INTRA- AND INTER-SPECIFIC SENSITIVITY TO CLIMATE IN TWO TREE SPECIES OF THE WHITE MOUNTAINS, NEW HAMPSHIRE.

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Final Report, 7th North American Dendroecological Field Week
Bartlett Experimental Forest, Bartlett, New Hampshire
August 17-24, 1996

INTRODUCTION

The Bartlett Experimental Forest (BEF) in the White Mountains of central New Hampshire consists of 2600 acres of typical mixed eastern coniferous/deciduous forest distributed over an elevational gradient ranging from 680 to 2995 feet. Some tree species within this montane zone and within the BEF have been demonstrated to record a climate signal; therefore, the forest is well suited to tiered analyses of species- and site-specific differences to climatic response.

Leak and Smith (1996) have shown that eastern hemlock (*Tsuga canadensis* (L.) Carr.) is the most climatically sensitive species in the region. Red spruce also has been correlated with climate on Mt. Washington by Kimball and Kiefer (1988). The range of hemlock generally does not exceed 1800 ft, above which red spruce (*Picea rubens* Sarg.) predominates. Spruce also occurs in mixed stands down to the lower elevational limits of the BEF.

The regional climate is characterized by warm summers and cold winters with extrenme temperatures above 90 F and below -30 F. Average annual precipitation at the town of Bartlett, located at the base of the BEF, is 130 cm, and is evenly distributed throughout the year. In the winter months (December through April), snow accumulations are typically 150 to 180 cm. Edaphic conditions vary considerably in the BEF and were a factor that affected stand selection for this study. In general, soils in the forest are spodosols, mostly developed on glacial till derived from granite and gneiss. However, in at least part of the forest, the soils are derived from lacustrine deposits of a former lakebed.

Drainage is specific to different edaphic conditions. In the upper elevations where soils are thin and droughty, lithic histosols are well drained. General edaphic conditions at the three sites ranged from poorly developed, shallow-to-bedrock soils at the upper site through increasingly deeper and more mature soils developed from glacial outwash at the middle and lower sites (Fig 2). Drainage, in general, was good at all sites. However, at locations where red spruce was collected, drainage was comparatively better on the upper sites, low at the middle site and poorest at the lower site. Eastern hemlock was found along poorly drained depressions at the middle site, but was well drained at the lower site.

Site/stand specific conditions in the BEF, in combination with a fairly well documented history of stand composition and distribution over the past century, provides the basic framework within which to investigate the variability that exists in species-specific tree response to climate. Although eastern hemlock is known to be climatically sensitive, the species does not occur at upper elevations. One goal of this study was to determine the climatic sensitivity of red spruce, a species that occurs over the entire elevational range of the BEF. Additionally, this study addresses the question of sensitivity as a function of species and edaphic conditions.

METHODS

Tree growth was measured by acquiring 4.3 mm increment core samples from trunks of mature red spruce and eastern hemlock trees selected from three sites at 270 m (lower), 550 m (middle), and 880 m (upper) along the western boundary of Bartlett Experimental Forest, south and adjacent to Bartlett, New Hampshire. The upper and middle sites were on the south facing aspect of Upper Haystack Mountain. The lower site was relatively flat and located in Study Area 25 bordering Louisville Brook (Fig. 1). Cores were collected from 27 spruce trees at the upper and 15 trees each of spruce and hemlock at both the middle and lower sites. Samples were mounted on wooden core mounts, then sanded with progressively finer paper until eventually using a 400 grit. All tree rings were crossdated using the skeleton plot and list methods, measured on a Velmex measurement system, and output to files in Decadal format.

Crossdating was verified using COFECHA, which tests the accuracy of the dating using 50-year segments of the measurement series against a master dating series developed from the remaining cores. Measurements were edited as necessary after verifying that a dating or measurement series had potential problems. All measurement series were then standardized for each species and site using the program CRONOL contained in the ITRDB Program Library. For the high elevation red spruce chronology, the standardization program ARSTAN was used in an effort to amplify the climate signal while deemphasizing the noise due to stand dynamics processes.

Climatic effects that may have existed in the final chronologies were then analyzed by comparing the chronologies to New Hampshire Region 2 temperature and precipitation data to explore the relationship between climate and tree growth. This analysis was done using PRECON, and response functions were generated for each species and site. For the high elevation red spruce site, response functions were generated using both the standard and ARSTAN chronologies.

SUMMARY OF RESULTS

1. Based on skeleton plot analysis, this study was unsuccessful in identifying common patterns among wood anatomical variables, such as thin late wood.

2. Composite data (combined data from different elevations) for red spruce and eastern hemlock resulted in high R^2 values for different climate samples (indicating that sample size was adequate to test our hypotheses)

3. Previous year's growth explained a significant portion of the variation in tree-ring width. This variation was not removable by ARSTAN.

4. Both red spruce and hemlock showed increasing climate sensitivity with elevation (higher elevation stands showed greater sensitivity than lower elevation stands)

5. Both red spruce and hemlock respond positively to spring rain and high summer temperature.

6. Hemlock is generally more responsive to climate than spruce.

7. Hemlock and red spruce respond to slightly different portions of the climate signal. For example, at the lower site, hemlock responded positively to July precipitation whereas spruce responded negatively.

8. Differential species responses to climate suggest that climate change may be capable of leading to changes in plant species composition.

