Time Series Analysis of Lake Koshkonong Water Levels

Data Validation

The USGS in cooperation with Rock County operates a water-stage recorder for Lake Koshkonong (USGS 05427235 LAKE KOSHKONONG NEAR NEWVILLE). However, the period of record for this station is limited to recent years (July 1987 to current).

USGS 05427235 LOCATION.--Lat 42°51'27", long 88°56'27", in NW 1/4 NE 1/4 sec.34, T.5 N., R.13 E., Jefferson County, Hydrologic Unit 07090001, 80 ft east of Pottawatomi Trail Bridge at Bingham Point Estates, and 4.5 mi northeast of Newville. DRAINAGE AREA.--2,560 square miles, at lake outlet. Area of Lake Koshkonong, 16.3 square miles. PERIOD OF RECORD.--July 1987 to current year. GAGE.--Water-stage recorder. Datum of gage is 770.00 ft above sea level. REMARKS.--Lake level regulated by dam at Indianford. Gage-height telemeter at station.Station operated in cooperation with Rock County

However, Fort Atkinson Water Plant staff has recorded daily water levels of the river adjacent to the plant since 1932. DNR staff received detailed annual graphs (1932-1998) of these water level records (Appendix___).

The reach of river between the water plant and Lake Koshkonong is very low gradient. Because of its extremely low gradient, changes in water levels recorded upstream at Fort Atkinson may be reflective of the lake levels and accurately track annual trends in water levels of the lake. To examine the utility of the Fort Atkinson water level data we compared Lake Koshkonong daily water levels found at the Lake Koshkonong gage to those recorded at the Fort Atkinson gage for the period October, 1998 though September, 2003.

Water level records at Fort Atkinson correspond to and track water levels recorded for Lake Koshkonong (Figure 1). Water levels recorded at Fort Atkinson average 0.177 feet higher than those reported for Lake Koshkonong (Figure 2). The magnitude of the difference between water levels is a function of river flows/discharge, and is described by a linear regression function where: Difference (Fort-Lake (ft.)) = 0.000169139*(FTDISCHARG) - 0.065917605. FTDISCHARG is the flow (cfs) reported for the Rock River at Fort Atkinson (Figure 3; P<0.001 Table 1).

Figure 2.

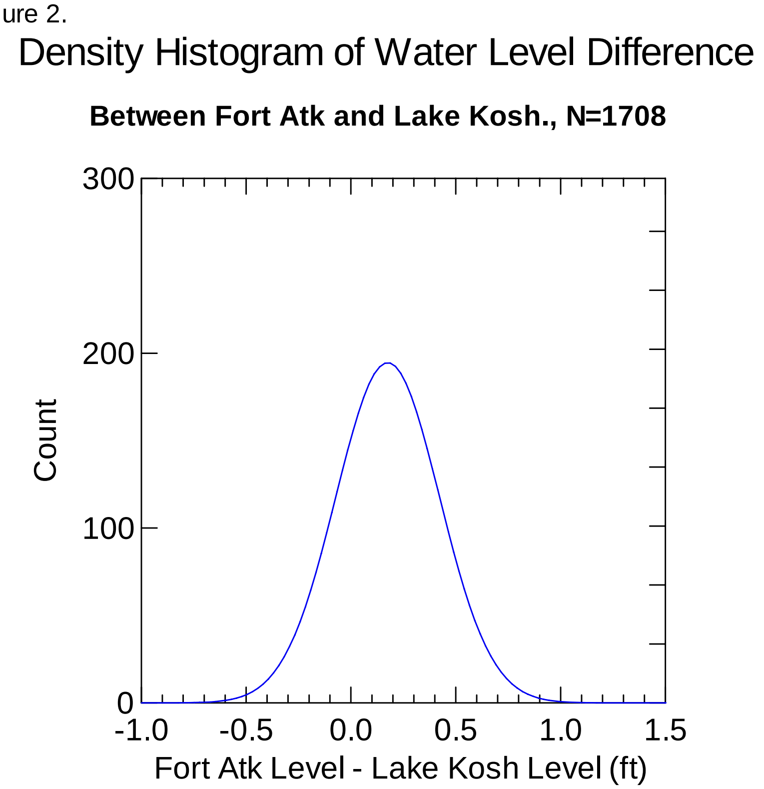


Figure 1. **1987-2004 Rock River, Water Level Data from Fort Atkinson and Lake Koshkonong**

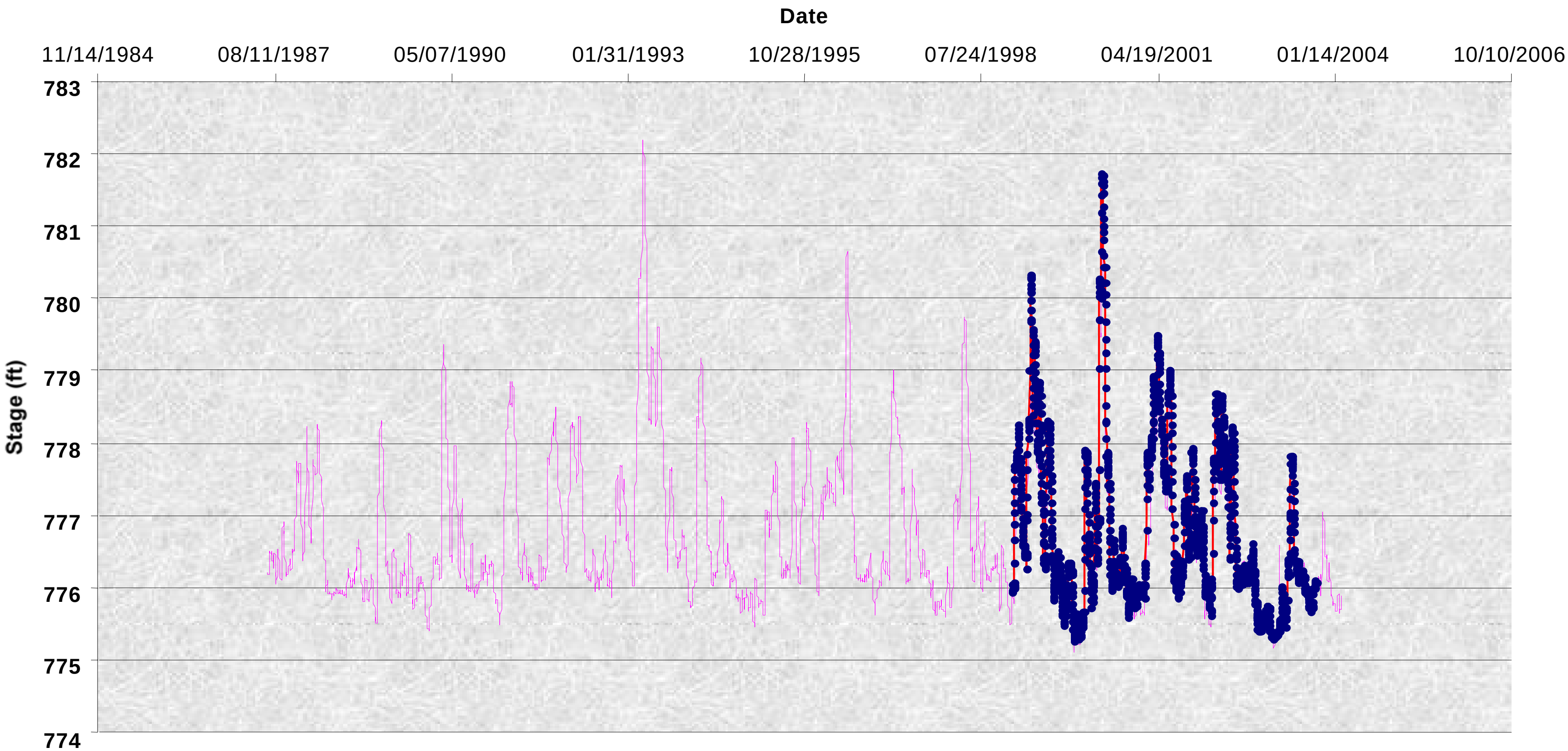


Table 1.

