NIST Economic Analysis Brief 13

The Geographic Footprint of NIST Cooperative Research and Development Agreements and Licenses: Fiscal Year 2019

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Key Findings

- In this paper, we show the geographic distribution of active NIST cooperative research and development agreements (CRADAs) and invention licenses in fiscal year 2019.
- We show that NIST had 388 CRADAs in 34 states and the District of Columbia with a national rate of 1.17 CRADAs per million population.
- We show that NIST has 69 invention licenses in 20 states and the District of Columbia with a national rate of 0.21 licenses per million population.
- Of the six Federal Laboratory Consortium regions, the Mid-Atlantic region had the highest rates of CRADAs per million population with 3.27 and of invention licenses per million population with 0.78.

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1 INTRODUCTION

The modernization of the measurement of federal technology transfer was a stated policy objective of multiple Presidential administrations [1-2]. Their objective was echoed by the National Institutes of Standards and Technology's (NIST) Return on Investment Initiative's Green Paper [3], which found improving understanding of science and technology trends, through improved metrics, as one of its cross-agency priority goal strategies. The Green Paper stated that "metrics can be an important source of information used by organizations" to better understand their operations. This report on the geographic distribution of technology transfer activities provides an initial source of information to better understand the influence of NIST technology transfer activities across the United States.

Previously, NIST has published reports on the geographic distribution of a broad range of NIST's technology transfer activities across the United States [4-5]. This report builds upon those works by focusing on NIST's cooperative research and development agreements (CRADAs) and invention licenses, providing data at more narrowly defined geographic levels (e.g., ZIP codes, states), and presenting per capita measures of NIST CRADA and licensing activities.

This report shows the geographic footprint of NIST's CRADAs and invention licenses across the United States. We use groupings of states and territories defined by the Federal Laboratory Consortium (FLC)[1] [6] to combine states and territories into geographically linked regions and analyze NIST's CRADA and invention license activities in each region. For each region, we show the geographic footprint of NIST CRADAs and invention licenses in two formats. The first format is a table that lists the number of CRADAs and invention licenses in each state in the region. In addition to the absolute numbers, we show the per capita values for each measure. The second format is a map showing the geographic location of each ZIP code in which there is at least one NIST CRADA or invention license.

We summarize our analysis of the data as follows. During fiscal year 2019, NIST had 388 active CRADAs and 69 invention licenses. NIST had active CRADAs in 34 states and the District of Columbia and invention licenses in 20 states and the District of Columbia. At the national level, NIST had 1.17 active CRADAs per million population and 0.21 active invention licenses per million population. NIST's geographic footprint was most pronounced in areas around NIST's two largest facilities, located in

[1] The FLC "is the formally chartered, nationwide network of over 300 federal laboratories, agencies, and research centers that fosters commercialization best practice strategies and opportunities for accelerating federal technologies from out of the labs and into the marketplace." [7] The FLC was "formally chartered by the Federal Technology Transfer Act of 1986 to promote and strengthen technology transfer nationwide." [8]

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Gaithersburg, MD and Boulder, CO. These areas had the highest per capita rates of CRADAs and licenses. The states of Colorado, Maryland, and Virginia and the District of Columbia had both CRADAs per million rates and invention licenses per million rates that were in the top 5 of states and territories. Of all FLC-defined regions, the FLC's Mid-Atlantic region—which includes Maryland, Virginia, and the District of Columbia—had the highest CRADAs per million population rate with 3.27 and licenses per million population rate with 0.78.

The remainder of this report is organized as follows. Section 2 outlines the data we use in the analysis. Section 3 shows the geographic footprint of NIST's CRADA and licensing activity across the FLC-defined regions. Section 4 compares the NIST CRADA and invention licensing activities across individual states and territories. Section 5 summarizes the analysis, provides some initial observations, and suggests avenues for future research.

2 DATA AND MEASURES

This work draws on two forms of data: data on NISTS's CRADAs and invention licenses and data on the population of geographic areas. The CRADA and invention license data include the type of transfer agreement and the location of the CRADA partner or invention licensee. Data on the population of the geographic area provides a measure for the relative size of the area in terms of the number of people who live there. With these data we can show the absolute level of CRADA and invention licensing activity and the intensity of these activities relative to the population for geographic regions as per capita measures.

The data for this analysis comes from NIST's database of NIST invention licenses and CRADAs. This work focuses exclusively on NIST's technology transfer activities and does not include information on technology transfer activities led by other agencies. This analysis considers only CRADAs and invention licenses that were active during fiscal year 2019 (i.e., October 1, 2018 to September 30, 2019). The CRADAs we include in the data set are either bi-lateral CRADAs or NIST-led consortia.[2] The invention licenses we include in this set are one of the following: an exclusive license, a non-exclusive license, a research license, or a custody-transfer agreement.[3]

[2] This restriction limits our analysis to CRADAs where NIST has agreed to conduct research jointly with one or more non-NIST entities (e.g., a university) or where NIST serves as the lead entity on a joint research consortium. This restriction excludes consortia led by entities other than NIST and other forms of CRADAs such as facility use agreements and material transfer agreements.