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A BEGINNER'S EXPERIENCE

Mr. Jan Peczkis

My interest in dendrochronology began about two years ago. I had read about the multimillennial Bristlecone-pine and Irish-oak chronologies, and was fascinated about how the component trees had been cross-matched. So I read all I could about the subject. Owing to the fact that I had many questions that had gone unanswered by my reading, I contacted some scientists at the University of Arizona Tree-Ring lab.

Most of my conversations were with Dr. Henri Grissino-Mayer. It was from him that I learned about the wealth of archival tree-ring data available from Colorado, as well as the freely-available dendrochronological software that could be obtained from the University of Arizona. I promptly got hold of some of the archival tree-ring series to work on, focusing on the 8000-year Methuselah Walk series in particular. I learned how to use the dpl.exe programs, especially COFECHA. However, all this time I realized the fact that, until I had obtained hands-on experience with wood, I was not yet a dendrochronologist.

So where to go learn about working with wood? I could not leave my home in Chicago in order to take many-month courses at the Tree-Ring Lab. So I found out about the weeklong course for beginners in Colorado. Signing up for it, it was with chagrin that I learned that it had been canceled for lack of students. So I went to the Dendro Fieldweek in late August 1996 instead. In doing so, I had potentially forfeited some last-minute job openings in the field of teaching (I am an unemployed schoolteacher).

Every day, I learned many new things. I took borehole samples of trees for the first time. Next, I learned how to mount and sand the cores. I had read about the skeleton plot long ago, and had practiced previously from some photos of tree-ring sections contained in the articles of the *Tree-Ring Bulletin*. Now I had a chance to cross-match the cores. I learned fast. By my second skeleton plot, Dr. Grissino-Mayer, the instructor, hardly had to correct anything at all in my skeleton plot. By my third plot, he saw no need to check my work, stating that he had confidence in its accuracy.

I thus made several skeleton plots, working with Red Spruce (*Picea rubens*). I could see for myself how they lined up, and how the pointer years (such as 1948) came through. I also applied some wood-anatomical data (such as TEW and TLW, incipient false rings, etc.), using them to assist in correlation. Needless to say, such things cannot be done by any computer program.

I am delighted that I had gotten my first experience with wood, and am grateful to the instructors for the time they had donated. Now, at last, I can validly call myself a dendrochronologist. And it is a dendrochronologist motivated by enthusiasm, not vocation. During WWII, General Bradley said to General Patton: "I perform my duties because that is what I have been trained to do. You do it because you love it." When it comes to dendrochronology, I am like General Patton.

