Supplement S1:

Supplemental Materials for "Dominant modes of agricultural production helped structure initial COVID-19 spread in the U.S. Midwest."

Bergmann, L.; Chaves, L.F.; O'Sullivan, D.; Wallace, R.G. Dominant modes of agricultural production helped structure initial COVID-19 spread in the U.S. Midwest. *ISPRS International Journal of Geo-Information* **2023**, *12*, 195.

Supplementary Methods

Identifying subperiods for analysis

We used SaTScan [25] to locate any boundaries between such subperiods. We calculated weekly new cases for each Friday from 3 January to 11 December 2020 in each county. Each county's population and population centroid were obtained from IPUMS NHGIS's dataset for 2020 [71]. We specifically used the SaTScan method for retrospective spacetime cluster detection [24]. This method assumes that cases follow a Poisson model and that cases occur within a population with known size. SaTScan tests the hypothesis that populations within the clusters have an elevated risk compared with populations outside the cluster. In brief, as we configured the algorithm, elliptic cylinders slide through spacetime populated by points that represent the population centroids for each county where transmission and cases are assumed to occur. We chose elliptic cylinders as they allow a wider range of cluster geometries than circular cylinders [72]. To test the significance of the cluster we employed a total of 1000 Monte Carlo simulations that compare the rank of the cluster's maximum likelihood estimate with the maximum likelihood from random datasets through likelihood ratio tests (LRT)[24].

Supplementary Tables and Figures

Table S1. Variables used in regression model selection for explaining COVID-19 across U.S. Midwest counties before the first vaccines received Emergency Use Authorization in the U.S.

Category	Variable Name(s)	Description	Source / Method
		Dependent Variables	

Total COVID-19 cases in counties per thousand residents within a time period	`COVID_cases_per_1000persons__over_period_1`
	
	`COVID_cases_per_1000persons__over_period_2`
	
	`COVID_cases_per_1000persons__over_both_periods`
		Cumulative number of cases in the period in question, divided by the thousands of residents in the county. Period 1 is between 2020-01-01 and 2020-10-09; Period 2 is between 2020-10-10 and 2020-12-11; and 'over both periods' combines both those periods' data.	Cumulative case data [22] was divided by population data from the US Census's [23] 5-year ACS 2016-2020, table B03002, retrieved using the R library *tidycensus* [73].

		Potential Covariates Examined	
Days since first COVID-19 case reported	`days_of_COVID_period_1`	Number of days between the the first day the county reported a case and the last update of case numbers in a county before the end of Period 1.	Calculated based on New York Times [22].
Medical insurance and the uninsured	`uninsured_pct`	Percentage of individuals who are uninsured in 2019, estimated to small areas by the US Census.	Small Area Health Insurance Estimates [74]. Data used here are the 2019 `PCTELIG` ("Percent uninsured in demographic group for all income levels") for `iprcat` of 0 ("All income levels").
Census concepts of race and ethnicity	`population_Black_pct`	Percentage of population identified as 'Not-Hispanic or Latino' and 'Black or African American Alone' by the US Census's American Community Survey (ACS).	Percentage ratio calculated from the US Census's [23] 5-year ACS 2016-2020, table B03002, lines 004 and 001, retrieved using the R library *tidycensus* [73].
	`population_Hispanic_pct`	Percentage of population identified as 'Hispanic or Latino' by the US Census's American Community Survey (ACS).	Percentage ratio calculated as described above, but from lines 012 and 001.

Category	Variable Name(s)	Description	Source / Method
	population_Asian_pct	Percentage of population identified as 'Not-Hispanic or Latino' and 'Asian Alone' by the US Census's American Community Survey (ACS).	Percentage ratio calculated as described above, but from lines 006 and 001.
	population_Native_pct	Percentage of population identified as 'Not-Hispanic or Latino' and 'American Indian and Alaska Native Alone' by the US Census's American Community Survey (ACS).	Percentage ratio calculated as described above, but from lines 005 and 001.
Inequality	income_inequality	A measure of income inequality in derived from the ratio of household incomes at the upper ends of the lowest quintile and the fourth quintiles of the income distribution (Mollalo et al. 2020)	Ratio calculated from the US Census's [23] 5-year ACS 2016-2020, table B19080, lines 004 and 001, retrieved using the R library *tidycensus* [73].
Life expectancy	life_expectancy_at_birth_2014	Life expectancy at birth in 2014.	Institute for Health Metrics and Evaluation [75,76].
Structure of the county economy quantified by mix of employment across sectors	employment_2019_percent_primary_agricultural_and_extractive_sectors	Percentage of 2019 county employment within Primary (agricultural and extractive) sectors.	U.S. Bureau of Economic Analysis [77] Regional Economic Accounts, Personal Income (State and Local), CAEMP25N (Total Full-Time and Part-Time Employment by NAICS Industry). We divided the sum of county employment under NAICS codes 111-112 ('Farm employment'), 113-115 ('Forestry, Fishing, and related activities'), and 21 ('Mining, quarrying, and oil and gas extraction') by total county employment on LineCode 10. Suppressed data (D) replaced with zeros.
	employment_2019_percent_secondary_goods_sectors	Percentage of 2019 county employment within Secondary (goods-producing) sectors.	Similar to the above but with the ratio numerator substituting in NAICS codes 22 ('Utilities'), 23

Category	Variable Name(s)	Description	Source / Method
			('Construction'), and 31-33 ('Manufacturing').
Slaughterhouses	`slaughterhouses`	Number of slaughter-houses per county in October 2020.	Obtained latitude and longitude coordinates from USDA Food Safety and Inspection Service (FSIS) Meat, Poultry and Egg Product Inspection Directory [78]. Counted number of establishments within each county.
Counties whose environments are inflected by conventional and/or regenerative agriculture	`conventional_food_system`	A sum of variables associated with *conventional* agricultural environments at a county scale around the year 2017: (Average farm size acres) + (Pesticide farms/total farms in the county) + (average PM2.5 in nonurban areas of a county) + (CH_4 per km^2 ag area) + (Food flow over 400 miles measured in weight x distance). Each such term was divided by its maximum value over the study area to render scales more commensurate.	The denominator of the regenerative-conventional agricultural index in Bergmann et al. [18], where the meaning and methods of individual terms are also explained.
	`regenerative_food_system`	A sum of variables associated with *regenerative* agriculture environments at a county scale around the year 2017: (Silvopasture farms/total farms) + (Conservation easement farms/total farms) + (No till farms/total farms) + (Cover crop farms/total farms) + (livestock diversity) + (crop diversity) + (Local direct sales farms/total farms). Each such term was divided by its maximum value over the study area to render scales more commensurate.	The numerator of the regenerative-conventional agricultural index in Bergmann et al. [18], where the meaning and methods of individual terms are also explained.
Spatial Weights Matrices (W)			

