Assessing Wading Bird Abundance and Alligator Nesting Trends in Everglades National Park using Generalized Additive Modeling

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Photograph by Elise Pearlstine

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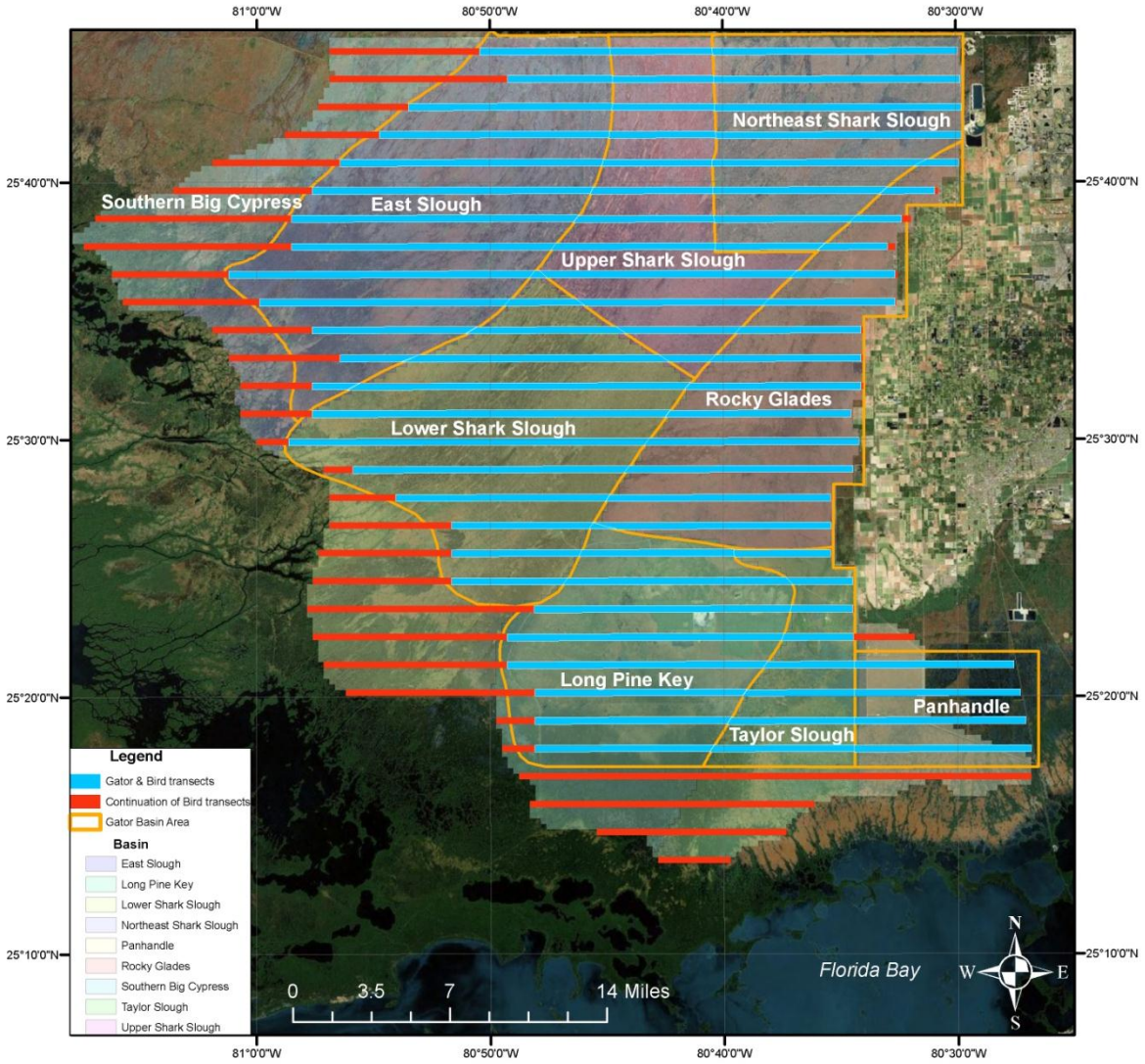
Photograph by Bill Perry

Purpose and Objectives

- Analyze long-term temporal and spatial wading bird abundance and alligator nesting trends in Everglades National Park
- Identify driving covariates linked with trends in wildlife abundance and nesting density
- Identify conservation, restoration and adaptive management recommendations for wading bird and alligator recovery

Systematic Reconnaissance Flight (SRF) Transects



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Methods

- SRF transect data sorted into basins
- Spatially interpolated daily stage (ARC GIS interpolation)
- Monthly rainfall and temperature
- Daily water discharges
- Monthly Southern Oscillation Index (SOI) - NOAA
- Multicolinearity – Variance Inflation Factor and Kendall's R
- Regression analysis
- Backwards/forward stepwise regression model selection using stepGAIC (R-statistical software)

General Additive Models (GAMs)

- Modeling framework for wildlife trend analysis and nonparametric regression modeling (Fewster *et al.* 2000; Hastie and Tibshirani 1990).
- Relaxes modeling linearity assumption and allows for a flexible data structure exploration.
- Nonparametric smoothing splines for predictors.
- GAMLSS - Rigby and Stasinopoulos (2005) enhanced existing GLM and GAM packages.
  - Highly skewed and/or kurtotic distributions and zero-inflated data (Stasinopoulos *et al.* 2008).

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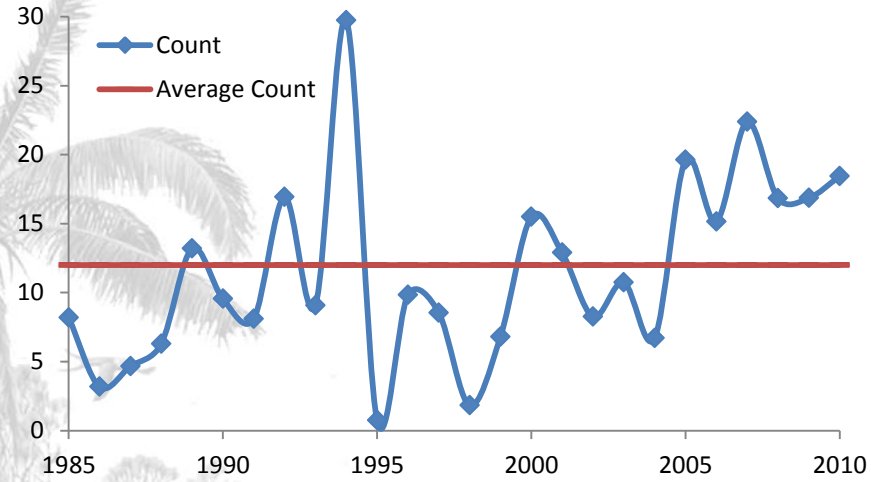
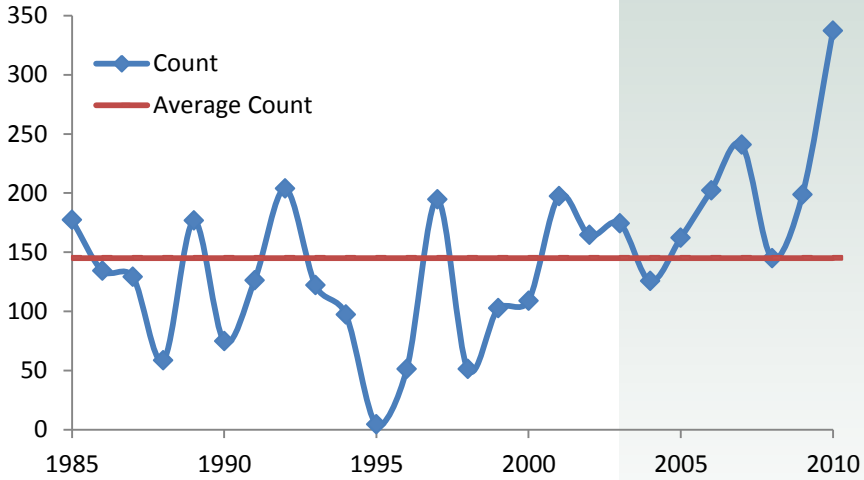
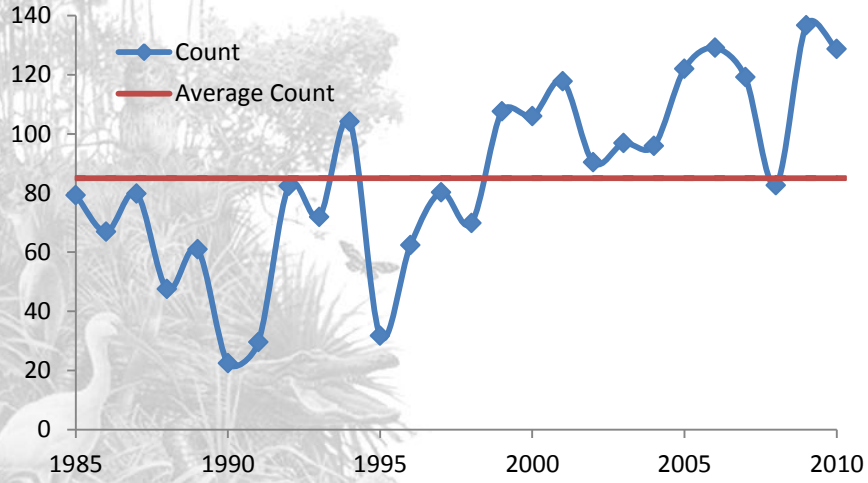
Wood Stork



White Ibis



Great Egret



Wading Bird Covariates

- Basin
- Sc. x coordinate
- Sc. y coordinate
- Sc. Discharges (Dec.-May)
- Rainfall (Jun.-Nov.; Dec.-May)
- Water Depth (Dec.-May)
- SOI (Dec.-May)
- Temperature (Jun.-May)
- Year

GAMLSS Wading Bird Models

Wood Stork~1 + as factor(basin) + *f*(Temp., Jun.-May) + *f*(Year,df=8) + *f*(Rainfall, Jun.-Nov.) + *f*(Sc. y coordinate) + *f*(SOI) + *f*(Avg. Sc. Discharges, Dec.-May) + *f*(Sc. x coordinate) + offset(log(Transect Area))

