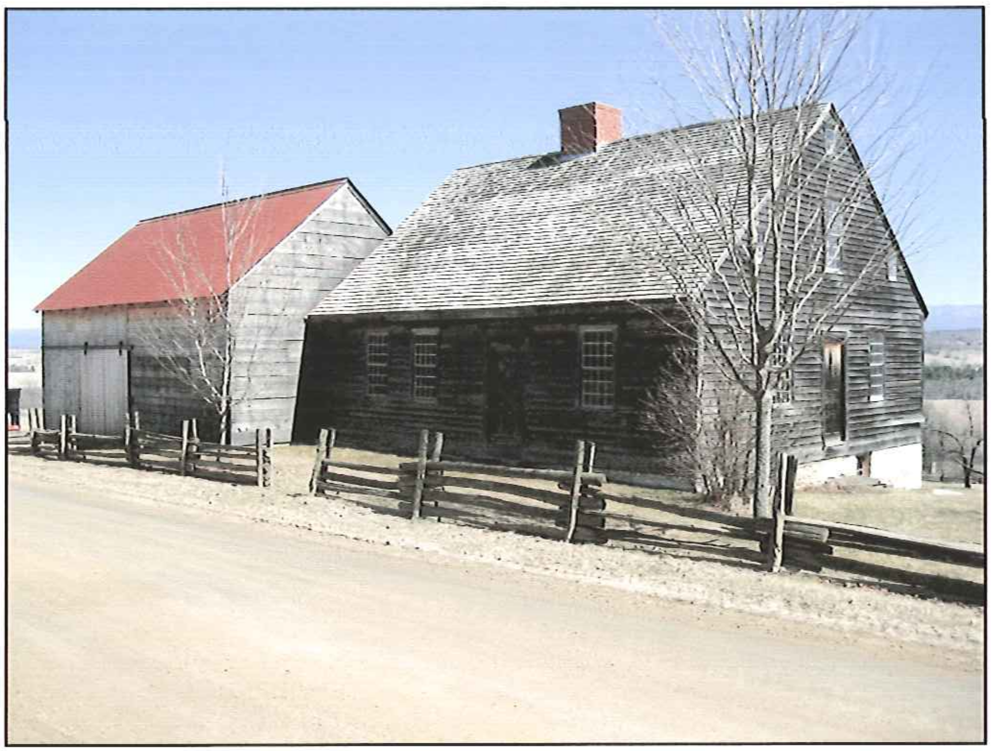
A Dendrochronology Study of Select Timbers from the Ephraim Fisher House, Orwell, Vermont



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May, 2013

A Dendrochronology Study of Select Framing Members from the Ephraim Fisher House, Orwell, Vermont

Introduction

On April 8th, 2013, a selection timbers from the Ephraim Fisher house located in Orwell, Vermont, were sampled by William Flynt for the purposes of conducting a dendrochronology study. The samples were 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 the data 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 (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.

To aid with this specific study, several regional masters were available including a wide ranging Hemlock master that encompasses portion of New York, Massachusetts, and Vermont (Cook, Flynt, Baisan) and a smaller oak master from Middlebury (Flynt).
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 years of growth is best, but more often than not, samples will range from 60 to 100+ years. While it is feasible to get dates on young samples, 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 date 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; OEF (Orwell, Ephraim Fisher) with the numbers that follow simply referring to the sequence in which the samples were taken.

Samples were taken 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 (80-600 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 by a visual review of all samples from the structures to determine if site-specific growth patterns could be picked out. 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 (measure) ring (LYOM), established as 1000, and proceeds to the center of the sample or first year of measure (FYOM). 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 PJK10v10e was used to compile each structure'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, samples from each site can be compared with each other to determine if all were cut more or less 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 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 the site master to see if additional samples align.
With COFECHA samples are broken down into ring groups of 50 years which are compared to various dated masters. The 50-year groupings in an individual sample are lagged a certain number of years (for 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 10 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 species 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.

Results (See Figure 1)
Of the17 samples extracted, fifteen were hemlock and two were oak.

Hemlock
The fifteen hemlock samples, all extracted from first floor framing system members located in the basement, were first tested against themselves in an effort to establish the age difference, if any, between the samples. Through a series of tests all samples successfully aligned with each other revealing that a majority were felled over a short period of time. Chart 1 reveals that with the exception of sample OEF-01, there appears to be a difference of one year. That said, it should be noted that a number of the samples had partial last year of growth rings indicating that the trees were felled when they were actively growing during the summer or fall. Thus, a review of Figure 1 reveals that many of the samples exhibiting a -1 on Chart 1 were, in reality, felled just prior to the ones exhibiting a 0 on Chart 1 suggesting that felling for framing of this house began in the late summer or early fall and continued in to the winter when the trees went dormant. Looking at Chart2, Part 2 of the COFECHA output related to Chart 1 displays extremely high correlation coefficients between samples suggesting that the trees for the structure were all growing in close proximity to each other. It is also quite possible that some of the timbers were cut from the same tree.
The next test compared the Fisher house samples to a geographically broad hemlock master composed of samples collected in eastern New York, western Massachusetts, and southern Vermont. Somewhat amazingly, in Chart 3 many of the Fisher house samples aligned well with dates that reflect the same differences in age as noted in Chart 1. Using

the data from these two charts, a local hemlock site master was developed by assigning the appropriate dates to the Fisher house samples. Chart 4 displays the results of comparing the undated Fisher house samples against the Fisher house hemlock dated site master which, not surprisingly, reveals strong correlations throughout.

