ANALYSIS OF CARRYOVER PREDICTIONS

1. Confidence intervals on new predictions.

Two types of confidence intervals (CI) for carryover predictions are presented:

a. 95% confidence interval for the mean prediction in any one year, and
b. 95% confidence interval for the prediction of a new observation in any one year.

The 95% CI for the mean prediction is a confidence interval that will contain the true mean carryover in 95% of all realizations of the stochastic process that produced the data from which the best regression model was calibrated. These CIs are illustrated on the plot of predicted versus observed carryover values for 1989-2008. The 95% CI for prediction of new observations is a confidence interval that will contain any individual prediction of carryover in 95% of all realizations of the stochastic process that produced the data from which the best regression model was calibrated. The latter is somewhat wider because it includes not only variability in the regression coefficients from which carryover predictions are made but also observed variability in carryover itself. Both types of CIs are illustrated on the time series plots. The half-width of the confidence intervals is given by $t(0.025, n-p)*s$, where $t(0.025, n-p)$ is the 97.5th percentile of Student's *t* distribution with $n-p$ degrees of freedom, $n = 23$ is the number of observations in the calibration period, *p* is the number of regression parameters estimated (including the intercept), and *s* is the appropriate standard deviation. The standard deviations on which the confidence intervals are based are reported in the data spreadsheet accompanying this document.

2. Comparison of explanatory variable ranges between calibration and prediction periods

Predictions made from the best regression model are most appropriate when made over combinations of explanatory variables that fall within the range of those over which the model was calibrated. It is important to note that this is not the same as the range of each explanatory variable taken individually. The best way to visualize the combinations of the explanatory variables is as scatter plots of each independent variable versus each other. The scatter plots below show these combinations for the calibration period (1964-1986) and the prediction period (1989-2008; 1987 and 1988 were omitted from this analysis). Scatter plots of carryover versus each explanatory variable individually also give some information about the applicability of the model to the prediction period. The scatter plots illustrate the following:

a. Variable combinations involving ALLOC, PDSI, HEISE, and ETR showed substantial overlap between the calibration and prediction periods for all irrigation companies except A&B Irrigation District and Milner Irrigation District. There were several years during the prediction period in which allocation for these two districts was much lower than those used in model calibration. The scatter plot of carryover versus allocation for A&B shows that the relationship between these variables was roughly the same between the calibration and prediction periods. For Milner, carryover depended negatively on allocation over both time periods, but the relationship during the prediction period is somewhat less linear than that over the calibration period. Low allocations in 1977 and/or 1979 for all other districts resulted in combinations of these variables that were similar between calibration and prediction periods.
b. For all irrigation companies for which EFFINDEX was an explanatory variable in the best model, there were substantial differences in combinations involving this variable

between calibration and prediction periods. Efficiency index values were higher during the prediction period for Minidoka, Burley, American Falls and North Side. For all four of these districts, carryover depended positively on efficiency during the calibration period, but when data for the prediction period were added, this dependence became negative. Efficiency index values were somewhat lower during the prediction period for A&B, but the positive dependence of carryover on efficiency was roughly the same between the two time periods.

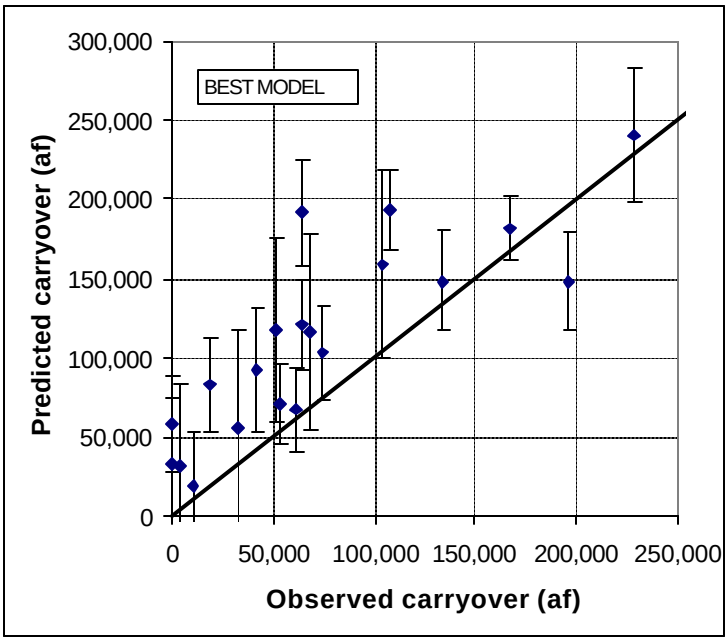
To a large extent, deviations in variable relationships between the two time periods are reflected in much larger confidence intervals for those predictions based on variable combinations that fell outside of the range over which the model was calibrated. Based on observation a. above, it is likely that any differences between the two time periods involving ALLOC are probably adequately reflected in these confidence intervals. That is, despite some differences in the range of variable combinations involving ALLOC between the two time periods, the model is most likely adequate for predicting 1989-2008 carryover based on allocation, albeit with wider confidence intervals around those predictions involving allocation values that fell outside of the range over which the model was calibrated.

On the other hand, it appears that the calibrated model is not adequate for predicting 1989-2008 carryover for Minidoka, Burley, American Falls and North Side because the apparent relationship between carryover and efficiency is fundamentally different between the calibration and prediction time periods (moderately positive during calibration period, weakly to moderately negative during the prediction period). One possibility for addressing this problem is to repeat the process of identifying the best model either without EFFINDEX or with another variable that contains some of the information in EFFINDEX but does not have the strictly increasing pattern with time shown by EFFINDEX for most of the irrigation companies.

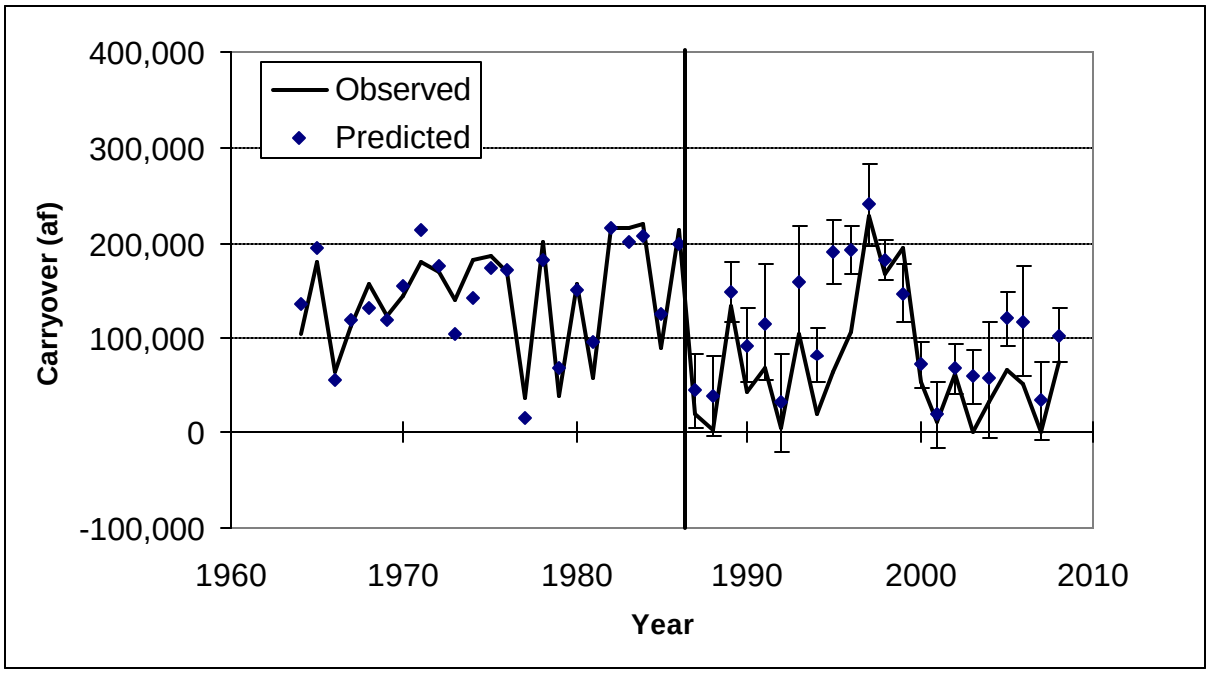
3. Temporal trends in predicted and observed carryover.

There was little autocorrelation in observed carryover during the calibration period, but there was strong, positive autocorrelation in observed carryover during the prediction period. In many cases, this was statistically significant. This illustrates the trend that wet and dry years occurred in more persistent sequences during the 1989-2008 time period than during the 1964-1986 period. Because the calibrated model satisfied assumptions of independent residuals, the difference between predicted and observed carryover showed no temporal trend (tables in previous document). However, the prediction residuals (predicted – observed carryover for the 1989-2008 time period) showed substantial positive autocorrelation in time for all seven irrigation companies. Autocorrelation in the prediction residuals for 1989-2008 generally mirrored that of the observed carryover during this time period. That is, the magnitude and direction of difference between predicted and observed carryover showed the same temporal persistence as observed carryover.

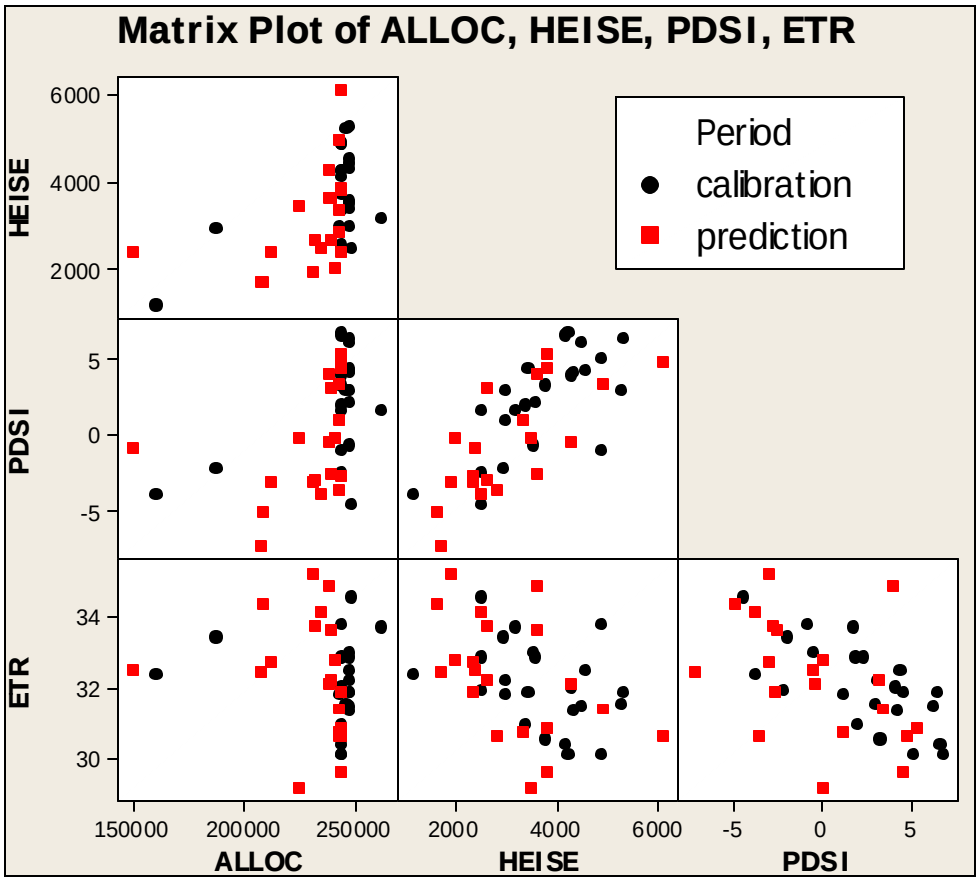
TWIN FALLS CANAL COMPANY



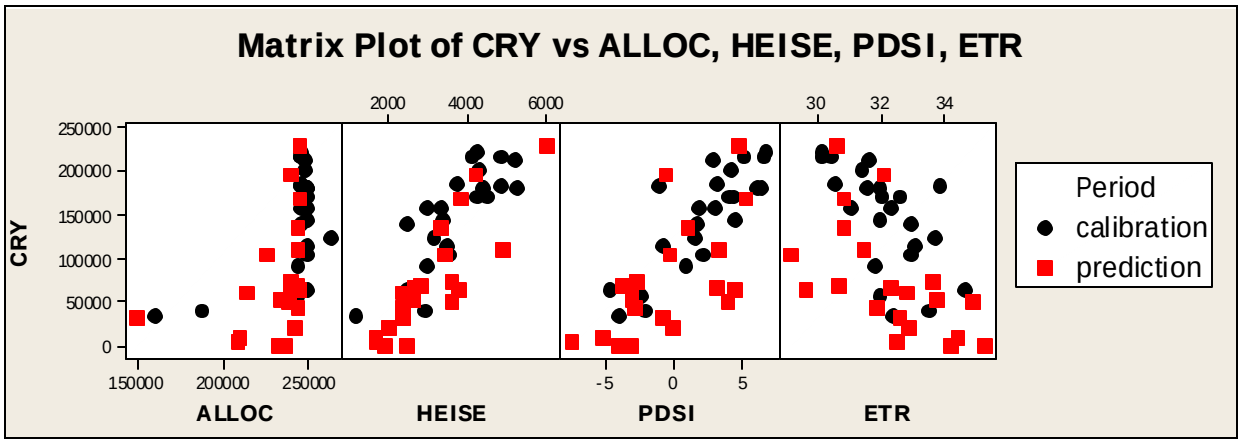
Predicted versus observed carryover, 1989-2008, Twin Falls Canal Company. Error bars show 95% confidence intervals for predicted mean carryover.



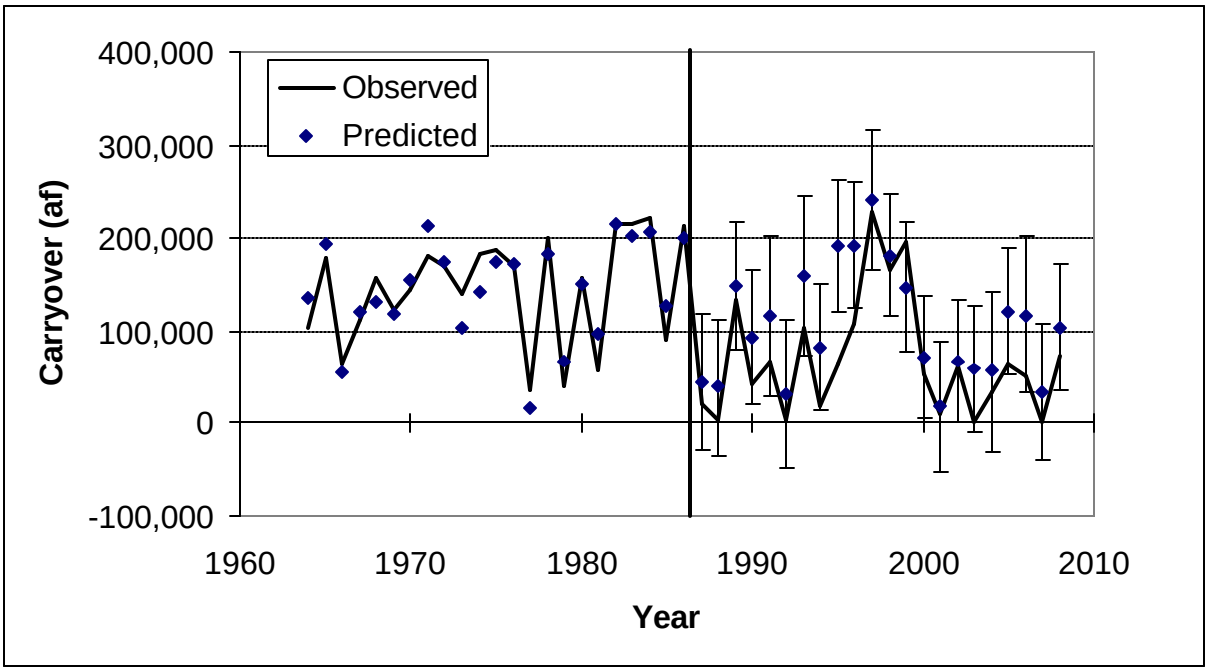
Predicted and observed carryover versus time, Twin Falls Canal Company. "Predicted" values for the 1964-1986 calibration period are values fitted to best regression model. Error bars for 1987-2008 values show 95% confidence intervals for predicted mean carryover.