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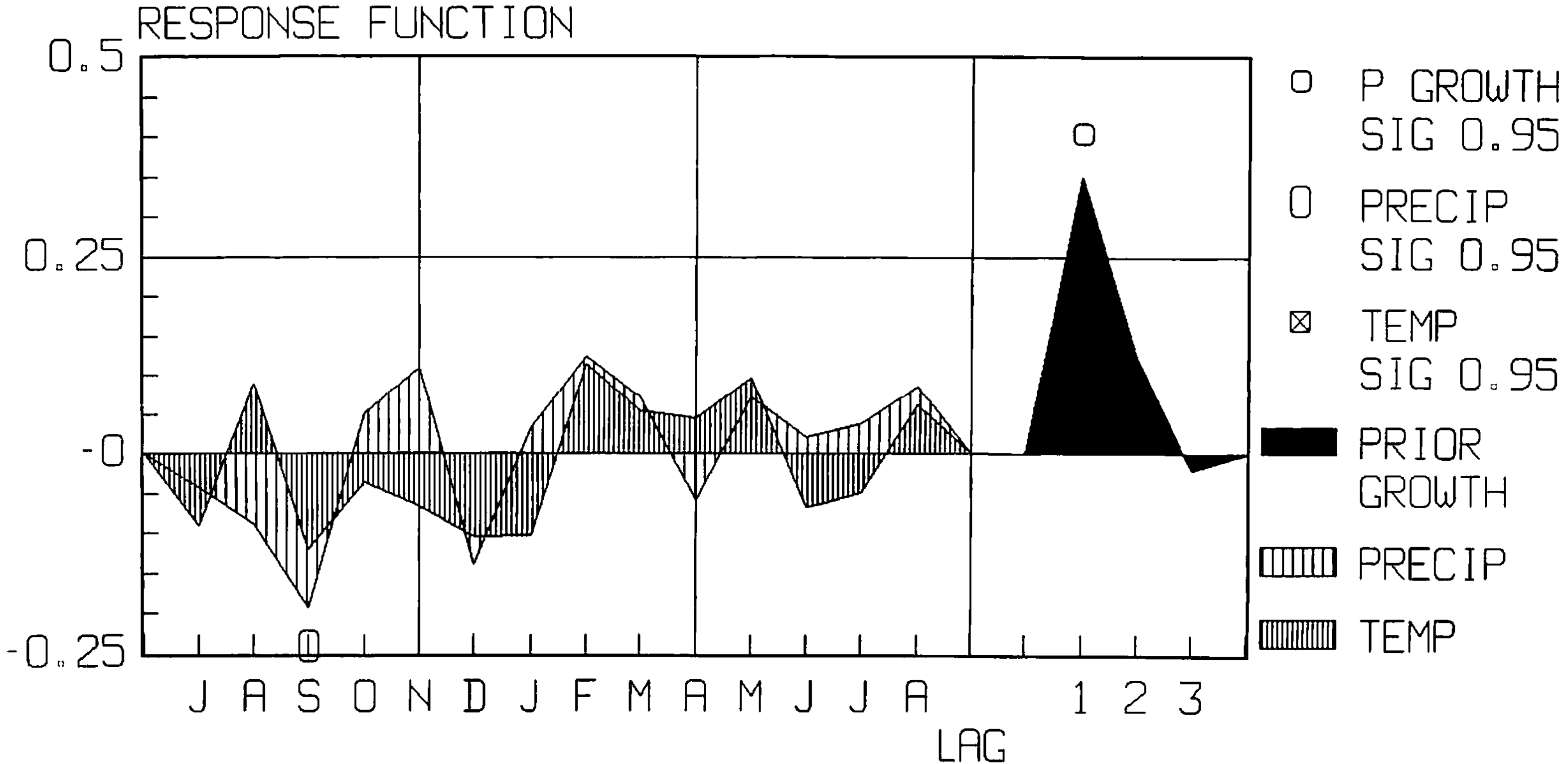
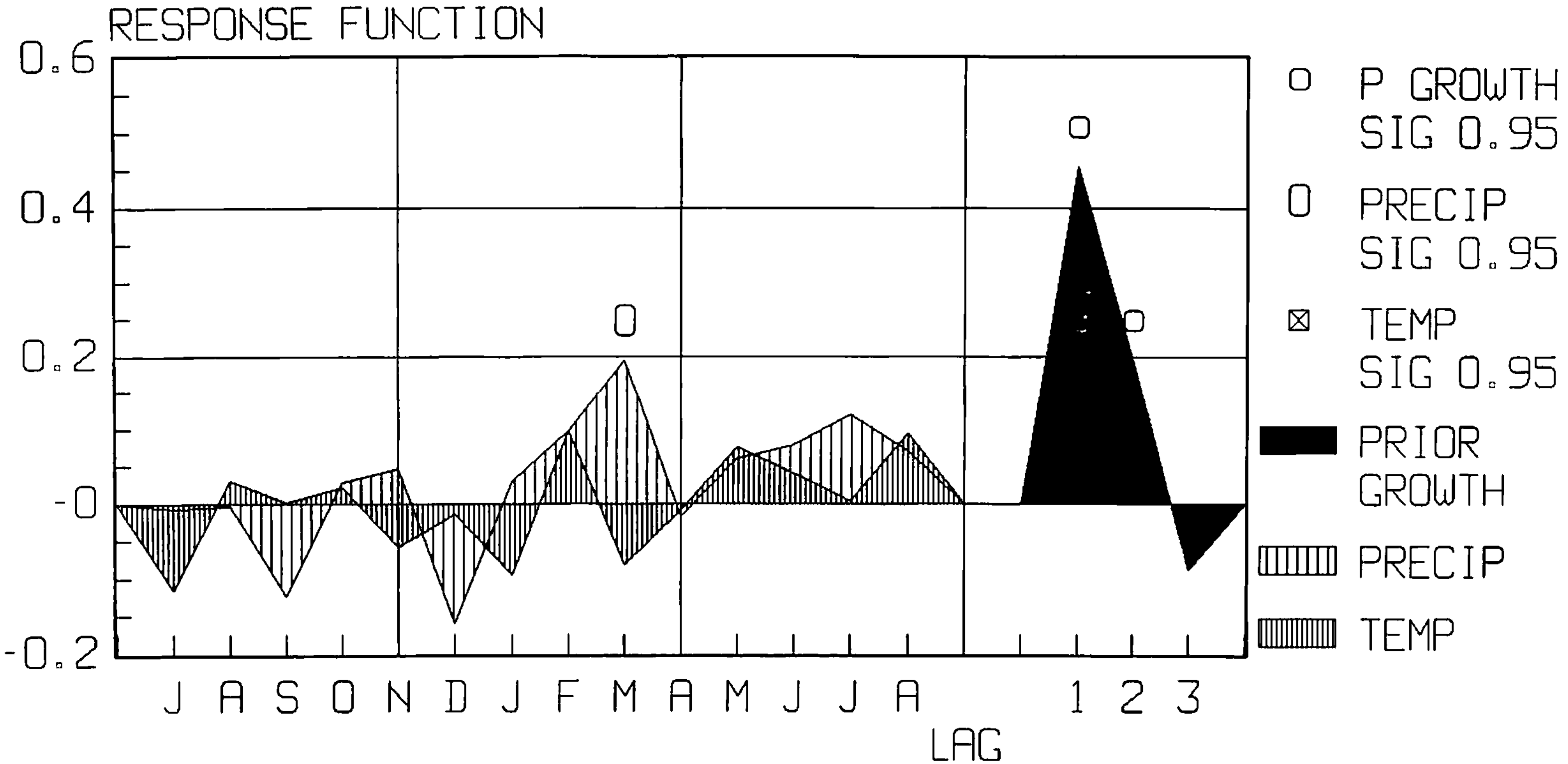
USCRNXXB NH2XXXXX NH2XXXXX DIV: 0
TEM & PRE, 1896-1995 ,JUL-AUG, N=100
50 REP, Rd:.742+/-.043, Ri: .370+/-.120
RSQ: CL= .227, P GRO= .241, TOT= .468