Category	Variable Name(s)	Description	Source / Method
Inverse distance squared	`1/Dist`^{2}	Distances between representative centers of counties were raised to the -2 power.	Intercounty distance matrix entries given by Roth [79] were raised to the -2 power. All entries corresponding to distances greater than 250km were set to 0. The matrix was row-normalized to sum to 1 on the rows.
Food system interconnections	`foodflows`	Connections between counties associated with the food system was proxied by trade flows measured by mass in the form of live animals, grain, meat, and products prepared from meats and grains, among others.	A matrix of food flows (in units of mass) between all counties modeled by Lin et al [32] was added to its transpose to symmetrize relations and then row-normalized in the manner described above.
Commuting patterns	`commute`	Connections between counties associated with workplace spatial relations were proxied by commuting flows.	The latest county-level commuting flow matrix from the U.S. Census [74] is from the 2011-2015 5-year ACS; we added this to its transpose to symmetrize the relations and then row-normalized in the manner described above.

Table S2. Best linear regression model for cumulative COVID-19 cases per thousand residents in Period 1, until 9 October 2020, across 1050 U.S. Midwest counties.

Coefficient	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	-111.95145	19.36045	-5.782	0.000000	***
COVID_days_period_1	0.03385	0.01329	2.548	0.010992	*
uninsured_pct	0.32698	0.11929	2.741	0.006230	**
income_inequality	2.04051	0.55773	3.659	0.000266	***
population_Black_pct					
population_Hispanic_pct	0.76714	0.06212	12.350	0.000000	***
population_Asian_pct					
population_Native_pct	0.28631	0.04533	6.316	0.000000	***
life_expectancy_at_birth_2014	1.39068	0.22622	6.147	0.000000	***
employment_2019 _percent_primary _agricultural_and_extractive_sectors	-0.12878	0.05076	-2.537	0.011318	*
employment_2019 _percent_secondary _goods_sectors					
slaughterhouses	1.21165	0.52138	2.324	0.020322	*
conventional_food_system	6.69066	1.47845	4.525	0.000007	***
regenerative_food_system	-3.25352	0.81963	-3.970	0.000077	***
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					

Error SD: 10.32 on 1039 DF
Multiple R-squared: 0.3121
F: 47.13 on 10 and 1039 DF, p-value: < 2.2e-16

Table S3. Best linear regression model for cumulative COVID-19 cases per thousand residents in Period 2, from 10 October 2020 to 11 December 2020, across 1050 U.S. Midwest counties.

Coefficient	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	-174.32622	28.23105	-6.175	0.0000	***
COVID_days_period_1					
uninsured_pct	-0.65794	0.18525	-3.552	0.0004	***
income_inequality					
population_Black_pct					
population_Hispanic_pct	0.30415	0.09911	3.069	0.0022	**
population_Asian_pct	-1.70971	0.39022	-4.381	0.0000	***
population_Native_pct	0.93915	0.06791	13.829	0.0000	***
life_expectancy_at_birth_2014	2.89158	0.35167	8.222	0.0000	***
employment_2019 _percent_primary _agricultural_and_extractive_sectors	0.15915	0.07689	2.070	0.0387	*
employment_2019 _percent_secondary _goods_sectors					
slaughterhouses					
conventional_food_system	10.57019	2.31934	4.557	0.0000	***
regenerative_food_system	-6.21507	1.28922	-4.821	0.0000	***
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					

Error SD: 16.32 on 1041 DF
Multiple R-squared: 0.2502
F: 43.41 on 8 and 1041 DF, p-value: < 2.2e-16

Table S4. Best linear regression model for total COVID-19 cases per thousand residents up until 11 December 2020 across 1050 U.S. Midwest counties.

Coefficient	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	-277.38008	37.31155	-7.434	0.00000	***
COVID_days_period_1					
uninsured_pct	-0.36713	0.21451	-1.711	0.08729	.
income_inequality	2.49987	1.19828	2.086	0.03720	*
population_Black_pct					
population_Hispanic_pct	1.09398	0.12900	8.481	0.00000	***
population_Asian_pct	-1.33806	0.49988	-2.677	0.00755	**
population_Native_pct	1.20130	0.09439	12.727	0.00000	***
life_expectancy_at_birth_2014	4.21443	0.43654	9.654	0.00000	***
employment_2019_percent_primary_agricultural_and_extractive_sectors					
employment_2019_percent_secondary_goods_sectors					
slaughterhouses					
conventional_food_system	17.74621	3.04271	5.832	0.00000	***
regenerative_food_system	-9.11374	1.62964	-5.592	0.00000	***
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					

Error SD: 21.53 on 1041 DF
Multiple R-squared: 0.3012
F: 56.09 on 8 and 1041 DF, p-value: < 2.2e-16

Table S5. Best spatial lag model for cumulative COVID-19 cases per thousand residents in Period 1, until 9 October 2020, across 1050 U.S. Midwest counties.

Coefficient	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	-8.908981	2.371247	-3.7571	0.0001719	***
COVID_days_period_1					
uninsured_pct	0.143806	0.086514	1.6622	0.0964676	.
income_inequality	1.414170	0.468413	3.0191	0.0025356	**
population_Black_pct					
population_Hispanic_pct	0.700762	0.053061	13.2068	0.0000000	***
population_Asian_pct	0.374069	0.205927	1.8165	0.0692925	.
population_Native_pct	0.113072	0.037626	3.0052	0.0026543	**
life_expectancy_at_birth_2014					
employment_2019 _percent_primary _agricultural_and_extractive_sectors	-0.186643	0.039652	-4.7070	0.0000025	***
employment_2019 _percent_secondary _goods_sectors	0.067707	0.037200	1.8201	0.0687434	.
slaughterhouses	1.656796	0.432884	3.8273	0.0001295	***
conventional_food_system					
regenerative_food_system					
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					
W Matrix: Row-normalized (0.95 * Distance^-2 + 0.05 * foodflows)					
Rho: 0.89025, LR test value: 373.36, p-value: < 2.22e-16 Asymptotic standard error: 0.025964 z-value: 34.288, p-value: < 2.22e-16					

Table S6. Best spatial lag model for cumulative COVID-19 cases per thousand residents in Period 2, from 10 October 2020 to 11 December 2020, across 1050 U.S. Midwest counties.

