

**Appendix 22. Weighted Regressions on Time, Discharge,
and Season Model Evaluation and Trend Analysis Graphical
Output for Orthophosphate during January 1, 1999, through
December 31, 2019**

All graphics were produced using R programming language (R Core Team, 2019) and the Exploration and Graphics for RivEr Trends (EGRET) and EGRETci packages. More information on these packages and methods can be found in Hirsch and De Cicco (2015) and Hirsch and others (2015).

Functions used to produce the following outputs are included as text preceding the graphic.

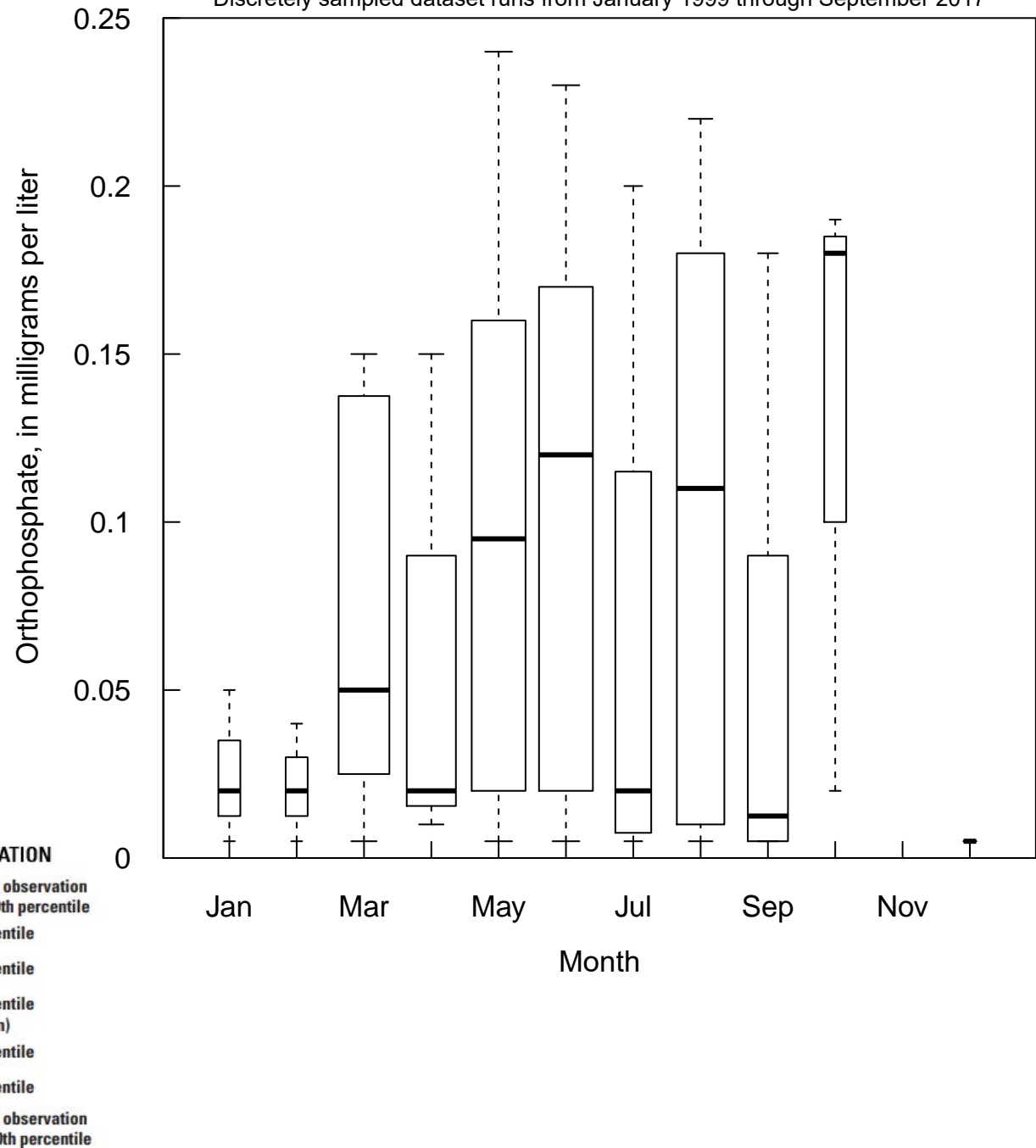
Orthophosphate (00671)

Sample Data

```
boxConcMonth(wrtds)
```

North Fork Ninescah River Above Cheney Reservoir, KS Boxplots of sample values by month

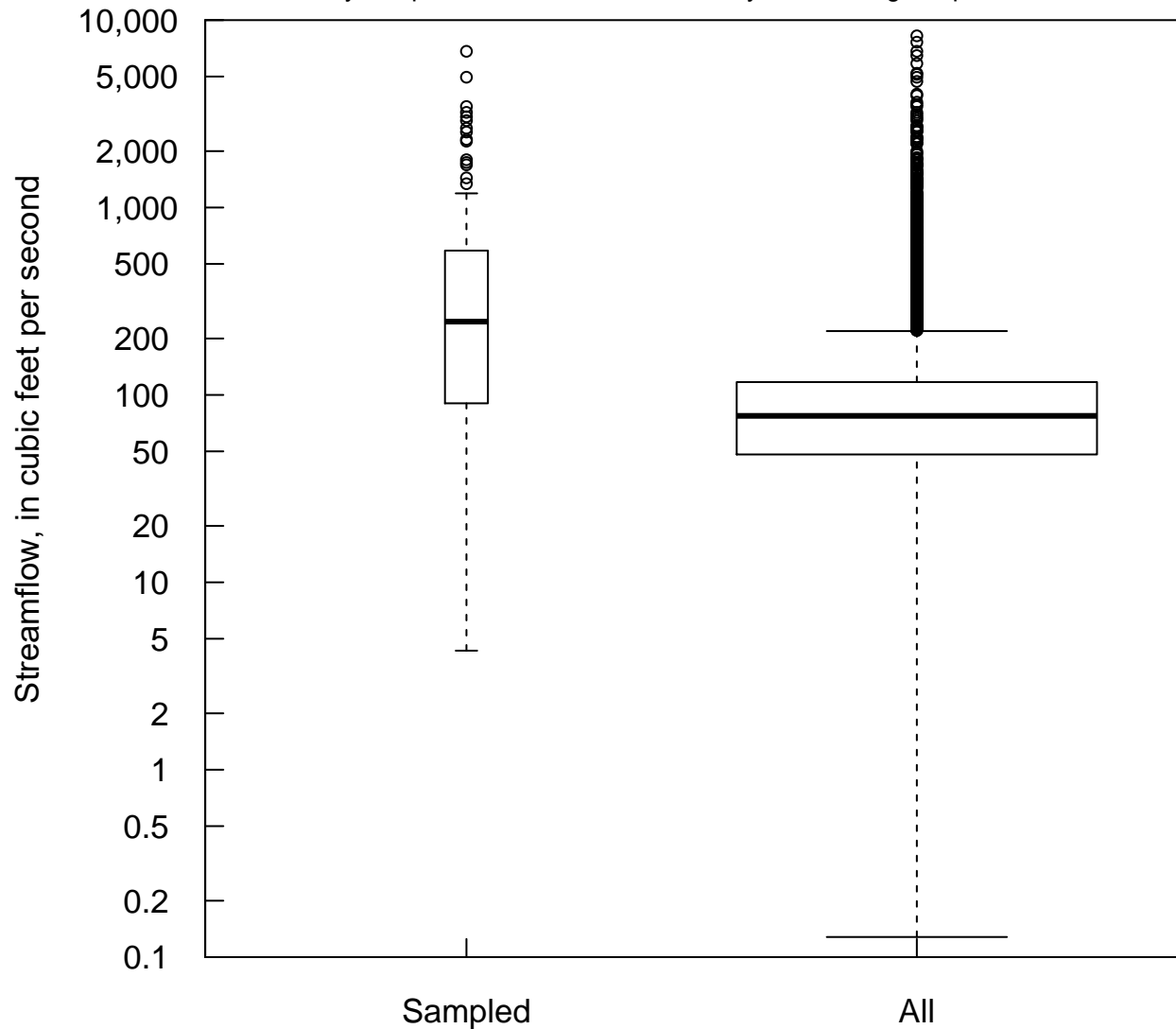
Discretely sampled dataset runs from January 1999 through September 2017



```
boxQTwice(wrtds, qUnit=1)
```

North Fork Ninescah River Above Cheney Reservoir, KS
Orthophosphate
Comparison of distribution of
Sampled Streamflow and All Daily Streamflow

