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## In the Mid-Atlantic Fruit and Vegetable Industry, Market Workers and Local Specialized Freight Truckers May be at Greatest Risk

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Meat packing plants have received considerable attention in recent weeks because of their vital importance in supply chains, and the cascading implications for upstream suppliers and downstream purchasers when a plant shuts down. While meat production is a year round operation, field fruit and vegetable growers are just starting their seasonal operations in the mid-atlantic region.<sup>1</sup> Here we examine potential bottlenecks along fruit and vegetable (F&V) supply chains, focusing on establishment locations relative to concentrations of COVID-19 infections. To assess this risk, we conduct simple and more advanced spatial correlation analysis between the number of establishments and total workers in the county and the number of infections per 100,000 population (Table 1). In this table, processing industry members are listed in order from producers to processors and consumers (i.e., F&V markets).

**Table 1: Characteristics of MidAtlantic F&V Processing, and COVID-10 Correlations**

F&V Subsector	Total count		Workers per firm	Correlation coefficient <sup>b</sup>	
	Firms <sup>a</sup>	Workers		Firms, CV	Workers, CV
Fruit operations with sales	14,860	na	na	0.066	na
Vegetable operations with sales	28,810	na	na	0.145***	na
Refrigerated Warehousing and Storage (NAICS 49312)	254	11,452	45	0.360***	0.181***
Farm Product Warehousing and Storage (NAICS 49313)	63	1,153	18	0.273***	0.235***
Spec. Freight (except Used Goods) Trucking, Local (NAICS 48422)	6,611	48,914	7	0.436***	0.320***
Frozen Fruit, Juice, and Vegetable Manufacturing (NAICS 311411)	24	1,971	82	0.086*	0.031
F&V Canning (NAICS 311421)	209	10,449	50	0.290***	0.070
Specialty Canning (NAICS 311422)	33	4,375	133	0.238***	-0.005
Dried and Dehydrated Food Manufacturing (NAICS 311423)	29	1,348	46	0.258***	0.200***
Fresh Fruit and Vegetable Merchant Wholesale (NAICS 424480)	1,210	25,689	21	0.320***	0.316***
F&V Markets (NAICS 44523)	1,149	9,715	8	0.273***	0.357***

a. Establishments (CBD, 2016) or operations (NASS, 2017)

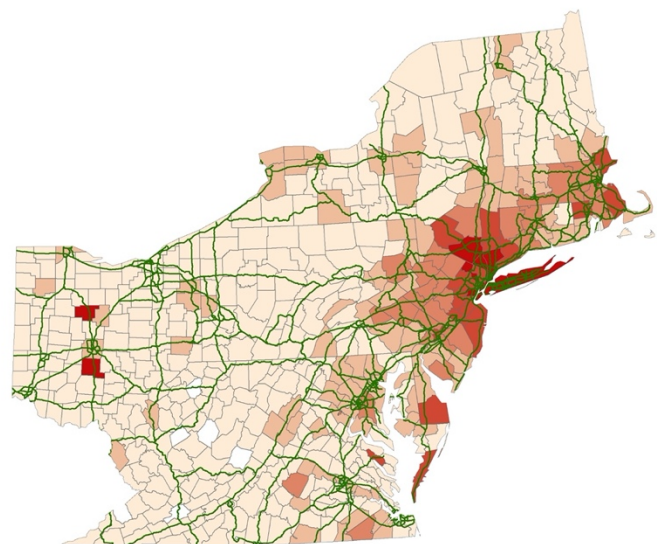
b. Simple coefficient of variation with number of COVID-19 cases in county per 100,000.

\* and \*\*\* represent statistical significance at the 10 and 1% levels or lower, respectively.

<sup>1</sup> Note that we include states that are within a 500 miles radius of PA as part of the mid-Atlantic region, because we are interested in regional processing capacity or potential; in a supplemental brief we also include Maine in the analysis.

Workers in the F&V industry retail markets are potentially at greatest risk to exposure to the COVID-19, because they are more likely to work in counties with high current numbers of infected individuals per 100,000. This is followed by workers in specialized local freight trucking and wholesale markets and fresh F&V merchant wholesalers. For establishments, the largest correlation coefficient with infections per 100,000 is also for specialized freight truckers, followed by refrigerated product warehousing and storage, and fresh F&V wholesale merchants.

The number of COVID-19 cases per 100,000 population is highest in the densely settled and highly interconnected corridor of Boston-New York City and Philadelphia, and into the tip of the DELMARVA peninsula (Figure 1). Anecdotal evidence suggests that the virus has travelled into and out of the greater NYC region along the interstate highway commuter sheds into New Jersey as well as into Connecticut, and there is some evidence of spreading along the interstates in upper New York state. In general, however, the more rural counties outside of big cities tend to have fewer confirmed cases per capita. Despite early concerns that rural areas would be especially hard hit by the virus, our early analysis suggests this is not the case.<sup>2</sup> Less impacted areas include large stretches of I-80 in western Pennsylvania as well as along the PA Turnpike (I-76). Interstate truckstops were temporarily shut because of fears of spreading the virus, but this was quickly reversed when the implications for the food system became obvious.<sup>3</sup> On the other hand, certain areas in the eastern part of Pennsylvania have over 100 cases per 100,000 people and reported deaths that are of concern for rural communities in the southeast especially considering that the F&V growing and market season is starting.