Coefficient	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	7.845524	4.063516	1.9307	0.053517	.
COVID_days_period_1					
uninsured_pct	-0.344984	0.131754	-2.6184	0.008834	**
income_inequality					
population_Black_pct					
population_Hispanic_pct	0.116055	0.076297	1.5211	0.128239	
population_Asian_pct	-1.249280	0.299832	-4.1666	0.000031	***
population_Native_pct	0.347300	0.051784	6.7067	0.000000	***
life_expectancy_at_birth_2014					
employment_2019 _percent_primary _agricultural_and_extractive_sectors	-0.174525	0.059809	-2.9180	0.003522	**
employment_2019 _percent_secondary _goods_sectors	0.127829	0.053902	2.3715	0.017716	*
slaughterhouses					
conventional_food_system	4.643297	1.822361	2.5480	0.010836	*
regenerative_food_system	-3.062712	0.999805	-3.0633	0.002189	**
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					
W Matrix: Row-normalized (0.95 * Distance^-2 + 0.05 * Commute_bidirectional)					
Rho: 0.93209, LR test value: 518.1, p-value: < 2.22e-16 Asymptotic standard error: 0.024973 z-value: 37.324, p-value: < 2.22e-16					

Table S7. Best spatial lag model for total COVID-19 cases per thousand residents up until 11 December 2020 across 1050 U.S. Midwest counties.

Coefficient	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	2.435568	4.520828	0.5387	0.590064	
COVID_days_period_1					
uninsured_pct					
income_inequality					
population_Black_pct					
population_Hispanic_pct	0.735178	0.091931	7.9970	0.000000	***
population_Asian_pct	-0.765488	0.376891	-2.0311	0.042249	*
population_Native_pct	0.461049	0.062095	7.4249	0.000000	***
life_expectancy_at_birth_2014					
employment_2019 _percent_primary _agricultural_and_extractive_sectors	-0.445423	0.071183	-6.2574	0.000000	***
employment_2019 _percent_secondary _goods_sectors	0.176167	0.067912	2.5940	0.009486	**
slaughterhouses	1.474516	0.800871	1.8411	0.065601	.
conventional_food_system	5.175589	2.242611	2.3078	0.021008	*
regenerative_food_system	-3.614137	1.247722	-2.8966	0.003772	**
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					
W Matrix: Row-normalized (0.95 * Distance^-2 + 0.05 * Commute_bidirectional)					
Rho: 0.95839, LR test value: 658.81, p-value: < 2.22e-16 Asymptotic standard error: 0.017409 z-value: 55.051, p-value: < 2.22e-16					

Table S8. Best spatial error model for cumulative COVID-19 cases per thousand residents in Period 1, until 9 October 2020, across 1050 U.S. Midwest counties.

Coefficient	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	7.605246	7.239213	1.0506	0.2934596	
COVID_days_period_1					
uninsured_pct					
income_inequality	0.910480	0.447928	2.0326	0.0420883	*
population_Black_pct					
population_Hispanic_pct	1.089570	0.059624	18.2740	0.0000000	***
population_Asian_pct	0.521962	0.203644	2.5631	0.0103738	*
population_Native_pct	0.074682	0.038263	1.9518	0.0509606	.
life_expectancy_at_birth_2014					
employment_2019_percent_primary_agricultural_and_extractive_sectors	-0.204227	0.041059	-4.9740	0.0000007	***
employment_2019_percent_secondary_goods_sectors	0.071090	0.038273	1.8575	0.0632465	.
slaughterhouses	1.496803	0.406392	3.6832	0.0002304	***
conventional_food_system	2.943408	1.833709	1.6052	0.1084573	
regenerative_food_system	-1.595432	0.904202	-1.7645	0.0776538	.
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					
W Matrix: Row-normalized (0.95 * Distance^-2 + 0.05 * foodflows)					
Lambda: 0.96105, LR test value: 502.51, p-value: < 2.22e-16 Asymptotic standard error: 0.019132 z-value: 50.233, p-value: < 2.22e-16					

Table S9. Best spatial error model for cumulative COVID-19 cases per thousand residents in Period 2, from 10 October 2020 to 11 December 2020, across 1050 U.S. Midwest counties.

Coefficient	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	118.296232	31.884638	3.7101	0.0002072	***
COVID_days_period_1					
uninsured_pct	-0.481362	0.191751	-2.5104	0.0120609	*
income_inequality					
population_Black_pct					
population_Hispanic_pct					
population_Asian_pct	-1.005493	0.319004	-3.1520	0.0016217	**
population_Native_pct	0.246700	0.070269	3.5108	0.0004468	***
life_expectancy_at_birth_2014	-0.851030	0.384787	-2.2117	0.0269880	*
employment_2019_percent_primary_agricultural_and_extractive_sectors	-0.331989	0.069538	-4.7742	0.0000018	***
employment_2019_percent_secondary_goods_sectors	0.223537	0.059769	3.7400	0.0001840	***
slaughterhouses					
conventional_food_system	5.529534	2.863740	1.9309	0.0534981	.
regenerative_food_system	-2.972269	1.441034	-2.0626	0.0391511	*
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					
W Matrix: Row-normalized (0.95 * Distance^-2 + 0.05 * Commute_bidirectional)					
Lambda: 0.96175, LR test value: 487.92, p-value: < 2.22e-16 Asymptotic standard error: 0.018428 z-value: 52.189, p-value: < 2.22e-16					

Table S10. Best spatial error model for total COVID-19 cases per thousand residents up until 11 December 2020 across 1050 U.S. Midwest counties.

Coefficient	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	141.423766	42.240603	3.3481	0.0008138	***
COVID_days_period_1					
uninsured_pct	-0.416523	0.252635	-1.6487	0.0992063	.
income_inequality					
population_Black_pct					
population_Hispanic_pct	1.112496	0.121096	9.1869	0.0000000	***
population_Asian_pct					
population_Native_pct	0.312595	0.085673	3.6487	0.0002636	***
life_expectancy_at_birth_2014	-1.080069	0.452348	-2.3877	0.0169543	*
employment_2019 _percent_primary _agricultural_and_extractive_sectors	-0.518768	0.084271	-6.1559	0.0000000	***
employment_2019 _percent_secondary _goods_sectors	0.294783	0.071594	4.1174	0.0000383	***
slaughterhouses	1.232190	0.776223	1.5874	0.1124183	
conventional_food_system	8.646530	3.550328	2.4354	0.0148746	*
regenerative_food_system	-4.715958	1.749266	-2.6960	0.0070185	**
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					
W Matrix: Row-normalized (0.95 * Distance^-2 + 0.05 * Commute_bidirectional)					
Lambda: 0.97946, LR test value: 658.06, p-value: < 2.22e-16 Asymptotic standard error: 0.011864 z-value: 82.555, p-value: < 2.22e-16					

