The Lake Drummond Cypress

A few months ago I mentioned that I had done some tree-ring work in the Dismal Swamp. Among data that I was able to find were tree-ring measurements of cypress trees growing in Lake Drummond. The outside rings on the increment cores represented the year 1976. I asked if you could supply me with lake level data prior to 1977. You, and subsequently the Corp of Engineers, responded almost immediately with daily data back to 1926. In that earlier note to you, I said that after I played around with the lake level data a bit, I would forward some results. Herewith are some results. The results have to be considered as "quick and dirty" or preliminary, but I hope they might be of some possible interest nonetheless.

To reiterate a bit about Lake Drummond cypress as discussed in my earlier note, 30-some odd years ago I had tried to correlate temperature and precipitation data with Lake Drummond cypress tree-ring data and got nothing. When I got a correlation between tree rings and lake level, I speculated that decrease in lake level did not cause a decrease in tree growth, but that some conditions under which lake level decreased (such as extreme temperatures of the black water lake surface during cloudless days) may also affect a decrease in growth. Thus, though there was a correlation between lake level and tree growth, it was not a cause and effect thing.

The cypress trees were nearly all hollow shells; hence, the tree rings contained on each core represented only a small fraction of the age of any given tree. The amount of sound wood and the number of rings contained thereon varied considerably from core to core. The number of rings and the inside dates of the core samples are included in Table 1. A subscript to the inside date indicates whether the sample was included in the 19-core subset (all dating back to 1926) and the 8-core subset (all dating back to 1902). These subsets will be referred to later.

Table 1. *Number of rings measured on each core sample. Also included are date of inside ring and mean width of measured rings. Outside date of all samples is 1976.*

Core	Number of rings	Inside Date	Mean Width (cm)
L010	44	1933	0.291±0.187
L020	39	1938	0.347±0.179
L031	63	1914_{19}	0.142±0.109
L032	68	1909_{19}	0.132±0.076
L041	53	1924_{19}	0.120±0.078
L042	58	1919_{19}	0.127±0.097
L050	57	1920_{19}	0.050±0.023
L061	69	1908_{19}	0.136±0.089
L062	123	$1854_{19\text{-}8}$	0.133±0.106
L071	76	$1901_{19\text{-}8}$	0.125±0.134
L072	75	$1902_{19\text{-}8}$	0.208±0.220
L081	103	$1874_{19\text{-}8}$	0.114±0.062
L082	66	1911_{19}	0.071±0.058
L090	138	$1839_{19\text{-}8}$	0.081±0.064
L100	75	$1902_{19\text{-}8}$	0.118±0.076
L200	80	$1897_{19\text{-}8}$	0.061±0.037
L210	63	1914_{19}	0.168±0.076
L220	61	1916_{19}	0.051±0.028
L231	64	1913_{19}	0.097±0.089
L232	135	$1842_{19\text{-}8}$	0.064±0.067
L240	48	1929	0.112±0.080
L250	44	1933	0.212±0.107
L260	67	1910_{19}	0.205±0.174
L270	43	1934	0.251±0.129

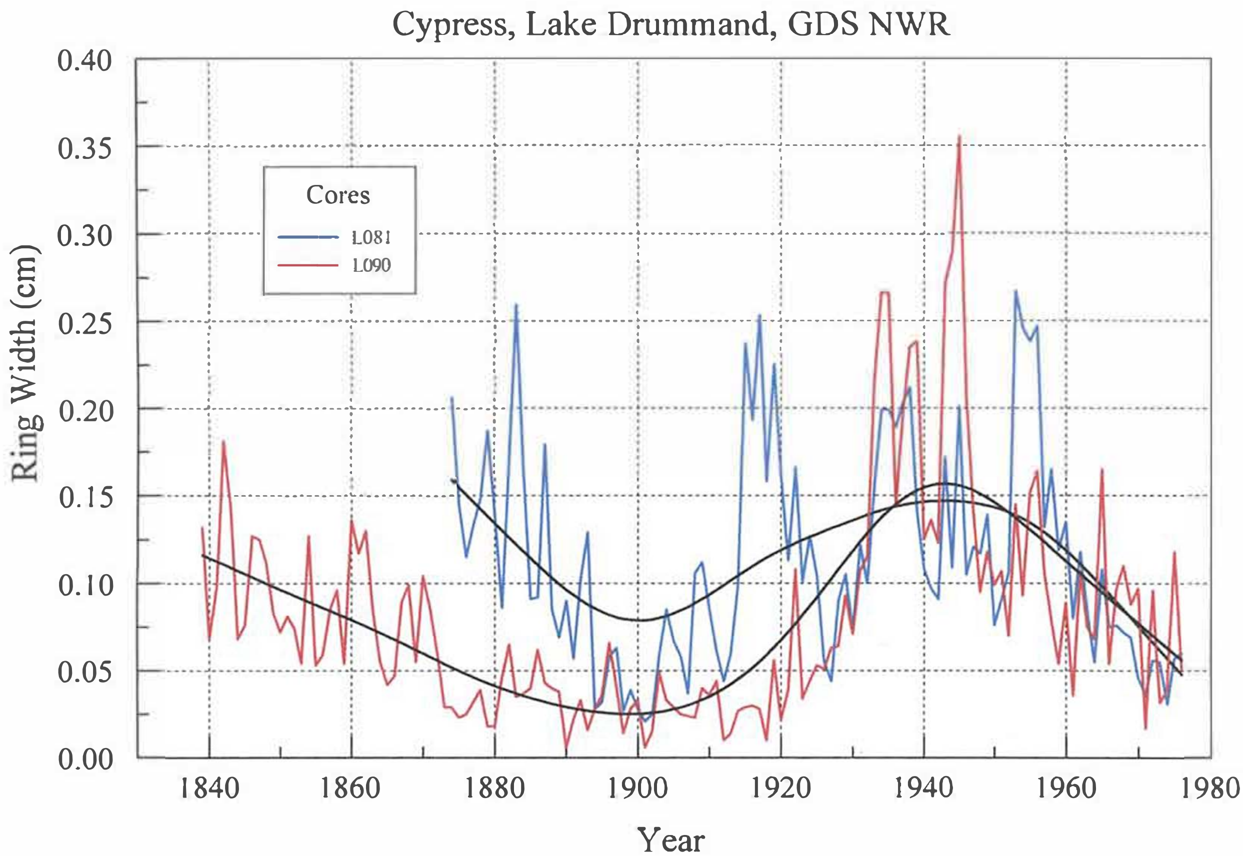

Figure 1. Ring-width series of two core samples, L081 and L080. Ring-width trends (black curves) were determined with a cubic spline.

