A Dendrochronology Study of Select Timbers from the Shepherd Barn, Historic Northampton, Northampton, Massachusetts

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Introduction

On July 20th, 2016, a selection of timbers from the Shepherd barn located on the Historic Northampton campus in Northampton, Massachusetts 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 data and confirm 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.

To aid with this specific study several local and regional oak and pitch pine master chronologies developed by the author are available for comparative purposes.

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 50 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 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; NSB (Northampton, Shepherd Barn) 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 can be ascertained in order to help 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 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 (Holmes, 1983), the samples from this 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 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 the site master to see if additional samples align.

With COFECHA samples are broken down into ring groups of 50 years that are then 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 lags of 5 and 10 years were 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	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
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 for further scrutiny.

Results (See Figure 1)

Pine

Twelve of the thirteen samples are pitch pine, a species which is commonly found used in constructing early valley architecture and as such has been the subject of numerous dendroarcheological studies. Ring counts in the samples ranged from rather short (42) to respectable (109) with a majority falling within the range of being meaningful. Three had under 50 rings and thus do not hold much weight.

When the samples were tested against themselves in an attempt to build a floating chronology they indicated that, for the most part, they were felled over several seasons. Chart 1, Part 8, reveals samples NSB-05,06,12, and 13 were felled the same year whereas NSB-01,02, and 04 came down the year after. While it appears NSB-03,07, 08, and 11 came down the year before this is really not the case as all had a partial last ring which was not measured but still needs to be added back. This partial ring indicates the tree was felled during the following year growing season. Sample NSB-09, an internal post, indicates having been felled 20 years previous which may indicate one of two things. Either it was reused or in storage prior to being used here, or what was determined to be a waney edge was in fact, not. Part 2 of Chart 1 reveals that all the aligned sampled have strong inter-correlations ranging from the mid .40s to the low.80s with the exception of the very early years of samples NSB-05 and 09. This is not of much concern due to the fact that NSB-05's early year growth rings are typically large whereas NSB-09's growth rings are much tighter in the range where these two samples overlap between rings 890 and 900.

The next step entailed running a comparison of the barn pitch pine against a rather extensive Connecticut River Valley of Massachusetts dated pitch pine master. Chart 2

reveals NSB-01, 02 and 04 aligning to 802 (1802), NSB-03,07,08, and11 aligning with 800 (1800), and NSB-05,12, and 13 aligning with 801 (1801). NSB-09 shows respectable strength for wanting to align with 1781 in its latter years of growth. In all cases the correlation coefficients are strong and the relationships of the ages delineated align well with the data displayed on Chart 1. With such strong results, further testing against other pitch pine masters was not deemed necessary. The samples were assigned the dates displayed on Chart 2, creating a Shepherd barn pitch pine site master, which is depicted on Chart 3.

Oak

One lone oak sample was obtained from a north wall stud. Due to its relatively short ring count, the lag was dropped to 5 years when the sample was tested against a Connecticut River Valley (MA) oak chronology and a Deerfield oak chronology. Chart 4 reveals the stud wants to date to 1804 in both instances, though not with great strength throughout it sequence.

Discussion

The pitch pine samples clearly indicate the framing for the barn was felled over a two year period beginning in the summer of 1801 and continuing into the late fall/winter of 1802. This would then indicate that the earliest the frame could have been raised was the spring of 1803. That said, the lone oak sample throws a bit of a wrench into the mix as its felling date in the winter of 1804 would suggest a spring of 1805 raising date. Careful scrutiny of this stud (and the others as well) should be undertaken to determine if the studs are mortised into the framing top and bottom (and thus inserted at the time of the raising) or if they are installed in such a way as to allow for later insertion. A review of tax records for the property from 1800 to 1806 might just reveal when the barn was raised.

Acknowledgments

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Sources:

Baillie, M.G.L. 1982 *Tree-Ring Dating and Archeology.* Croom Helm, London and Canberra.

Flynt, W. 2004. *A Dendrochronological Study of a Select Group of Deerfield, Massachusetts Buildings.* Deerfield, MA.