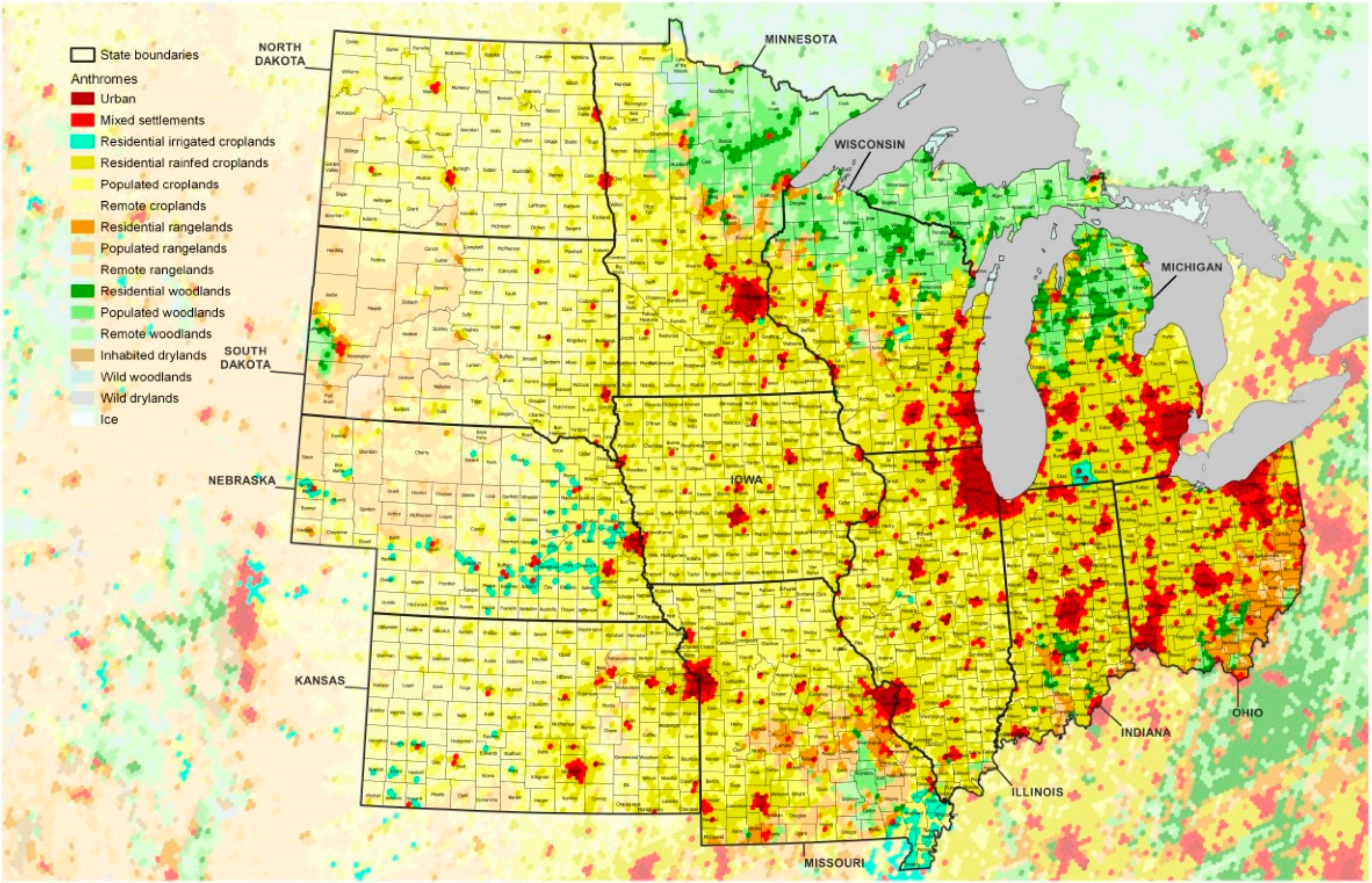

Figure S1. Map of study location, of names of administrative boundaries including states and counties, and of landscape context in the form of the land use / land cover 'anthromes' for 2017 [80].

Figure S2. Maps of all variables either chosen as possible covariates for the models for this study as well or chosen as response variables. See Table S1 for explanations, sourcing, and methodological considerations in the construction of these variables.