[3] In general terms, one may consider these license agreements as follows. Exclusive licenses grant the licensee exclusive right to practice the invention commercially. Non-exclusive licenses grant the licensee non-exclusive rights to practice the invention commercially. Research licenses grant the licensee the right to practice the invention for research purposes. Custody transfer agreements grant rights of use of the invention to other agencies.

One important limitation of these technology transfer agreement data is that they represent only a single year. NIST CRADAs and invention license agreements may have agreement periods of several years. We are focusing exclusively on a single year and do not capture information about the stage of the agreement, how long it has been in place, or how long it will continue. Further, we do not consider royalties or other transfers associated with these agreements that might provide details on the magnitude of the impacts of these agreements. Information on these and other factors would be necessary to conduct detailed analysis on the impacts of these CRADAs and invention licenses.

In this work, we assign the location of each agreement to be the ZIP code listed on the agreement. When possible, we defined the ZIP code of an agreement to be the ZIP code of the principle investigator of the agreement. We make this definition as we assume the location of the principle investigator is the location, among the observable locations, that most accurately represents where the technology transfer activities occur. When the ZIP code of the principle investigator was not available, we defined the ZIP code of an agreement to be the ZIP code of the partner entity listed on the agreement. This ZIP code may represent the location of some non-research aspect of the partner entity's organization such as a legal office or headquarters.

We make two caveats based on features of this location data. First, the activities related to the agreement may occur outside of the ZIP code in which the agreement is listed. That is, a partner entity may list their headquarters in one ZIP code while the activities related to the agreement are conducted in a laboratory located in a different ZIP code, state, or region. This may be true even when we can observe the ZIP code of the principle investigator of an agreement. Second, while we outline congressional districts on the maps we provide, congressional districts and ZIP codes do not match on a one-to-one basis and some partner entities may execute agreements in ZIP codes that cross multiple congressional districts.

For each geographic region, we present both the total numbers of CRADAs and invention licenses as well as CRADAs per million population and invention licenses per million population. Scaling by the relative size of the geographic region provides information into the intensity of interaction in a geographic area and not merely the volume of interactions in that area. We use data on the estimated population of each state, the District of Columbia, and the territory of Puerto Rico in 2019 published by the U.S. Census Bureau [9-10].

We provide CRADAs per million population and licenses per million population at three geographic levels: the state or territory, the FLC region, and the nation. At each level, we calculate the CRADAs per million population rate as the number of CRADAs in that area (i.e., state or territory, FLC region, or the entire nation) divided by the total population in that area (i.e., state or territory, FLC region, or the entire nation). Similarly, we calculate the licenses per million population rate as the number of licenses in an area (i.e., state or territory, FLC region, or the entire nation) divided by the total population in that area (i.e., state or territory, FLC region, or the entire nation).

For geographic areas that include multiple states and territories (i.e., FLC regions and the nation), we include the populations of all states and all territories in the defined area regardless of the number of CRADAs or licenses in that state or territory. For example, the population of a state or territory in an FLC region would be included in the calculation of the CRADAs per million population of an FLC region, even if that state had no CRADAs.

3 FOOTPRINTS ACROSS FLC REGIONS

We begin our analysis of the geographic footprint of NIST CRADAs and licenses by first considering their distribution across regions of the United States as defined by the FLC. The FLC organizes the states, the District of Columbia, and the territory of Puerto Rico into six regions: Far West, Mid-Atlantic, Mid-Continent Midwest, Northeast, and Southeast.

For each region we provide a table that summarizes NIST's CRADAs, invention licenses, CRADAs per million population rate, and invention licenses per million population rate for each state or territory in the region. Each table also includes these measures calculated at the region level.

Additionally, for each region, we also provide a map that depicts the geographic location of ZIP codes that have at least one NIST CRADA or invention license and congressional districts for each region. We illustrate the congressional districts for this map constructed using U.S. Census Bureau's map for the 116th Congress [11].

Far West:

The FLC defines the Far West region to consist of the states of Alaska, Arizona, California, Hawaii, Idaho, Nevada, Oregon, and Washington. Table 1 shows the number of CRADAs and invention licenses in each state in the Far West region. Table 1 also shows the active CRADAs per million population rate and invention licenses per million population rate in each state.

Table 1. CRADA and Invention Licenses in Far West States

State	CRADAs	CRADAs /Million	Invention Licenses	Licenses/Million
Alaska	0	0.00	0	0.00
Arizona	2	0.27	1	0.14
California	74	1.87	6	0.15
Hawaii	0	0.00	0	0.00
Idaho	0	0.00	0	0.00
Nevada	0	0.00	0	0.00
Oregon	11	2.61	0	0.00
Washington	11	1.44	3	0.39
All States	98	1.49	10	0.15

In the Far West region, NIST had CRADAs in 4 states totaling 98 agreements and a CRADAs per million population rate of 1.49. NIST had active invention licenses in 3 states totaling 10 licenses and a licenses per million population rate of 0.15. California was the state with the largest number of each agreement type with 74 CRADAs and 6 licenses. Oregon had the highest CRADAs per million population rate with 2.61. Washington had the highest licenses per million population rate with 0.39. Four states, Alaska, Hawaii, Idaho, and Nevada did not have either a CRADA or an invention license.