AIC: 8336

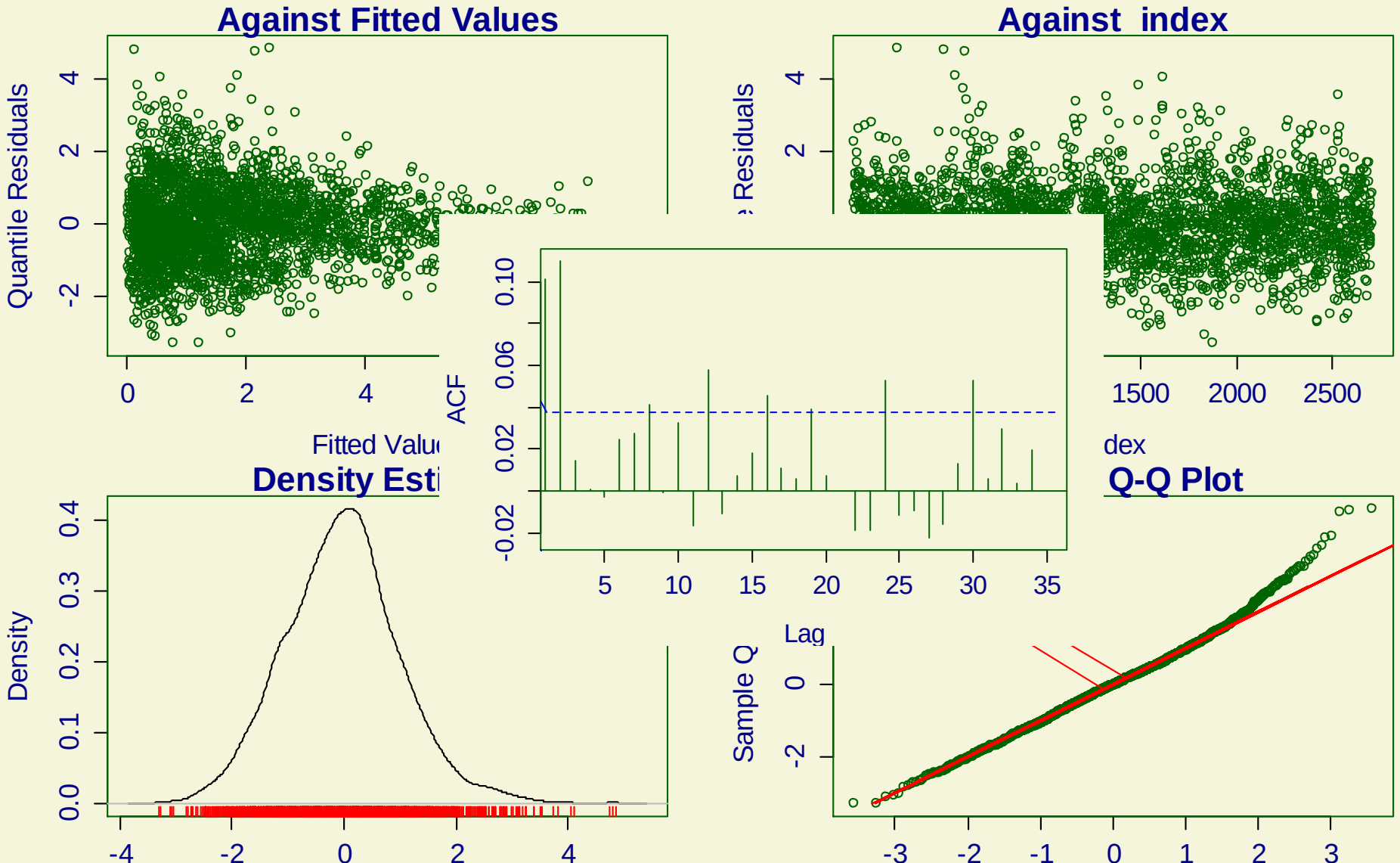
White Ibis~1 + *f*(Avg. Sc. Discharges, Dec.-May) + as factor(basin) + *f*(Temp., Jun.-May) + *f*(Year,df=8) + *f*(Sc. y coordinate) + *f*(Rainfall, Dec.-May) + *f*(Water Depth, Dec.-May) + *f*(Sc. x coordinate) + offset(log(Transect Area))

AIC: 13,246

Great Egret~1 + *f*(Avg. Sc. Discharges, Dec.-May) + as factor(basin) + *f*(Year,df=8) + *f*(Rainfall, Jun.-Nov) + *f*(Sc. y coordinate) + *f*(SOI) + *f*(Water Depth, Dec.-May) + *f*(Sc. x coordinate) + offset(log(Transect Area))

AIC: 11,268

Wood Stork Model Validation



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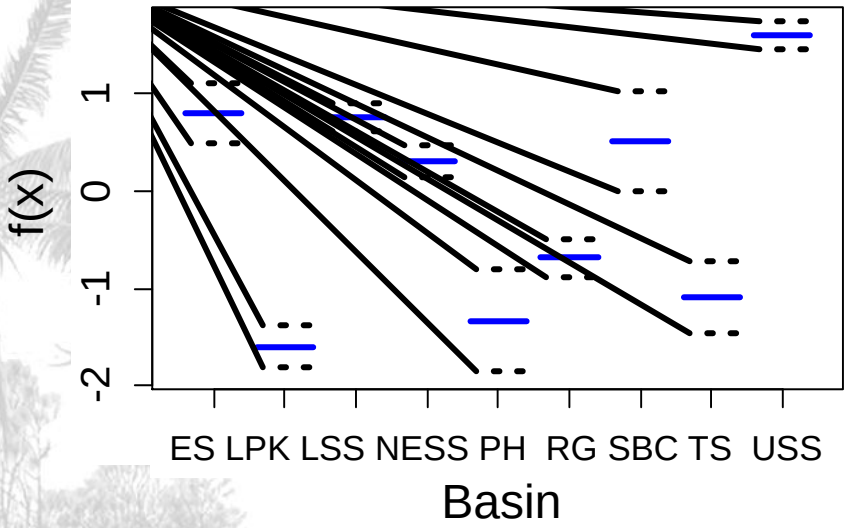
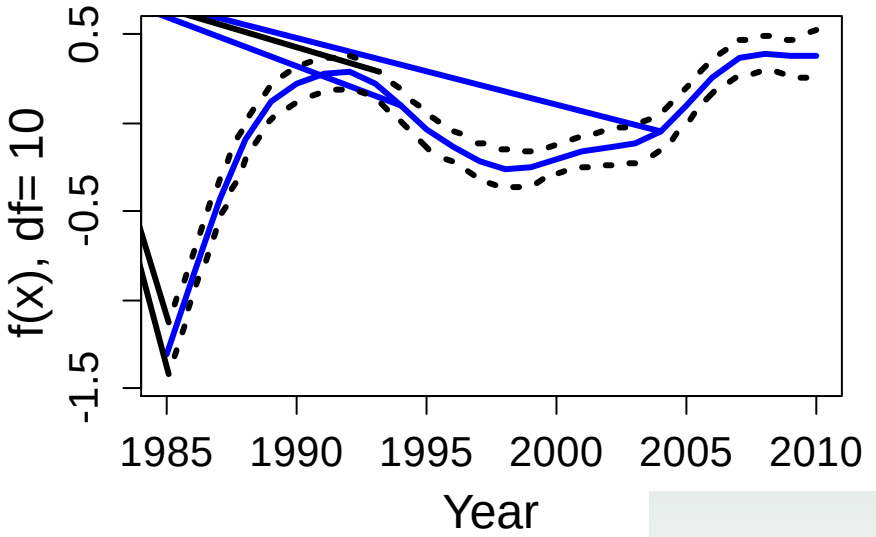
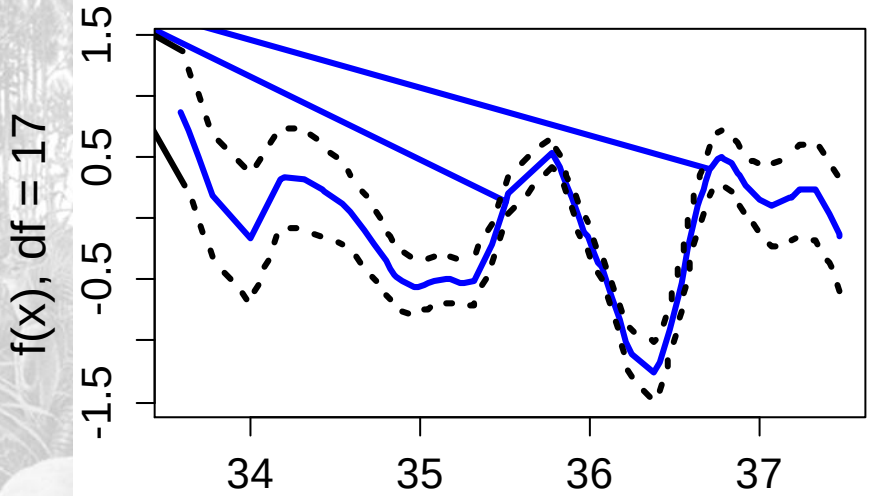
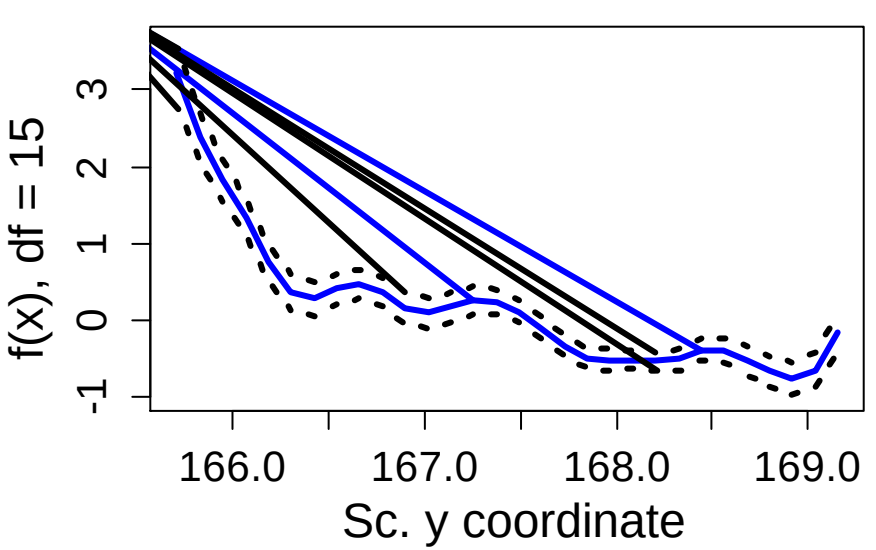
Covariate Response (Wood Stock)