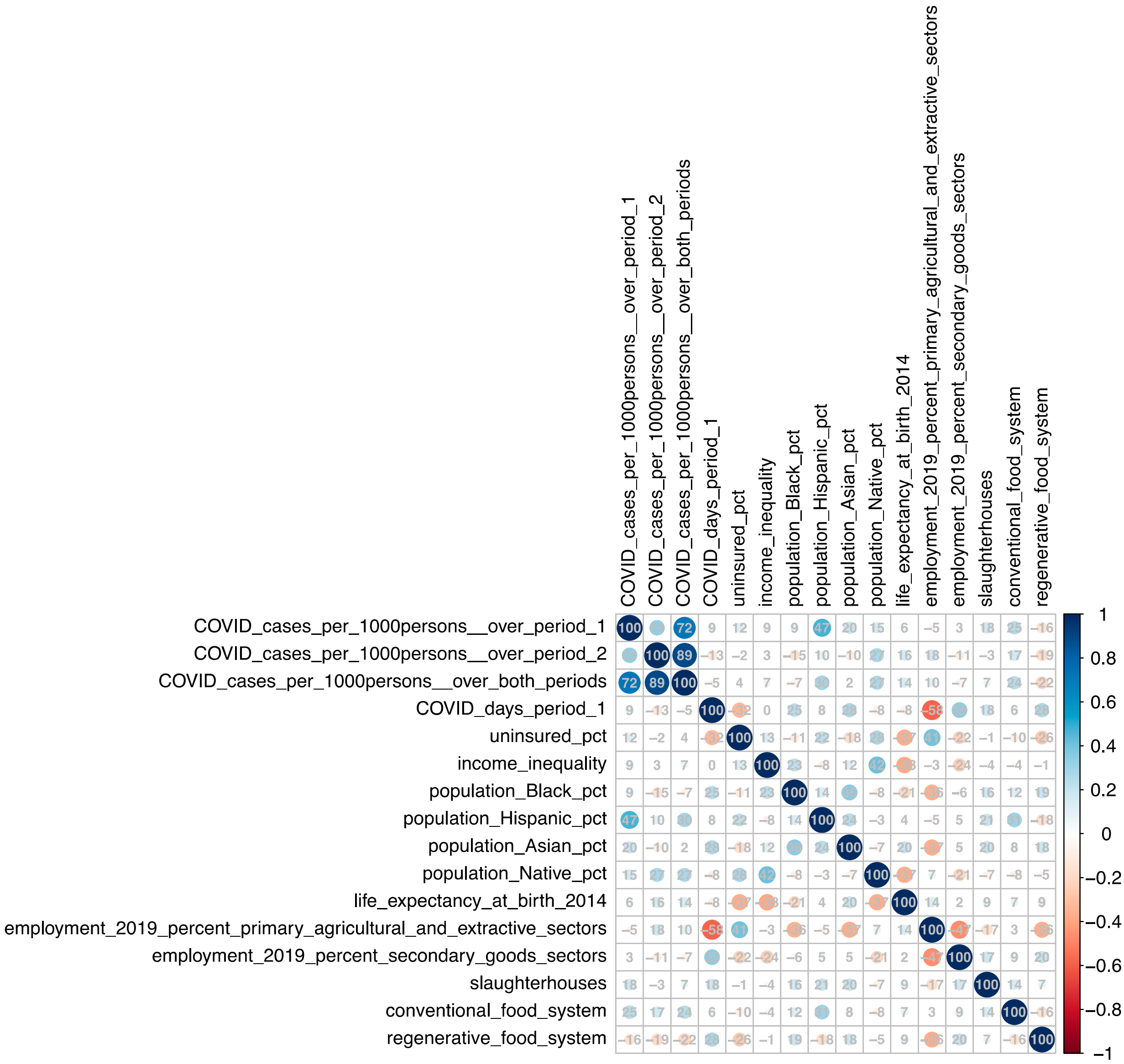

Figure S3. Pearson's Correlation Coefficients calculated among all pairs of variables either chosen as possible covariates for the models for this study as well or chosen as response variables.

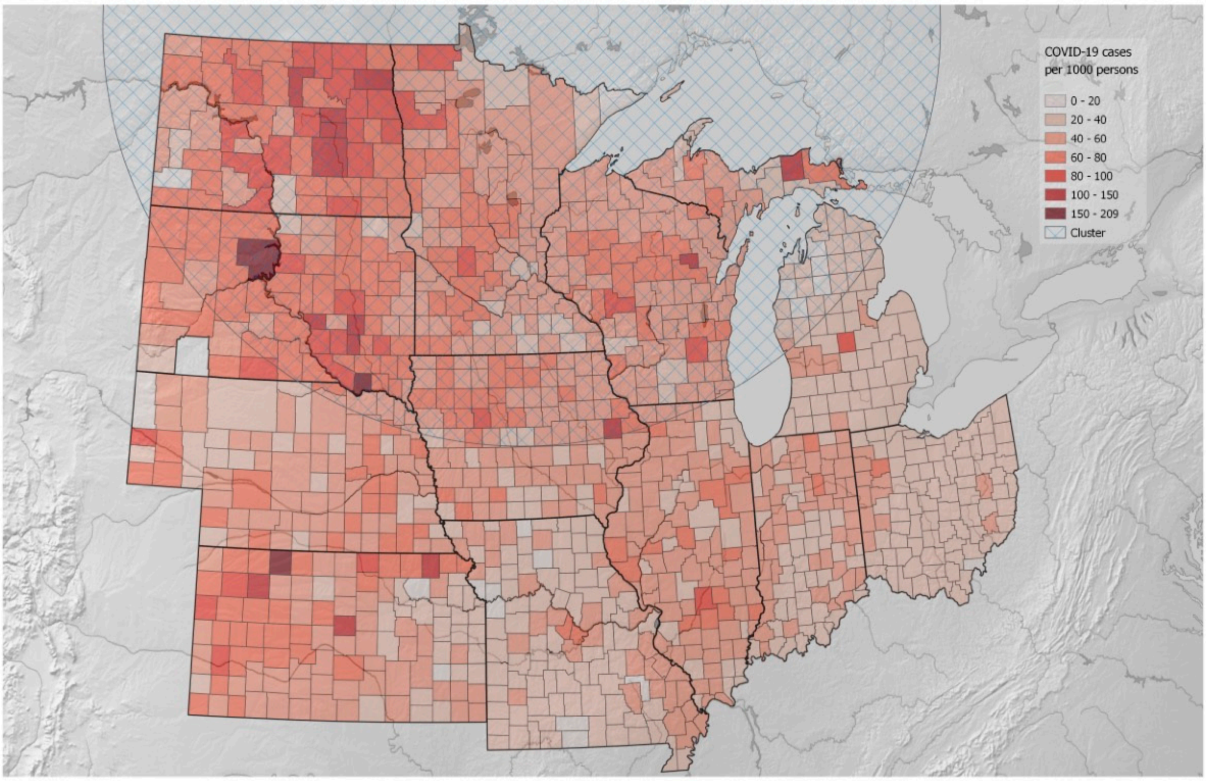

Figure S4. Map of spatiotemporal cluster detected by SaTScan. The relative risk for this cluster was 7.66 (LRT= 1551352, P<0.001) when compared with counties outside the cluster. The cluster is mapped over the total cases reported during the duration of the cluster, a duration which defines the second period of our study, with cases arising from 10 October to 11 December 2020, when the first vaccine received Emergency Use Authorization in the United States.