Figure 1 depicts the geographic distribution of the ZIP codes with at least one NIST CRADA or invention license in states that make up the FLC-defined Far West region. The lines represent the borders of the congressional districts in this region. The blue dots represent the ZIP codes with at least one NIST CRADA. The orange dots represent the ZIP codes with at least one NIST invention license. Alaska and Hawaii are not shown on Figure 1 as neither state had a CRADA or an invention license.

Figure 1. Map of CRADAs and Invention Licenses in Far West States

Mid-Atlantic:

The FLC defines the Mid-Atlantic region to consist of Delaware, Maryland, Pennsylvania, Virginia, and West Virginia as well as the District of Columbia. Table 2 shows the CRADAs and invention licenses for each state in the Mid-Atlantic region and the District

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of Columbia. Table 2 also shows the CRADAs per million population rate and the licenses per million population rate for each state in this region and the District of Columbia.

Table 2. CRADAs and Invention Licenses in Mid-Atlantic States

State	CRADAs	CRADAs /Million	Invention Licenses	Licenses /Million
Delaware	4	4.11	0	0.00
District of Columbia	6	8.50	3	4.25
Maryland	38	6.29	13	2.15
Pennsylvania	13	1.02	2	0.16
Virginia	40	4.69	6	0.70
West Virginia	0	0.00	0	0.00
All States and DC	101	3.27	24	0.78

In the Mid-Atlantic region, NIST had 101 CRADAs in 4 states and the District of Columbia with a CRADAs per million population rate of 3.27. NIST had 24 invention licenses in 3 states and the District of Columbia with a licenses per million population rate of 0.78. Virginia had the greatest number of CRADAs with 40. Maryland had the greatest number of invention licenses with 13. The District of Columbia had the highest CRADAs per million population rate with 8.50 and licenses per million population rate with 4.25. West Virginia was the only state in the Mid-Atlantic region to have neither a CRADA nor an invention license.

Figure 2 shows the geographic distribution of ZIP codes with at least one NIST CRADA or invention license in the Mid-Atlantic region. The lines on the figure indicate the congressional districts for each state. The blue dots indicate the ZIP codes with at least one NIST CRADA. The orange dots indicate the ZIP codes with at least one NIST invention license.

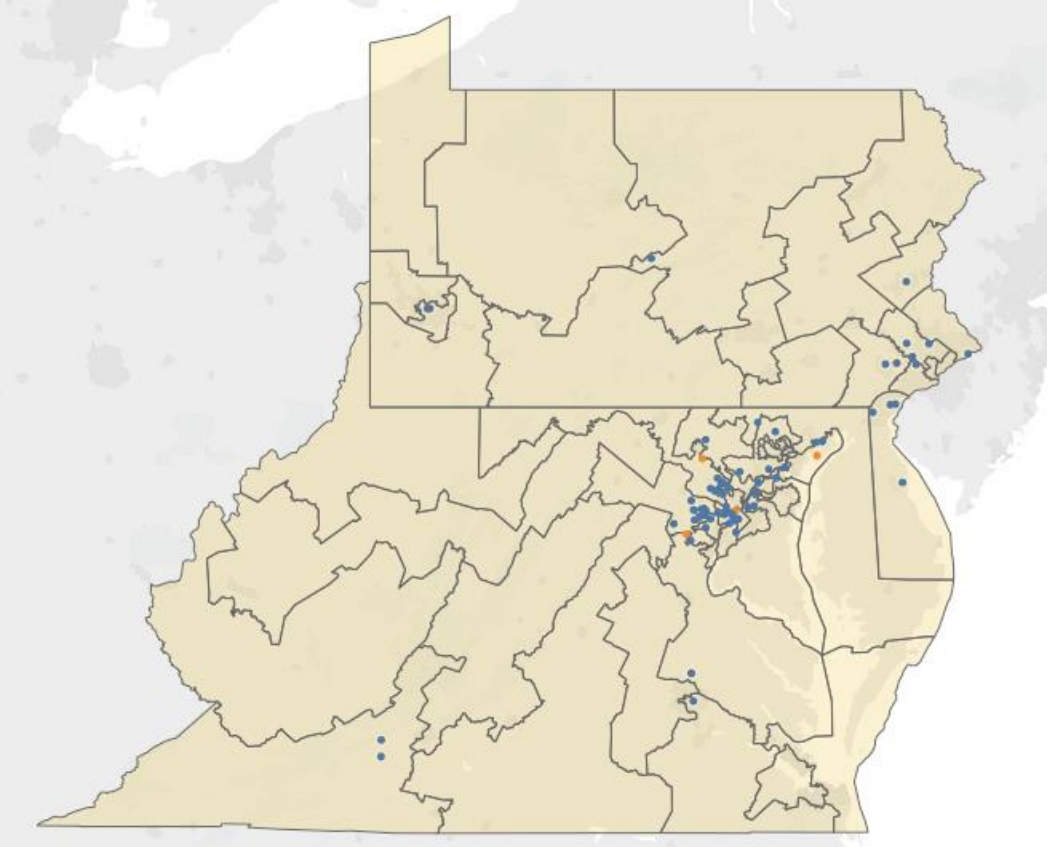

Figure 2. Map of CRADAs and Invention Licenses in Mid-Atlantic States

Mid-Continent:

The FLC defines the Mid-Continent region to consist of the states of Arkansas, Colorado, Iowa, Kansas, Missouri, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, Utah, and Wyoming. Table 3 shows the CRADAs, CRADAs per million population rates, invention licenses, and licenses per million population rates for these states.