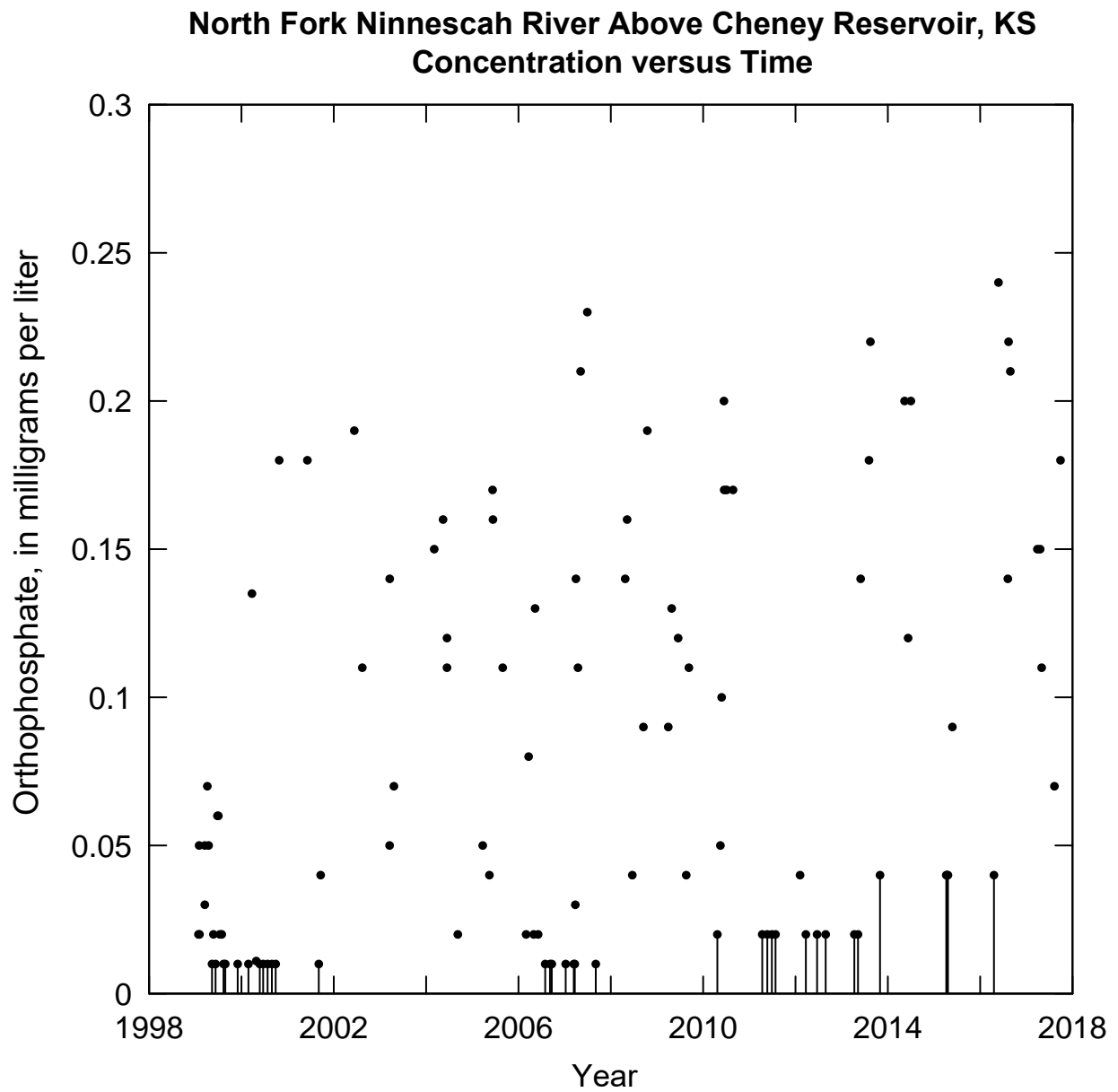
Discretely sampled dataset runs from January 1999 through September 2017



EXPLANATION

- Individual observation above 90th percentile
- 90th percentile
- 75th percentile
- 50th percentile (median)
- 25th percentile
- 10th percentile
- Individual observation below 10th percentile

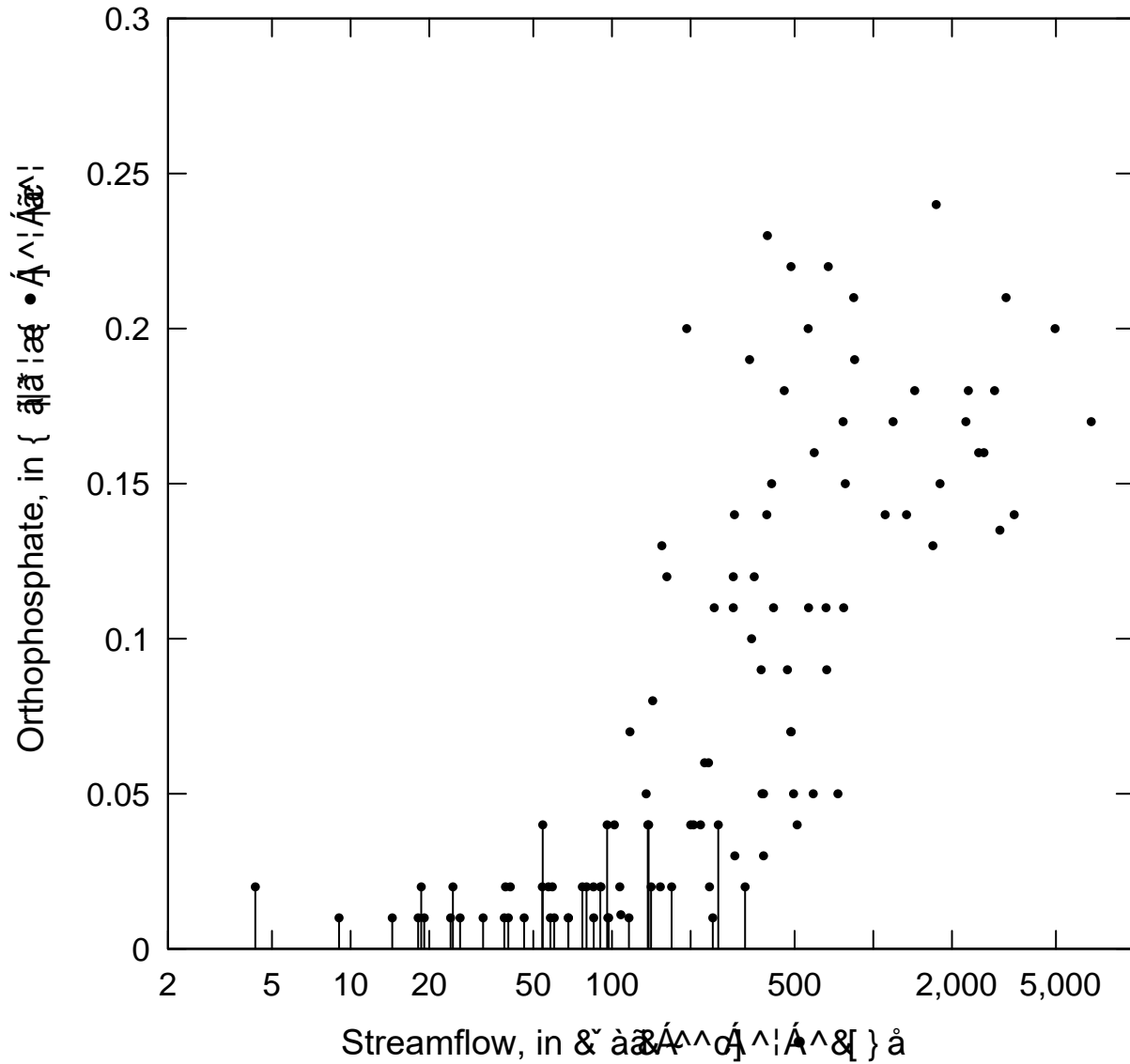
```
plotConcTime(wrtds)
```



```
plotConcQ(wrtds, qUnit=1)
```

North Fork Ninnescah River Above Cheney Reservoir, KS Concentration versus Streamflow

Discretely sampled dataset runs from January 1999 through September 2017



Weighted Regression on Time, Discharge, and Season Model Results

```
fluxBiasStat(wrtds$Sample)
```