Holmes, R. L. 1983. Computer-Assisted Quality Control in Tree Ring Dating and Measurement. *Tree-ring Bulletin*, 4:69-78.

Krusic, P.J. and Cook E.R. 2001. *The Development of Standard Tree-Ring Chronologies for Dating Historic Structures in Eastern Massachusetts, Phase I.* Great Bay Tree-Ring Lab and The Society for the Preservation of New England Antiquities, Durham, NH and Boston.

Krusic, P.J. 2001 *Dendrochronological Examination of Wood Samples from Three Historic Deerfield Homes.* The Great Bay Tree-Ring Lab, Durham, NH

Miles,D.W.H., Worthington, M.J. and Grady,A.A. 2002. *Development of Standard Tree-Ring Chronologies for Dating Historic Structures in Eastern Massachusetts, Phase II.* The Society for the Preservation of New England Antiquities and Oxford Dendrochronological Lab. Boston and Oxfordshire.

Miles,D.W.H., Worthington,M.J. and Grady, A.A. 2003. *Development of Standard Tree-Ring Chronologies for Dating Historic Structures in Eastern Massachusetts, Phase III.* The Society for the Preservation of New England Antiquities and Oxford Dendrochronological Lab, Boston and Oxfordshire.

Miles,D.W.H.,Worthington, M.J. and Grady,A.A. 2005. *Development of Standard Tree-Ring Chronologies for Dating Historic Structures in Eastern Massachusetts, Phase IV.* The Society for the Preservation of New England Antiquities and Oxford Dendrochronology Laboratory, Boston and Oxfordshire.

Speer, James H.2010. *Fundamentals of Tree-Ring Research*, The University of Arizona Press, Tucson.

FIGURE 1

SHEPHERD BARN, HISTORIC NORTHAMPTON, NORTHAMPTON, MA

SAMPLE	AGE	FYOG	LYOG	DATE	WANE	SPECIES	LOCATION
NSB-01	55	946	1000	1802	Y	PIRI	SOUTHEAST CORNER POST
NSB-02	70	931	1000	1802	Y	PIRI	FIRST POST NORTH OF NSB-01
NSB-03	67	934	1000	1800*	Y	PIRI	SECOND POST NORTH OF NSB-01
NSB-04	87	914	1000	1802	Y	PIRI	NORTHEAST CORNER POST
NSB-05	109	892	1000	1801	Y	PIRI	NORTH WALL MIDDLE POST
NSB-06	44	957	1000	1801	Y	PIRI	NORTHWEST CORNER POST
NSB-07	48	953	1000	1800*	Y	PIRI	RUNWAY SOUTH SIDE TIE BEAM AT PLATE
NSB-08	59	942	1000	1800*	Y	PIRI	RUNWAY NORTH SIDE TIE BEAM AT PLATE
NSB-09	92	909	1000	1781*	Y?	PIRI	RUNWAY NORTH SIDE MIDDLE POST
NSB-10	63	938	1000	1804	Y	QUSP	EAST WALL STUD, 2ND SOUTH OF NSB-03
NSB-11	57	944	1000	1800*	Y	PIRI	SOUTH WALL MIDDLE POST
NSB-12	42	959	1000	1801	Y	PIRI	RUNWAY SOUTH SIDE MIDDLE POST
NSB-13	60	941	1000	1801	Y	PIRI	BEAM BETWEEN NSB-11 AND NSB-12

FYOG = FIRST YEAR OF GROWTH (AS MEASURED)
LYOG = LAST YEAR OF GROWTH
* = PARTIAL LAST RING, NOT MEASURED. TIMBER FELLED DURING FOLLOWING GROWING SEASON
    1800* = SUMMER 1801
    1781* = SUMMER 1782
PIRI = PITCH PINE
QUSP = OAK