In the Mid-Continent region, NIST had 57 CRADAs in 9 states with a CRADA rate per million population of 0.88. NIST had 10 invention licenses in 3 states with an invention license rate per million population of 0.16. Colorado was the state with the greatest number of CRADAs with 18 and invention licenses with 7. Colorado also had the highest CRADA rate per million population rate with 3.13 and the highest licenses per million population rate with 1.22. The states of Arkansas, Kansas, Oklahoma, South Dakota, and Wyoming had neither a CRADA nor invention license.

Table 3. CRADAs and Invention Licenses in Mid-Continent States

State	CRADAs	CRADAs /Million	Invention Licenses	Licenses /Million
Arkansas	0	0.00	0	0.00
Colorado	18	3.13	7	1.22
Iowa	5	1.58	0	0.00
Kansas	0	0.00	0	0.00
Missouri	4	0.65	2	0.33
Montana	1	0.94	0	0.00
Nebraska	1	0.52	0	0.00
New Mexico	2	0.95	1	0.48
North Dakota	1	1.31	0	0.00
Oklahoma	0	0.00	0	0.00
South Dakota	0	0.00	0	0.00
Texas	17	0.59	0	0.00
Utah	8	2.50	0	0.00
Wyoming	0	0.00	0	0.00
All States	57	0.88	10	0.16

Figure 3 shows the geographic distribution of ZIP codes with at least one NIST CRADA or invention license in the Mid-Continent region. The lines on the figure indicate the congressional districts for each state. The blue dots indicate the ZIP codes with at least one NIST CRADA. The orange dots indicate the ZIP codes with at least one NIST invention license.

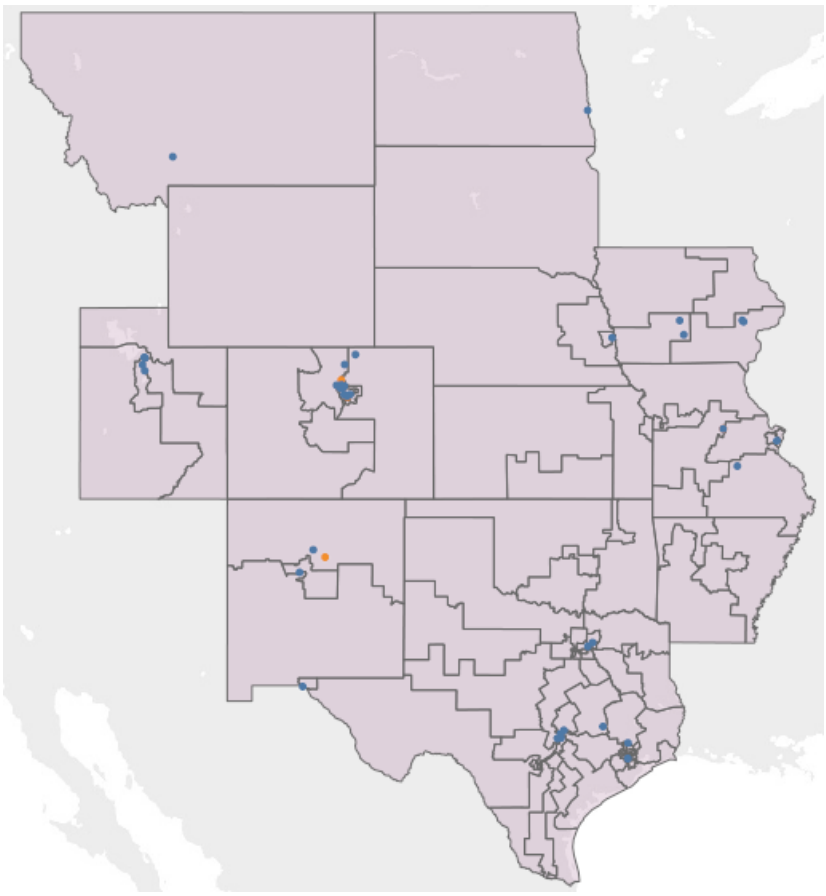

Figure 3. Map of CRADAs and Invention Licenses in Mid-Continent States

Midwest:

The FLC defines the Midwest region to consist of the states of Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin. Table 4 shows the CRADAs, CRADAs per million population rates, invention licenses, and licenses per million population rates for these states.

Table 4. CRADA and Invention Licenses in Midwest States

State	CRADAs	CRADAs /Million	Invention Licenses	Licenses /Million
Illinois	12	0.95	3	0.24
Indiana	3	0.45	2	0.30
Michigan	10	1.00	1	0.10
Minnesota	10	1.77	1	0.18
Ohio	12	1.03	2	0.17
Wisconsin	2	0.34	1	0.17
All States	49	0.93	10	0.19

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In the Midwest region, NIST had 49 CRADAs in 6 states with a CRADAs per million population rate of 0.93. In this region, NIST had 10 licenses in 6 states with a licenses per million population rate of 0.19. Illinois had the greatest number of CRADAs with 12 and licenses with 3. Minnesota had the highest CRADAs per million population rate with 1.77. Indiana had the highest licenses per million population rate with 0.30. Every state in the Midwest region had at least 1 CRADA and 1 invention license.