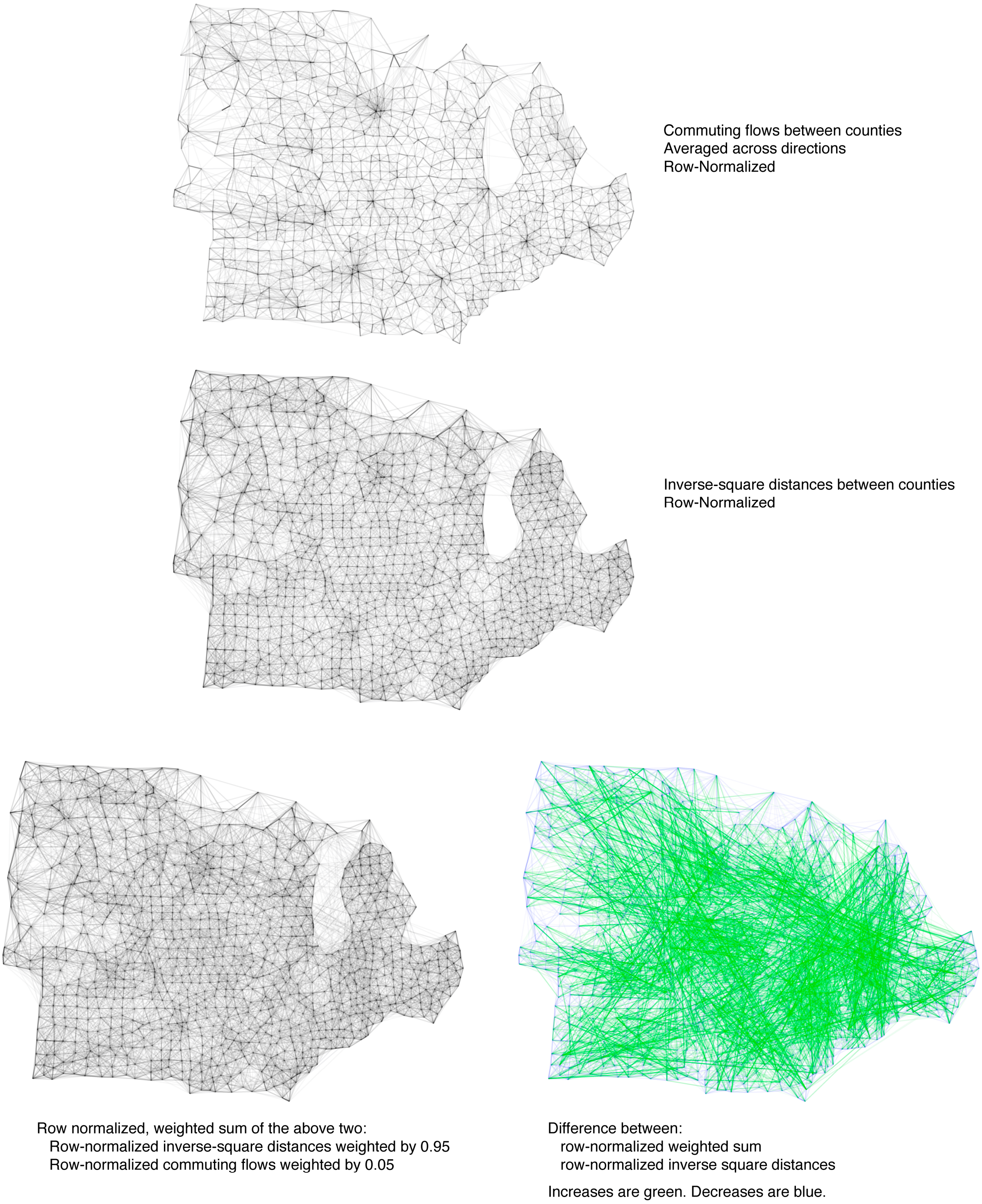

Figure S5. Inverse-square distance and commuting spatial weights matrices. Bottom row shows row-normalized result of 0.95 weighting of inverse-square distance added to 0.05 weighting of the commuting matrix. Left side shows result; right side shows difference from the inverse-square distance matrix shown in the middle row of the figure. Connections to populated centers near and far become more apparent.

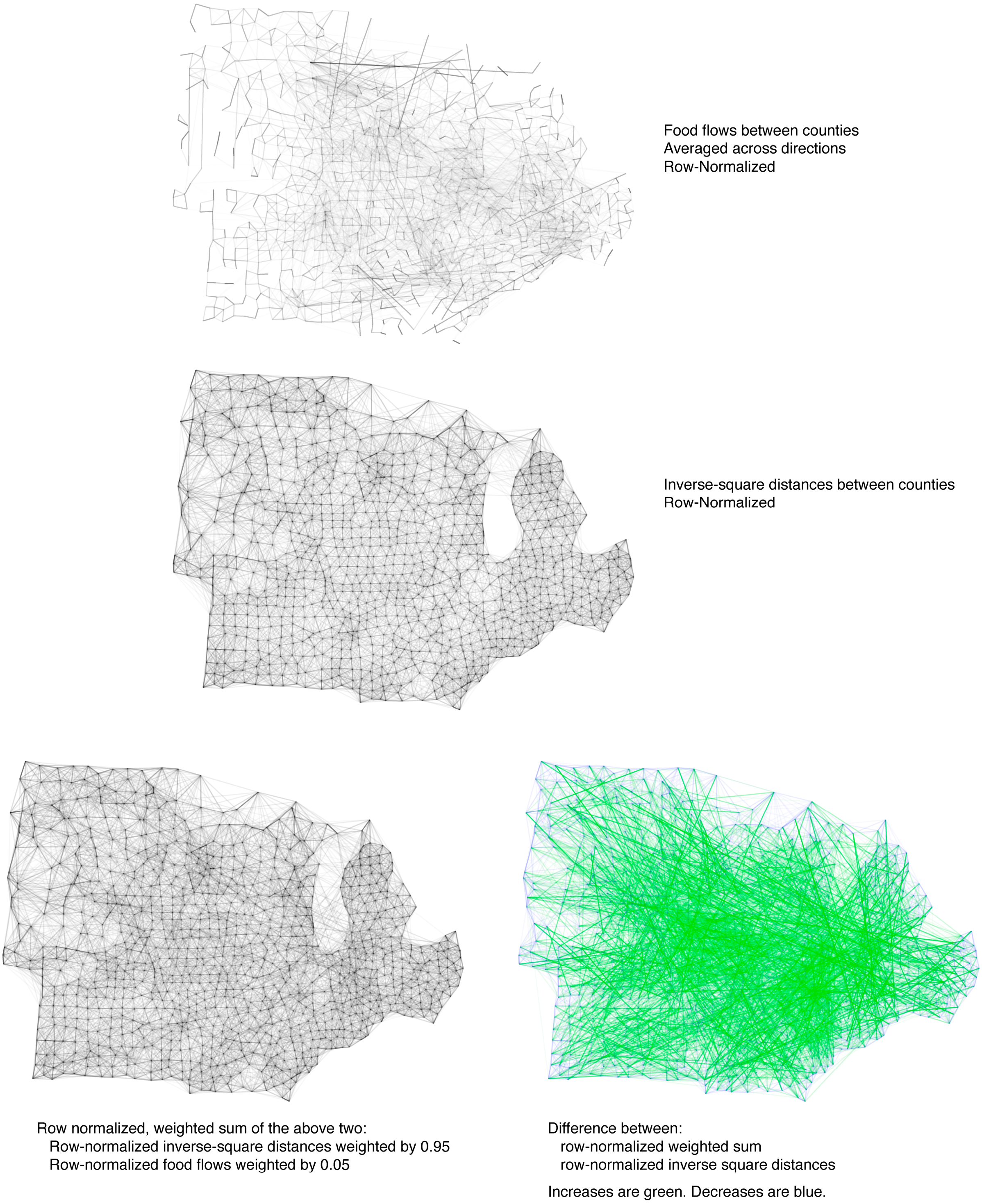

Figure S6. Inverse-square distance and food flow spatial weights matrices. Bottom row shows row-normalized result of 0.95 weighting of inverse-square distance added to 0.05 weighting of the food flow matrix. Left side shows result; right side shows difference from the inverse-square distance matrix shown in the middle row of the figure. Many food flow connections are over considerable distances.