Oak

While only two oak samples could be obtained from the framing, just one turned out to have a sufficient ring count to make analysis possible. This lone sample was compared to a small oak site chronology from the Middlebury, Vermont Congregational Church compiled by the author and, as luck would have it, the sample dated convincingly (Chart 5). The early date is not the true felling date of the tree as measuring of the sample was started 13 rings in from the waney edge. Adding 13 years to the 1787 date puts the actual felling date at 1800, in line with what the hemlock revealed. The reason for starting the measuring 13 years back from the waney edge had to do with the last years of growth being very slow resulting in very narrow rings, which, with oak, can be problematic due to the large early wood cells skewing very narrow ring widths.

Conclusion

The samples from both species of wood in the Fisher house dated extremely well against master chronologies for these species revealing a rather short period of tree felling to accumulate enough material to frame up the structure. The felling began during the warmer months of 1800 and continued into the late fall and possibly the winter of 1800/01 after the trees had ceased growing for the season. It is likely that the frame was raised in 1801 as framers preferred to work timbers green rather than dried.

What was remarkable about this study was the degree to which the samples aligned amongst themselves and with the masters they were compared to, especially the hemlock. The geographic distance between Orwell and the regions where the hemlock master samples were obtained is rather substantial. As more studies are completed where hemlock is used it is becoming clear that this species has great potential for dating over great distances. Thankfully the Fisher house framers used hemlock as the primary framing material (at least in the accessible basement areas) as very little exists in the way of master chronologies for other wood species for the northern portions of Vermont.

Acknowledgments

The author would like to thank Walter Phelps for his interest in having this study undertaken in spite of the paucity of local dated masters.

Sources:

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FIGURE 1

EPHRAIM FISHER HOUSE, ORWELL, VT

SAMPLE	AGE	FYOG	LYOG	DATE	WANE	SPECIES	LOCATION
EAST BASEMENT							
OEF-01	106	895	1000	1795*	Y	TCSA	SE CORNER,1ST JOIST FROM E.WALL
OEF-02	103	898	1000	1800	Y	TCSA	2ND JOIST FROM E. WALL
OEF-03	98	903	1000	1799^	Y	TCSA	3RD JOIST FROM E. WALL
OEF-04	119	882	1000	1799	Y	TCSA	4TH JOIST FROM E. WALL
OEF-05	113	888	1000	1799^	Y	TCSA	N-S GIRT AT MIDDLE BEARING WALL
WEST BASEMENT							
OEF-06	91	910	1000	1799^	Y	TCSA	1ST JOIST FROM S. WALL
OEF-07	101	900	1000	1799^	Y	TCSA	2ND JOIST FROM S. WALL
OEF-08	96	905	1000	1799^	Y	TCSA	6TH JOIST FROM S. WALL
OEF-09	95	906	1000	1799	Y	TCSA	7TH JOIST FROM S. WALL
OEF-10	80	921	1000	1799^	Y	TCSA	8TH JOIST FROM S. WALL
OEF-11	79	922	1000	1800	Y	TCSA	9TH JOIST FROM S. WALL
OEF-12	99	902	1000	1799^	Y	TCSA	2ND JOIST FROM N. WALL
OEF-13	69	932	1000	1800	Y	TCSA	1ST JOIST FROM N. WALL
EAST BASEMENT							
OEF-14	132	869	1000	1800	Y	TCSA	JOIST OVER BASEMENT DOOR, N.LEAF HINGE
OEF-15	101	900	1000	1800	Y	TCSA	JOIST OVER BASEMENT DOOR, S.LEAF HINGE
OEF-16	81	920	1000	1787**	Y	QUAL	HEWN GIRT HOLDING HEARTH AND OEF-14,15
OEF-17	Too short				Y	QUAL	HEWN GIRT EMBEDDED IN E.SIDE OF CHIMNEY BASE

FYOG = FIRST YEAR OF GROWTH (AS MEASURED)
LYOG = LAST YEAR OF GROWTH
TCSA = HEMLOCK
QUAL = OAK
*= LAST 2+ YEARS NOT MEASURED. ADD AT LEAST 2 YEARS TO DATE SHOWN (1797+)
^= PARTIAL LAST RING, NOT MEASURED. TREE FELLED DURING FOLLOWING SUMMER/FALL(1800)
**= LAST 13 YEARS OF GROWTH NOT MEASURED, BUT COUNTED, DUE TO BEING VERY NARROW ADD 13 TO DATE SHOWN (1800)