Dep Var: FORTMSLK N: 1688 Multiple R: 0.815166549 Squared multiple R: 0.664496502

Adjusted squared multiple R: 0.664297508 Standard error of estimate: 0.146024709

Effec	Coefficient	Std Error	Std Coef	Tolerance	t
CONSTAN	-0.065917605	0.005504569	0.000000000	.	-1.19E01
FTDISCHAR	0.000169139	0.000002927	0.815166549	1.00E+00	57.78653

Analysis of Variance

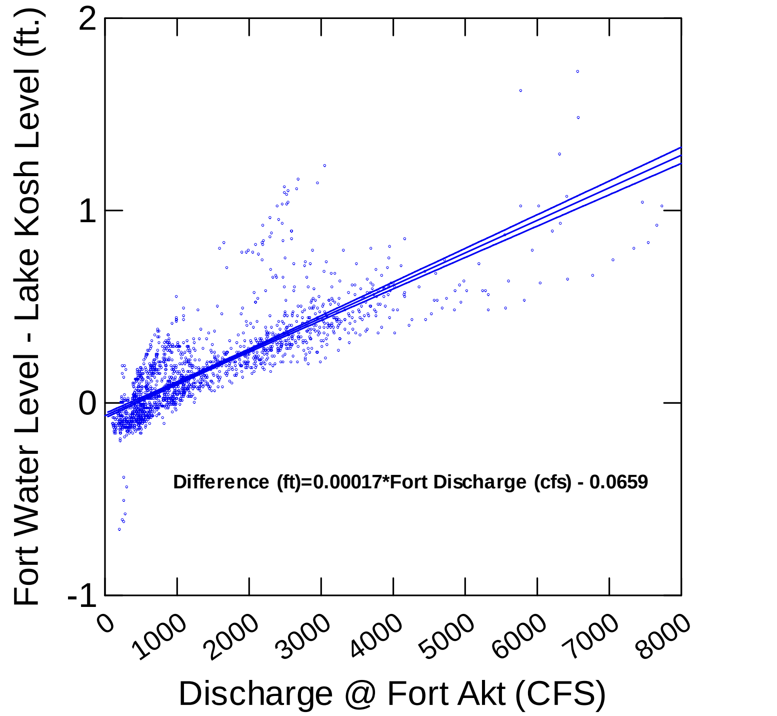
Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	7.12042E+01	1	7.12042E+01	3.33928E+03	0.000000000
Residual	3.59509E+01	1686	0.021323216		

Water Level Time Series Analysis

Figure 3.

Difference in Station Levels by Discharge

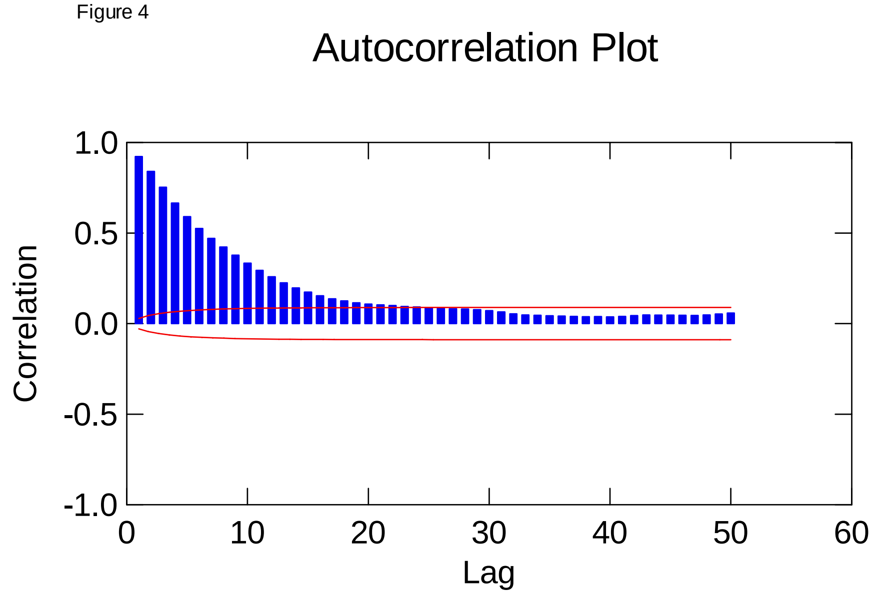
Lines show linear regression and the 90% confidence interval of the regression, N=1708, data from 1/16/99 to 9/30/03.



Our primary objective is to examine long term trends in water level during the summer period, when flow is reflective of base levels and is not so strongly affected by the extreme runoff events that occur in spring. Data points from the Fort Atkinson Water Plant graphs were systematically interpolated on days 1,5,10, 15,20, and 25 of each month and entered into a database for analysis. For data after 1998, daily water level records were electronically available. Mean water levels were calculated by month and by season (spring, summer, fall winter) for each year.

The individual observations in a time series such as this are frequently not independent of one another. Because water level changes in a continuous manner, observations closer together in time will be more highly correlated with one another than are those far apart (and this was confirmed by the autocorrelation function values computed; Figure 4.). This type of correlation pattern must be accounted for in data analysis because many standard statistical methods assume that observations are independent. An additional complication with this series is that there appears a seasonal pattern.

Figure 4



An approach that addresses our objective and avoids problems with autocorrelation and seasonality is to compute the average summer elevation (the average of all measurements during the summer period for each year) and base trend analyses on these annual averages. Seasonality is eliminated by this procedure and autocorrelation is at least greatly reduced. These annual averages for one season are based on 18 observations at taken at 5 day intervals, and represent a good summary of water level in each season. We used interpretations of Indianford seasonal discharge data (Figure 5) to aid in segmenting the year into seasons. All records for dates in March-May, June-August, September-November, December-February were respectively identified as spring, summer, fall, and winter. We tested for significant changes in water levels for the whole period (ANOVA; 1932-2003). Next, we used analysis of covariance to test for differences in slopes of water level changes for two distinct periods: We considered years 1932-1960 as a period of more intensive dam operation for maximize power generation, and after that (1961-2003), less intensive power generation and period of less intense gate manipulation. Finally, we investigated annual trends for the remaining seasons; spring, fall, and winter.

Data Subset Method-Elimination of Wet Summers

Our objective is to determine whether a pattern in dam management for water levels exists in the time series data. A review of the data indicates that the changes in Indianford Dam operational procedures may be able to produce noticeable effects on Lake Koshkonong at relatively low flow conditions. Because the dam controls water levels during base-flow conditions during the summer period, we rated the water-level years for the purpose of eliminating variable and high precipitation years from the data. Detailed annual graphs (1932-1998) of water levels recorded by Fort Atkinson Water Plant staff (Appendix___) were individually examined. Each year of the summer water level record for the period 1932-1998 was classified by the following criteria:

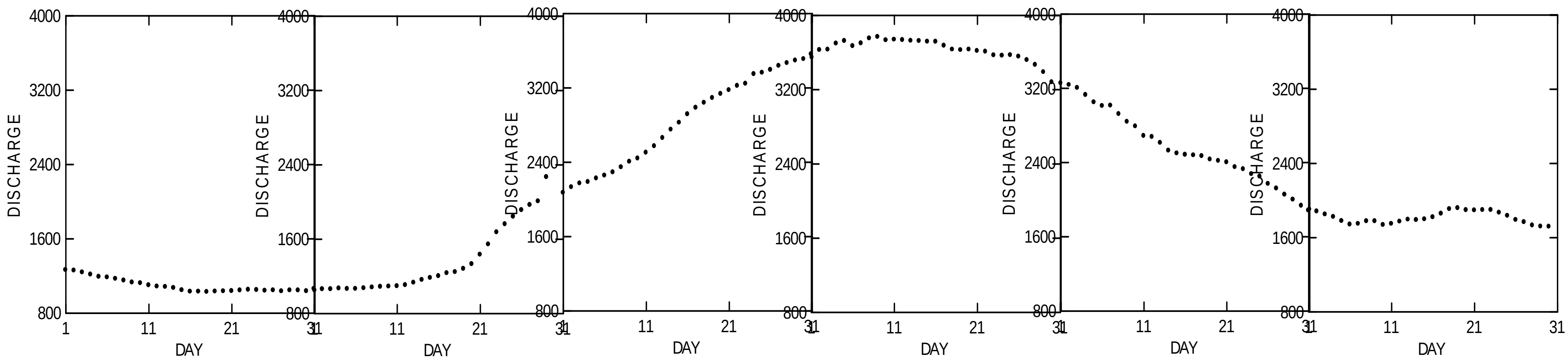
1 = level nearly constant during the summer
2 = some variablility (usually June) but level had a long stable period
3 = much variability, but a some constant level periods remaining
4 = highly variable with no constant level periods

The peak water-level was recorded for each year. We then eliminated class 4 summers and examined trends in among the remaining years (summer-peak value). Next, we eliminated class 3 and 4 summers and investigated trends in remaining years for summer peak levels.

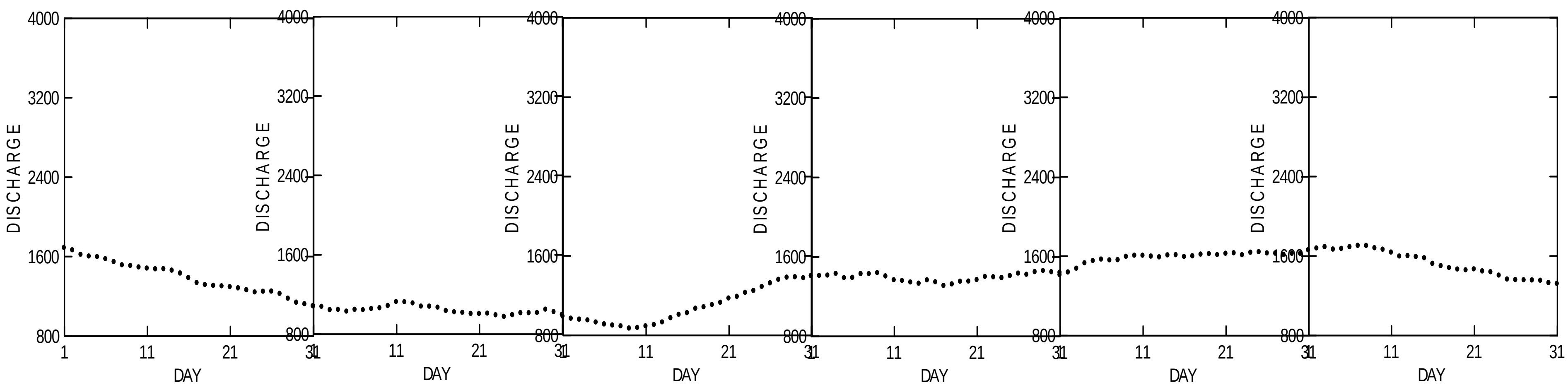
Figure 5.