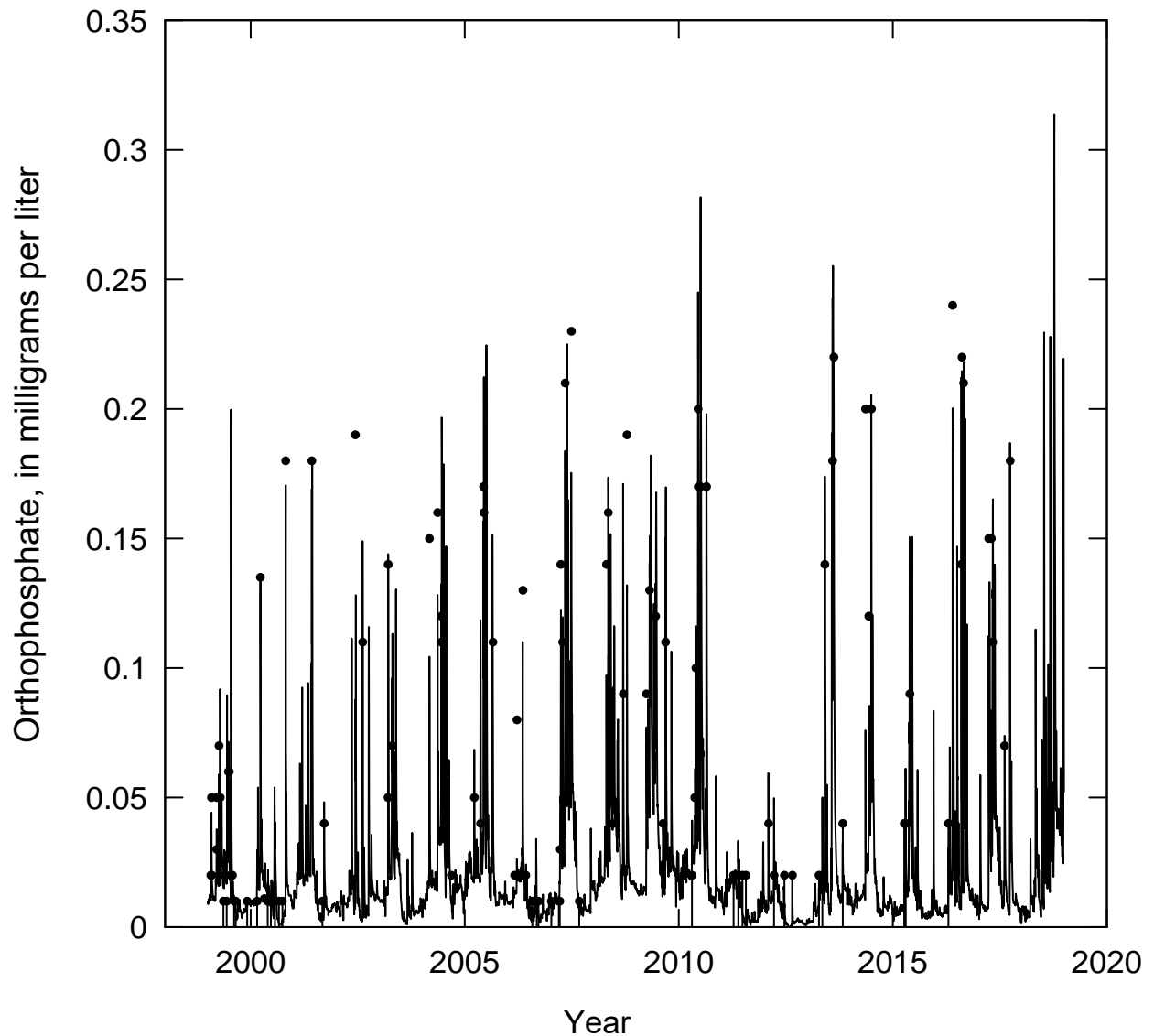
```
##          bias1
```

```
## 0.0998928842034262
```

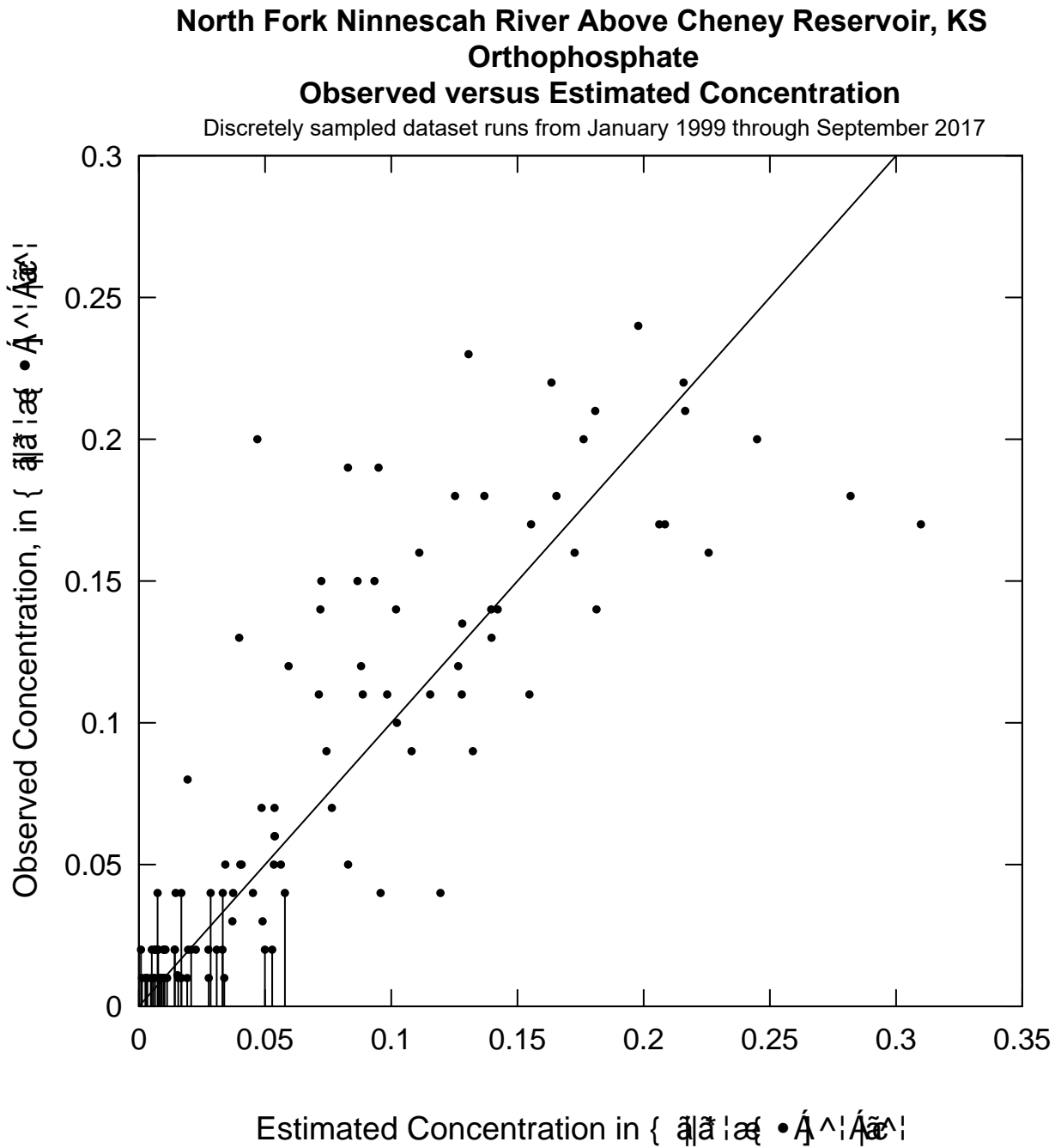
The flux bias statistic is $(\text{Mean Of Estimated Flux} - \text{Mean Of Observed Flux}) / \text{Mean Of Observed Flux}$. The statistic assumes all the censored values are the mean. In Hickman and Hirsch (2017) they used -0.20 to 0.20 as guidance for acceptability of the flux bias statistic.

```
plotConcTimeDaily(wrtds)
```

North Fork Ninnescah River Above Cheney Reservoir, KS Observed and Estimated Concentration versus Time