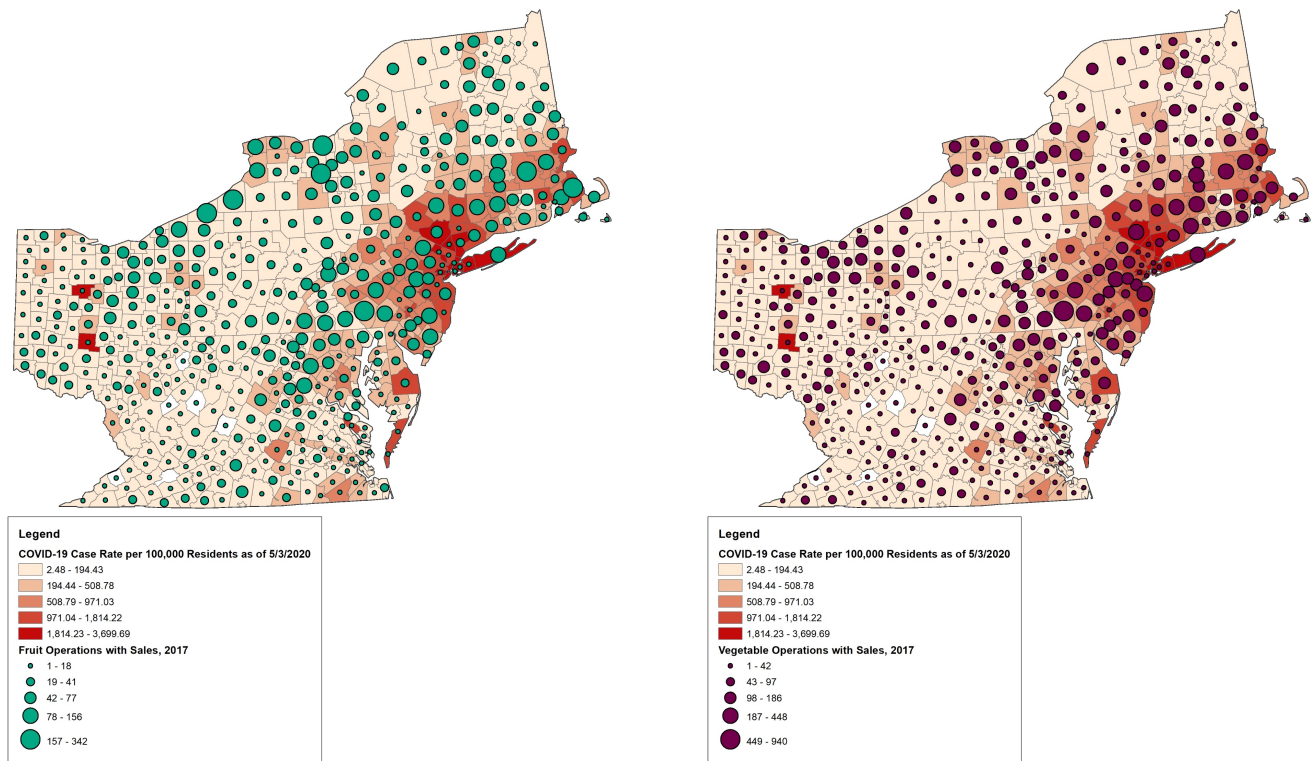
**Figure 1: Mid-Atlantic COVID-19 Cases and Interstates**

Indeed, a key feature of parts of Northeast fruit and vegetable production is the close proximity of operations to areas (counties) with higher population densities. For fresh products, this allows more rapid and timely delivery of products to consumers (Figure 2). Clearly, many of the F&V operations with sales also are located in close proximity to the highly concentrated populations of the eastern Seaboard. In contrast, there are fewer operations in the more rural areas of the state, although at least one operation can be found in each county. Table 1 suggests a positive and statistically significant correlation between the number of vegetable operations and COVID-19 cases per 100,000 but not for fruit operations, which tend to be located in more rural areas with fewer cases (including along Lake Erie). This correlation is consistent with a large number of small farms producing vegetables and using direct to consumer sales proximate to areas characterized by higher population density. Medium sized and larger-scale vegetable farm operations located in more rural areas are mostly devoted to serving wholesale markets, produce auctions, and vegetable processing facilities. As the prevalence of small family businesses is also associated with a low reliance on seasonal H-2A workers, the diversity of the PA vegetable industry

<sup>2</sup> <https://aese.psu.edu/nercrd/publications/covid-19-issues-briefs/adjacency-matters-nonmetro-covid-19-cases>

<sup>3</sup> <https://www.inquirer.com/health/coronavirus/penn-dot-trucks-cornavirus-rest-stop-ban-20200318.html>

could be an asset in minimizing any risk of vegetable supply disruption. In these small farm businesses maximum precautions should be taken to prevent COVID-19 contamination as the occurrence of positive cases within the family may imperil the entire business. Given the nature of the virus spreading primarily from people to people in close contact, the same concept applies to produce auctions that should take precautions and implement adequate plans to reduce the number of people entering the auctions and avoiding any close interaction.



**Figure 2:** Locations of Fruit and Vegetable Operations with Sales, and COVID-19 cases/100,000

Specialty canning has the largest number of workers per firm on average (133), and specialized local freight trucking the smallest (7) followed by F&V markets (8). Therefore, the implementation of adequate management plans to assure safety and adequate protection of people employed in vegetable processing facilities which normally may be working at close proximity is critical to minimize risks of disruption of these operations. In fact, the disruption of a vegetable processing facility may have a high negative impact especially upstream on the supply chain, because the inability or reduced ability to receive and process fresh produce will affect growers serving the facility with products that are highly perishable and that may not be set to serve alternative markets in a short time period.