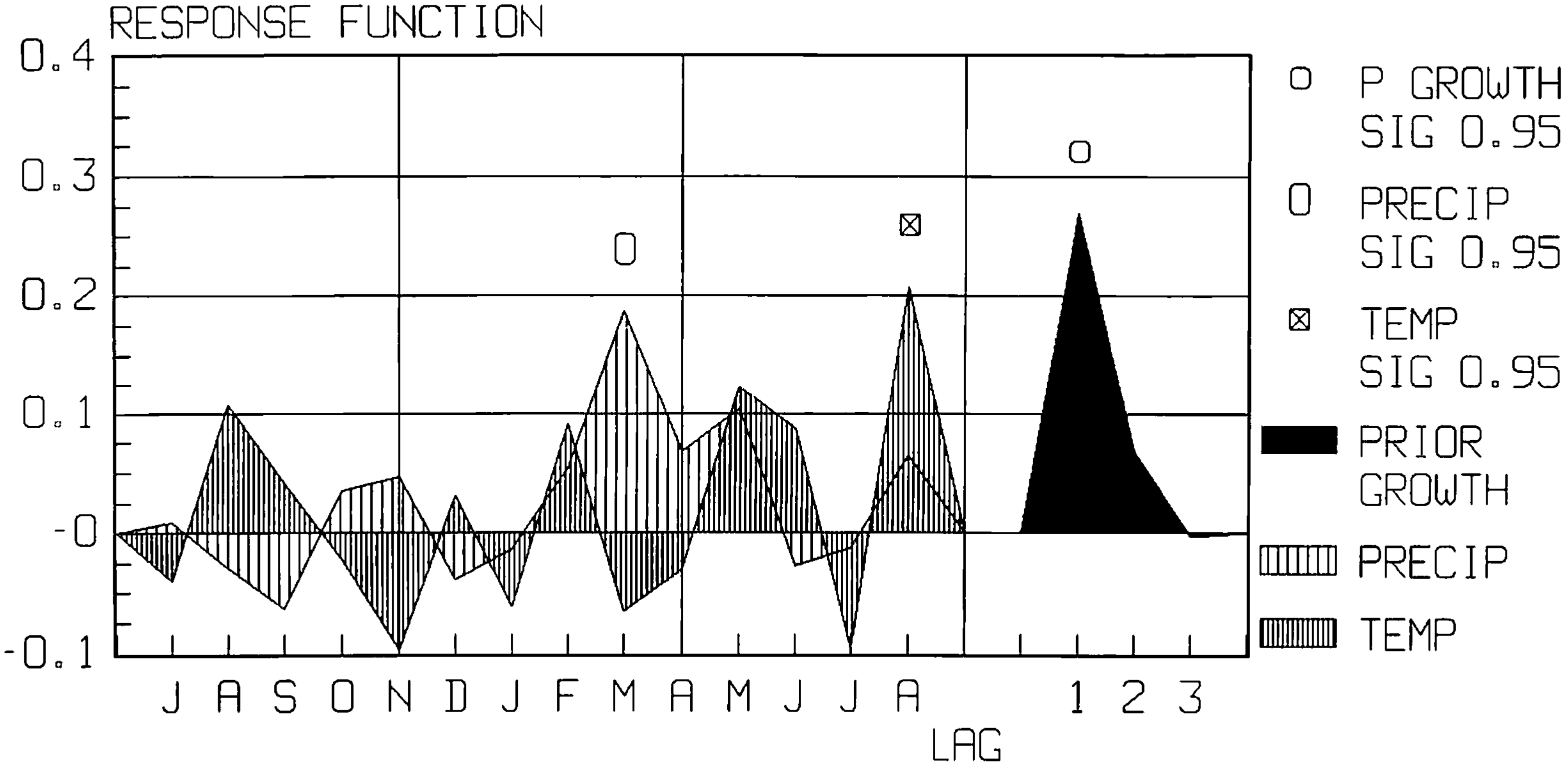
NUMBER 6, 14 MONTHS, JUL-AUG
& 3 LAGS PRIOR GROWTH

MSCRNXXB NH2XXXXX NH2XXXXX DIV: 0
TEM & PRE, 1896-1995 ,JUL-AUG, N=100
50 REP, Rd: .777+/-.039, Ri: .402+/-.111
RSQ: CL= .177, P GRO= .342, TOT= .518