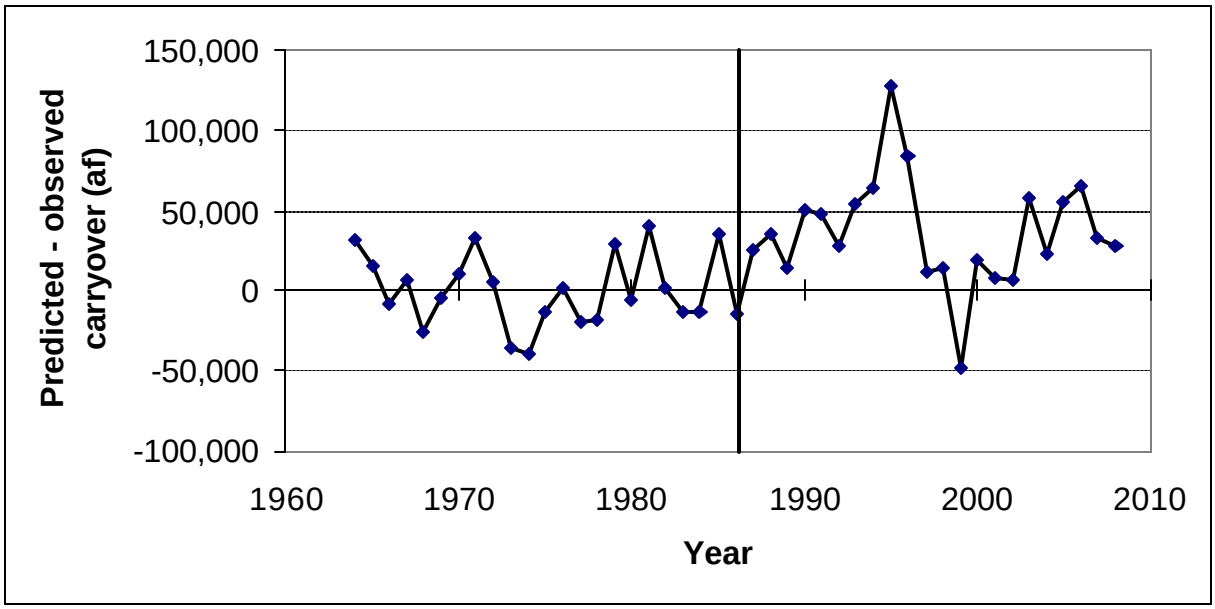
Scatter plots for all combinations of independent variables, Twin Falls Canal Company. Prediction period is 1989-2008.



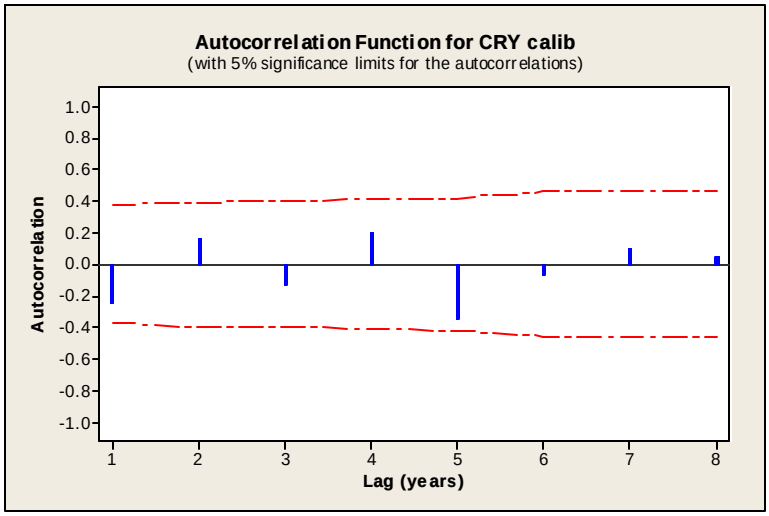
Scatter plots of carryover versus each independent variable, Twin Falls Canal Company. Prediction period is 1989-2008.



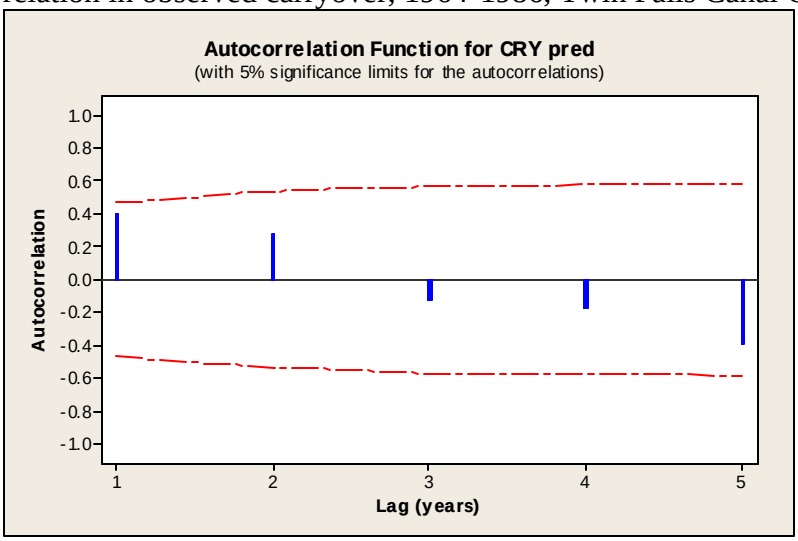
Predicted and observed carryover versus time, Twin Falls Canal Company. "Predicted" values for the 1964-1986 calibration period are values fitted to best regression model. Error bars for 1987-2008 values show 95% confidence intervals for prediction of new observation.



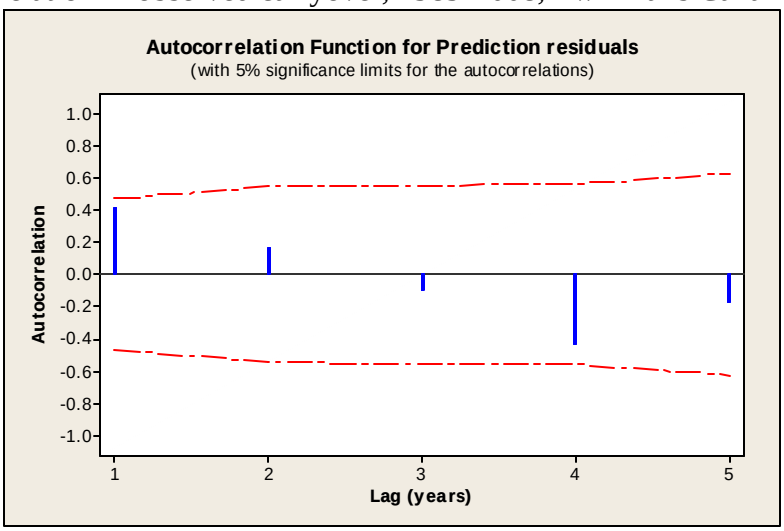
Prediction residuals (predicted carryover minus observed carryover) versus time, Twin Falls Canal Company. "Predicted" values for the 1964-1986 calibration period are values fitted to best regression model.



Temporal autocorrelation in observed carryover, 1964-1986, Twin Falls Canal Company.

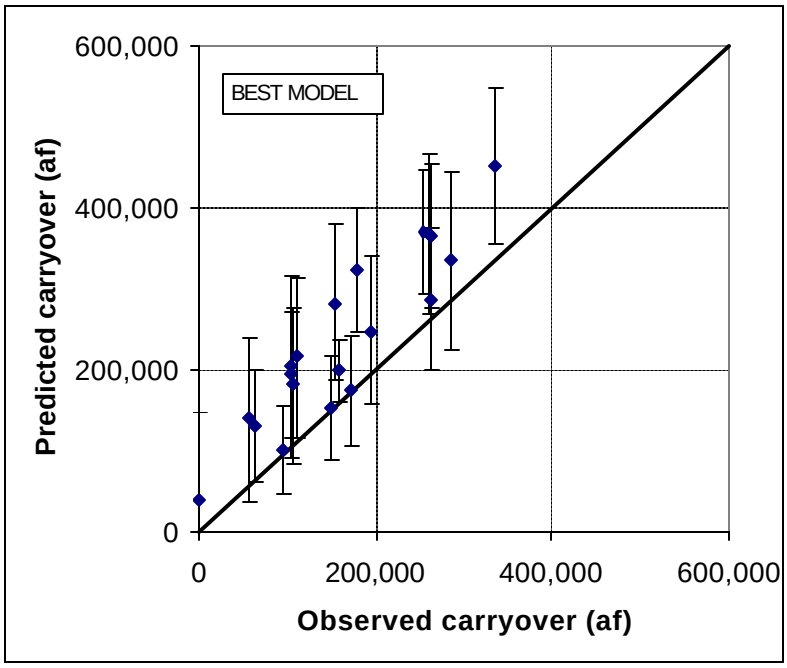


Temporal autocorrelation in observed carryover, 1989-2008, Twin Falls Canal Company.

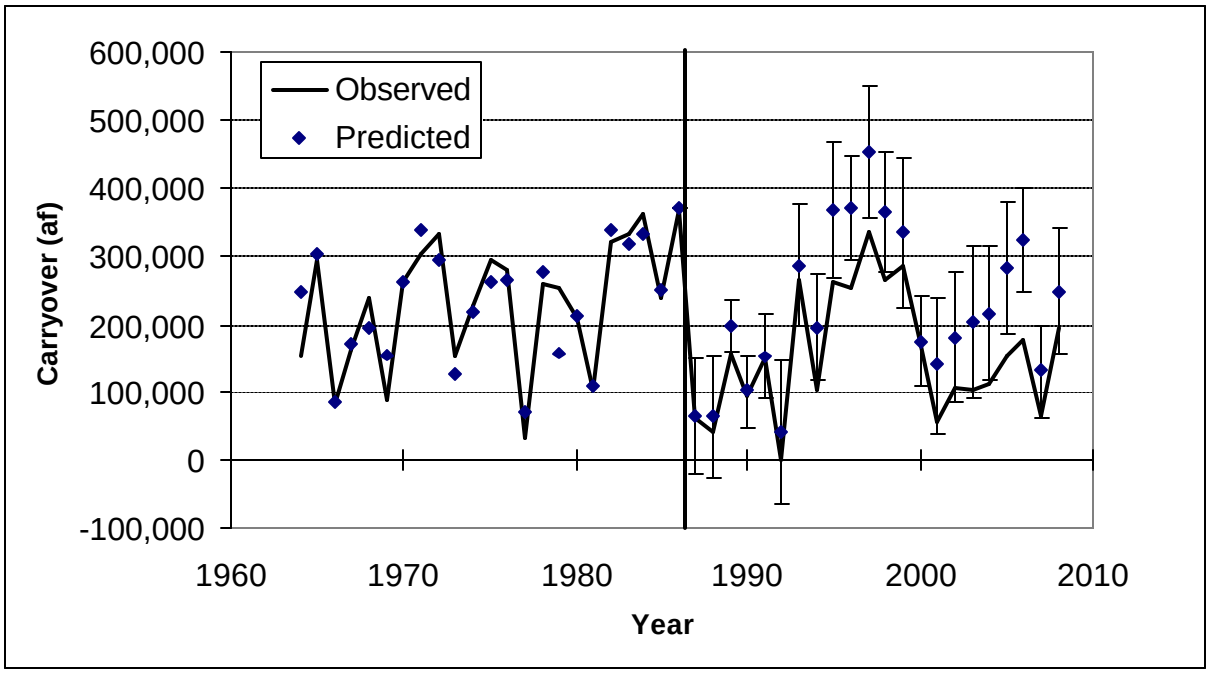


Temporal autocorrelation in prediction residuals, 1989-2008, Twin Falls Canal Company.

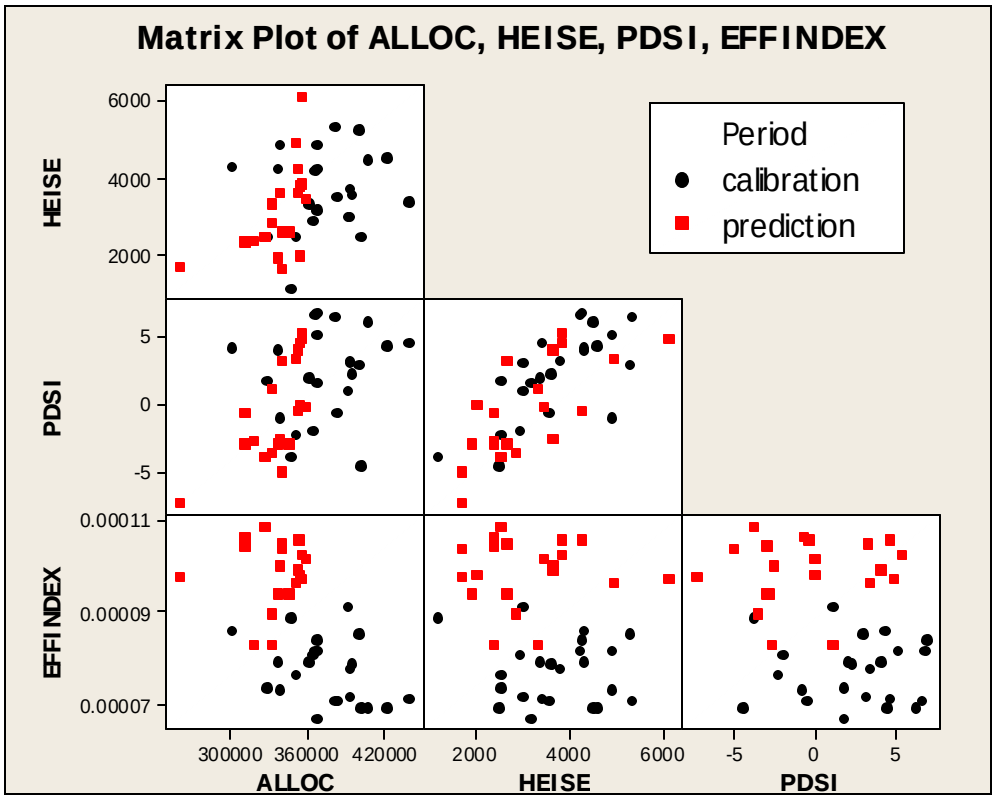
MINIDOKA IRRIGATION DISTRICT



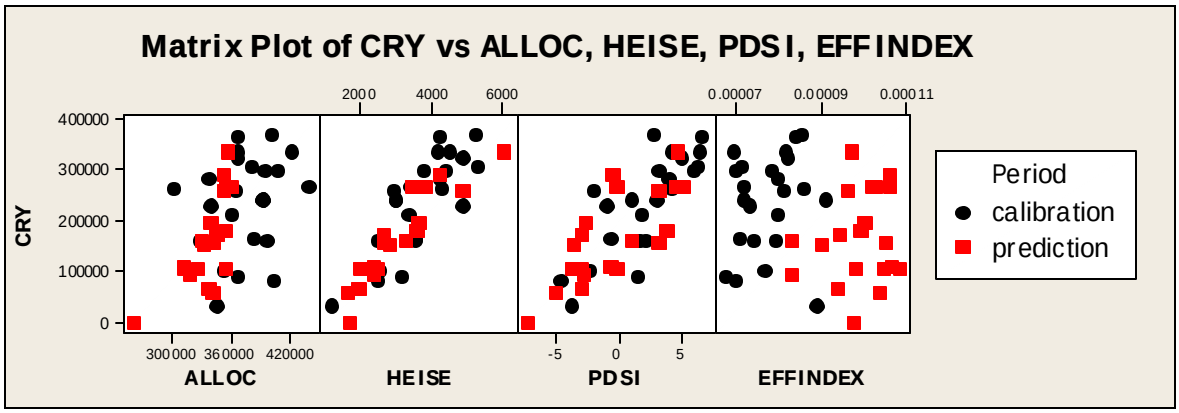
Predicted versus observed carryover, 1989-2008, Minidoka Irrigation District. Error bars show 95% confidence intervals for predicted mean carryover.



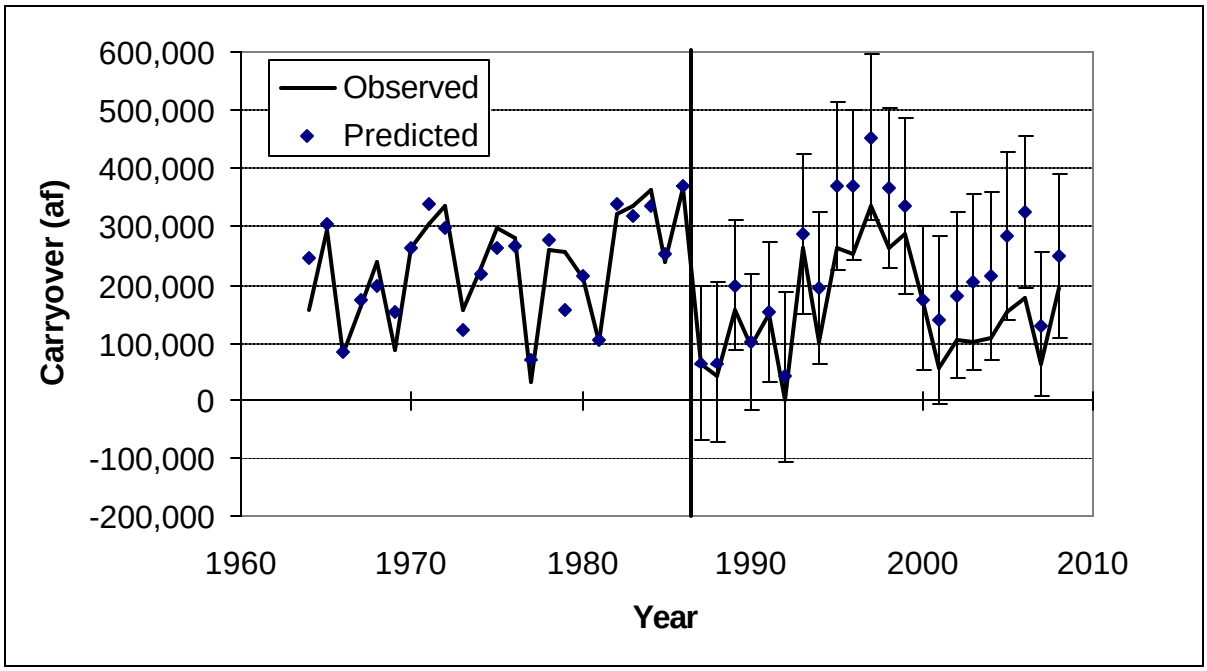
Predicted and observed carryover versus time, Minidoka Irrigation District. "Predicted" values for the 1964-1986 calibration period are values fitted to best regression model. Error bars for 1987-2008 values show 95% confidence intervals for predicted mean carryover.