CHART 1

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

OEF-H VS OEF-H ALIGNED
50-YEAR SEGMENTS LAGGED 25 YEARS

SERIES	COUNTED SEGMENT	CORR ADD # 1	CORR ADD # 2	CORR ADD # 3	CORR ADD # 4	CORR ADD # 5	CORR ADD # 6	CORR ADD # 7	CORR ADD # 8	CORR ADD # 9	CORR ADD #10	CORR ADD #11
OEF-01	895- 944	-5 .82	53 .38	-24 .33	24 .29	34 .27	-20 .22	40 .21	10 .21	39 .20	26 .19	11 .18
OEF-01	920- 969	-5 .85	24 .32	-44 .30	-21 .24	7 .24	10 .23	27 .20	-32 .20	0 .17	9 .17	8 .16
OEF-01	945- 994	-5 .86	-63 .29	-50 .27	-34 .19	-68 .18	-37 .18	-19 .17	0 .16	-49 .16	-70 .15	-6 .13
OEF-01	951-1000	-5 .84	-50 .35	-37 .28	-77 .26	-63 .26	-19 .25	-34 .24	-49 .21	-6 .17	-58 .15	-35 .15
OEF-02	898- 947	0 .76	29 .32	44 .30	-15 .29	14 .22	-5 .21	21 .20	39 .19	-19 .19	34 .18	-21 .17
OEF-02	923- 972	0 .84	14 .31	-15 .28	-39 .25	-12 .19	18 .18	17 .17	2 .17	-29 .17	-42 .16	-13 .15
OEF-02	948- 997	0 .82	-32 .32	-29 .31	-58 .28	-45 .22	-72 .21	-17 .21	-14 .20	-12 .20	-1 .18	-57 .18
OEF-02	951-1000	0 .80	-29 .32	-32 .28	-58 .25	-68 .25	-72 .23	-45 .23	-14 .21	-12 .17	-17 .17	-15 .17
OEF-03	903- 952	-1 .73	44 .42	12 .39	31 .29	14 .26	21 .21	-25 .21	47 .19	28 .18	43 .18	15 .17
OEF-03	928- 977	-1 .79	-40 .36	-27 .34	21 .26	-33 .25	-13 .23	-58 .22	14 .19	12 .16	-46 .15	4 .15
OEF-03	951-1000	-1 .83	-59 .37	-73 .31	-15 .26	-33 .25	-78 .24	-58 .23	-46 .22	-18 .22	-10 .21	-31 .19
OEF-04	882- 931	-1 .82	14 .39	-7 .26	5 .24	62 .20	-5 .19	37 .19	38 .18	67 .18	23 .18	57 .15
OEF-04	907- 956	-1 .79	-24 .25	13 .24	-28 .22	6 .21	-26 .21	28 .20	4 .19	14 .18	-11 .18	-32 .17
OEF-04	932- 981	-1 .80	-40 .37	13 .29	-32 .25	-27 .24	-6 .23	4 .19	-45 .18	2 .16	-35 .15	-63 .14
OEF-04	951-1000	-1 .82	-23 .21	-30 .21	-73 .20	-32 .20	-48 .19	-15 .18	-80 .18	-2 .18	-47 .18	-18 .18
OEF-05	888- 937	-1 .84	57 .38	38 .26	7 .21	44 .20	12 .19	43 .17	-16 .16	-11 .15	33 .15	52 .14
OEF-05	913- 962	-1 .90	28 .29	31 .22	25 .17	12 .17	-14 .16	13 .15	30 .15	29 .14	11 .13	-28 .12
OEF-05	938- 987	-1 .89	-14 .29	-40 .24	-15 .22	-27 .19	-59 .18	-30 .17	-42 .16	13 .15	-18 .14	-66 .14
OEF-05	951-1000	-1 .68	-15 .31	-46 .26	-80 .26	-33 .19	-42 .18	-78 .17	-59 .17	-27 .17	-16 .16	-13 .16
OEF-06	910- 959	-1 .43	13 .33	25 .31	-3 .27	20 .25	10 .22	-26 .19	24 .19	-14 .18	-6 .17	30 .17
OEF-06	935- 984	-1 .80	13 .26	-59 .24	-14 .23	-33 .23	-46 .20	-6 .18	-63 .18	-32 .16	-30 .15	16 .14
OEF-06	951-1000	-1 .76	-78 .34	-33 .32	-59 .27	-18 .22	-15 .22	-63 .22	-46 .21	-2 .20	-16 .20	-47 .19
OEF-07	900- 949	-1 .73	48 .38	31 .35	-16 .28	47 .21	-24 .19	-31 .18	4 .18	28 .16	38 .16	2 .15
OEF-07	925- 974	-1 .78	-40 .27	13 .22	14 .20	-30 .19	2 .19	-15 .19	-6 .18	16 .17	-46 .17	-8 .17
OEF-07	950- 999	-1 .81	-30 .35	-69 .25	-15 .24	-46 .24	0 .22	-59 .21	-78 .20	-33 .20	-45 .20	-54 .17