Figure 4 shows the geographic distribution of ZIP codes with at least one NIST CRADA or invention license in the Midwest region. The lines on the figure indicate the congressional districts for each state.[4] The blue dots indicate ZIP codes with at least one NIST CRADA. The orange dots indicate ZIP codes with at least one NIST invention license.

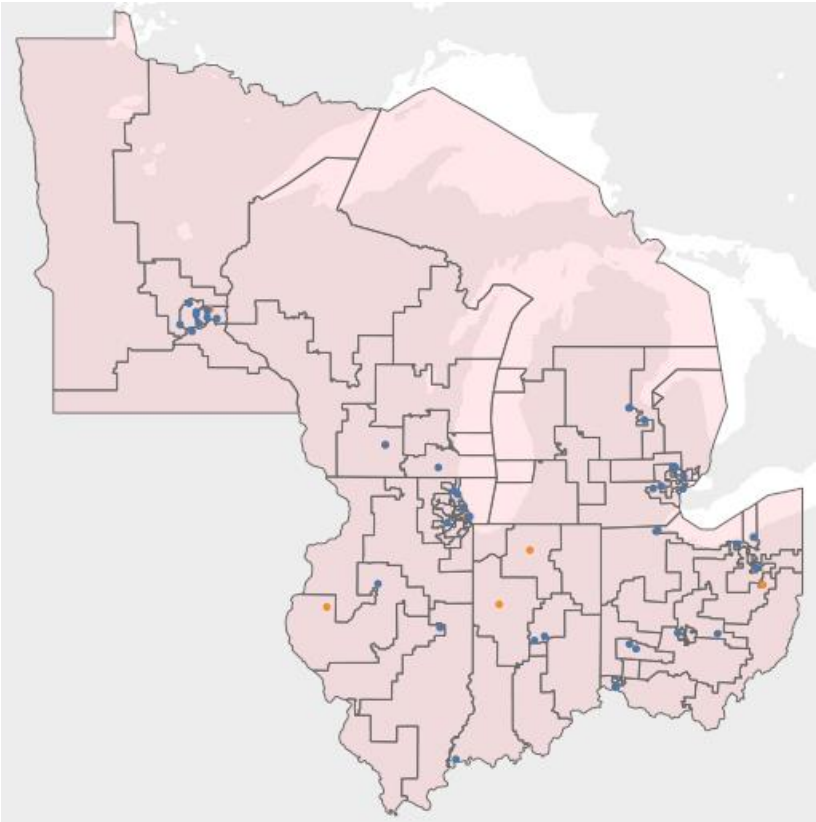

Figure 4. Map of CRADAs and Invention Licenses in Midwest States

[4] We created Fig. 4 with the 116th congressional district shapefile published by the Census Bureau [9]. Figure 4 erroneously shows congressional districts entirely located within the Great Lakes of Michigan, Huron, and Eire. There are no such congressional districts. The land-based district boundaries are correct.

Northeast:

The FLC defines the Northeast region to consist of the states of Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont, and the territory of Puerto Rico.[5] Table 5 shows the CRADAs, CRADAs per million population rates, invention licenses, and licenses per million population rates for these states.

Table 5. CRADA and Invention Licenses in Northeast States

State	CRADAs	CRADAs /Million	Invention Licenses	Licenses /Million
Connecticut	2	0.56	1	0.28
Maine	0	0.00	0	0.00
Massachusetts	28	4.06	3	0.44
New Hampshire	2	1.47	0	0.00
New Jersey	9	1.01	2	0.23
New York	14	0.72	4	0.21
Puerto Rico	0	0.00	0	0.00
Rhode Island	0	0.00	0	0.00
Vermont	0	0.00	0	0.00
All States and PR	55	1.19	10	0.22

In the Northeast region, NIST had 55 CRADAs in 5 states with a CRADAs per million rate of 1.19. In this region, NIST had 10 invention licenses in 4 states with a licenses per million rate of 0.22. Massachusetts had the greatest number of CRADAs with 28. New York had the greatest number of licenses with 4. Massachusetts had the highest CRADAs per million rate with 4.06 and licenses per million population rate of 0.44. Maine, the territory of Puerto Rico, Rhode Island, and Vermont had neither a CRADA nor an invention license.

Figure 5 shows the geographic distribution of ZIP codes with at least one NIST CRADA or invention license in the Northeast region. Puerto Rico is not shown as it had neither a CRADA nor an invention license. The lines on the figure indicate the congressional districts for each state. The blue dots indicate the ZIP codes with least one NIST CRADA. The orange dots indicate the ZIP codes with at least one NIST invention license.

[5] Per communication with members of the FLC's Executive Board, Puerto Rico is included in the Northeast region for historical reasons despite its physical proximity to the Southeast region states.