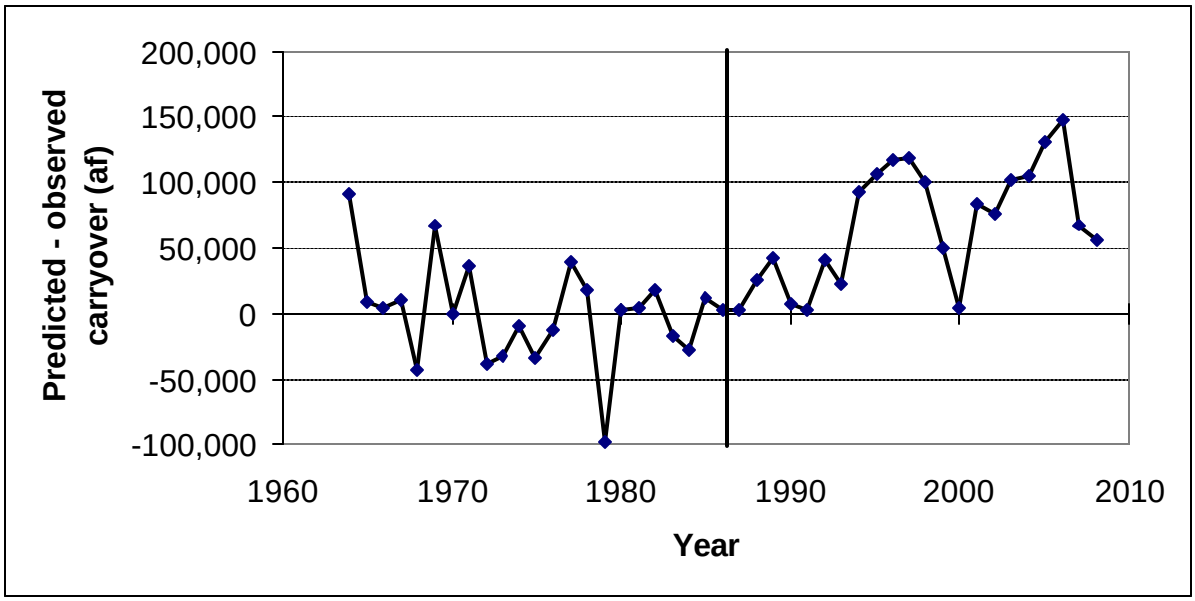
Scatter plots for all combinations of independent variables, Minidoka Irrigation District. Prediction period is 1989-2008.



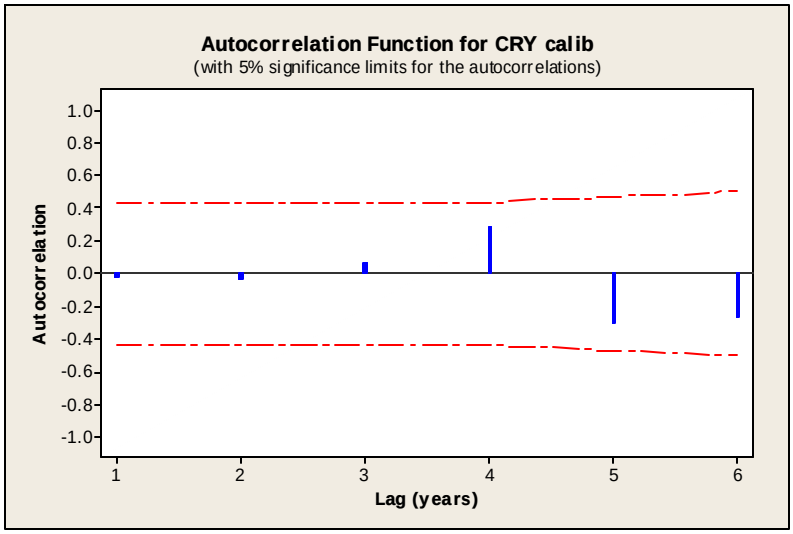
Scatter plots of carryover versus each independent variable, Minidoka Irrigation District. Prediction period is 1989-2008.



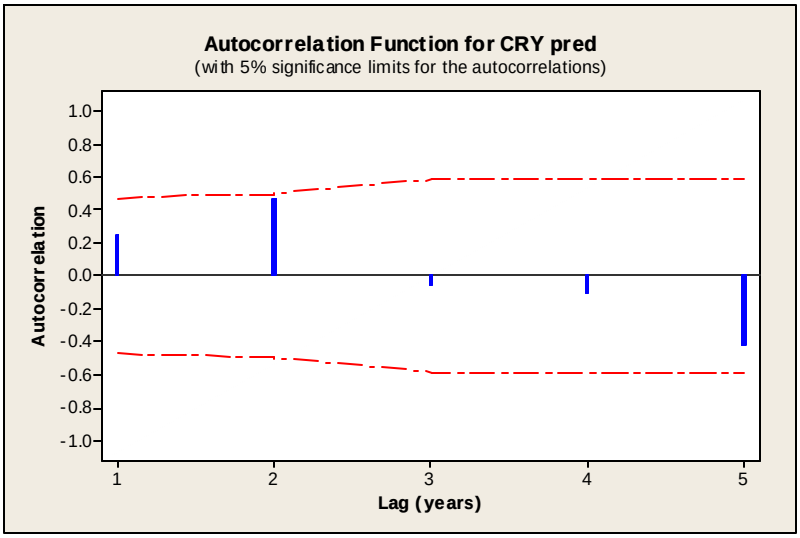
Predicted and observed carryover versus time, Minidoka Irrigation District. "Predicted" values for the 1964-1986 calibration period are values fitted to best regression model. Error bars for 1987-2008 values show 95% confidence intervals for prediction of new observation.



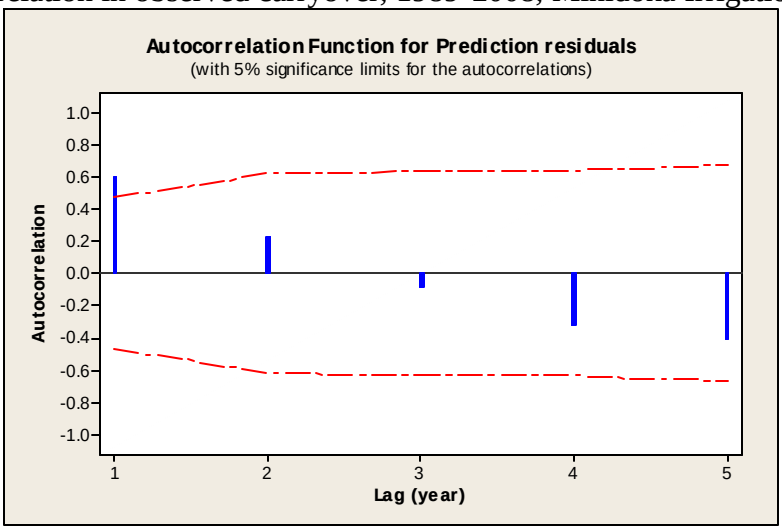
Prediction residuals (predicted carryover minus observed carryover) versus time, Minidoka Irrigation District. "Predicted" values for the 1964-1986 calibration period are values fitted to best regression model.



Temporal autocorrelation in observed carryover, 1964-1986, Minidoka Irrigation District.

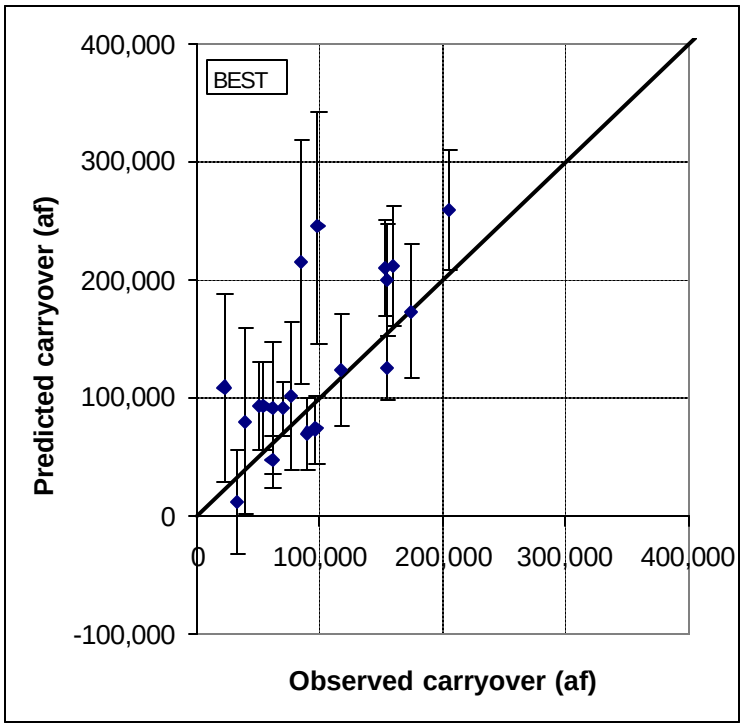


Temporal autocorrelation in observed carryover, 1989-2008, Minidoka Irrigation District.

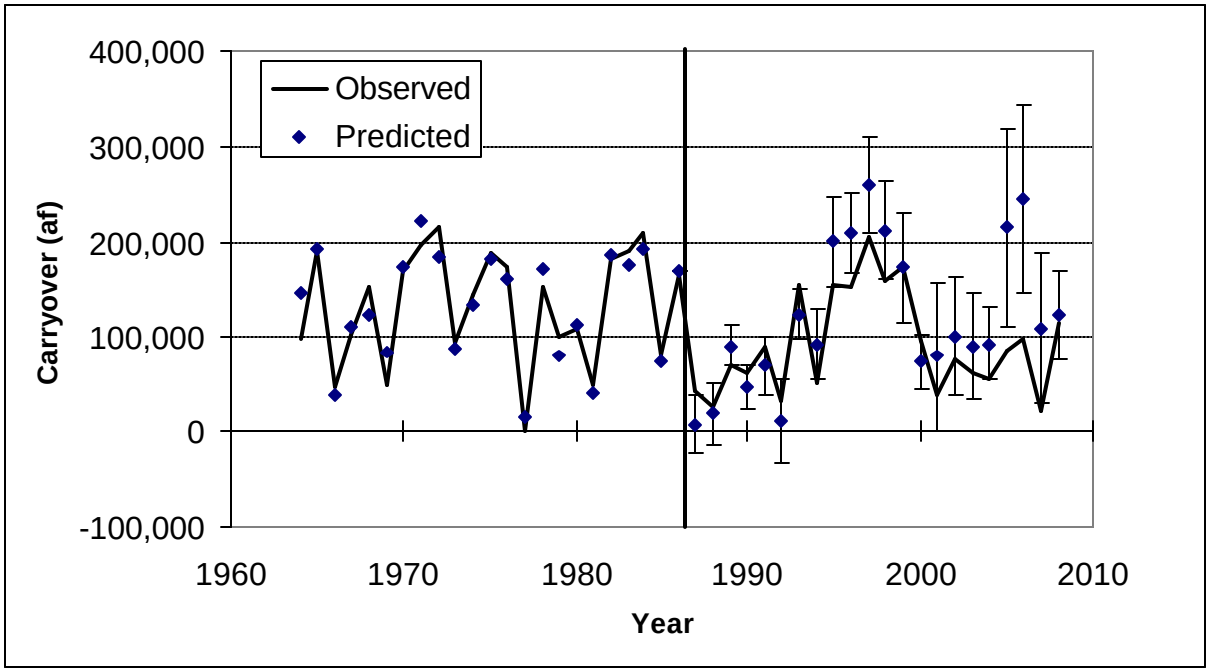


Temporal autocorrelation in prediction residuals, 1989-2008, Minidoka Irrigation District.

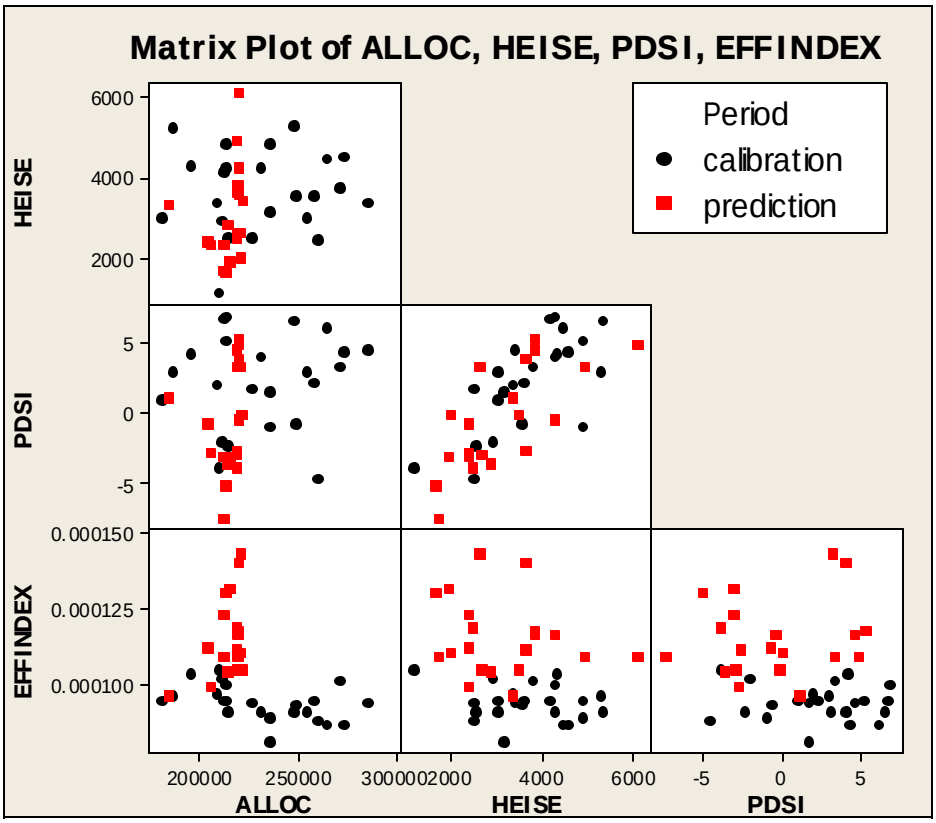
BURLEY IRRIGATION DISTRICT



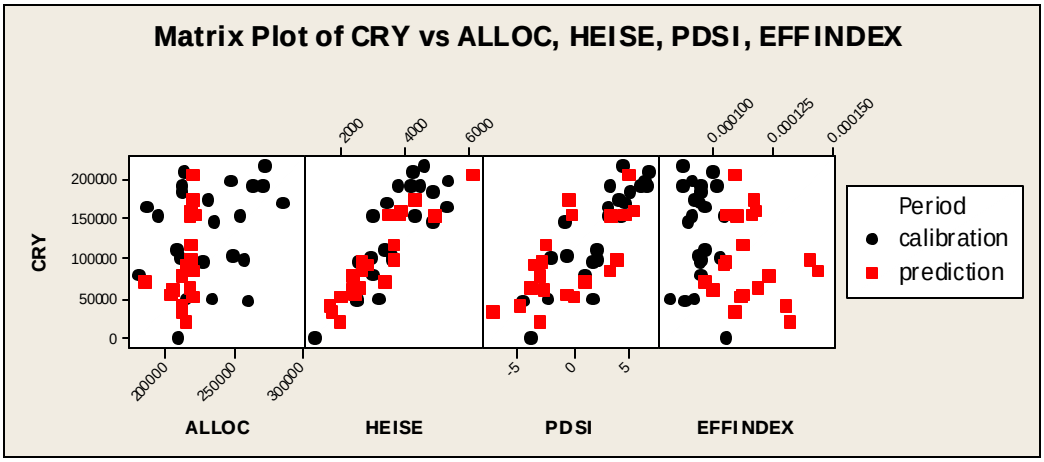
Predicted versus observed carryover, 1989-2008, Burley Irrigation District. Error bars show 95% confidence intervals for predicted mean carryover.