USGS 05427570 ROCK RIVER AT INDIANFORD, WI . Daily Mean Discharge for the period 05/07/1975 through 09/30/2003.

January through June



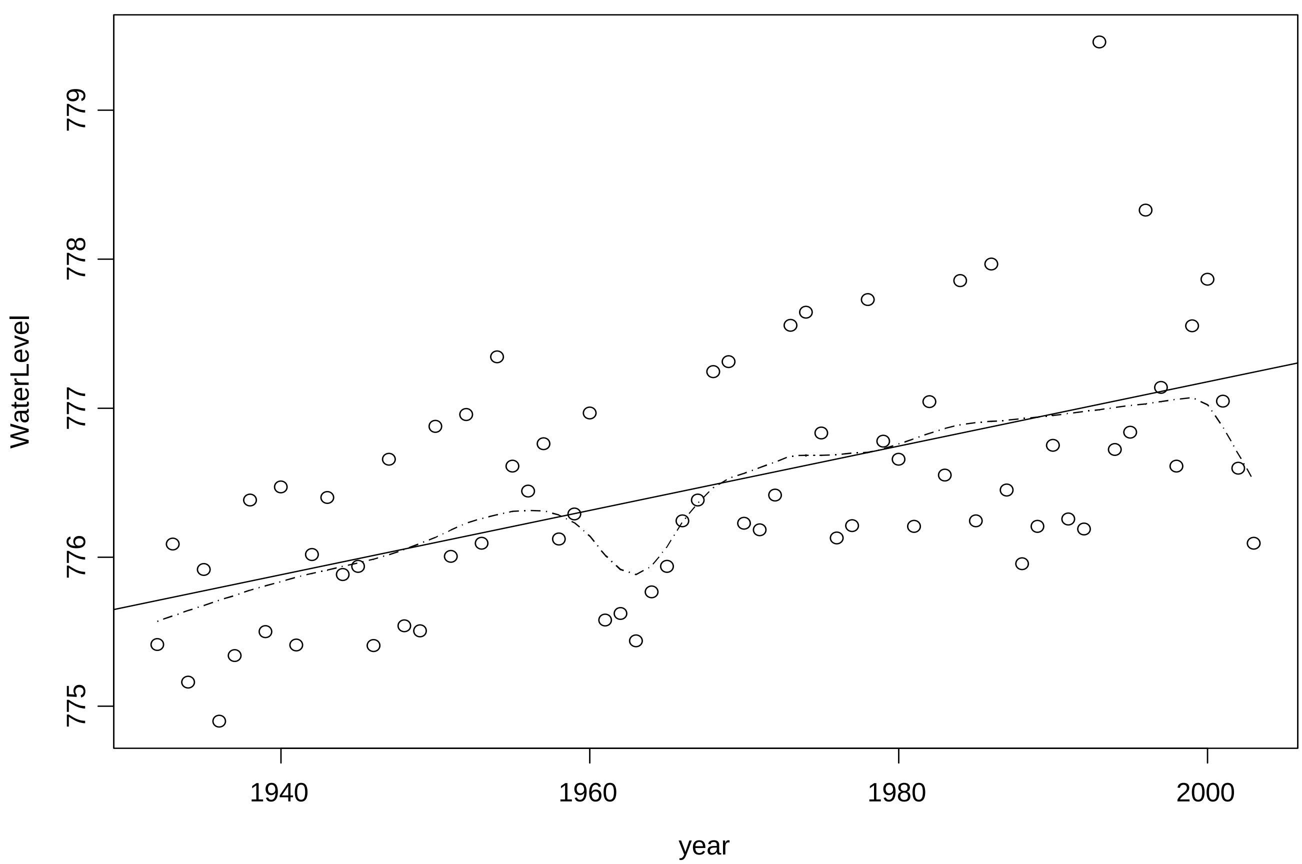
July through December



Annual Trends in Summer Water Levels

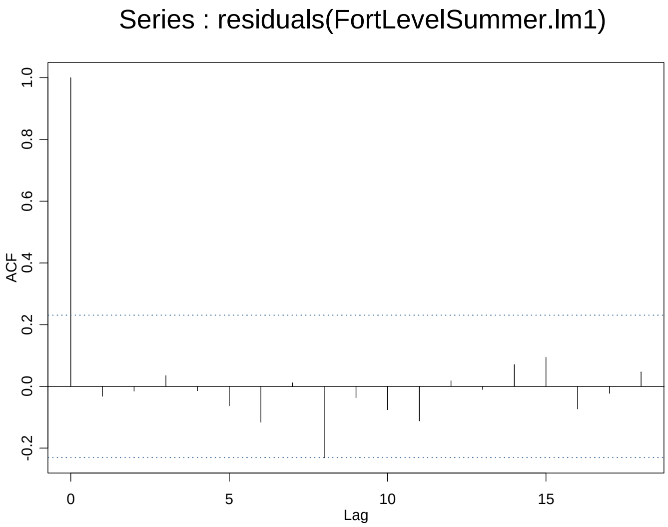
Mean summer water levels have markedly increased through the years 1932-2003 by 1.532 feet. Mean summer water levels for the period 1932-2003 is shown in figure 6. The solid line in figure 6 is the simple linear regression line (water level = 734.0195 + 0.02158*year, SE of the intercept is 7.506, SE of the slope is 0.00381, $P < 0.001$ for both, residual standard error is 0.6727). The change in water level predicted by this model for the period 1932-2003 is 1.532 feet (predicted level of 775.709 in 1932 and of 777.241 in 2003). The estimated slope indicates that water level has changed by 0.02158 feet per year over this period. There is no indication of autocorrelation in the residuals (fig. 7). Roughly speaking, the smoothed line in figure 6 shows the middle of the distribution of water levels for each small range of years. Smoothed lines are useful in showing how the empirical distribution of water levels changes over the years, without imposing a linear model or some other parametric model on the data. This smoothed line parallels the linear regression line closely except in the period just after 1960 and 2000. This suggests a short-term drop in average summer water level after 1960 and also a drop at the end of the period (2000-2003). Otherwise this smoothed line follows the linear regression line remarkably closely, thus the linear regression model appears to be a reasonable representation of the long term trend in water level.

Figure 6.



There was no difference in the slopes (ANCOVA; p=0.270) or intercepts (ANCOVA; p=0.161) of summer water levels between the two time periods,1932-1960 and 1961-2003.

Figure 7.



Annual Trends in Spring, Fall, and Winter Water Levels

Water levels have significantly increased through the years 1932-2003 (Figure 8; P<0.001) for all seasons. Trends for spring, fall, and winter mean water levels are somewhat similar to summer water-levels trends, although less variance is explained by year. Annual variation in water levels is greatest in the spring, followed by fall, winter, and spring (Figure 8). R^2 values for the seasonal relationships were 0.099 for spring, 0.314 for summer, 0.179 for fall, and 0.236 for winter.

There were no differences in the slopes or intercepts of mean water levels between the time periods 1932-1960 and 1961-2003, for any of the seasons (Table 2).

Table 2. ANCOVA-Test of slopes and intercepts between periods 1932-1960 and 1961-2003.