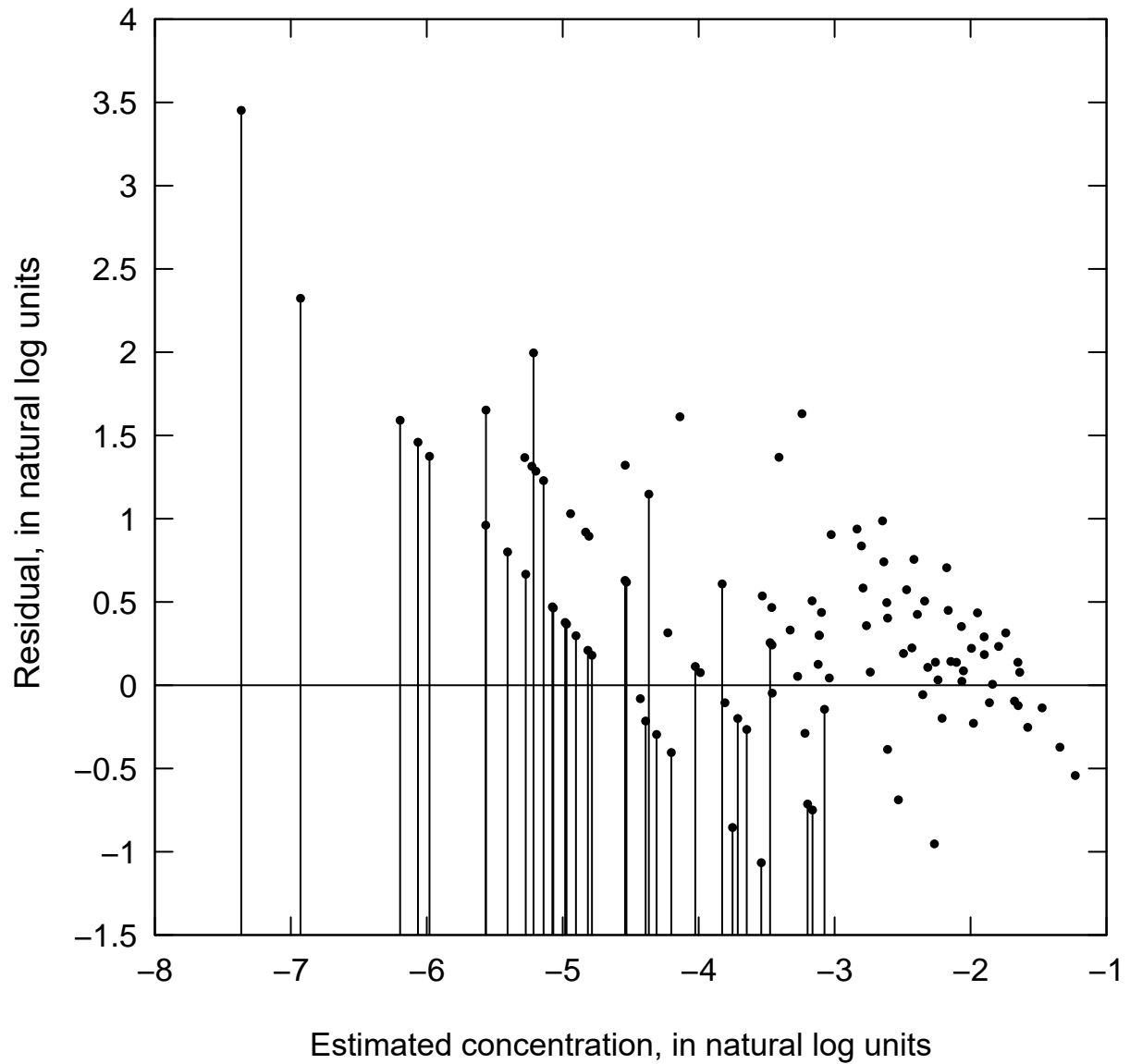
```
plotConcPred(wrtds)
```



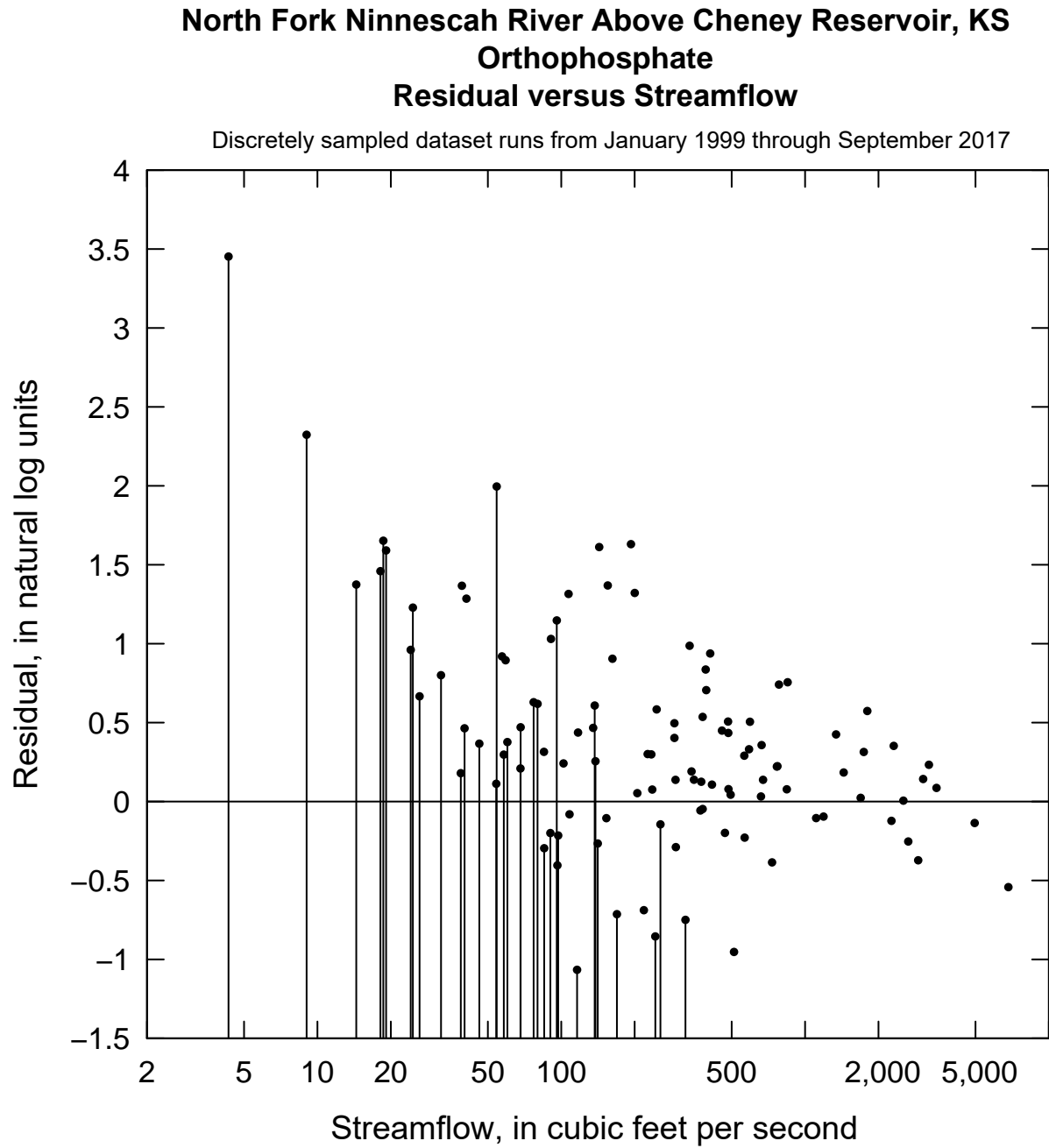
```
plotResidPred(wzrtds)
```

North Fork Ninnescah River Above Cheney Reservoir, KS
Orthophosphate
Residual versus Estimated Concentration

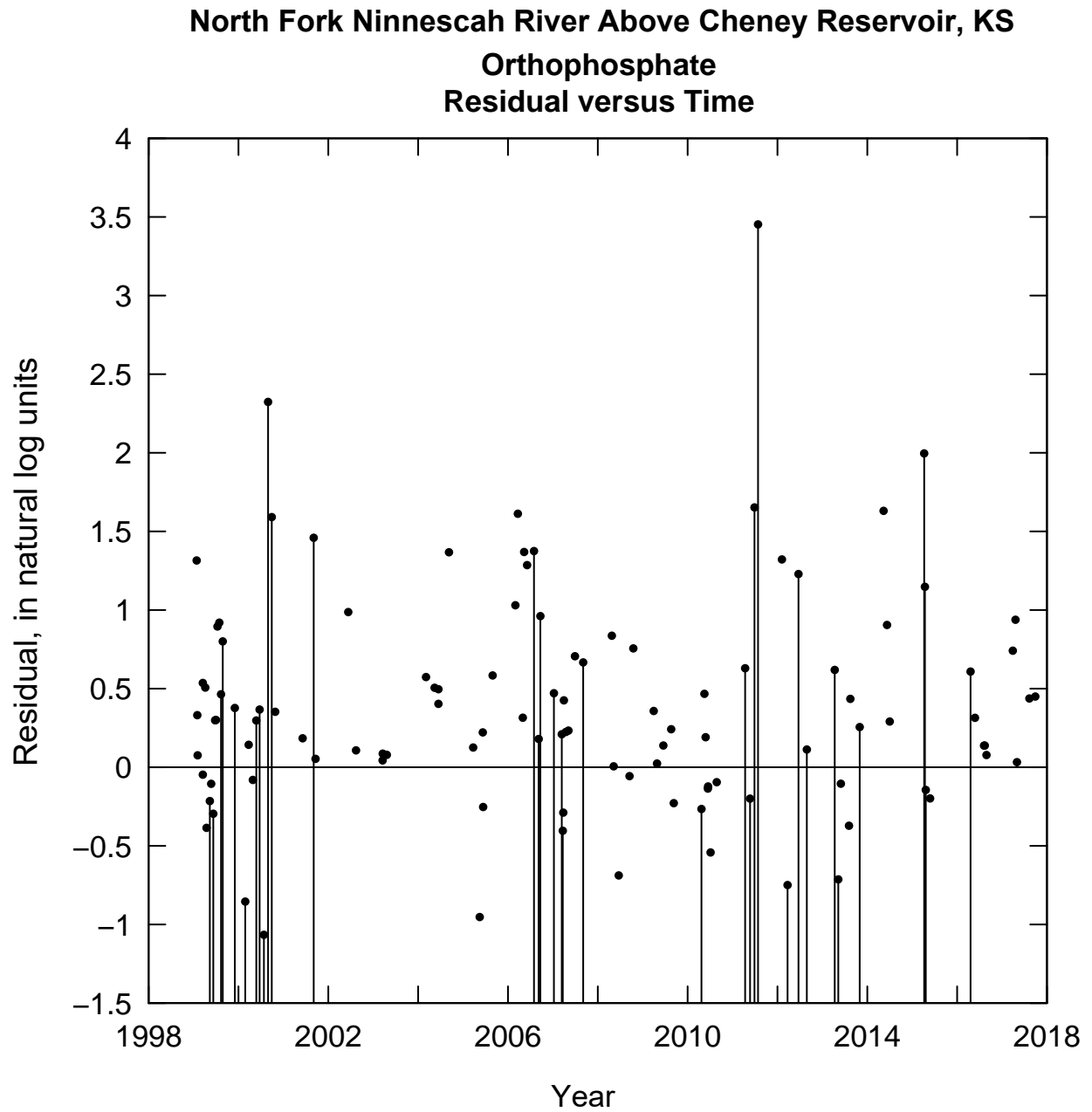
Discretely sampled dataset runs from January 1999 through September 2017




```
plotResidQ(wrtds, qUnit=1)
```



