NTIA Report 23-567

An Analysis of Aggregate CBRS SAS Data from April 2021 to January 2023

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Technical Report

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U.S. DEPARTMENT OF COMMERCE

Alan Davidson
Assistant Secretary of Commerce for Communications and Information
National Telecommunications and Information Administration

May 2023

DISCLAIMER

Certain commercial equipment and materials are identified in this report to specify adequately the technical aspects of the reported results. In no case does such identification imply recommendation or endorsement by the National Telecommunications and Information Administration, nor does it imply that the material or equipment identified is the best available for this purpose.

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ABBREVIATIONS AND ACRONYMS

AGL	above ground level
AMSL	above mean sea level
Cat A	Category A CBSD, permitted to transmit a maximum EIRP of 1 W (20 dBm/MHz) and only to be deployed indoors or outdoors with antenna heights less than 6 m above average terrain height.
Cat B	Category B CBSD, permitted to transmit a maximum EIRP of 50 W (37 dBm/MHz) outdoors and are expected to have antenna heights greater than 6 m above average terrain height.
CBRS	Citizens Broadband Radio Service
CBSD	CBRS Device, a fixed station that authorizes and controls End User Devices on a Priority Access or General Authorized Access basis, as defined in Part 96 of Title 47 in the U.S. Code of Federal Regulations.
CFR	Code of Federal Regulations
CONUS	continental United States
CW	continuous wave
DPA	Dynamic Protection Area
E_UTRA	Evolved Universal Terrestrial Radio Access
EIRP	equivalent isotropically radiated power
FAD	full activity dump
FCC	Federal Communications Commission
FSS	fixed satellite service
GAA	General Authorized Access
ITS	Institute for Telecommunication Sciences
LTE	Long-Term Evolution
NTIA	National Telecommunications and Information Administration
NR	5G New Radio
OCONUS	outside CONUS
PAL	Priority Access License
SAS	Spectrum Access System
U.S.	United States
WInnForum	Wireless Innovation Forum

EXECUTIVE SUMMARY

The Citizens Broadband Radio Service (CBRS) band at 3550–3700 MHz was authorized for shared commercial use in the United States (established June 23, 2015) through the efforts of the Federal Communications Commission (FCC), Department of Defense (DoD), and the National Telecommunications and Information Administration (NTIA). One unique aspect of CBRS was the introduction of Dynamic Protection Areas (DPAs) in which commercial entrants could dynamically share the spectrum with protected incumbents. Dynamic sharing is enabled by automated Spectrum Access Systems (SASs), which, among other tasks, manage the operation of commercial entrants to protect incumbent users when and where they operate. The goals of CBRS were to facilitate growth in wireless broadband devices, provide cost-effective wireless broadband access for rural communities, enhance economic competitiveness by creating new jobs and new businesses, increase productivity, spur innovation, and improve public safety.

To quantify progress towards meeting these goals, the NTIA's Institute for Telecommunication Sciences (ITS) obtained operational data from the SAS administrators on a quarterly basis to facilitate longitudinal analyses. This report provides a presentation and analysis of the data acquired for the period from April 1, 2021, to January 1, 2023.

Nationwide numbers of Citizens Broadband Radio Service Devices (CBSDs) by quarter are provided, broken down into the following categories: type (i.e., Category A or B), installation type (i.e., indoor or outdoor), license tier (i.e., Priority Access, General Authorized Access, or mixed license), air interface, and location type (i.e., urban or rural). Nationwide numbers of active grants by quarter provided are broken down by license tier, maximum allowed radiated power, bandwidth, and channel usage. Choropleth maps illustrate categorical CBSD statistics by state and county. Mean band utilization, defined as the mean number of channels granted per county, is used to quantify the amount of newly available spectrum that is used throughout the country. Finally, the report examines active CBSD counts and band utilization within DPA-impacted and non-impacted counties to investigate the impact of dynamic spectrum sharing.

The following are key findings from this analysis:

- CBRS deployments grew at a steady rate with a mean quarterly increase of 12.0% and a total increase of 121% over the 21-month analysis period.
- On January 1, 2023, there were 128,351 active CBSDs in DPA-impacted counties with a total population of 232,348,897 residents.
- The number of CBSDs with Priority Access License (PAL) grants grew consistently with a mean increase of 17% per quarter, but General Authorized Access (GAA) CBSDs dominated deployments. On January 1, 2023, four out of five active CBSDs were GAA-only, 85% of the active grants were GAA, and two-thirds of active CBSDs with a PAL grant had at least one active GAA grant.
- More than 70% of all active CBSDs were deployed in rural census blocks on January 1, 2023.

The authors are especially grateful for the cooperation and assistance of both the SAS administrators and the FCC in developing this first-of-its-kind report. Without their support, this report would not have been possible.

AN ANALYSIS OF AGGREGATE CBRS SAS DATA FROM APRIL 2021 TO JANUARY 2023

Douglas Boulware,[1] Anthony Romaniello,[1] Rebecca L. Dorch,[2] and Michael G. Cotton[1]

This report presents an analysis of aggregate Citizens Broadband Radio Service (CBRS) Spectrum Access System (SAS) data reported quarterly from April 1, 2021, to January 1, 2023. The data provide valuable insights into the growth of CBRS, the impact of dynamic spectrum sharing, the role of General Authorized Access (GAA) spectrum usage, and CBRS's role in rural wireless connectivity. CBRS deployments grew at a steady rate with a mean quarterly increase of 12.0% and a total increase of 121% over the 21-month analysis period. On January 1, 2023, there were 128,351 active CBSDs (i.e., 45% of the total number of CBSDs) in Dynamic Protection Area (DPA)–impacted counties. The number of CBSDs with Priority Access License (PAL) grants grew consistently with a mean increase of 17% per quarter, but GAA CBSDs dominated deployments. On January 1, 2023, four out of five active CBSDs were GAA-only, 85% of the active grants were GAA, and 66.7% of the 56,529 CBSDs with a PAL also had at least one active GAA grant. Finally, on January 1, 2023, more than 70% of all active CBSDs were deployed in rural census blocks.

Keywords: 3550–3700 MHz; 5G; cellular; Citizens Broadband Radio Service (CBRS); Citizens Broadband Radio Service Device (CBSD); rural connectivity; Spectrum Access System (SAS); spectrum management; spectrum sharing; spectrum utilization

1. INTRODUCTION

The purpose of this report is to quantify commercial use of the 3550–3700 MHz Citizens Broadband Radio Service (CBRS) band in the United States from April 1, 2021 to January 1, 2023.

The process that eventually created CBRS began with a 2010 Presidential Memorandum [1] that stated:

> *Few technological developments hold as much potential to enhance America's economic competitiveness, create jobs, and improve the quality of our lives as wireless high-speed access to the Internet. Innovative new mobile technologies hold the promise for a virtuous cycle — millions of consumers gain faster access to more services at less cost, spurring innovation, and then a new round of consumers benefit from new services…*

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> *Expanded wireless broadband access will trigger the creation of innovative new businesses, provide cost-effective connections in rural areas, increase productivity, improve public safety, and allow for the development of mobile telemedicine, telework, distance learning, and other new applications that will transform Americans' lives.*

Subsequently, the National Telecommunications and Information Administration (NTIA) produced *An Assessment of the Near-Term Viability of Accommodating Wireless Broadband Systems in the 1675–1710 MHz, 1755–1780 MHz, 3500–3650 MHz, and 4200–4220 MHz, 4380–4400 MHz Bands* [2] and recommended reallocating 100 MHz (3550–3650 MHz) for wireless broadband use within five years. In 2012, the President's Council of Advisors on Science and Technology (PCAST) responded to the "challenges and technological opportunities" that had arisen since the 2010 memorandum with a report to the President [3] that issued several recommendations including:

> *Recommendation 2.2: The Secretary of Commerce, working through the National Telecommunications and Information Administration (NTIA) and the FCC, should authorize and implement, directly or through commercial providers, a Federal Spectrum Access System (SAS) to serve as an information and control clearinghouse for the band-by-band registrations and conditions of use that will apply to all users with access to each shared Federal band under its jurisdiction…*
>
> *Recommendation 4.1: PCAST recommends that policies enabling commercial access to Federal spectrum be based primarily on their effects on innovation and growth in wireless devices, services, and associated markets…*

On June 23, 2015, the Federal Communications Commission (FCC) established spectrum-sharing rules, Part 96 of Title 47 in the U.S. Code of Federal Regulations [4], governing commercial use of CBRS in the U.S. from 3550 MHz to 3700 MHz. NTIA and the Department of Defense (DoD) have worked closely with the FCC as it has implemented the rules. With CBRS, the FCC established a ground-breaking spectrum-sharing paradigm that enabled commercial access to mid-band spectrum, demonstrating the success of a collaborative partnership among stakeholders in government and industry.

A CBRS Device (CBSD) is a fixed station or access point that operates according to CBRS rules. Category B (Cat B) CBSDs are only allowed to be deployed outdoors with antenna heights greater than 6 m above average terrain height, and a maximum allowable equivalent isotropically radiated power (EIRP) of 37 dBm/MHz (i.e., 47dBm/10 MHz). CBRS introduces indoor deployment opportunities with Category A (Cat A) CBSDs. Cat A CBSDs may also be deployed outdoors, with antenna heights less than 6 m above average terrain height and a 20 dBm/MHz (i.e., 30 dBm/10 MHz) maximum allowable EIRP.

CBRS rules also established a three-tiered system in which commercial entrants dynamically share the band with protected incumbents. Incumbent access users, in Tier 1, receive protection against harmful interference from commercial entrants in Tiers 2 and 3. Permanent incumbent users include all authorized federal users and fixed satellite service (FSS) earth stations. Tier 2, or the priority access tier, includes Priority Access Licenses (PALs), auctioned on a county-by-county basis in 10 MHz channels from 3550 MHz to 3650 MHz. Devices operating with a PAL

must protect and accept interference from Tier 1 incumbents but receive protection from Tier 3 General Authorized Access (GAA) users. Tier 3 is licensed-by-rule to permit open, flexible access throughout the entire band. GAA users must protect and accept interference from Tier 1 and Tier 2 users. Spectrum Access Systems (SASs) provide automated frequency coordination and manage access and operations in the band for the commercial entrants.

Where spectrum sharing may occur, Dynamic Protection Areas (DPAs) define the areas or points with frequency ranges where incumbent access users are protected from interference from PAL and GAA users. Each DPA has a neighborhood distance within which CBSDs must be evaluated in aggregate interference calculations when the DPA is activated. Neighborhood distances vary based on location, terrain, CBSD category, and whether protection is needed against co-channel versus out-of-band interference. In the most extreme cases, the neighborhood distances can exceed 450 km. Multiple types of DPAs exist, with different rules for activation. Typically, when a DPA is active, the SAS applies a "move list" based on each CBSD's predicted interference contribution.[3] The SAS will suspend or terminate grants of CBSDs within the neighborhood of the DPA until the predicted aggregate interference is below the protection threshold.

In January 2020, the FCC authorized full use of the CBRS band [5]. To date, six SASs have been certified by the FCC as compliant with CFR Part 96. CBRS use cases include, for example, public and private networks that utilize 4G Long Term Evolution (LTE) and/or 5G New Radio (NR) technologies to deliver small-cell networks; fixed wireless access; massive multiple input, multiple output hotspots; and industrial Internet of Things. As of November 2022, WInnForum recognized eight air interfaces within the CBRS band including: E_UTRA (3GPP TS 36.300 [6]), NR (3GPP TS 38.300 [7]), 4G_BBW_SAA_1 (IEE 802.16e), CAMBIUM_NETWORKS, DOODLE_CBRS, REDLINE, TARANA_WIRELESS, and CW (continuous wave transmissions for test purposes) [8]. Note that CBSDs registered as NR may include CBSDs with NR air interface only or CBSDs with both NR and E_UTRA LTE air interfaces. The standards document WINNF-TS-0096 [9] provides a detailed specification of the signaling procedures and SAS-to-SAS interface, WINNF-TS-0016 [10] details the SAS to CBSD interface, and WINNF-TS-0112 [11] details the requirements for the commercial operation of CBRS.

Now that several years have passed since the start of CBRS operations, there is an opportunity to assess the state and growth of CBRS. On March 21, 2021, NTIA requested that SAS administrators begin submitting operational data on a quarterly basis starting April 1, 2021, in order to facilitate a longitudinal analysis.

This report provides a summary of the data acquired from April 2021 to January 2023. Section 2 gives a description of the aggregate data acquired from the SAS administrators. Sections 3, 4, and 5 provide nationwide, state-resolution, and county-resolution statistics and maps to quantify and characterize the state and growth of CBRS, and Section 6 provides a summary of conclusions drawn from the data.

[3] Ground-based DPAs, which are always active, do not use a move list. See WINNF-TSR-5003 [23] for details.

2. DATA COLLECTION

NTIA coordinated with the SAS administrators and the FCC to determine data that would be appropriate for sharing with federal regulators to support this study. To facilitate data quality and anonymization requirements, ITS developed a `fad_processor` Python script that the SAS administrators used to build aggregate datasets from full activity dump (FAD) data.

The `fad_processor` script aggregates Category A and B data for each census block nationwide. Figure 1 provides an example of the aggregate data consisting of: (1) total number of CBSDs; (2) number of indoor CBSDs; (3) number of CBSDs using E_UTRA, NR, or Other air interfaces; (4) number of CBSDs per antenna height above ground level (AGL), counted in 3 m bins; (5) number of CBSDs per antenna height above mean sea level (AMSL), counted in 3 m bins; (6) number of grants per maximum EIRP, counted in 5 dBm/MHz bins going down from a maximum of 37 dBm/MHz; (7) number of grants per 10 MHz channel from 3550 MHz to 3700 MHz; and (8) the distribution of grants bandwidths. In addition to this information at the census block level, the aggregate data provided the total number of GAA and PAL grants, the total number of CBSDs with only GAA grants, and the total number of CBSDs with only PAL grants.

The FAD data provide grant information for any CBSD with at least one active grant. Grants are the mechanism by which a SAS authorizes a CBSD to use spectrum within CBRS. The grant procedure [10] is initiated with a request from a CBSD. A CBSD may request and receive multiple active grants. A grant includes a contiguous frequency range, defined by a low frequency and a high frequency, and a maximum EIRP. The grant bandwidth ranges from 5 MHz to 150 MHz. A grant can be issued as a PAL or a GAA. A single grant cannot combine PAL and GAA spectrum, i.e., combined usage can only be achieved through multiple grants.

In each quarterly dataset the `fad_processor` failed to resolve the census block location of a small number of CBSDs. In each dataset the percentage of CBSDs with unresolved locations represented less than 0.1% of the total number of CBSDs. The data for these CBSDs were still included in the aggregate data and thus are still included in all nationwide statistics in Section 3 except the urban and rural statistics. CBSDs in unknown census block locations are not included in the state and county statistics and maps. The number of CBSDs in each quarterly dataset for which the census block could not be resolved are detailed as “Unknown” within the “Location Type” attribute in Table 1.