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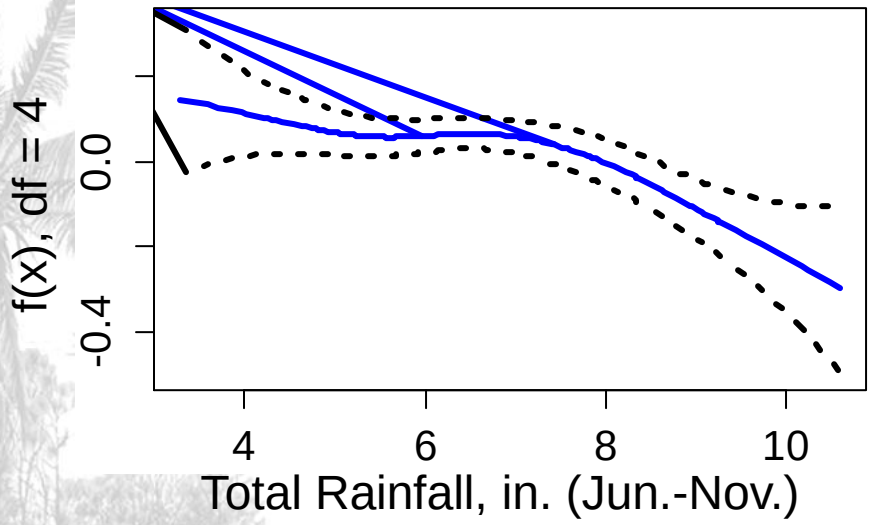
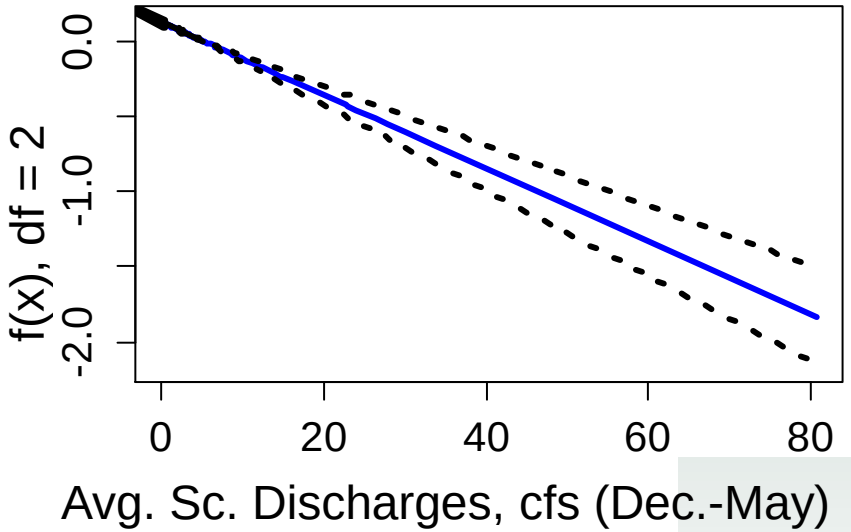
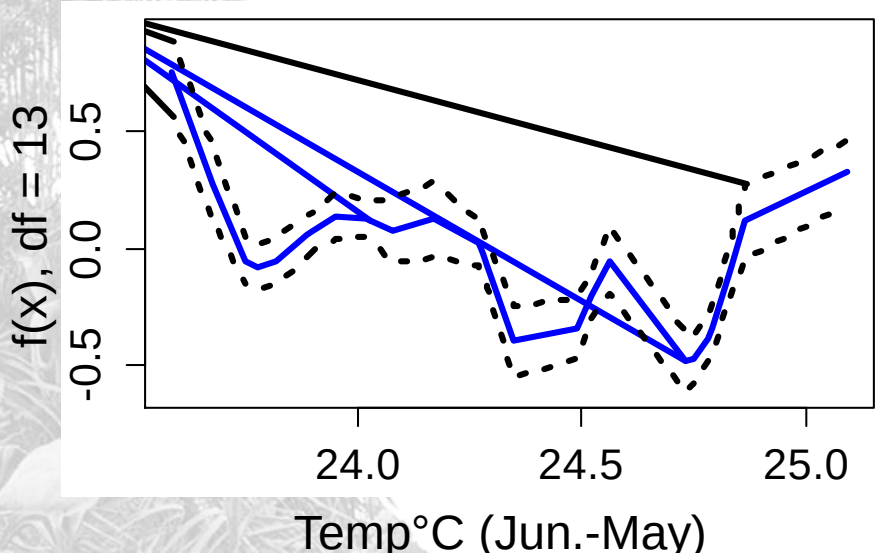
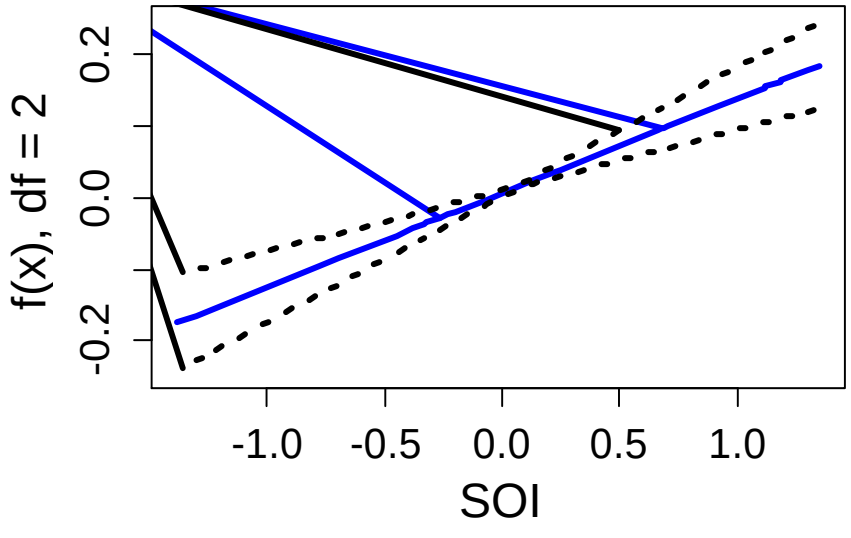
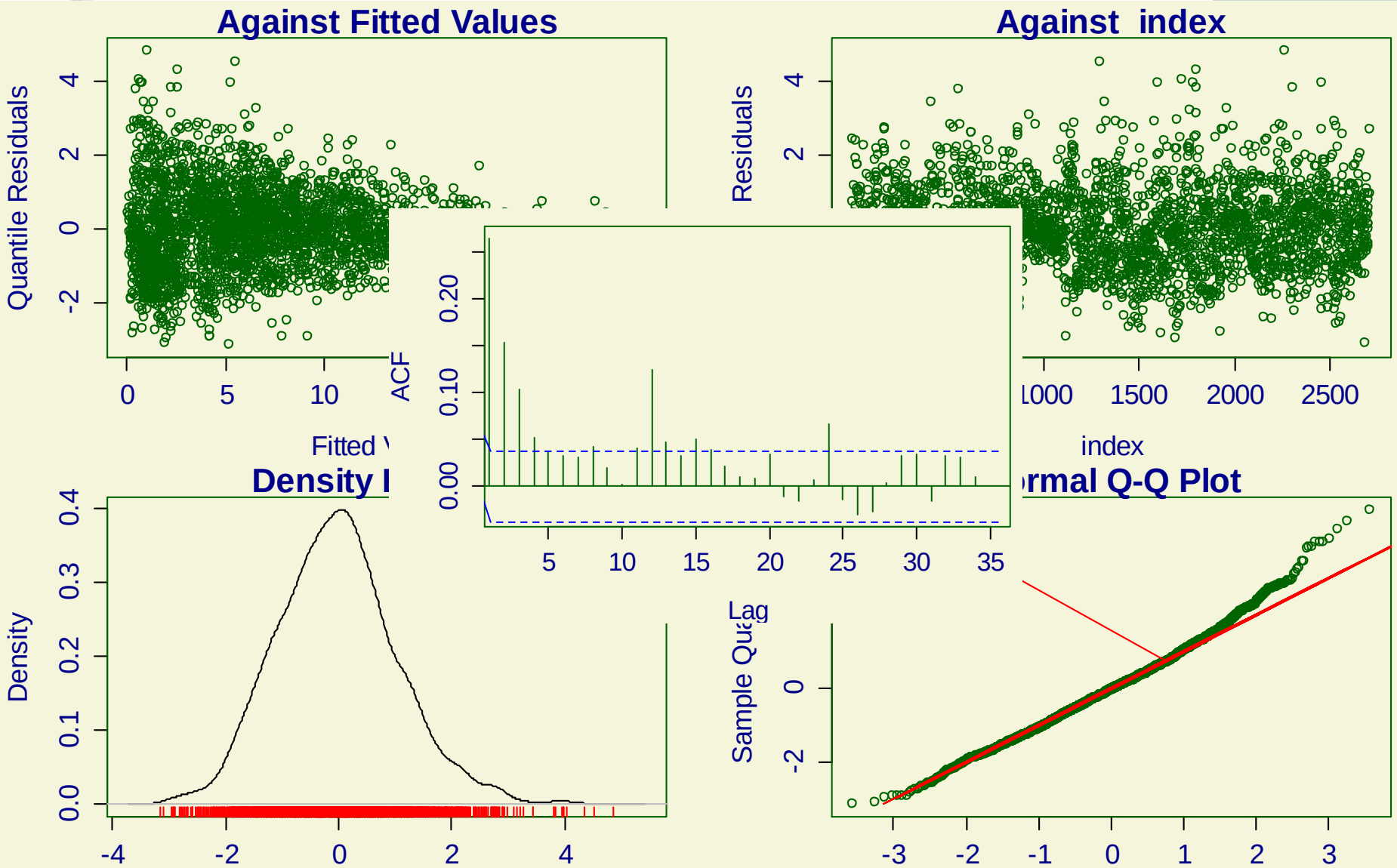