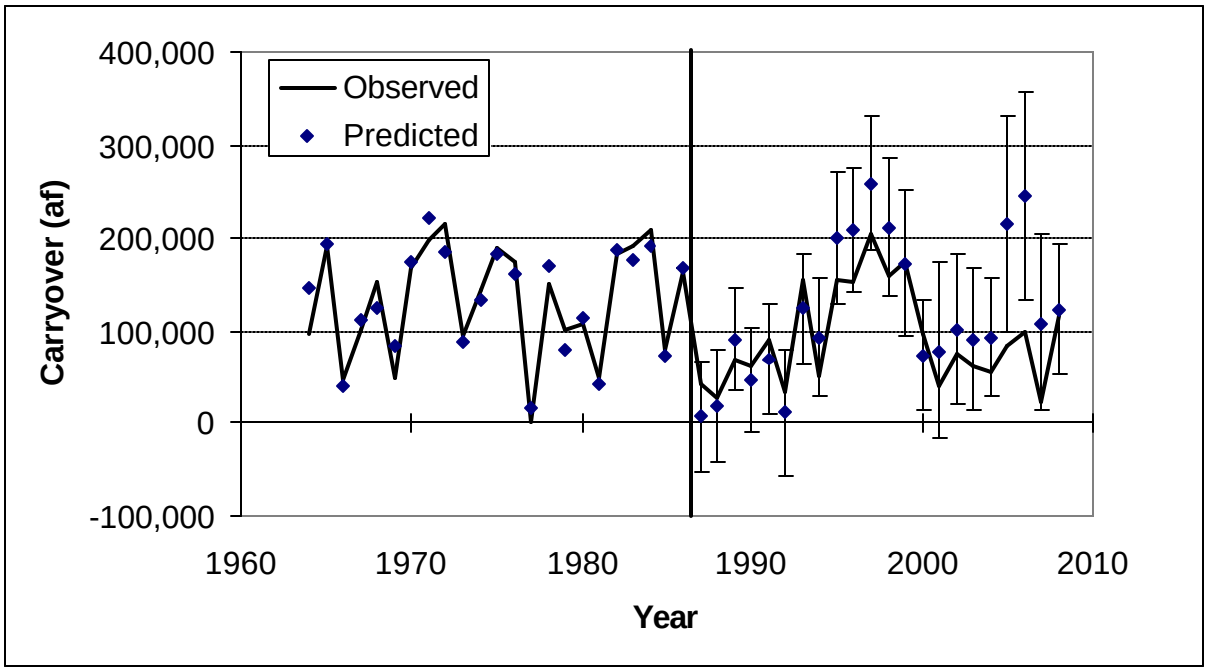
Predicted and observed carryover versus time, Burley Irrigation District. "Predicted" values for the 1964-1986 calibration period are values fitted to best regression model. Error bars for 1987-2008 values show 95% confidence intervals for predicted mean carryover.



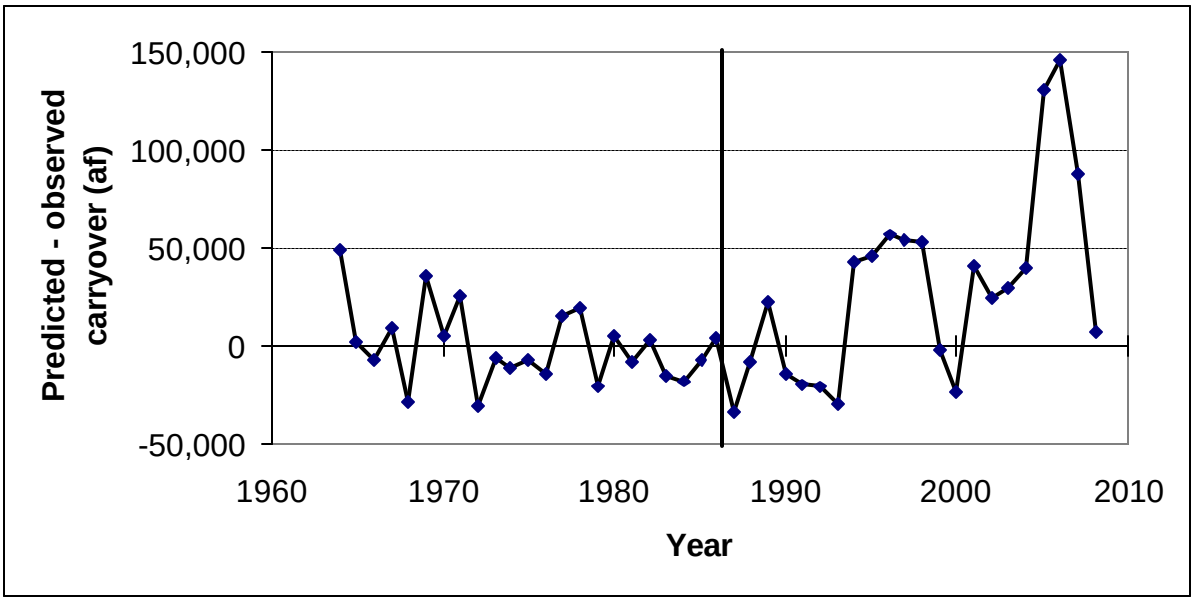
Scatter plots for all combinations of independent variables, Burley Irrigation District. Prediction period is 1989-2008.



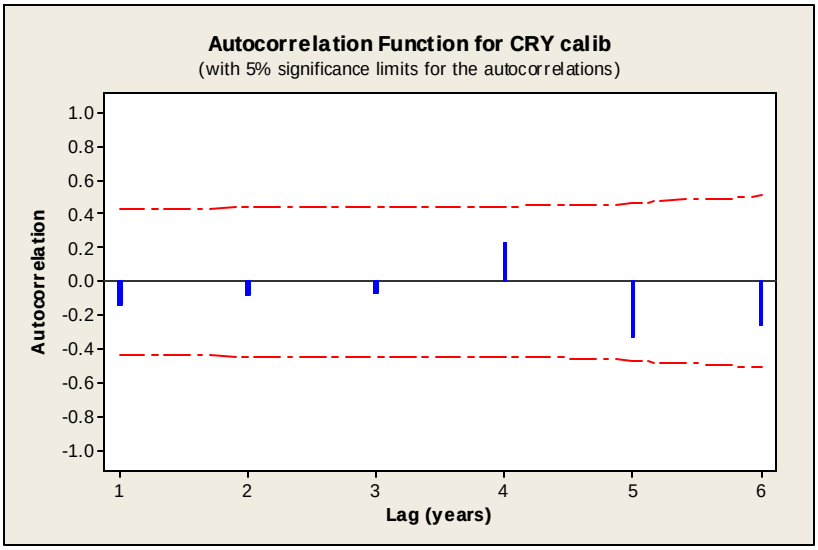
Scatter plots of carryover versus each independent variable, Burley Irrigation District. Prediction period is 1989-2008.



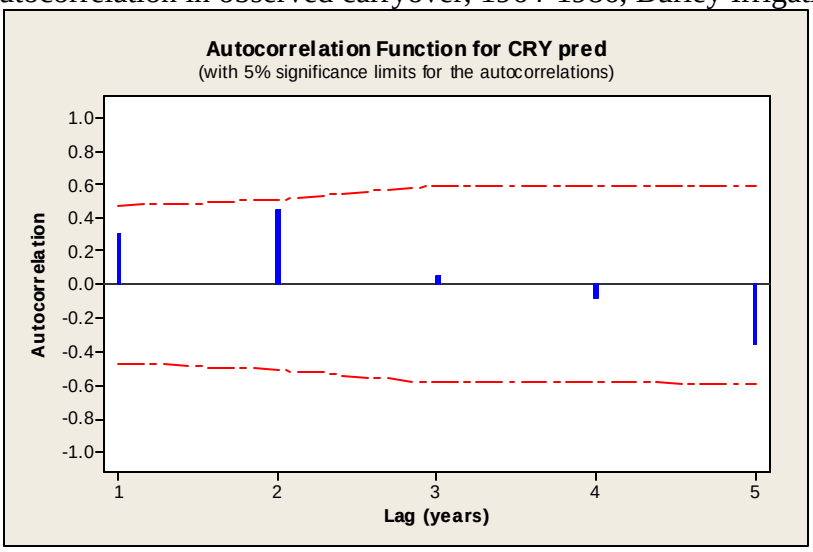
Predicted and observed carryover versus time, Burley Irrigation District. "Predicted" values for the 1964-1986 calibration period are values fitted to best regression model. Error bars for 1987-2008 values show 95% confidence intervals for prediction of new observation.



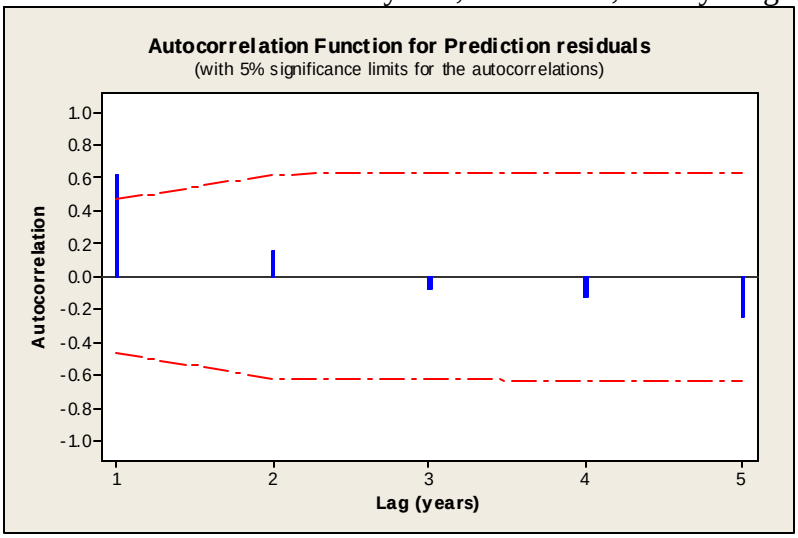
Prediction residuals (predicted carryover minus observed carryover) versus time, Burley Irrigation District. "Predicted" values for the 1964-1986 calibration period are values fitted to best regression model.



Temporal autocorrelation in observed carryover, 1964-1986, Burley Irrigation District.

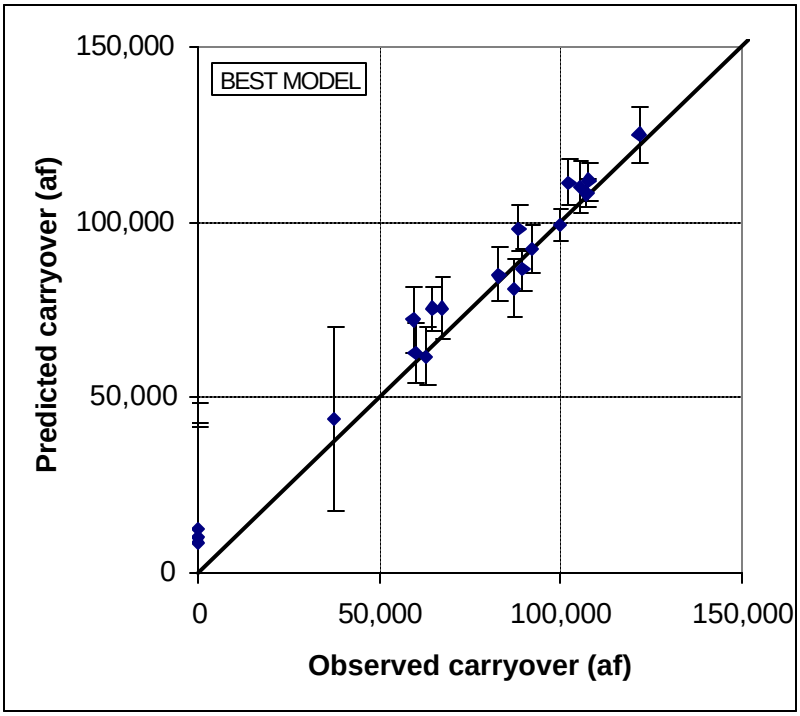


Temporal autocorrelation in observed carryover, 1989-2008, Burley Irrigation District.

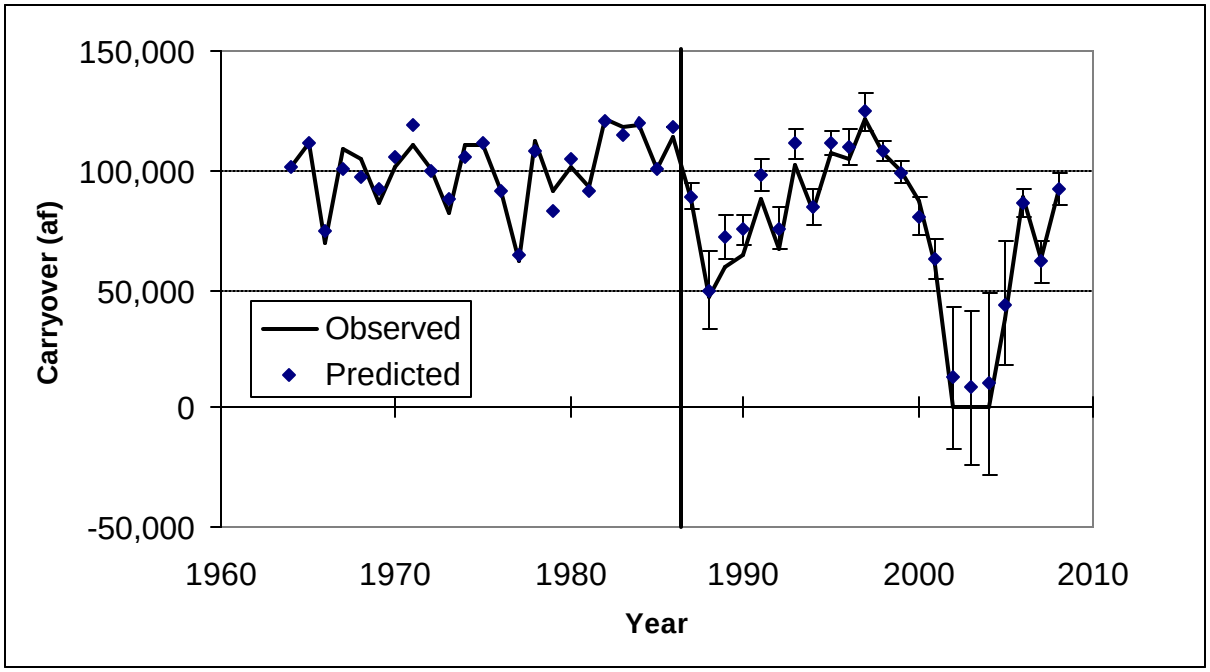


Temporal autocorrelation in prediction residuals, 1989-2008, Burley Irrigation District.

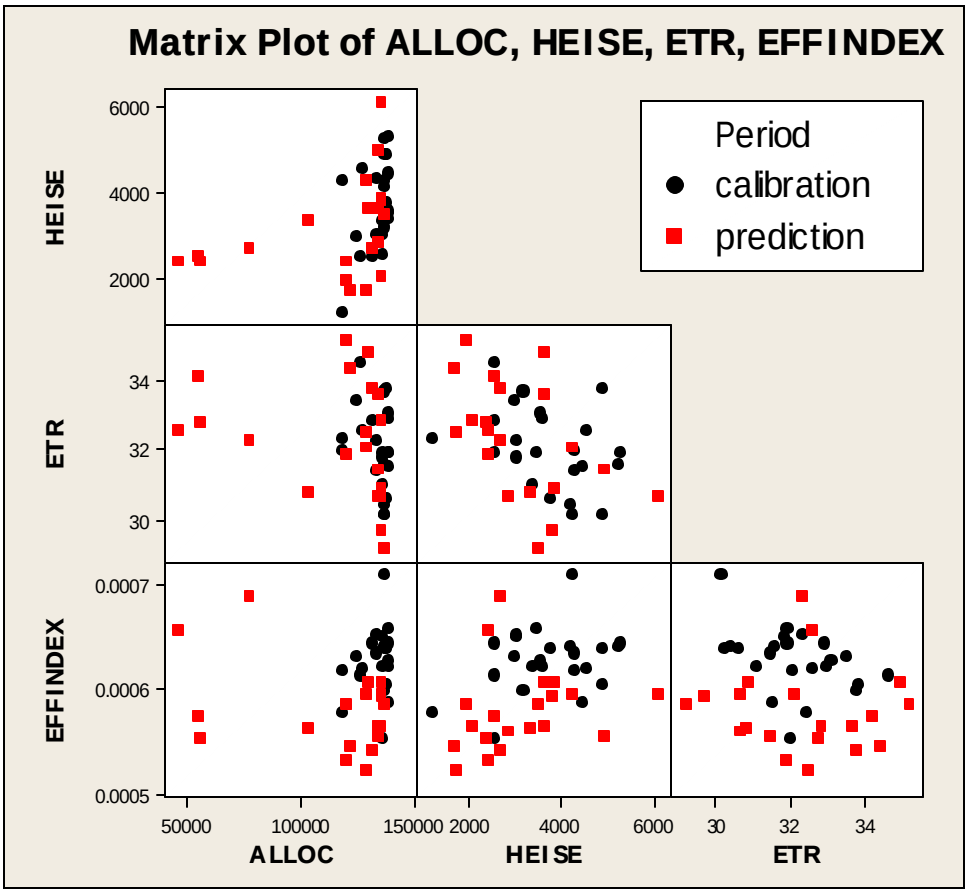
A&B IRRIGATION DISTRICT



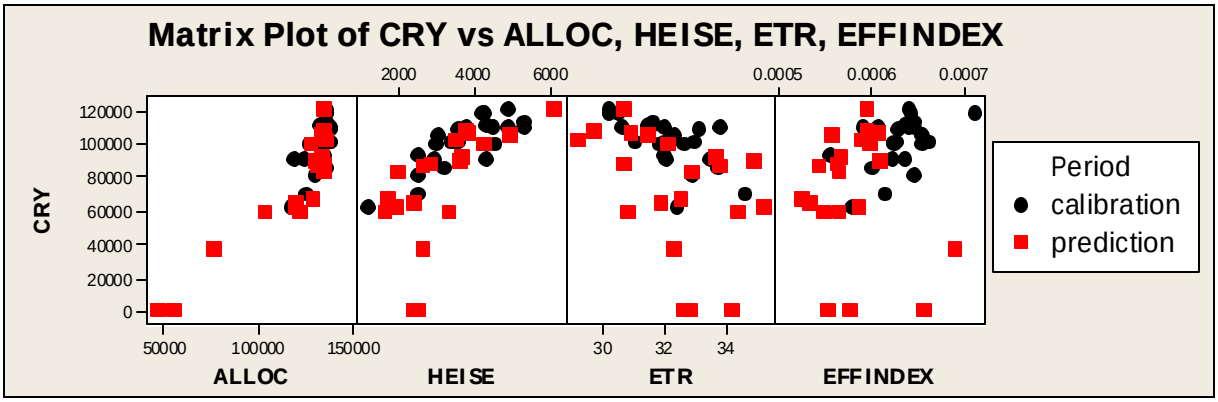
Predicted versus observed carryover, 1989-2008, A&B Irrigation District. Error bars show 95% confidence intervals for predicted mean carryover.