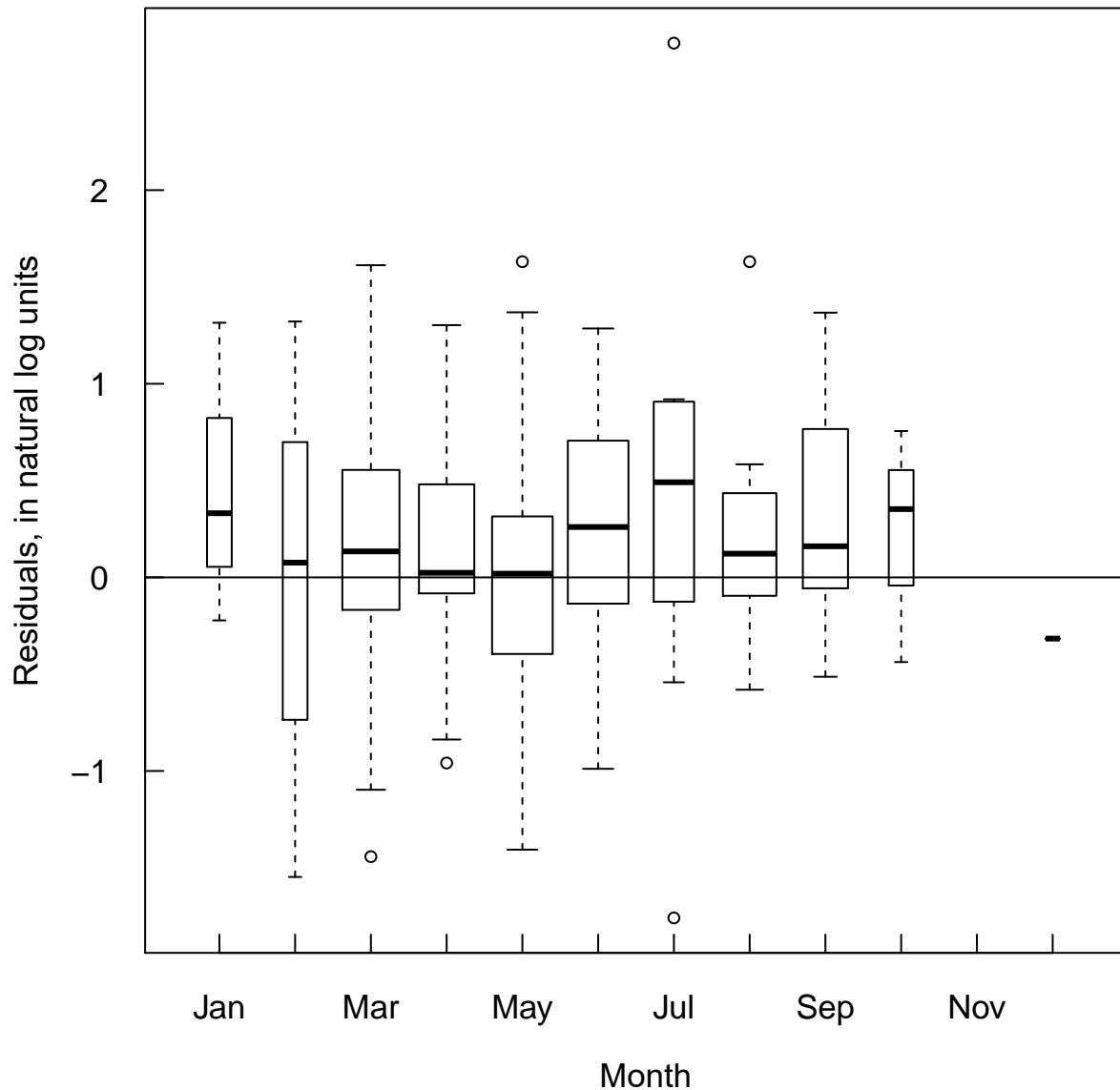
```
plotResidTime(wrtds)
```



```
boxResidMonth(wrtds)
```

North Fork Ninescaw River Above Cheney Reservoir, KS Orthophosphate Boxplots of residuals by month

Discretely sampled dataset runs from January 1999 through September 2017

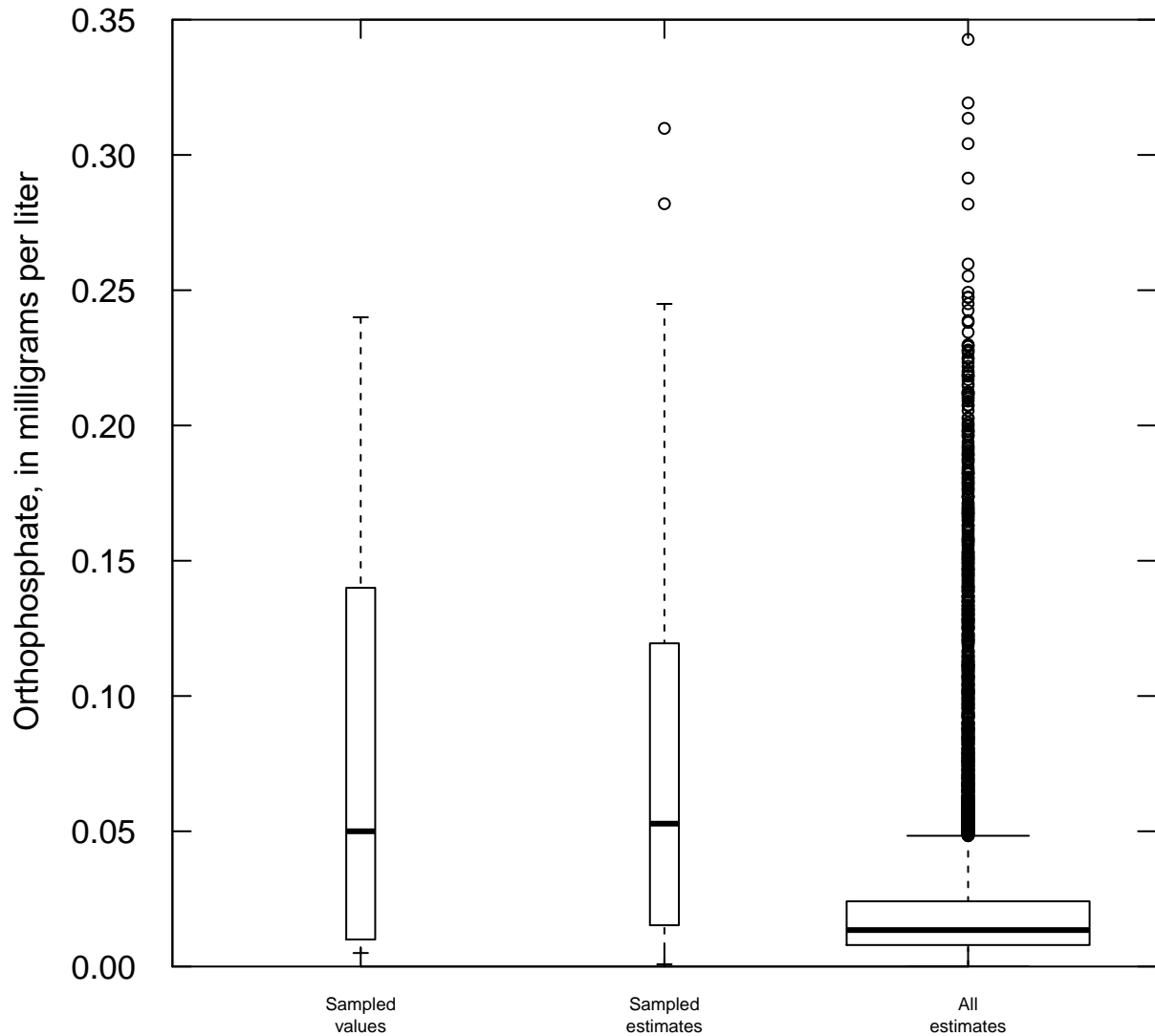


EXPLANATION

- Individual observation above 90th percentile
- 90th percentile
- 75th percentile
- 50th percentile (median)
- 25th percentile
- 10th percentile
- Individual observation below 10th percentile

North Fork Ninnescah River Above Cheney Reservoir, KS **Comparison of distribution of sampled concentrations** **with estimates on sampled days and on all days using WRTDS**