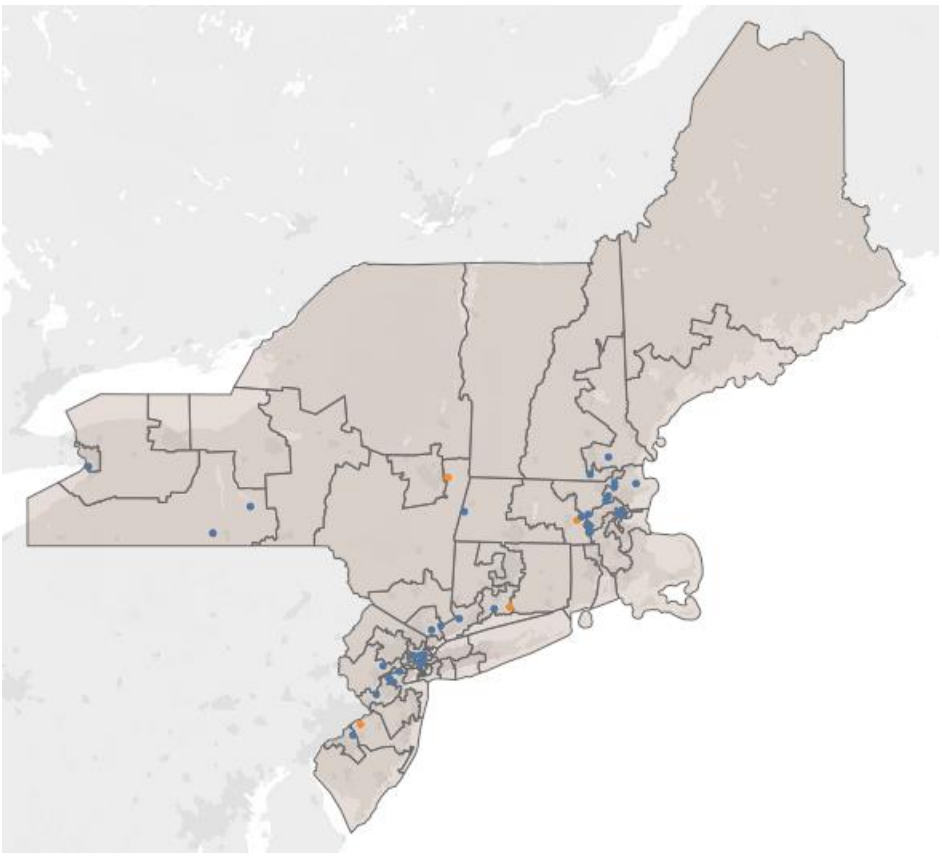

Figure 5. Map of CRADAs and Invention Licenses in Northeast States

Southeast:

The FLC defines the Southeast region to consist of the states of Alabama, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, and Tennessee. Table 6 shows the CRADAs, CRADAs per million population rate, invention licenses, and licenses per million population rate for the states in the Southeast region.

Table 6. CRADA and Invention Licenses in Southeast States

State	CRADAs	CRADAs /Million	Invention Licenses	Licenses /Million
Alabama	2	0.41	0	0.00
Florida	3	0.14	0	0.00
Georgia	6	0.57	0	0.00
Kentucky	0	0.00	0	0.00
Louisiana	0	0.00	0	0.00
Mississippi	0	0.00	0	0.00
North Carolina	6	0.57	4	0.38
South Carolina	1	0.19	0	0.00
Tennessee	10	1.46	1	0.15
All States	28	0.39	5	0.07

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In the Southeast region, NIST had 28 CRADAs in 6 states with a CRADAs per million population rate of 0.39. In this region, NIST had 5 licenses in 2 states with a licenses per million population rate of 0.07. Tennessee had the greatest number of CRADAs with 10. North Carolina had the greatest number of licenses with 4. Tennessee had the highest CRADAs per million population rate with 1.46. North Carolina had the highest licenses per million population rate with 0.38. Kentucky, Louisiana, and Mississippi had neither a CRADA nor an invention license.

Figure 6 shows the geographic distribution of ZIP codes with at least one NIST CRADA or invention license in the Southeast region. The lines on the figure indicate the congressional districts for each state. The blue dots indicate the ZIP codes with at least one NIST CRADA. The orange dots indicate the ZIP codes with at least one NIST invention license.