Ring-width trends were identified by smoothing the ring-width series with a cubic spline (fig. 1). The ring widths were divided by the corresponding values from the curves, thereby producing an index series from which the trend had been removed (fig. 2).

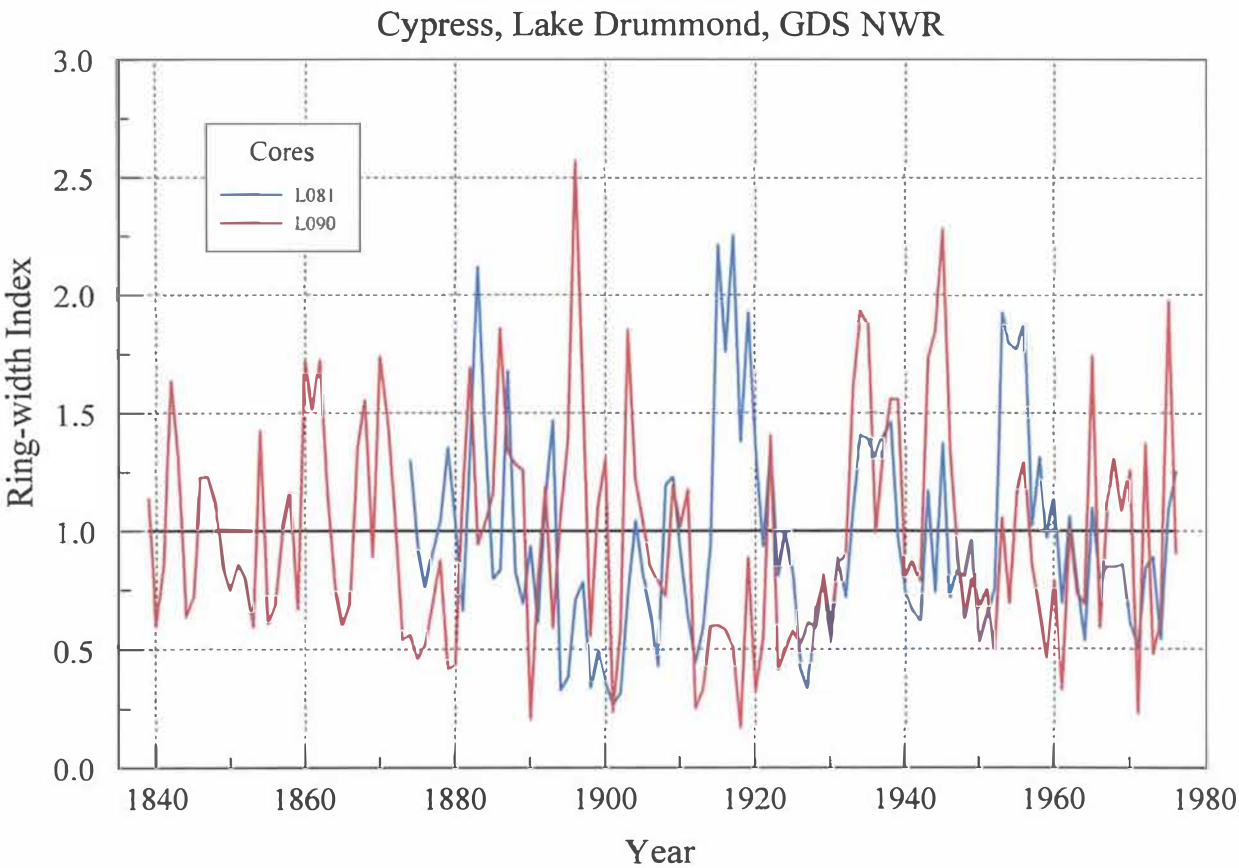

Figure 2. Tree-ring indices for the two increment core samples (L081 and L090) illustrated in fig. 1.

Stepwise multiple regression was used to elucidate relationships between tree rings and monthly lake level. The tree-ring indices of individual samples were merged into a set of mean collection indices that were used as the dependent variable. Monthly lake level of all months were available for selection as independent variables in the stepwise process. This was an attempt to describe tree growth from lake level data. Results showed that a relationship between lake level and tree rings definitely existed (fig. 3), but was hardly anything worth writing home about.