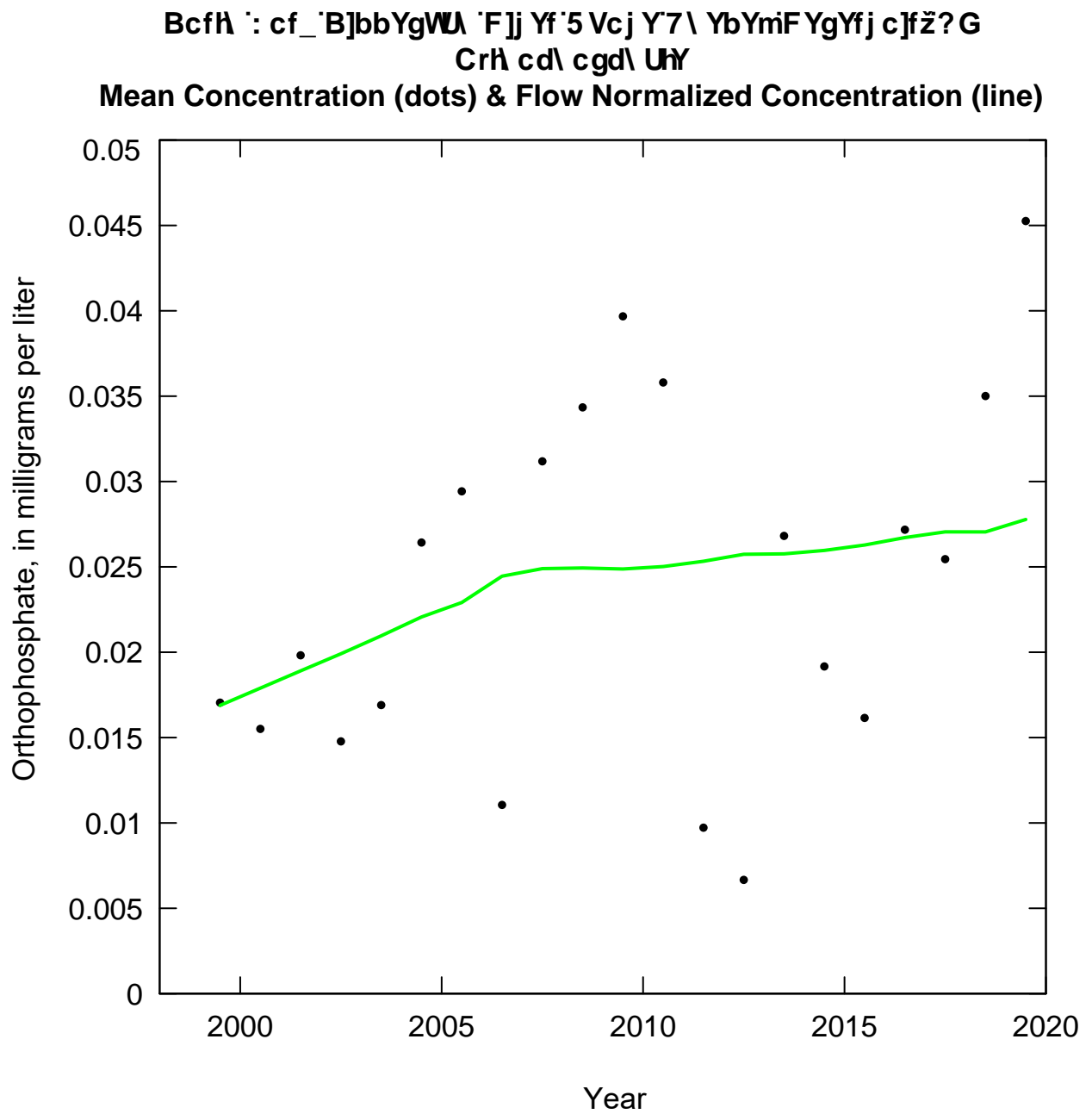
Discretely sampled dataset runs from January 1999 through September 2017



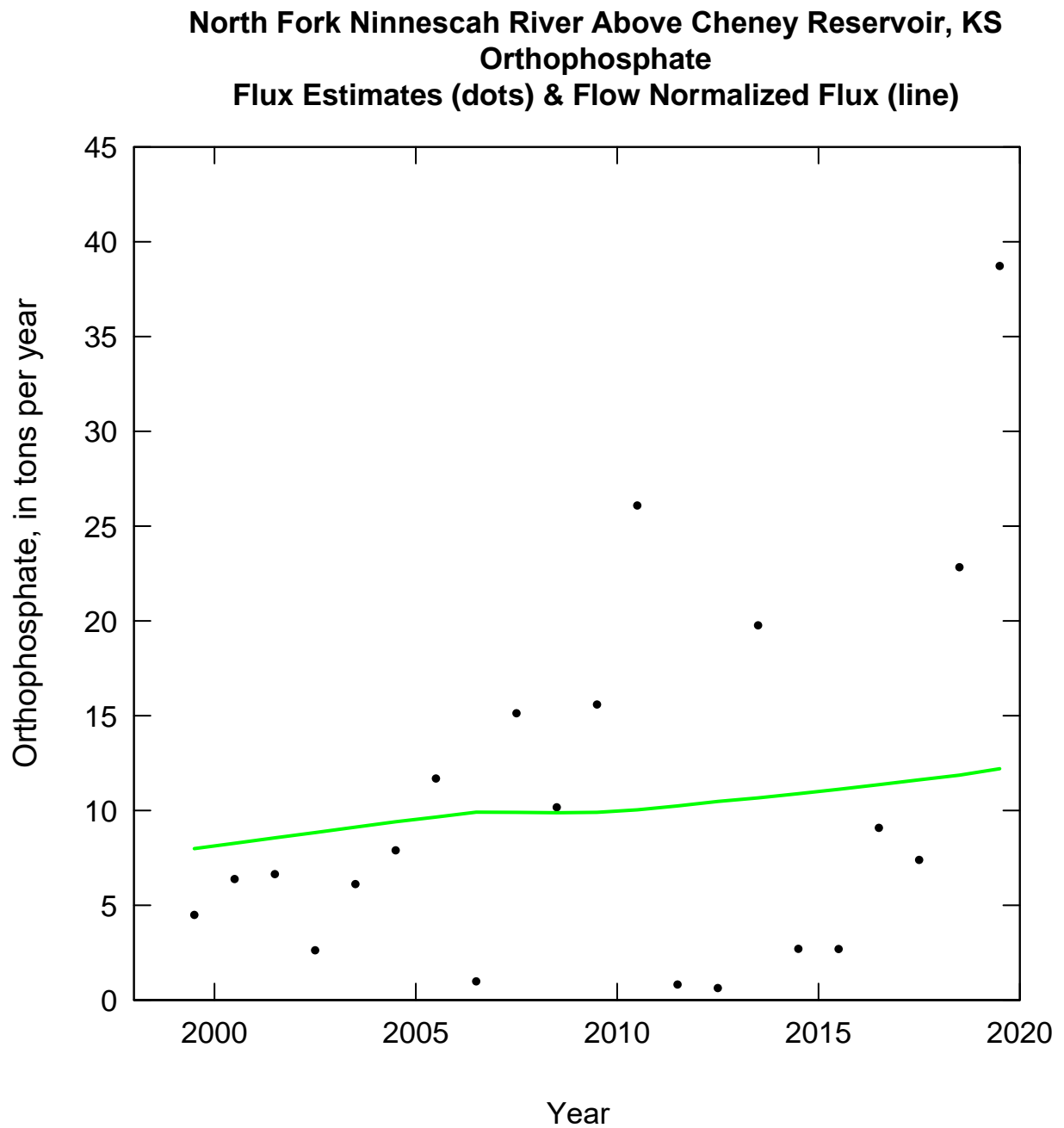
EXPLANATION

- Individual observation above 90th percentile
- 90th percentile
- 75th percentile
- 50th percentile (median)
- 25th percentile
- 10th percentile
- Individual observation below 10th percentile

```
plotConcHist(wrtds)
```



```
plotFluxHist(wrtds)
```



Trend (using EGRETci)

North Fork Ninnescah River Above Cheney Reservoir, KS Orthophosphate

Calendar Year

Bootstrap process, for change from calendar year 1999 to 2017
dataset runs from January 1999 to September 2017 Bootstrap
block length in days 200
bootBreak is 39 confStop is 0.7

Weighted Regressions on Time, Discharge and Season (WRTDS) estimated
concentration change is 0.0111 milligrams per liter (mg/L)

WRTDS estimated flux change is 0.003377 10^6 kilograms per year (kg/yr)

Should we reject H_0 that Flow Normalized Concentration Trend = 0 ? Do Not Reject H_0
best estimate is 0.0111 mg/L
Lower and Upper 90% CIs 0.00230 0.02922
also 95% CIs -0.00381 0.03270
and 50% CIs 0.00927 0.01853
approximate two-sided p-value for Conc 0.068

Likelihood that Flow Normalized Concentration is trending up = 0.971 is trending down = 0.0294

Should we reject H_0 that Flow Normalized Flux Trend = 0 ? Reject H_0
best estimate is 0.003377 10^6 kg/year
Lower and Upper 90% CIs 0.000803 0.008024
also 95% CIs 0.000689 0.008871
and 50% CIs 0.002732 0.005399
approximate two-sided p-value for Flux 0.039