OEF-07	951-1000	-1 .80	-30 .35	-15 .25	-69 .25	-78 .23	-59 .22	-46 .22	0 .21	-45 .20	-33 .20	-54 .18
OEF-08	905- 954	-1 .82	44 .32	-14 .26	31 .25	-16 .25	-6 .23	-32 .20	-24 .20	43 .19	26 .18	46 .17
OEF-08	930- 979	-1 .86	-40 .43	-14 .22	-30 .21	-6 .21	13 .20	-16 .20	-32 .20	9 .18	16 .18	14 .16
OEF-08	951-1000	-1 .86	-59 .30	-31 .29	-33 .25	-2 .23	-30 .22	-48 .20	-46 .19	-23 .17	-18 .15	-45 .14
OEF-09	906- 955	-1 .81	-32 .30	44 .29	15 .25	-24 .25	13 .22	-14 .19	-17 .18	12 .16	-28 .16	-13 .15
OEF-09	931- 980	-1 .84	-40 .33	-30 .25	-32 .21	13 .21	-14 .21	-33 .19	-16 .19	-59 .18	-29 .17	-47 .16
OEF-09	951-1000	-1 .79	-15 .30	-33 .29	-30 .28	-59 .28	-58 .25	-73 .23	0 .22	-47 .21	-32 .19	-78 .18
OEF-10	921- 970	-1 .55	30 .36	-15 .33	-2 .29	-40 .27	16 .24	-17 .23	-42 .22	-46 .21	13 .20	-28 .16
OEF-10	946- 995	-1 .82	-46 .42	-59 .30	-30 .27	-69 .24	-15 .23	-33 .22	-73 .20	-65 .18	-2 .17	0 .15
OEF-10	951-1000	-1 .87	-46 .34	-59 .29	-30 .27	-33 .25	-73 .24	-15 .22	-69 .20	-23 .15	-16 .14	-2 .14
OEF-11	922- 971	0 .81	-26 .37	13 .28	29 .25	-53 .23	-34 .21	-45 .20	-16 .19	15 .19	5 .17	-13 .16
OEF-11	947- 996	0 .91	-29 .40	-32 .38	-45 .31	-58 .26	-72 .23	1 .23	-57 .19	-48 .16	-17 .16	-30 .15
OEF-11	951-1000	0 .91	-29 .41	-32 .32	-45 .31	-58 .27	-68 .23	-72 .23	-30 .21	-77 .19	-15 .19	-47 .16
OEF-12	902- 951	-1 .73	44 .30	28 .27	31 .24	38 .22	-16 .20	-28 .19	15 .19	-25 .17	-19 .17	-32 .16
OEF-12	927- 976	-1 .77	-40 .43	-46 .31	-14 .31	-15 .23	-33 .23	-30 .22	-56 .19	-27 .17	14 .16	-48 .15
OEF-12	951-1000	-1 .85	-30 .44	-15 .39	-33 .33	-46 .31	-59 .28	0 .27	-78 .26	-32 .23	-45 .23	-16 .22
OEF-13	932- 981	0 .81	-32 .31	-13 .31	-39 .30	-53 .26	-45 .24	-15 .22	17 .22	19 .20	-26 .19	-16 .19
OEF-13	951-1000	0 .91	-32 .39	-29 .37	-45 .36	-77 .33	-14 .29	-15 .26	-68 .23	-58 .22	-31 .18	-76 .16
OEF-14	869- 918	0 .79	39 .32	6 .28	54 .28	19 .27	15 .20	68 .19	53 .18	29 .17	58 .17	57 .15
OEF-14	894- 943	0 .72	39 .31	54 .28	32 .26	-21 .25	29 .24	13 .22	53 .18	45 .18	51 .15	-15 .14
OEF-14	919- 968	0 .89	32 .32	29 .30	17 .22	-14 .20	-48 .19	22 .18	-40 .17	-7 .16	-46 .16	14 .16
OEF-14	944- 993	0 .90	-32 .35	-29 .34	-45 .28	-72 .18	1 .18	-22 .18	-17 .18	-44 .17	-14 .15	-30 .15
OEF-14	951-1000	0 .89	-45 .31	-32 .30	-29 .26	-47 .22	-22 .21	-72 .19	-64 .18	-30 .17	-68 .17	-48 .17
OEF-15	900- 949	0 .79	-8 .26	39 .23	12 .21	-23 .17	23 .17	-5 .17	-16 .15	-15 .15	36 .14	-31 .14
OEF-15	925- 974	0 .88	-39 .39	12 .22	14 .20	-29 .20	22 .18	-32 .17	13 .14	-16 .14	-26 .13	-13 .12
OEF-15	950- 999	0 .90	-45 .35	-29 .28	-1 .27	-58 .25	-32 .23	-14 .21	-31 .17	-72 .16	-48 .14	-78 .13
OEF-15	951-1000	0 .90	-45 .37	-29 .30	-32 .23	-68 .21	-1 .21	-58 .18	-78 .18	-14 .18	-47 .16	-72 .16