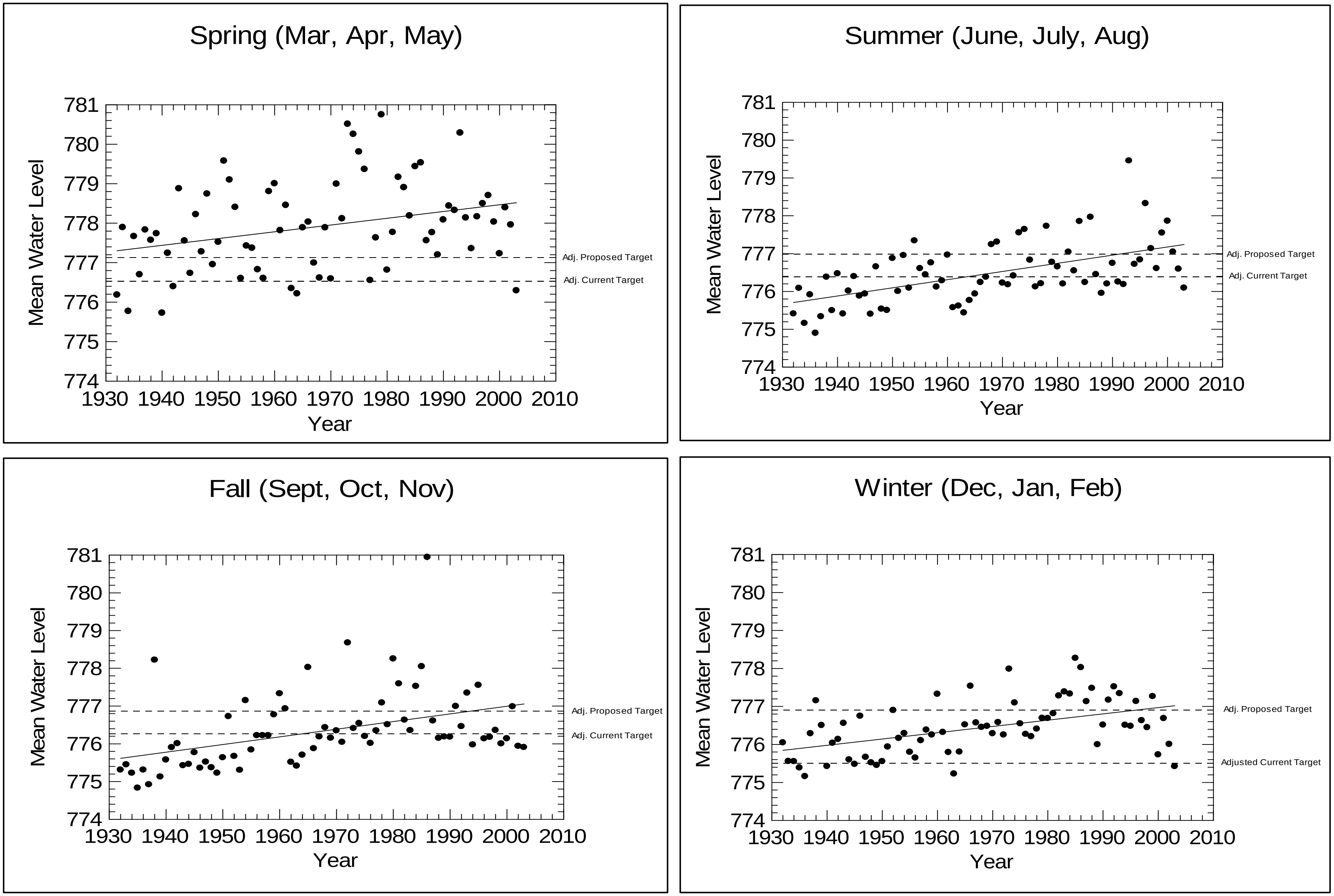
Test for difference in slopes

season	error df	F-statistic	P-value
Spring	68	1.56	.215
Summer	68	1.24	.270
Fall	68	2.85	.096
Winter	68	0.52	.474

Test for difference in intercepts

season	df	F-statistic	P-value
Spring	69	0.02	0.883
Summer	69	2.01	0.161
Fall	69	0.91	0.342

Figure 8. Annual Trends in water levels (Fort Atkinson reported) by season. Line shown is linear regression function. Dashed lines show both current and proposed flow-adjusted target levels. To calculate the adjusted levels, mean flows were calculated for each season, then mean flows were applied to the regression model in figure 3 to calculate average seasonal difference between the Fort Atk. gage and Lake gage. This difference was used to adjust the targets accordingly. Current target shown in the winter season plot reflect the winter drawdown



Data Subset Method-Elimination of Wet Summers

The following years were classified as level four, meaning highly variable with no constant level periods; 1935, 1938, 1940, 1950, 1952, 1954, 1955, 1960, 1968, 1968, 1978 1982, 1986, 1990, and 1997. The following years were classified as level three, meaning much variability but a some constant level periods remaining; 1942, 1943, 1947, 1972, 1979, 1980, 1984, 1993, 1994, 1996, 1998. Peak summer water levels containing class 1-3 years and class 1-2 years are shown in figures 9 and 10, respectively. After elimination of wet/variable summers increasing trends are apparent for "base-flow" condition summers (Figs. 9-10). A linear regression of peak summer level on year for class 1-2 years is described by the following equation: **Peak Summer Level (ft.)= 0.0208(Year) + 735.** Linear regression model predicts a peak summer level of 775.19 in 1932 and a peak summer level of 776.56, representing 1.37 ft. increase over the period (Figure 10).

Figure 9. Peak summer water levels for class 1, 2, and 3 years.

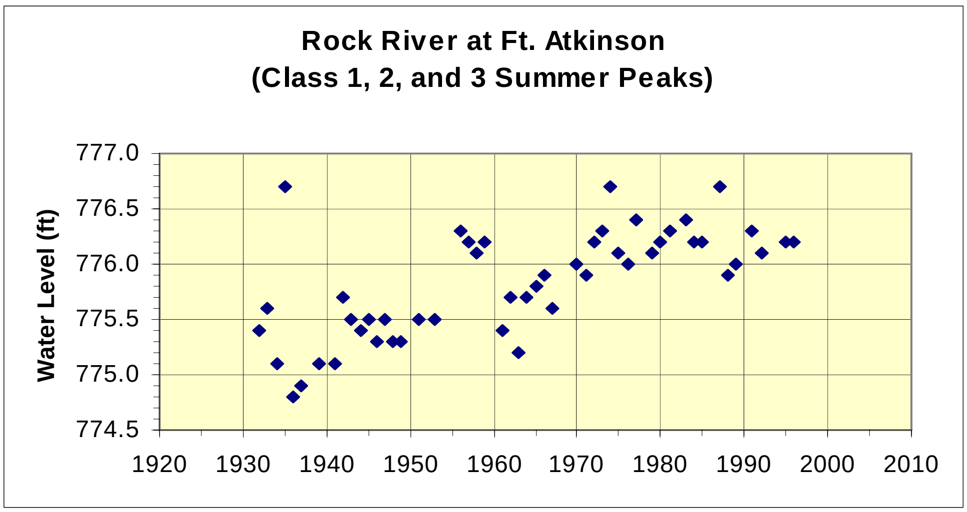
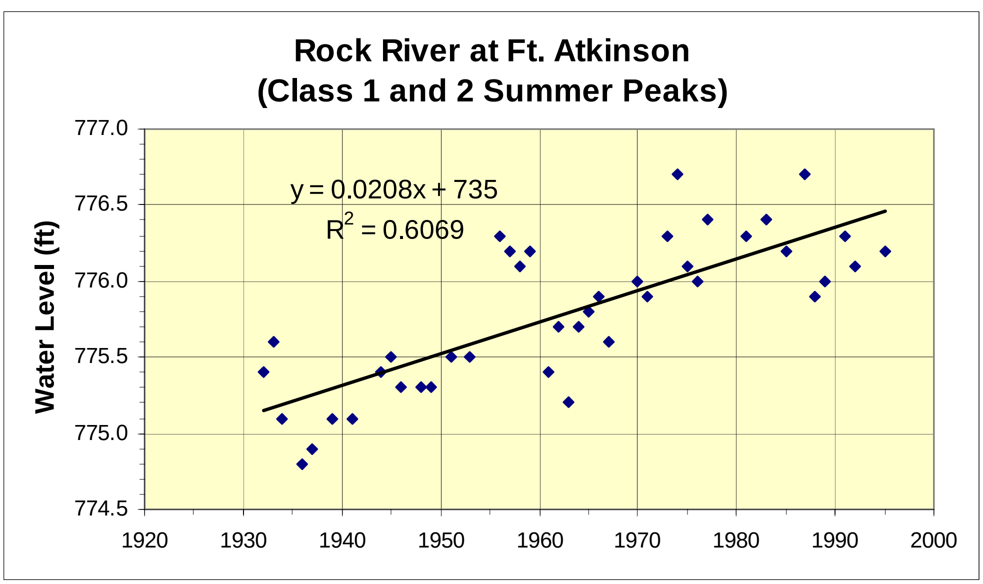


Figure 10. Peak summer water levels for class 1 and 2 years.



Time Series Analysis of Lake Koshkonong Receiving Flows

From our earlier analysis, average summer water levels at the Fort Atkinson (reflective of Lake Koshkonong levels) has increased by approximately 1.5 feet between 1932 and 2003. We sought to explore whether the increase in Lake Koshkonong water levels could be explained solely by increases in flow upstream from Lake Koshkonong. We primarily analyzed river flow information from two USGS gauging stations; the Rock River gaging station at Watertown, and the Crawfish River near Milford. We analyzed data from two gaging stations because of their valuable long-term records; these two stations contain data for the period 1931 to present, which is nearly identical to our water level records available just upstream of Lake Koshkonong at Fort Atkinson (1932 to present). These two gages have separate drainage areas and they both contribute flows to Rock River and comprise 65.8% of the drainage area upstream of the Indianford gage. For the period 1975 to present, combined flows (Watertown flows+Crawfish flows) account for 62% of the mean total flow on the Rock River at Indianford. Analysis of Watertown gage records and Milford gage records well represent receiving flows and have the advantager of much longer datasets, comparable to our Fort Atkinson water level dataset.

