Table 1a. Description of parameters used in the model. See Materials and Methods for relevant equations and detailed descriptions.

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Name** | **Description** | |
| Overall |  |  | |
|  | Mean abundance | Mean abundance at time *t* and site *s* | |
|  | Coefficients | Vector of fixed-effect coefficients on abundance | |
| Detection | | |
|  | Detection rate | Mean log-rate of capturing an individual given that it is present at site *s* and time *t* (“log-detection rate”) | |
|  | Variation in detection | Variation in log-detection rate among sites and years | |
|  | Detection variance | Variance of | |
| Spatial |  |  | |
|  | Spatial contribution | Spatial contribution (component?, variation?) to abundance following an Ornstein-Uhlenbeck process | |
|  | Spatial variance | Variance between site and its parent-site following an OU process | |
|  | Spatial decorrelation per kilometer | Exponential spatial decay rate in the correlation between parent and child nodes | |
|  | Asymptotic spatial variation | Parameter governing asymptotic variation in the spatial OU process for two sites that are far apart | |
|  | Spatial correlation | Spatial correlation for site and its parent-site , resulting from an OU process | |
| Temporal | | |
|  | Temporal variation | Temporal variation in abundance resulting from AR1 autoregressive process | |
|  | Temporal correlation per year | Temporal correlation in the annual AR1 process | |
|  | Temporal variance | Variance describing the temporal AR1 process | |
| Spatio-temporal | | |
|  | Spatio-temporal variation | Spatio-temporal variation in abundance resulting from OU process | |
|  | Spatio-temporal variance | Spatio-temporal variance between site and its parent-site | |
|  | Spatio-temporal correlation per year | Temporal decay rate of spatio-temporal variation, representing correlation for a given site in year and year | |
|  | Spatio-temporal correlation | Spatio-temporal correlation between site and its parent-site , resulting from an OU process | |
|  | Spatio-temporal decorrelation per kilometer | Spatial decay rate for spatio-temporal variation | |
|  | Asymptotic spatio-temporal variance | Parameter governing asymptotic variance describing the spatio-temporal OU process for two sites that are far apart | |
| Independent | | |
|  | Overdispersion | Random log-normal variation beyond Poisson expectation (also termed overdispersion or nugget) | |
|  | Overdispersion variance | Variance term for the Poisson log-normal overdispersion term [] | |
|  |  |  | |

Table 1b. Description of data used in the model. See Materials and Methods for relevant equations and detailed descriptions.

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Name** | **Description** |
|  | Covariate data | Row-vector of measured variables affecting abundance (which includes an intercept term) |
|  | Count data | Counts of fish for depletion pass (), site and year *t* assuming that each individual is equally likely to be captured in a depletion pass given that it was not removed during a previous pass |
|  | Offset | Relative length of stream surveyed to standardize abundance to fish per 100 m (Offset = Length­survey/100) |
|  |  |  |

Table 2. Summary table of covariate values for the W. Susquehanna watershed by catchment for draining into each stream reach.

|  |  |  |  |
| --- | --- | --- | --- |
| Variable | Mean | Min | Max |
| Percent forest cover (%) | 79.15 | 0 | 100 |
| Percent surficial coarseness (AB?) | 6.62 | 0 | 100 |
| Previous summer mean temperature (C) | 17.74 | 15.21 | 21.66 |
| Previous fall mean temperature (C) | 3.49 | -0.09 | 7.3 |
| Winter mean temperature (C) | -1.77 | -7.99 | 2.87 |
| Spring mean temperature (C) | 14.63 | 10.31 | 17.31 |
| Previous summer mean precipitation (mm) | 3.78 | 1.59 | 8.92 |
| Previous fall mean precipitation (mm) | 2.99 | 1.29 | 5.01 |
| Winter mean precipitation (mm) | 2.58 | 1.1 | 4.73 |
| Spring mean precipitation (mm) | 2.91 | 1.42 | 6.9 |

Table 3. Description of models compared with AIC for adult and YOY Brook Trout populations in the West Susquehanna watershed.

|  |  |  |
| --- | --- | --- |
| Num | Model | Model components |
| 1 | Basic |  |
| 2 | Spatial (S) |  |
| 3 | Temporal (T) |  |
| 4 | S + T |  |
| 5 | Spatio-temporal (ST) |  |
| 6 | S + ST |  |
| 7 | T + ST |  |
| 8 | S + T + ST |  |

Table 4. Comparison of Brook Trout models for the West Susquehanna watershed using AIC. The models (6 & 8) that included spatial and spatio-temporal components failed to converge with adult data and were not used in the comparison.