White Ibis Model Validation



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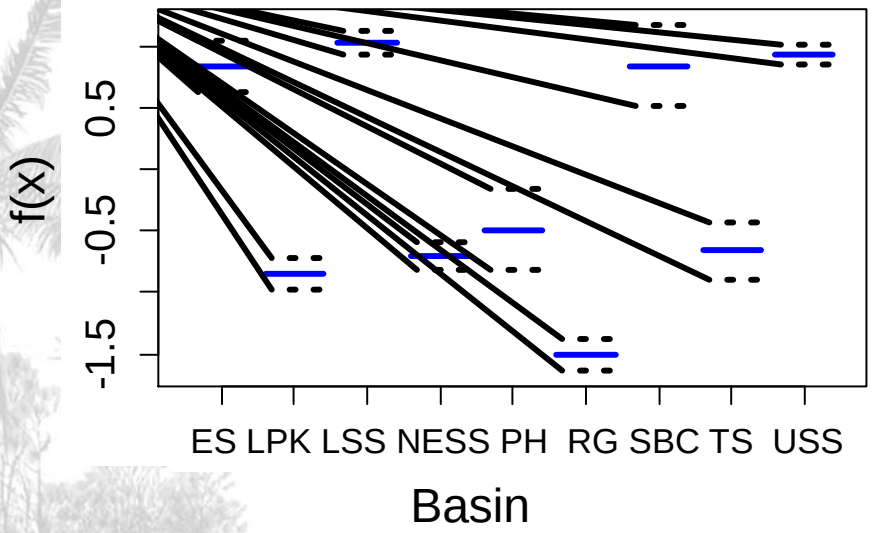