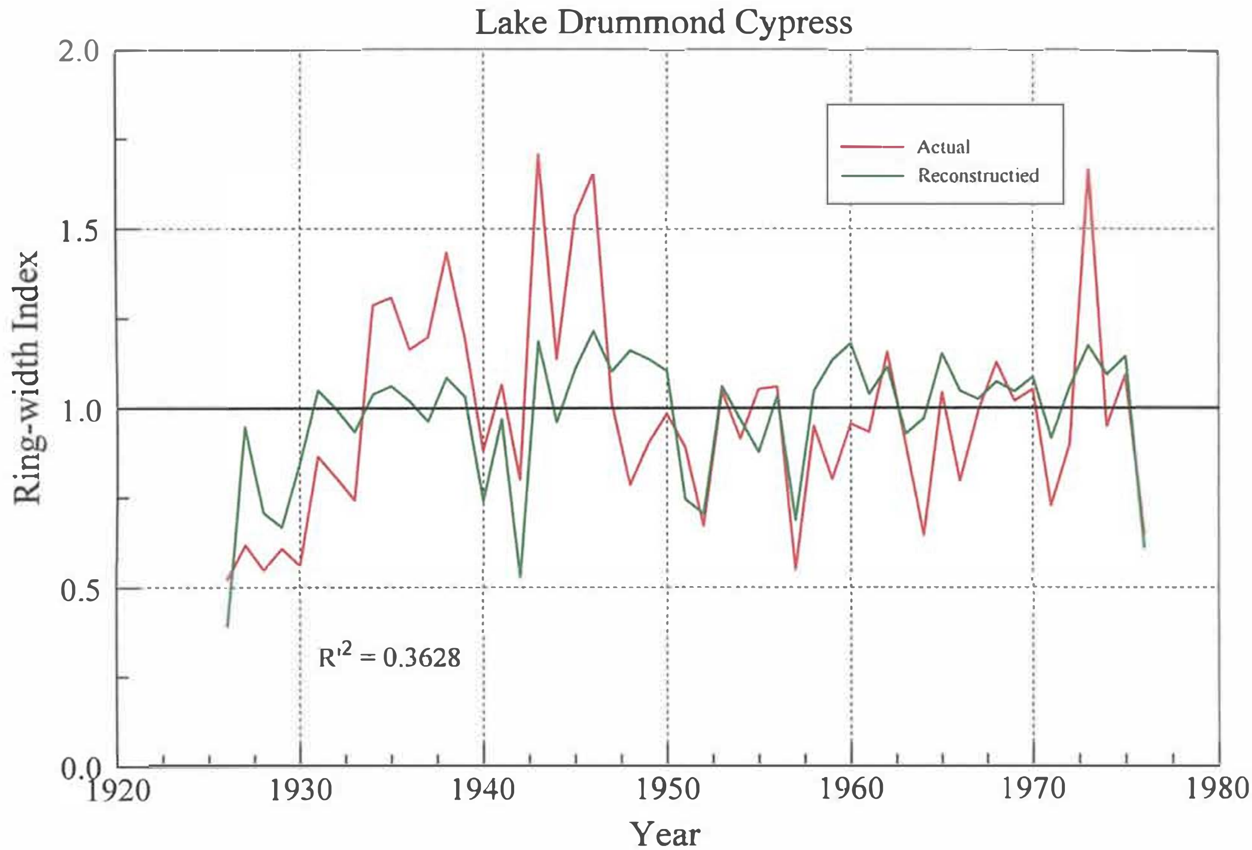

Figure 3. Prediction of yearly variations in cypress tree rings from monthly lake level data.

Because there is considerable variation among cores (note that the patterns of the two cores shown in fig. 2 don't match up very precisely on a year by year basis), I thought that it might be interesting to try to turn things around and describe (predict) monthly lake level from tree rings of the individual cores. A reasonably strong first order serial correlation was evident in the tree-ring indices; therefore, I used previous year's index as well as the current year's to predict the current year's lake level. This meant that in the 19-core subset, a total of 38 variables were available for selection in the stepwise process.

Lake level data were available back to 1926, and the tree-ring samples were collected after the 1976 growing season. Because of including previous year indices along with current year indices as predictors, correlations were for 1927 – 1976. R^2 values provided by my statistics package were adjusted for degrees of freedom lost according to the equation:

$$R'^2 = 1 - \left(\frac{n-1}{n-m-1}\right)(1 - R^2)$$

Percent variance explained ranged from 11% (Dec) to 66% (Aug); see Table 2. Comparing actual monthly lake level with that reconstructed from tree rings (fig. 4), reveals some similarity (some peaks and valleys on the same year), and the percent variance explained was definitely better for some months than was the reconstruction of tree-ring indices from lake level. Of interest, though, was that reconstructed lake levels (blue in fig. 4) were generally greater than actual lake level prior to 1950 and less than actual after 1950. This would suggest that the relationship between lake level and tree rings was not quite the same after 1950 as it was before. Returning again to fig. 1, ring widths were on an increasing trend from about 1900 to the mid-1940's, followed by a sharp decline after the mid-1940's. This same pattern was common among nearly all the samples. This also supports the suggestion that something was affecting tree growth differently between 1900 and the mid-1940's than between the mid-1940's and 1976; hence, it might make sense to calibrate those two time periods separately.

Table 2. *Number of variables selected and percent variance accounted for (R'^2 x 100) in stepwise regression estimations of monthly lake level from tree rings (19-core subset) for the period in common between lake level and tree-ring data (1927 – 1976), an early period of increasing ring widths (1927 – 1951) and a late period of decreasing ring widths (1951 – 1976).*

	1927-1976		1927-1951		1951-1976	
	Variables	Percent	Variables	Percent	Variables	Percent
January	4	31.3	15	96.7	2	23.1
February	11	62.2	9	89.1	3	33.2
March	6	49.0	7	82.8	7	71.4
April	4	54.0	10	92.3	10	92.6
May	3	35.5	7	83.8	4	58.2
June	7	42.2	2	35.7	7	74.5
July	7	61.7	8	76.2	8	80.5
August	7	65.5	7	84.1	6	67.2
September	6	43.0	5	65.6	5	62.9
October	3	22.4	6	57.2	3	37.5
November	9	38.1	4	57.2	2	25.9
December	2	11.0	4	56.2	2	17.0