**Adult**

|  |  |  |  |
| --- | --- | --- | --- |
| Num | Model | AIC | ΔAIC |
| 5 | Spatio-temporal | 9408 | 0.0 |
| 7 | T + ST | 9408 | 0.3 |
| 4 | S + T | 9583 | 175 |
| 2 | Spatial | 9588 | 180 |
| 3 | Temporal | 9783 | 375 |
| 1 | Basic | 9794 | 387 |
| 6 | S + ST | NA | NA |
| 8 | S + T + ST | NA | NA |

**YOY**

|  |  |  |  |
| --- | --- | --- | --- |
| Num | Model | AIC | ΔAIC |
| 7 | T + ST | 9592 | 0 |
| 8 | S+T+ST | 9596 | 4 |
| 5 | Spatio-temporal | 9663 | 71 |
| 6 | S + ST | 9666 | 74 |
| 4 | S + T | 9739 | 147 |
| 2 | Spatial | 9801 | 209 |
| 3 | Temporal | 9925 | 333 |
| 1 | Basic | 10048 | 456 |

Table 5. Summary of parameter estimates from the model including temporal and spatio-temporal components for adult Brook Trout in the West Susquehanna watershed. The YOY model did not include the previous summer temperature or precipitation since they were not yet laid as eggs. Refer to Table 1 for naming of parameters. The first 11 parameters were fixed effects on abundance contained in the vector of coefficients .

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  |  |
|  | Adult | | YOY | |
| Parameter | Estimate | SE | Estimate | SE |
| Intercept | -2.45 | 0.13 | -3.41 | 0.30 |
| Forest cover | 0.82 | 0.12 | 1.12 | 0.16 |
| Surficial coarseness | 0.01 | 0.06 | 0.04 | 0.08 |
| Summer temperature | -0.26 | 0.05 |  |  |
| Fall temperature | 0.09 | 0.03 | 0.02 | 0.11 |
| Winter temperature | -0.01 | 0.03 | 0.05 | 0.11 |
| Spring temperature | -0.16 | 0.05 | -0.68 | 0.16 |
| Summer precipitation | -0.02 | 0.01 |  |  |
| Fall precipitation | 0.05 | 0.02 | 0.01 | 0.04 |
| Winter precipitation | 0.04 | 0.02 | -0.01 | 0.05 |
| Spring precipitation | 0.05 | 0.02 | -0.06 | 0.06 |
| Detection rate ( | 1.35 | 0.02 | 1.08 | 0.02 |
| Detection SD ( | 0.21 | 0.02 | 0.30 | 0.02 |
| Temporal decorrelation per year ( | 0.59 | 0.26 | -0.05 | 0.21 |
| Temporal SD ( | 0.16 | 0.06 | 0.76 | 0.13 |
| Spatio-temporal decorrelation per year ( | 0.97 | 0.01 | 0.98 | 0.01 |
| Spatio-temporal decorrelation per kilometer ( | 0.16 | 0.03 | 0.13 | 0.02 |
| Asymptotic spatio-temporal SD ( | 0.59 | 0.06 | 0.65 | 0.07 |
| Overdispersion SD ( | 0.36 | 0.04 | 0.53 | 0.04 |

Figure 1. Diagram of network structure with parent-child relationships

Figure 2. Parameter estimates across different values of from the spatial simulation study varying and (Eq. 5). Lower values of represent higher correlation with distance. Parameter estimates and accuracy (RMSE) were compared for the spatial model (Model 2 in Table 3) and a non-spatial model (Model 1 in Table 3). Ranges in the boxplots represent the combined uncertainty from 200 simulations and variation in simulated levels of .

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Figure 3. Parameter estimates across different values of from the spatial simulation study varying and (Eq. 5). Parameter estimates accuracy (RMSE) were compared for the spatial model (Model 2 in Table 3) and a non-spatial model (Model 1 in Table 3). Ranges in the boxplots represent the combined uncertainty from 200 simulations and variation in simulated levels of .

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Figure 4. Results from the power analysis simulations showing the effect of varying the number years each site is surveyed. Variation described by each boxplot resulted from the 200 simulations and varying the number of sites (while holding the number of years constant). For each simulation, we used , , , , , , detection probability , site-level covariate on abundance, and mean abundance = 10.