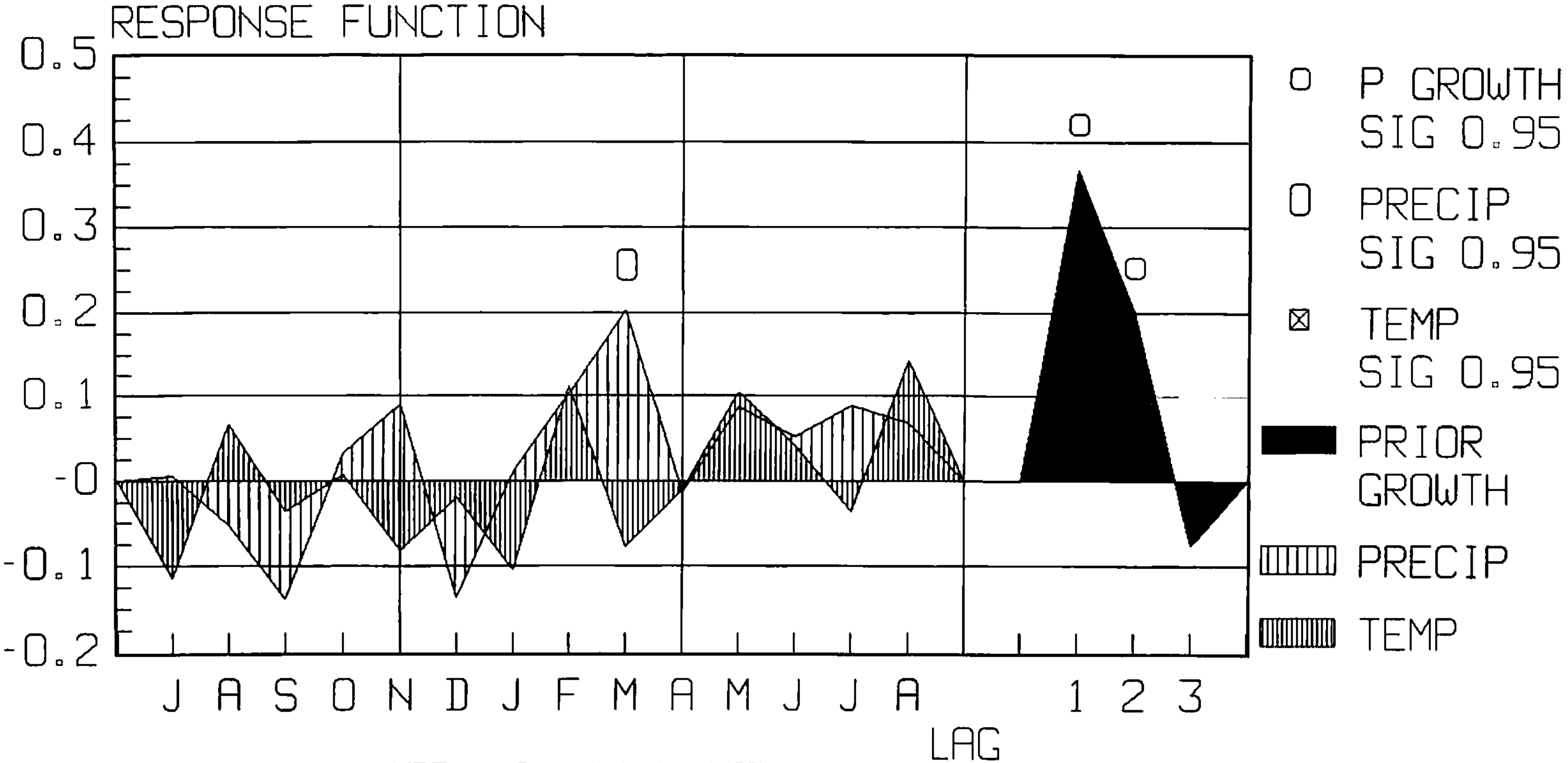
NUMBER 6, 14 MONTHS, JUL-AUG
& 3 LAGS PRIOR GROWTH

lscrnXXB NH2XXXXX NH2XXXXX DIV: 0
TEM & PRE, 1896-1995 ,JUL-AUG, N=100
50 REP, Rd .655+/-.063, Ri: .075+/-.131
RSQ: CL= .183, P GRO= .110, TOT= .293