The Indian Ford gage accounts for a drainage area of 2,630 sq. miles
LOCATION.--Lat 42°48'15", long 89°05'25", in SW 1/4 SW 1/4 sec.16, T.4 N., R.12 E., Rock County, Hydrologic Unit 07090001, on right bank 50 ft upstream from bridge on County Trunk Highways F and M,250 ft upstream from dam in Indianford, and 1.8 mi upstream from Yahara River.DRAINAGE AREA.--2,630 square miles. PERIOD OF RECORD.--May 1975 to current year. REVISED RECORDS.--WDR WI-79-1: Drainage area. GAGE.--Water-stage recorder and crest-stage gage. Datum of gage is 763.84 ft above sea level (Rock County Surveyor bench mark). Prior to Oct. 1, 1990, at datum 0.10 ft lower. REMARKS.--Natural flow of stream affected by dam in Indianford. Discharge is adjusted for flow through wicket gates. Gage-height telemeter at station.

The Watertown gage (Rock River) accounts for a drainage area of 969 sq. miles.
LOCATION.--Lat 43°11'17", long 88°43'34", in SW 1/4 sec.4, T.8 N., R.15 E., Jefferson County, Hydrologic Unit 07090001, on left bank, 700 ft downstream from Milwaukee Street bridge, 1.1 mi downstream from Silver Creek, at Watertown. DRAINAGE AREA.--969 square miles. PERIOD OF RECORD.--June 1931 to September 1970, October 1976 to current year. REVISED RECORDS.--WSP 1438: 1933,1935(M), 1937(M), 1938-39, 1945(M); WDR WI-79-1: Drainage area. GAGE.--Water-stage recorder. Datum of gage is 792.58 ft above sea level. Prior to Sept. 26, 1933, nonrecording gage at site 700 ft upstream at different datum.

The Crawfish River gage accounts for a drainage area of 762 sq. miles.
LOCATION.--Lat 43°06'00", long 88°50'58", in SW 1/4 sec.4, T.7 N., R.14 E., Jefferson County, Hydrologic Unit 07090002, on left bank near upstream side of highway bridge in Milford, 1.4 mi downstream from Rock Creek and 9.8 mi upstream from mouth.**DRAINAGE AREA**.--762 square miles.**PERIOD OF RECORD**.--June 1931 to current year.**REVISED RECORDS**.--WSP 975: 1937-38. WSP 1438: 1932-33(M), 1935(M), 1937, 1938-41(M),1943-44(M),1947-48(M).WDR WI-79-1: Drainage area.**GAGE**.--Water-stage recorder. Datum of gage is 779.40 ft above sea level. Prior to July 28, 1966, nonrecording gage at present site and datum.

Annual Trends in Spring, Summer, Fall, and Winter Flows

Annual Trends of increasing flow are apparent during summer and fall periods, whereas trends are not as evident during winter and spring seasons (Table 3; Figures 11-18). For both the Rock River and Crawfish River there was a significant increase in summer flow (5.07 per year for the Rock R., 5.29 per year for the Crawfish R.). In both rivers the variance of flow also appeared to increase over time. This suggests it may be more appropriate to log transform flow before carrying out the regression. There was a significant increase in log of flow for both rivers as well (these convert to a 1.71% increase in flow per year for the Rock R., and a 2.05% increase in flow per year for the Crawfish R.).

Note that the R-squared values are often quite low (Table 3; Figures 11-18); expectedly there's a lot of variability about the regression line that's not explained by the regression on year. Across all seasons, year explains less of the variability of the flow data compared to water level data. In some cases, the trend with respect to time (year) is significant, in others it's not significant.

Table 3. Summary of Regression Results

Season	Station	Data Metric	Significant Trend	R^2
Spring	Rock River @ Watertown	Log Mean Flow	No	0.045
	Crawfish River @ Milford	Log Mean Flow	No	0.045
	Fort Atkinson	Water Level	Increase	0.099
Summer	Rock River @ Watertown	Log Mean Flow	Increase	0.138
	Crawfish River @ Milford	Log Mean Flow	Increase	0.199
	Fort Atkinson	Water Level	Increase	0.314
Fall	Rock River @ Watertown	Log Mean Flow	Increase	0.167
	Crawfish River @ Milford	Log Mean Flow	Increase	0.136
	Fort Atkinson	Water Level	Increase	0.179
Winter	Rock River @ Watertown	Log Mean Flow	No	0.05
	Crawfish River @ Milford	Log Mean Flow	Increase	0.08
	Fort Atkinson	Water Level	Yes, Increase	0.236

Interactions Among Water Levels and Receiving Flows

We know that increasing flows in the watershed has confused our interpretation of changes in water levels for Lake Koshkonong. If both the flow into the lake and the water level of the lake have increased since 1932, is the increase in water level of Lake Koshkonong solely explained by increasing flows? Multiple regression is useful analytical approach that enables us to remove the effects of increasing flows and understand whether water levels are increasing independent of flow. Multiple regression uses multiple independent variables, in our model the three independent variables are: year, Crawfish River flows, and Rock River flows. We fit the summer flow and water level data to a multiple regression model of the following general form:
Waterlevel = β_0 + β_1(Year) + β_2(Rock_flow) + β_3(Crawfish_flow).

Multiple regression results indicate that after accounting for differences in seasonal flows for each year, we still observe significant year effect for summer water levels (Table 4). Flow does affect downstream water level, but once the flow effects are accounted for there still remains a significant linear increase in water level over time. Results from this model indicated that there was a significant positive relationship between upstream flow and downstream lake level, and that even when the upstream flow was accounted for, there was still an increase in downstream level over time (slope = 0.00854, $P < 0.001$).

Table 4. Multiple Regression Results for Summer Period

Analysis of Variance					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	3	38.61452	12.87151	172.82	<.0001
Error	62	4.61777	0.07448		
Corrected Total	65	43.23230			

Root MSE	0.27291	**R-Square**	0.8932
Dependent Mean	776.44621	**Adj R-Sq**	0.8880
Coeff Var	0.03515		

Parameter Estimates					
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	1	758.83960	3.38712	224.04	<.0001
ME1WATERTOWN	1	0.00090102	0.00025145	3.58	0.0007
ME2CRAWFISH	1	0.00158	0.00029504	5.35	<.0001
YEAR	1	0.00854	0.00173	4.94	<.0001

Conclusions

- **In summary, average summer water levels of Lake Koshkonong (as recorded at Fort Atkinson) has increased by approximately 1.5 feet between 1932 and 2003.**

- **Linear regression results of time series data of water levels predicts (after Fort vs Lake differential adjustments) a mean summer water level of 775.52 ft in year 1932, which is 0.68 feet below the water level target in the current order.**

- **Linear regression results of time series data of water levels predicts (after Fort vs Lake differential adjustments) a mean summer water level of 777.05 ft in year 2003, which is 0.8 feet above the water level target in the current order.**

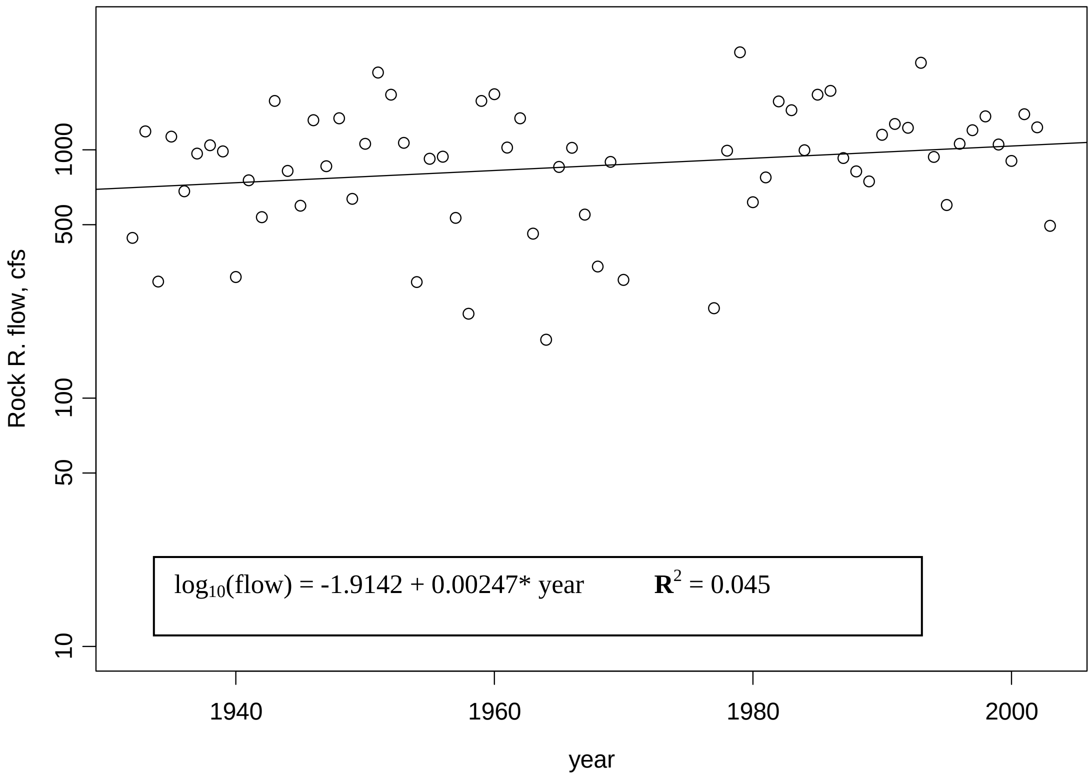
- **Trend analysis of summers typified by "base-flow" conditions (Elimination of Wet and Variable Summers--data Subset Method) predicts a peak summer level of 775.19 in 1932 and a peak summer level of 776.56 in 1998; an increase of 1.37 ft. in summer water levels during the period.**