A note on the establishments vs. employment counts: Table 1 suggests that the correlation coefficients with COVID-19 infections are in some cases higher for establishment counts compared to employment counts; maps in the supplemental materials show how establishments and employment are distributed across the counties. For economic cluster analyses, establishments are often more useful than employment counts because they better reflect the degree of competition (or collaboration) among firms. In the present context, having more establishments in a county can also be important for re-routing of product among competing processing firms, in the event that any one firm is shut down (e.g., a canning operation) because of worker illness. This may be true unless the firms are so specialized that this kind

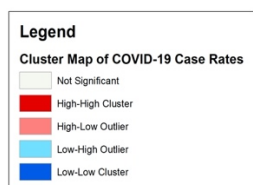
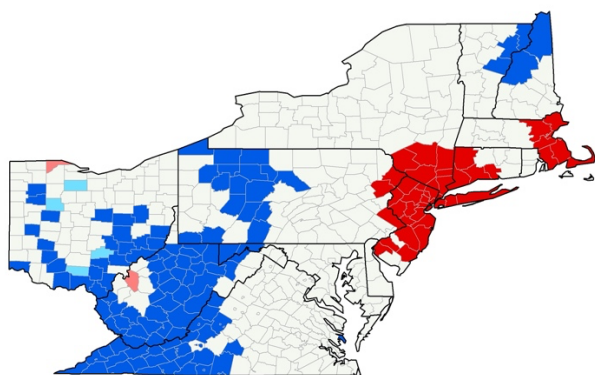
of substitution cannot happen (or firms are already at capacity because of seasonal processing windows). In the case of meat processing, the impacts of a plant failing are significant because the plants have become so large in order to capture economies of scale that there are few if any competing operations in a region to which animals destined for slaughter can be redirected. This may be less of an issue for F&V processors.

To further analyze the spatial association between the various F&V supply chain members and COVID-19 cases, we present univariate and bivariate Moran's I coefficients (Table 2). This coefficient varies from -1 to 1, signifying a highly negative spatial autocorrelation, and a positive spatial autocorrelation, respectively, with 0 indicating no spatial autocorrelation. A value of 1 indicates that businesses tend to cluster near one another in space. Table 2 indicates a higher degree of positive spatial autocorrelation for F&V operations than for all of the other establishments except specialized freight. But none of the coefficients are as high as that for COVID-19, where the Moran's I is 0.610\*\*\*. The relatively higher degree of positive spatial autocorrelation observed for F&V operations and specialized freight companies further highlights that the large number of small F&V farms and freight firms that operate in proximity to high population density areas constitute a great asset in terms of food resilience for the Northeast. The diversity and flexibility of the NE vegetable industry and the specialized freight operation in proximity of densely populated areas is such that the potential disruption of the activity of a small farm or of a market in a certain area may not put the availability of fresh produce at risk (in areas where this applies). We can speculate that the benefits of flexibility and the advantage of a diverse vegetable industry located in proximity of densely populated areas in the NE are already evident from the rapid surge of direct sales by small F&V farms since the beginning of the COVID-19 crisis. Small F&V farm businesses have in fact quickly adjusted their operation by offering online sales and curbside pickup or home delivery. Despite the many challenges posed by the COVID-19 pandemic, this could present an opportunity for small F&V farms in the NE region to regain their market share, especially from competitors that normally offer produce transported from a long distance.

**Table 2: Measures of Spatial Association (county-level)**

Subsector	Moran's I		Bivariate Moran's I	
	Firms	Workers	Firms, CV	Workers, CV
Fruit operations with sales	0.324***	na	0.077***	na
Vegetable operations with sales	0.372***	na	0.152***	na
Refrigerated Warehousing and Storage (NAICS 49312)	0.280***	0.152***	0.345***	0.157***
Farm Product Warehousing and Storage (NAICS 49313)	0.097***	0.036*	0.175***	0.146***
Spec. Freight (except Used Goods) Trucking, Local (NAICS 48422)	0.337***	0.262***	0.372***	0.298***
Frozen Fruit, Juice, and Vegetable Manufacturing (NAICS 311411)	0.092***	0.019*	0.056***	0.026*
F&V Canning (NAICS 311421)	0.090***	0.072***	0.283***	0.083***
Specialty Canning (NAICS 311422)	0.090***	0.033*	0.266***	0.013
Dried and Dehydrated Food Manufacturing (NAICS 311423)	0.093***	0.030*	0.281***	0.198***
Fresh Fruit and Vegetable Merchant Wholesale (NAICS 424480)	0.116***	0.150***	0.319***	0.291***
F&V Markets (NAICS 44523)	0.095***	0.137***	0.294***	0.359***

Note: \* and \*\*\* represent statistical significance at the 10% and 1% levels, respectively  
 COVID Moran's I: 0.610\*\*\*



**Figure 1a:** Hot and coldspots for COVID-19

**Supplemental Materials: Maps of locations of establishments and employment in each of the sectors in Table 1 relative to COVID-19 cases per 100,000 (see next pages)**