* Note p-value should be considered to be < stated value

Likelihood that Flow Normalized Flux is trending up = 0.99 is trending down = 0.0098

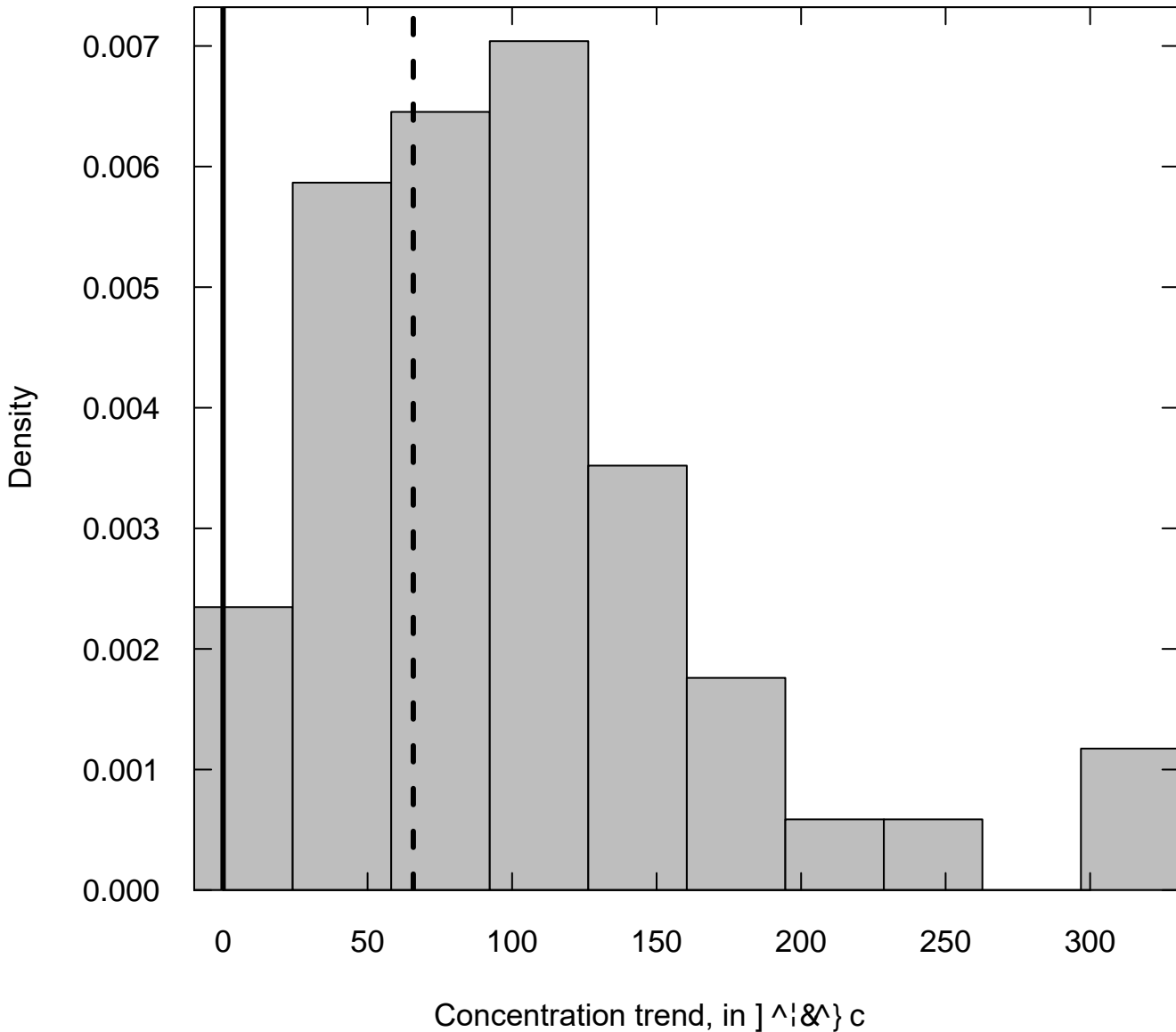
Upward trend in concentration is highly likely
Upward trend in flux is highly likely
Downward trend in concentration is highly unlikely
Downward trend in flux is highly unlikely

```

par(mar=c(5,6,5,0))
par(mfrow=c(2,1))
plotHistogramTrend(wrtds, eBoot, caseSetUp, flux=FALSE)
plotHistogramTrend(wrtds, eBoot, caseSetUp, flux=TRUE)

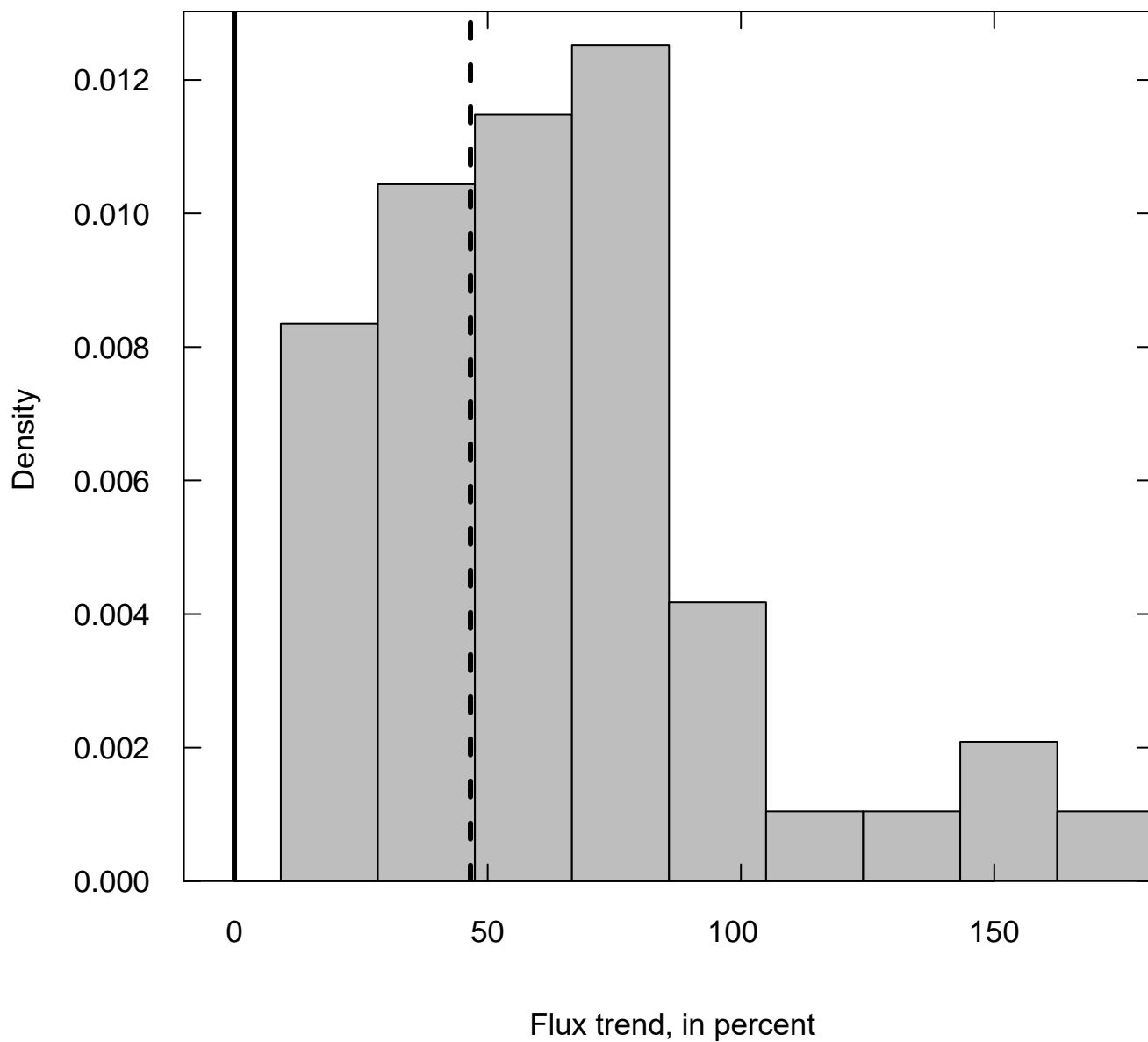
```

**Trend magnitude in Orthophosphate
Flow Normalized Concentration 1999 to 2017
North Fork Ninescah River Above Cheney Reservoir, KS**



solid line = zero line (no trend)
 dashed line = WRTDS trend estimate

**Trend magnitude in Orthophosphate
Flow Normalized Flux 1999 to 2017
North Fork Ninescah River Above Cheney Reservoir, KS**