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 10 YEARS

FLAGS: __A = CORRELATION UNDER 0.3281; __B = CORRELATION HIGHER AT OTHER POSITION

0SEQ	SERIES	INTERVAL	880 929	890 939	900 949	910 959	920 969	930 979	940 989	950 999	960 1009	970 1019	980 1029	990 1039	1000 1049	1010 1059	1020 1069	1030 1079	1040 1089	1050 1099	1060 1109	1070 1119	FLAGS/ TOTAL
1	NSB-01	947-1001	=	=	=	=	=	=	.68	.70	.69	=	=	=									0/ 3
+																							
2	NSB-02	932-1001	=	=	=	=	=	.46	.51	.49	.48	=	=	=									0/ 4
+																							
3	NSB-03	933- 999	=	=	=	=	=	.74	.76	.81	=	=	=	=									0/ 3
+																							
4	NSB-04	915-1001	=	=	=	.47	.64	.68	.65	.63	.65	=	=	=									0/ 6
+																							
5	NSB-05	892-1000	=	.12	.33	.51	.54	.63	.58	.59	.60	=	=	=									2/ 8
+				___B	___A																		
6	NSB-06	957-1000	=	=	=	=	=	=	=	.43	=	=	=	=									0/ 1
+																							
7	NSB-07	952- 999	=	=	=	=	=	=	=	.57	=	=	=	=									0/ 1
+																							
8	NSB-08	941- 999	=	=	=	=	=	=	.66	.65	=	=	=	=									0/ 2
+																							
9	NSB-09	892- 980	=	.13	.32	.43	.59	.67	.67	=	=	=	=	=									2/ 6
+				___B	___A																		
10	NSB-11	943- 999	=	=	=	=	=	=	.59	.67	=	=	=	=									0/ 2
+																							
11	NSB-12	959-1000	=	=	=	=	=	=	=	.56	=	=	=	=									0/ 1
+																							
12	NSB-13	941-1000	=	=	=	=	=	=	.71	.79	.79	=	=	=									0/ 3
+																							