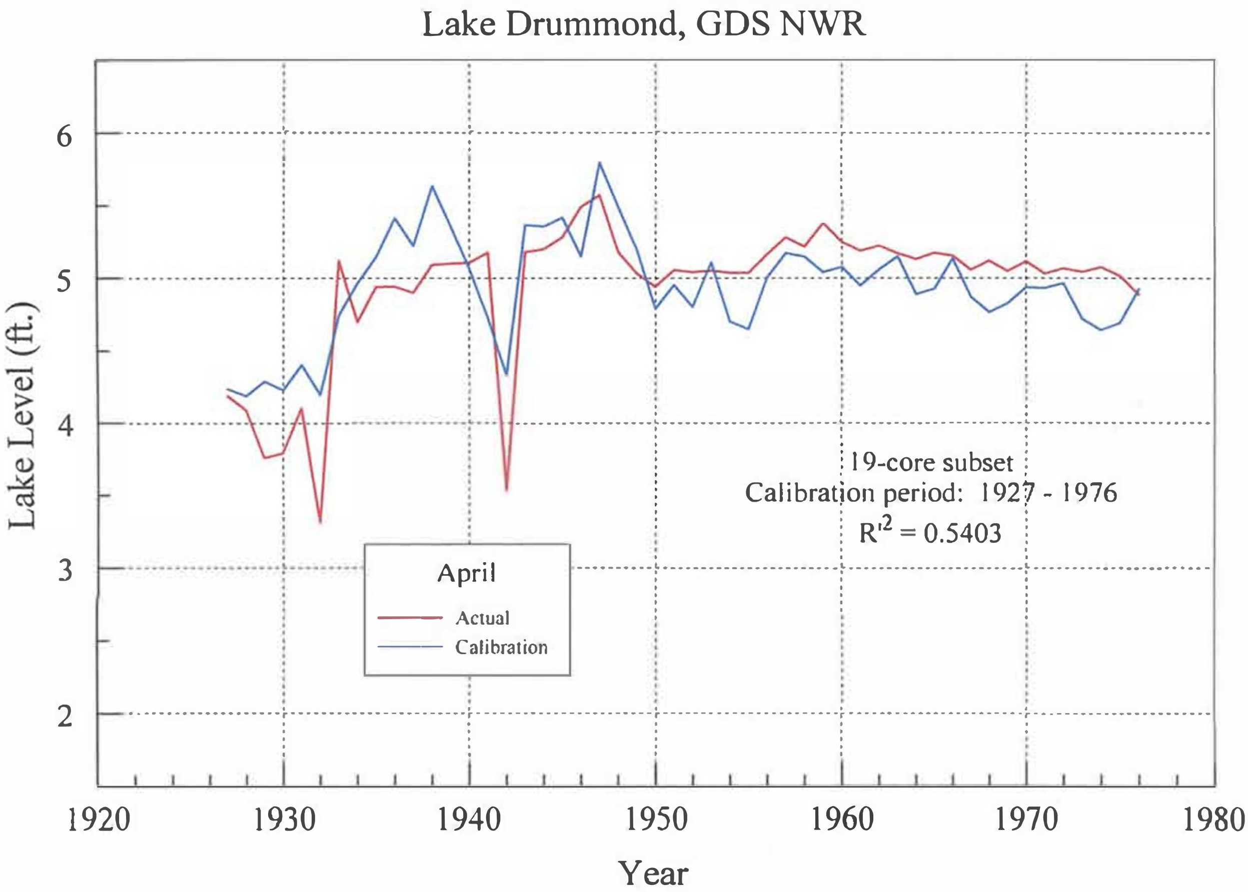

Figure 4. April lake level data and reconstruction of lake level from tree rings. Note that the tree rings (blue) generally over-estimate lake level before 1950 and under-estimate lake level after 1950.

Decreasing the length of the calibration period often tends to decrease the strength of the regression. That notwithstanding, I decided to split the 1927 – 1976 period in half and try new calibrations for an early period (1927 – 1951) and a late period (1951 – 1976). My hope was that whatever was lost by decreasing the length of the calibration period would be made up by separately describing the early and late periods.

Calibrating tree rings with lake level during the early period and then using that relationship to reconstruct the late period (fig. 5) shows a remarkable match during the early period and essentially no match at all during the late period. Turning this around, tree rings of the late period were calibrated with lake level and the resulting relationship was used to reconstruct lake levels for the early period (fig. 6).

The regression results for all months for the early period and the late period are included in Table 2. Though graphs of only April are here shown (fig. 5 and 6), they may be considered as representative of the stronger months, March, April, May, July and August (Table 2).

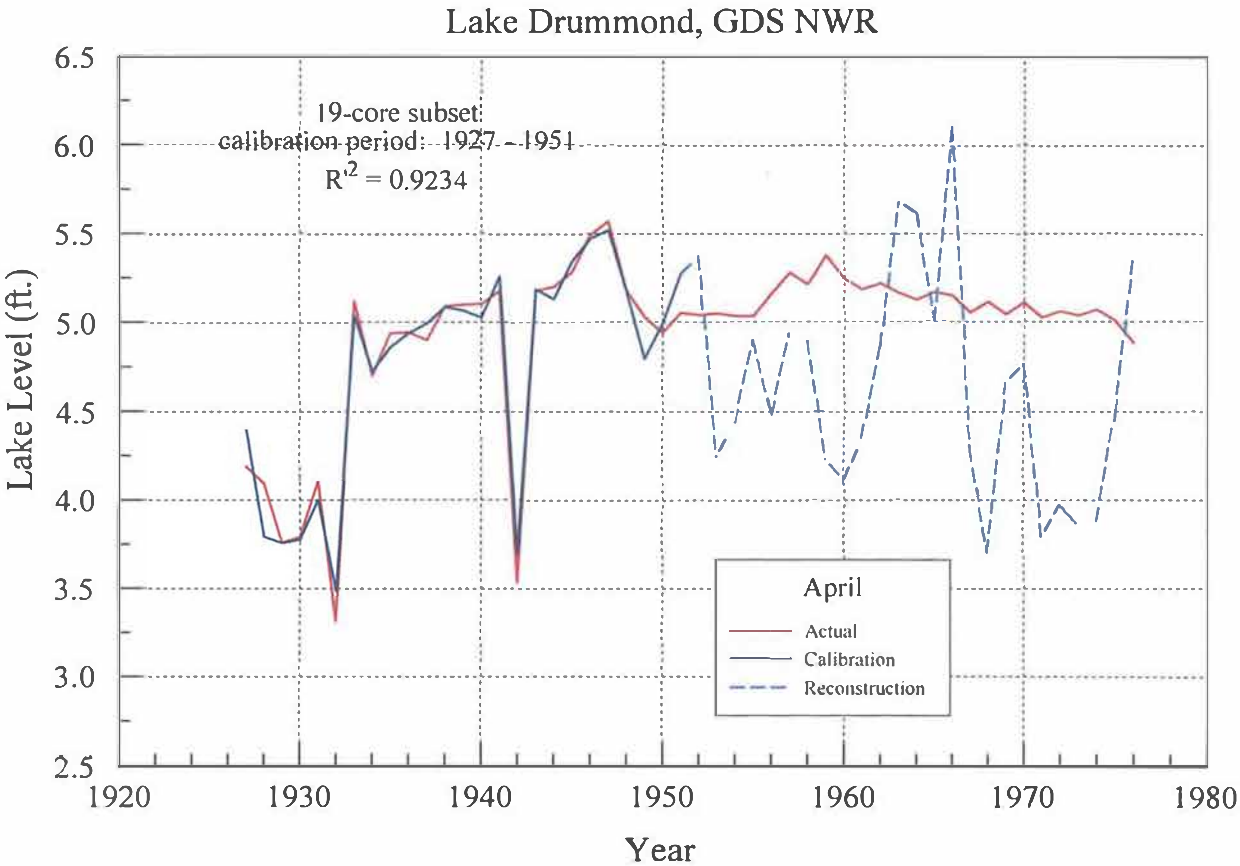

Figure 5. Actual lake level and lake level reconstructed from tree rings. Tree rings were calibrated with lake level for the 1927 – 1951 early period. The calibration period regression was then used to reconstruct lake level of the late period (1951 – 1976). The relationship established for the early period obviously does not hold for the late period.