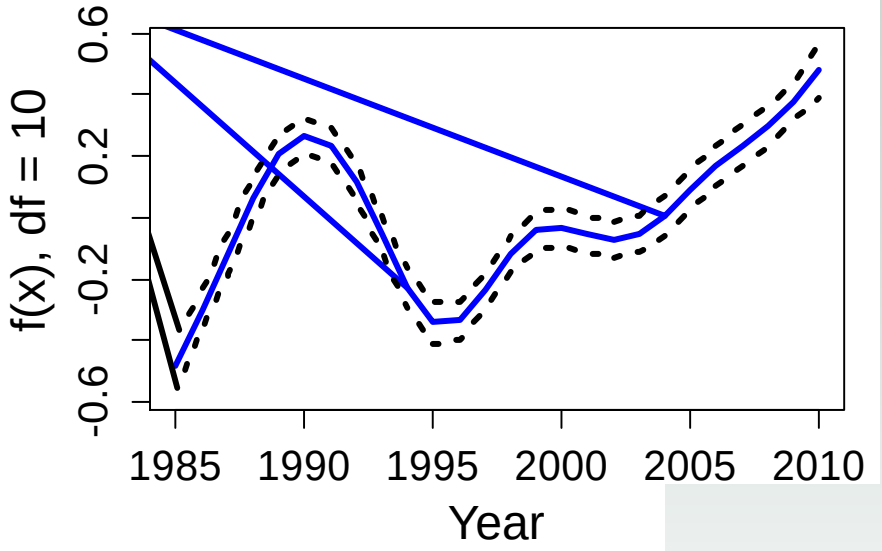

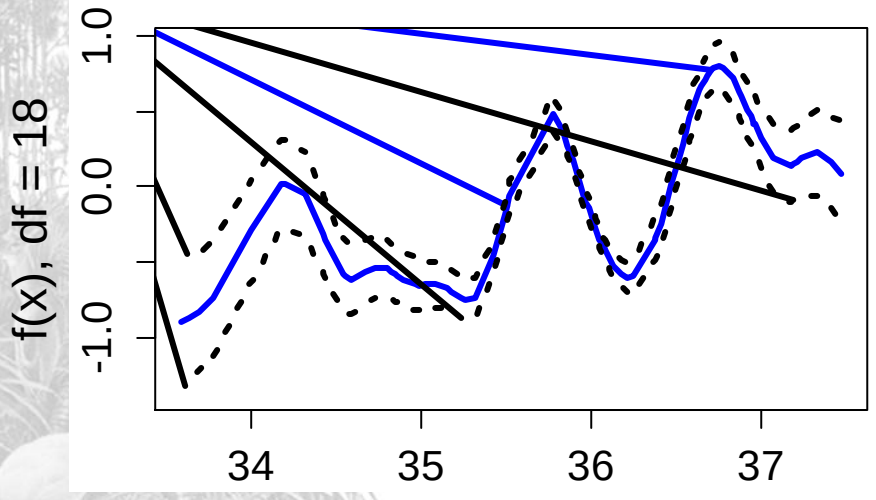

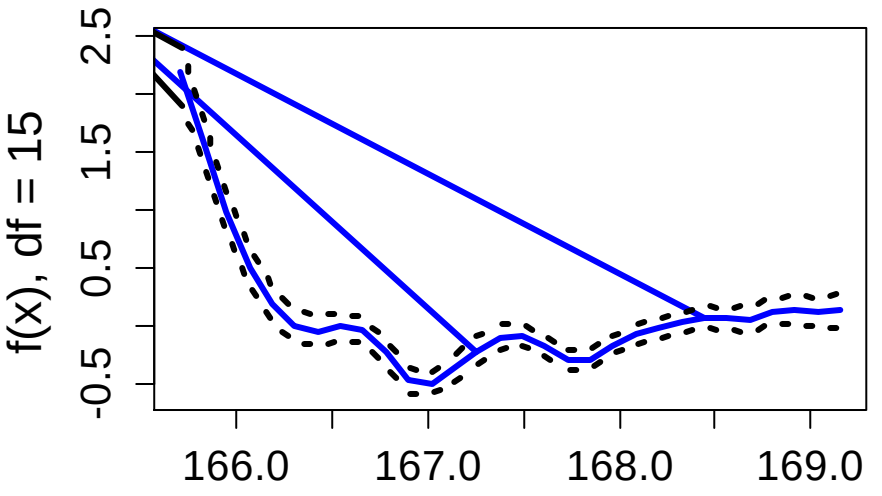

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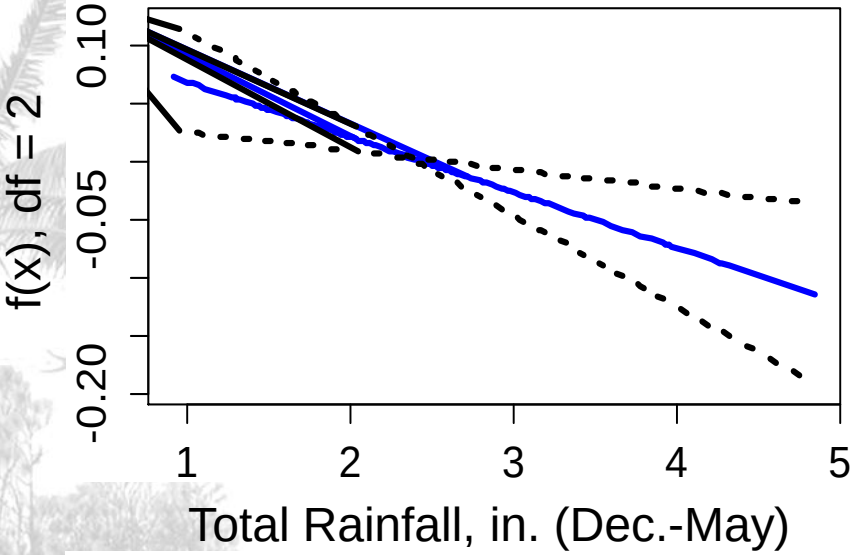
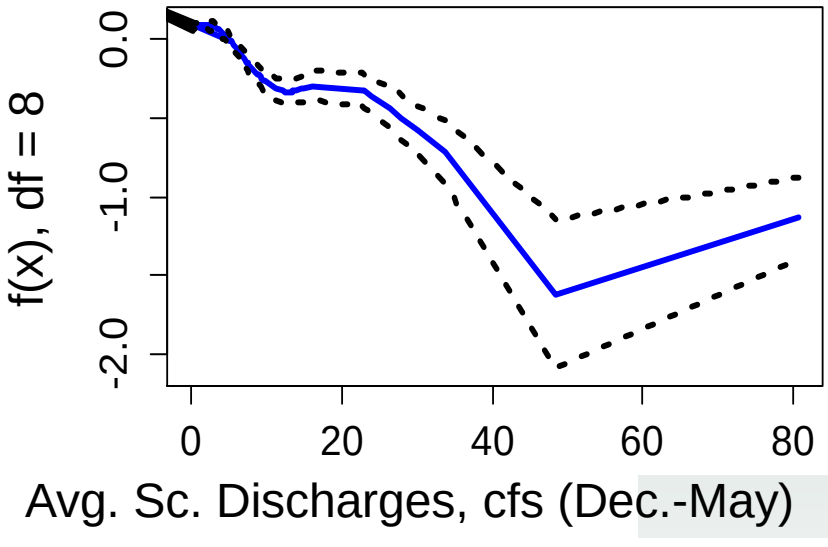
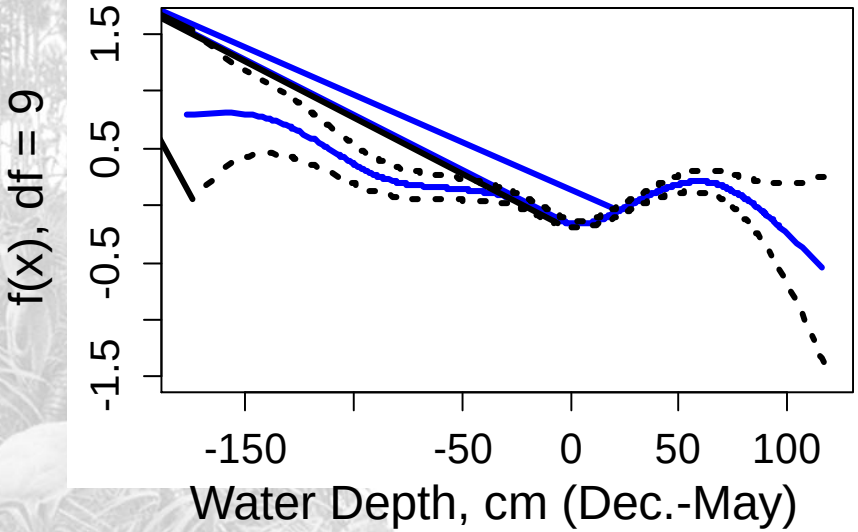
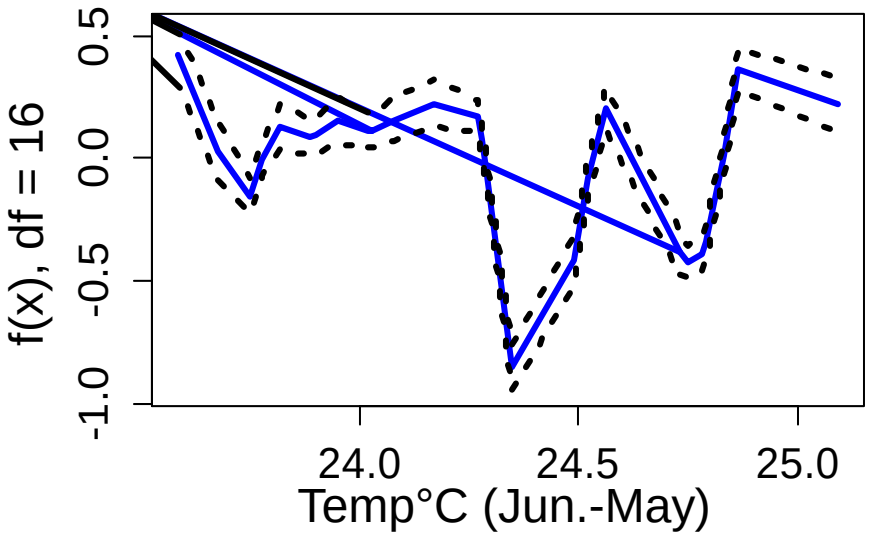
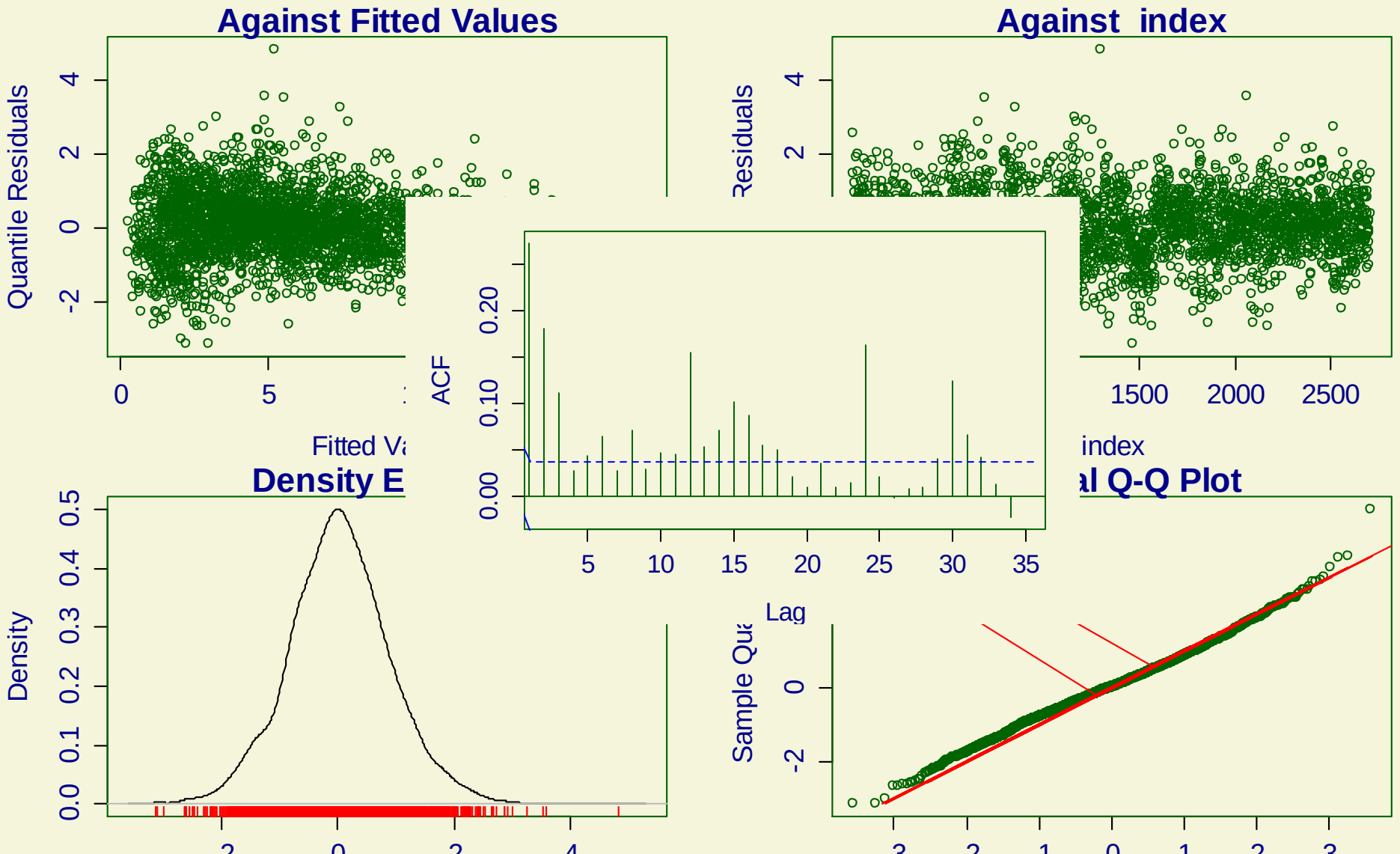








Great Egret Model Validation



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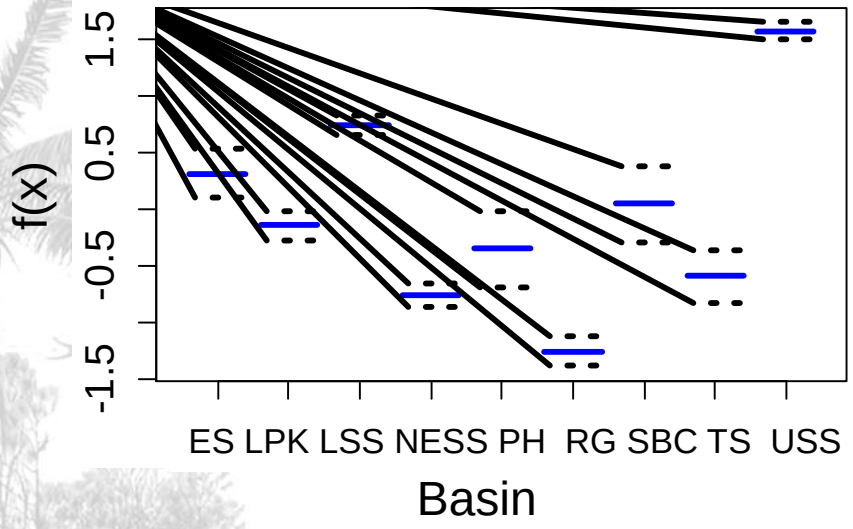
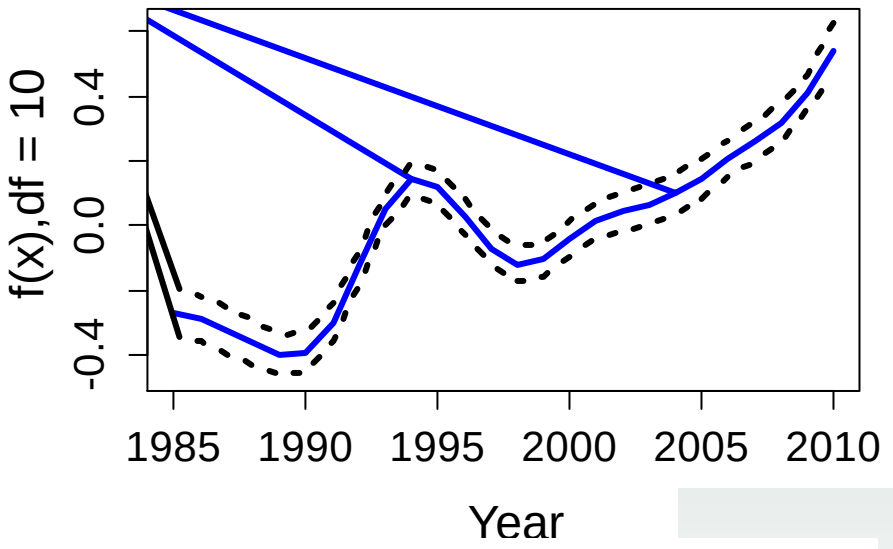
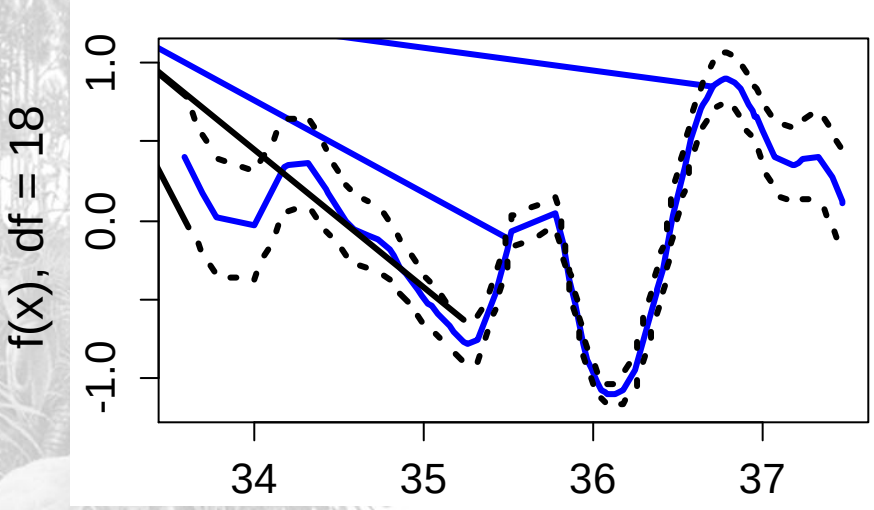
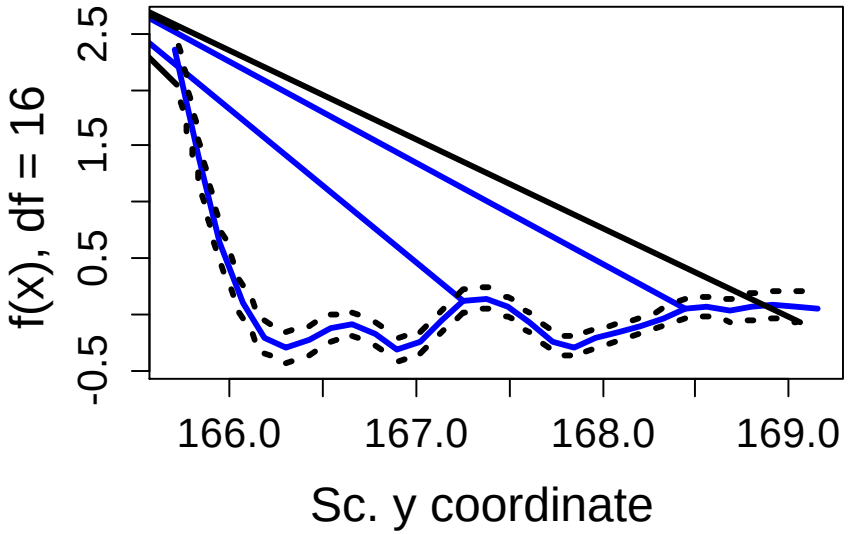
Covariate Response (Great Egret)