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        "Category_A": {...
         }
        "Category_B": {
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                },
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                "maxEirp": {
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                        ">27-32": 0,
                         ...
                        ">2-7": 0,
                        "<=2": 0
                },
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                        ...
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                        "3660000000-3670000000": 1,
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                },
                "count": 3,
                "indoor_deployment_count": 0
        }
}
```


Figure 1: Example aggregate data format.

3. NATIONWIDE STATISTICS

This section presents the national quarterly aggregate data from April 1, 2021, to January 1, 2023.

3.1 CBSD Statistics

This subsection provides quarterly statistics describing active CBSDs. Table 1 provides nationwide counts of CBSDs in total and by differentiating attributes including CBSD type (Cat A, Cat B), installation type (indoor, outdoor), license tier (GAA-only, PAL-only, mixed license), air interface (E_UTRA, NR, other), and location type (urban, rural, unknown).

Subsection 3.1.1 examines the nationwide growth in the number of active CBSDs, while growth and change within the distribution of CBSD type, installation type, license tier, air interface, and urban and rural CBSDs are discussed in Subsections 3.1.2, 3.1.3, 3.1.4, 3.1.5, and 3.1.6, respectively.

Table 1: Nationwide counts of active CBSDs by category.

Attribute	Value	4/1/2021	7/1/2021	10/1/2021	1/1/2022	4/1/2022	7/1/2022	10/1/2022	1/1/2023
CBSD Type	Cat A	1,114	1,327	2,818	3,180	4,369	5,713	8,778	10,545
	Cat B	128,668	149,990	171,508	188,161	209,176	228,605	251,740	276,488
Installation Type	Indoor	906	1,171	2,681	2,978	4,134	5,473	8,340	10,084
	Outdoor	128,876	150,146	171,645	188,363	209,411	228,845	252,178	276,949
License Tier	Only GAA	129,782	129,179	147,545	161,997	177,731	194,065	212,381	230,504
	Only PAL	0	9,717	12,437	14,219	15,675	16,992	18,325	18,807
	Mixed	0	12,421	14,344	15,125	20,139	23,261	29,812	37,722
Air Interface	E_UTRA	48,197	57,699	68,084	76,028	87,063	98,593	107,815	119,789
	NR	0	0	0	46	151	1,158	9,612	17,065
	Other	81,585	93,618	106,242	115,267	126,331	134,567	143,091	150,179
Location Type	Urban	25,996	30,742	35,996	40,867	47,653	54,683	66,989	80,889
	Rural	103,768	120,548	138,299	150,438	165,856	179,598	193,492	206,108
	Unknown	18	27	31	36	36	37	37	36
Number of Active CBSDs		129,782	151,317	174,326	191,341	213,545	234,318	260,518	287,033

3.1.1 Number of Active CBSDs

Figure 2 illustrates the steady growth in the number of active CBSDs nationwide that occurred over the 21-month analysis period. The total number of active CBSDs nationwide increased by 157,251 (121.2%) over this period with a mean quarterly increase of 22,464 (12.0%).

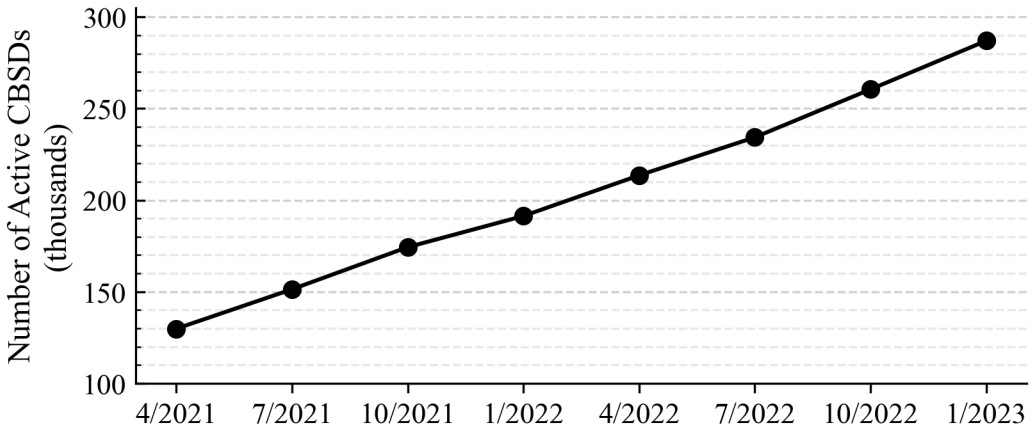

Figure 2: Nationwide number of active CBSDs from 4/1/2021 to 1/1/2023.

3.1.2 CBSD Type

As shown in Table 1, the number of Cat A CBSDs increased by 9,431 while the number of Cat B CBSDs increased by 147,820 over the analysis period. Although the numbers of both Cat A and Cat B CBSDs grew steadily, the mean quarterly increase of 21,117 Cat B CBSDs far outpaced the mean quarterly increase of 1,347 Cat A CBSDs.

Figure 3 illustrates quarterly distributions of all active CBSDs by category. The distributions remained largely unchanged throughout the analysis period, with Cat B CBSDs representing at least 96% of all active CBSDs each quarter. Although Cat A CBSDs account for a small portion of all active CBSDs, this percentage increased slightly over time, i.e., from 0.9% on April 1, 2021, to 3.7% on January 1, 2023.

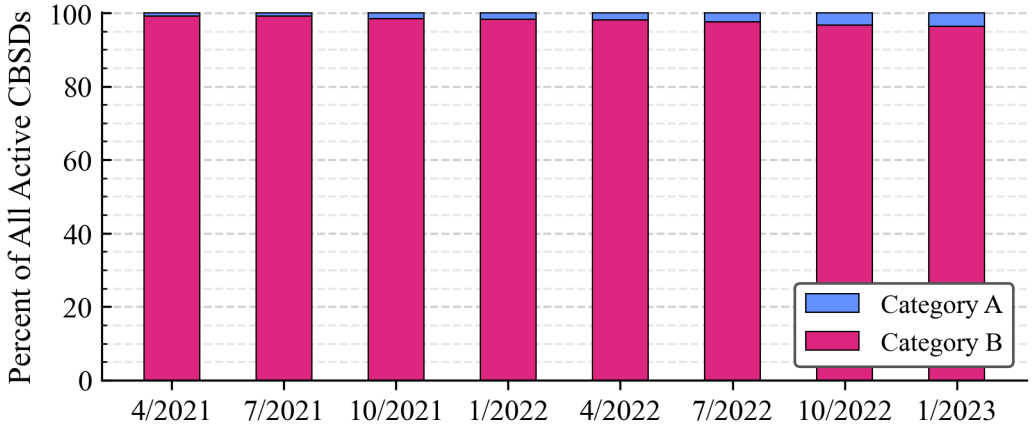

Figure 3: Nationwide percentage of active Cat A and Cat B CBSDs from 4/1/2021 to 1/1/2023.