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

NSB PITCH PINE VS NSB PITCH PINE ALIGNED
50-YEAR SEGMENTS LAGGED 10 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
NSB-01	946- 995	1 .74	-47 .49	-51 .26	-11 .20	-35 .18	-23 .17	-8 .16	4 .15	-36 .15	-38 .15	-33 .15
NSB-01	951-1000	1 .76	-47 .49	-23 .27	-51 .23	-33 .20	-12 .20	-11 .19	-9 .15	-36 .14	-8 .14	-52 .13
NSB-02	931- 980	1 .59	-17 .23	13 .20	-15 .19	12 .19	-13 .17	-8 .16	3 .15	11 .15	-28 .15	-41 .14
NSB-02	941- 990	1 .60	-47 .42	-15 .25	-51 .18	-13 .17	-28 .17	-36 .16	-11 .15	-27 .14	-41 .14	10 .14
NSB-02	951-1000	1 .59	-47 .30	-52 .26	-28 .23	-12 .22	0 .22	-59 .19	-62 .19	-49 .16	-11 .16	-10 .16
NSB-03	934- 983	-1 .81	11 .26	-13 .23	-3 .23	10 .18	1 .17	9 .16	13 .16	-27 .15	-21 .15	-40 .14
NSB-03	944- 993	-1 .82	-13 .40	-53 .29	-3 .29	-49 .28	-23 .28	-25 .24	-14 .19	-37 .17	1 .16	-21 .15
NSB-03	951-1000	-1 .85	-13 .31	-11 .25	-14 .23	-49 .23	-25 .23	-61 .21	-53 .20	-3 .19	-23 .19	-35 .16
NSB-04	914- 963	1 .67	17 .41	-16 .29	29 .25	4 .24	21 .16	-25 .15	26 .14	38 .11	-19 .11	-15 .10
NSB-04	924- 973	1 .81	17 .29	25 .24	4 .24	-8 .22	13 .21	-12 .21	-10 .18	26 .17	16 .15	3 .12
NSB-04	934- 983	1 .72	-12 .37	-10 .29	13 .26	-23 .24	-8 .21	17 .19	4 .16	16 .15	-25 .15	3 .14
NSB-04	944- 993	1 .76	-23 .33	-39 .28	-10 .27	-12 .25	-11 .21	-9 .19	-8 .19	-47 .16	-21 .15	-50 .15
NSB-04	951-1000	1 .73	-23 .36	-12 .30	-11 .29	-24 .26	-10 .26	-59 .25	-21 .24	-39 .22	-9 .22	-61 .19
NSB-05	892- 941	0 .64	60 .29	9 .24	33 .20	53 .19	39 .16	48 .15	52 .14	17 .13	37 .13	-1 .12
NSB-05	902- 951	0 .75	9 .24	28 .23	18 .22	42 .18	-13 .17	39 .17	-9 .16	33 .15	40 .15	16 .15
NSB-05	912- 961	0 .79	-14 .25	-18 .24	28 .21	-17 .20	20 .17	-9 .14	24 .13	37 .12	-13 .12	18 .12
NSB-05	922- 971	0 .74	20 .25	12 .25	-32 .24	22 .20	-18 .17	16 .17	18 .17	28 .17	-14 .14	-17 .13
NSB-05	932- 981	0 .73	12 .33	20 .30	-32 .28	-24 .20	-13 .19	-14 .16	-4 .16	-40 .15	-28 .14	-37 .12
NSB-05	942- 991	0 .67	-48 .33	-32 .28	-28 .26	-40 .24	-24 .22	-16 .19	-4 .19	-14 .17	-3 .16	-31 .14
NSB-05	951-1000	0 .68	-24 .31	-3 .30	-12 .26	-48 .26	-16 .25	-53 .23	-40 .22	-60 .22	-4 .21	-13 .20
NSB-06	957-1000	0 .52	-44 .28	-40 .28	-28 .25	-3 .23	-56 .23	-31 .21	-52 .20	-57 .20	-51 .20	-24 .19
NSB-07	953-1000	-1 .66	-11 .42	-35 .29	-47 .28	-61 .26	-13 .25	-21 .20	-22 .20	-23 .19	-54 .16	-63 .15
NSB-08	942- 991	-1 .71	-21 .25	-49 .23	-36 .21	-40 .20	-37 .18	9 .17	-53 .17	-43 .16	10 .16	-17 .16
NSB-08	951-1000	-1 .70	-25 .30	-61 .27	-53 .23	-49 .23	-21 .23	-54 .21	-33 .19	-43 .18	-36 .17	-27 .14
NSB-09	909- 958	-20 .84	34 .34	-2 .30	32 .26	-3 .24	40 .22	31 .20	20 .20	6 .16	-14 .16	0 .15
NSB-09	919- 968	-20 .80	19 .29	32 .25	-2 .20	20 .18	-25 .18	30 .17	-26 .17	-16 .16	6 .15	0 .14
NSB-09	929- 978	-20 .75	-26 .28	-25 .24	19 .22	20 .21	-14 .17	-34 .16	6 .14	-7 .14	-2 .12	22 .12
NSB-09	939- 988	-20 .72	-7 .33	4 .32	-44 .23	-36 .21	-10 .21	-8 .19	-18 .18	-9 .17	6 .17	-26 .13
NSB-09	949- 998	-20 .77	-10 .28	-44 .28	-8 .24	-7 .22	-9 .19	-46 .16	-28 .14	-34 .13	-33 .12	-18 .11
NSB-09	951-1000	-20 .76	-10 .30	-44 .28	-8 .25	-7 .23	-62 .17	-9 .17	-33 .16	-46 .14	-28 .12	-18 .12
NSB-11	944- 993	-1 .68	-13 .40	-40 .35	-22 .28	-11 .21	-35 .20	-41 .19	-55 .18	-3 .16	-54 .15	-37 .14
NSB-11	951-1000	-1 .75	-13 .39	-61 .38	-22 .28	-11 .24	-35 .23	-24 .21	-26 .21	-40 .20	-54 .16	-53 .16
NSB-12	959-1000	0 .63	-10 .38	-12 .33	-25 .27	-42 .27	-34 .26	-60 .22	1 .22	-24 .20	-22 .19	-40 .16
NSB-13	941- 990	0 .77	-52 .25	-12 .23	-40 .21	-34 .19	10 .19	2 .19	-26 .19	-45 .18	-11 .18	-39 .15
NSB-13	951-1000	0 .83	-60 .38	-12 .27	-24 .24	-40 .20	-34 .18	-37 .18	-52 .16	-13 .15	-53 .15	-45 .14

