912	821 .67	887 .45	802 .40	874 .36	871 .32	840 .29	866 .26	808 .25	832 .23	850 .22	895 .22
PHW-07	888- 937	821 .63	802 .33	874 .33	871 .33	743 .32	850 .30	779 .27	837 .27	813 .24	842 .24	847 .20
PHW-07	913- 962	821 .75	758 .37	779 .31	784 .28	732 .27	787 .27	847 .24	845 .22	797 .20	808 .20	858 .18
PHW-07	938- 987	821 .79	699 .33	787 .26	758 .23	723 .21	719 .21	738 .21	700 .20	795 .19	832 .19	804 .18
PHW-07	951-1000	821 .73	760 .27	738 .27	700 .27	727 .27	699 .26	795 .25	746 .24	702 .20	754 .20	817 .18
PHW-08	926- 975	821 .78	699 .34	736 .28	757 .27	843 .26	804 .23	691 .22	771 .21	729 .20	712 .20	789 .19
PHW-08	951-1000	821 .73	669 .30	747 .29	760 .27	734 .24	801 .23	767 .22	799 .20	691 .19	703 .19	772 .18
PHW-09	909- 958	821 .78	787 .38	742 .36	838 .30	795 .29	826 .29	813 .28	755 .28	781 .23	792 .23	721 .22
PHW-09	934- 983	821 .79	699 .41	742 .36	787 .31	755 .30	768 .28	690 .27	792 .26	736 .25	689 .24	813 .24
PHW-09	951-1000	821 .70	760 .38	765 .34	681 .30	727 .25	723 .25	691 .24	690 .24	746 .23	809 .22	770 .22
PHW-10	871- 920	745 .87	823 .42	782 .34	875 .32	867 .31	848 .31	897 .27	833 .27	849 .22	876 .21	842 .20
PHW-10	896- 945	745 .81	730 .30	766 .29	862 .29	808 .26	739 .26	783 .25	724 .22	749 .22	858 .21	727 .21
PHW-10	921- 970	745 .79	811 .40	709 .37	764 .35	830 .30	708 .30	803 .27	787 .27	730 .25	832 .24	724 .23
PHW-10	946- 995	745 .71	787 .38	782 .36	779 .35	763 .27	719 .26	771 .26	726 .25	753 .23	716 .22	764 .20
PHW-10	951-1000	745 .67	782 .37	779 .37	787 .36	719 .28	763 .25	726 .24	716 .23	771 .22	686 .20	722 .20

FIGURE 2



WOODWORTH HOUSE HEMLOCK
EASTERN NEW YORK HEMLOCK MASTER
1500
1600
1700
1800
1900
Year