3.1.3 Installation Type

The CBRS rules allow for Cat A CBSDs to be deployed indoors or outdoors, while Cat B CBSDs may only be deployed outdoors. Given the predominance of Cat B CBSDs, a similar majority in outdoor CBSDs is observed in Table 1. Indoor CBSDs grew from 0.7% of all active CBSDs on April 1, 2021 to 3.5% on January 1, 2023.

While indoor deployments represent a minority use case overall, they constitute the majority of deployments for Cat A CBSDs. Figure 4 illustrates quarterly distributions of indoor and outdoor Cat A CBSDs over the analysis period and shows that outdoor deployments became less common for Cat A CBSDs. Specifically, the percentage of active Cat A CBSDs deployed outdoors decreased from 18.7% on April 1, 2021, to only 4.4% on January 1, 2023. After October 1, 2021, this percentage remained relatively stable.

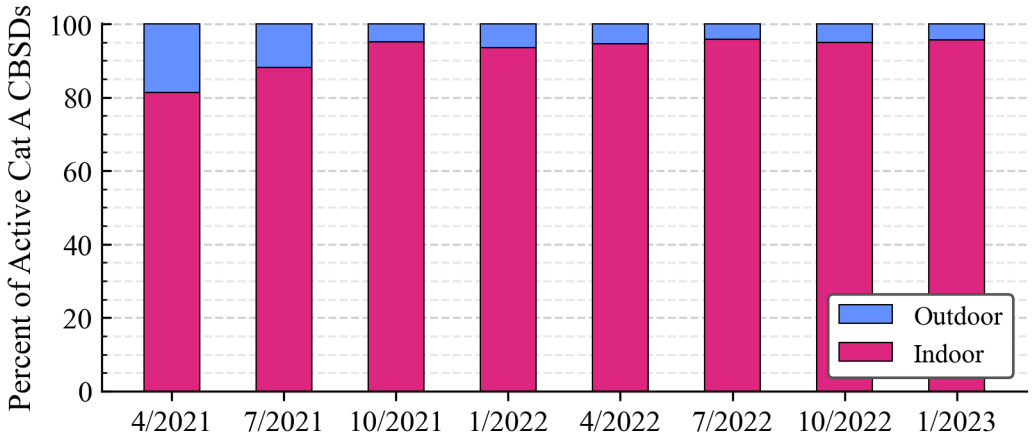

Figure 4: Nationwide percentage of active Cat A CBSDs with indoor versus outdoor installations from 4/1/2021 to 1/1/2023.

3.1.4 License Tier

A single CBSD may possess active PAL grants and active GAA grants at the same time. The GAA tier presents an interesting case study because it is licensed-by-rule to provide lower-cost access to the band. Although GAA grants do not require an expensive license, SAS coordination and fees are required. Additionally, GAA users must accept interference from PALs and have no expectation of protection from other GAAs.

Figure 5(a) illustrates the number of active nationwide CBSDs that use only PAL grants, only GAA grants, and mixed license (i.e., GAA and PAL grants). As shown in Table 1 and Figure 5(a), CBSDs with only GAA grants decreased by 603 CBSDs immediately after the introduction of PALs and thereafter steadily increased by 100,722 to a total of 230,504 active CBSDs. After PAL deployments began in April 2021 [12], the number of CBSDs with PAL grants grew quickly—to 22,138 CBSDs on July 1, 2021, and then steadily to a total of 56,529 CBSDs on January 1, 2023.

Figure 5(b) illustrates these counts as percentages of the total number of active nationwide CBSDs on each date. GAA-only CBSDs make up more than 80% of all CBSDs in every quarter, but the percentage of PAL-only and mixed license CBSDs increased after April 2021.

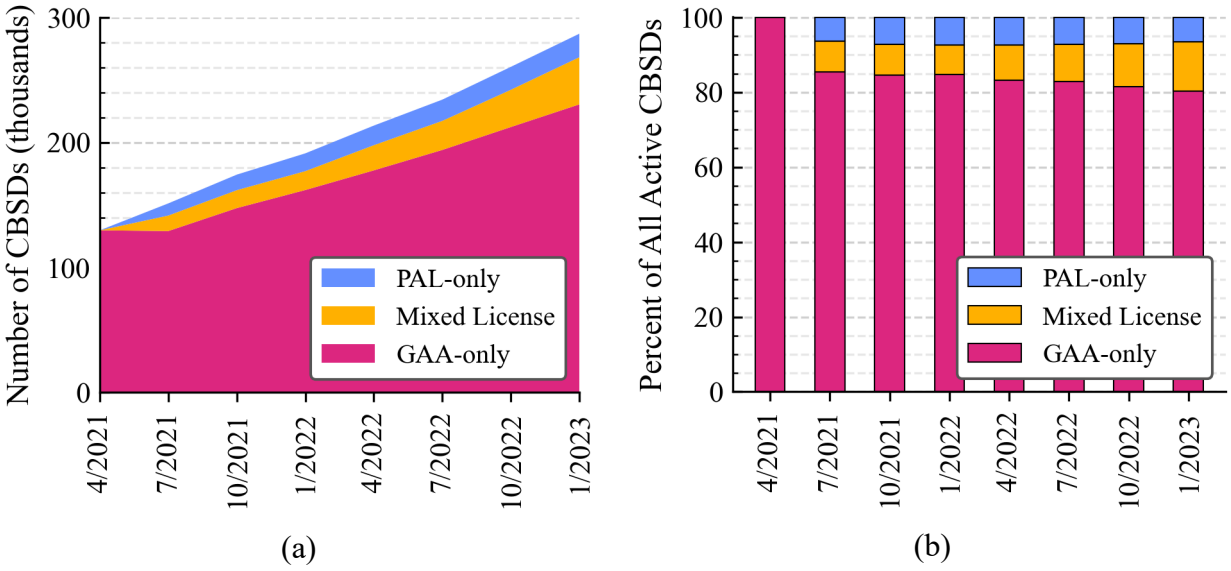

Figure 5: Nationwide number (a) and percentage (b) of active CBSDs with PAL-only, GAA-only, and mixed license from 4/1/2021 to 1/1/2023.

Regarding active CBSDs with at least one active PAL grant, Figure 6 contrasts the percentage of CBSDs that are PAL-only with those that are mixed license. The data illustrated by this figure demonstrate that the GAA tier has been a popular supplement to PALs. Over the analysis period, the percentage of active CBSDs with a PAL grant that were also using at least one GAA grant remained above 51% and reached a maximum of 66.7% on January 1, 2023.

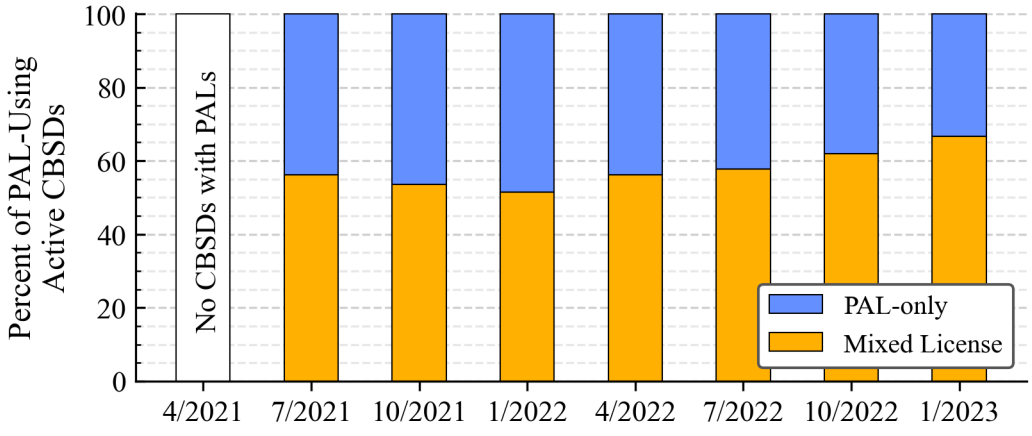

Figure 6: Nationwide percentage of active CBSDs with at least one PAL grant that were PAL-only versus mixed license from 4/1/2021 to 1/1/2023.

3.1.5 Air Interfaces

As shown in Table 1, instances of E_UTRA, NR, and Other air interfaces increased every quarter. Note that the specific distribution of the individual interfaces within this Other category is not separated out in the aggregate FAD data. Between April 1, 2021 and January 1, 2023, E_UTRA had the largest increase of 71,592 CBSDs, compared to 17,065 for NR and 68,594 for Other air interfaces.

Figure 7 illustrates the distribution of air interfaces from April 1, 2021 to January 1, 2023. E_UTRA rose from 37.1% on April 1, 2021 to 41.7% on January 1, 2023, and NR CBSDs increased from 0.0% to 6.0% over the same period. The percentage of CBSDs using an air interface other than E_UTRA or NR declined from 62.9% to 52.3% over the analysis period.

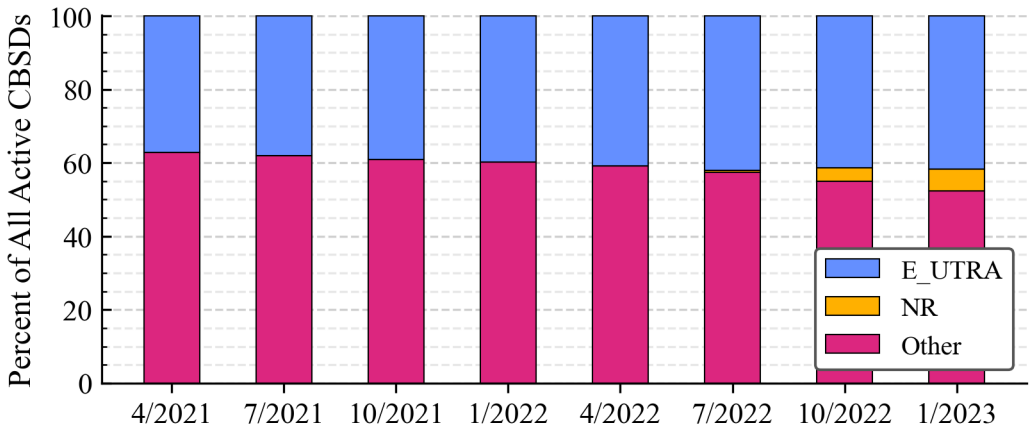

Figure 7: Nationwide percentage of active CBSDs with NR, E_UTRA, and Other air interfaces from 4/1/2021 to 1/1/2023.