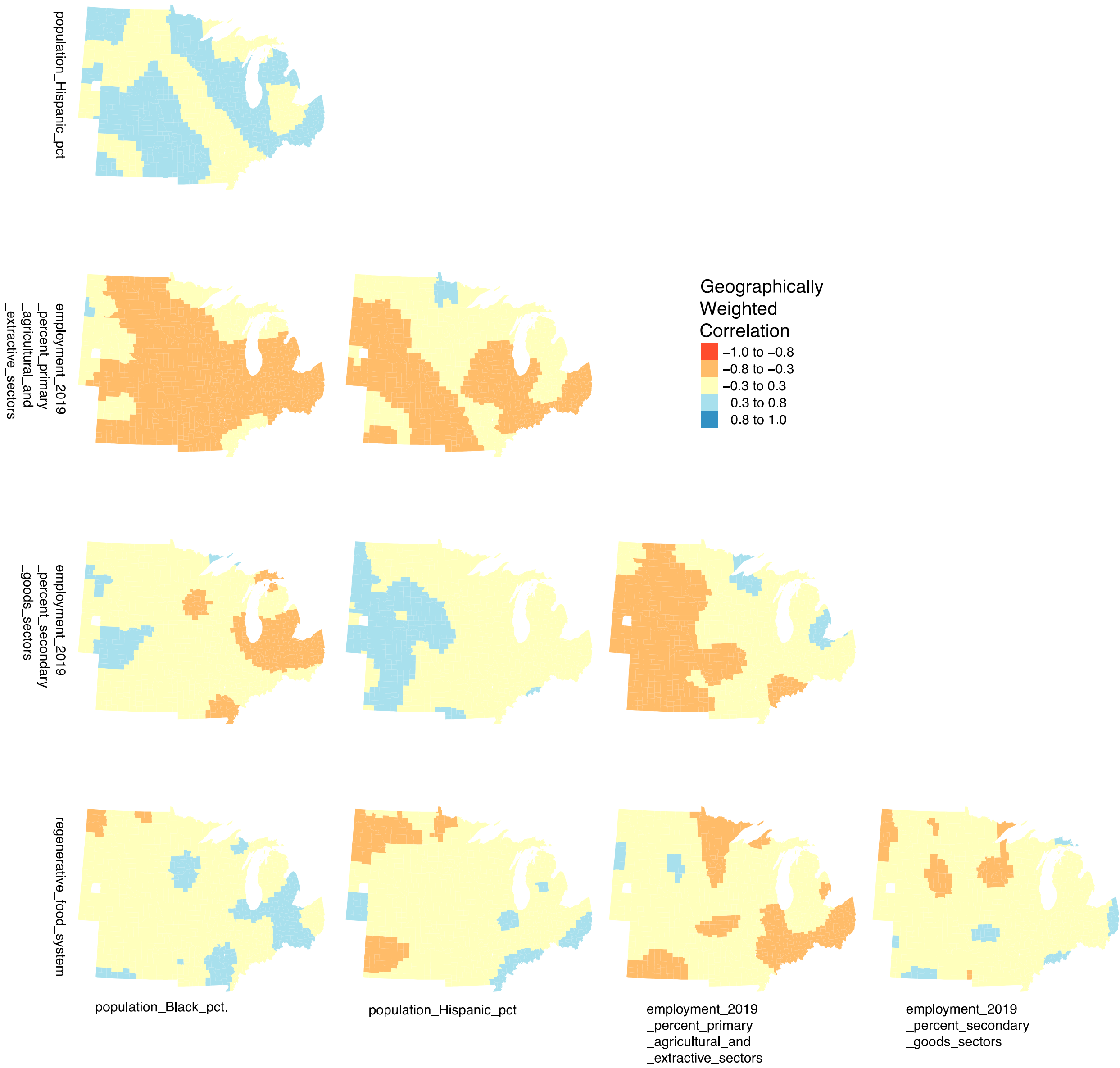

Figure S7. Geographically Weighted Correlations between all pairs of covariates for the AICc-minimizing backward-selected model in Period 1. According to the considerations around local collinearity articulated by Lu et al. [31] and Comber et al. [41], substantial areas of values with magnitude greater than 0.8 would have been grounds for concern, and in our case, selection of the next lowest AICc model. Yet none of the above maps show strong local collinearity.