CHART 2

OEF HEMLOCK SITE MASTER
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

FLAGS: _A = CORRELATION UNDER 0.3281; _B = CORRELATION HIGHER AT OTHER POSITION

	SEQ	SERIES	INTERVAL	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	1275 1324	1300 1349	1325 1374	FLAGS/ TOTAL
+	1	OEF-01	890- 995	=	.76	.83	.83	.81	=															0/ 4
+	2	OEF-02	898-1000	=	.71	.75	.80	.78	.77															0/ 5
+	3	OEF-03	902- 999	=	=	.68	.75	.81	=															0/ 3
+	4	OEF-04	881- 999	=	.71	.72	.71	.77	=															0/ 4
+	5	OEF-05	887- 999	=	.77	.83	.89	.63	=															0/ 4
+	6	OEF-06	910- 999	=	=	.46	.63	.72	=															0/ 3
+	7	OEF-07	899- 999	=	.67	.68	.74	.76	=															0/ 4
+	8	OEF-08	904- 999	=	=	.78	.82	.83	=															0/ 3
+	9	OEF-09	905- 999	=	=	.77	.81	.75	=															0/ 3
+	10	OEF-10	920- 999	=	=	.49	.58	.85	=															0/ 3
+	11	OEF-11	922-1000	=	=	.78	.77	.89	.89															0/ 4
+	12	OEF-12	901- 999	=	=	.68	.72	.83	=															0/ 3
+	13	OEF-13	932-1000	=	=	=	.78	.87	.89															0/ 3
+	14	OEF-14	881-1000	=	.62	.70	.89	.87	.87															0/ 5
+	15	OEF-15	900-1000	=	=	.74	.87	.89	.89															0/ 4