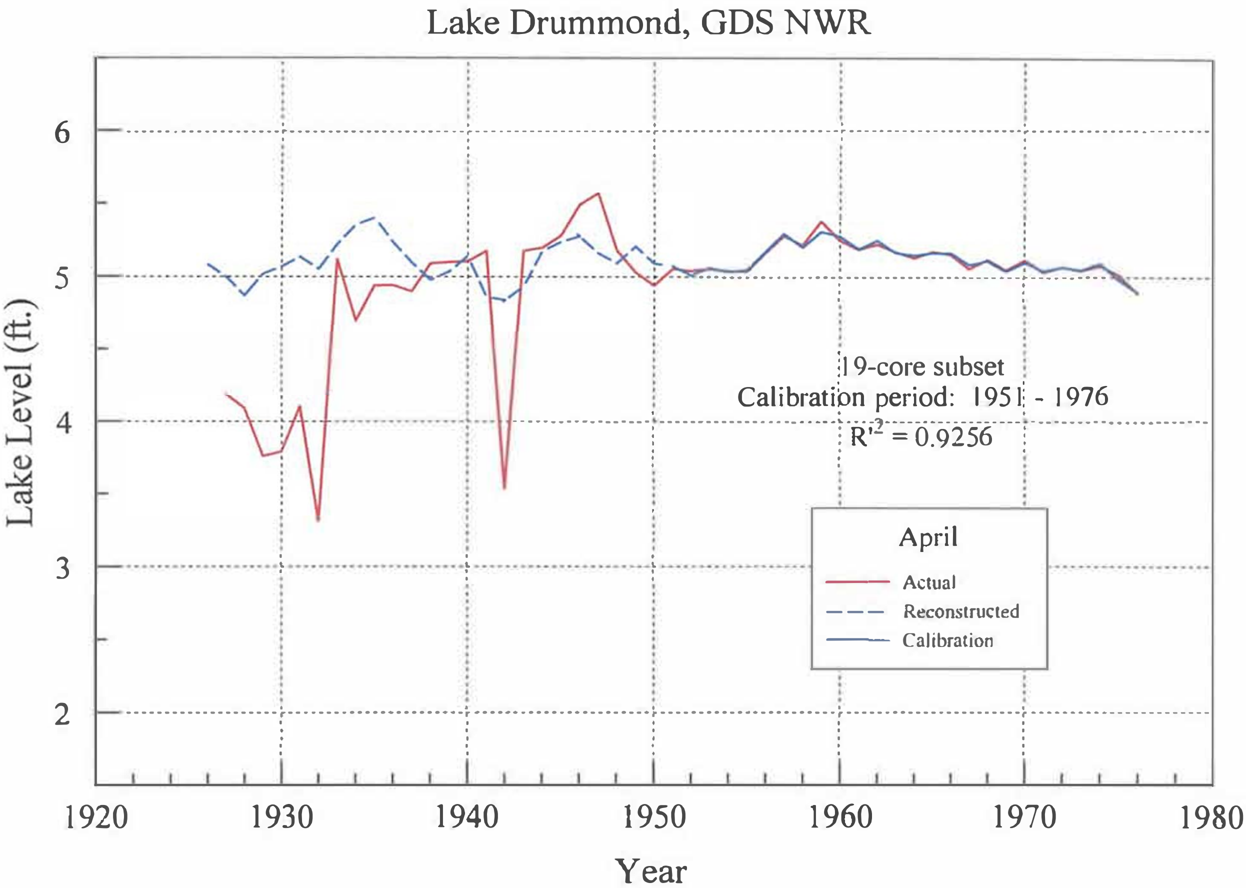

Figure 6. Actual lake level and lake level reconstructed from tree rings. Tree rings were calibrated with lake level for the 1951 – 1976 late period. The calibration period regression was then used to reconstruct lake level of the early period (1927 – 1951). The relationship established for the late period does not hold for the early period.

Referring again to fig. 1, it appears that the ring-width trend backwards from the mid-1940's continues right on back to around 1900. This implies that the relationship between tree rings and lake level also remains consistent throughout the period. Because the regressions seemed to work reasonably well for the 1927 – 1951 period, I thought that it might be possible to extend the lake level record backwards in time before 1927. Another inflection in width trend occurred around 1900, meaning that it would have been pointless to reconstruct lake level for anything earlier than 1900. Eight core samples dated back to 1902 (Table 1), which allowed reconstructions back to 1903. A new set of calibrations based on the 8-core subset (Table 3) were calculated for the 1927 – 1951 time period.

Table 3. *Number of variables selected and percent variance accounted for ($R^{'2}$ x 100) in step-wise regression estimations of monthly lake level from tree rings (8-core subset) for the early period of increasing ring widths (1927 – 1951).*

	Variables	Percent
January	3	40.0
February	3	43.7
March	3	53.6
April	3	60.2
May	3	46.2
June	1	19.7
July	4	44.7
August	3	53.3
September	4	47.0
October	3	42.6
November	6	70.7
December	5	58.0