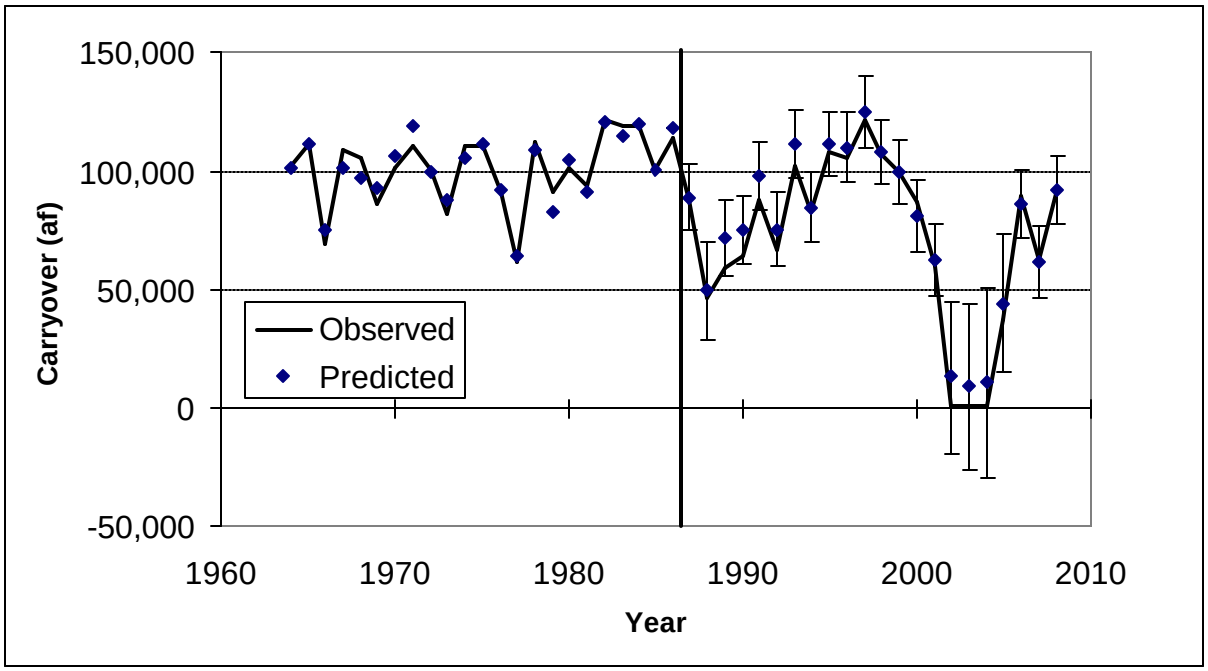
Predicted and observed carryover versus time, A&B Irrigation District. "Predicted" values for the 1964-1986 calibration period are values fitted to best regression model. Error bars for 1987-2008 values show 95% confidence intervals for predicted mean carryover.



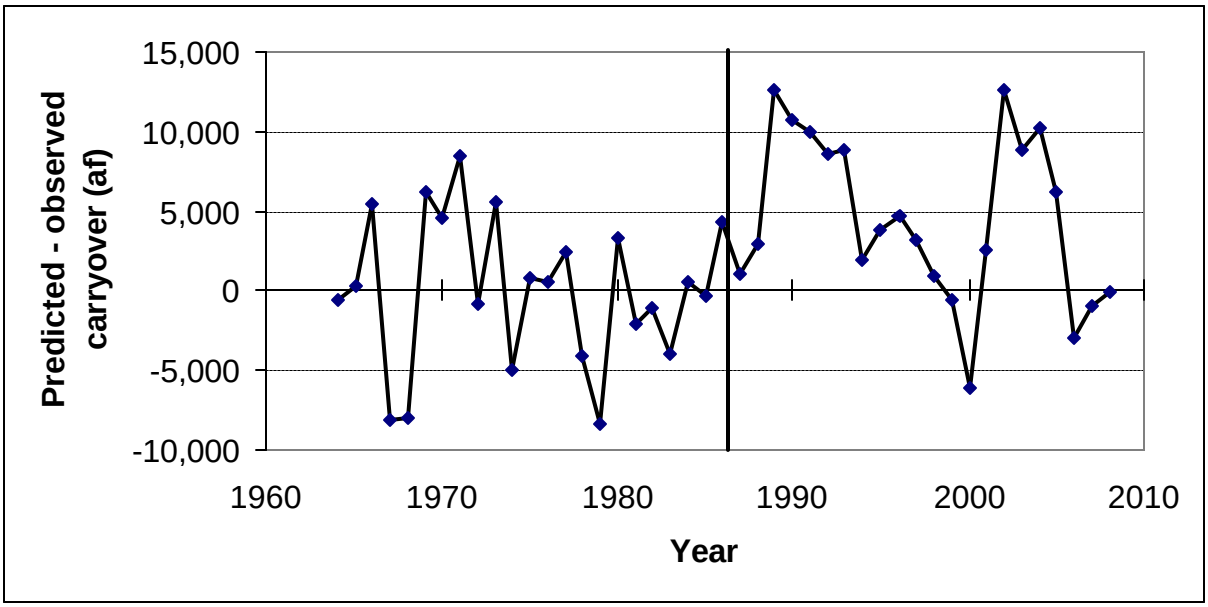
Scatter plots for all combinations of independent variables, A&B Irrigation District. Prediction period is 1989-2008.



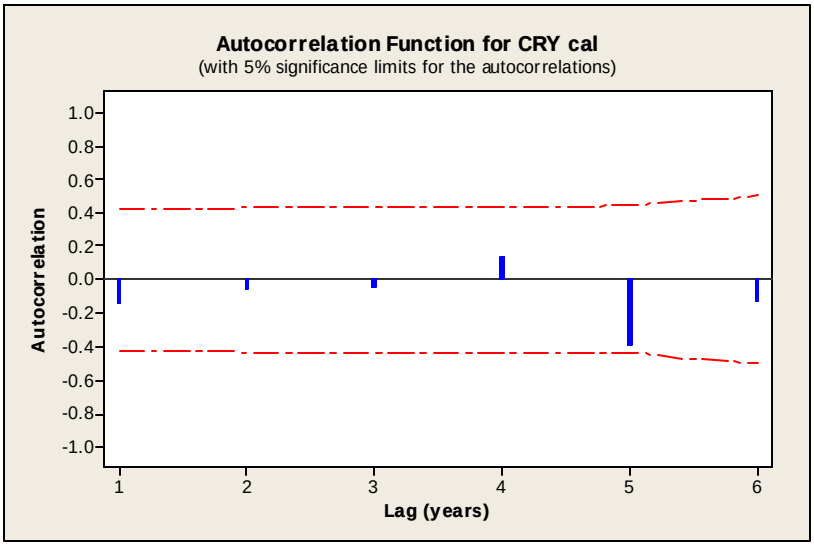
Scatter plots of carryover versus each independent variable, A&B Irrigation District. Prediction period is 1989-2008.



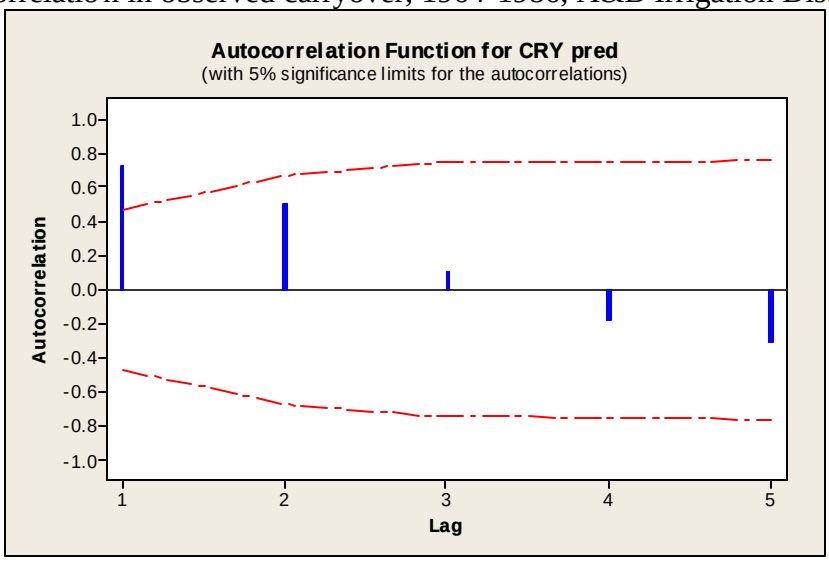
Predicted and observed carryover versus time, A&B Irrigation District. "Predicted" values for the 1964-1986 calibration period are values fitted to best regression model. Error bars for 1987-2008 values show 95% confidence intervals for prediction of new observation.



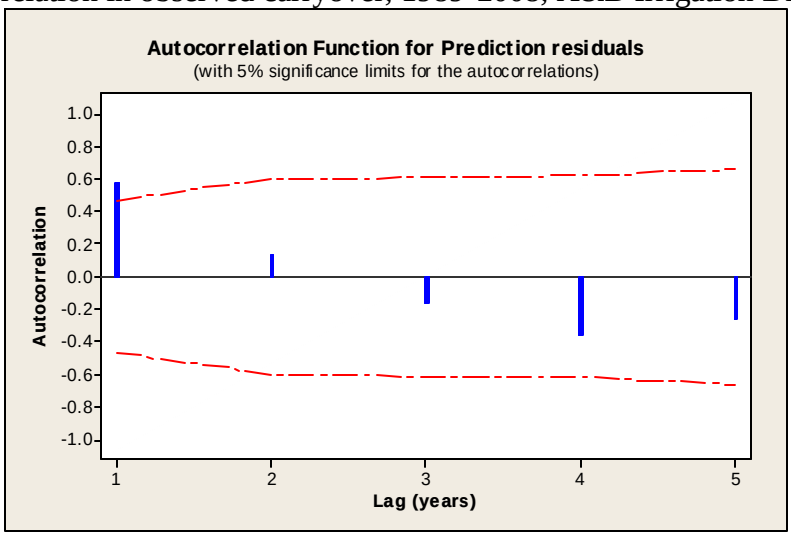
Prediction residuals (predicted carryover minus observed carryover) versus time, A&B Irrigation District. "Predicted" values for the 1964-1986 calibration period are values fitted to best regression model.



Temporal autocorrelation in observed carryover, 1964-1986, A&B Irrigation District.

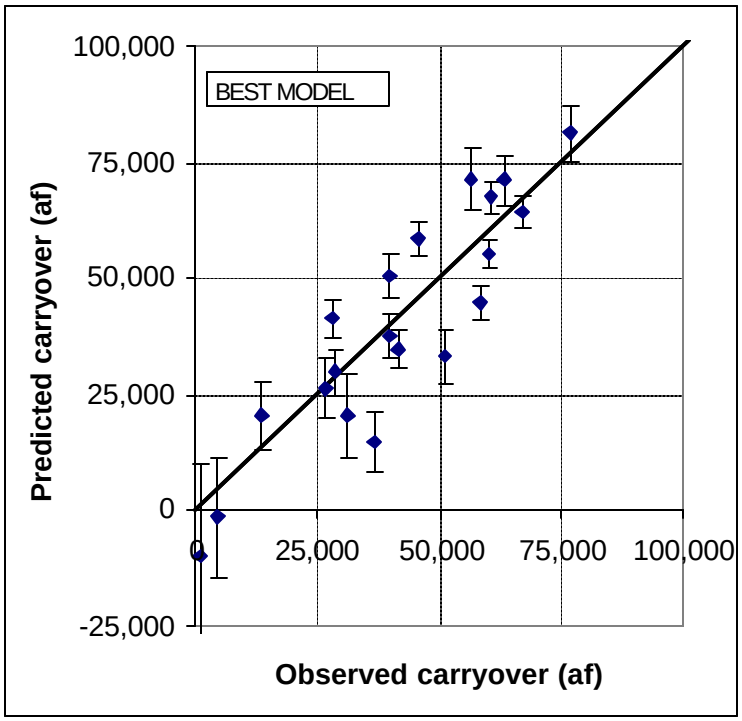


Temporal autocorrelation in observed carryover, 1989-2008, A&B Irrigation District.

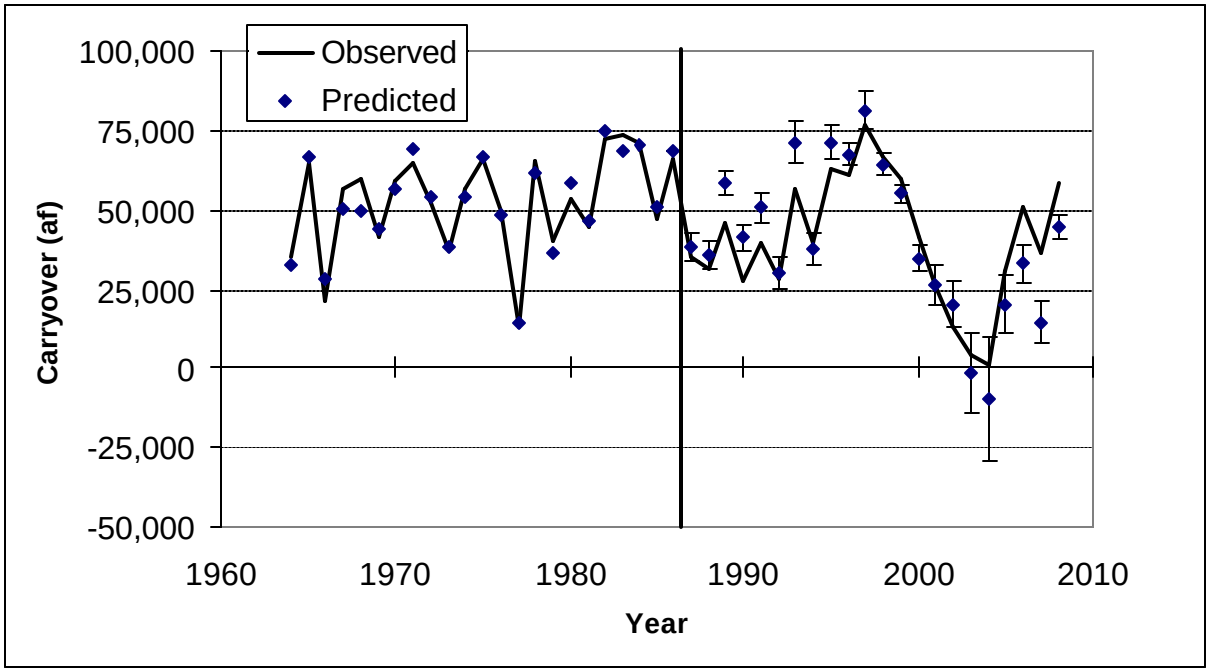


Temporal autocorrelation in prediction residuals, 1989-2008, A&B Irrigation District.