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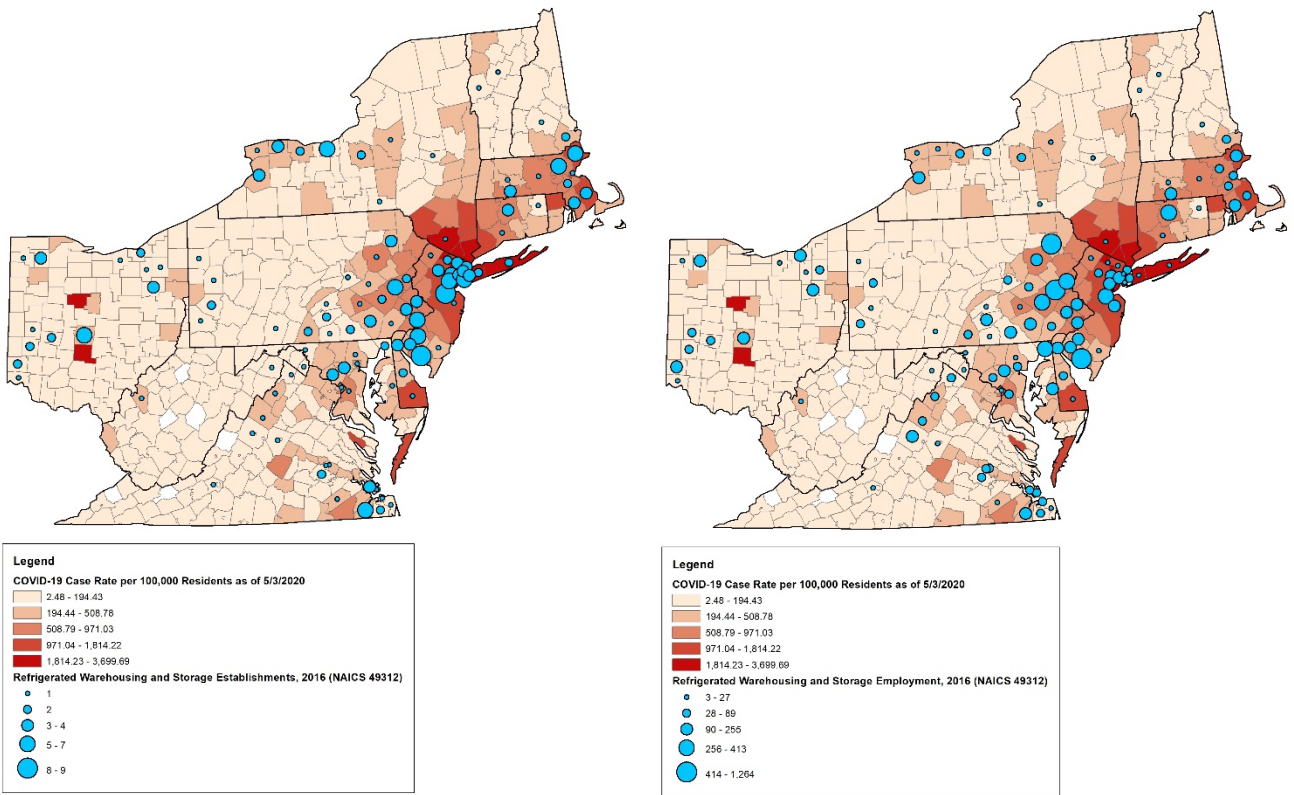


Figure 3. County-level COVID-19 Case Rates and Number of Refrigerated Warehousing and Storage Establishments (left) and Employees (right)