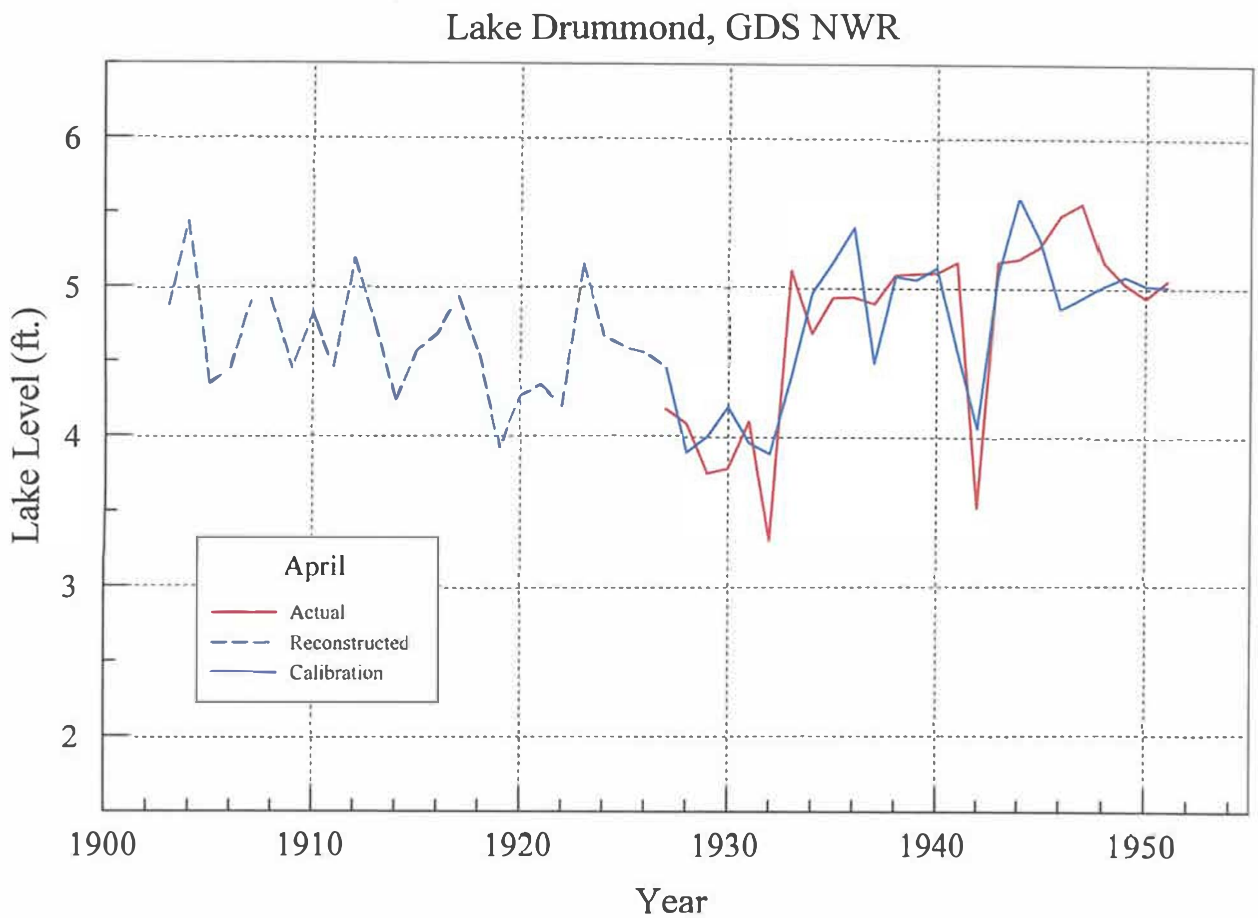

Figure 7. Reconstruction of April lake level from tree rings.

Again, using April lake level as an example (fig. 7), it can be seen that the 8-core regression does not reproduce the lake level record as faithfully as does the 19-core regression (fig. 5). That notwithstanding, lake levels were reconstructed for all months back to 1903. Even though the variance accounted for was reasonably strong, the reconstructions for October, November and December seemed a bit flaky, so for this "quick and dirty" description, I sort of arbitrarily deleted those three months.

Actual monthly lake level, 1951 – 1976, seemed to hover remarkably close to 5 ft. during winter months with marked summer decreases being common (fig. 8). Lake level for 1926 – 1951 is similar, except that there appears to be a declining trend in winter levels from 1926 – 1930 (fig. 9).

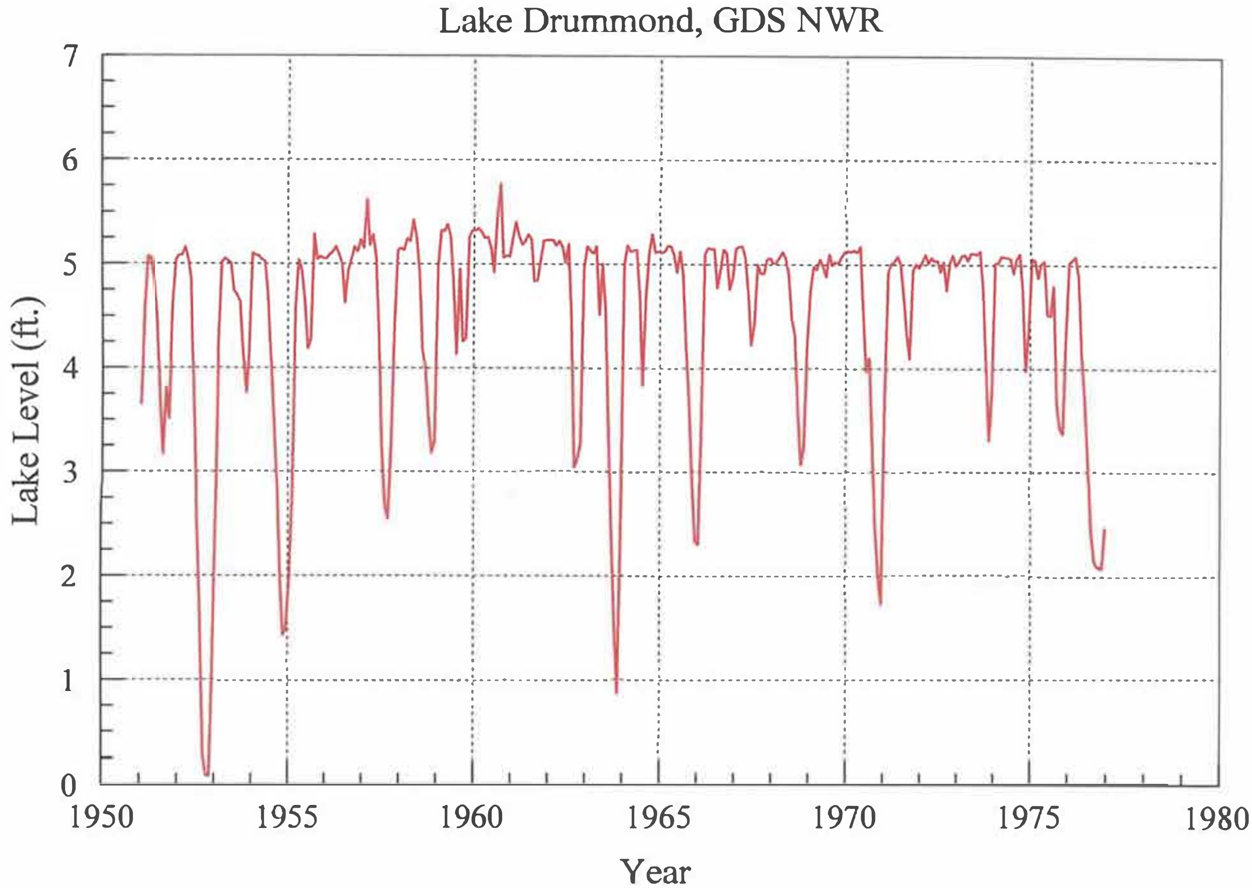

Figure 8. Monthly lake level, Lake Drummond, 1951 – 1976.