3.1.6 Location Type

Recently, there has been an emphasis on closing the digital divide in rural America [13]–[15] and speculation that CBRS may play a role in increasing broadband access in rural communities [16], [17]. This section examines the role of CBRS in enabling rural wireless connectivity. We define urban versus rural CBSDs as CBSDs that are located or not located in a Census Bureau designated urban area [18].

Figure 8(a) illustrates quarterly growth in the number of CBSDs in urban and rural areas and shows a substantial number of deployments in rural areas. Both urban and rural CBSD deployments experienced significant and steady increases. Over the analysis period, rural CBSDs increased by 102,340 CBSDs (14,620 per quarter, on average) compared to an increase of 54,893 urban CBSDs (7,842 per quarter, on average).

Figure 8(b) illustrates these counts as a percentage of the total number of active CBSDs on each date. As shown, urban CBSDs increased from 20.0% of all active CBSDs on April 1, 2021 to 28.2% on January 1, 2023. Additionally, the increase in this metric grew each quarter, indicating that urban deployments are accelerating.

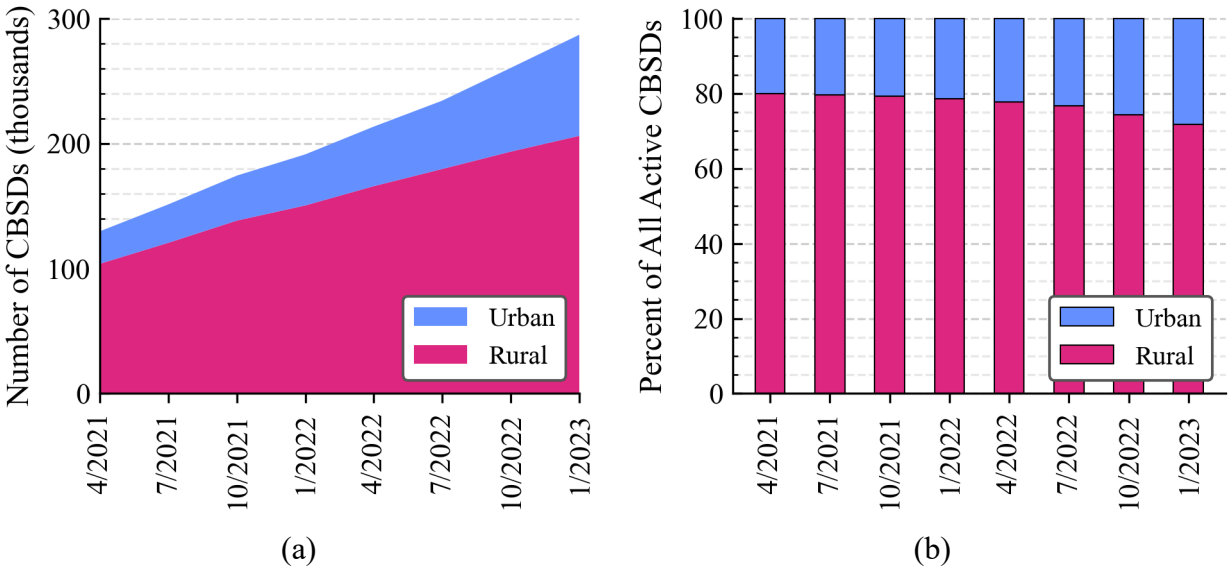

Figure 8: Nationwide number (a) and percentage (b) of urban and rural CBSDs from 4/1/2021 to 1/1/2023.

3.2 Grant Statistics

This subsection provides quarterly statistics describing active grants. Details regarding the distribution of CBSDs that use PAL and GAA grants are discussed in subsections 3.2.1 (number and type of active grants), 3.2.2 (maximum EIRP), and 3.2.3 (bandwidth and channel utilization).

3.2.1 Number and License Tier of Active Grants

Table 2 and Figure 9(a) illustrate quarterly nationwide counts of active PAL and GAA grants. Figure 9(b) illustrates the distribution of grant types on each date. On January 1, 2023, 85% of the active grants were GAA.

Table 2: Nationwide counts of active grants by license tier.

Type	4/1/2021	7/1/2021	10/1/2021	1/1/22	4/1/22	7/1/22	10/1/22	1/1/2023
PAL	0	40,435	48,629	53,242	67,229	74,120	91,488	107,479
GAA	182,109	248,935	312,504	349,694	406,606	464,705	536,599	612,607
Total	182,109	289,370	361,133	402,936	473,835	538,825	628,087	720,086

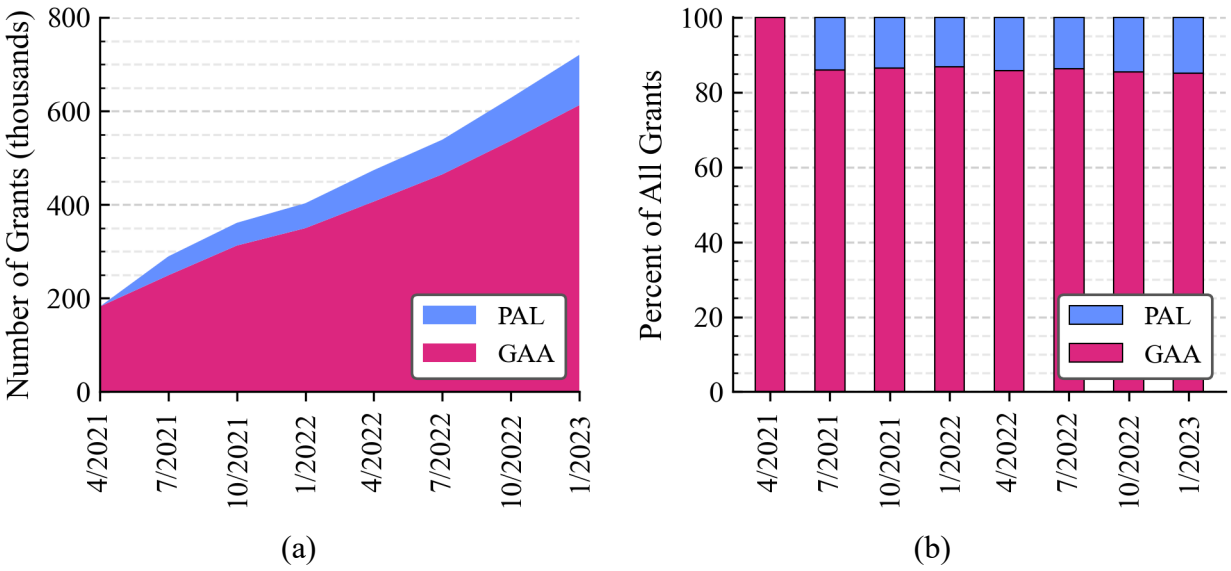

Figure 9: Nationwide number (a) and percentage (b) of PAL and GAA grants from 4/1/2021 to 1/1/2023.

3.2.2 Maximum EIRP

Table 3 provides distributions of grants within each maximum EIRP range for Cat A and Cat B CBSDs. The same maximum EIRP ranges were used for both Cat A and Cat B distributions even though Cat A CBSDs are limited to 20 dBm/MHz.

Table 3: Percents of nationwide Cat A/B active grants with maximum EIRP (denoted by "x") within EIRP ranges.

Max. EIRP (dBm/MHz)	Grant Type	4/1/2021	7/1/2021	10/1/2021	1/1/2022	4/1/2022	7/1/2022	10/1/2022	1/1/2023
x ≤ 2	Cat A	2.0	1.6	1.0	2.0	1.5	0.7	0.4	0.4
	Cat B	0.1	0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.4	0.2
2 < x ≤ 7	Cat A	0.6	0.7	0.6	0.7	0.5	0.4	0.8	0.3
	Cat B	< 0.1	0.1	< 0.1	0.1	0.1	0.1	0.1	0.1
7 < x ≤ 12	Cat A	28.1	30.9	22.2	18.7	14.8	12.7	10.6	8.6
	Cat B	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2
12 < x ≤ 17	Cat A	36.8	26.1	40.9	43.6	50.2	43.2	39.4	32.9
	Cat B	1.3	1.1	1.0	0.9	0.7	0.6	0.6	0.5
17 < x ≤ 22	Cat A	32.5	40.7	35.3	35.1	33.0	43.1	48.9	57.8
	Cat B	4.3	4.2	4.1	4.1	4.0	4.0	3.9	3.9
22 < x ≤ 27	Cat B	10.6	8.6	8.2	8.3	8.4	8.0	7.4	8.0
27 < x ≤ 32	Cat B	21.5	20.3	17.4	16.8	15.2	14.6	13.7	12.2
32 < x ≤ 37	Cat B	61.9	65.4	68.9	69.6	71.4	72.6	73.8	75.0

3.2.3 Bandwidth and Channel Usage

Table 4 details the percent of grants with each grant bandwidth. Figure 10 illustrates the percent of active grants nationwide by bandwidth for the five most common grant bandwidths. Note that these percentages are based on individual grants and do not correspond to the total bandwidth used by CBSDs. As shown, there was a significant shift toward using 10 MHz grants. The number of 10 MHz grants increased from 28.2% of all active grants on April 1, 2021 to 68.7% on January 1, 2023. The number of 5 MHz grants increased slightly from 0.8% to 4.9%. All other grant bandwidths shown in Figure 10 decreased as a percentage of all grants from April 1, 2021 to January 1, 2023.