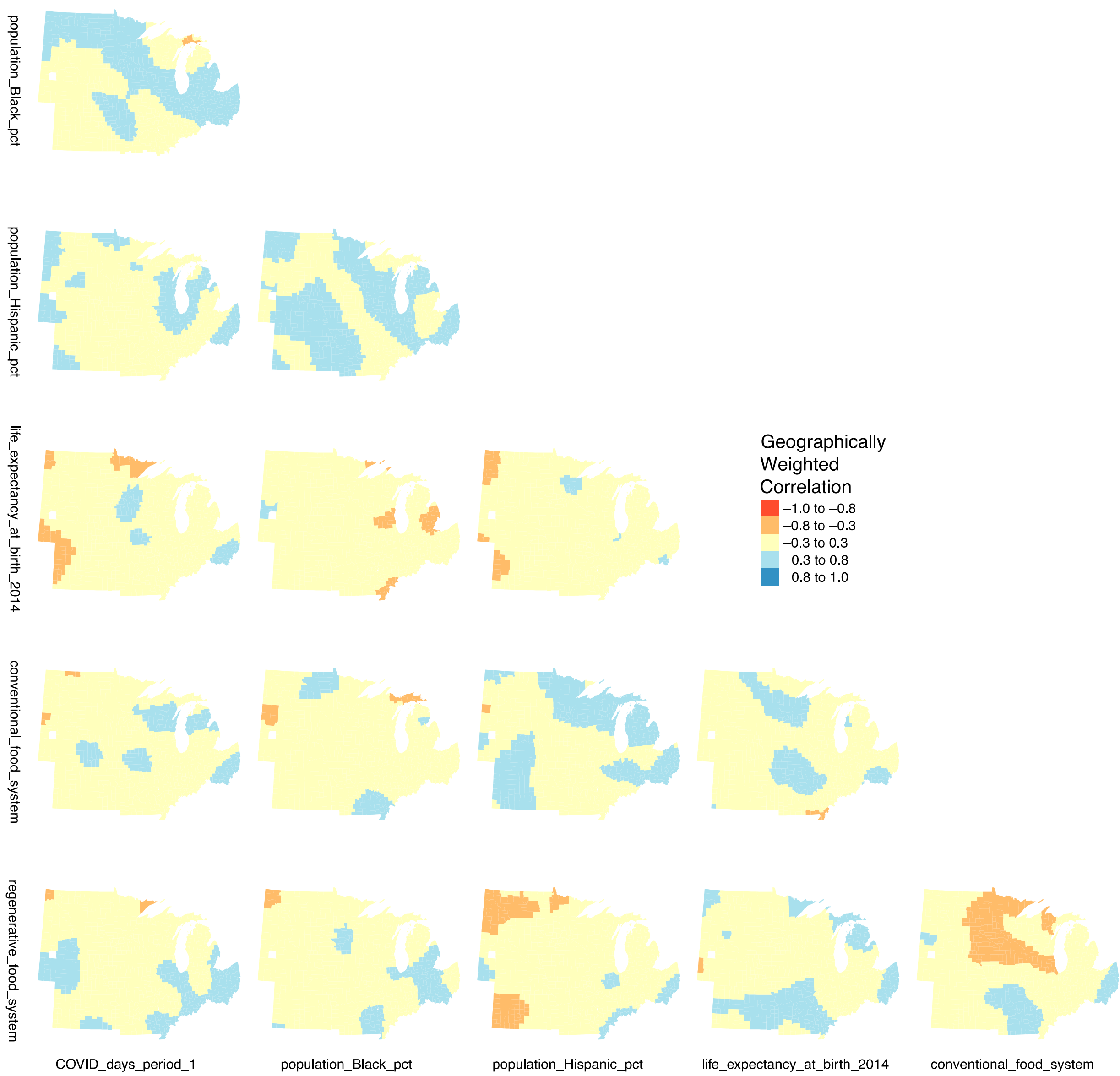

Figure S8. Geographically Weighted Correlations between all pairs of covariates for the AICc-minimizing backward-selected model in Period 2. According to the considerations around local collinearity articulated by Lu et al. [31] and Comber et al. [41], substantial areas of values with magnitude greater than 0.8 would have been grounds for concern, and in our case, selection of the next lowest AICc model. Yet none of the above maps show strong local collinearity.

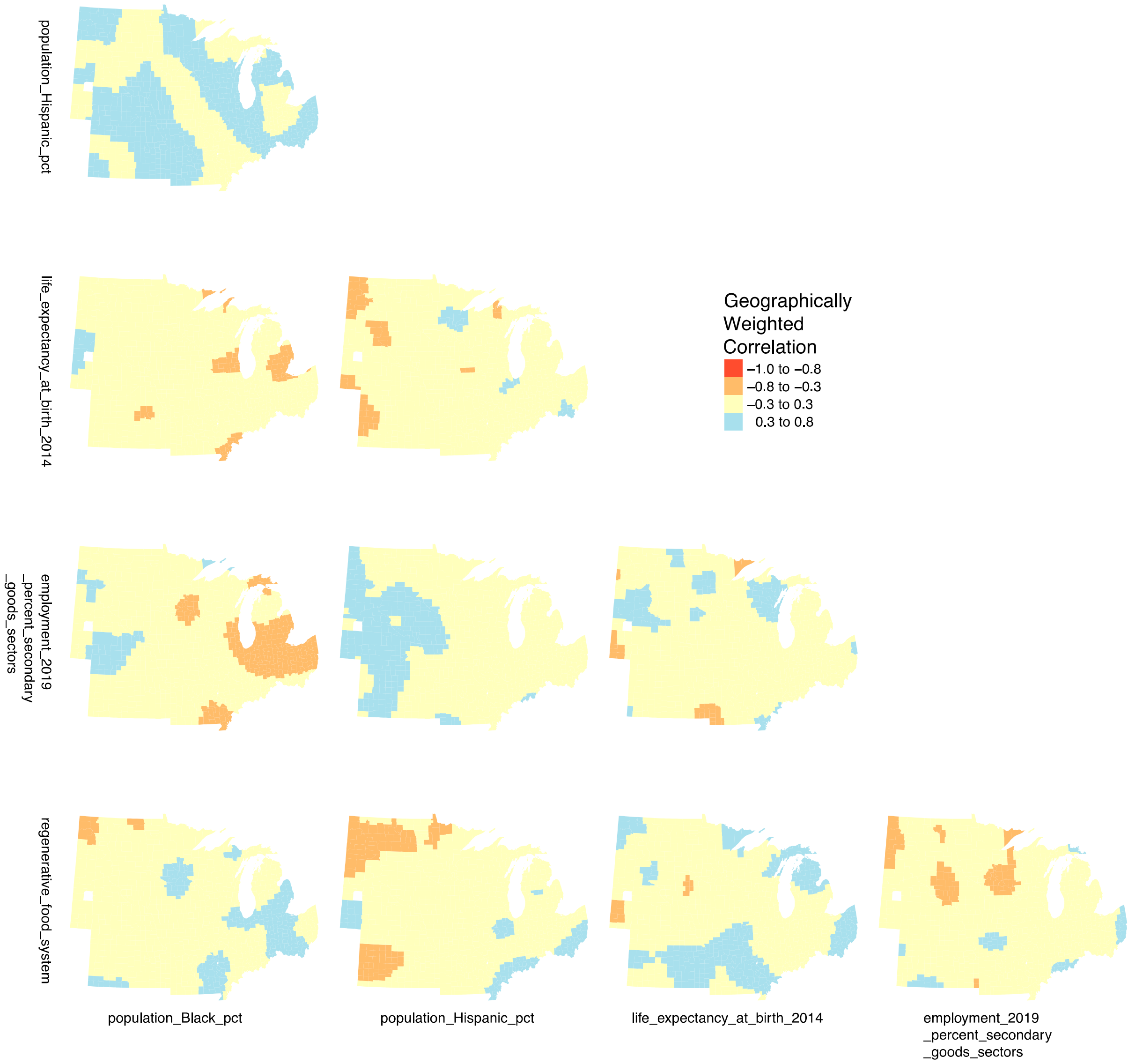

Figure S9. Geographically Weighted Correlations between all pairs of covariates for the AICc-minimizing backward-selected model across both periods. According to the considerations around local collinearity articulated by Lu et al. [31] and Comber et al. [41], substantial areas of values with magnitude greater than 0.8 would have been grounds for concern, and in our case, selection of the next lowest AICc model. Yet none of the above maps show strong local collinearity.

Supplementary Results S1

These supplementary results offer additional description of the model fitting and selection process for the GWR models of the study.

In the Period 1 model, the selected regression used a bandwidth of 101 km, had 229 effective parameters, 824 effective degrees of freedom, an R^2 of 0.70. Further dropping of parameters would have been justified by the AICc-minimization criterion alone, however the resulting model fits were not used as they violated key diagnostic desiderata around local collinearity as described above [31, 41]. In the discarded model simplifications, geographically weighted correlations between `population_Black_pct` and `population_Hispanic_pct` were above 0.8 in areas.

In the Period 2 model, the selected regression used a bandwidth of 117 km, had 203 effective parameters, 851 effective degrees of freedom, an R^2 of 0.65.

In the model for the overall period combining Periods 1 and 2, the selected regression used a bandwidth of 103 km, had 220 effective parameters, 833 effective degrees of freedom, an R^2 of 0.72.

While we have not included the maps of the local variance inflation factors (VIFs) for any of the models' coefficients here, none of them were over 10, which meets the threshold suggested by Lu et al. [31]. The lack of substantial local collinearity in these models as quantified and mapped via geographically weighted correlations is also shown through Figures S7-S9 above.