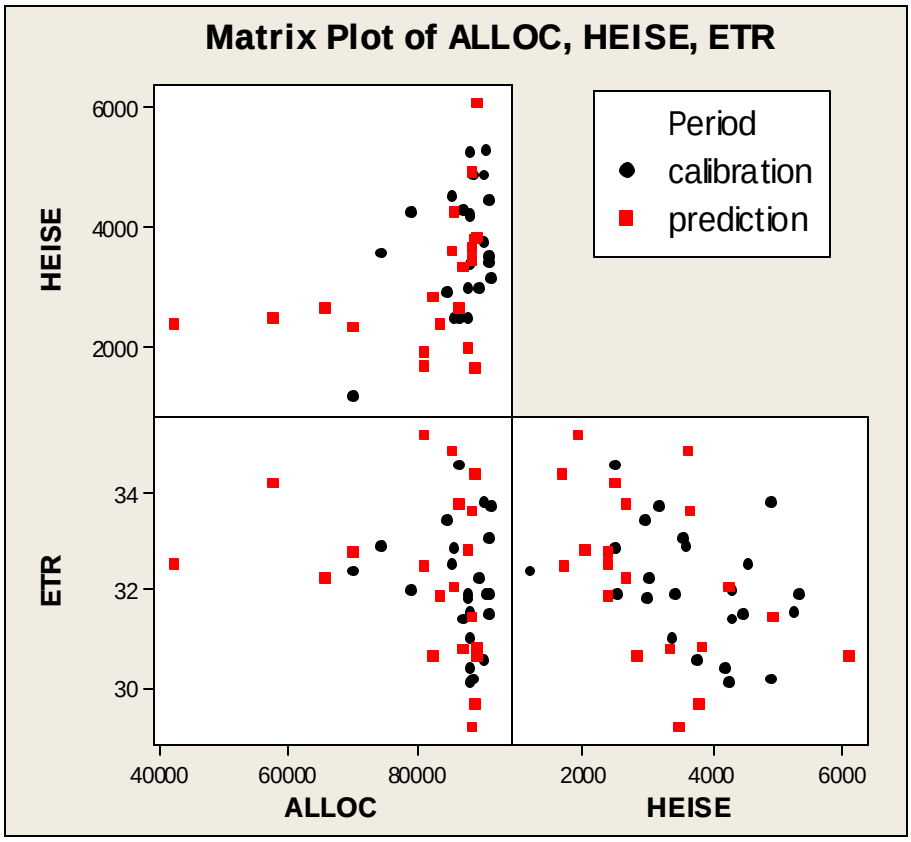
MILNER IRRIGATION DISTRICT



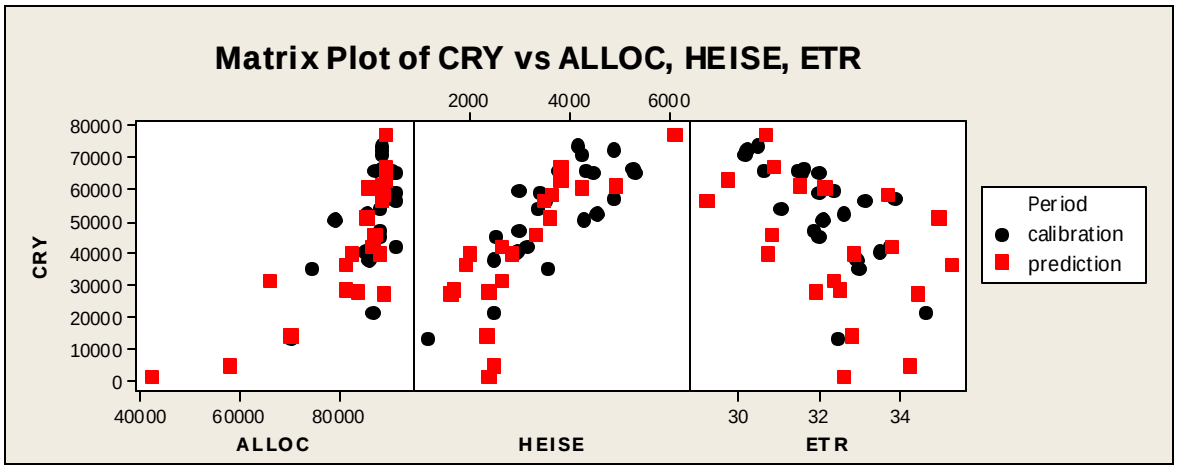
Predicted versus observed carryover, 1989-2008, Milner Irrigation District. Error bars show 95% confidence intervals for predicted mean carryover.



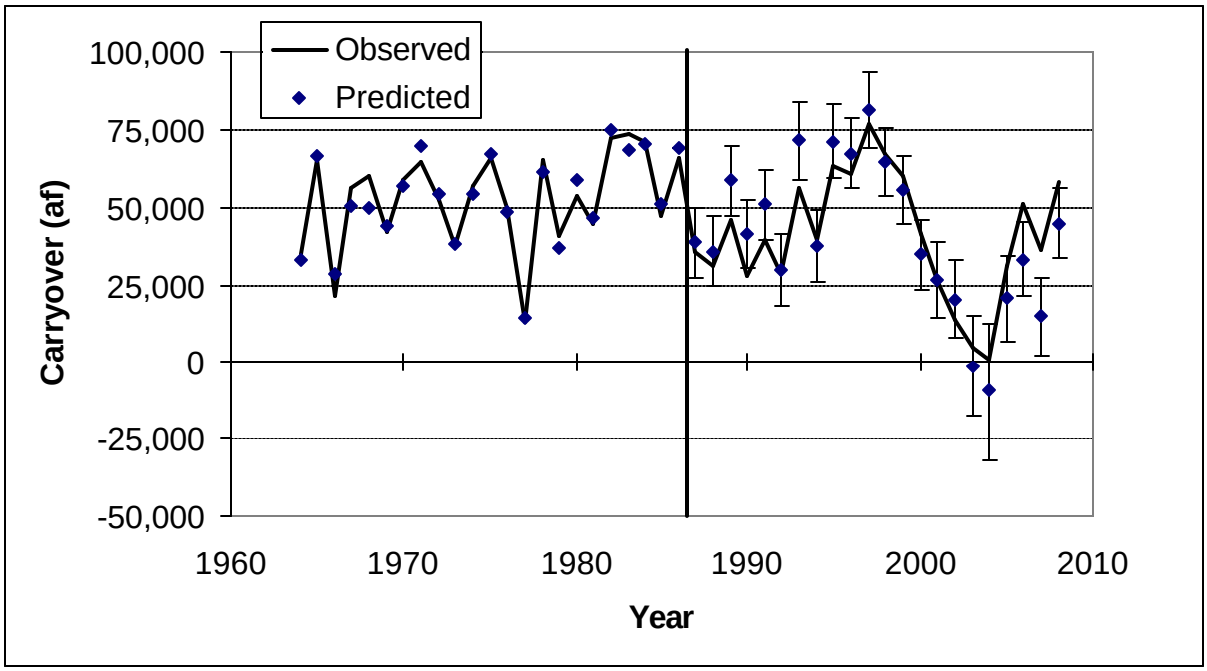
Predicted and observed carryover versus time, Milner Irrigation District. "Predicted" values for the 1964-1986 calibration period are values fitted to best regression model. Error bars for 1987-2008 values show 95% confidence intervals for predicted mean carryover.



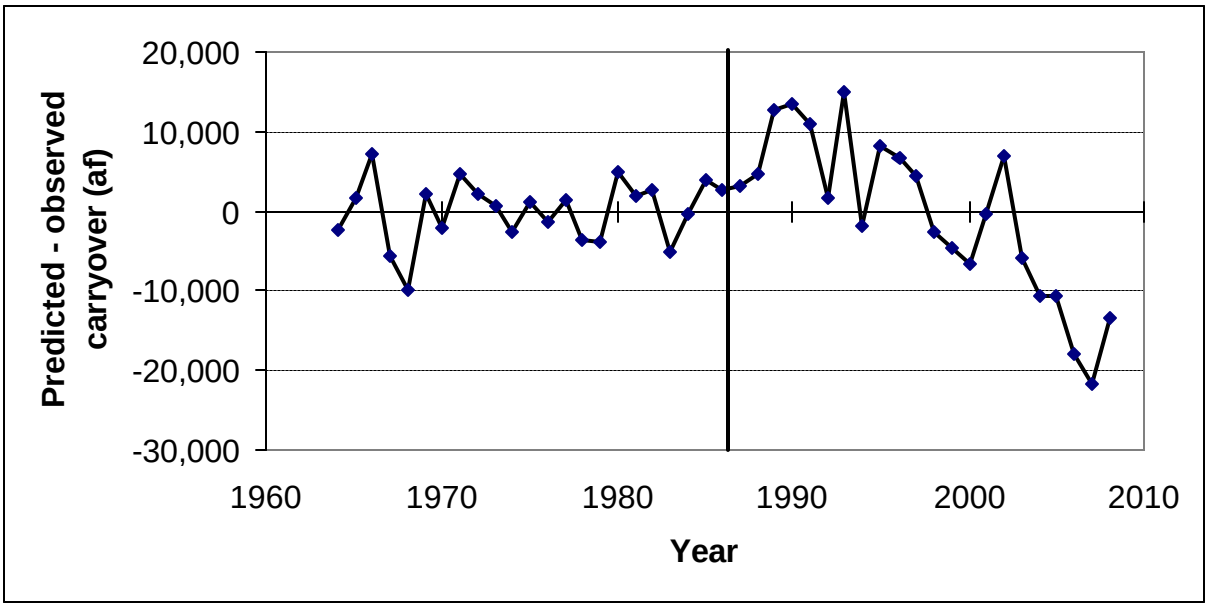
Scatter plots for all combinations of independent variables, Milner Irrigation District. Prediction period is 1989-2008.



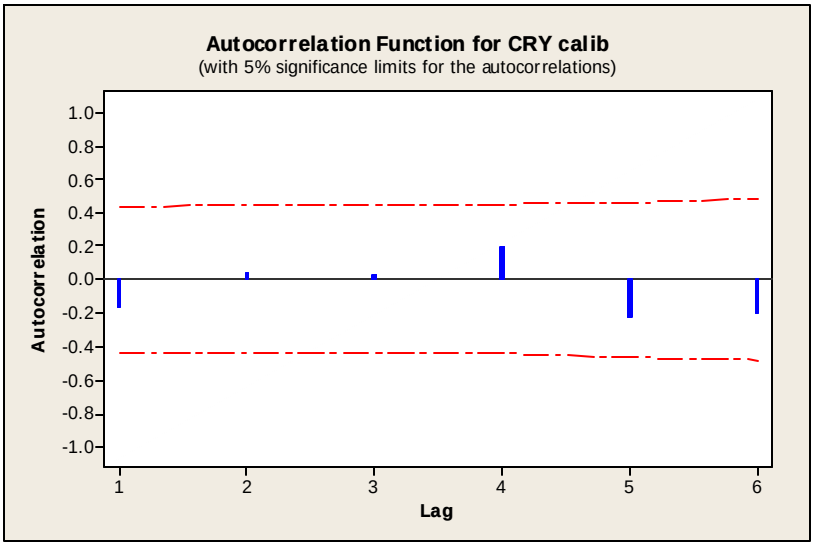
Scatter plots of carryover versus each independent variable, Milner Irrigation District. Prediction period is 1989-2008.



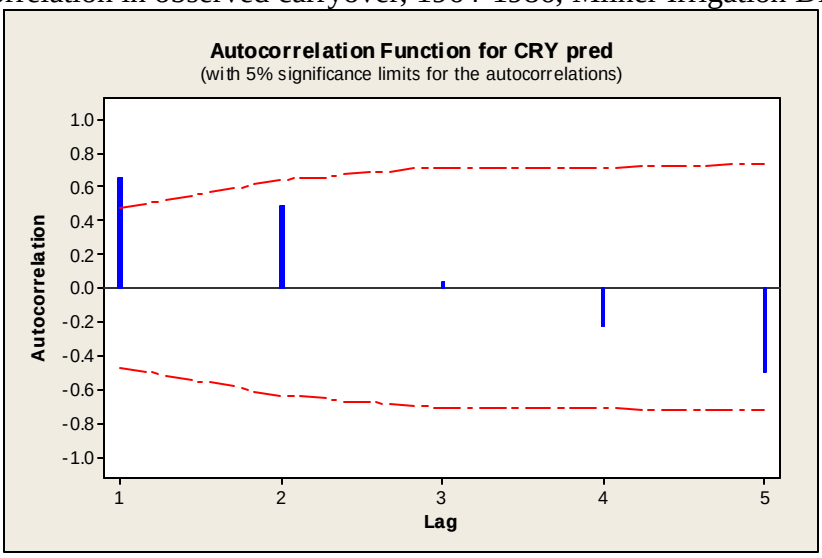
Predicted and observed carryover versus time, Milner Irrigation District. "Predicted" values for the 1964-1986 calibration period are values fitted to best regression model. Error bars for 1987-2008 values show 95% confidence intervals for prediction of new observation.



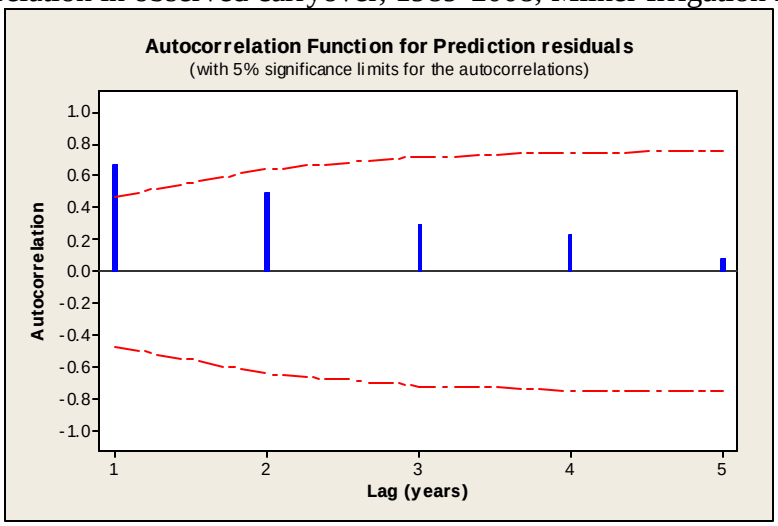
Prediction residuals (predicted carryover minus observed carryover) versus time, Milner Irrigation District. "Predicted" values for the 1964-1986 calibration period are values fitted to best regression model.



Temporal autocorrelation in observed carryover, 1964-1986, Milner Irrigation District.

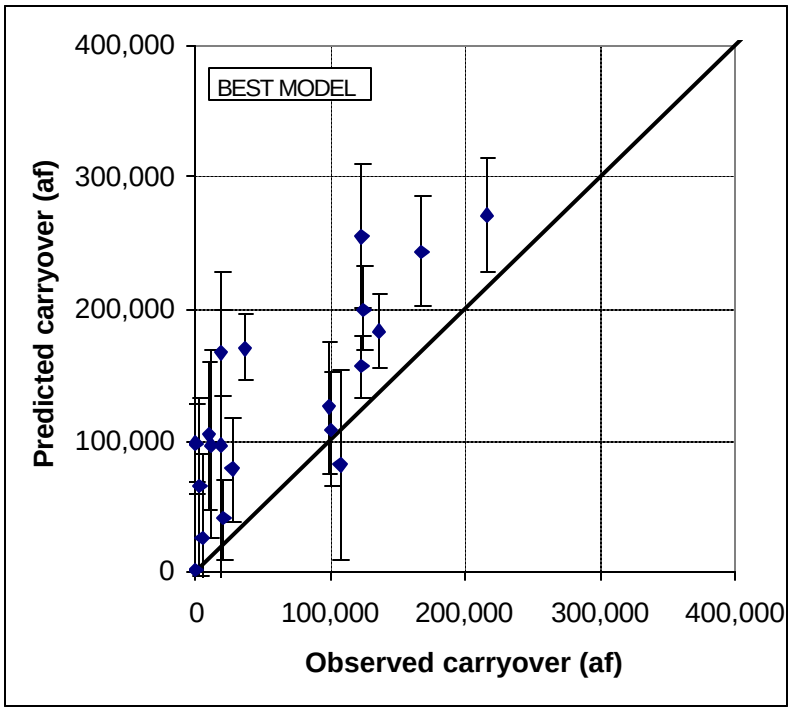


Temporal autocorrelation in observed carryover, 1989-2008, Milner Irrigation District.

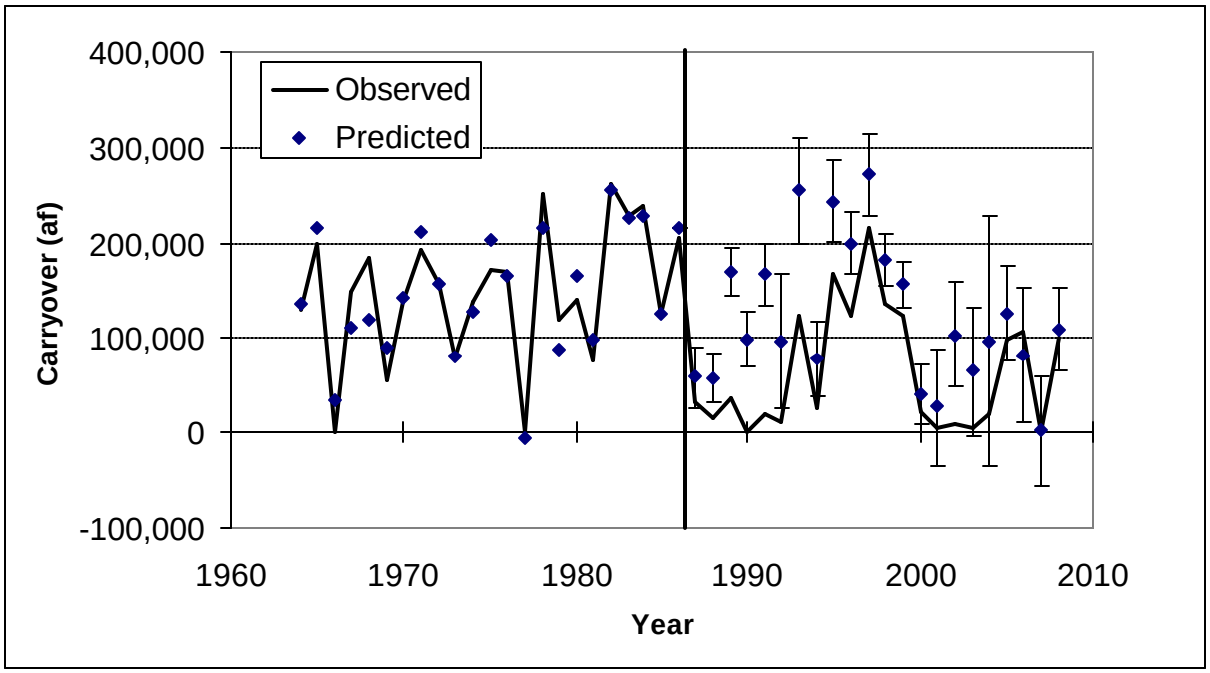


Temporal autocorrelation in prediction residuals, 1989-2008, Milner Irrigation District.