CHART 2

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

NSB PITCH PINE VS CONNECTICUT RIVER VALLEY (MA) PITCH PINE MASTER TO 1848
50-YEAR SEGMENTS LAGGED 10 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
NSB-01	946- 995	802 .62	765 .53	826 .47	569 .39	754 .37	741 .33	837 .31	707 .30	847 .30	631 .29	701 .29
NSB-01	951-1000	802 .67	765 .53	826 .41	741 .34	569 .33	847 .32	754 .31	607 .30	707 .30	608 .30	778 .29
NSB-02	931- 980	802 .53	749 .41	631 .36	713 .34	826 .32	728 .32	605 .30	672 .30	711 .29	765 .29	813 .28
NSB-02	941- 990	802 .48	749 .37	672 .36	728 .34	713 .33	605 .32	683 .32	631 .31	765 .29	707 .29	608 .29
NSB-02	951-1000	802 .53	765 .36	672 .36	707 .31	812 .31	749 .27	605 .26	608 .26	567 .26	742 .25	764 .25
NSB-03	934- 983	800 .50	787 .47	824 .42	845 .38	739 .36	738 .34	763 .33	751 .33	811 .32	709 .31	713 .31
NSB-03	944- 993	800 .59	751 .40	811 .40	739 .40	763 .38	787 .38	824 .37	738 .34	713 .31	567 .31	699 .30
NSB-03	951-1000	800 .64	810 .43	763 .43	812 .40	739 .40	738 .39	833 .36	824 .35	845 .34	811 .29	603 .28
NSB-04	914- 963	661 .44	802 .41	818 .41	676 .36	701 .36	744 .33	885 .33	731 .30	785 .30	642 .29	805 .28
NSB-04	924- 973	802 .50	731 .41	661 .40	789 .38	793 .33	597 .32	780 .31	742 .31	677 .31	805 .30	767 .29
NSB-04	934- 983	789 .50	802 .48	731 .42	661 .37	596 .34	793 .32	847 .32	767 .31	769 .31	597 .30	860 .28
NSB-04	944- 993	802 .50	568 .40	789 .38	731 .35	596 .34	836 .33	822 .31	765 .31	767 .28	677 .28	661 .28
NSB-04	951-1000	802 .56	568 .44	847 .42	789 .39	822 .38	836 .38	765 .35	652 .30	767 .28	731 .27	677 .27
NSB-05	892- 941	658 .50	801 .49	637 .44	678 .39	873 .39	741 .33	894 .32	728 .31	849 .29	699 .27	677 .26
NSB-05	902- 951	801 .47	658 .46	708 .40	728 .35	840 .33	873 .33	637 .31	721 .30	792 .30	678 .25	635 .24
NSB-05	912- 961	801 .50	658 .48	708 .33	884 .30	728 .28	792 .28	840 .27	853 .26	607 .25	873 .25	628 .25
NSB-05	922- 971	801 .42	671 .40	676 .33	833 .28	739 .28	821 .27	658 .26	792 .26	660 .25	704 .25	641 .24
NSB-05	932- 981	801 .53	671 .36	833 .32	792 .28	821 .28	764 .28	739 .28	676 .27	696 .27	788 .27	864 .26
NSB-05	942- 991	801 .42	833 .41	696 .34	764 .34	821 .28	738 .28	575 .28	788 .28	739 .28	708 .27	792 .26
NSB-05	951-1000	764 .58	801 .55	748 .41	567 .34	688 .34	616 .31	811 .29	821 .28	738 .28	846 .28	706 .26
NSB-06	957-1000	726 .45	739 .38	788 .37	810 .35	620 .33	761 .31	651 .31	822 .31	815 .31	613 .31	615 .30
NSB-07	953-1000	800 .48	812 .44	824 .40	763 .33	595 .30	705 .28	833 .27	790 .27	564 .27	814 .26	668 .26
NSB-08	942- 991	800 .68	576 .37	735 .36	834 .35	845 .34	705 .34	751 .33	605 .33	711 .33	787 .31	747 .31
NSB-08	951-1000	800 .66	705 .45	834 .40	810 .38	763 .38	845 .35	747 .34	605 .32	824 .30	576 .30	739 .27
NSB-09	909- 958	847 .44	746 .41	798 .37	794 .33	652 .32	756 .32	820 .31	653 .30	734 .30	691 .28	638 .28
NSB-09	919- 968	820 .49	638 .40	781 .37	599 .32	652 .32	794 .32	847 .31	740 .31	772 .30	756 .30	657 .29
NSB-09	929- 978	781 .38	820 .38	599 .34	756 .33	638 .33	845 .31	814 .30	865 .29	792 .29	757 .28	660 .28
NSB-09	939- 988	781 .43	826 .39	730 .38	734 .33	794 .28	839 .28	825 .28	593 .28	587 .27	631 .26	651 .25
NSB-09	949- 998	781 .52	826 .44	805 .34	660 .32	692 .31	744 .30	836 .30	596 .29	815 .28	768 .28	631 .28
NSB-09	951-1000	781 .52	826 .45	805 .34	692 .32	836 .31	707 .31	744 .30	596 .30	768 .29	660 .29	730 .27
NSB-11	944- 993	800 .61	812 .53	618 .41	833 .38	824 .37	753 .36	717 .35	845 .34	617 .34	832 .29	576 .28
NSB-11	951-1000	800 .58	812 .45	833 .43	753 .40	845 .40	618 .37	617 .36	717 .35	740 .34	810 .34	824 .32
NSB-12	959-1000	801 .48	676 .41	813 .38	845 .36	812 .34	556 .34	565 .33	754 .32	646 .32	764 .32	822 .31
NSB-13	941- 990	801 .60	814 .35	846 .34	813 .31	632 .30	604 .28	689 .28	742 .28	716 .28	764 .27	835 .27
NSB-13	951-1000	801 .65	764 .44	835 .42	846 .35	813 .32	607 .30	741 .29	789 .27	716 .27	648 .25	567 .25