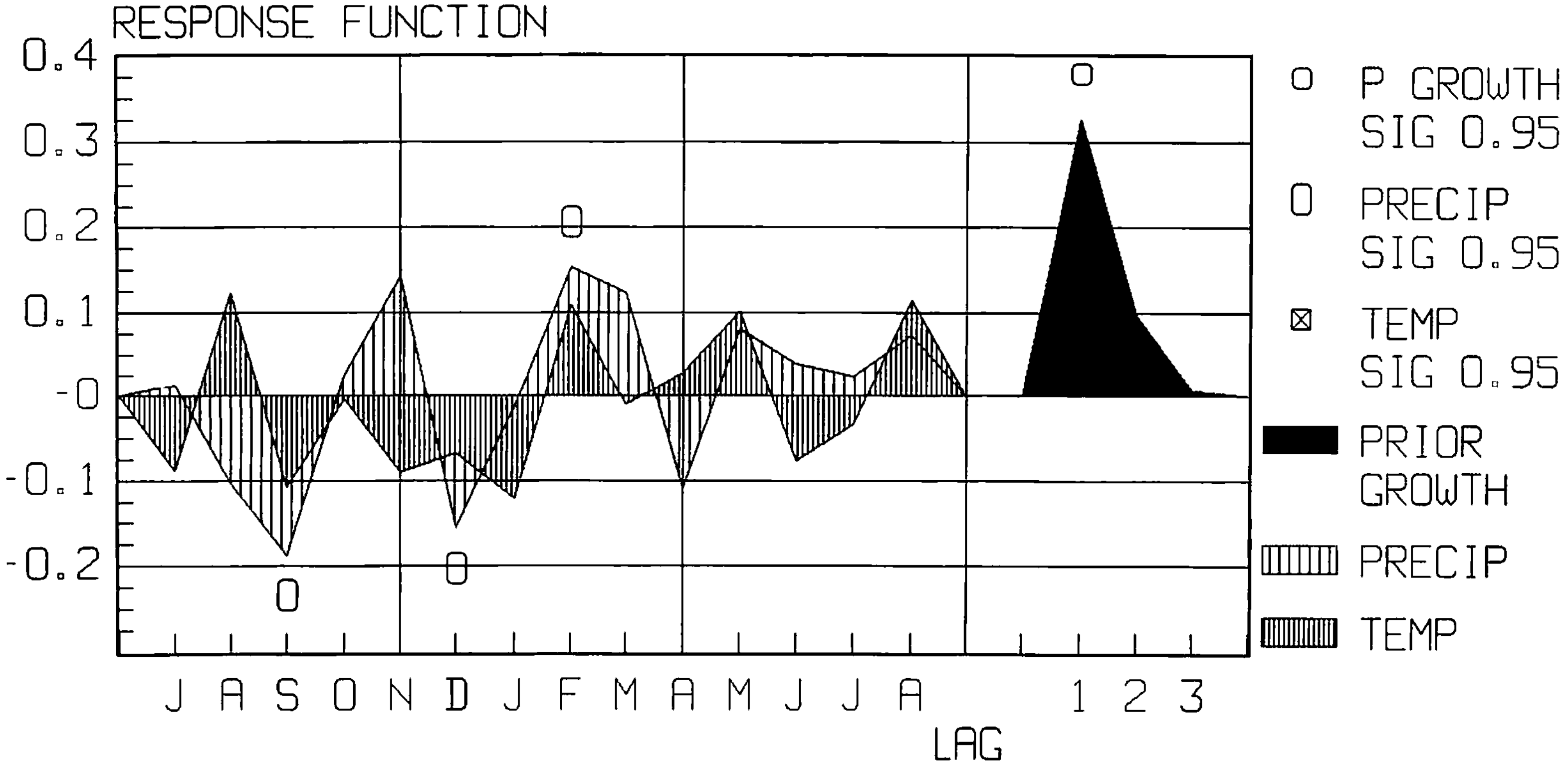
NUMBER 2, 14 MONTHS, JUL-AUG
& 3 LAGS PRIOR GROWTH

SPRCRNXB NH2XXXXX NH2XXXXX DIV: 0
TEM & PRE, 1896-1995 ,JUL-AUG, N=100
50 REP, Rd: .740+/-.039, Ri: .321+/-.108
RSQ CL= .218, P GRO= .226, TOT= .444



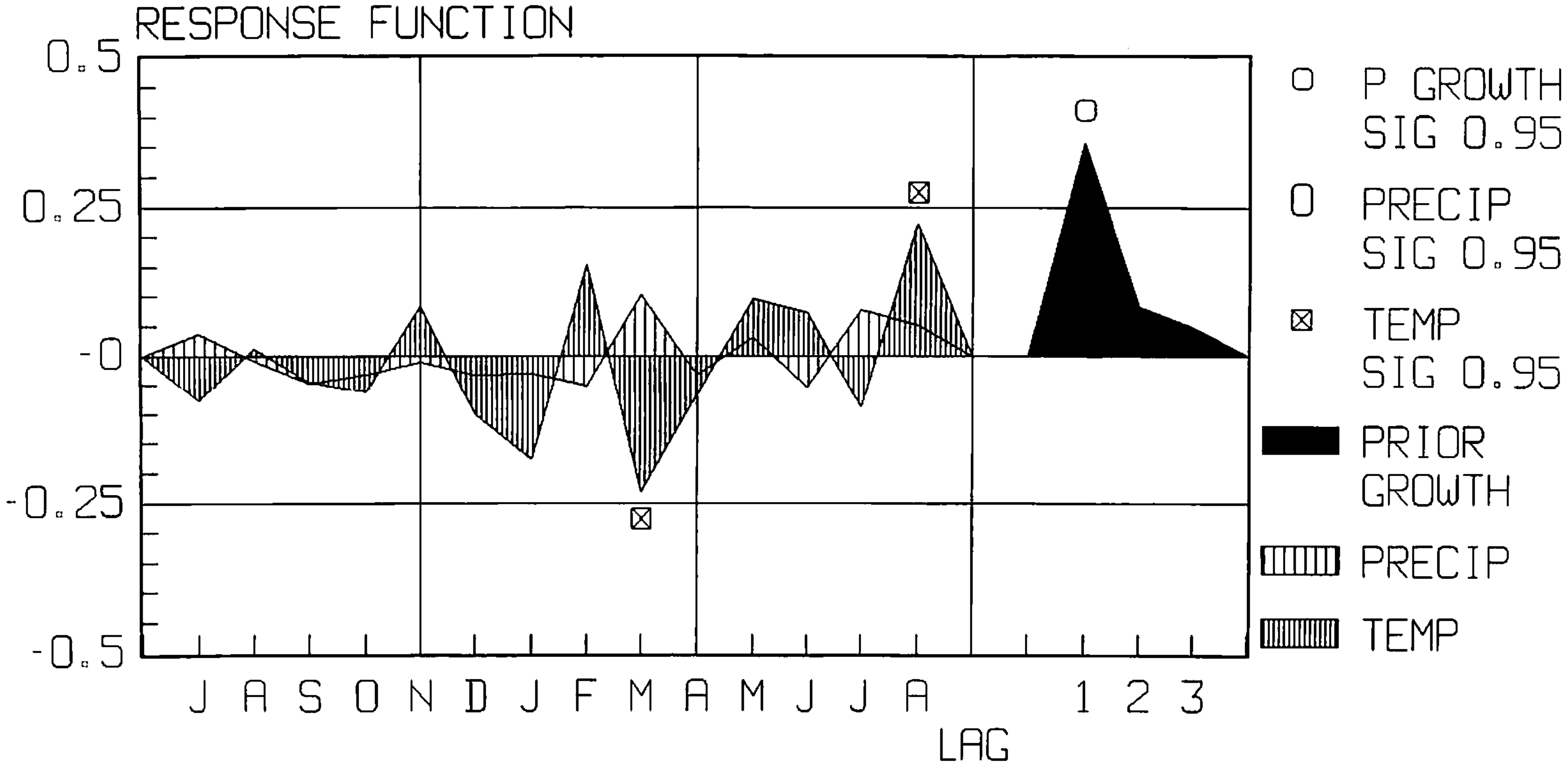
NUMBER 6, 14 MONTHS, JUL-AUG
& 3 LAGS PRIOR GROWTH