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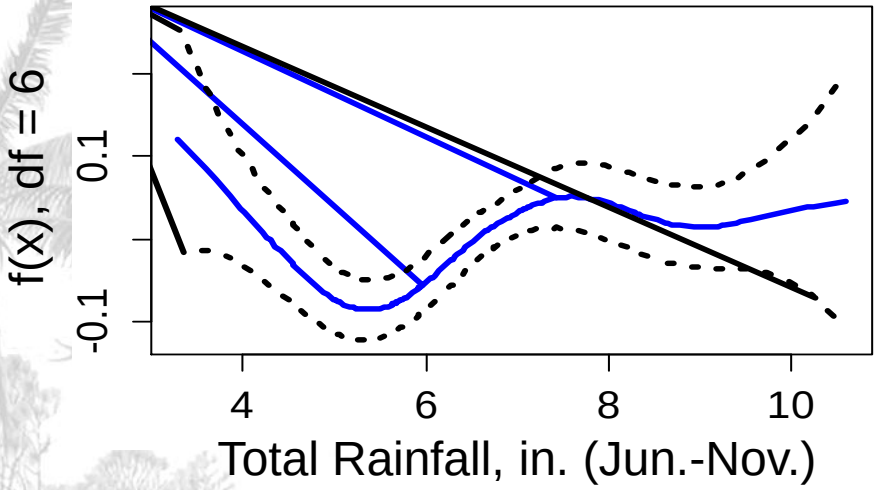
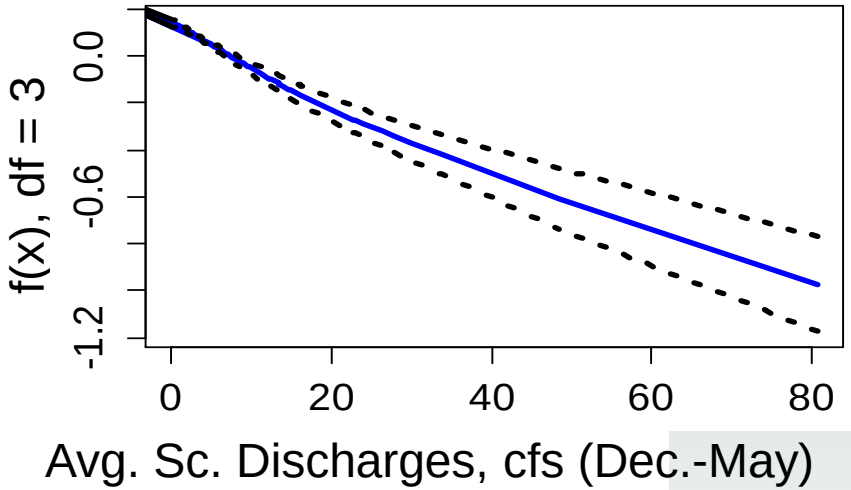
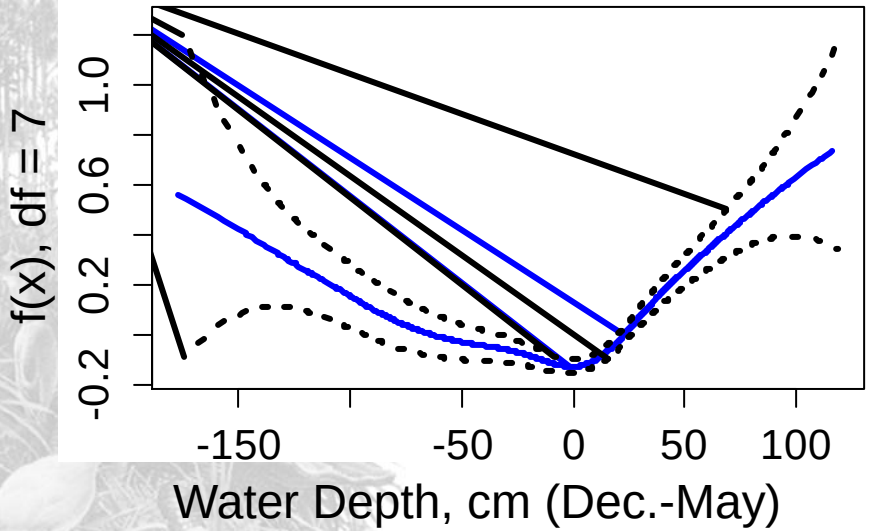
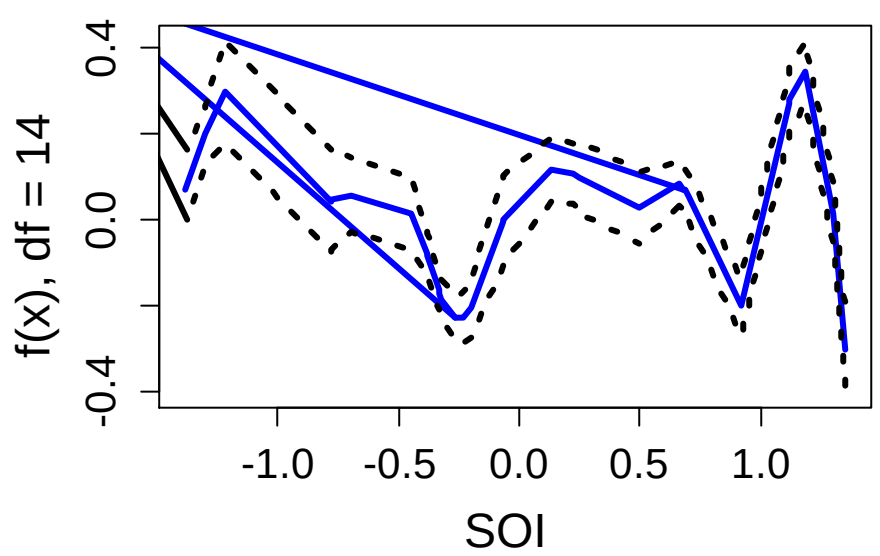
Covariate Response (Great Egret)

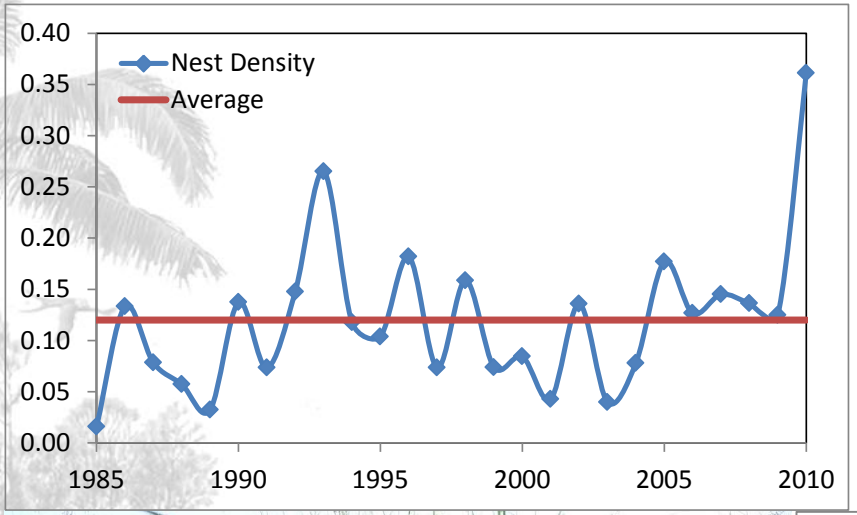


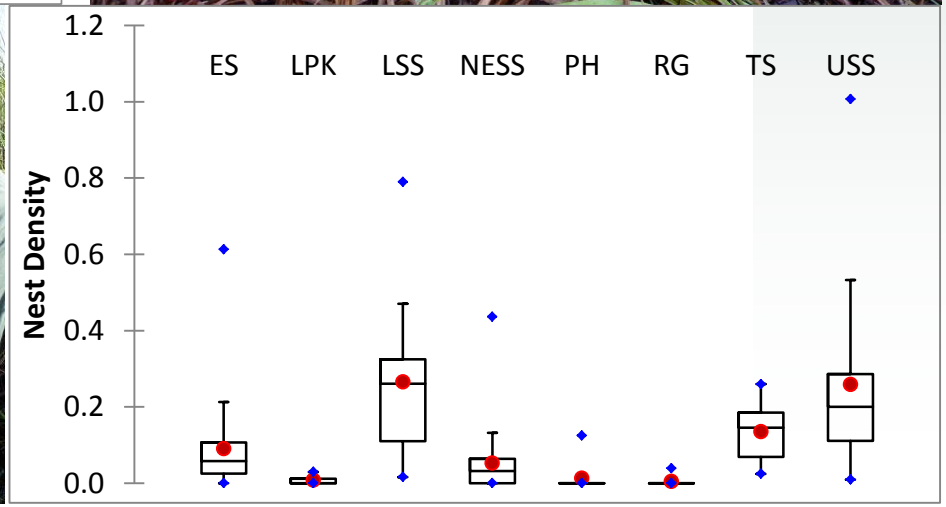






Alligator Nesting Densities





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Alligator Covariates

Stage	Breeding Potential (female growth & survival)	Courtship & Mating	Egg Development	Nest Building	Egg Incubation
Period	April 16- April 15	April 16- May 31	May 16- June 30	June 15- July 15	July 01- Sept. 15