Table 4: Percents of active grants nationwide by bandwidth and date.

Bandwidth (MHz)	4/1/2021	7/1/2021	10/1/2021	1/1/2022	4/1/2022	7/1/2022	10/1/2022	1/1/2023
5	0.8	3.1	3.2	3.8	3.5	4.1	4.9	4.9
10	28.2	60.7	66.0	67.5	69.7	70.2	69.9	68.7
15	0.4	0.1	0.1	0.1	0.0	0.0	0.0	0.0
20	48.7	28.4	25.4	23.9	22.7	22.0	21.5	22.6
25	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.0	< 0.1	< 0.1
30	14.3	4.4	3.0	2.6	2.0	1.6	1.4	1.2
35	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
40	7.5	3.2	2.3	2.1	1.9	2.0	2.3	2.6
45	0.0	0.0	0.0	0.0	< 0.1	0.0	0.0	0.0
50	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
60	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
70	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
80	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
90	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
100	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
110	< 0.1	0.0	0.0	0.0	< 0.1	0.0	< 0.1	< 0.1
120	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
130	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
140	< 0.1	< 0.1	0.0	< 0.1	0.0	0.0	0.0	< 0.1
150	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1

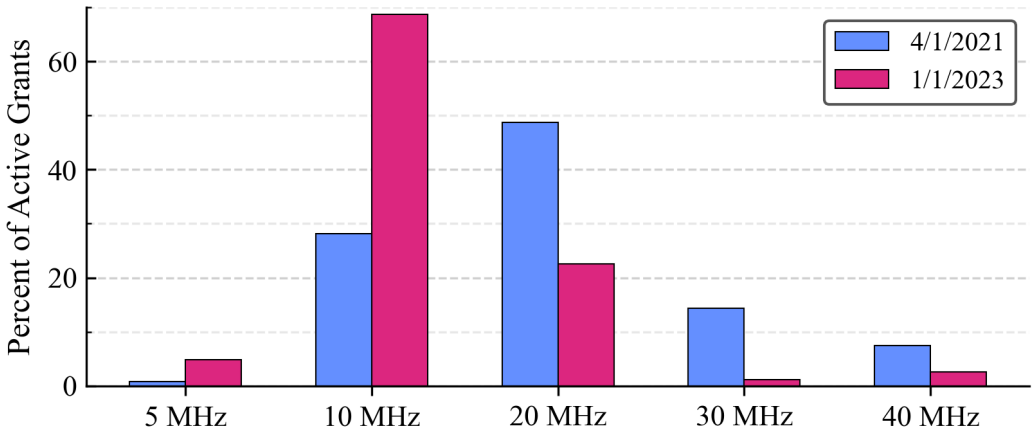

Figure 10: Percent of active grants nationwide with the five most common bandwidths on 4/1/2021 and 1/1/2023.

CBSDs often have multiple active grants. We define the CBSD bandwidth as the summation of the bandwidths of all active grants for a given CBSD. For example, the CBSD bandwidth is 30 MHz for a CBSD with three active 10 MHz grants. Mean CBSD bandwidths on a national scale are shown for each quarterly dataset in Figure 11. This figure demonstrates that, despite larger grant bandwidths becoming less common over time, mean CBSD bandwidth increased over the analysis period, i.e., from 28.2 MHz on April 1, 2021 to 32.7 MHz on January 1, 2023.

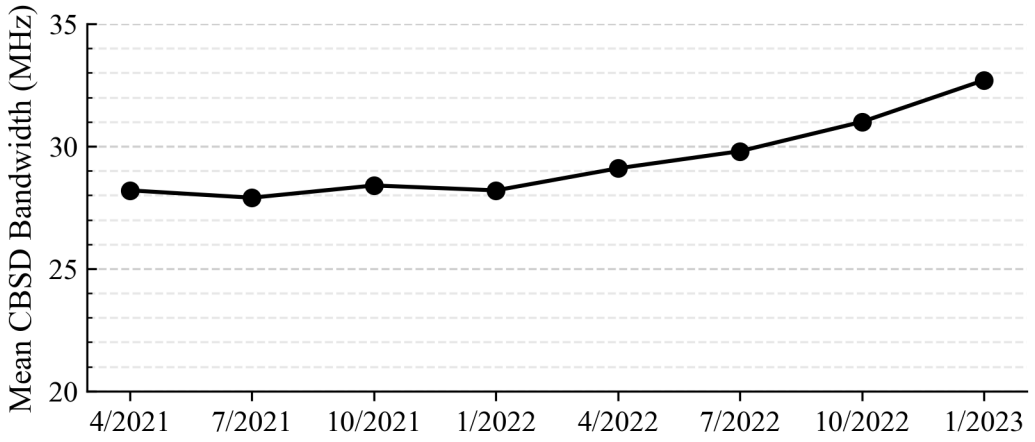

Figure 11: Nationwide mean CBSD bandwidth from 4/1/2021 to 1/1/2023.

Table 5 and Figure 12 detail the percent of grants using each channel. Note that the percentages do not add to 100% because grants vary in bandwidth. If there were two grants, for example, one spanning from 3550 to 3570 MHz and the other from 3550 to 3560 MHz, the 3550–3560 MHz channel would be considered used in 100% of the grants, while the 3560–3570 MHz channel would be used in 50% of the grants. On April 1, 2021, channels in the lower portion of the band were used more frequently than channels in the upper portion of the band. Since April 1, 2021, channel usage has become more uniform, but 3690–3700 MHz remains the least frequently granted channel at a rate that is slightly below the mean of 9% on January 1, 2023.

Table 5: Percents of nationwide active grants using each channel.

Channel (MHz)	4/1/2021	7/1/2021	10/1/2021	1/1/2022	4/1/2022	7/1/2022	10/1/2022	1/1/2023
3550–3560	20.5	12.2	11.1	10.5	10.1	9.6	9.5	10.0
3560–3570	21.6	13.1	12.2	11.5	11.1	10.6	10.4	11.1
3570–3580	19.5	12.5	11.0	10.5	10.2	9.6	9.6	9.8
3580–3590	20.1	12.8	10.9	10.3	10.0	9.5	9.7	9.7
3590–3600	16.6	10.9	9.6	8.8	9.0	8.5	8.5	8.6
3600–3610	17.9	12.2	10.9	9.7	9.8	9.2	9.1	9.2
3610–3620	16.1	11.6	10.6	10.2	9.8	9.5	9.3	9.5
3620–3630	16.5	11.6	10.7	10.4	10.1	9.9	9.7	9.7
3630–3640	13.9	10.2	9.7	9.6	9.2	9.4	9.1	9.1
3640–3650	10.2	8.2	7.9	8.1	8.1	8.4	8.4	8.3
3650–3660	7.1	7.1	7.5	7.8	7.3	7.7	8.0	8.4
3660–3670	7.5	7.6	8.3	8.5	8.1	8.5	8.8	9.2
3670–3680	6.2	6.0	6.4	6.9	6.9	7.4	7.5	7.5
3680–3690	8.8	8.1	8.1	8.5	8.2	8.6	8.4	8.2
3690–3700	7.6	7.0	6.9	7.2	6.7	6.9	6.6	6.2

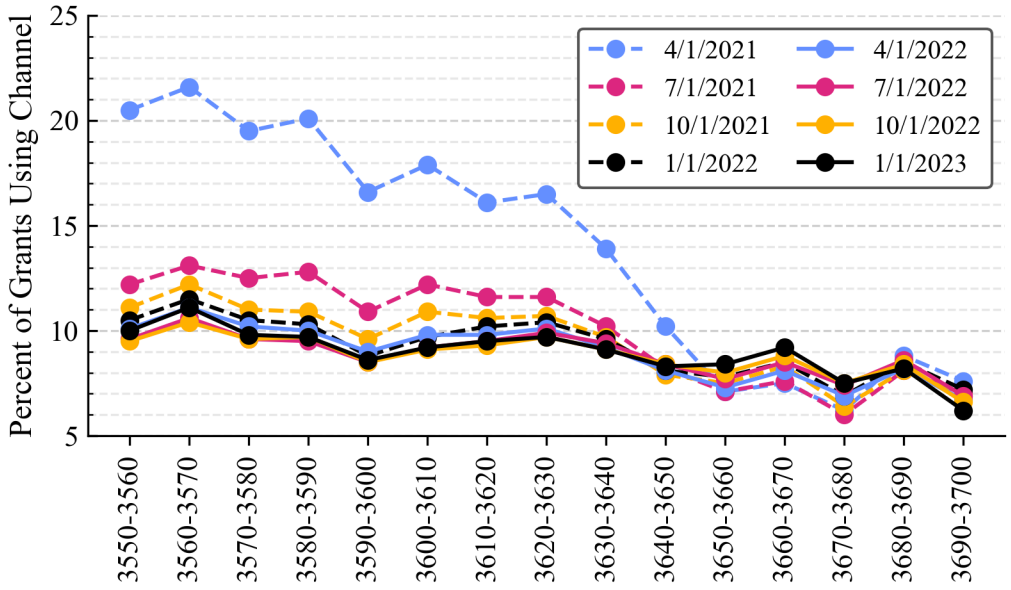

Figure 12: Nationwide percentage of active grants using each 10 MHz channel from 4/1/2021 to 1/1/2023.

4. STATE DATA