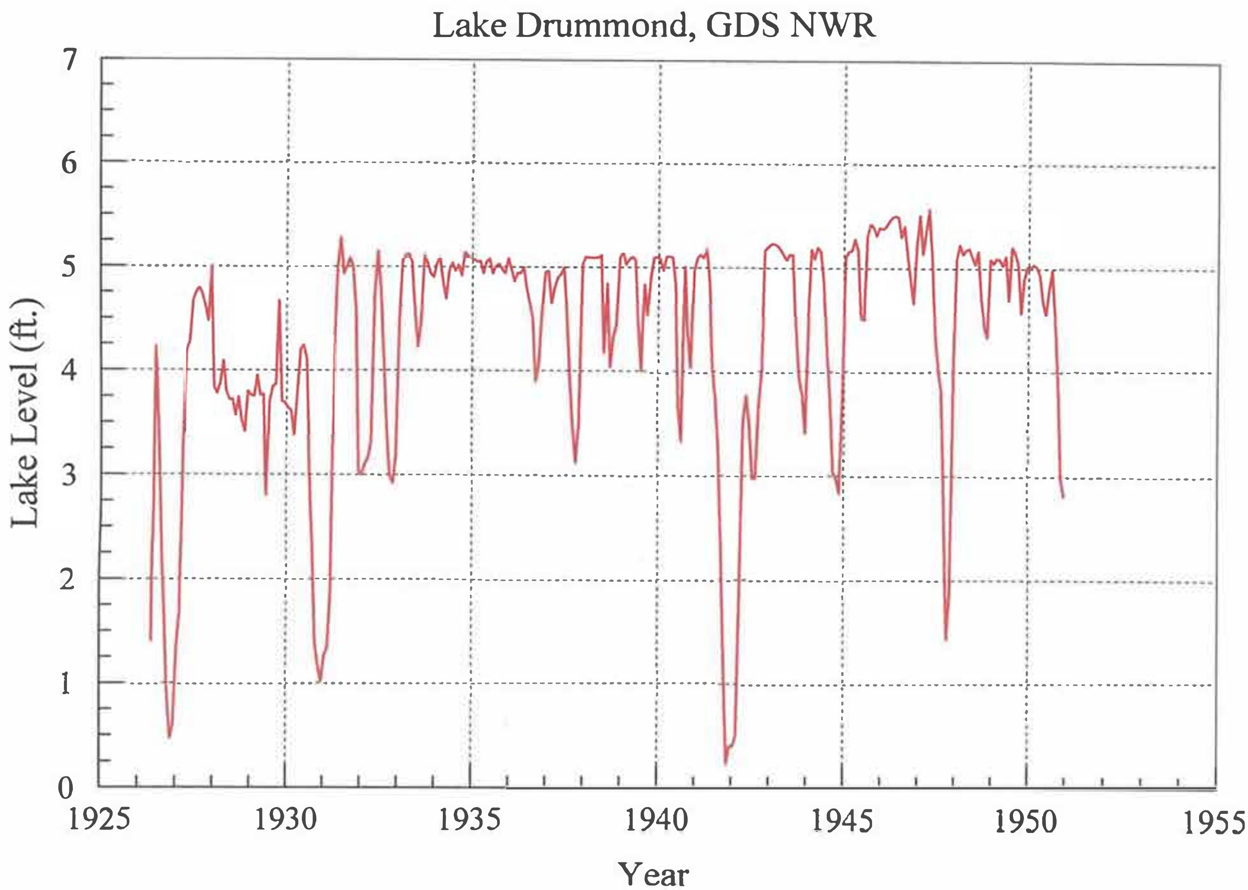

Figure 9. Monthly lake level, Lake Drummond, 1926 – 1950.