- **This increase cannot be explained solely by increases in flow in the Rock and Crawfish Rivers upstream from Lake Koshkonong.**

- **After upstream flow was accounted for, there was still an increase in summer water levels of Lake Koshkonong over time (slope = 0.00854, P < 0.001).**

- **A comparison of the slopes of the time series among seasons indicates that water level increases during the summer and fall has been greater than those for spring and winter periods.**

Figure 11. Mean spring (Mar, Apr, May) log-transformed flows reported from the Rock River at Watertown. NOTE: To convert the slope from a model with $\log_{10}$ transformed response variable to a percent change, use the following formula (let b = slope estimate) – percent change = $100\,(10^b - 1)$.

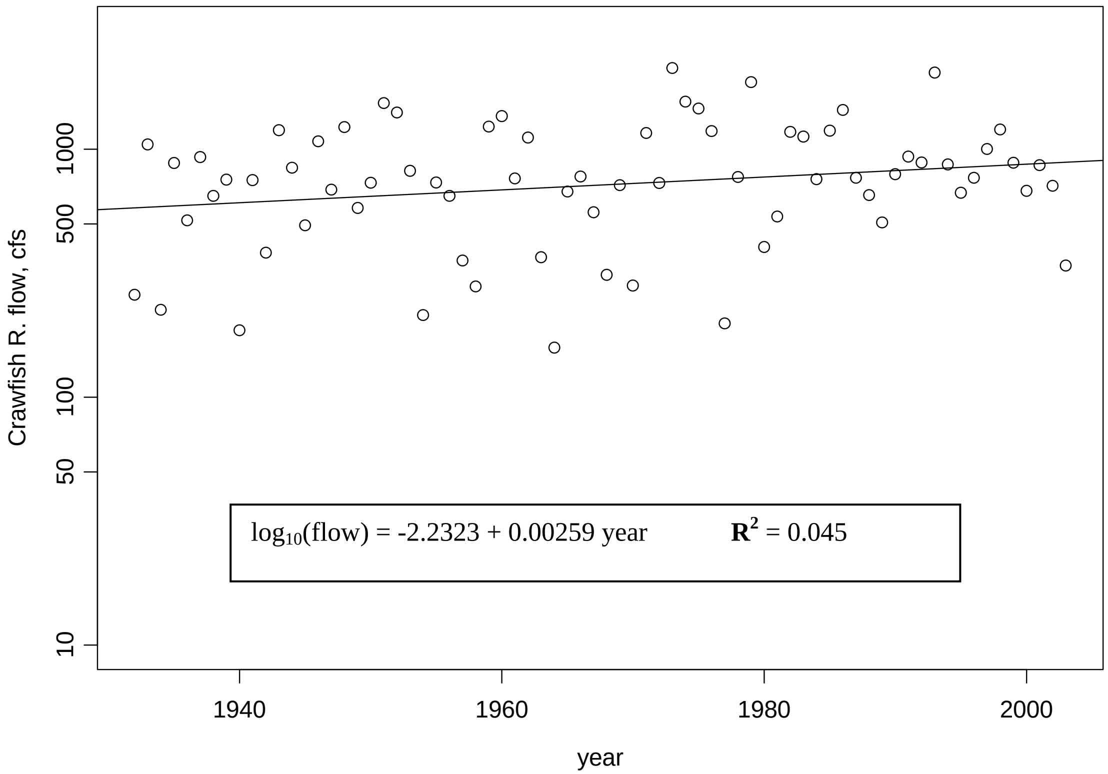


Analysis of Variance					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	1	0.18744	0.18744	3.02	0.0869
Error	64	3.96916	0.06202		
Corrected Total	65	4.15660			

Root MSE	0.24903	**R-Square**	0.0451
Dependent Mean	2.93452	**Adj R-Sq**	0.0302
Coeff Var	8.48637		

Parameter Estimates					
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	1	-1.91425	2.78926	-0.69	0.4950
YEAR	1	0.00247	0.00142	1.74	0.0869

Figure 12. Mean spring (Mar, Apr, May) log-transformed flows reported from the Crawfish River at Milford. NOTE: To convert the slope from a model with $\log_{10}$ transformed response variable to a percent change, use the following formula (let b = slope estimate) – percent change = $100\,(10^b - 1)$.

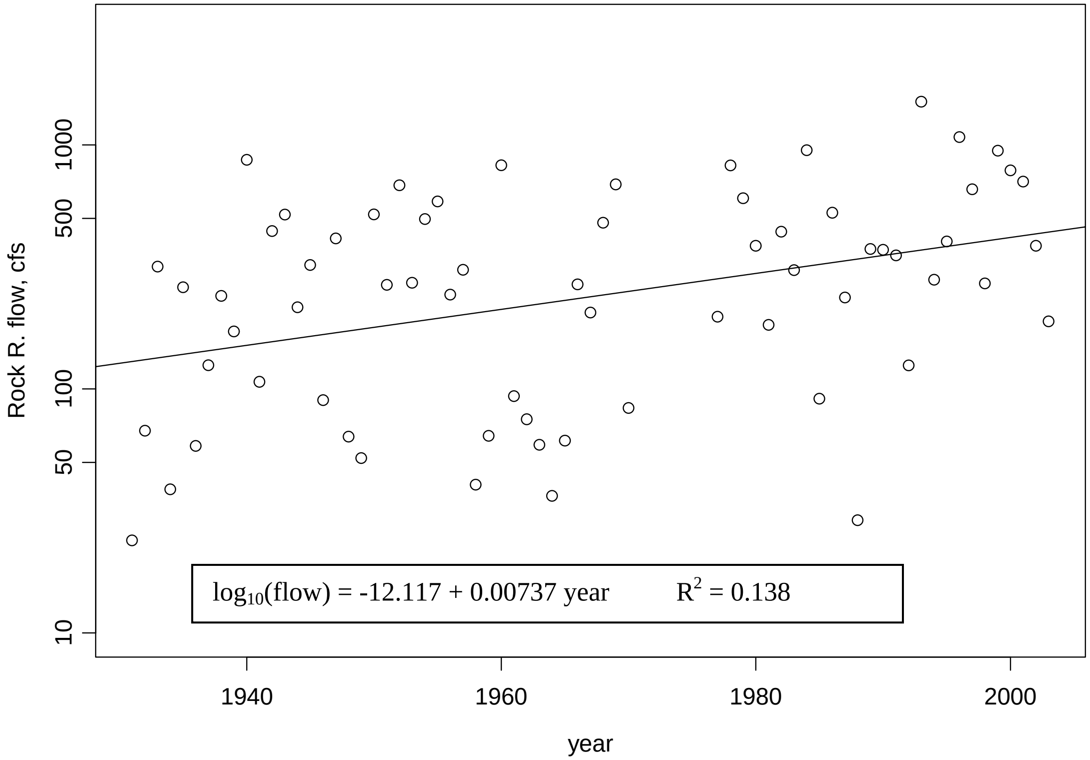


Analysis of Variance					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	1	0.20798	0.20798	3.31	0.0732
Error	70	4.40038	0.06286		
Corrected Total	71	4.60836			

Root MSE	0.25072	**R-Square**	0.0451
Dependent Mean	2.85594	**Adj R-Sq**	0.0315
Coeff Var	8.77904		

Parameter Estimates					
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	1	-2.23226	2.79749	-0.80	0.4276
YEAR	1	0.00259	0.00142	1.82	0.0732

Figure 13. Mean summer (June, July, Aug) log-transformed flows reported from the Rock River at Watertown. NOTE: To convert the slope from a model with $\log_{10}$ transformed response variable to a percent change, use the following formula (let b = slope estimate) – percent change = $100\,(10^b - 1)$.