This section illustrates the aggregate data at the state level, based on the United States Census definition of the state geographic level. This is limited to all U.S. states, the District of Columbia, Puerto Rico, the U.S. Virgin Islands, Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands. Subsection 4.1 provides illustrations of the number of and growth in CBSDs by state, and subsection 4.2 provides choropleth maps [19] illustrating CBSD statistics by state.

4.1 Number of CBSDs by State

Figure 13 characterizes the growth in the number of CBSDs per state that occurred from April 1, 2021 to January 1, 2023. The figure provides the percent of states in which the number of CBSDs is equal to or greater than the value on the x-axis (abscissa). On April 1, 2021, for example, 94.6% of states and island areas had one or more CBSDs, 75% had at least 172, 50% had at least 1,220, 25% had at least 2,663, and none had more than 24,515. On January 1, 2023, 98.2% of states and island areas had at least one CBSD, 75% had at least 851, 50% had at least 3,161, 25% had at least 7,184, and none had more than 40,953.

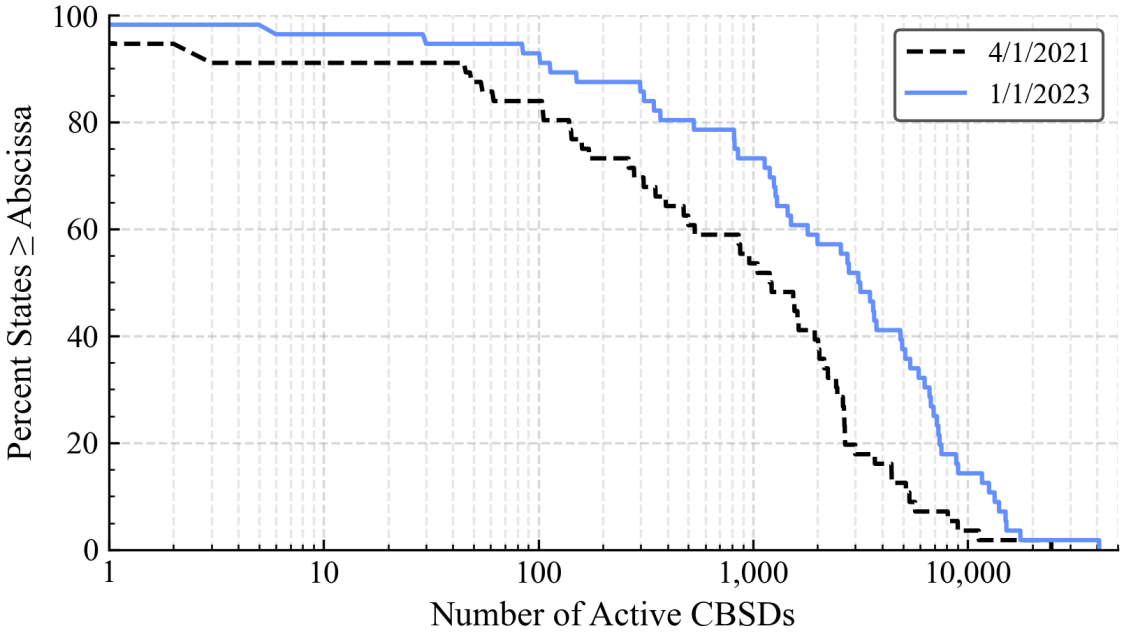

Figure 13: Percent of states and island areas in which the number of active CBSDs is equal to or greater than the value on the x-axis, on 4/1/2021 and 1/1/2023.

To illustrate this growth in absolute terms, Figures 14 and 15 provide the number of CBSDs added to each state or island area between April 1, 2021, and January 1, 2023. The mean increase over this period was 2,808 CBSDs per state or island area, with a standard deviation of 3,113. Texas led other states and island areas with an increase of 16,438 active CBSDs (more than 4 standard deviations above the mean). The state with the second-largest increase in active CBSDs over the entire 21-month period was California, with an increase of 10,718, more than 2 standard deviations above the mean. No CBSDs were added in the Northern Mariana Islands, and the Virgin Islands increased by five CBSDs. Choropleth maps of the increase in CBSDs per state are provided in Figures 22 and 23.

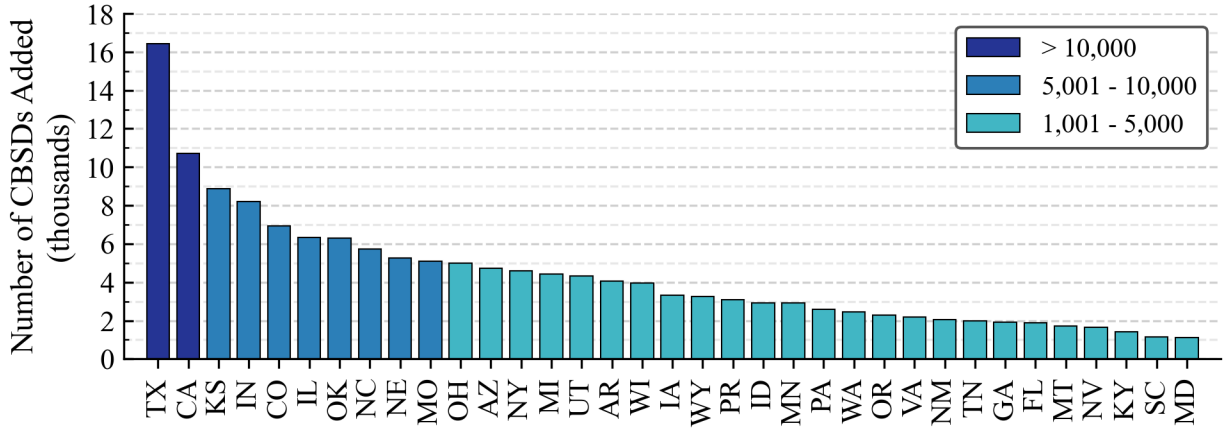

Figure 14: Increase in number of active CBSDs per state and island area (for those that increased by more than 1,000 CBSDs) from 4/1/2021 to 1/1/2023.

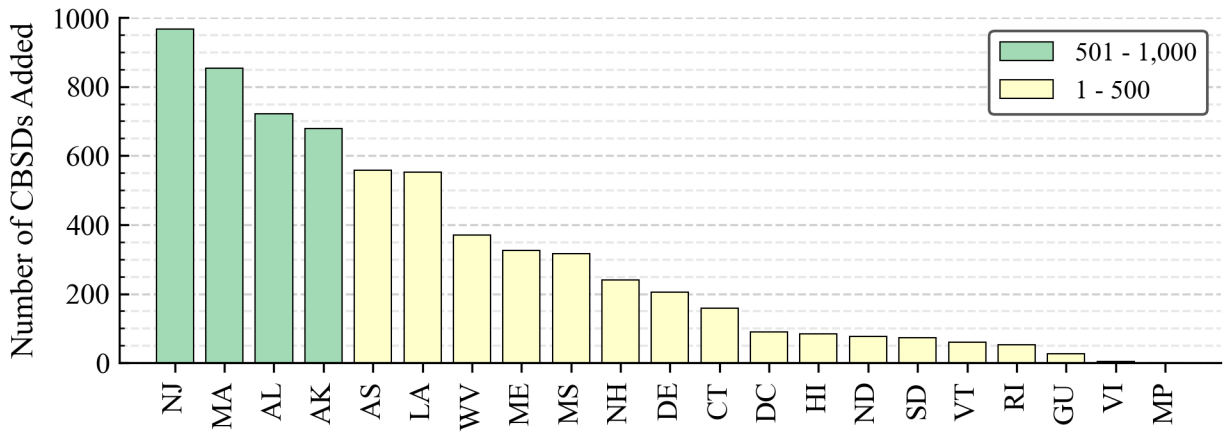

Figure 15: Increase in number of active CBSDs per state and island area (for those that increased by less than 1,000 CBSDs) from 4/1/2021 to 1/1/2023.

Finally, Figures 16 and 17 show the counts of active CBSDs in each state or island area on January 1, 2023. The mean number of active CBSDs per state or island area on January 1, 2023, was 5,125 CBSDs. Texas remained the state or island area with the most active CBSDs with 40,953 active CBSDs (greater than five standard deviations above the mean). Hawaii, Guam, the Virgin Islands, and the Northern Mariana Islands each had less than 100 active CBSDs, and the Northern Mariana Islands was the only state or island area with no active CBSDs. Choropleth maps of this data are provided in Figures 20 and 21.

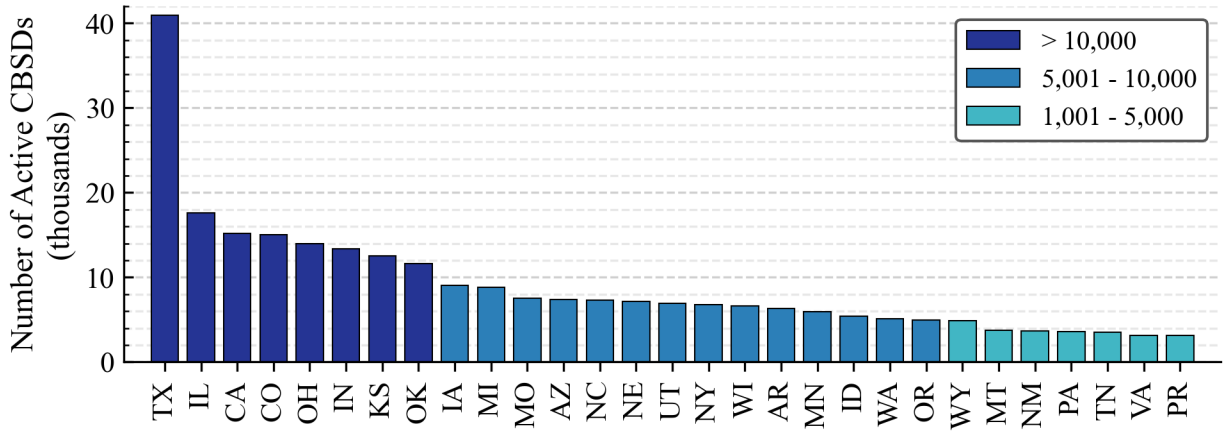

Figure 16: Number of active CBSDs in states or island areas with more than 3000 CBSDs on 1/1/2023.

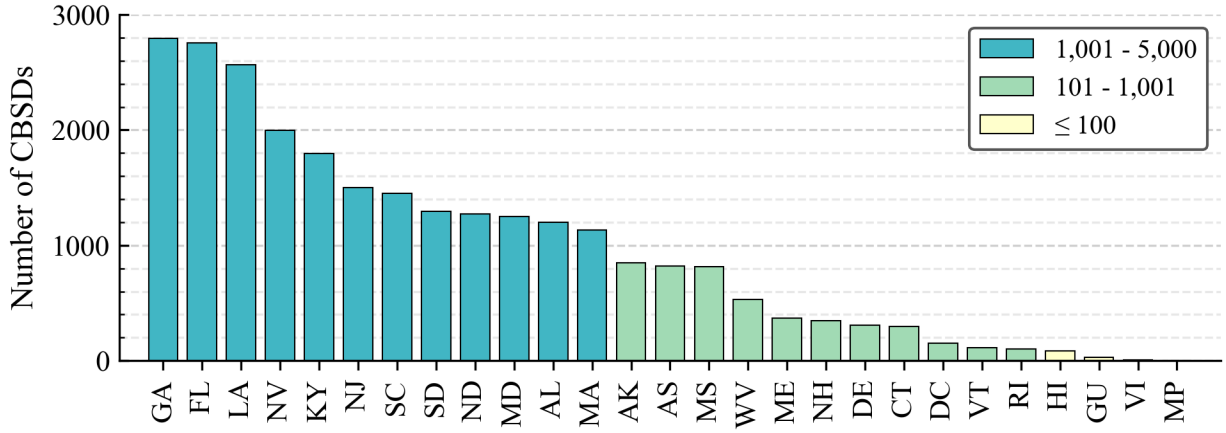

Figure 17: Number of active CBSDs in states or island areas with fewer than 3000 CBSDs on 1/1/2023.

4.2 Choropleth Maps Illustrating Categorical CBSD Statistics by State

Choropleth maps are provided to illustrate categorical CBSD statistics by state for the contiguous (CONUS) and non-contiguous (OCONUS) U.S. and Table 6 provides a summary of these maps. In addition to absolute counts of active CBSDs in each state and island area, figures are provided which normalize the CBSD counts by the total population of each state or island area as "active CBSDs per 10,000 people." Data from the 2020 United States Census is used for the normalization.

Table 6: State choropleth map descriptions.

Figures	Description
Figures 18 and 19	Number of active CBSDs on 4/1/2021
Figures 20 and 21	Number of active CBSDs on 1/1/2023
Figures 22 and 23	Increase in number of active CBSDs from 4/1/2021 to 1/1/2023