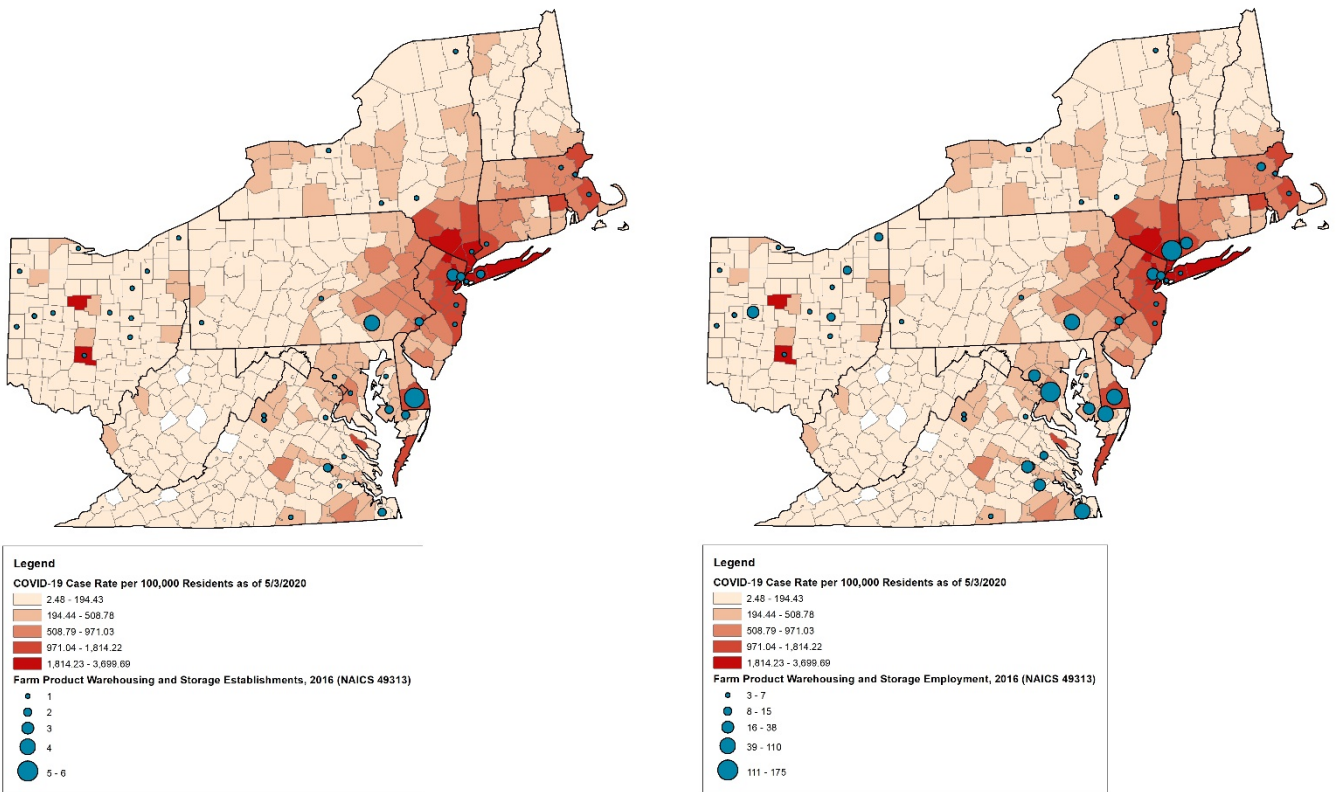


Figure 4. County-level COVID-19 Case Rates and Number of Farm Product Warehousing and Storage Establishments (left) and Employees (right)

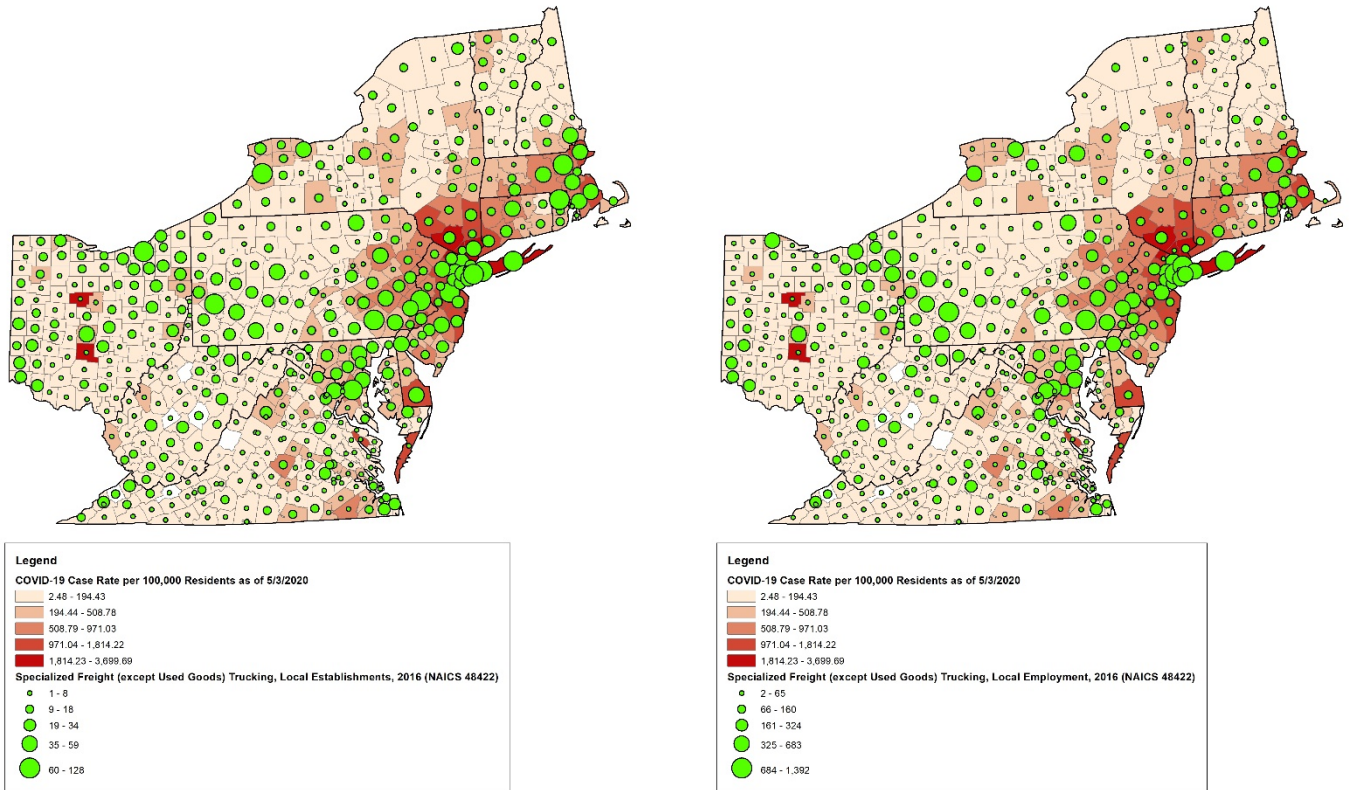


Figure 5. County-level COVID-19 Case Rates and Number of Specialized Freight Establishments (left) and Employees (right)