- Average water depths
- Total rainfall during dry (Nov.-May) & wet (June-Oct.) season and annually
- Average discharge during dry & wet season and annually
- Average annual Southern Oscillation Index (SOI)
- Average annual temperature, Dec.–Apr. average temperature
- Transect centroid coordinates
- Basin
- Year

GAMLSS Alligator Model

- stepGAIC procedure- selects explanatory terms using GAIC

Start: AIC= 3118, family = ZINB, Distribution parameter: mu

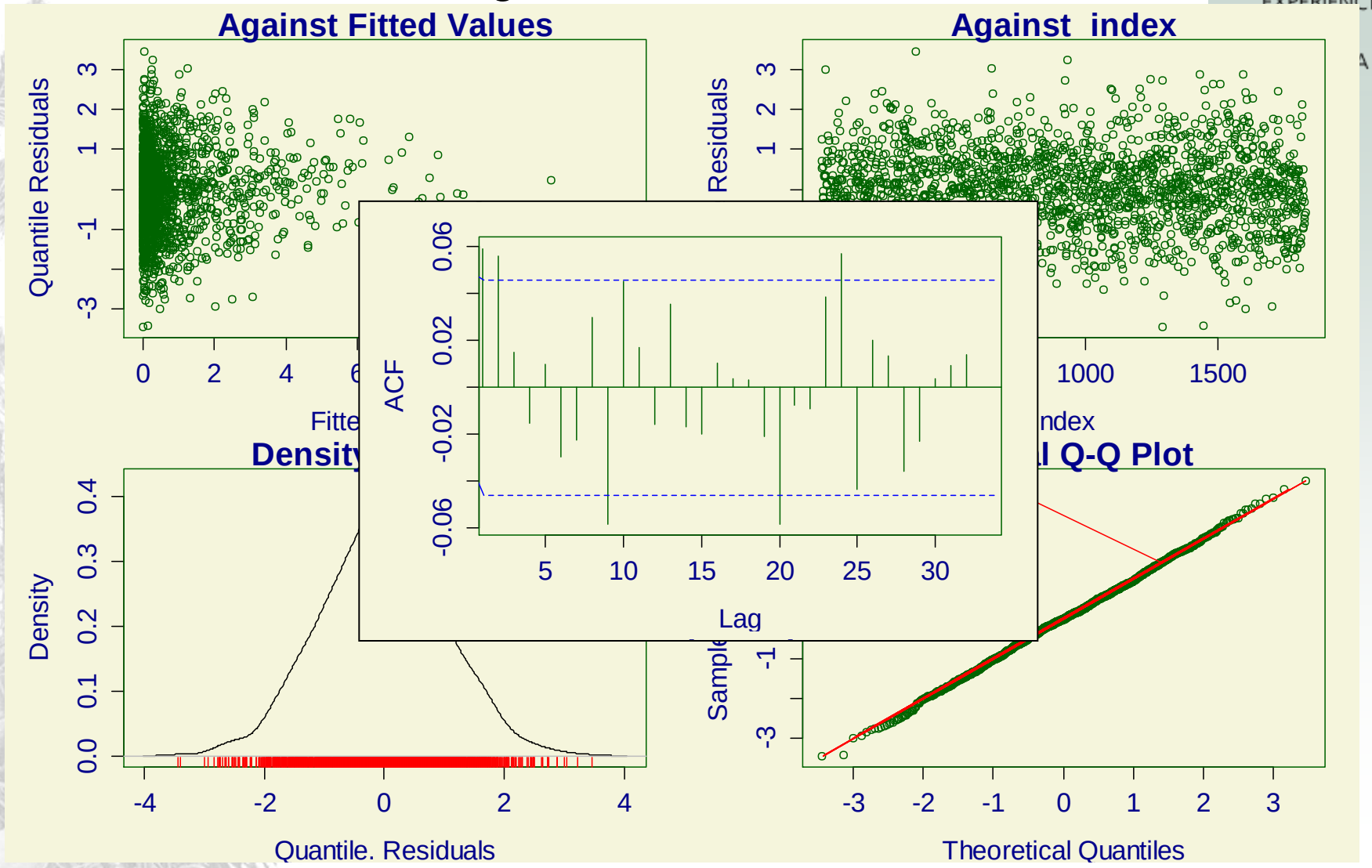
c.nest ~ 1 + offset(log(area.sqkm)) + as.factor(basin) + *f*(flow.wet.scaled) + *f*(x.scaled) + *f*(flow.dry.scaled) + *f*(cmwd) + *f*(nbwd) + *f*(y.scaled) + *f*(Ann.Temp) + *f*(year) + *f*(soi.noaa) + *f*(rf.wet) + *f*(rf.dry)

End: AIC= 3098

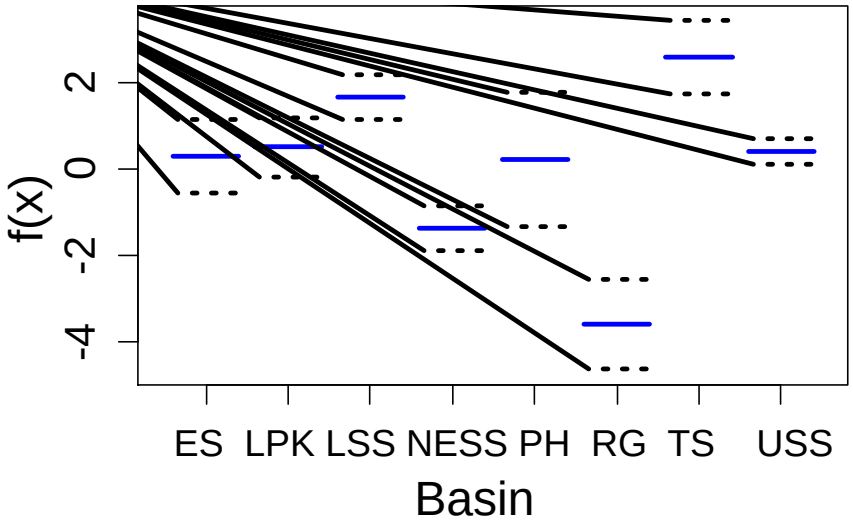
c.nest ~ as.factor(basin) + *f*(x.scaled) + *f*(flow.dry.scaled) + *f*(cmwd) + *f*(y.scaled) + *f*(Ann.Temp) + *f*(year) + *f*(rf.dry) + offset(log(area.sqkm))

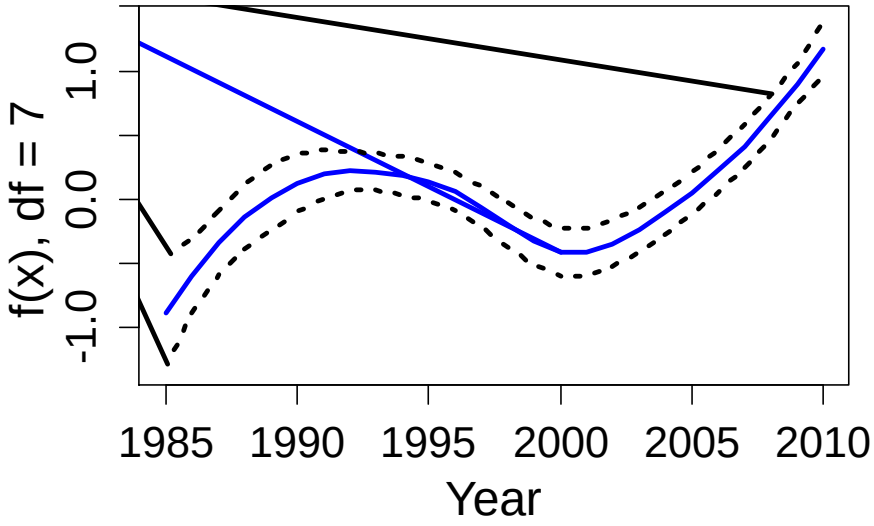
	Df	AIC
<none>		3098.2
- *f*(rf.dry)	-0.1	3099.6
- *f*(x.scaled)	1.2	3099.8
+ *f*(rf.wet)	0.8	3099.9
+ *f*(soi.noaa)	-0.1	3100.4
+ *f*(flow.wet.scaled)	-3.1	3115.3
+ *f*(nbwd)	-4.0	3119.1
- *f*(flow.dry.scaled)	6.3	3119.5
- *f*(cmwd)	-1.5	3119.6
- *f*(Ann.Temp)	5.6	3131.4
- as.factor(basin)	-3.4	3192.1
- *f*(year)	10.0	3206.3
- *f*(y.scaled)	4.8	3240.5