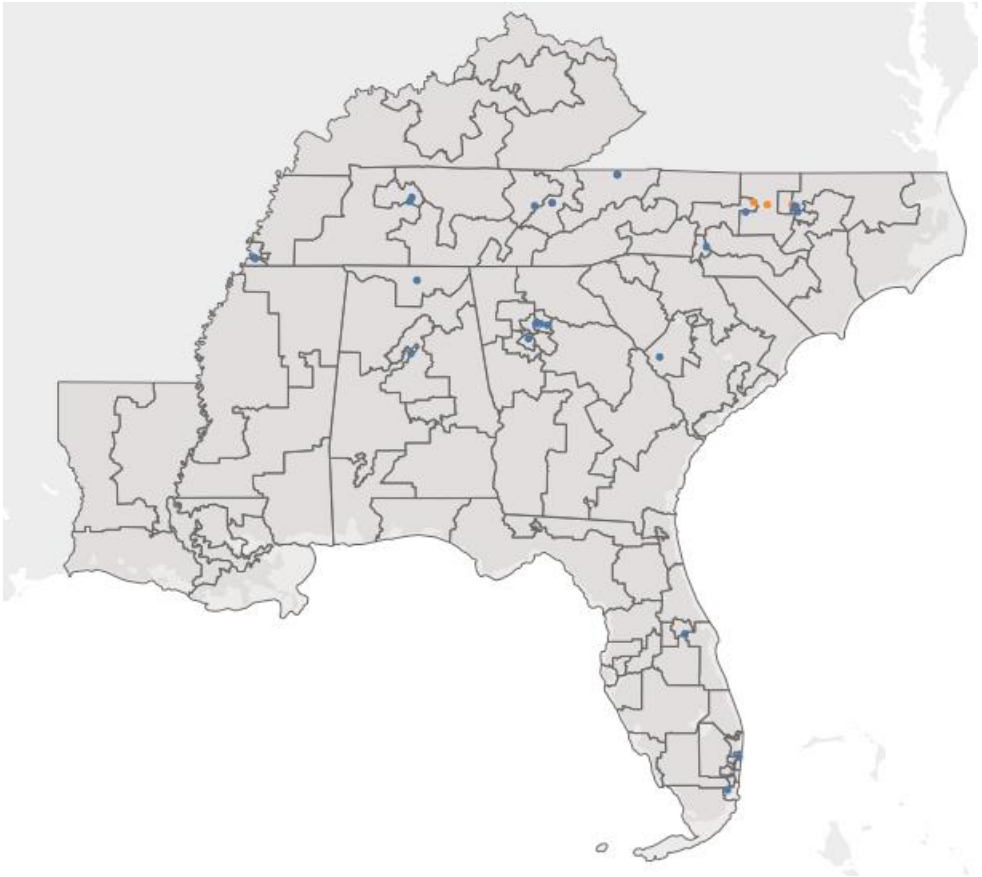

Figure 6. Map of CRADA and Invention Licenses in Southeast States

4 FOOTPRINTS ACROSS STATES AND TERRITORIES

We continue our analysis of the geographic footprint of NIST's technology transfer activities by examining the distribution of NIST CRADAs and invention licenses across

individual states and territories. We use the CRADAs per million population rates and licenses per million population rates for each state to compare the relative intensity of NIST technology transfer activities for each state and territory.

Table 7 shows the states and territories with the highest CRADAs per million population rates and licenses per million population rates. The District of Columbia has the highest CRADAs per million population rate and invention licenses per million population rate, followed by Maryland in both categories. One may observe from Table 7 that states and territories that are geographically close to NIST's two primary campuses (e.g., Gaithersburg, MD and Boulder, CO) appear on both lists. These states and territories include the District of Columbia, Maryland, Colorado, and Virginia. All of these three states and the District of Columbia and are among the states and territories with the highest rates for both CRADAs per million population and licenses per million population. As previously stated, the national rates of CRADAs per million population and of licenses per million population are calculated using the total number of CRADAs or licenses in all states, the District of Columbia, and Puerto Rico, divided by the population in all states, the District of Columbia, and Puerto Rico.

Table 7. States with the highest agreements per million population

State	CRADAs / Million	State	License /Million
District of Columbia	8.50	District of Columbia	4.25
Maryland	6.29	Maryland	2.15
Virginia	4.69	Colorado	1.22
Delaware	4.11	Virginia	0.70
Massachusetts	4.06	New Mexico	0.48
Colorado	3.13	Massachusetts	0.44
Oregon	2.61	Washington	0.39
Utah	2.50	North Carolina	0.38
California	1.87	Missouri	0.33
Minnesota	1.77	Indiana	0.30
National	1.17	National	0.21

Figure 7 shows the rate of CRADAs per million population for each state or territory that has at least one CRADA. Of states or territories with at least one CRADA, Florida has the lowest CRADAs per million population rate with 0.14, and the District of Columbia has the highest CRADAs per million population rate with 8.5. The District of Columbia and 14 states had a CRADA per capita rate greater than the national rate of 1.17.