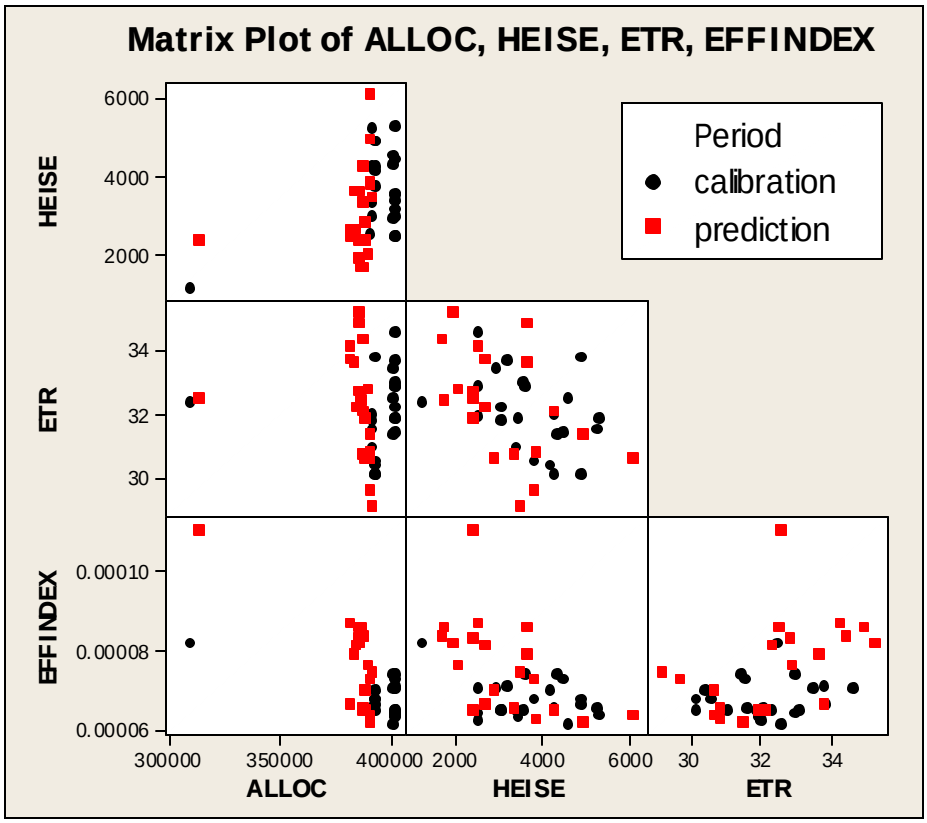
AMERICAN FALLS RESERVOIR DISTRCT 2



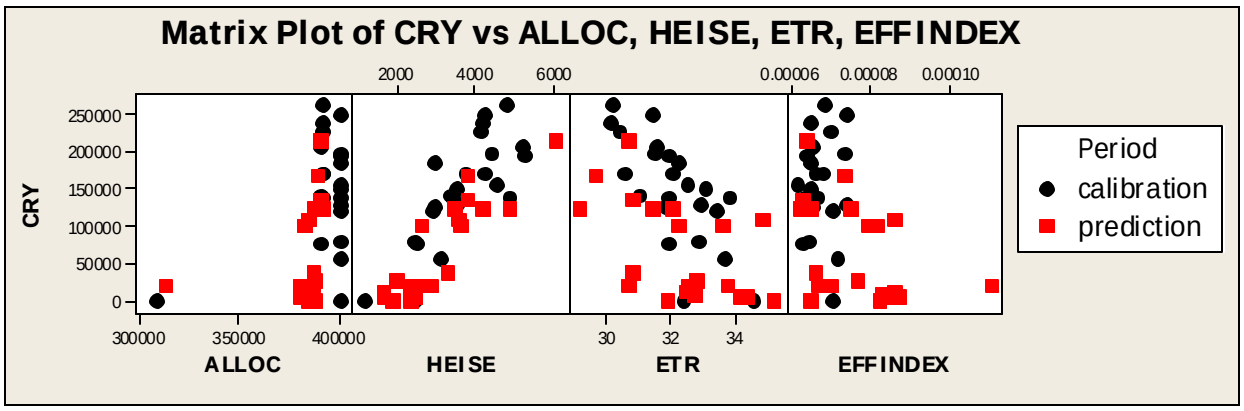
Predicted versus observed carryover, 1989-2008, American Falls RD2. Error bars show 95% confidence intervals for predicted mean carryover.



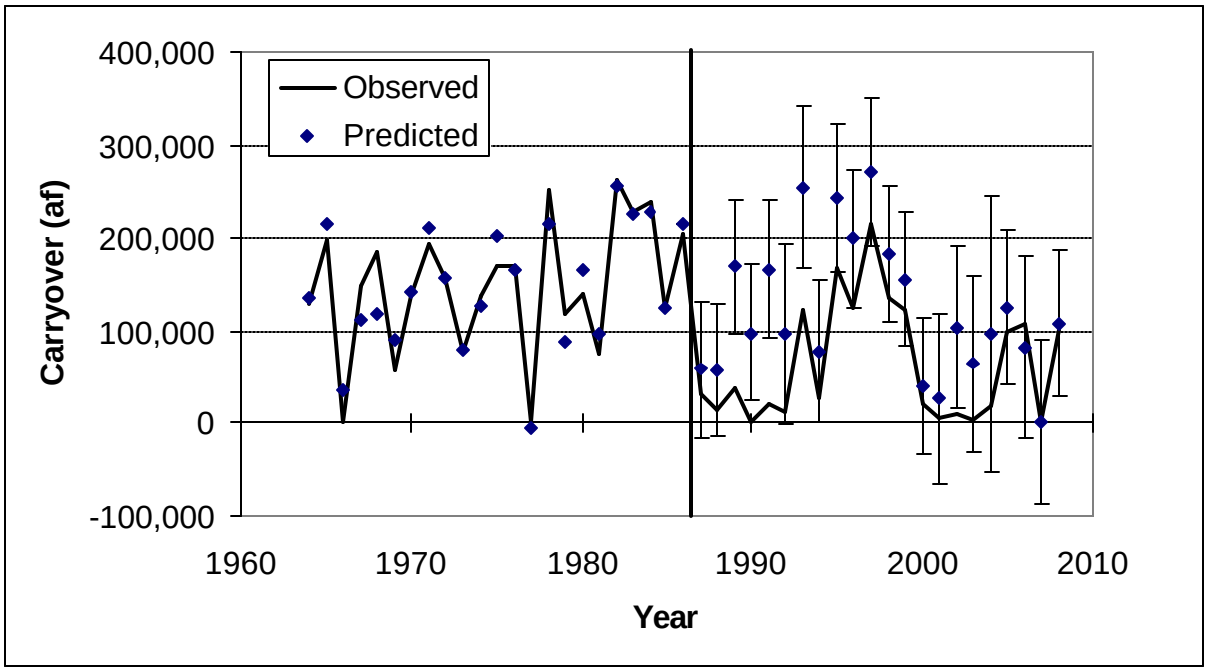
Predicted and observed carryover versus time, American Falls RD2. "Predicted" values for the 1964-1986 calibration period are values fitted to best regression model. Error bars for 1987-2008 values show 95% confidence intervals for predicted mean carryover.



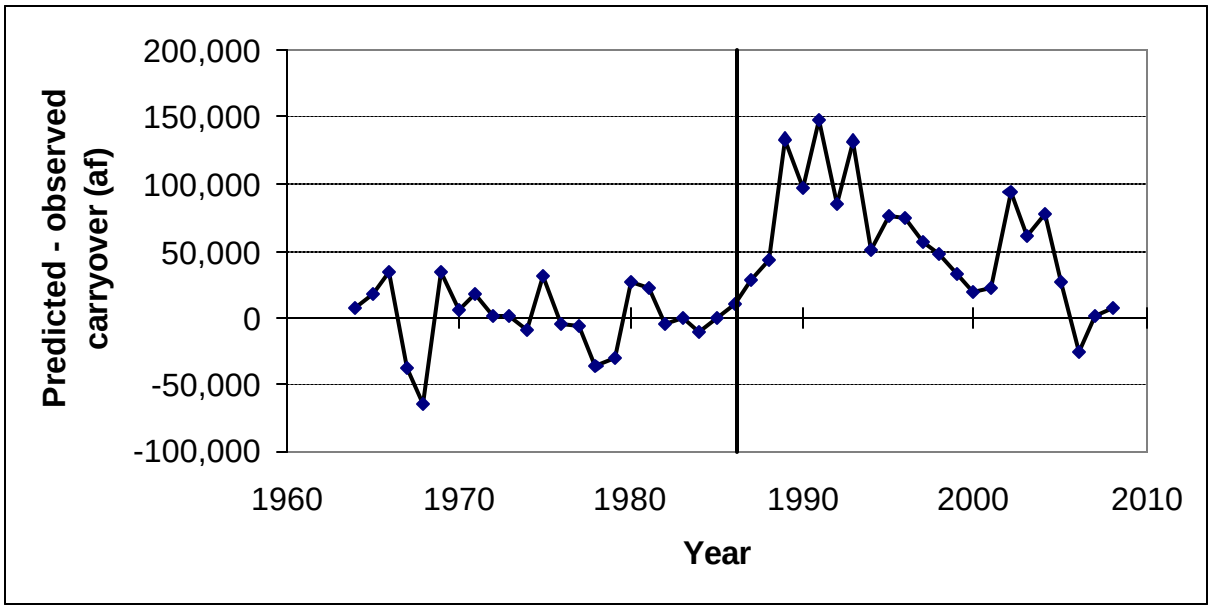
Scatter plots for all combinations of independent variables, American Falls RD2. Prediction period is 1989-2008.



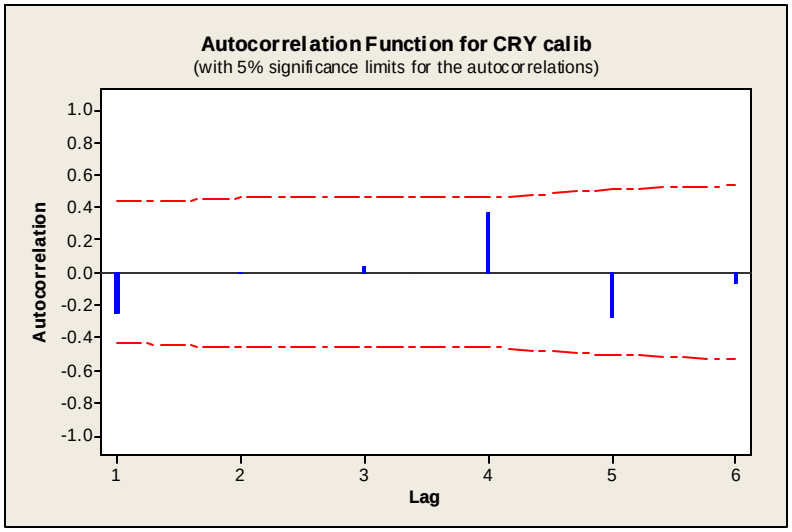
Scatter plots of carryover versus each independent variable, American Falls RD2. Prediction period is 1989-2008.



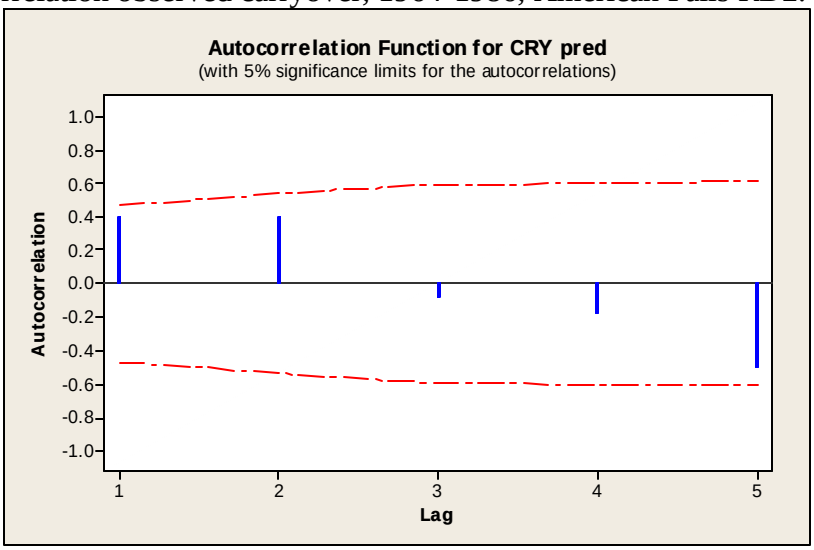
Predicted and observed carryover versus time, American Falls RD2. "Predicted" values for the 1964-1986 calibration period are values fitted to best regression model. Error bars for 1987-2008 values show 95% confidence intervals for prediction of new observation.



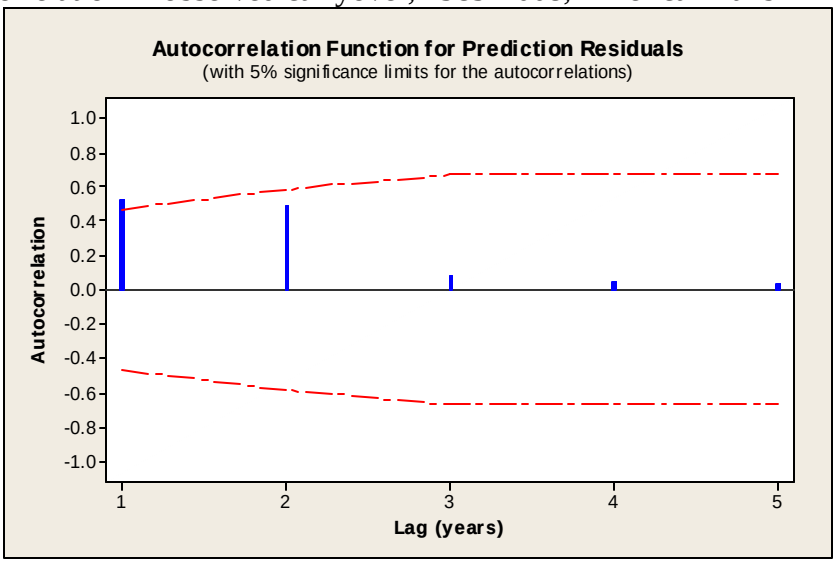
Prediction residuals (predicted carryover minus observed carryover) versus time, American Falls RD2. "Predicted" values for the 1964-1986 calibration period are values fitted to best regression model.



Temporal autocorrelation observed carryover, 1964-1986, American Falls RD2.

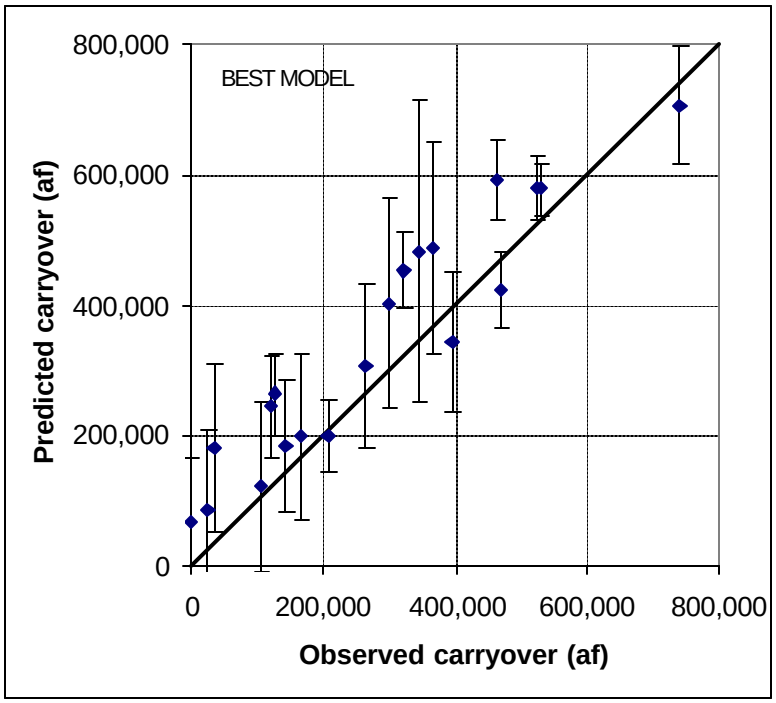


Temporal autocorrelation in observed carryover, 1989-2008, American Falls RD2.