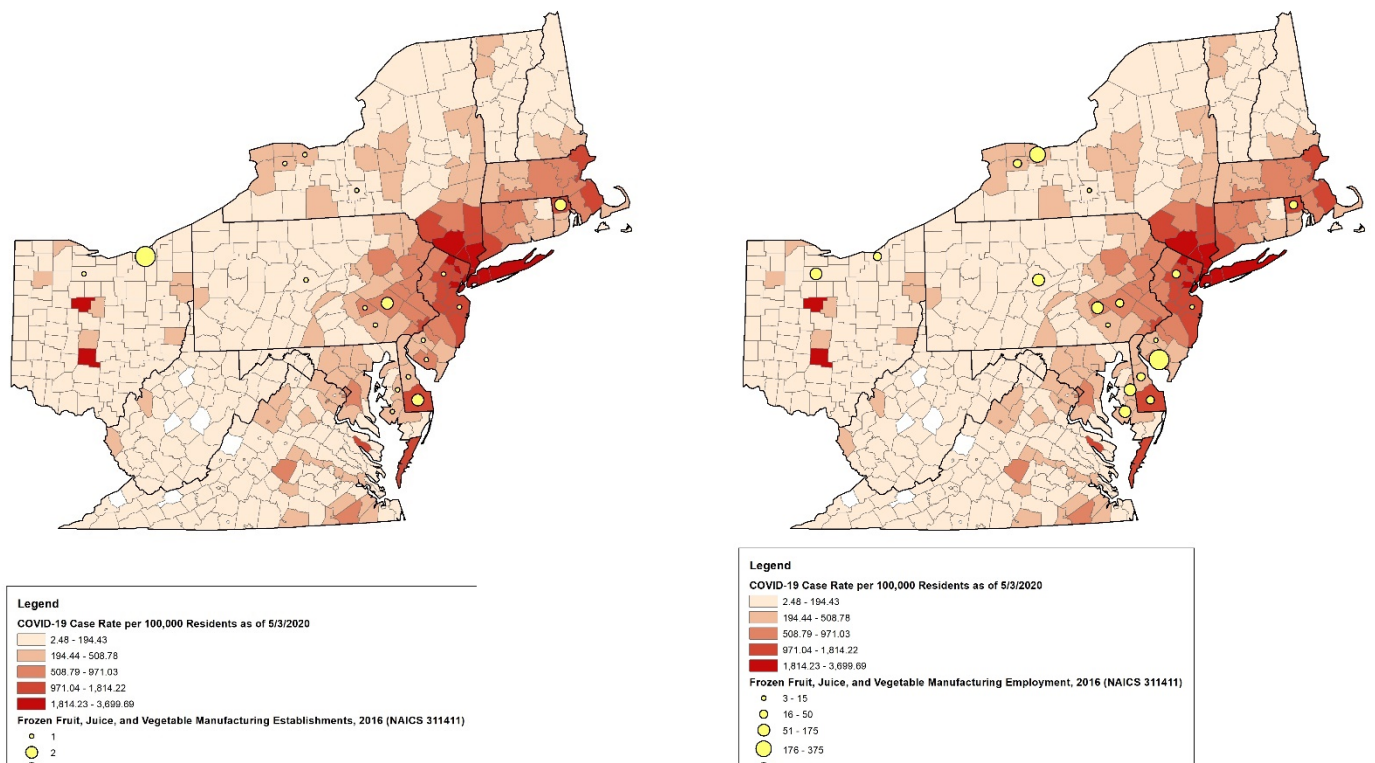


Figure 6. County-level COVID-19 Case Rates and Number of Frozen Fruit, Juice, and Vegetable Manufacturing Establishments (left) and Employees (right)