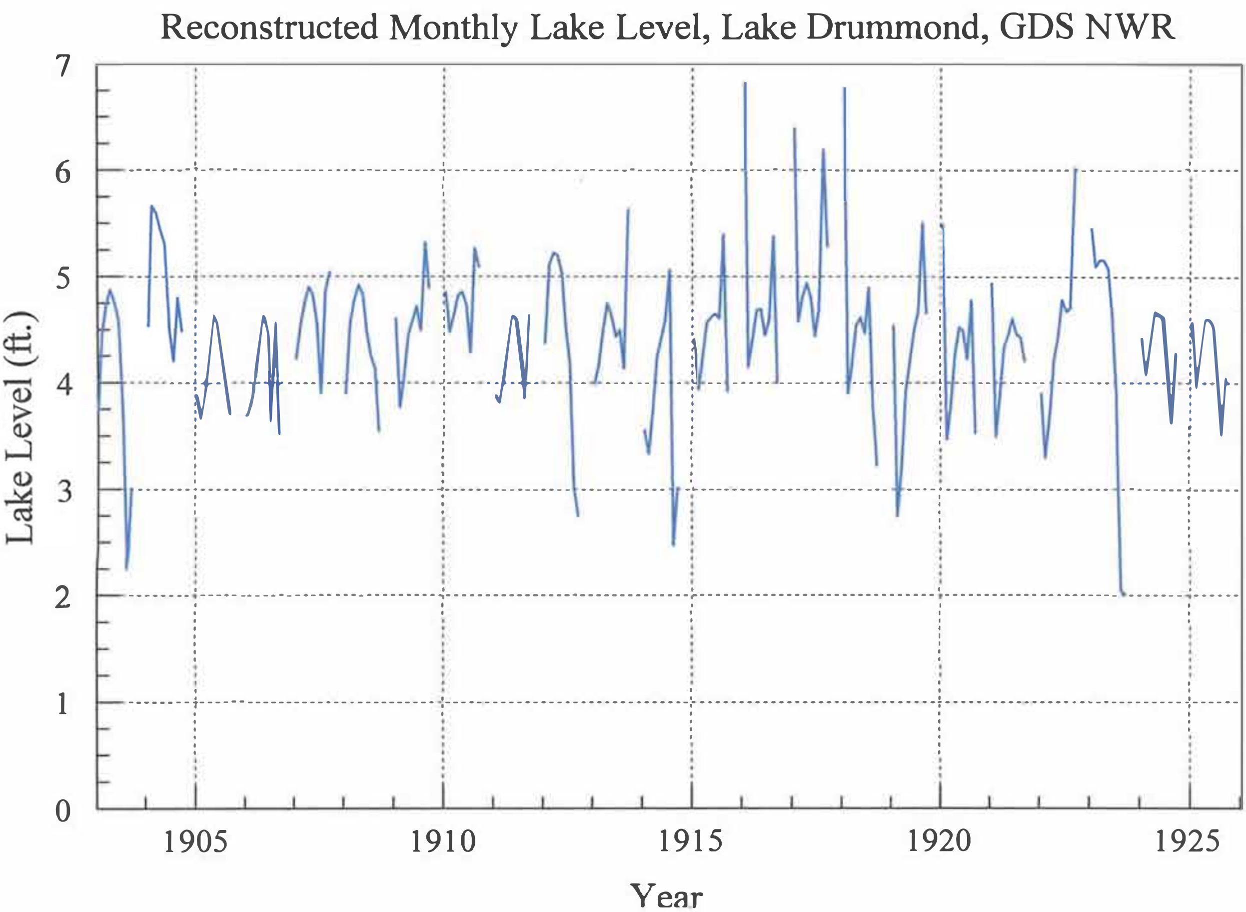

Figure 10. Monthly lake level, Lake Drummond, for January through September, 1903 – 1925, as reconstructed from tree rings of baldcypress, *Taxodium distichum*, growing in the lake.

Two or three things about the lake levels reconstructed for 1903 – 1925 are immediately apparent (fig. 10). Lake level does not appear to come back to something around 5 feet quite as consistently as it does after 1930. None of the summer lows seem to get quite as low as they do after 1930. There seems to be a hint at a decreasing trend in winter levels from about 1916 – 1925. Indeed, there appears to be a declining trend in winter levels that starts out well above 6 ft. in 1916 and continues to around 4 ft. in 1930 (fig. 11). Winter levels appear to hover around 5 ft. prior to 1916 similar to, if not as consistently, as they do after 1930.

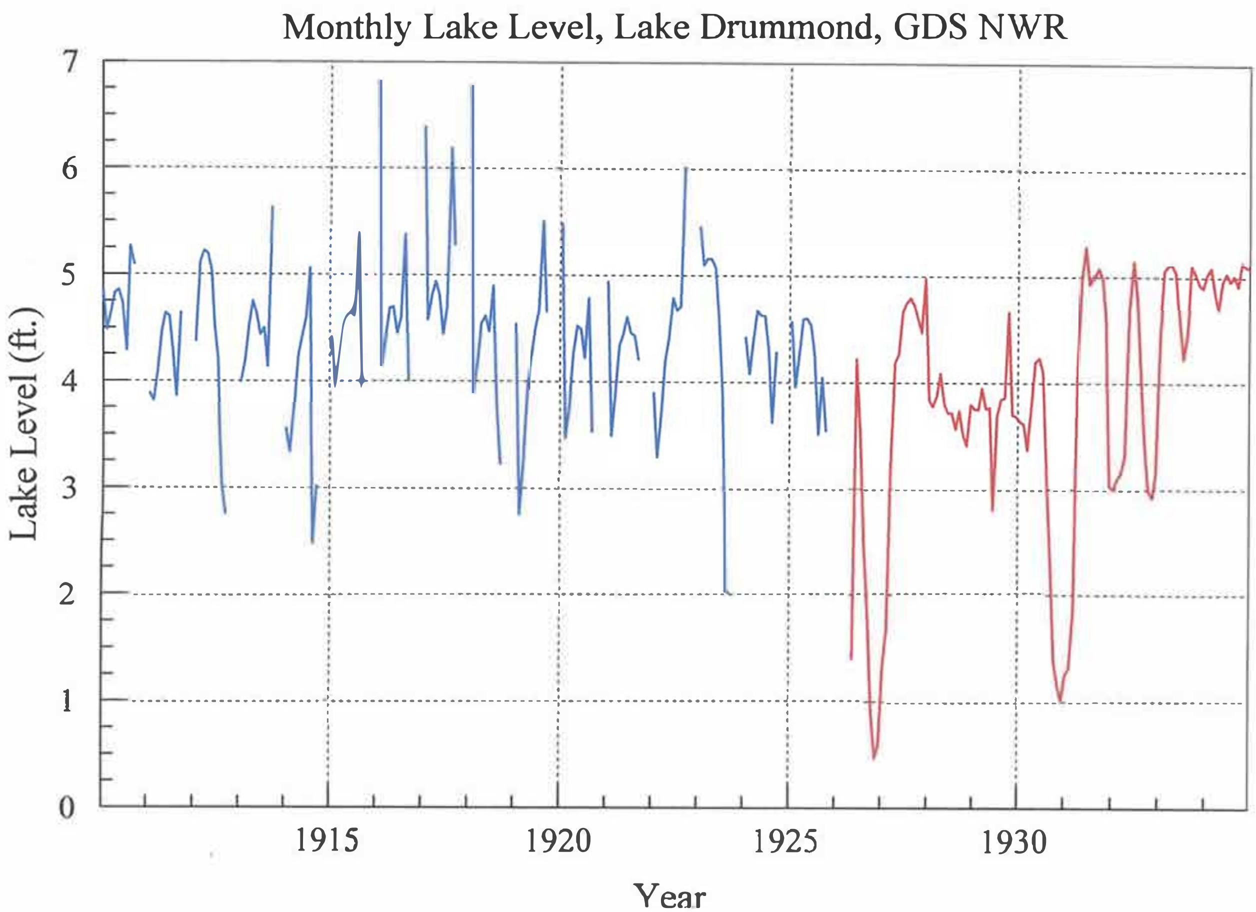

Figure 11. Monthly lake level, Lake Drummond, from 1910 – 1935.

Some parting thoughts—

- Are the tree-ring reconstructions of water level reliable enough to accept that there was some sort of anomaly that took place in 1916 – 1930?
- What went on in the swamp that resulted in the 1916 – 1930 water level anomaly?
- I wonder what Union Camp lumbering records would show, particularly as it relates to the 1916 – 1930 period?

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March 8, 2009