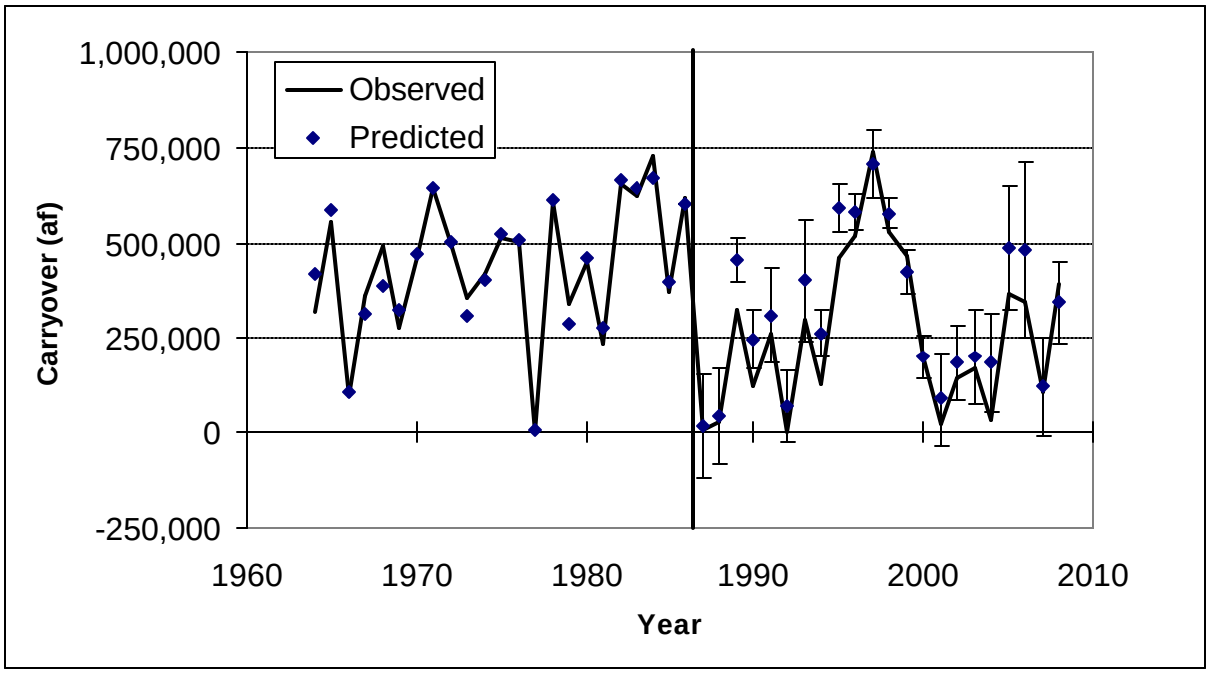


Temporal autocorrelation in prediction residuals, 1989-2008, American Falls RD2.

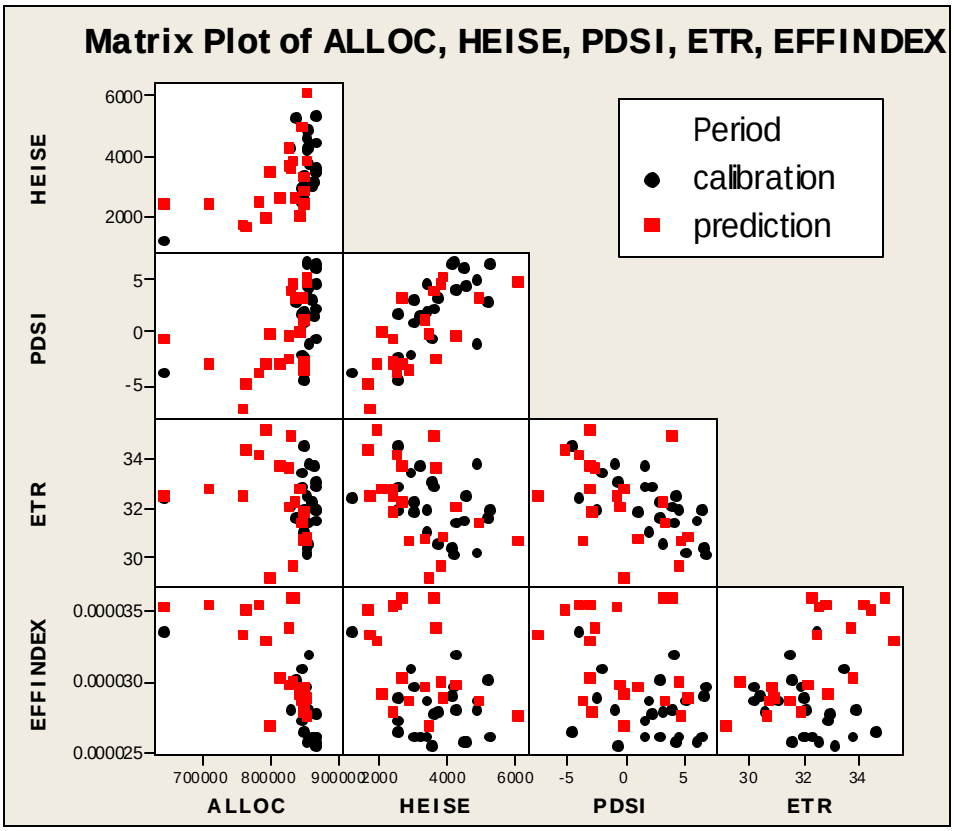
NORTH SIDE CANAL COMPANY



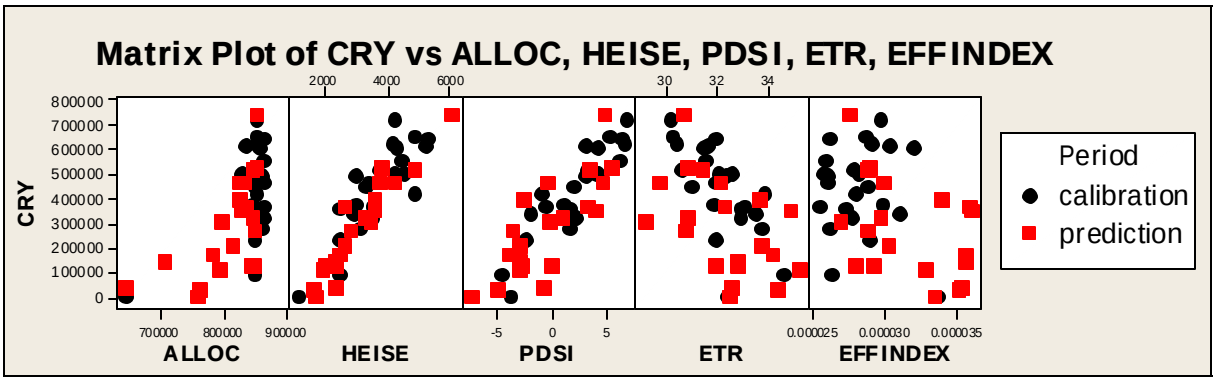
Predicted versus observed carryover, 1989-2008, North Side Canal Company. Error bars show 95% confidence intervals for predicted mean carryover.



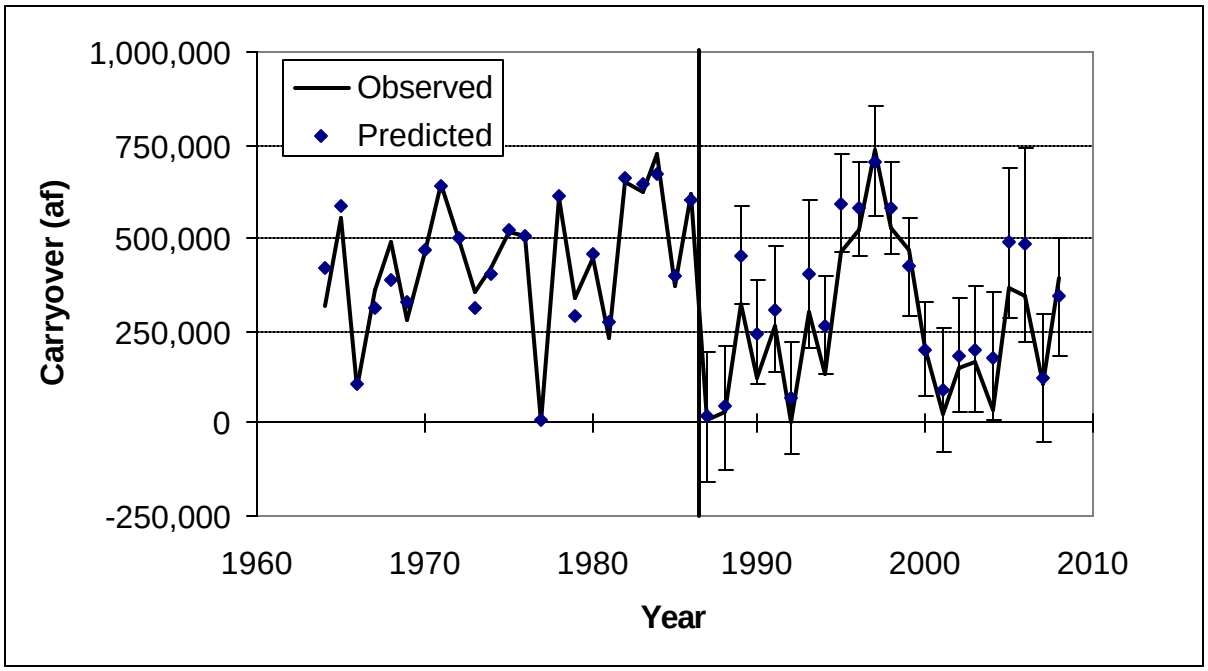
Predicted and observed carryover versus time, North Side Canal Company. "Predicted" values for the 1964-1986 calibration period are values fitted to best regression model. Error bars for 1987-2008 values show 95% confidence intervals for predicted mean carryover.



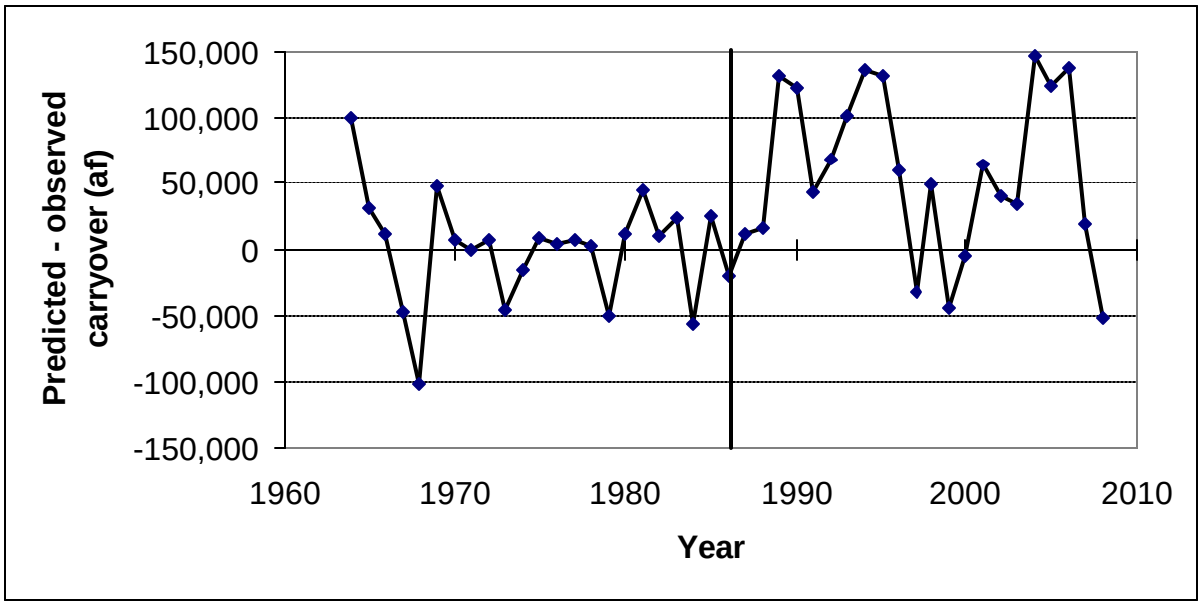
Scatter plots for all combinations of independent variables, North Side Canal Company. Prediction period is 1989-2008.



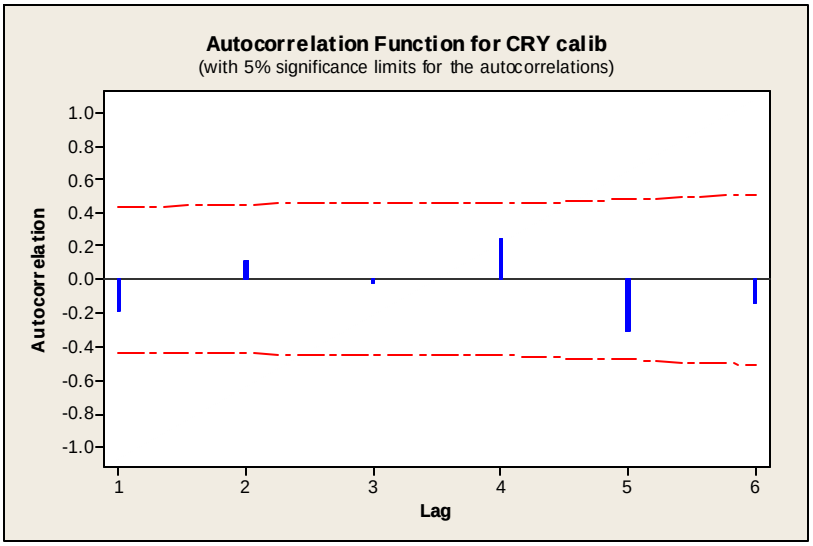
Scatter plots of carryover versus each independent variable, North Side Canal Company. Prediction period is 1989-2008.



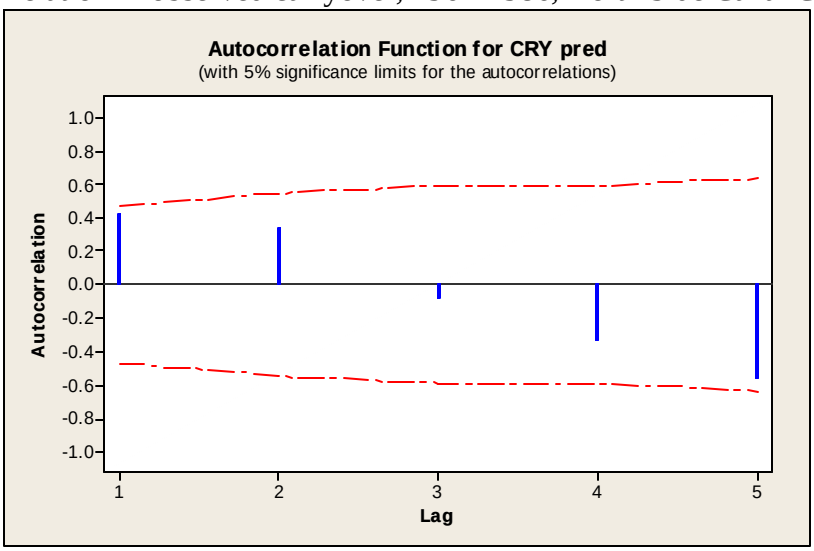
Predicted and observed carryover versus time, North Side Canal Company. "Predicted" values for the 1964-1986 calibration period are values fitted to best regression model. Error bars for 1987-2008 values show 95% confidence intervals for prediction of new observation.



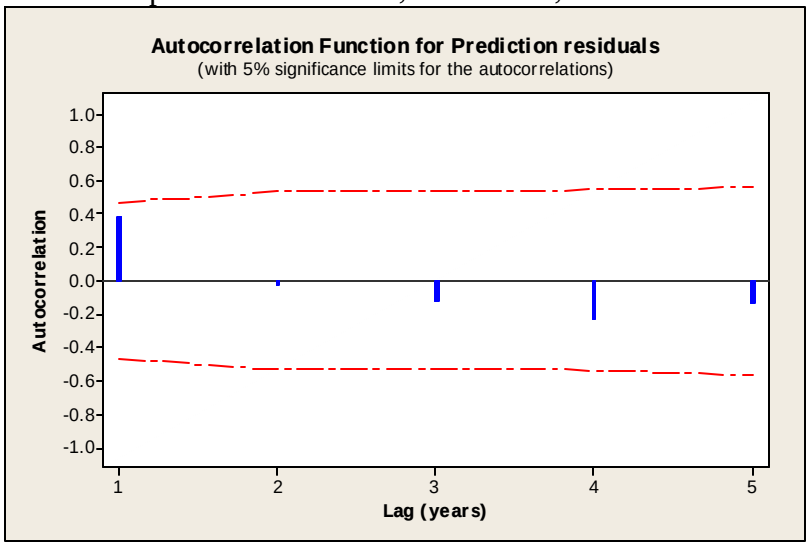
Prediction residuals (predicted carryover minus observed carryover) versus time, North Side Canal Company. "Predicted" values for the 1964-1986 calibration period are values fitted to best regression model.



Temporal autocorrelation in observed carryover, 1964-1986, North Side Canal Company.



Temporal autocorrelation in prediction residuals, 1989-2008, North Side Canal Company.



Temporal autocorrelation in prediction residuals, 1989-2008, North Side Canal Company.