CHART 3

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

OEF-H VS NY-VT-MA HEMLOCK MASTER
50-YEAR SEGMENTS LAGGED 25 YEARS

SERIES	COUNTED SEGMENT	CORR ADD # 1	CORR ADD # 2	CORR ADD # 3	CORR ADD # 4	CORR ADD # 5	CORR ADD # 6	CORR ADD # 7	CORR ADD # 8	CORR ADD # 9	CORR ADD #10	CORR ADD #11
OEF-01	895- 944	795 .40	990 .37	974 .35	883 .34	1020 .33	574 .32	853 .32	722 .31	1055 .30	604 .30	948 .30
OEF-01	920- 969	795 .64	745 .39	596 .37	996 .35	575 .31	933 .30	883 .29	825 .29	654 .29	604 .28	594 .27
OEF-01	945- 994	795 .66	660 .42	695 .36	686 .34	945 .32	839 .30	629 .30	617 .29	719 .29	578 .29	596 .28
OEF-01	951-1000	795 .65	686 .42	514 .37	945 .37	719 .37	660 .36	695 .33	840 .32	533 .32	578 .32	629 .31
OEF-02	898- 947	800 .53	1001 .39	1025 .37	968 .34	781 .33	673 .33	888 .32	601 .30	688 .30	903 .29	844 .28
OEF-02	923- 972	800 .58	986 .38	859 .36	750 .35	596 .33	1001 .33	585 .33	571 .33	776 .30	601 .29	665 .29
OEF-02	948- 997	570 .42	800 .37	634 .37	724 .37	743 .34	859 .33	846 .32	688 .31	845 .31	538 .30	938 .30
OEF-02	951-1000	570 .37	688 .36	724 .35	859 .34	743 .32	707 .32	634 .31	846 .31	538 .30	845 .30	602 .29
OEF-03	903- 952	627 .42	799 .41	990 .39	640 .38	857 .35	870 .33	1045 .33	922 .33	844 .32	1000 .31	614 .30
OEF-03	928- 977	799 .58	664 .46	985 .40	936 .38	699 .35	716 .34	736 .34	773 .34	540 .33	621 .32	595 .29
OEF-03	951-1000	799 .65	742 .46	586 .41	664 .38	690 .37	540 .36	537 .35	673 .35	985 .34	943 .34	845 .32
OEF-04	882- 931	814 .40	926 .38	1001 .38	633 .35	1066 .33	799 .32	780 .32	1009 .32	693 .31	945 .30	1036 .30
OEF-04	907- 956	799 .52	600 .43	1000 .40	862 .32	895 .30	990 .30	570 .30	721 .30	659 .28	790 .28	757 .27
OEF-04	932- 981	799 .55	971 .34	664 .34	600 .33	1011 .32	659 .32	699 .31	907 .31	773 .30	936 .30	848 .29
OEF-04	951-1000	799 .52	633 .43	742 .36	552 .35	526 .32	690 .29	870 .28	628 .28	627 .27	828 .26	699 .26
OEF-05	888- 937	926 .35	711 .35	799 .35	978 .33	712 .32	1066 .31	594 .31	899 .29	1024 .29	791 .27	679 .26
OEF-05	913- 962	799 .67	544 .50	829 .41	1032 .38	570 .37	600 .37	595 .37	902 .32	749 .32	711 .31	680 .30
OEF-05	938- 987	799 .62	773 .42	699 .41	664 .37	843 .35	582 .35	723 .34	786 .32	936 .30	829 .30	971 .30
OEF-05	951-1000	799 .46	569 .44	723 .37	632 .37	736 .34	786 .30	555 .29	843 .28	699 .28	773 .27	797 .27
OEF-06	910- 959	595 .44	842 .43	992 .36	658 .35	799 .34	664 .34	1014 .34	901 .33	716 .32	829 .32	820 .30
OEF-06	935- 984	799 .61	595 .47	829 .47	664 .41	532 .38	843 .32	650 .32	522 .31	786 .30	716 .30	658 .29
OEF-06	951-1000	799 .53	596 .39	664 .38	914 .37	532 .37	742 .35	855 .33	932 .33	829 .33	621 .32	595 .31
OEF-07	900- 949	799 .47	600 .37	752 .36	990 .35	848 .34	681 .32	874 .32	1047 .31	659 .31	1000 .29	726 .28
OEF-07	925- 974	799 .49	829 .38	600 .38	716 .37	664 .37	549 .36	570 .35	595 .34	659 .31	687 .30	907 .29
OEF-07	950- 999	799 .49	633 .42	870 .34	885 .33	627 .33	664 .32	547 .31	527 .30	699 .29	845 .29	743 .28
OEF-07	951-1000	799 .49	633 .40	870 .33	885 .33	547 .32	627 .32	743 .30	664 .30	845 .28	699 .28	596 .28
OEF-08	905- 954	799 .49	887 .39	681 .36	990 .35	608 .33	659 .31	915 .30	787 .29	867 .28	870 .28	844 .28
OEF-08	930- 979	799 .56	664 .45	549 .38	733 .37	816 .36	716 .36	699 .35	985 .35	923 .35	946 .34	595 .34
OEF-08	951-1000	799 .53	664 .42	844 .36	586 .32	890 .32	690 .32	566 .32	703 .32	742 .31	855 .30	825 .30
OEF-09	906- 955	799 .53	749 .43	857 .42	600 .37	936 .34	985 .32	595 .28	790 .27	962 .27	703 .27	990 .26
OEF-09	931- 980	799 .43	985 .41	595 .38	936 .38	786 .37	829 .36	664 .35	843 .35	736 .35	749 .35	621 .33
OEF-09	951-1000	621 .37	742 .36	552 .35	799 .34	566 .33	586 .32	706 .31	828 .31	874 .31	684 .31	538 .29
OEF-10	921- 970	799 .43	858 .35	881 .35	891 .35	816 .33	695 .31	720 .29	945 .28	664 .28	673 .28	658 .27
OEF-10	946- 995	799 .49	844 .45	664 .38	621 .37	923 .34	595 .32	541 .30	742 .30	842 .29	933 .29	627 .28
OEF-10	951-1000	799 .40	844 .38	664 .37	586 .37	566 .36	742 .32	621 .31	595 .31	855 .30	541 .29	653 .28
OEF-11	922- 971	800 .50	893 .37	717 .37	743 .36	986 .36	634 .35	734 .35	856 .32	830 .31	665 .31	596 .30
OEF-11	947- 996	800 .69	743 .50	538 .46	634 .43	665 .36	519 .35	846 .33	969 .33	691 .32	871 .32	986 .32
OEF-11	951-1000	800 .61	538 .50	743 .49	846 .34	542 .34	567 .33	665 .32	691 .32	969 .29	635 .29	570 .29
OEF-12	902- 951	799 .49	640 .38	1045 .35	624 .35	994 .34	653 .34	1000 .33	744 .33	1039 .31	857 .31	781 .31
OEF-12	927- 976	799 .52	829 .38	936 .36	900 .36	773 .34	946 .33	958 .33	664 .33	552 .33	608 .33	595 .32
OEF-12	951-1000	799 .55	569 .35	518 .33	914 .33	736 .32	664 .31	845 .30	979 .29	633 .29	538 .29	723 .28
OEF-13	932- 981	665 .46	830 .41	908 .41	800 .38	596 .37	743 .36	717 .34	819 .32	972 .31	893 .31	615 .30
OEF-13	951-1000	800 .38	915 .36	665 .35	743 .35	518 .31	634 .29	602 .28	942 .27	587 .27	542 .27	972 .27
OEF-14	869- 918	800 .42	628 .40	933 .39	913 .36	858 .35	1002 .33	992 .32	887 .32	1073 .31	679 .29	854 .29
OEF-14	894- 943	673 .44	688 .40	800 .40	638 .38	991 .35	900 .34	775 .33	875 .32	888 .31	995 .31	787 .31
OEF-14	919- 968	800 .51	986 .45	700 .37	1033 .37	924 .34	536 .34	717 .33	835 .33	1031 .33	651 .31	571 .31
OEF-14	944- 993	800 .61	634 .40	737 .39	986 .39	846 .34	700 .34	519 .32	622 .32	871 .31	743 .31	541 .31
OEF-14	951-1000	800 .51	846 .41	634 .38	635 .38	743 .37	665 .31	587 .31	622 .30	541 .30	986 .30	765 .29
OEF-15	900- 949	800 .53	1043 .35	682 .35	1001 .35	991 .34	883 .32	563 .32	596 .32	624 .31	704 .31	960 .30
OEF-15	925- 974	800 .51	596 .47	986 .44	998 .36	787 .35	700 .35	550 .32	937 .32	900 .32	859 .32	829 .31
OEF-15	950- 999	634 .42	800 .41	570 .38	845 .36	743 .35	596 .33	665 .32	567 .32	538 .30	587 .30	846 .29
OEF-15	951-1000	800 .42	634 .40	743 .39	596 .38	570 .38	845 .35	665 .33	538 .29	846 .28	704 .28	924 .28