Analysis of Variance

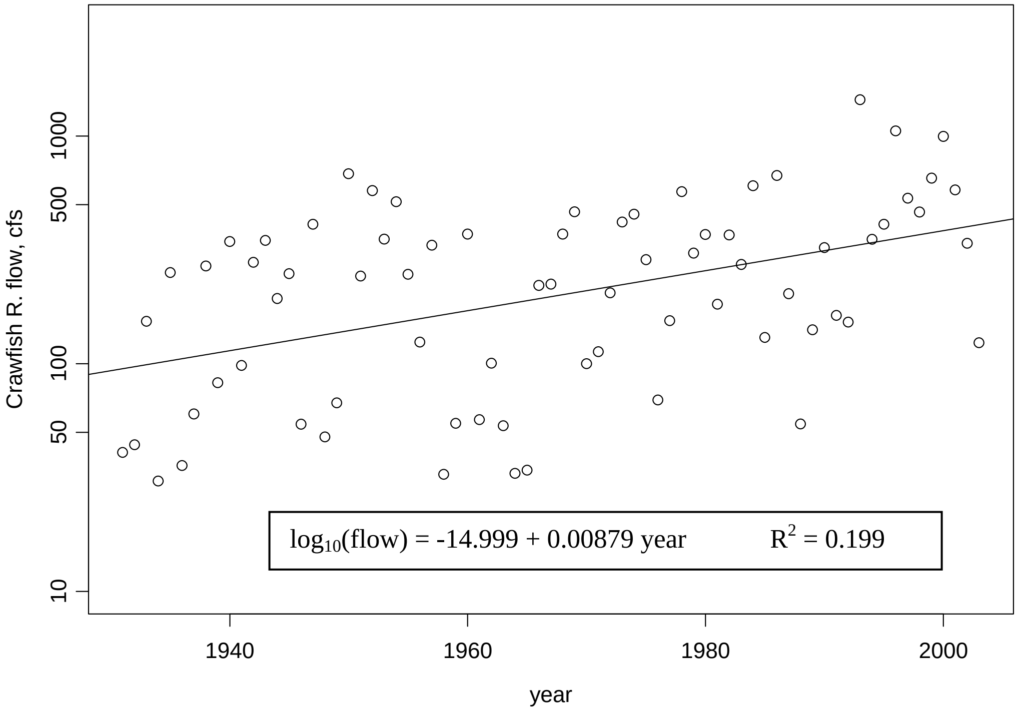
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	1.74421	1.74421	10.37	0.0020
Error	65	10.93199	0.16818		
Corrected Total	66	12.67620			

Root MSE	0.41010	**R-Square**	0.1376
Dependent Mean	2.37366	**Adj R-Sq**	0.1243
Coeff Var	17.27726		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-12.11737	4.50007	-2.69	0.0090
YEAR	1	0.00737	0.00229	3.22	0.0020

Figure 14. Mean summer (June, July, Aug) log-transformed flows reported from the Crawfish River at Milford. NOTE: To convert the slope from a model with $\log_{10}$ transformed response variable to a percent change, use the following formula (let b = slope estimate) – percent change = 100 (10^b – 1) .



Analysis of Variance					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	1	2.50555	2.50555	17.63	<.0001
Error	71	10.09048	0.14212		
Corrected Total	72	12.59603			

Root MSE	0.37699	**R-Square**	0.1989
Dependent Mean	2.29515	**Adj R-Sq**	0.1876
Coeff Var	16.42535		

Parameter Estimates					
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	1	-14.99916	4.11911	-3.64	0.0005
YEAR	1	0.00879	0.00209	4.20	<.0001

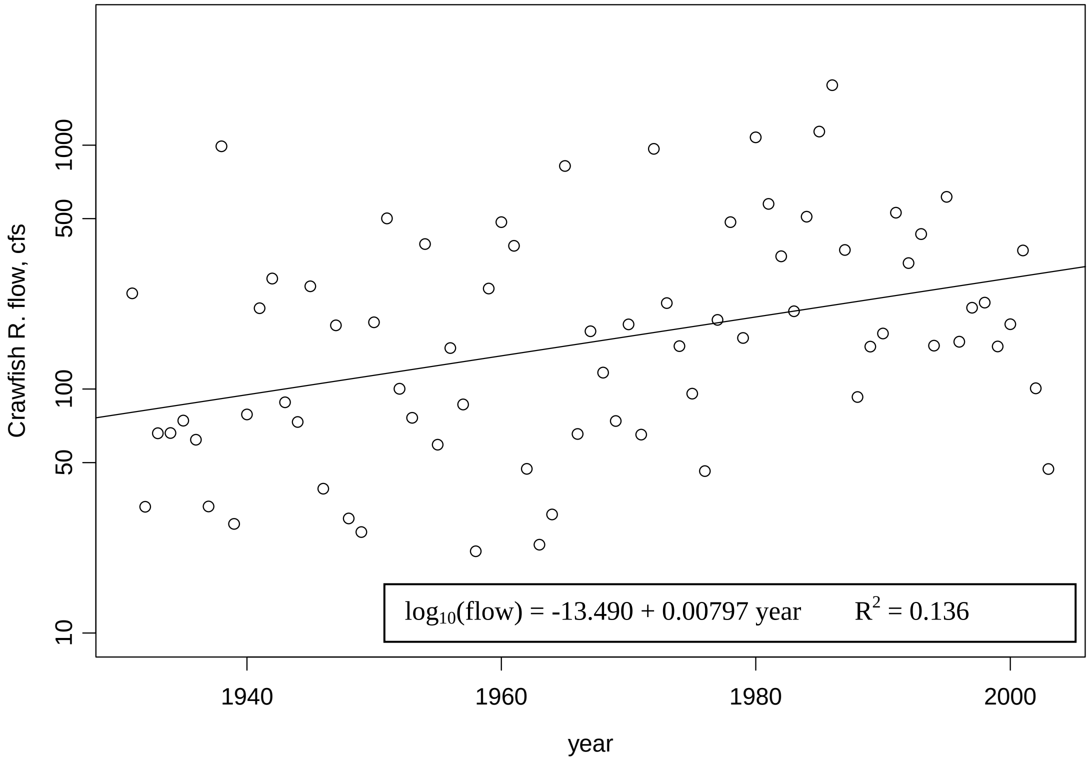
Figure 15. Mean Fall (Sept, Oct, Nov) log-transformed flows reported from the Rock River at Watertown. NOTE: To convert the slope from a model with $\log_{10}$ transformed response variable to a percent change, use the following formula (let b = slope estimate) – percent change = $100\,(10^b - 1)$.

Analysis of Variance					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	1	2.86564	2.86564	13.23	0.0005
Error	66	14.29803	0.21664		
Corrected Total	67	17.16367			

Root MSE	0.46544	**R-Square**	0.1670
Dependent Mean	2.26175	**Adj R-Sq**	0.1543
Coeff Var	20.57891		

Parameter Estimates					
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	1	-16.28769	5.10050	-3.19	0.0022
YEAR	1	0.00943	0.00259	3.64	0.0005

Figure 16. Mean Fall (Sept, Oct, Nov) log-transformed flows reported from the Crawfish River at Milford. NOTE: To convert the slope from a model with log_{10} transformed response variable to a percent change, use the following formula (let b = slope estimate) – percent change = $100 (10^b – 1)$.

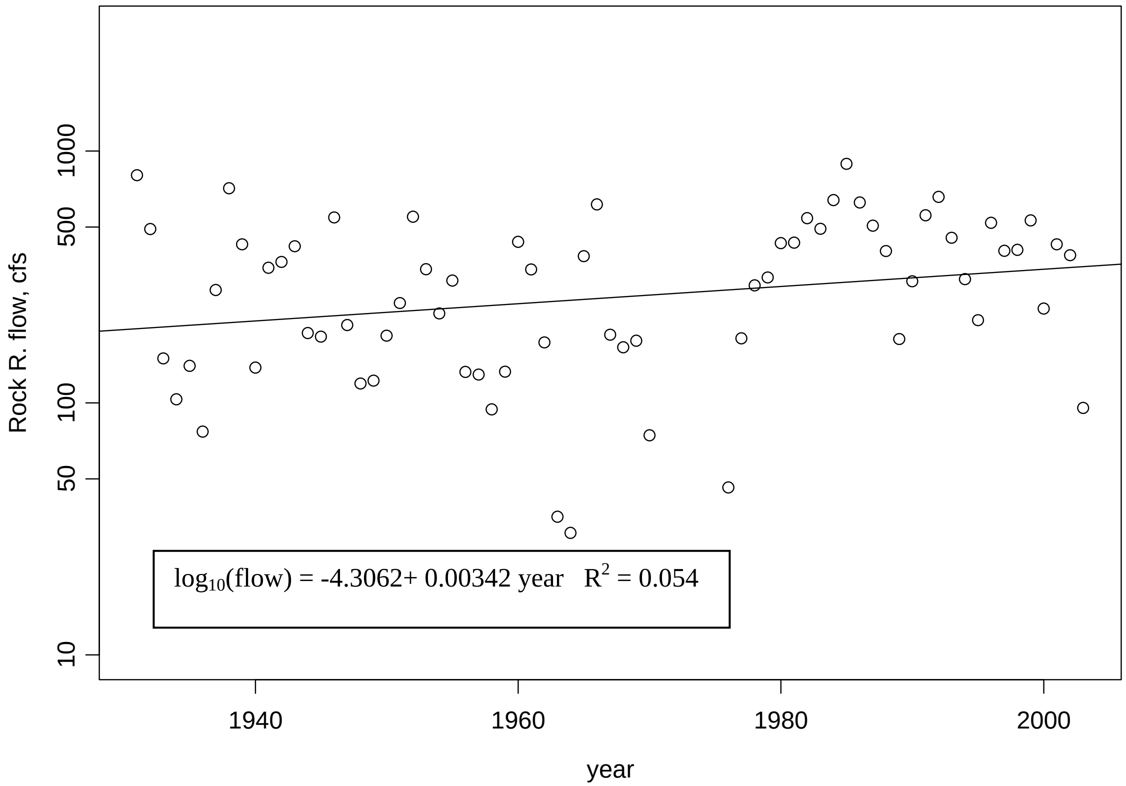


Analysis of Variance					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	1	2.06020	2.06020	11.21	0.0013
Error	71	13.04739	0.18377		
Corrected Total	72	15.10759			

Root MSE	0.42868	**R-Square**	0.1364
Dependent Mean	2.19202	**Adj R-Sq**	0.1242
Coeff Var	19.55639		

Parameter Estimates					
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	1	-13.49014	4.68392	-2.88	0.0053
YEAR	1	0.00797	0.00238	3.35	0.0013

Figure 17. Mean Winter (Dec, Jan, Feb) log-transformed flows reported from the Rock River at Watertown. NOTE: To convert the slope from a model with $\log_{10}$ transformed response variable to a percent change, use the following formula (let b = slope estimate) – percent change = $100\,(10^b - 1)$.