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 10 YEARS

FLAGS: __A = CORRELATION UNDER 0.3281; __B = CORRELATION HIGHER AT OTHER POSITION

0SEQ	SERIES	INTERVAL	1680 1729	1690 1739	1700 1749	1710 1759	1720 1769	1730 1779	1740 1789	1750 1799	1760 1809	1770 1819	1780 1829	1790 1839	1800 1849	1810 1859	1820 1869	1830 1879	1840 1889	1850 1899	1860 1909	1870 1919	FLAGS/ TOTAL
1	NSB-01	1748-1802	=	=	=	=	=	=	.68	.70	.69	=	=	=									0/ 3
2	NSB-02	1733-1802	=	=	=	=	=	.46	.52	.49	.48	=	=	=									0/ 4
3	NSB-03	1734-1800	=	=	=	=	=	.74	.74	.78	.81	=	=	=									0/ 4
4	NSB-04	1716-1802	=	=	=	.47	.60	.71	.66	.65	.65	=	=	=									0/ 6
5	NSB-05	1693-1801	=	.12 ___B	.32 ___A	.47	.52	.63	.58	.59	.60	=	=	=									2/ 8
6	NSB-06	1758-1801	=	=	=	=	=	=	=	.43	=	=	=	=									0/ 1
7	NSB-07	1753-1800	=	=	=	=	=	=	=	.57	=	=	=	=									0/ 1
8	NSB-08	1742-1800	=	=	=	=	=	=	.66	.65	.65	=	=	=									0/ 3
9	NSB-09	1693-1781	=	.13 ___B	.34	.43	.53	.67	.67	=	=	=	=	=									1/ 6
10	NSB-11	1744-1800	=	=	=	=	=	=	.59	.64	.67	=	=	=									0/ 3
11	NSB-12	1760-1801	=	=	=	=	=	=	=	=	.56	=	=	=									0/ 1
12	NSB-13	1742-1801	=	=	=	=	=	=	.71	.79	.79	=	=	=									0/ 3