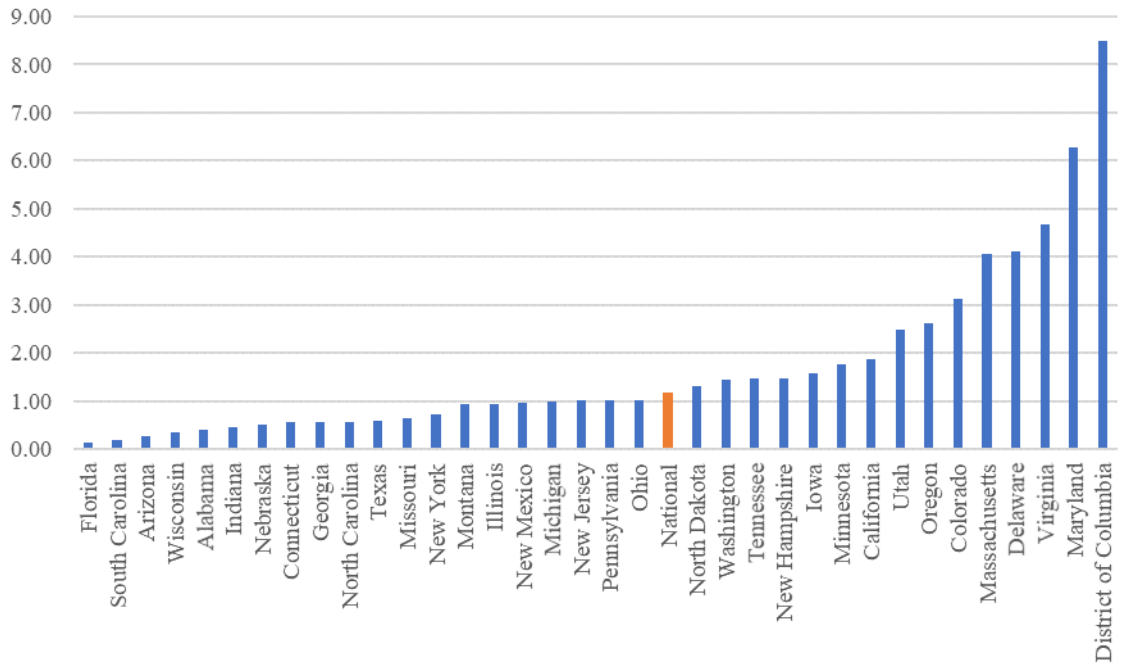

Figure 7. CRADAs per million population

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Figure 8 shows the invention licenses per million population rate for each state or territory that has at least one invention license. Of the states or territories with at least one license, Michigan has the lowest rate with 0.10, and the District of Columbia had the highest rate with 4.25. The District of Columbia and 13 states have rates of invention licenses per million population above the national rate of 0.21.

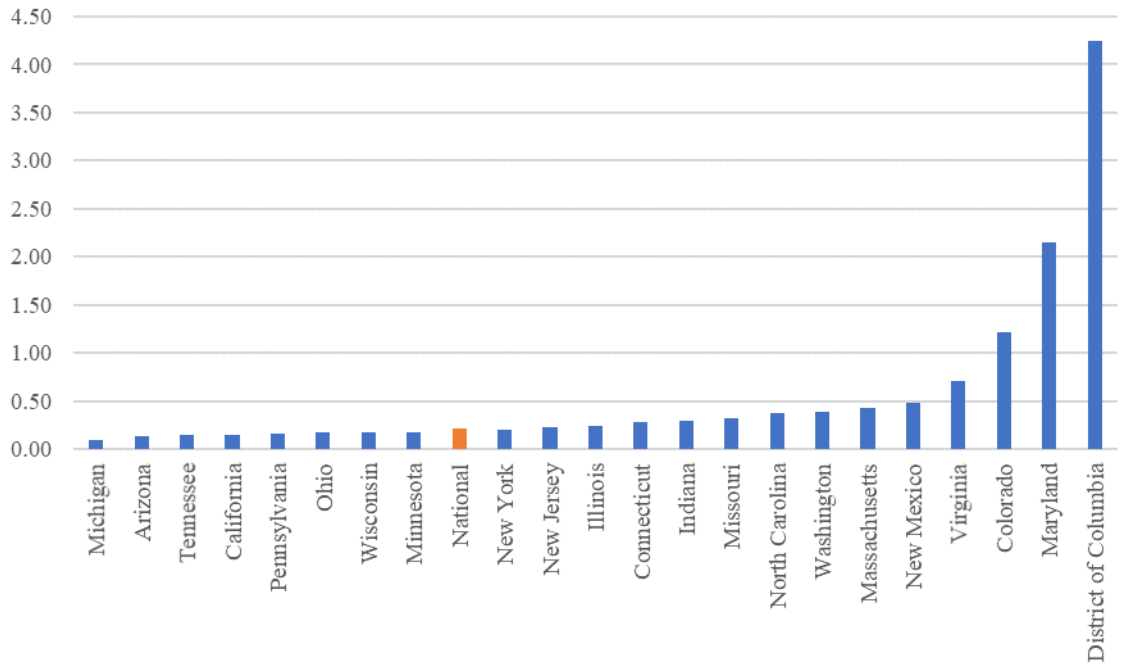

Figure 8. Invention Licenses per million population

5 SUMMARY

This work shows the geographic footprint of NIST's active CRADAs and invention licenses for fiscal year 2019. During fiscal year 2019, NIST had 388 CRADAs in 37 states and the District of Columbia, with a CRADAs per million population rate of 1.17. NIST also had 69 invention licenses in 20 states and the District of Columbia, with a invention licenses per million population rate of 0.21.

Of the six FLC-defined regions, the Mid-Atlantic region had the greatest number of CRADAs with 101, followed by the Far West region with 98. The Mid-Atlantic had the greatest number of invention licenses with 24, followed by the Far West, Mid-Continent, Midwest, and Northeast regions with 10. The Southeast region had the fewest CRADAs with 28 and of invention licenses with 5. The Mid-Atlantic region had the highest CRADAs per million population rate with 3.27 and the highest licenses per million population rate with 0.78.

The District of Columbia, Maryland, Virginia, and Colorado were all in the top six states or territories with the highest CRADAs per million population rates. The District of

Columbia, Maryland, Virginia, and Colorado were the four states or territories with the highest invention licenses per population rates. The proximity of these states and the District of Columbia to NIST's campuses in Gaithersburg, MD, and Boulder, CO, may have some correlation to these higher rates.

The limitations of this analysis suggest potential areas for future research. This work focused exclusively on technology transfer activities at NIST, future work may expand upon this by considering other agreement types and including data from other agencies. Additionally, this work did not consider other factors that may be correlated with the geographic distribution of NIST CRADAs and invention licenses. Further, future works might explore the relationship between the geographic distribution of CRADAs and invention licenses and other factors that may include education levels, university and industry concentration, and state and local policies.

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