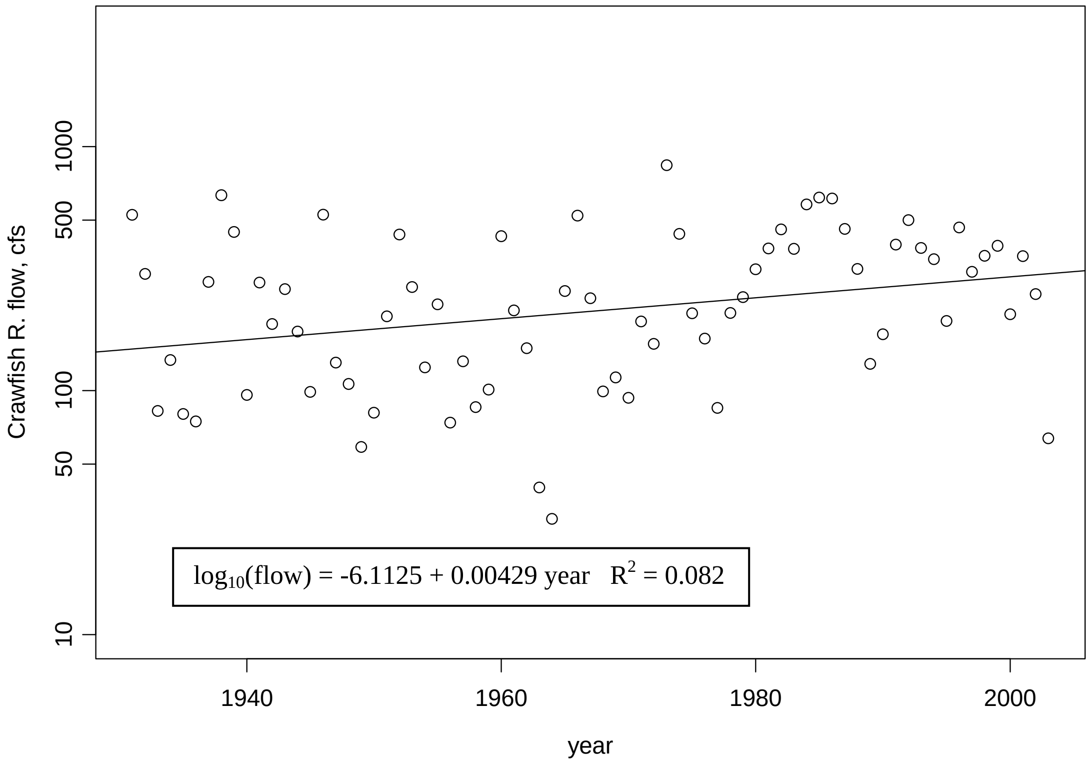


Analysis of Variance					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	1	0.37642	0.37642	3.75	0.0570
Error	66	6.62087	0.10032		
Corrected Total	67	6.99728			

Root MSE	0.31673	**R-Square**	0.0538
Dependent Mean	2.41669	**Adj R-Sq**	0.0395
Coeff Var	13.10585		

Parameter Estimates					
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	1	-4.30618	3.47082	-1.24	0.2191
YEAR	1	0.00342	0.00176	1.94	0.0570

Figure 18. Mean Winter (Dec, Jan, Feb) log-transformed flows reported from the Crawfish River at Milford. NOTE: To convert the slope from a model with $\log_{10}$ transformed response variable to a percent change, use the following formula (let b = slope estimate) – percent change = $100\ (10^b - 1)$.



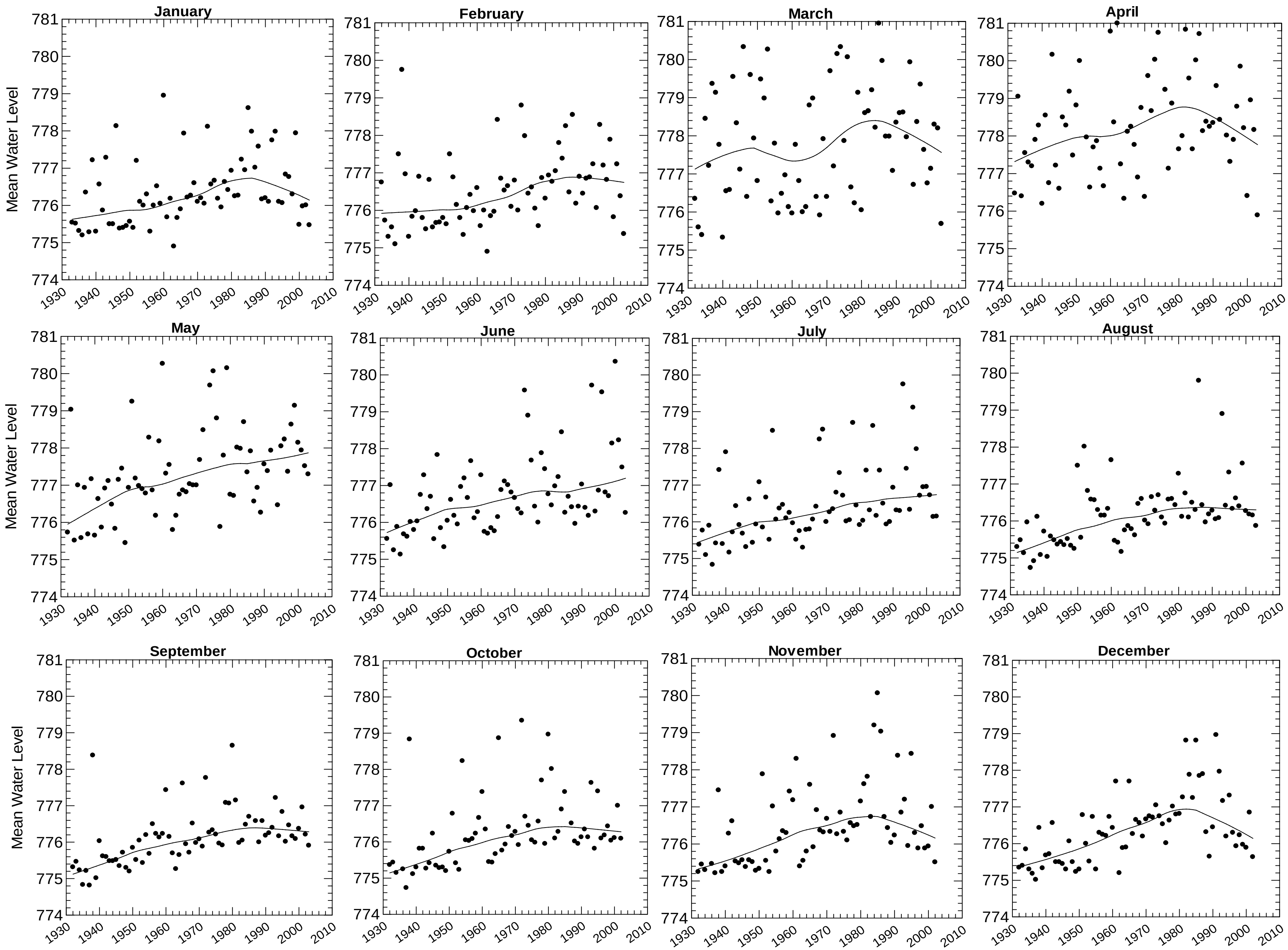
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.59637	0.59637	6.30	0.0144
Error	71	6.72399	0.09470		
Corrected Total	72	7.32036			

Root MSE	0.30774	**R-Square**	0.0815
Dependent Mean	2.32494	**Adj R-Sq**	0.0685
Coeff Var	13.23646		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-6.11246	3.36249	-1.82	0.0733
YEAR	1	0.00429	0.00171	2.51	0.0144


January
February
March
April
May
June
July
August
September
October
November
December
Mean Water Level
774
775
776
777
778
779
780
781
1930
1940
1950
1960
1970
1980
1990
2000
2010