CHART 4

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

OEF-H VS OEF-H DATED
50-YEAR SEGMENTS LAGGED 25 YEARS

SERIES	COUNTED SEGMENT	CORR ADD # 1	CORR ADD # 2	CORR ADD # 3	CORR ADD # 4	CORR ADD # 5	CORR ADD # 6	CORR ADD # 7	CORR ADD # 8	CORR ADD # 9	CORR ADD #10	CORR ADD #11
OEF-01	895- 944	795 .82	853 .38	776 .33	824 .29	834 .27	780 .22	840 .21	810 .21	839 .20	826 .20	811 .18
OEF-01	920- 969	795 .85	824 .32	756 .30	779 .24	807 .24	810 .23	827 .20	768 .20	809 .17	800 .16	808 .16
OEF-01	945- 994	795 .86	737 .29	750 .28	766 .19	732 .18	763 .18	781 .17	800 .16	751 .16	730 .15	794 .13
OEF-01	951-1000	795 .84	750 .35	763 .28	737 .26	723 .26	781 .25	766 .24	751 .21	794 .17	765 .15	742 .14
OEF-02	898- 947	800 .77	829 .32	844 .30	785 .29	814 .22	795 .21	821 .20	839 .19	781 .19	834 .18	779 .18
OEF-02	923- 972	800 .84	814 .31	785 .28	761 .25	788 .19	818 .18	771 .18	817 .17	802 .17	758 .16	787 .16
OEF-02	948- 997	800 .82	768 .32	771 .31	742 .28	755 .22	783 .21	728 .21	786 .20	788 .20	799 .18	743 .18
OEF-02	951-1000	800 .80	771 .32	768 .28	742 .26	732 .24	755 .23	728 .23	786 .21	788 .17	783 .17	785 .17
OEF-03	903- 952	799 .73	844 .42	812 .40	831 .29	814 .26	775 .21	821 .21	847 .20	828 .18	843 .18	815 .17
OEF-03	928- 977	799 .79	760 .35	773 .34	821 .27	767 .25	787 .23	742 .22	814 .19	812 .16	754 .15	804 .15
OEF-03	951-1000	799 .83	741 .37	727 .30	785 .27	767 .25	722 .24	742 .23	754 .22	782 .22	790 .21	769 .19
OEF-04	882- 931	799 .82	814 .40	793 .26	805 .24	862 .20	795 .19	837 .19	838 .18	867 .18	823 .17	818 .15
OEF-04	907- 956	799 .79	776 .25	813 .24	772 .22	774 .22	806 .21	828 .20	804 .19	814 .18	768 .18	789 .17
OEF-04	932- 981	799 .80	760 .37	813 .29	768 .25	773 .24	794 .23	804 .18	755 .18	802 .16	765 .15	737 .15
OEF-04	951-1000	799 .82	777 .21	770 .21	768 .20	727 .20	752 .20	720 .19	785 .18	798 .18	753 .17	782 .17
OEF-05	888- 937	799 .84	857 .38	838 .26	807 .21	844 .20	812 .20	843 .17	784 .16	833 .15	789 .15	856 .14
OEF-05	913- 962	799 .91	828 .29	831 .22	812 .17	825 .17	786 .16	813 .15	830 .14	829 .14	811 .13	772 .12
OEF-05	938- 987	799 .89	786 .29	760 .24	785 .23	773 .19	770 .18	741 .18	758 .16	813 .15	734 .14	782 .14
OEF-05	951-1000	799 .68	785 .31	754 .26	720 .26	767 .20	722 .18	758 .17	741 .17	773 .17	784 .17	787 .16
OEF-06	910- 959	799 .44	813 .34	825 .31	797 .27	820 .24	810 .22	774 .19	824 .19	786 .18	794 .17	830 .17
OEF-06	935- 984	799 .80	813 .25	741 .24	786 .23	767 .22	754 .20	794 .18	737 .18	768 .16	770 .15	816 .15
OEF-06	951-1000	799 .76	722 .34	767 .32	741 .27	782 .22	785 .22	737 .22	754 .21	798 .20	784 .20	753 .19
OEF-07	900- 949	799 .73	848 .38	831 .35	784 .28	847 .21	776 .19	804 .18	769 .18	828 .16	802 .16	838 .16
OEF-07	925- 974	799 .78	760 .27	813 .22	814 .21	770 .20	802 .19	785 .19	794 .18	816 .17	754 .17	792 .17
OEF-07	950- 999	799 .81	770 .35	731 .25	785 .24	754 .24	800 .22	741 .21	767 .20	722 .20	755 .20	777 .17
OEF-07	951-1000	799 .80	770 .35	785 .25	731 .25	722 .23	741 .22	754 .22	800 .21	755 .20	767 .20	746 .18
OEF-08	905- 954	799 .82	844 .32	786 .26	831 .25	784 .25	794 .23	768 .20	843 .20	776 .19	826 .18	846 .17