usarsXXB NH2XXXXX NH2XXXXX DIV: 0
TEM & PRE, 1896-1995 ,JUL-AUG, N=100
50 REP, Rd:.743+/-.035, Ri: .402+/-.094
RSQ: CL= .284, P GRO= .187, TOT= .472



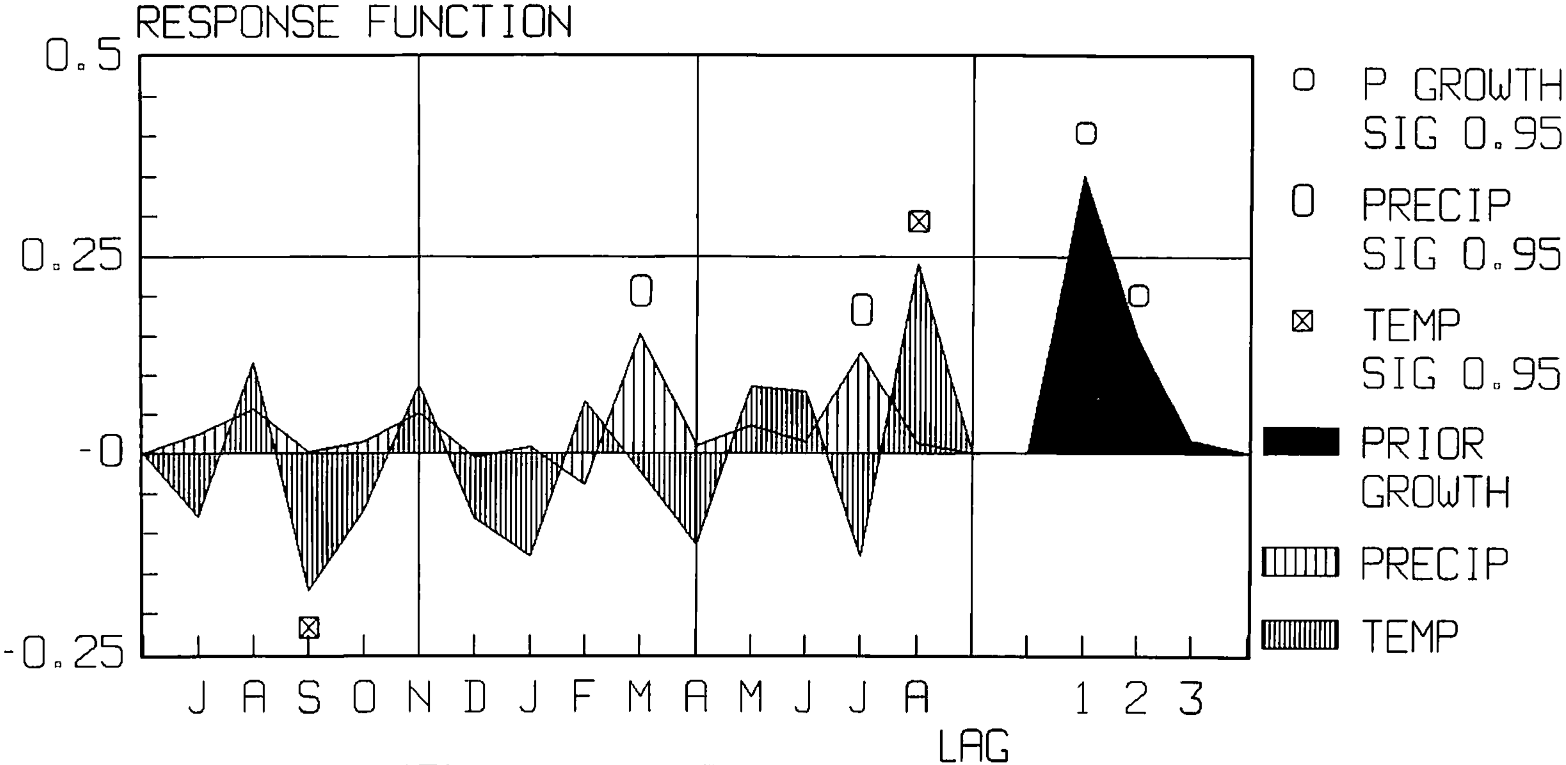
NUMBER 6, 14 MONTHS, JUL-AUG
& 3 LAGS PRIOR GROWTH