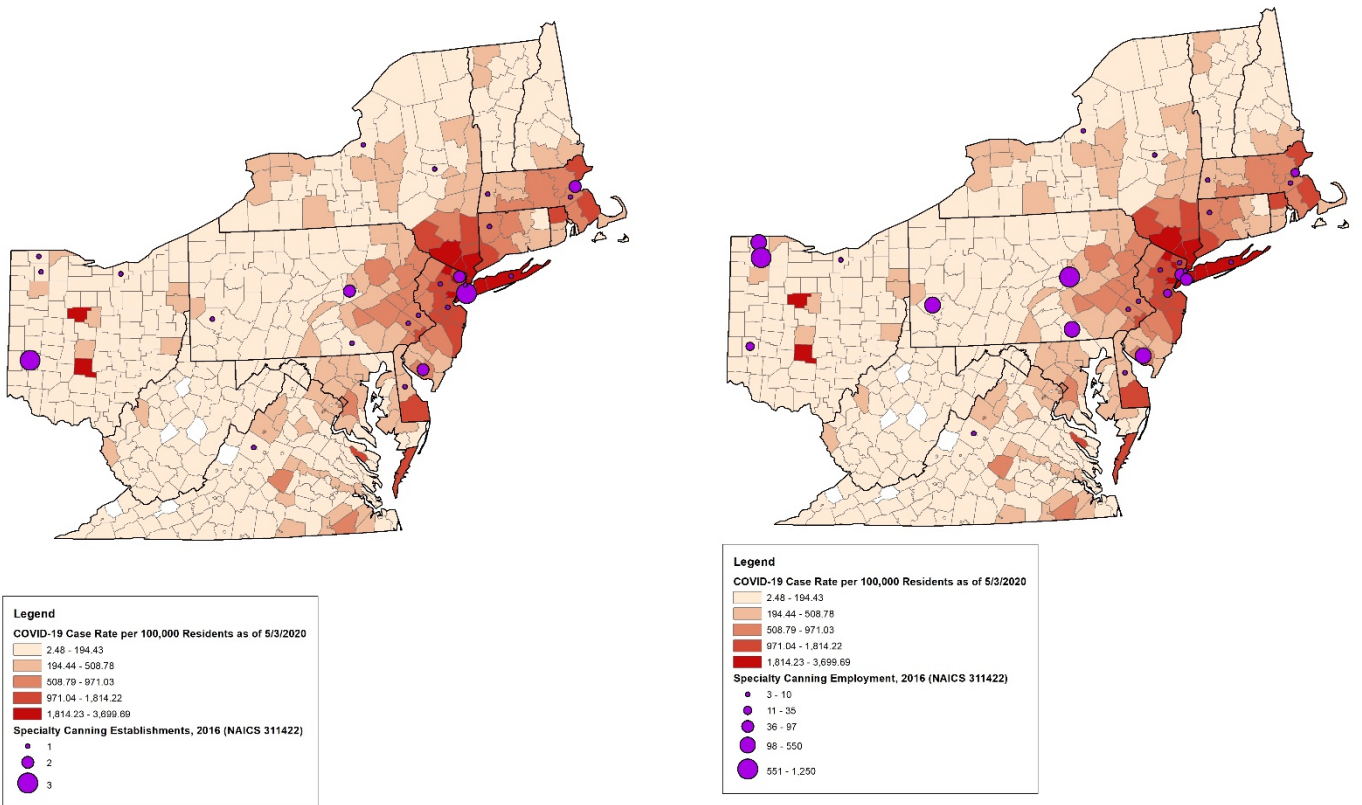


Figure 7. County-level COVID-19 Case Rates and Number of Specialty Canning Establishments (left) and Employees (right)

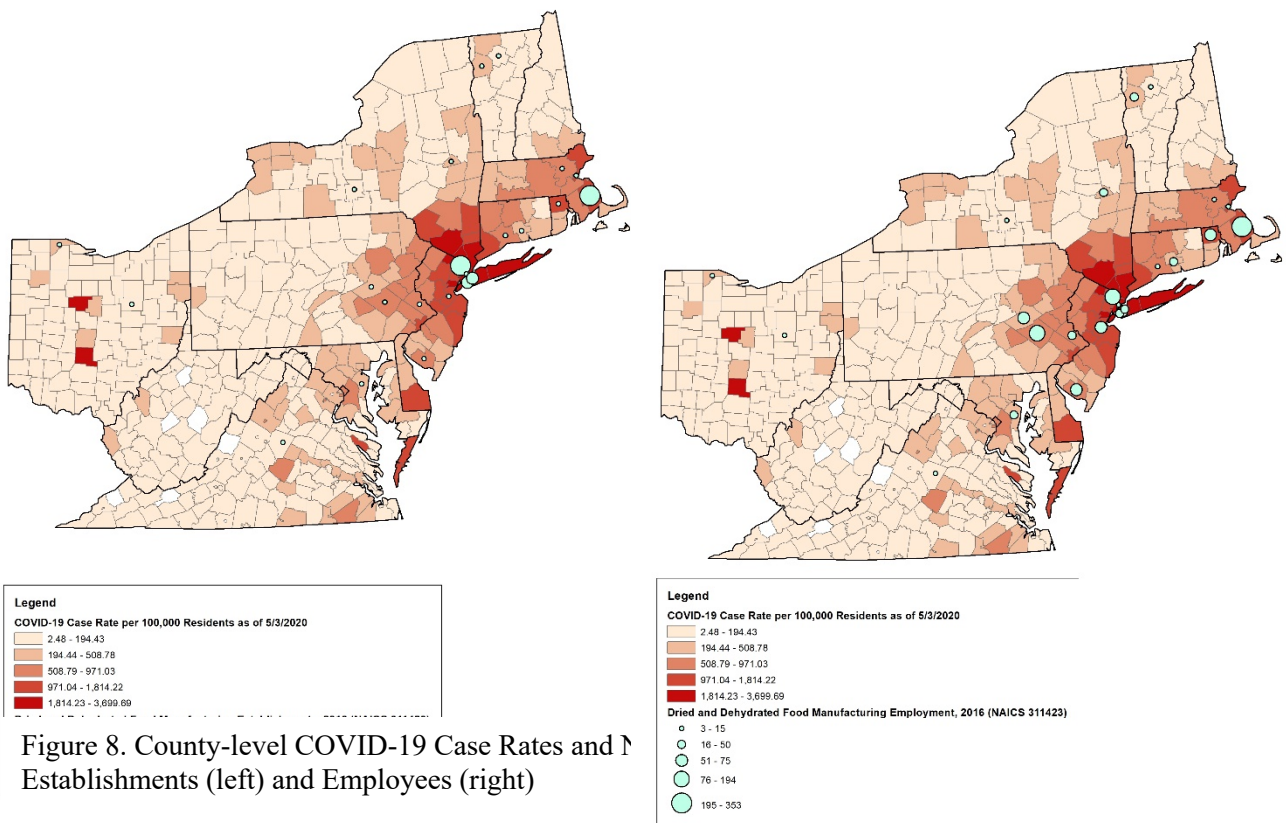


Figure 8. County-level COVID-19 Case Rates and Number of Dried and Dehydrated Food Manufacturing Establishments (left) and Employees (right)