OEF-08	930- 979	799 .86	760 .43	786 .22	770 .21	794 .21	813 .20	768 .20	784 .20	809 .18	816 .18	814 .16
OEF-08	951-1000	799 .86	741 .30	769 .28	767 .25	798 .23	770 .22	752 .21	754 .19	777 .17	782 .16	755 .14
OEF-09	906- 955	799 .81	768 .31	844 .29	815 .26	776 .24	813 .22	786 .19	783 .18	812 .16	772 .16	787 .15
OEF-09	931- 980	799 .84	760 .32	770 .25	768 .21	813 .21	786 .21	784 .19	767 .19	741 .18	771 .17	753 .16
OEF-09	951-1000	799 .79	785 .30	767 .29	770 .28	741 .28	742 .26	727 .23	800 .22	753 .21	768 .19	722 .18
OEF-10	921- 970	799 .55	830 .36	785 .34	798 .29	760 .27	816 .24	783 .23	758 .22	754 .21	813 .20	772 .16
OEF-10	946- 995	799 .82	754 .42	741 .30	770 .27	785 .23	731 .23	767 .22	727 .19	735 .18	798 .18	800 .15
OEF-10	951-1000	799 .87	754 .35	741 .29	770 .27	767 .26	727 .24	785 .22	731 .20	777 .15	723 .14	798 .14
OEF-11	922- 971	800 .81	774 .37	813 .29	829 .25	747 .23	766 .21	755 .20	784 .19	815 .19	805 .17	787 .17
OEF-11	947- 996	800 .91	771 .40	768 .38	755 .31	742 .27	728 .23	801 .23	743 .20	783 .16	752 .16	770 .15
OEF-11	951-1000	800 .91	771 .41	768 .32	755 .31	742 .27	732 .23	728 .22	770 .21	723 .19	785 .19	753 .17
OEF-12	902- 951	799 .73	844 .30	828 .27	831 .24	838 .22	784 .20	815 .19	772 .19	775 .18	781 .17	768 .16
OEF-12	927- 976	799 .77	760 .43	754 .31	786 .31	785 .23	767 .22	770 .22	744 .19	773 .17	814 .16	752 .15
OEF-12	951-1000	799 .85	770 .44	785 .39	767 .33	754 .31	741 .28	800 .27	722 .26	755 .23	768 .23	784 .22
OEF-13	932- 981	800 .81	768 .32	787 .31	761 .30	747 .26	755 .24	785 .22	817 .22	819 .20	774 .19	784 .19
OEF-13	951-1000	800 .91	768 .39	771 .37	755 .37	723 .33	786 .29	785 .26	732 .23	742 .22	769 .18	724 .16
OEF-14	869- 918	800 .79	839 .32	806 .28	854 .28	819 .27	815 .20	868 .19	853 .18	829 .17	858 .17	857 .15
OEF-14	894- 943	800 .72	839 .31	854 .28	832 .27	779 .26	829 .24	813 .22	853 .18	845 .17	785 .15	851 .15
OEF-14	919- 968	800 .88	832 .33	829 .30	817 .22	786 .20	752 .18	822 .18	760 .17	754 .16	793 .16	814 .16
OEF-14	944- 993	800 .90	768 .35	771 .35	755 .28	801 .18	728 .18	778 .18	783 .17	756 .17	786 .15	770 .15
OEF-14	951-1000	800 .89	755 .31	768 .30	771 .26	753 .23	778 .21	728 .19	736 .18	770 .17	732 .17	752 .17
OEF-15	900- 949	800 .79	792 .26	839 .23	812 .21	823 .18	795 .17	777 .17	784 .15	785 .15	836 .14	769 .14
OEF-15	925- 974	800 .88	761 .39	812 .23	771 .20	814 .20	822 .18	768 .17	813 .14	784 .14	774 .13	755 .13
OEF-15	950- 999	800 .90	755 .36	771 .28	799 .27	742 .25	768 .23	786 .21	769 .17	728 .15	752 .14	722 .13
OEF-15	951-1000	800 .90	755 .37	771 .30	768 .23	799 .21	732 .21	742 .18	722 .18	786 .18	753 .17	728 .16

CHART 5

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

OEF-16 VS MIDDLEBURY AREA PROVISIONAL OAK MASTER
50-YEAR SEGMENTS LAGGED 20 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
OEF-16	920- 969	787	.58	722	.41	597	.35	709	.32	628	.31	679	.27	774	.27	594	.25	755	.25	702	.24	810	.23
OEF-16	940- 989	787	.54	561	.45	778	.26	581	.26	572	.25	655	.25	610	.24	584	.23	588	.22	682	.21	750	.21
OEF-16	951-1000	787	.47	561	.44	584	.32	637	.30	693	.30	588	.27	674	.26	673	.26	778	.26	711	.25	777	.25