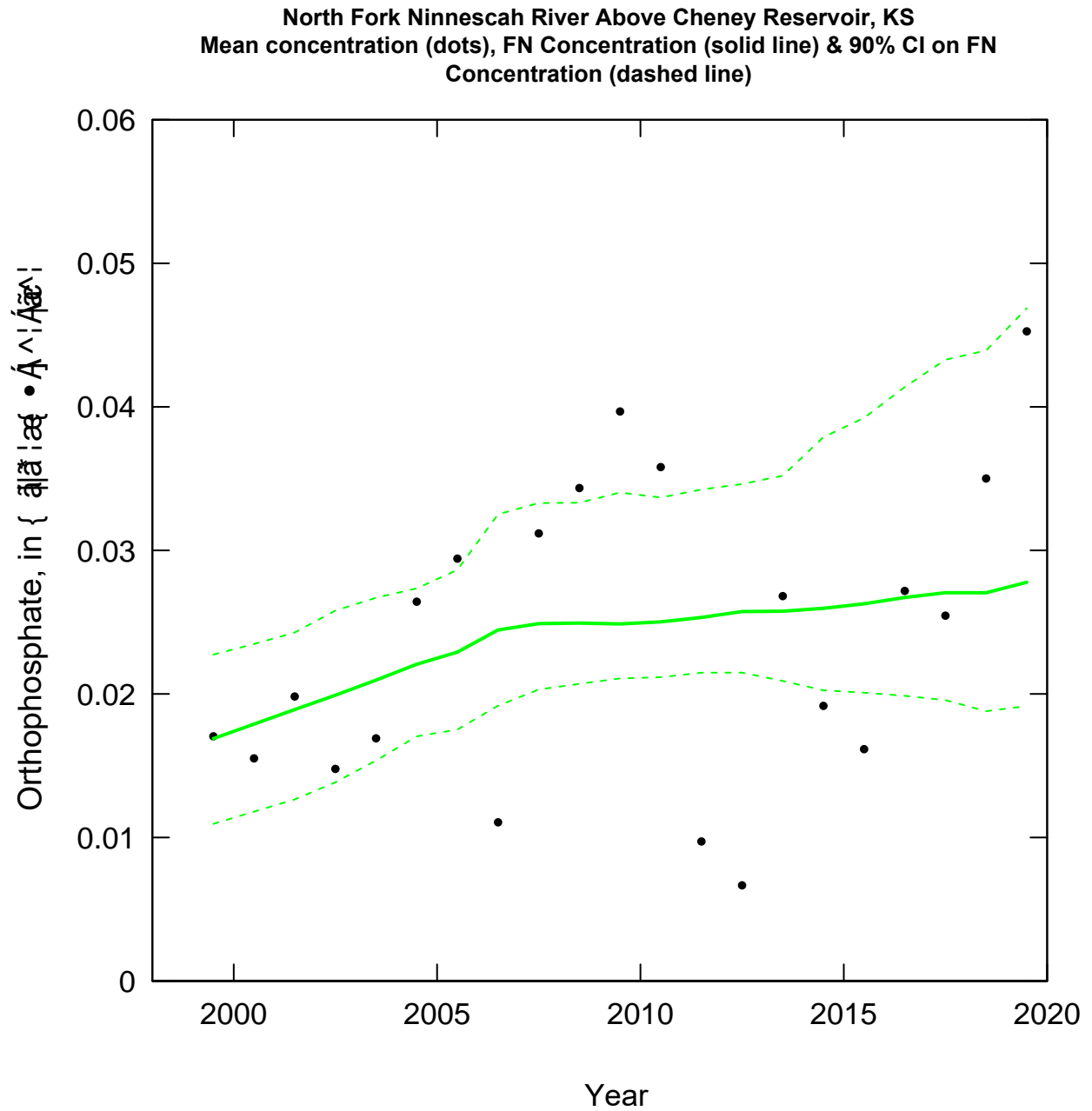


solid line = zero line (no trend)
dashed line = WRTDS trend estimate

```

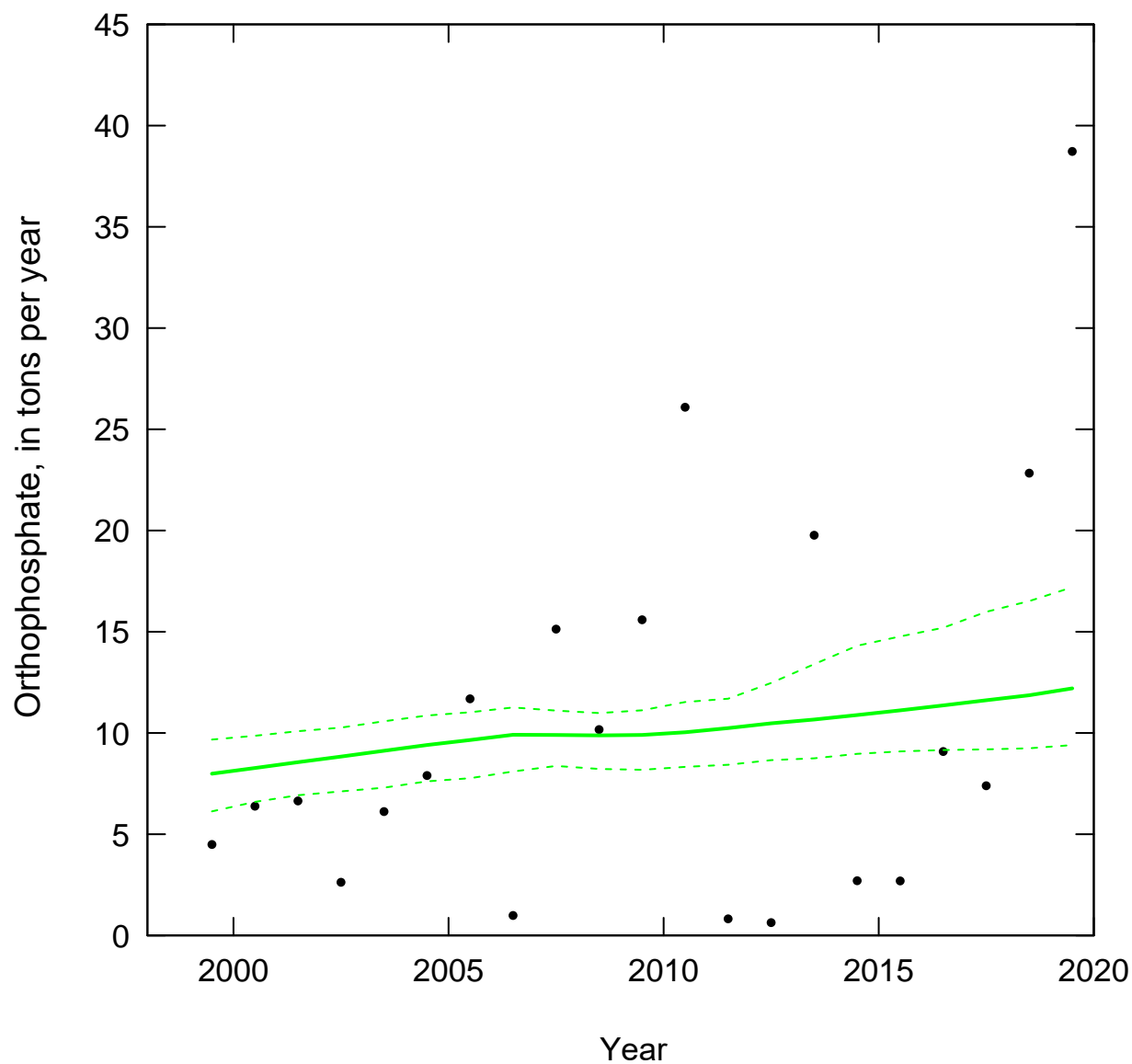
par(mfrow=c(2,1))
plotConcHistBoot(wrtds, CIAnnualResults)
plotFluxHistBoot(wrtds, CIAnnualResults)

```



FN = Flow Normalized
 CI = Confidence Interval

North Fork Ninescah River Above Cheney Reservoir, KS
Mean Flux (dots), FN Flux (solid line), 90% CI on FN Flux (dashed line),
Replicates = 100 , Block= 200 days



FN = Flow Normalized
CI = Confidence Interval

Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

References Cited

Hickman, R.E., and Hirsch, R.M., 2017, Trends in the quality of water in New Jersey streams, water years 1971–2011: U.S. Geological Survey Scientific Investigations Report 2016–5176, 58 p., accessed July 2020 at <https://doi.org/10.3133/sir20165176>.

Hirsch, R.M., Archfield, S.A., and De Cicco, L.A., 2015, A bootstrap method for estimating uncertainty of water quality trends: *Environmental Modelling & Software*, v. 73, p. 148–166. [Also available at <https://doi.org/10.1016/j.envsoft.2015.07.017>.]

Hirsch, R.M., and De Cicco, L.A., 2015, User guide to Exploration and Graphics for RivEr Trends (EGRET) and dataRetrieval—R packages for hydrologic data (ver. 2.0, February 2015): U.S. Geological Survey Techniques and Methods, book 4, chap. A10, 93 p., accessed July 2020 at <https://doi.org/10.3133/tm4A10>.

R Core Team, 2019, R—A language and environment for statistical computing: Vienna, Austria, R Foundation for Statistical Computing, accessed August 2019 at <https://www.R-project.org/>.