UHCRNXXB NH2XXXXX NH2XXXXX DIV: 0
TEM & PRE, 1896-1995 ,JUL-AUG, N=100
50 REP, Rd: .745+/-.050, Ri: .331+/-.120
RSQ: CL= .247, P GRO= .215, TOT= .463



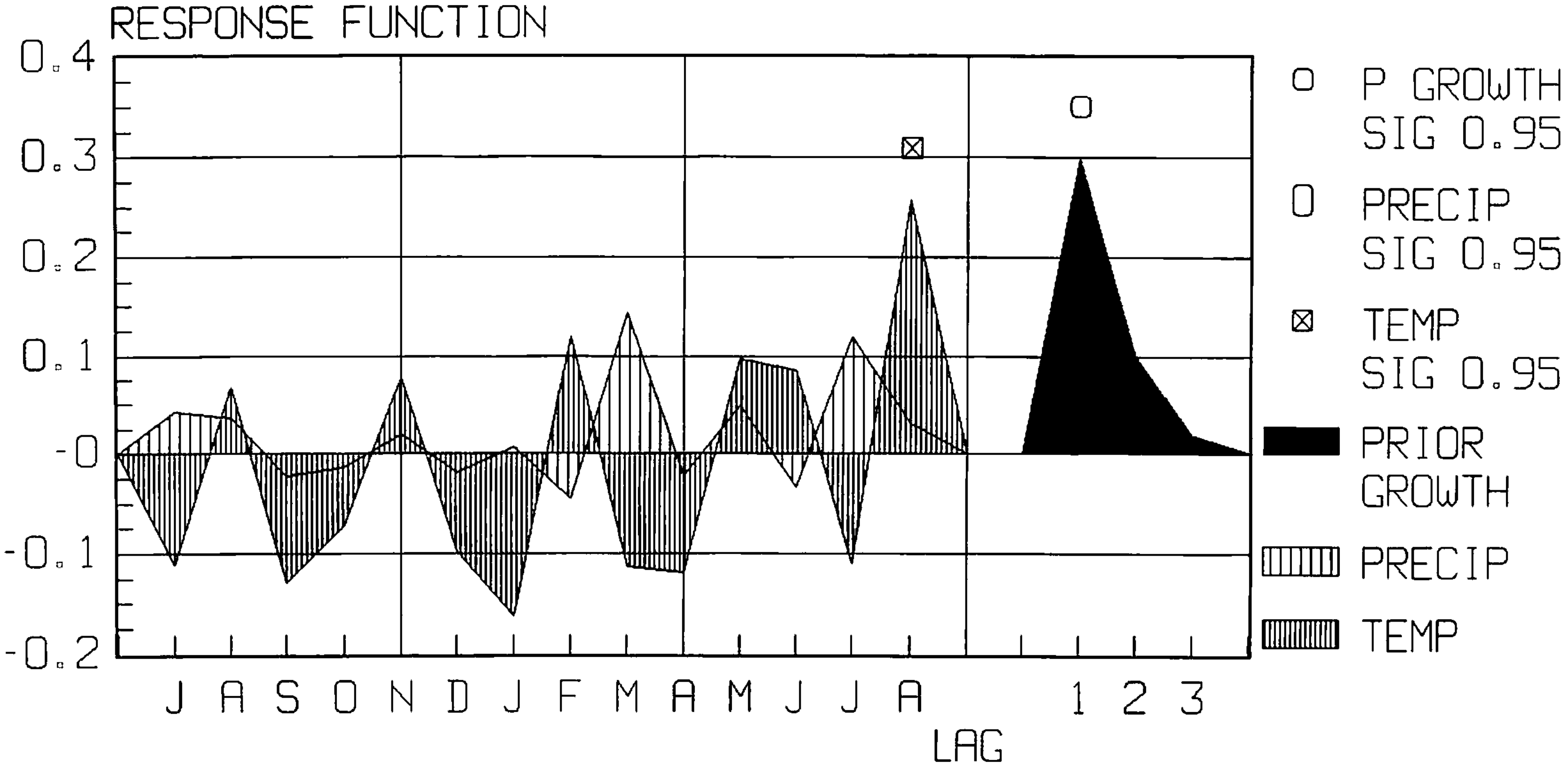
NUMBER 6, 14 MONTHS, JUL-AUG
& 3 LAGS PRIOR GROWTH

LHCRNXXB NH2XXXXX NH2XXXXX DIV: 0
TEM & PRE, 1896-1995 ,JUL-AUG, N=100
50 REP, Rd: .735+/-.037, Ri: .349+/-.118
RSQ: CL= .235, P GRO= .213, TOT= .447



NUMBER 6, 14 MONTHS, JUL-AUG
& 3 LAGS PRIOR GROWTH

hemcrnXB NH2XXXXX NH2XXXXX DIV: 0
TEM & PRE, 1896-1995 ,JUL-AUG, N=100
50 REP, Rd: .722+/-.050, Ri: .291+/-.109
RSQ: CL= .269, P GRO= .151, TOT= .421



NUMBER 6, 14 MONTHS, JUL-AUG
& 3 LAGS PRIOR GROWTH