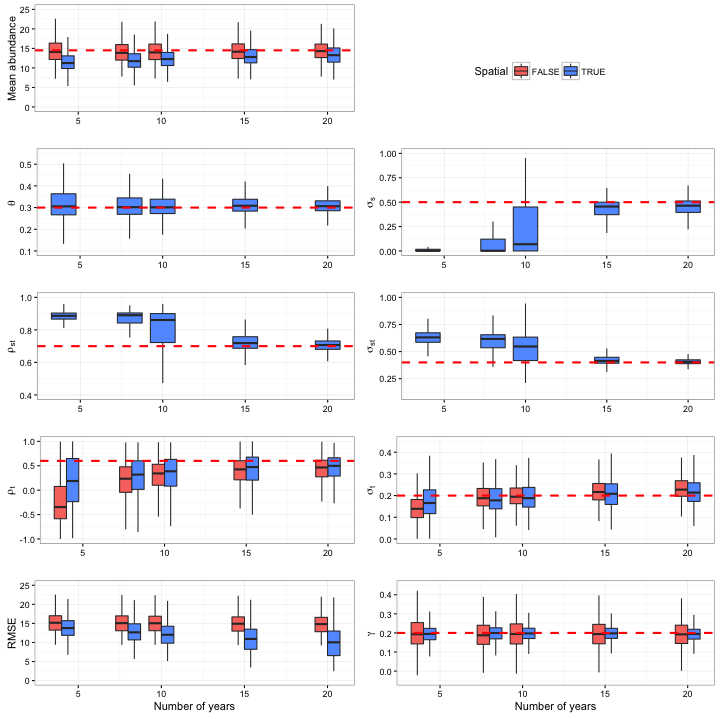


Figure 5. Results from the power analysis simulations showing the effect of varying the number sites surveyed. Variation described by each boxplot resulted from the 200 simulations and varying the number of years each site was surveyed (while holding the number of sites constant). For each simulation, we used , , , , , , detection probability , site-level covariate on abundance, and mean abundance = 10.

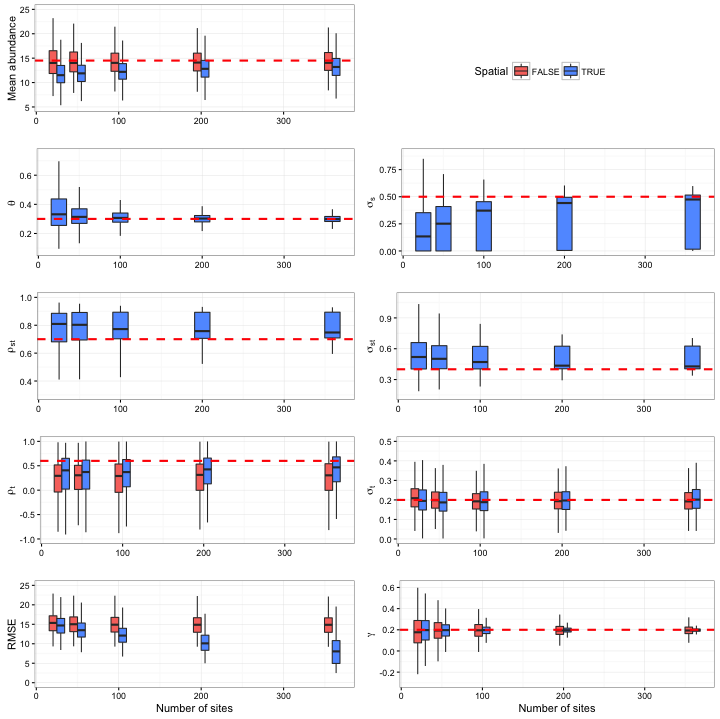
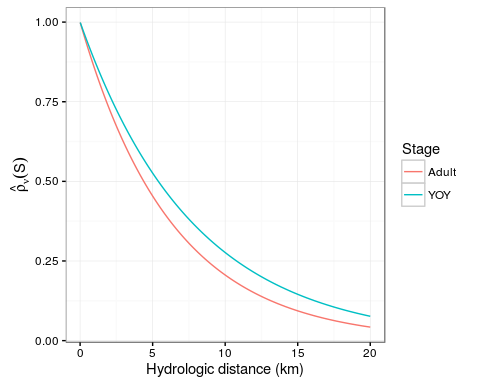


Figure 6 (low res). Example of a spatiotemporal simulation of the abundance along a stream network over time. The top row shows the true (simulated) abundances and the middle row depicts the mean expected abundance based on the matching spatiotemporal model (Eq. 1). The bottom row shows the mean expected density for a model with temporal autocorrelation but no spatial or spatiotemporal contributions (Model 3 in Table 3). The simulation used values of , , theta\_st, sigma\_st, AR1, sampled at N\_sites = 50 in N\_years = 8.

For each simulation, we used , , , , , , detection probability , site-level covariate on abundance, and mean abundance = 10.

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Figure 7. Spatio-temporal decay curves with distance for adult and YOY Brook Trout in the West Susquehanna watershed for the model including temporal and spatiotemporal components. is the expected correlation between parent and child nodes for a given distance (Eq. 11).



Below. Optional for paper or appendix but not including currently in either. Shows lack of stock-recruit relationship but modest effect of YOY to adult recruitment. These are both known for brook trout but I’m not sure how much they’re referenced directly. It’s not the focus of this paper and I think our model works modestly at best for YOY.