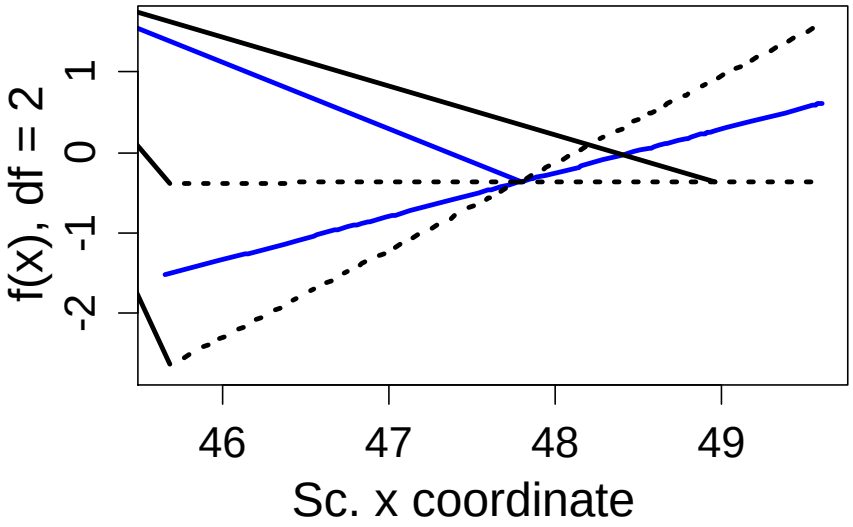
Alligator Model Validation

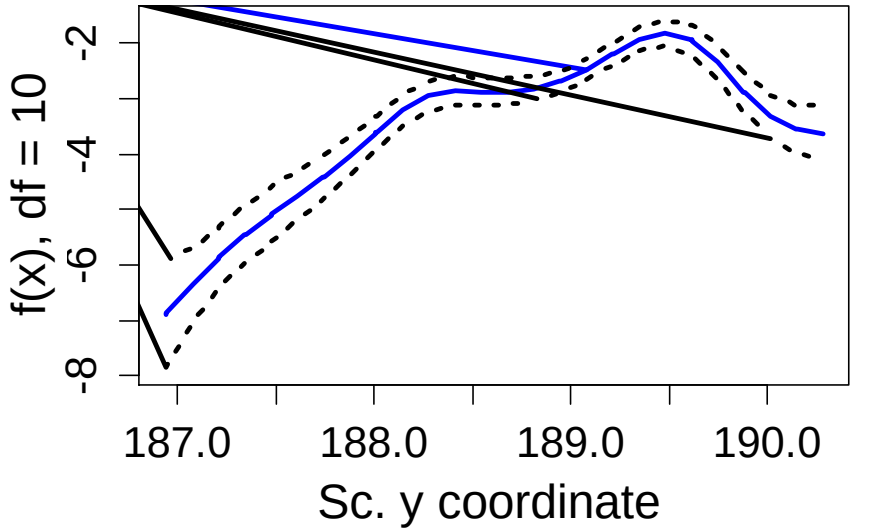


Covariate Response (Alligator)









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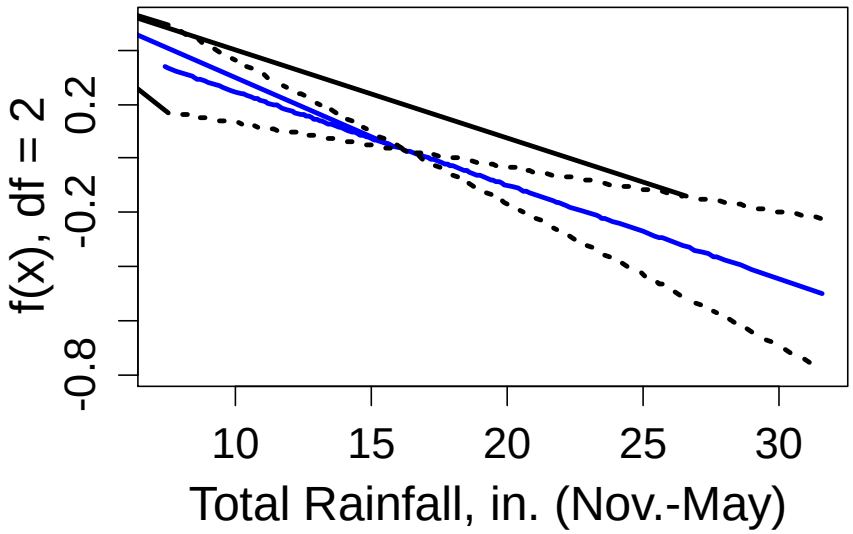

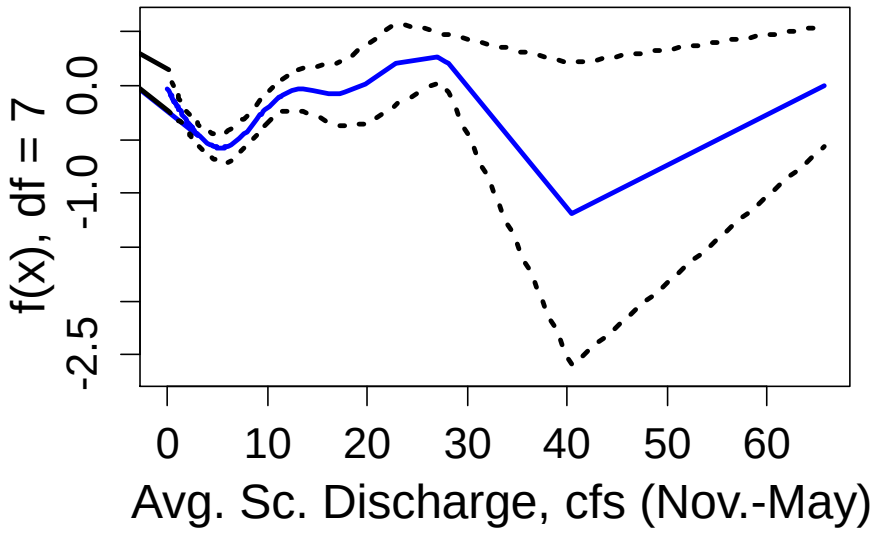

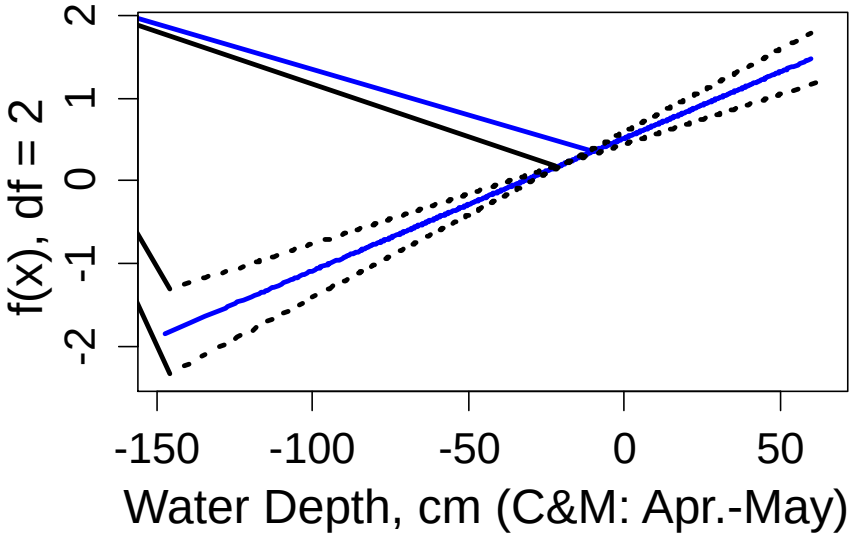

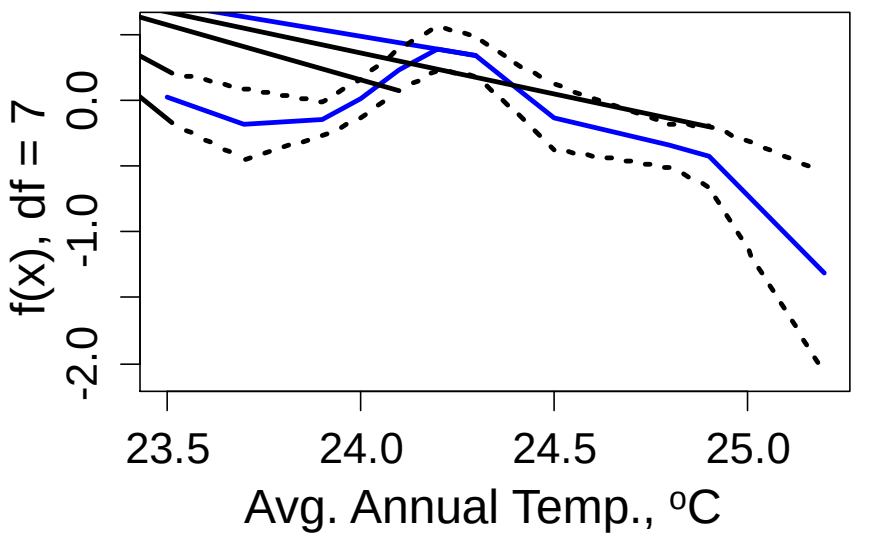

Conclusions

- *Aerial monitoring –effective method to monitor long-term wildlife trends*
- *GAM - a flexible modeling approach for modeling wildlife count data*
- *Anthropogenic and climatic covariates influence wading bird abundance and alligator nesting.*
- *Results provide viable information for water managers and restoration planners.*
- *Long-term monitoring programs important for detecting trends*

References

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Acknowledgements

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- Lori Oberhofer and Sonny Bass for supporting data collection.
- Leonard Pearlstine and Janice Lynch for providing general support to the project and analysis.
- Bill Perry and Elise Pearlstine for providing wildlife photographs.

Extra Slides

Nest Steps & Further Thought

- *Consider interactions of covariates in the modeling analysis*
- *Assess wildlife trends in individual basins to better understand spatial effects*
- *Link change points with environmental covariate time series*
- *Improved covariate data collection – water depth, digital elevation model update, vegetation layer*

Zero Inflated Models

- Ignoring zero inflation
  - Bias in estimated parameters and std. errors
  - May cause over-dispersion
- Solution-
  - Zero-inflated Poisson (ZIP), mixture model
  - Zero-inflated negative binomial (ZINB), mixture model
  - Zero-altered Poisson (ZAP), two-part model
  - Zero-altered negative binomial (ZANB), two-part model
- R- GAMLSS package (Rigby and Stasinopoulos 2005)
  - Includes ZIP, ZINB, ZAP, ZANB and many others

Regression Methods

- Simple linear model
- Generalized least square (GLS)
- Generalized linear models (GLM, GLMM)
- Generalized additive model (GAM, GAMM)
- Distributions-
  - Poisson, quasi-Poisson, negative-Binomial
- Software- R version 2.14.2 (2012-02-29)
- Packages- nmle, lme4, mgcv, gamm4, gamlss
- Zero inflated data-
  - Alligator-71%, woodstork-20%, great egret-6%, white ibis-39%

GLM Alligator Model Validation