Figures 24 and 25	Number of active CBSDs per 10,000 people on 4/1/2021
Figures 26 and 27	Number of active CBSDs per 10,000 people on 1/1/2023
Figures 28 and 29	Number of active NR CBSDs on 4/1/2021
Figures 30 and 31	Number of active NR CBSDs on 1/1/2023
Figures 32 and 33	Number of active indoor CBSDs on 4/1/2021
Figures 34 and 35	Number of active indoor CBSDs on 1/1/2023

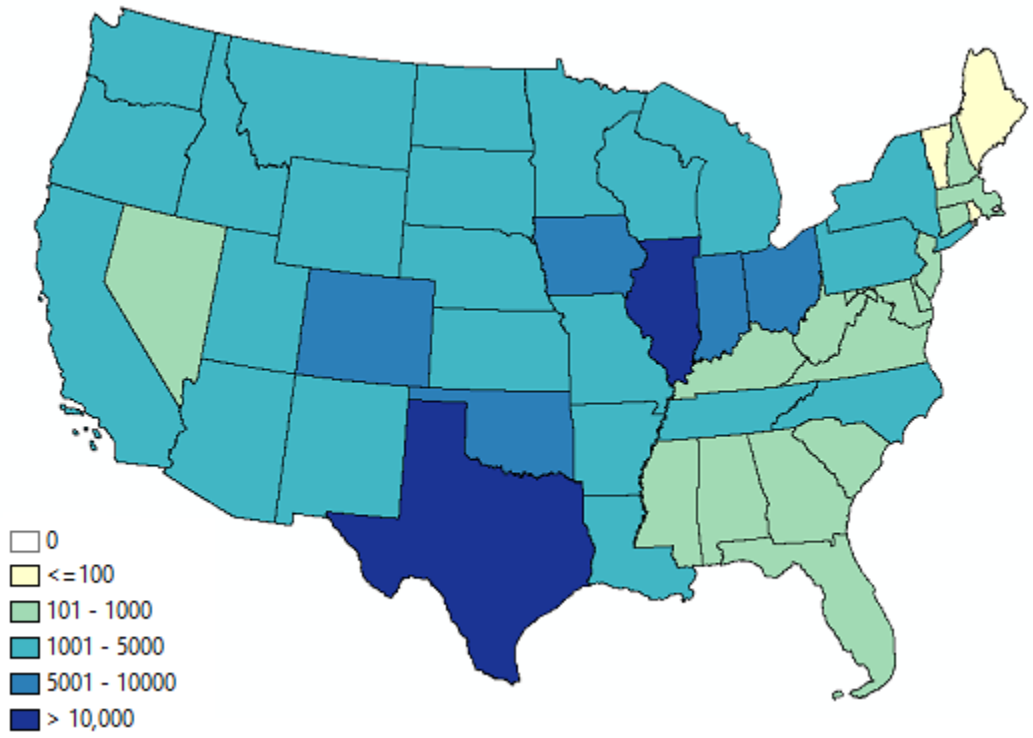

Figure 18: Number of active CBSDs by state for CONUS on 4/1/2021.

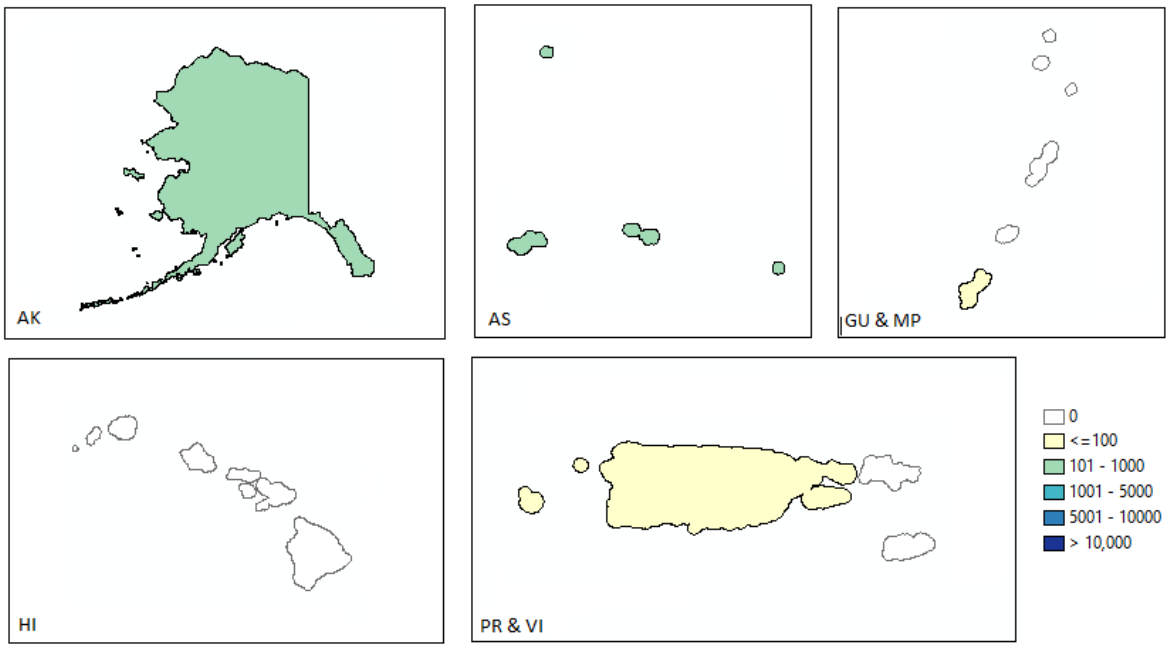

Figure 19: Number of active CBSDs by state and island area for OCONUS on 4/1/2021.

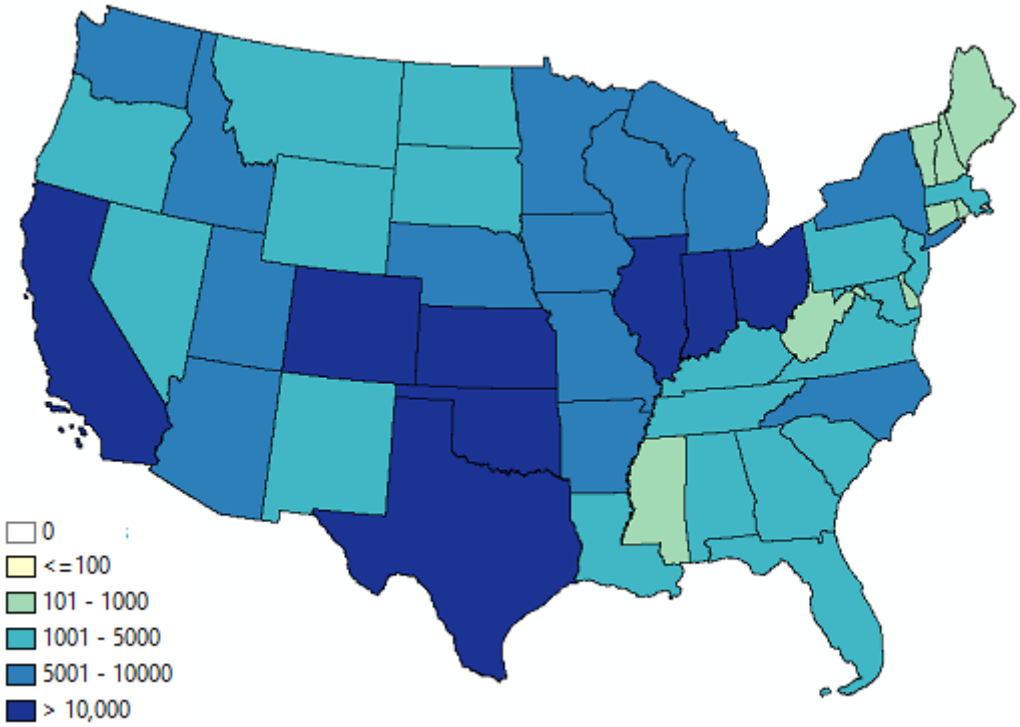

Figure 20: Number of active CBSDs by state for CONUS on 1/1/2023.

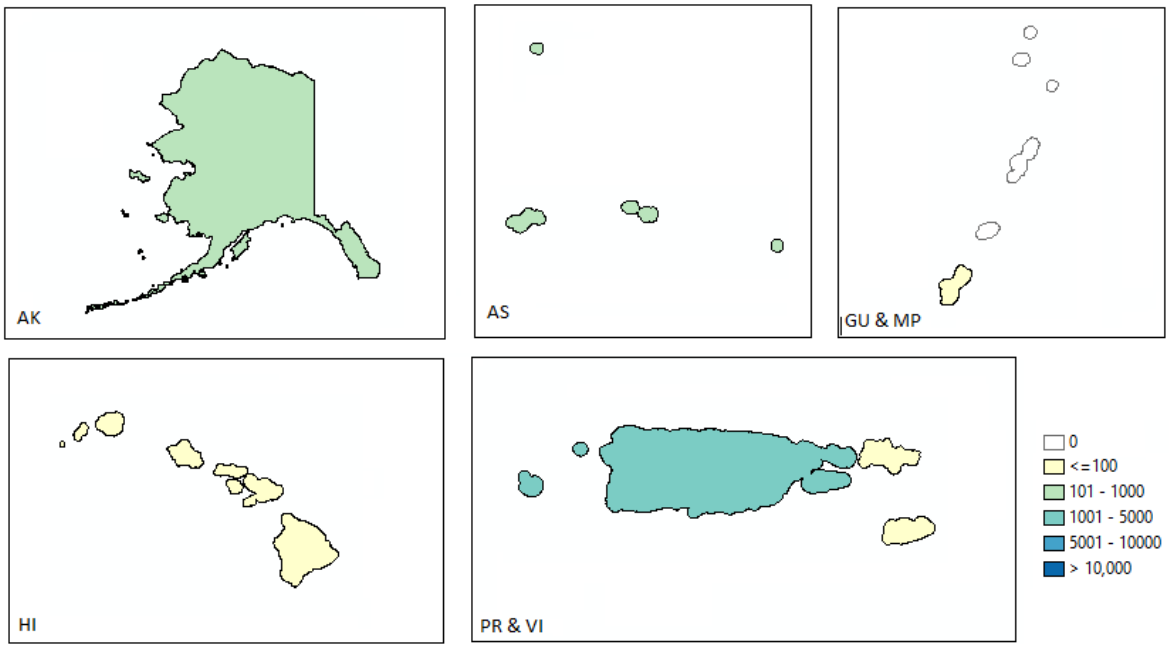

Figure 21: Number of active CBSDs by state and island area for OCONUS on 1/1/2023.

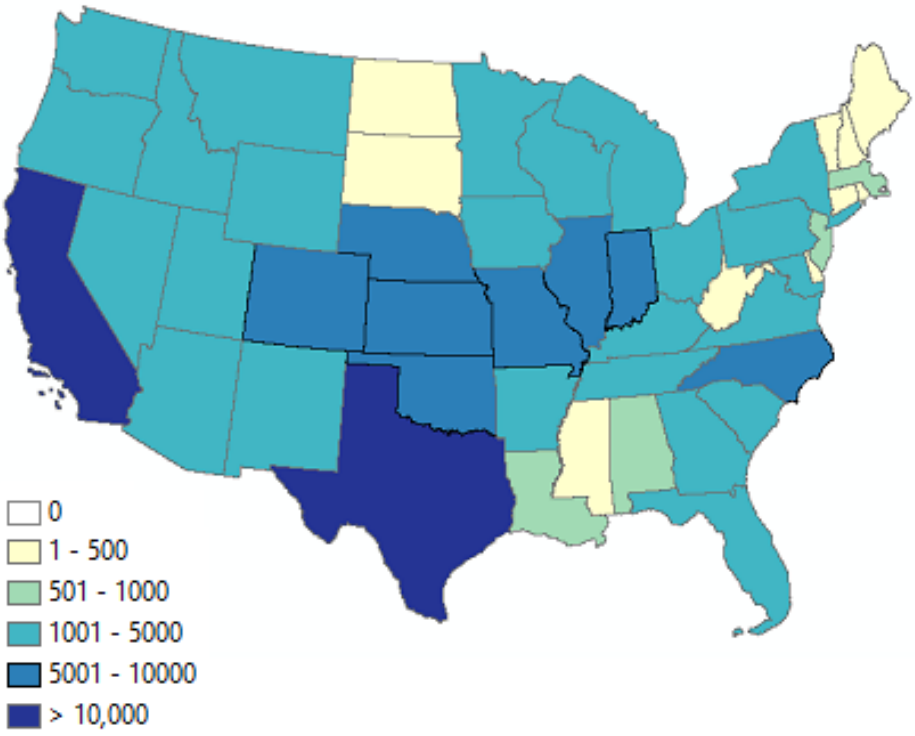

Figure 22: Increase in number of active CBSDs by state for CONUS from 4/1/2021 to 1/1/2023.

Figure 23: Increase in number of active CBSDs by state and island area for OCONUS from 4/1/2021 to 1/1/2023.

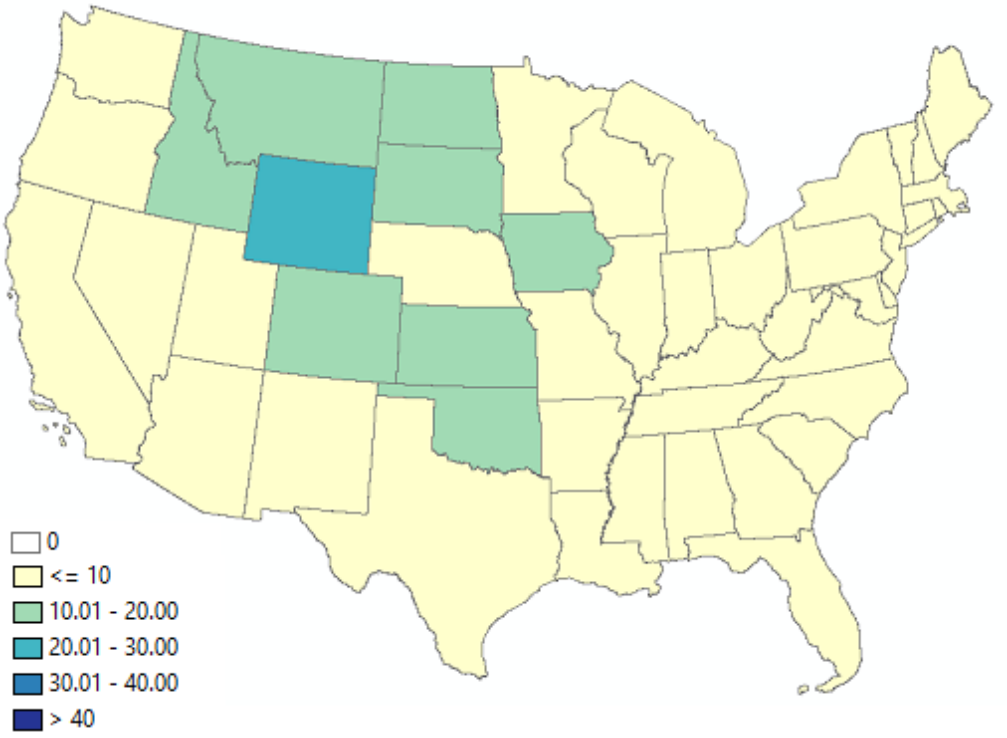

Figure 24: Number of CBSDs per 10,000 people by state for CONUS on 4/1/2021.

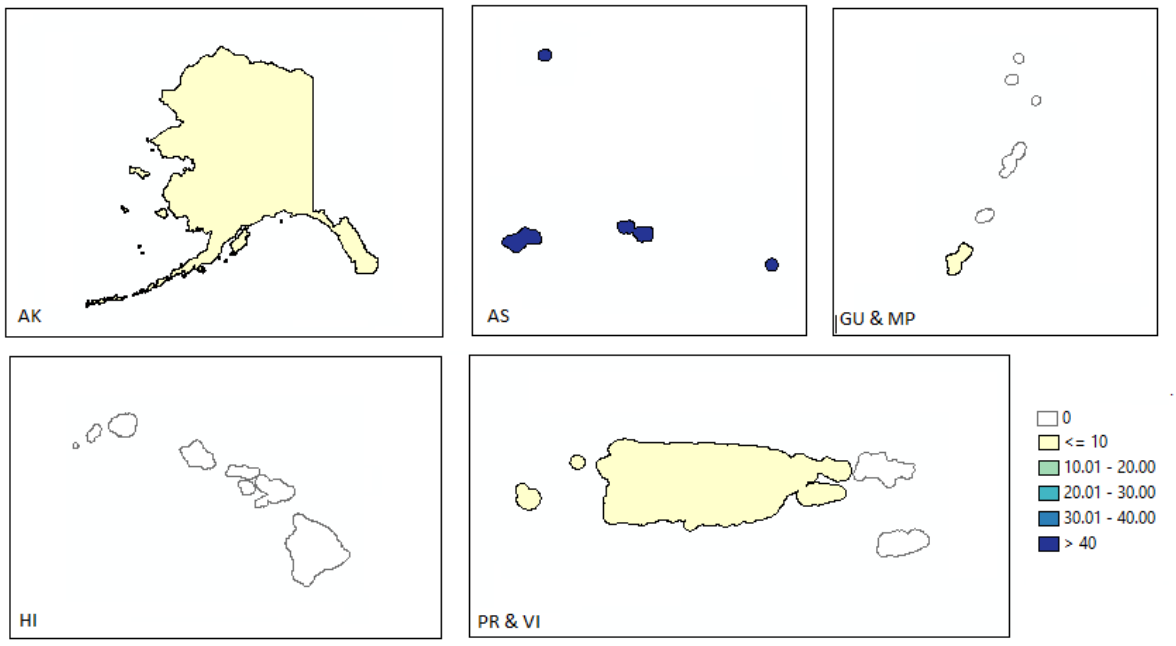

Figure 25: Number of active CBSDs per 10,000 people by state and island area for OCONUS on 4/1/2021.

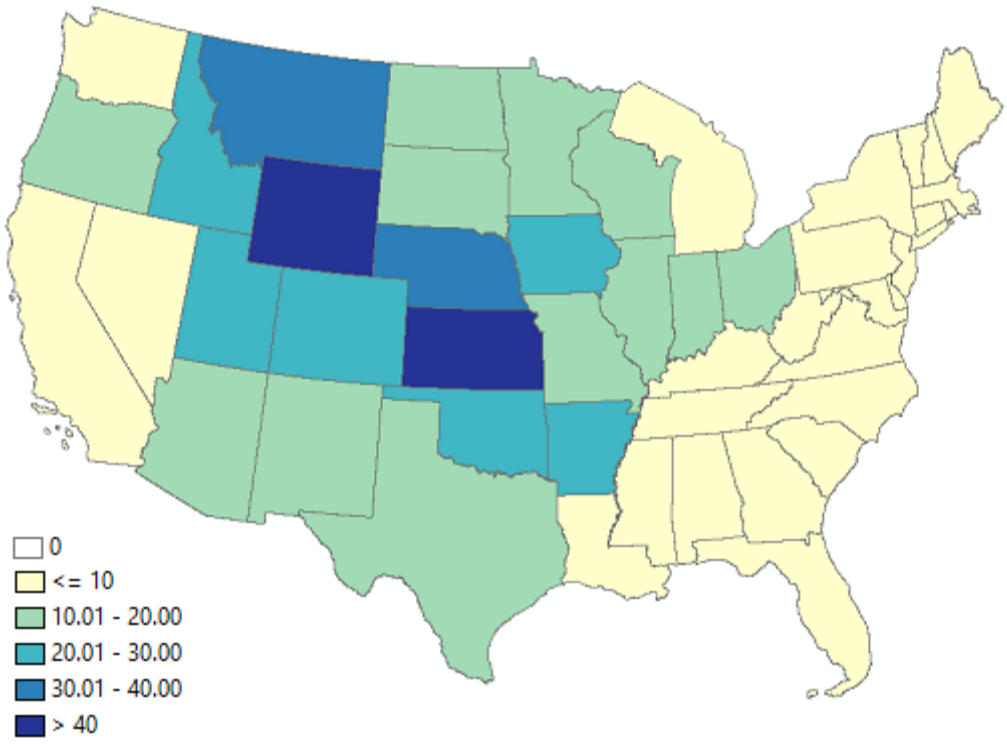

Figure 26: Number of active CBSDs per 10,000 people by state for CONUS on 1/1/2023.

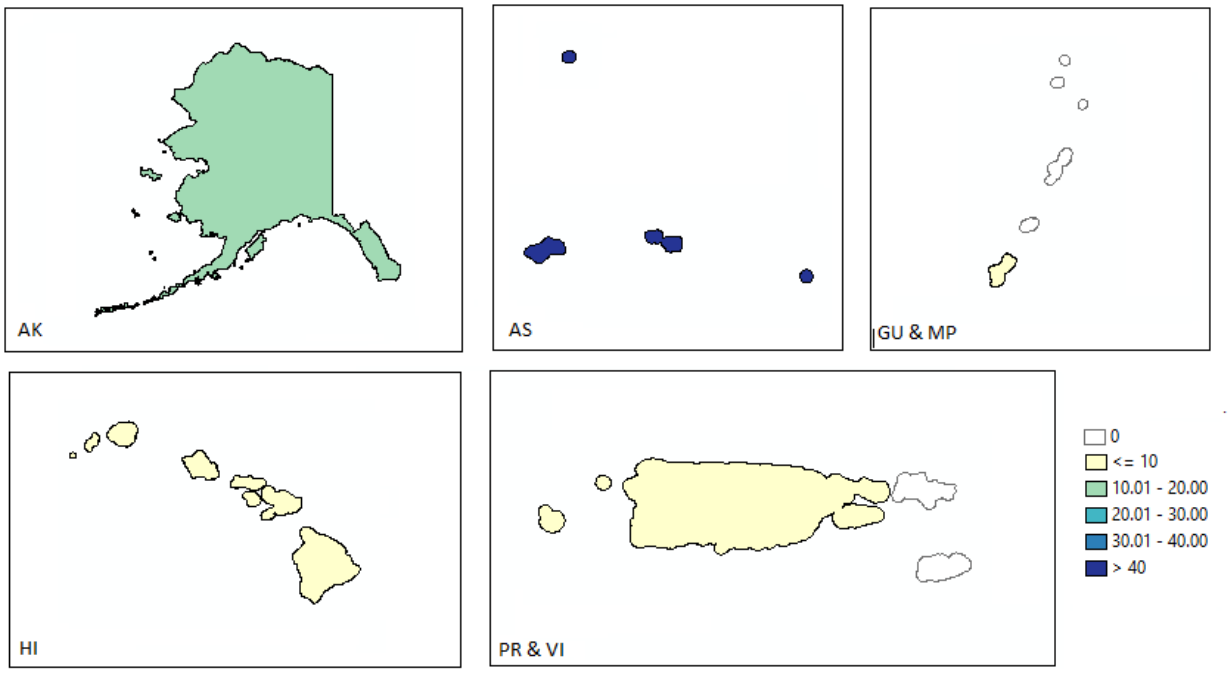

Figure 27: Number of active CBSDs per 10,000 people by state and island area for OCONUS on 1/1/2023.

Figure 28: Number of active NR CBSDs by state for CONUS on 4/1/2021.

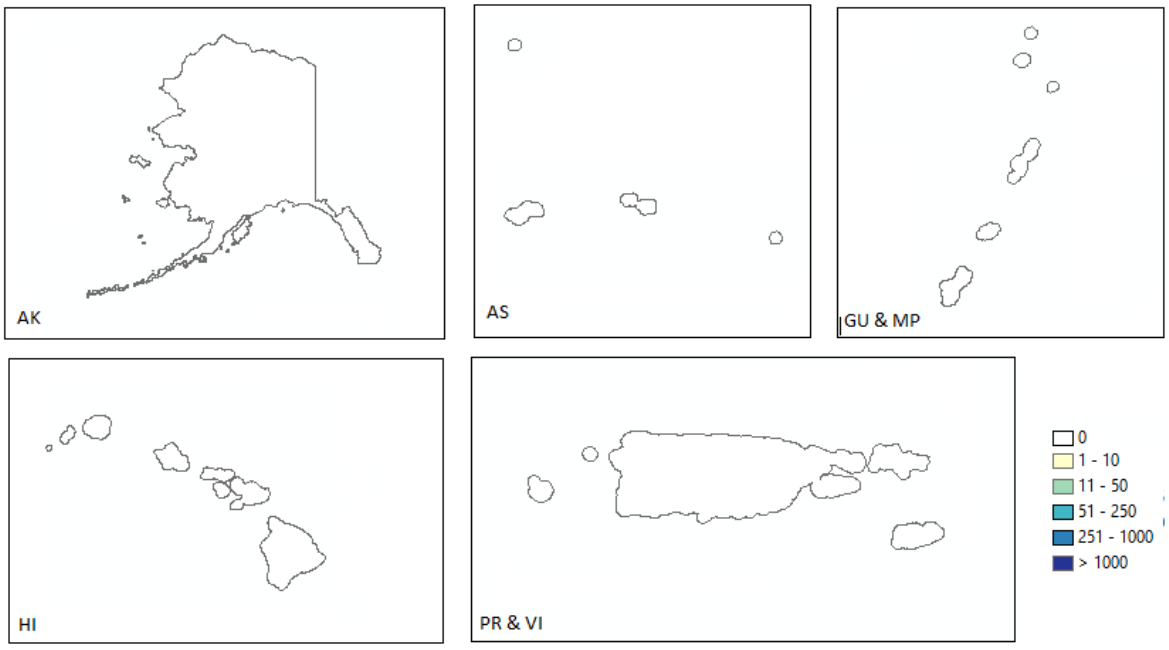

Figure 29: Number of active NR CBSDs by state and island area for OCONUS on 4/1/2021.

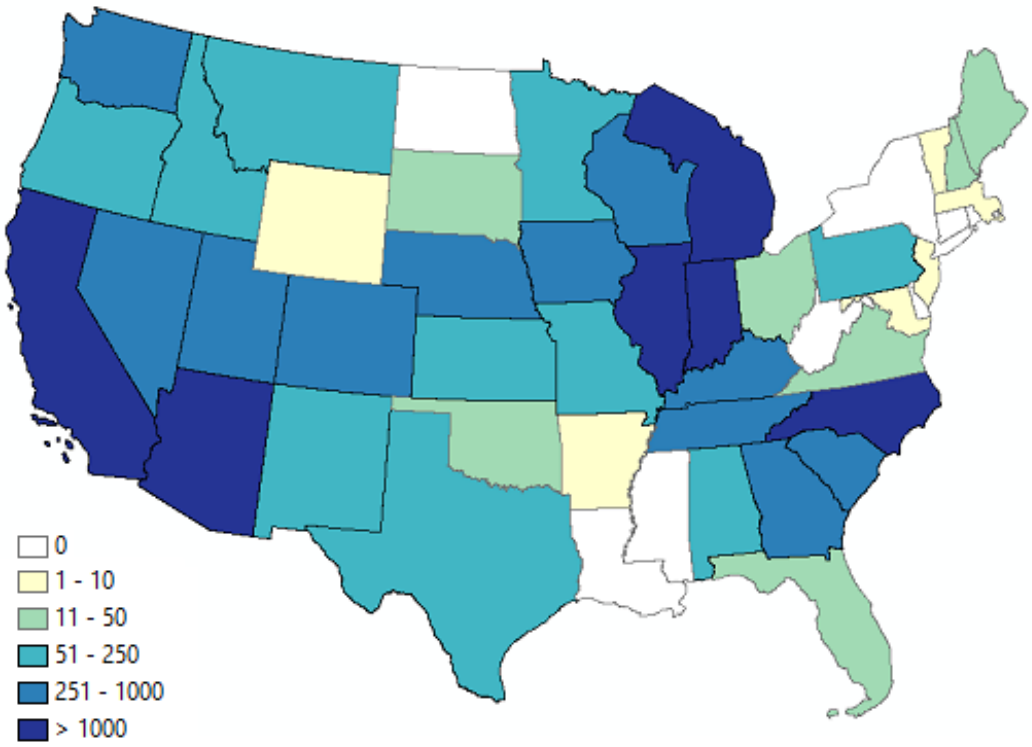

Figure 30: Number of active NR CBSDs by state for CONUS on 1/1/2023.

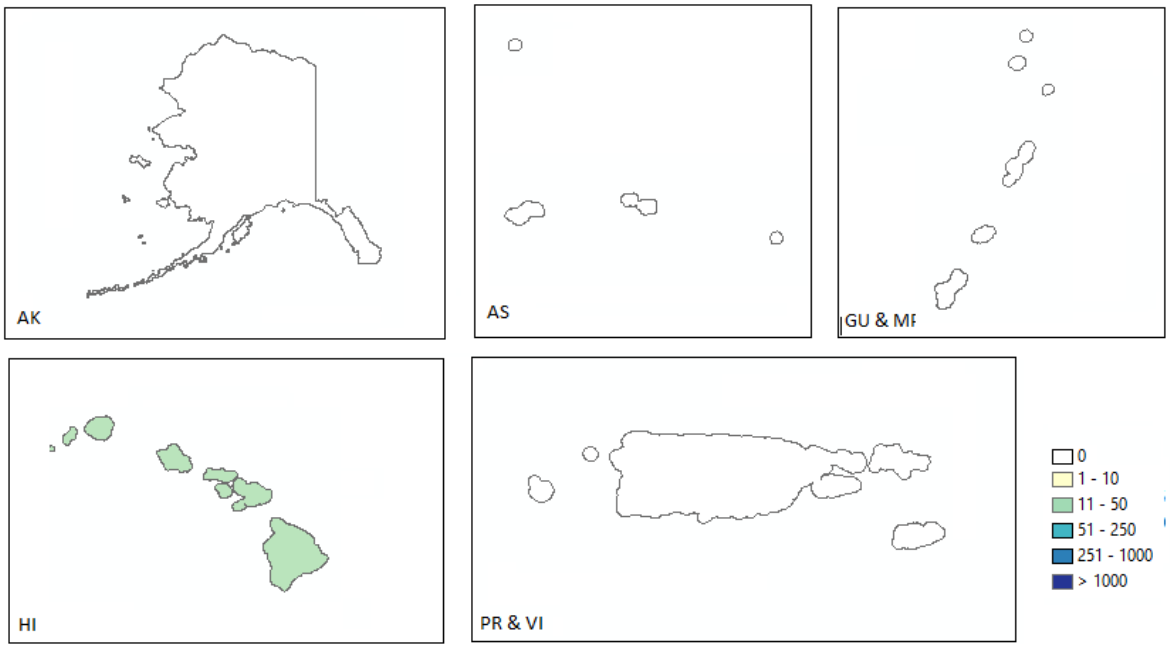

Figure 31: Number of active NR CBSDs by state and island area for OCONUS on 1/1/2023.

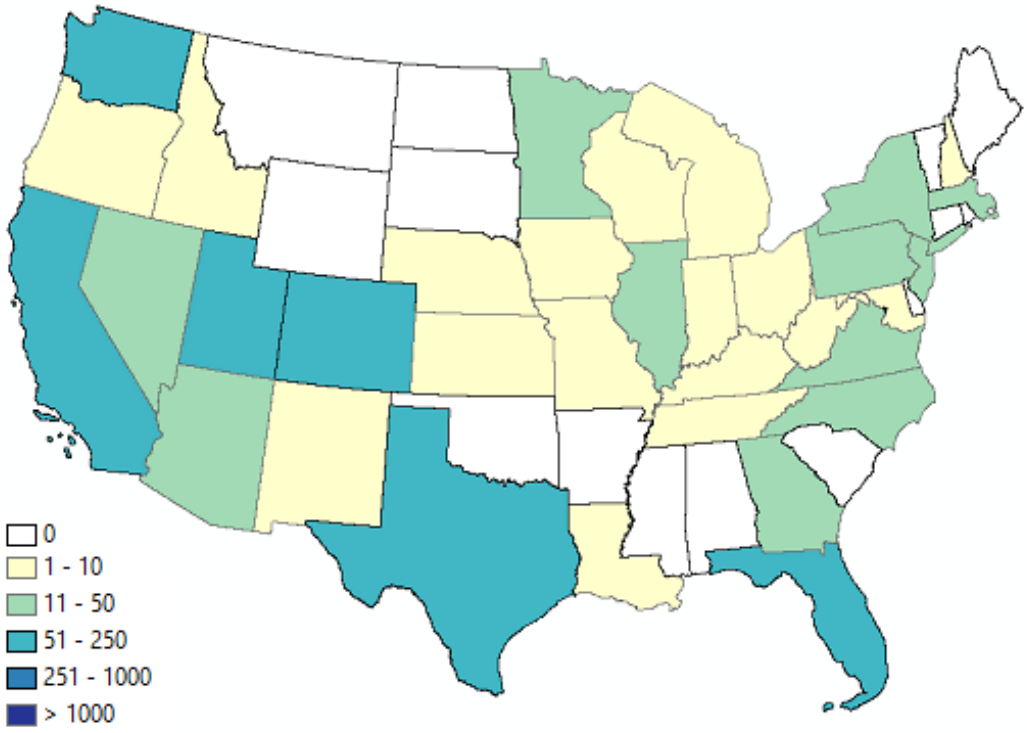

Figure 32: Number of indoor CBSDs by state for CONUS on 4/1/2021.

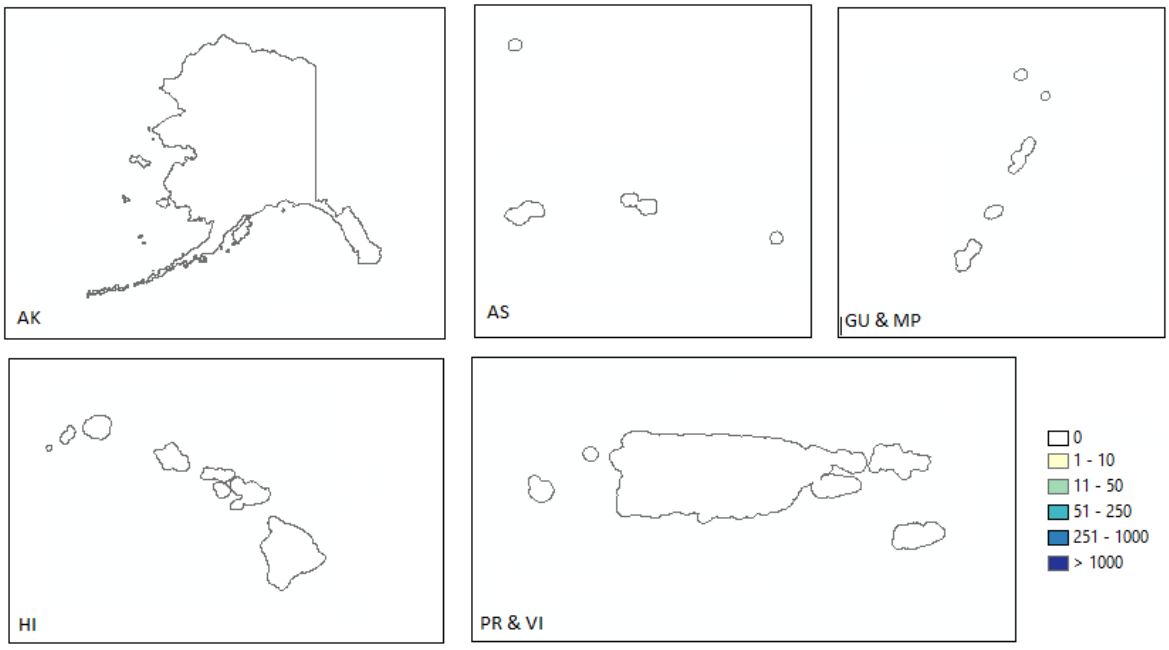

Figure 33: Number of indoor CBSDs by state and island area for OCONUS on 4/1/2021.

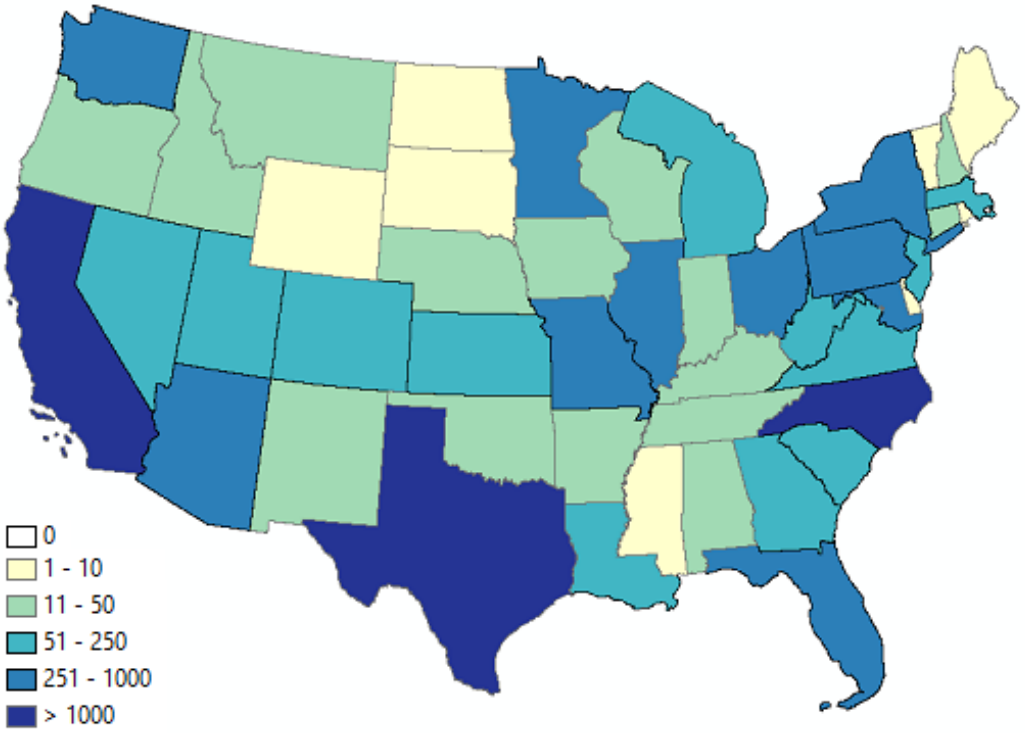

Figure 34: Number of indoor CBSDs by state for CONUS on 1/1/2023.

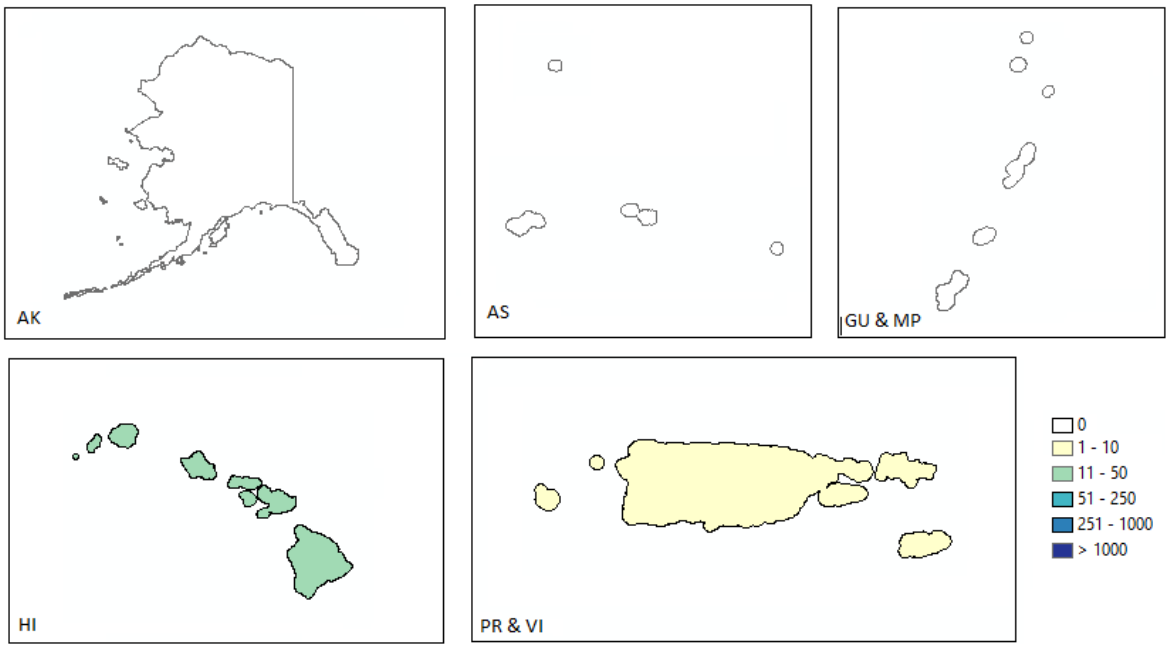

Figure 35: Number of indoor CBSDs by state and island area for OCONUS on 1/1/2023.

5. COUNTY DATA

The section illustrates the aggregate data at the county level. Subsection 5.1 provides an illustration of the number of and growth in CBSDs by county, and subsection 5.2 provides choropleth maps illustrating categorical CBSD statistics by county. Subsections 5.3 and 5.4 provide analysis on band utilization and DPA-impacted versus non-impacted statistics, respectively.

5.1 Number of CBSDs by County

Figure 36 provides the percent of counties in which the number of CBSDs is equal to or greater than the value on the x-axis (abscissa) from April 1, 2021 to January 1, 2023. On April 1, 2021, for example, 56.4% of counties had one or more CBSDs, as compared to 78.1% on January 1, 2023.

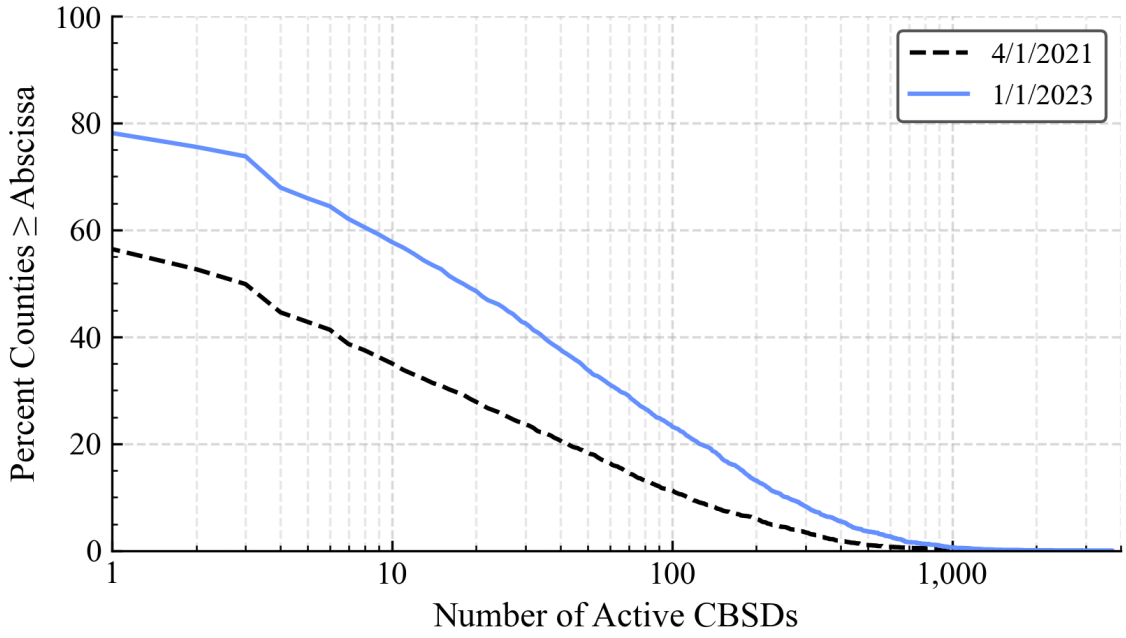

Figure 36: Percent of counties in which the number of CBSDs is equal to or greater than the value on the x-axis, on 4/1/2021 and 1/1/2023.

5.2 Choropleth Maps Illustrating Categorical CBSD Statistics by County

Choropleth maps are provided to illustrate categorical CBSD statistics by county for CONUS and OCONUS on April 1, 2021 and on January 1, 2023. Table 7 provides a summary of maps provided. In addition to absolute counts of active CBSDs in each county, figures are provided which normalize the CBSD counts by the total population of each county as "active CBSDs per 10,000 people." Data from the 2020 United States Census is used for the normalization.

Table 7: County choropleth map descriptions.

Figure	Description