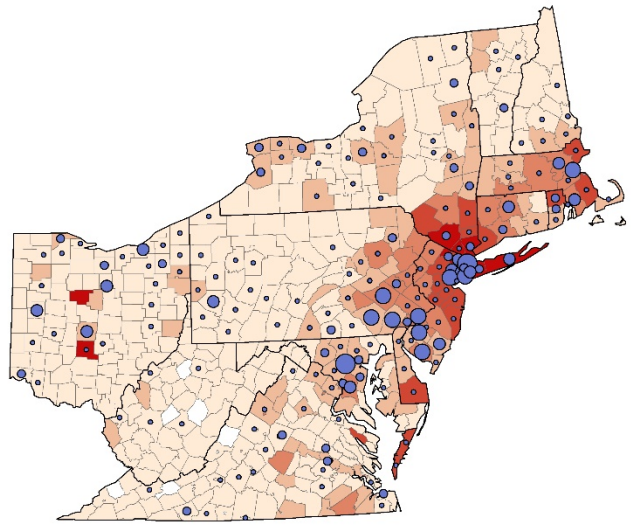
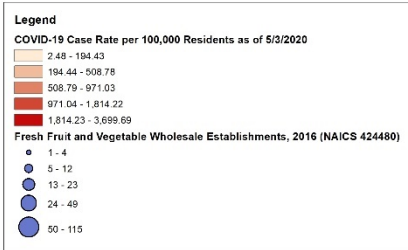
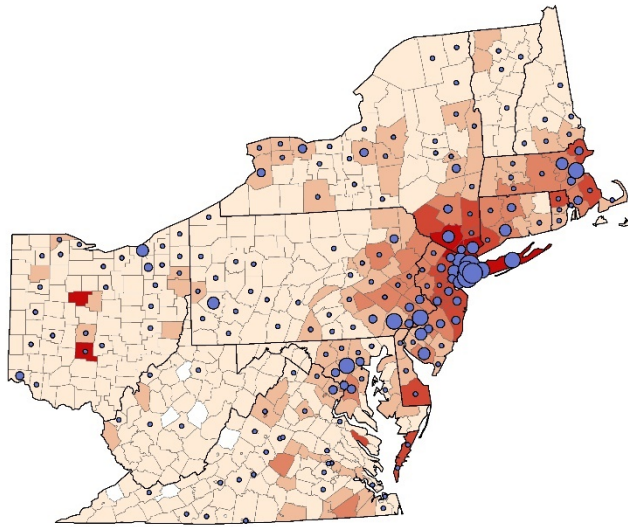


Figure 9. County-level COVID-19 Case Rates and Number of Fresh Fruit and Vegetable Wholesale Establishments (left) and Employees (right)

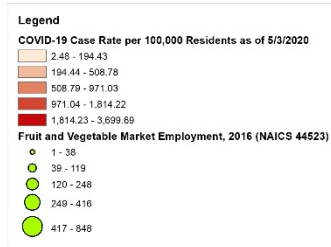
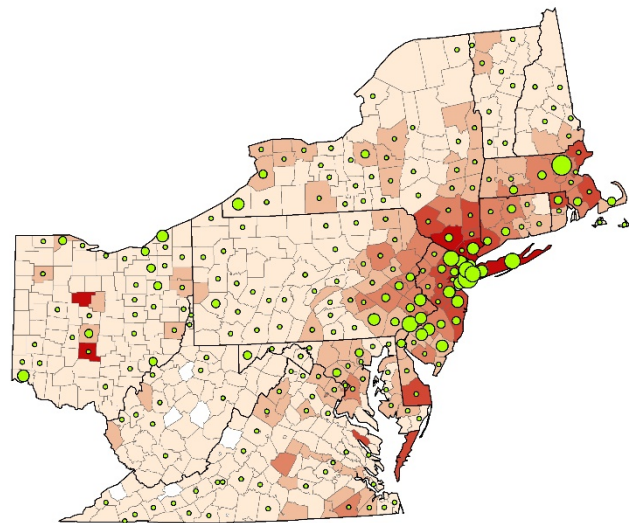
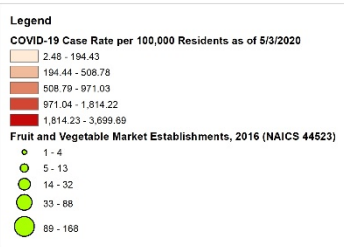
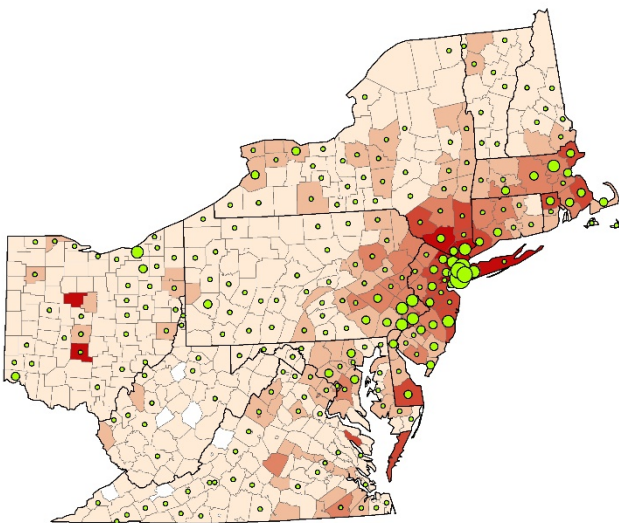


Figure 10. County-level COVID-19 Case Rates and Number of Fruit and Vegetable Market Establishments (left) and Employees (right)