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

NSB PITCH PINE VS NSB DATED PITCH PINE SITE MASTER
50-YEAR SEGMENTS LAGGED 10 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
NSB-01	946- 995	802 .74	754 .49	750 .26	790 .20	766 .18	778 .17	793 .16	805 .15	765 .15	763 .15	768 .15
NSB-01	951-1000	802 .76	754 .49	778 .27	750 .23	768 .20	789 .20	790 .19	792 .15	765 .14	793 .14	749 .13
NSB-02	931- 980	802 .59	784 .23	814 .20	786 .19	813 .19	788 .17	793 .16	812 .15	804 .15	773 .15	760 .14
NSB-02	941- 990	802 .60	754 .42	786 .25	750 .18	788 .17	773 .17	765 .16	790 .15	774 .14	760 .14	811 .14
NSB-02	951-1000	802 .59	754 .30	749 .26	773 .23	789 .22	801 .22	742 .19	739 .19	752 .16	790 .16	791 .16
NSB-03	934- 983	800 .81	812 .26	788 .23	798 .23	811 .18	802 .17	810 .16	814 .16	774 .15	780 .15	761 .14
NSB-03	944- 993	800 .82	788 .40	748 .29	798 .29	752 .28	778 .28	776 .24	787 .19	764 .17	802 .16	780 .15
NSB-03	951-1000	800 .85	788 .31	790 .25	787 .23	752 .23	776 .23	740 .21	748 .20	798 .19	778 .19	766 .16
NSB-04	914- 963	802 .67	818 .41	785 .29	830 .25	805 .24	822 .16	776 .15	827 .14	839 .11	782 .11	786 .10
NSB-04	924- 973	802 .81	818 .29	826 .24	805 .24	793 .22	814 .21	789 .21	791 .18	827 .17	817 .15	804 .12
NSB-04	934- 983	802 .72	789 .37	791 .29	814 .26	778 .24	793 .21	818 .19	805 .16	817 .15	776 .15	804 .14
NSB-04	944- 993	802 .76	778 .33	762 .28	791 .27	789 .25	790 .21	792 .19	793 .19	754 .16	780 .15	751 .15
NSB-04	951-1000	802 .73	778 .36	789 .30	790 .29	777 .26	791 .26	742 .25	780 .24	762 .22	792 .22	740 .19
NSB-05	892- 941	801 .64	861 .29	810 .24	834 .20	854 .19	840 .16	849 .15	853 .14	818 .13	838 .13	800 .12
NSB-05	902- 951	801 .75	810 .24	829 .23	819 .22	843 .18	788 .17	840 .17	792 .16	834 .15	841 .15	817 .15
NSB-05	912- 961	801 .79	787 .25	783 .24	829 .21	784 .20	821 .17	792 .14	825 .13	838 .12	788 .12	819 .12
NSB-05	922- 971	801 .74	821 .25	813 .25	769 .24	823 .20	783 .17	817 .17	819 .17	829 .17	787 .14	784 .13
NSB-05	932- 981	801 .73	813 .33	821 .30	769 .28	777 .20	788 .19	787 .16	797 .16	761 .15	773 .14	764 .12
NSB-05	942- 991	801 .67	753 .33	769 .28	773 .26	761 .24	777 .22	785 .19	797 .19	787 .17	798 .16	770 .14
NSB-05	951-1000	801 .68	777 .31	798 .30	789 .26	753 .26	785 .25	748 .23	761 .22	741 .22	797 .21	788 .20
NSB-06	957-1000	801 .52	757 .28	761 .28	773 .25	798 .23	745 .23	770 .21	749 .20	744 .20	750 .20	777 .19
NSB-07	953-1000	800 .66	790 .42	766 .29	754 .28	740 .26	788 .25	780 .20	779 .20	778 .19	747 .16	738 .15
NSB-08	942- 991	800 .71	780 .25	752 .23	765 .21	761 .20	764 .18	810 .17	748 .17	758 .16	811 .16	784 .16
NSB-08	951-1000	800 .70	776 .30	740 .27	748 .23	752 .23	780 .23	747 .21	768 .19	758 .18	765 .17	784 .14
NSB-09	909- 958	781 .84	835 .34	799 .30	833 .26	798 .24	841 .22	832 .20	821 .20	807 .16	787 .16	801 .15
NSB-09	919- 968	781 .80	820 .29	833 .25	799 .20	821 .18	776 .18	831 .17	775 .17	785 .16	807 .15	801 .14
NSB-09	929- 978	781 .75	775 .28	776 .24	820 .22	821 .21	787 .17	767 .16	807 .14	794 .14	799 .12	823 .12
NSB-09	939- 988	781 .72	794 .33	805 .32	757 .23	765 .21	791 .21	793 .19	783 .18	792 .17	807 .17	775 .13
NSB-09	949- 998	781 .77	791 .28	757 .28	793 .24	794 .22	792 .19	755 .16	773 .14	767 .13	768 .12	783 .11
NSB-09	951-1000	781 .76	791 .30	757 .28	793 .25	794 .23	739 .17	792 .17	768 .16	755 .14	773 .12	783 .12
NSB-11	944- 993	800 .68	788 .40	761 .35	779 .28	790 .21	766 .20	760 .19	746 .18	798 .16	747 .15	764 .14
NSB-11	951-1000	800 .75	788 .39	740 .38	779 .28	790 .24	766 .23	777 .21	775 .21	761 .20	747 .16	748 .16
NSB-12	959-1000	801 .63	791 .38	789 .33	776 .27	759 .27	767 .26	741 .22	802 .22	777 .20	779 .19	761 .16
NSB-13	941- 990	801 .77	749 .25	789 .23	761 .21	767 .19	811 .19	803 .19	775 .19	756 .18	790 .18	762 .15
NSB-13	951-1000	801 .83	741 .38	789 .27	777 .24	761 .20	767 .18	764 .18	749 .16	788 .15	748 .15	756 .14

CHART 4

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

NSB OAK VS CONNECTICUT RIVER VALLEY (MA) OAK MASTER
50-YEAR SEGMENTS LAGGED 5 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
NSB-10	938- 987	804 .59	642 .38	744 .32	723 .32	746 .32	630 .31	680 .31	820 .30	756 .30	701 .29	775 .26
NSB-10	943- 992	804 .47	756 .44	767 .33	746 .33	643 .33	828 .31	672 .30	775 .28	806 .25	833 .25	783 .24
NSB-10	948- 997	804 .35	806 .31	672 .31	781 .28	767 .28	756 .26	837 .24	744 .24	643 .24	642 .23	633 .23
NSB-10	951-1000	672 .33	804 .32	622 .29	754 .29	781 .27	756 .27	837 .27	767 .26	765 .25	633 .25	806 .24

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

NSB OAK VS DEERFIELD OAK MASTER
50-YEAR SEGMENTS LAGGED 5 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
NSB-10	938- 987	804 .56	756 .35	723 .33	746 .29	632 .28	661 .27	721 .25	775 .25	781 .24	820 .24	700 .22
NSB-10	943- 992	756 .48	804 .45	767 .36	672 .31	833 .30	746 .29	775 .29	632 .28	828 .27	695 .26	799 .26
NSB-10	948- 997	804 .33	672 .31	781 .30	831 .29	806 .28	696 .28	797 .27	767 .27	756 .24	775 .24	633 .23
NSB-10	951-1000	804 .32	672 .31	622 .29	754 .29	781 .28	756 .26	696 .26	765 .25	813 .25	775 .25	767 .24