Figures 37 and 38	Number of active CBSDs on 4/1/2021
Figures 39 and 40	Number of active CBSDs on 1/1/2023
Figures 41 and 42	Change in number of active CBSDs from 4/1/2021 to 1/1/2023
Figures 43 and 44	Number of active CBSDs per square kilometer on 4/1/2021
Figures 45 and 46	Number of active CBSDs per square kilometer on 1/1/2023
Figures 47 and 48	Number of active CBSDs per 10,000 people on 4/1/2021
Figures 49 and 50	Number of active CBSDs per 10,000 people on 1/1/2023
Figures 51 and 52	Number of active NR CBSDs on 4/1/2021
Figures 53 and 54	Number of active NR CBSDs on 1/1/2023
Figures 55 and 56	Number of active indoor CBSDs on 4/1/2021
Figures 57 and 58	Number of active indoor CBSDs on 1/1/2023
Figure 59 and Figure 60	Number of active rural CBSDs on 4/1/2021
Figure 61 and Figure 62	Number of active rural CBSDs on 1/1/2023
Figure 63 and Figure 64	Number of active urban CBSDs on 4/1/2021
Figure 65 and Figure 66	Number of active urban CBSDs on 1/1/2023
Figures 67 and 68	Number of channels granted on 4/1/2021
Figures 69 and 70	Number of channels granted on 1/1/2023

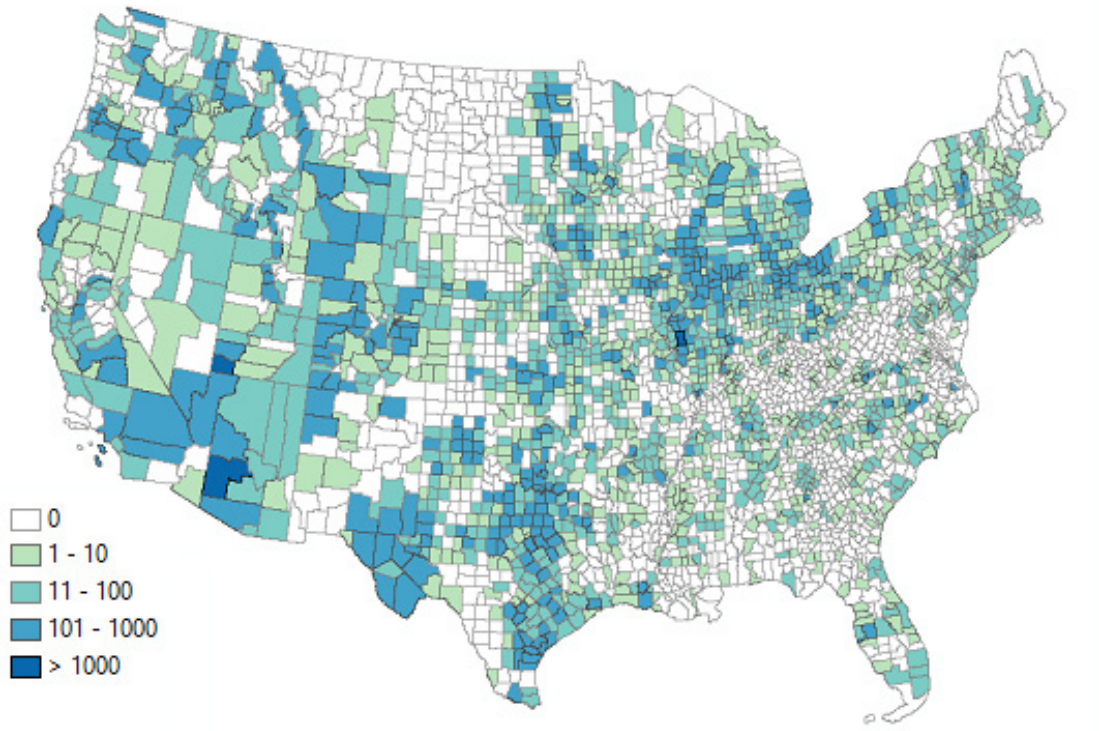

Figure 37: Number of active CBSDs by county for CONUS on 4/1/2021.

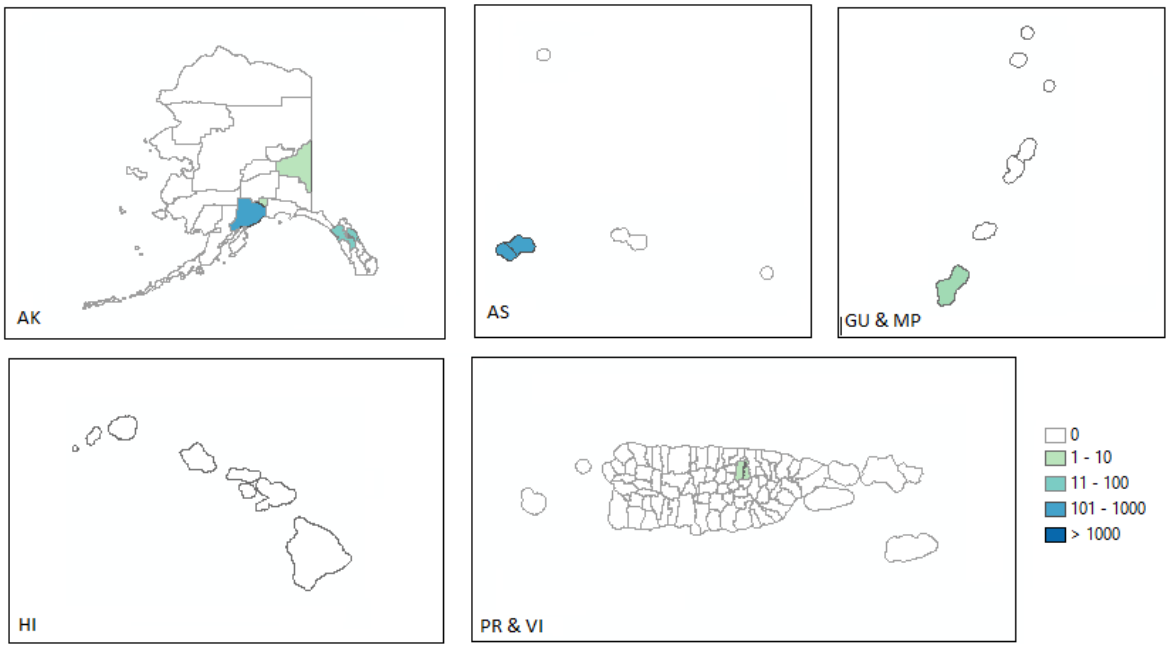

Figure 38: Number of active CBSDs by county for OCONUS on 4/1/2021.

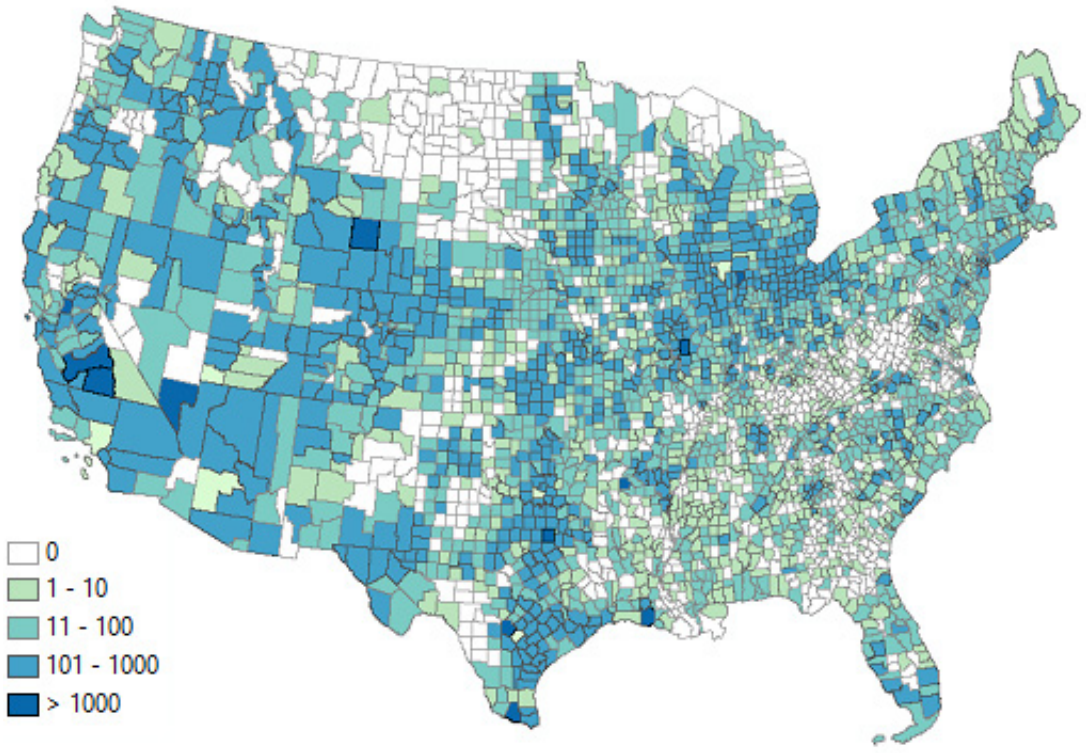

Figure 39: Number of active CBSDs by county for CONUS on 1/1/2023.

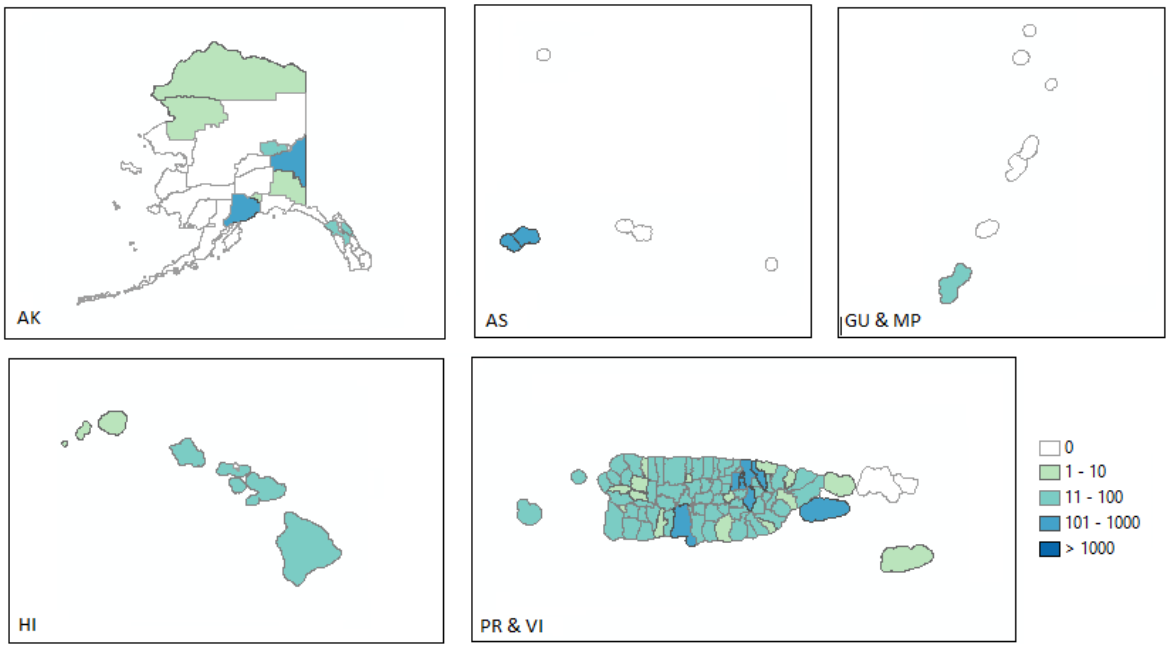

Figure 40: Number of active CBSDs by county for OCONUS on 1/1/2023.

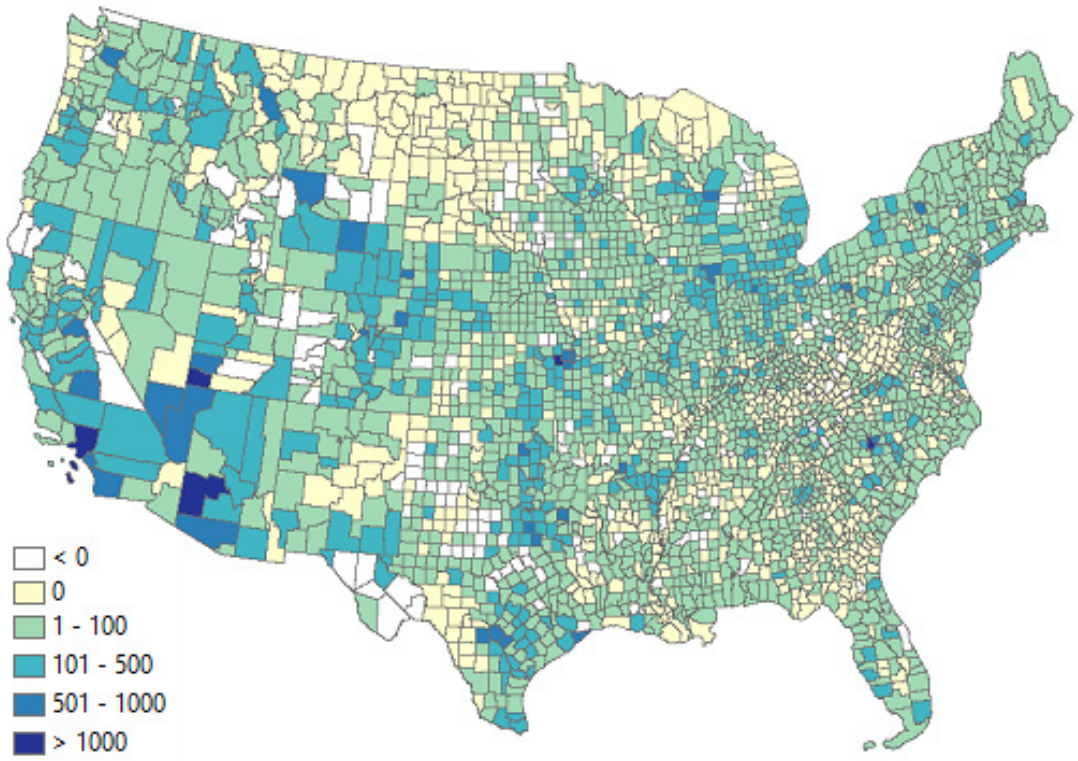

Figure 41: Change in number of active CBSDs by County for CONUS from 4/1/2021 to 1/1/2023.

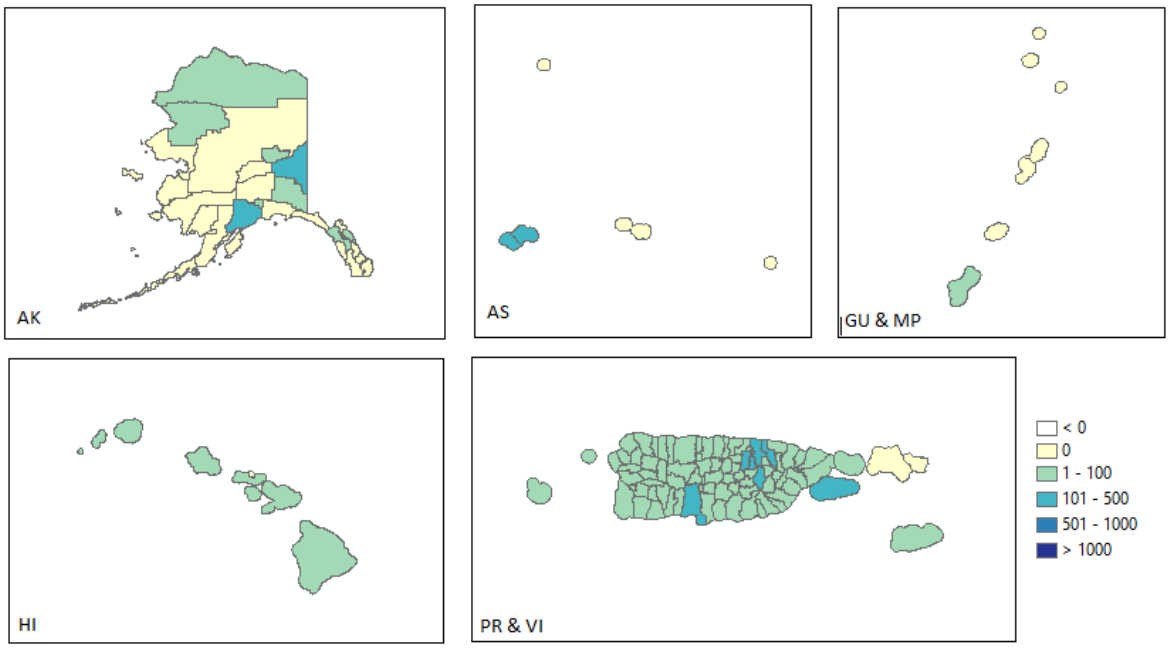

Figure 42: Change in number of active CBSDs by County for OCONUS from 4/1/2021 to 1/1/2023.

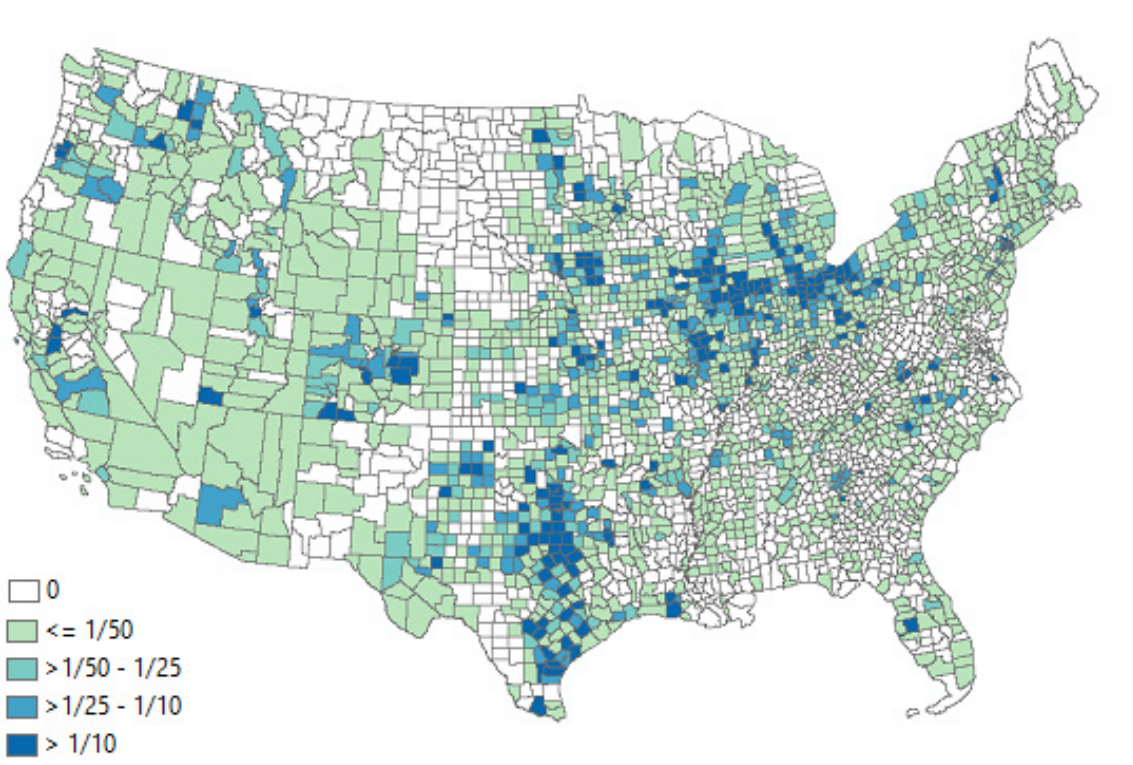

Figure 43: Number of active CBSDs per square kilometer by county for CONUS on 4/1/2021.

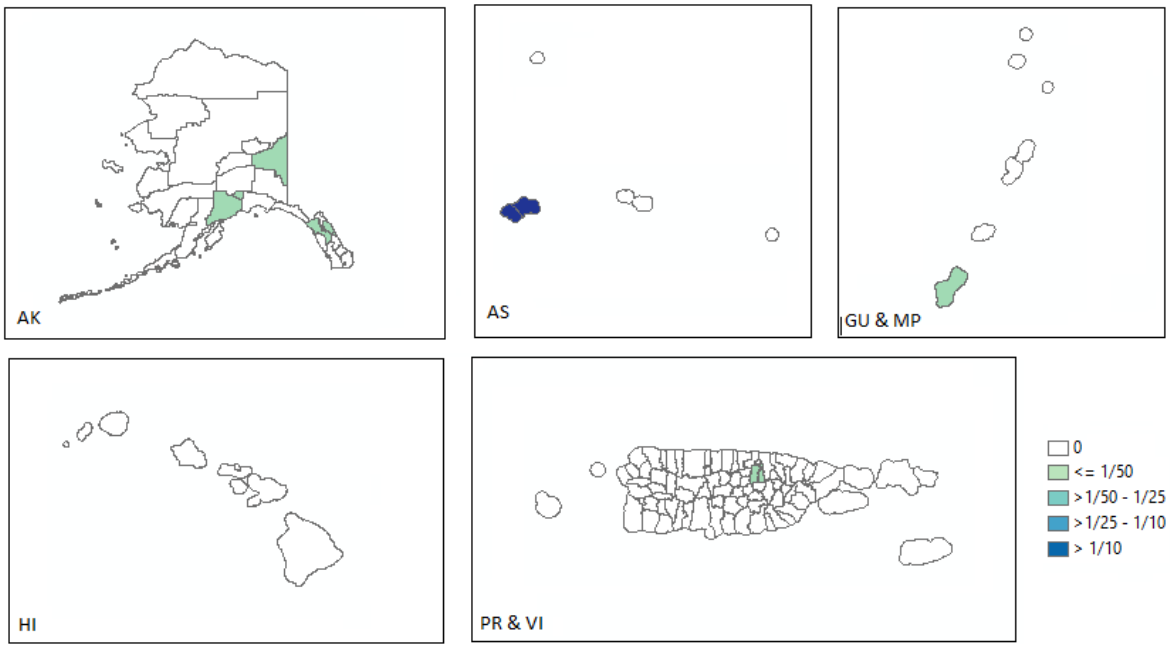

Figure 44: Number of active CBSDs per square kilometer by county for OCONUS on 4/1/2021.

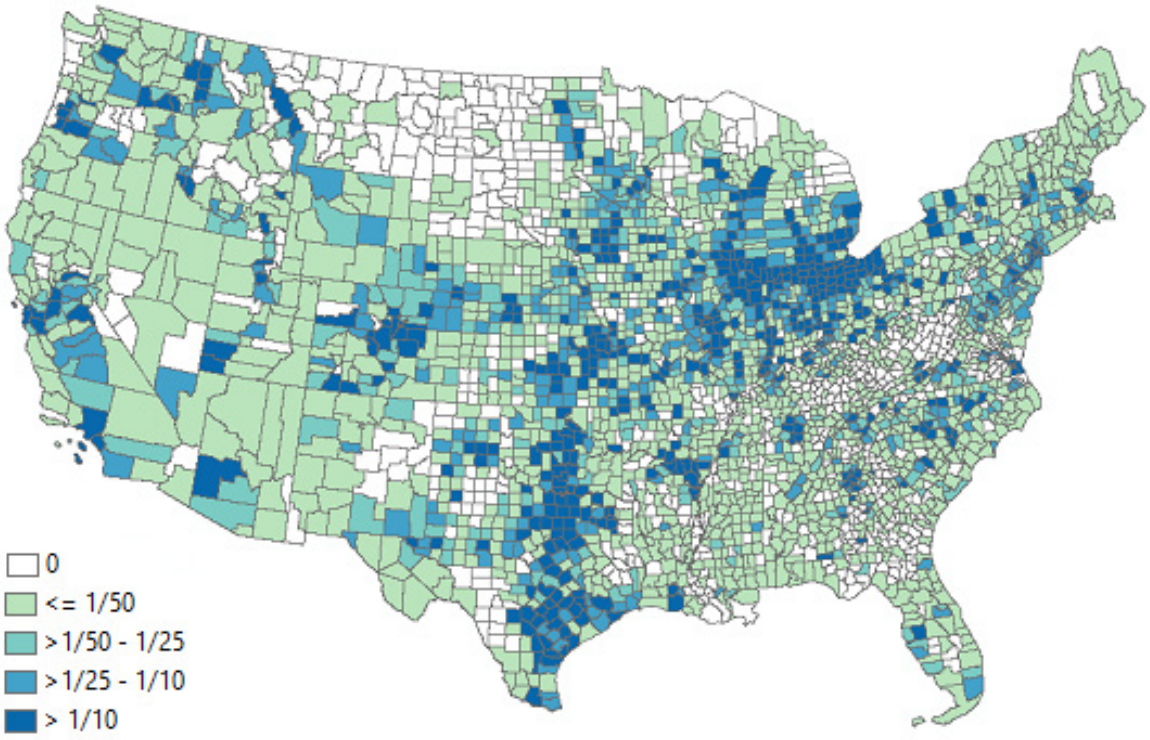

Figure 45: Number of active CBSDs per square kilometer by county for CONUS on 1/1/2023.

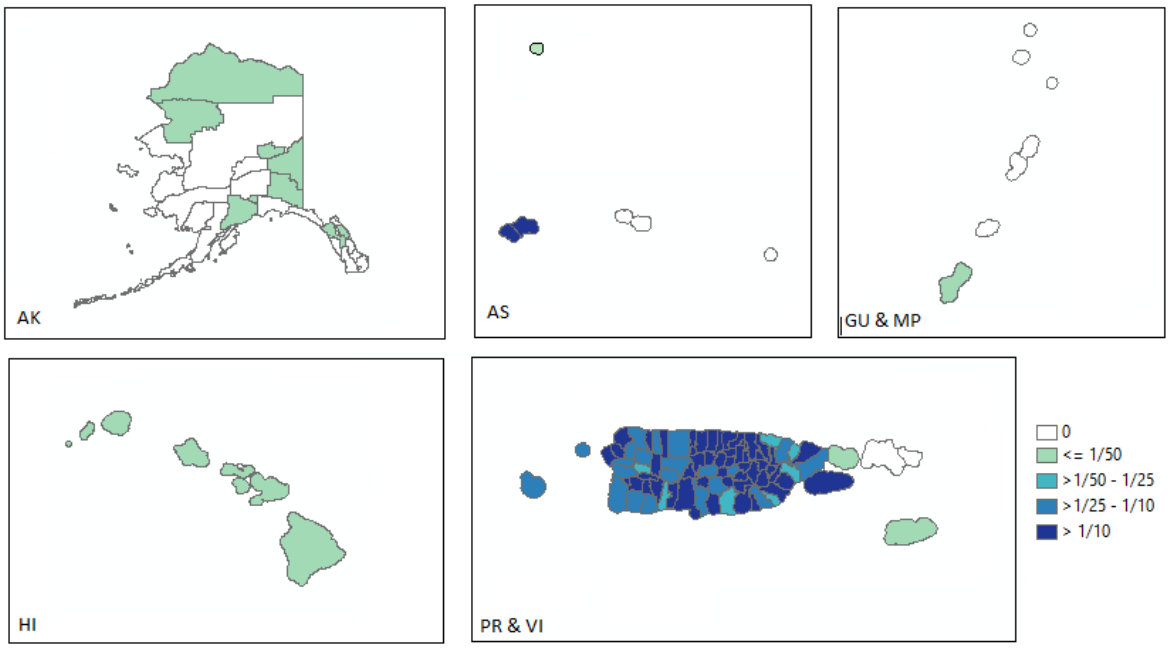

Figure 46: Number of active CBSDs per square kilometer by county for OCONUS on 1/1/2023.

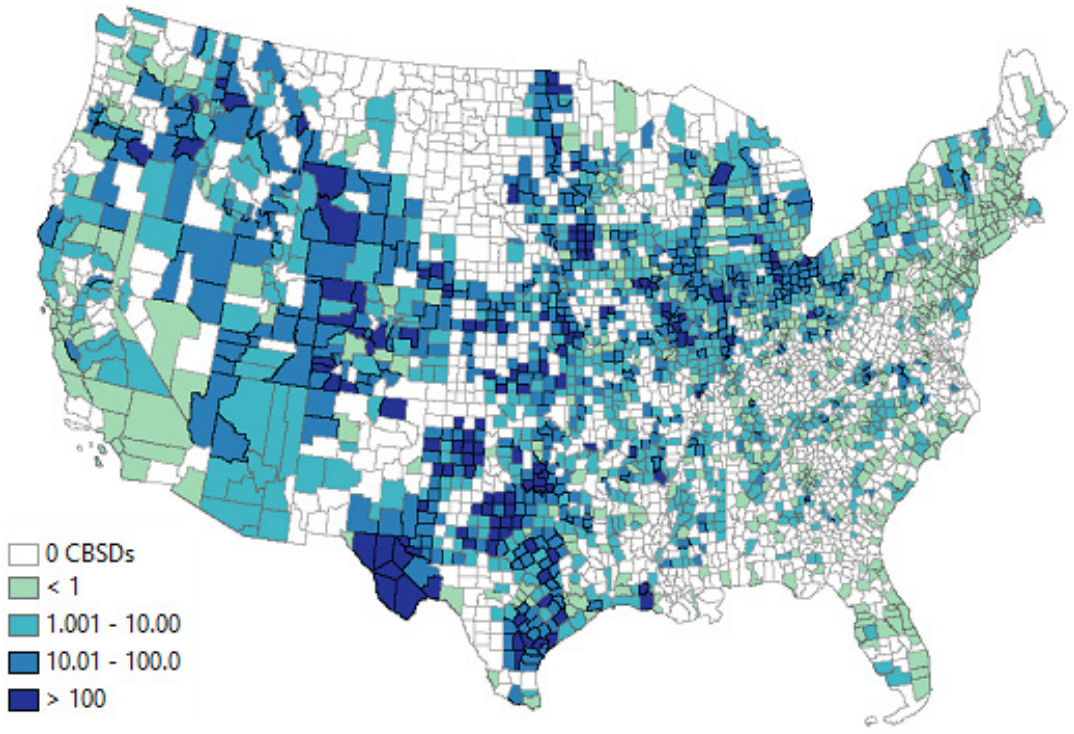

Figure 47: Number of active CBSDs per 10,000 people by county for CONUS on 4/1/2021.

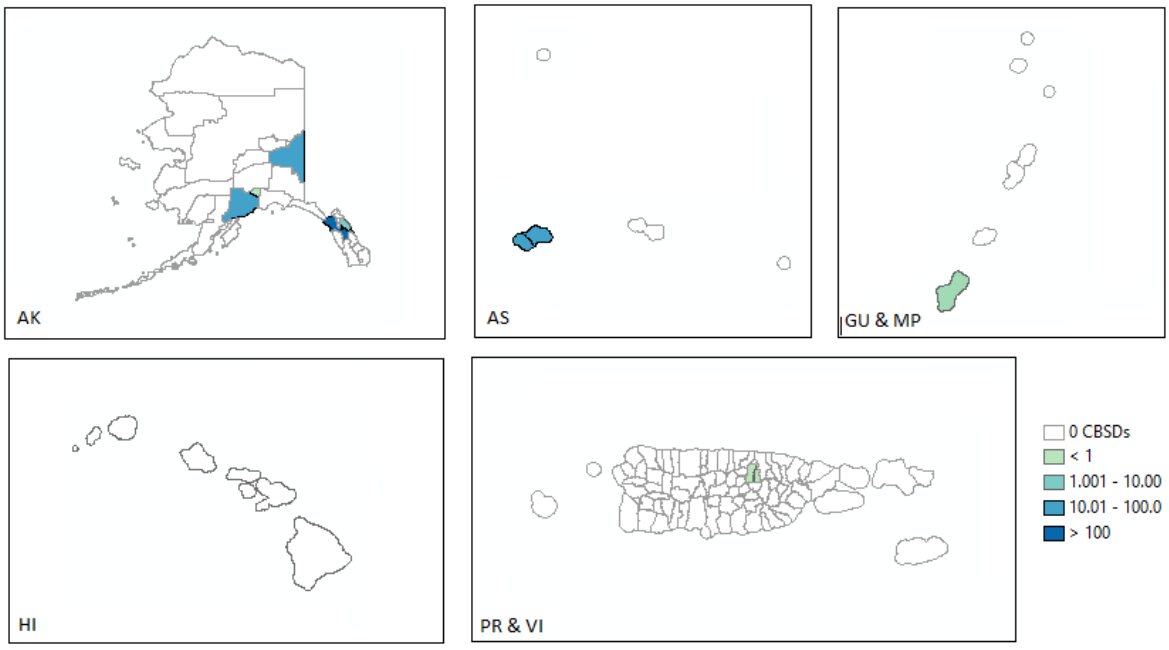

Figure 48: Number of active CBSDs per 10,000 people by county for OCONUS on 4/1/2021.

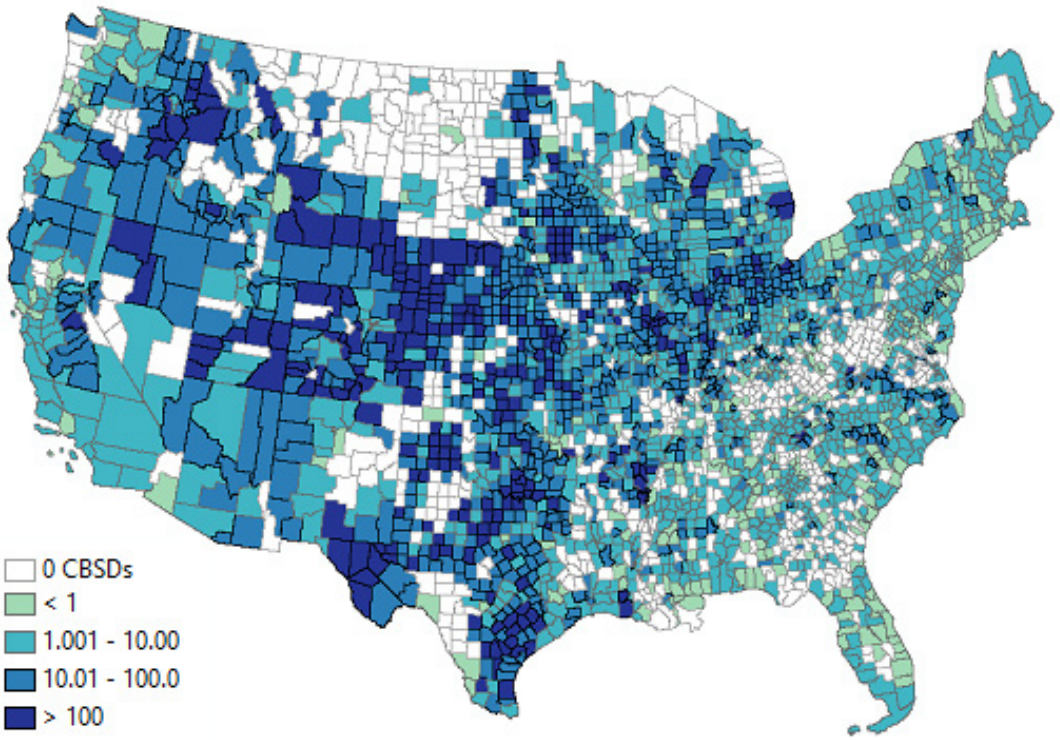

Figure 49: Number of active CBSDs per 10,000 people by county for CONUS on 1/1/2023.

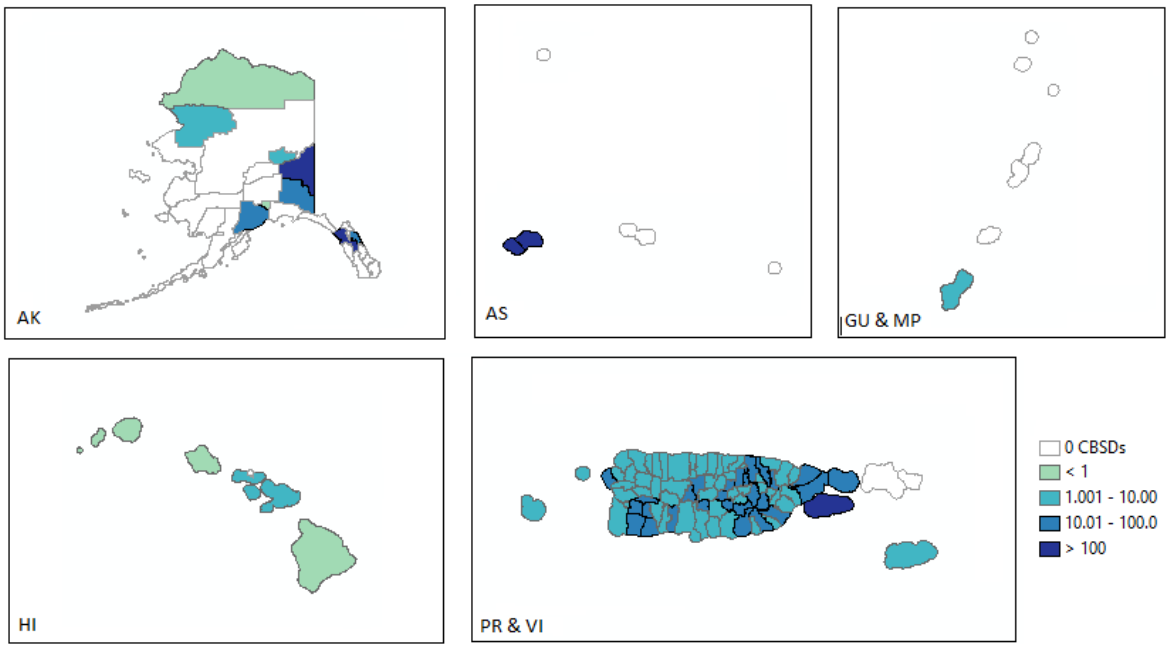

Figure 50: Number of active CBSDs per 10,000 people by county for OCONUS on 1/1/2023.

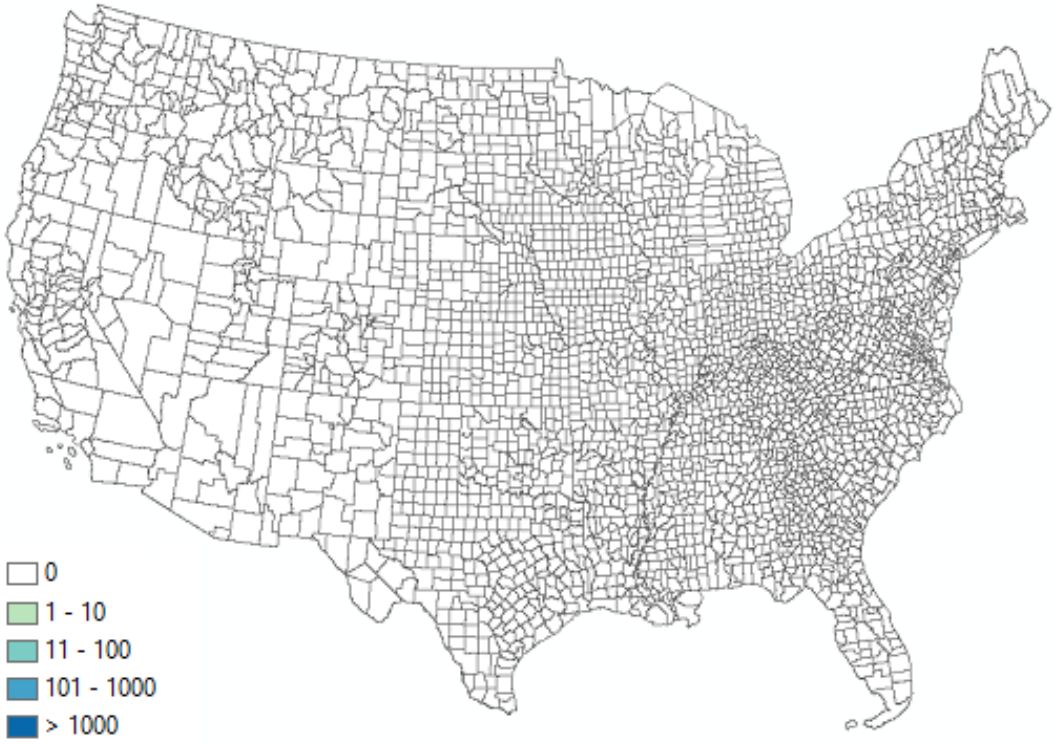

Figure 51: Number of active NR CBSDs by county for CONUS on 4/1/2021.

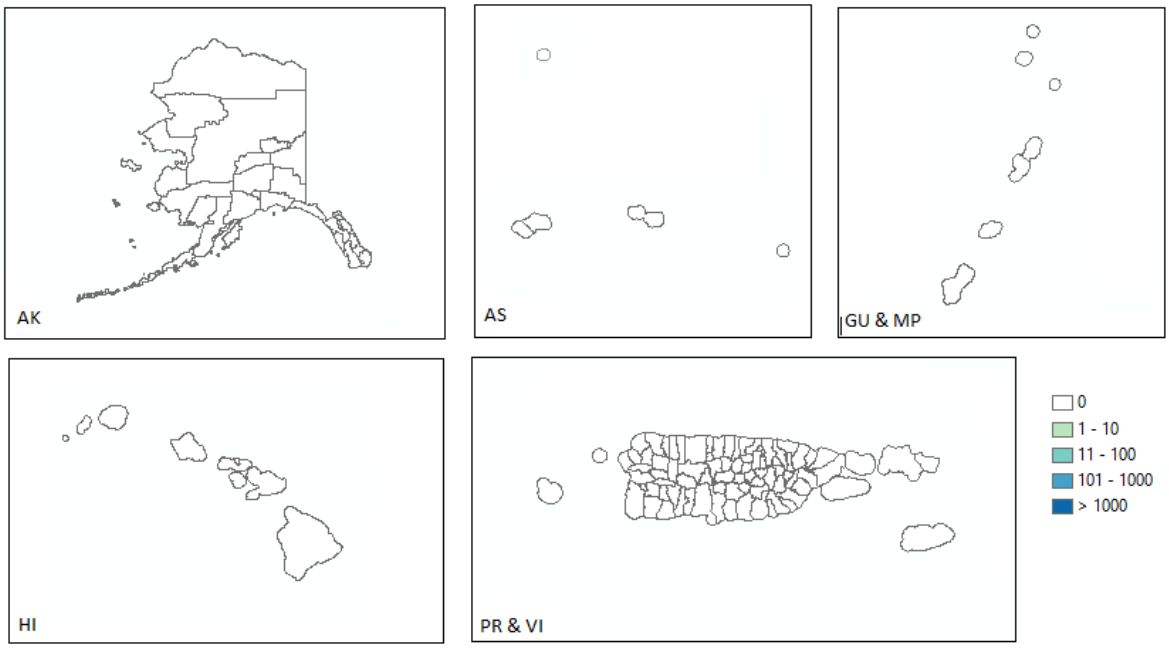

Figure 52: Number of active NR CBSDs by county for OCONUS on 4/1/2021.

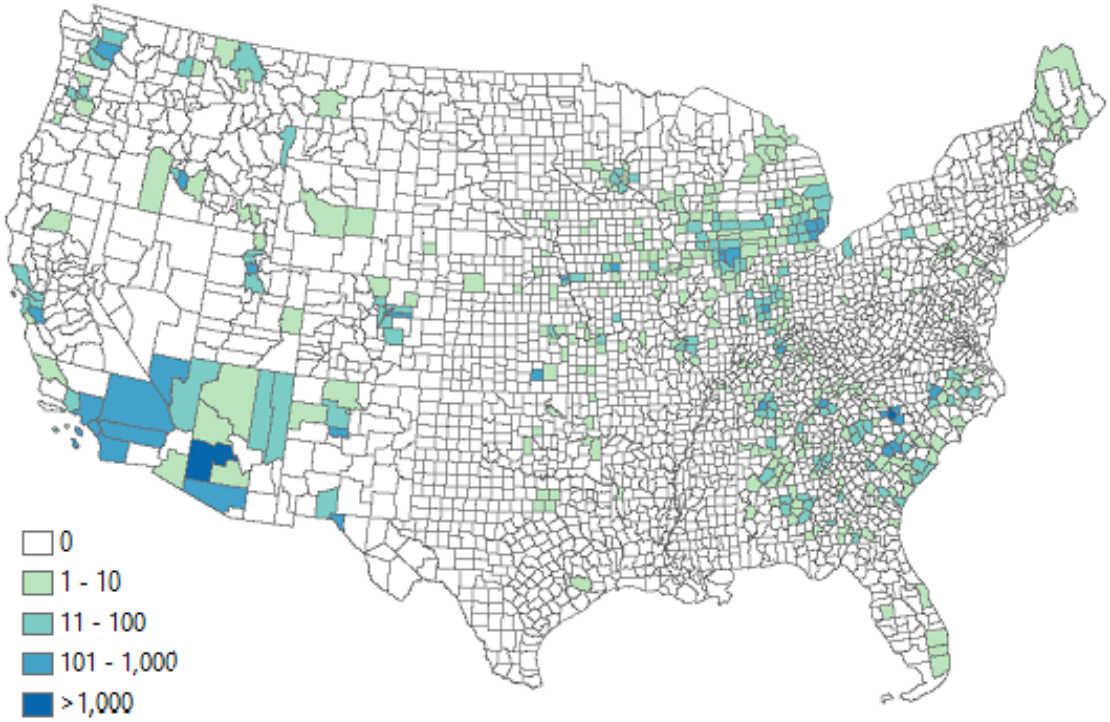

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Figure 53: Number of active NR CBSDs by county for CONUS on 1/1/2023.

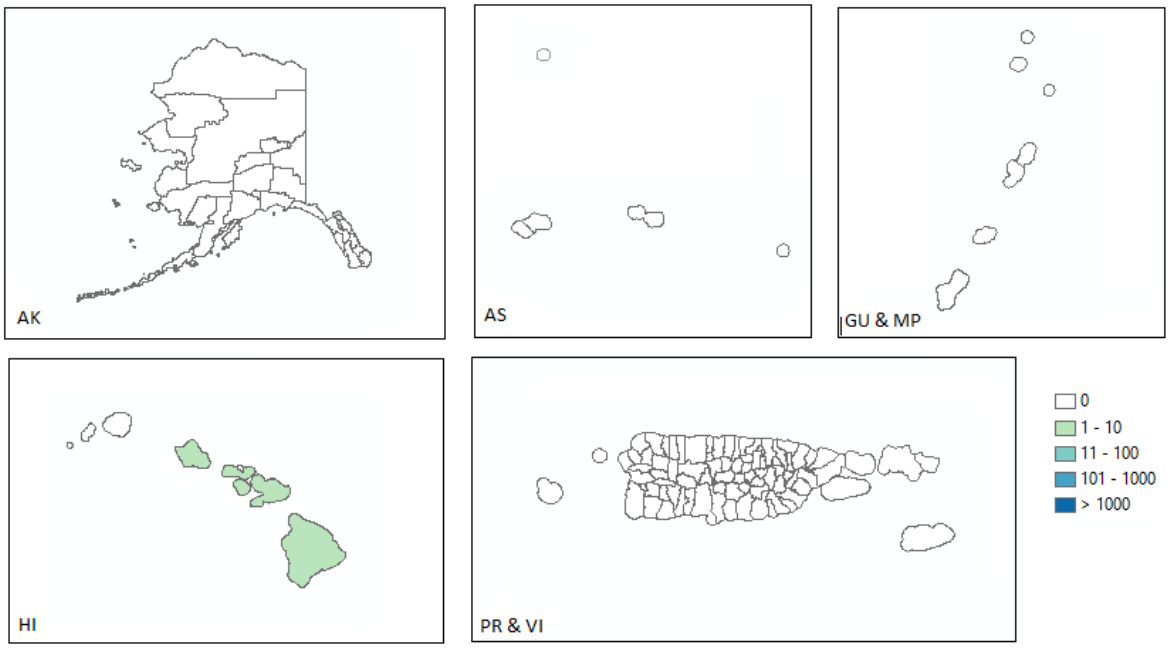

Figure 54: Number of active NR CBSDs by county for OCONUS on 1/1/2023.

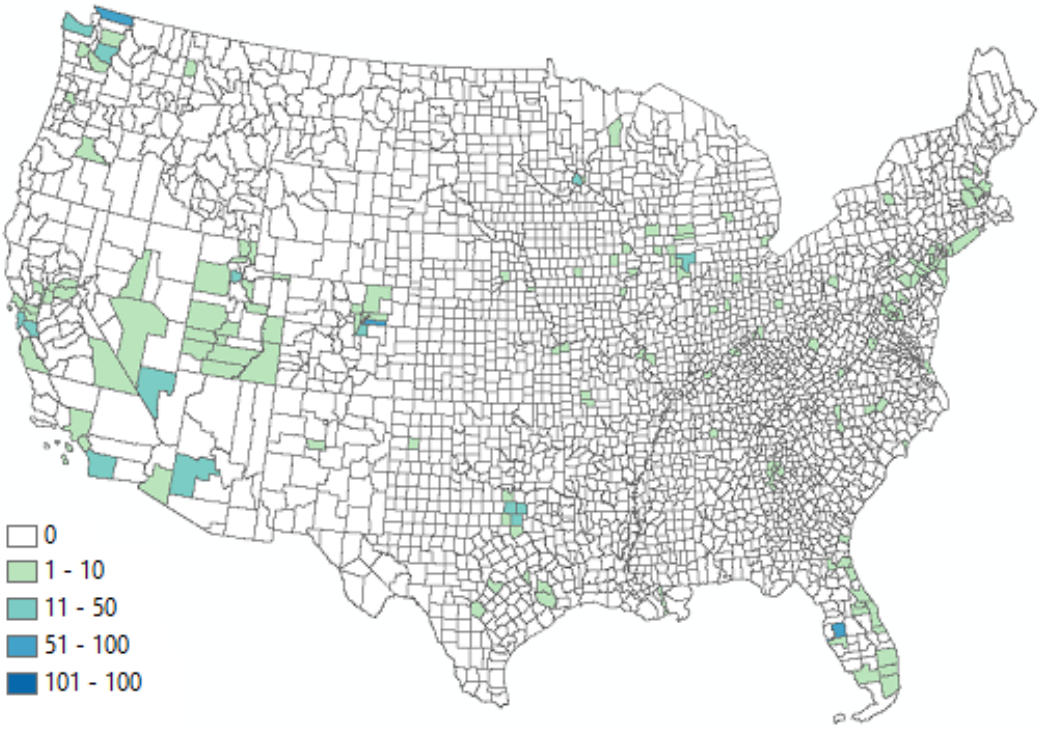

Figure 55: Number of active indoor CBSDs by county for CONUS on 4/1/2021.

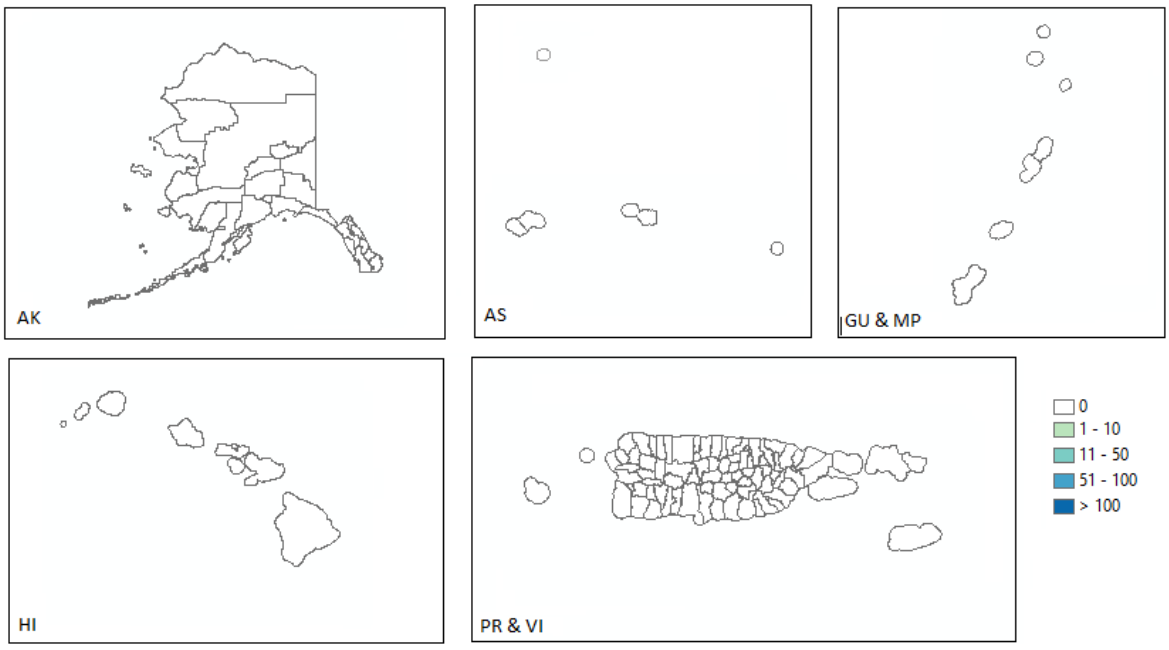

Figure 56: Number of active indoor CBSDs by county for OCONUS on 4/1/2021.

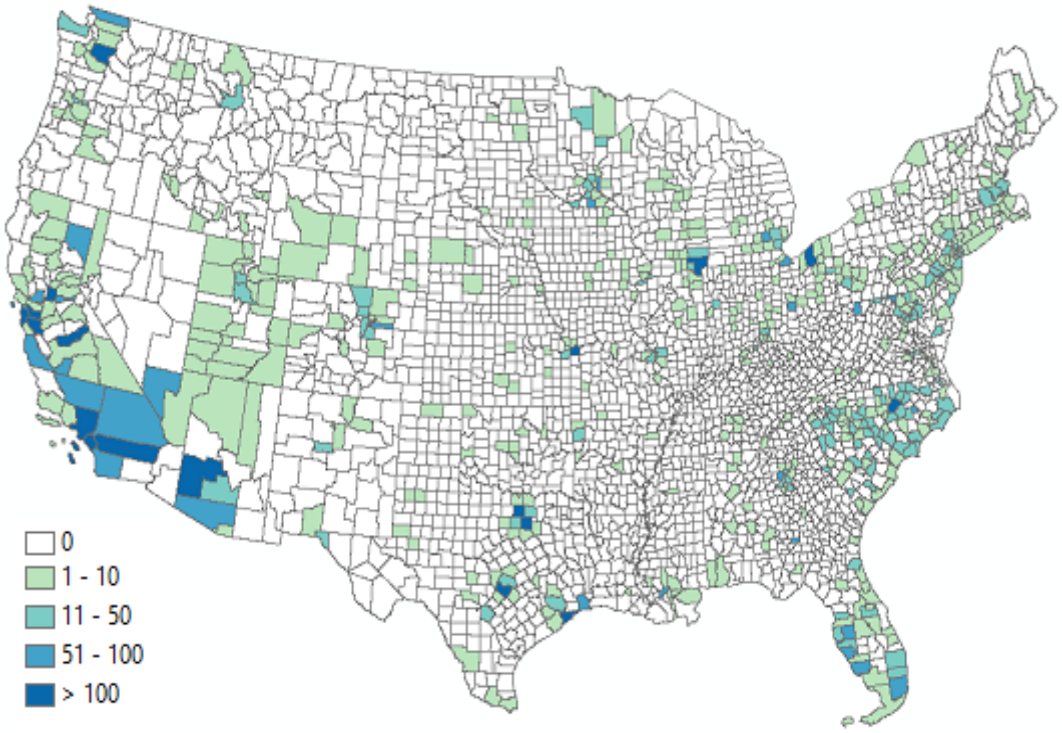

Figure 57: Number of active indoor CBSDs by county for CONUS on 1/1/2023.

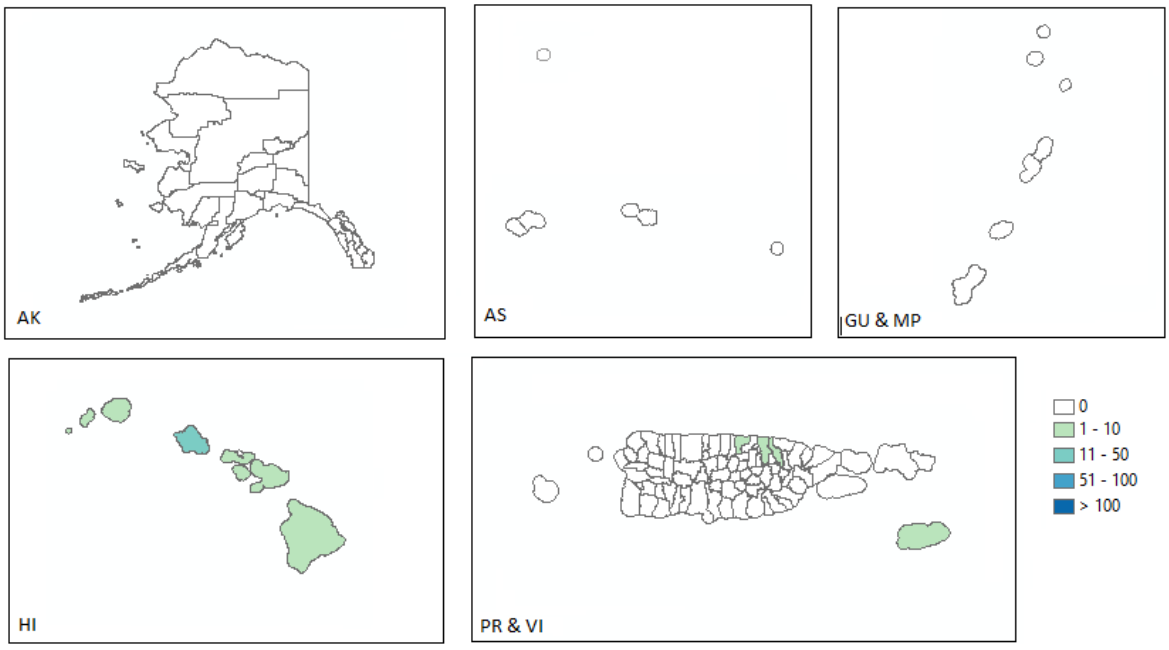

Figure 58: Number of active indoor CBSDs by county for OCONUS on 1/1/2023.

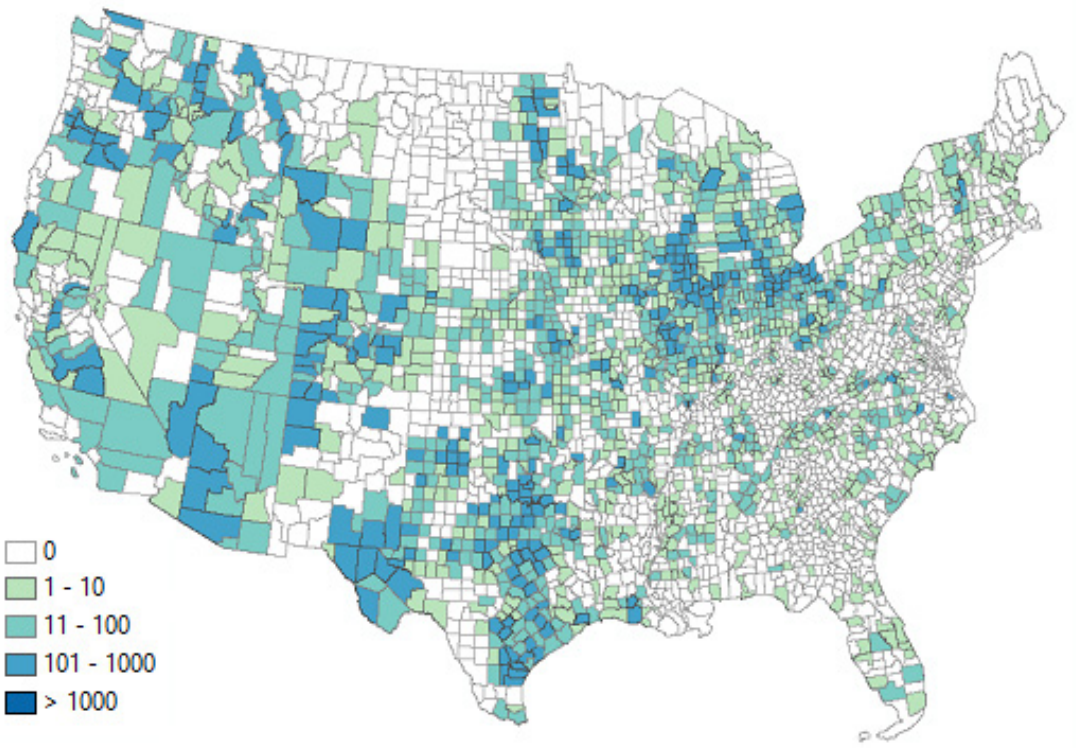

Figure 59: Number of active rural CBSDs by county for CONUS on 4/1/2021.

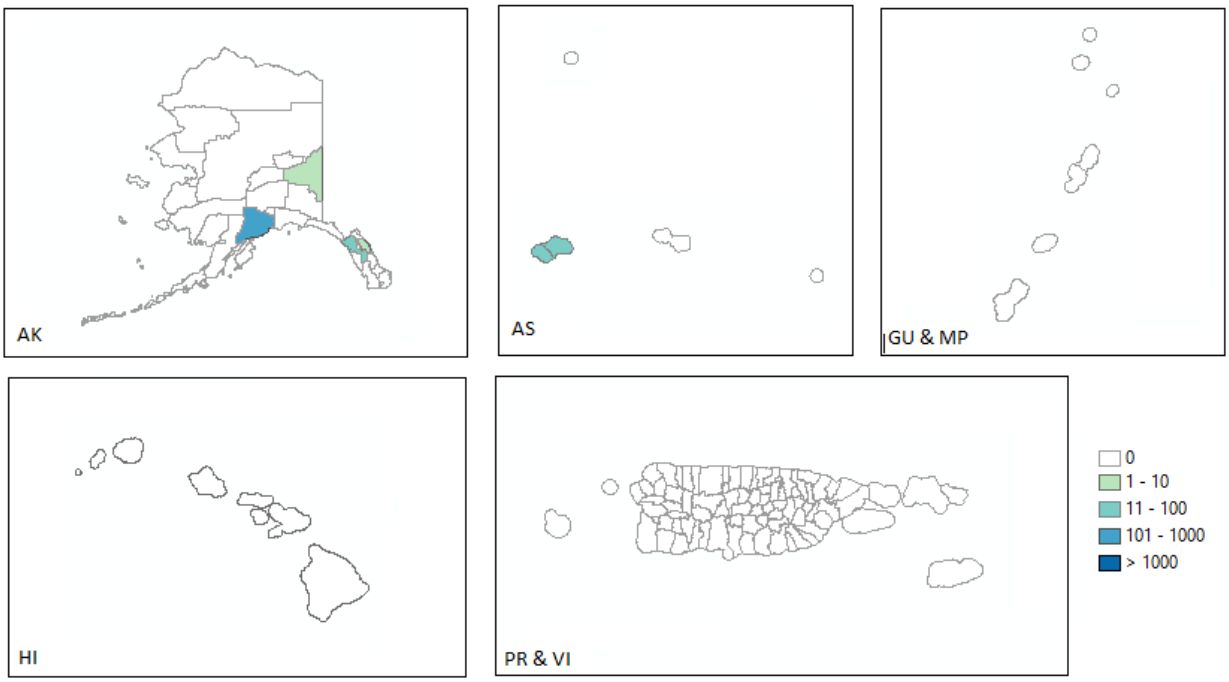

Figure 60: Number of active rural CBSDs by county for OCONUS on 4/1/2021.

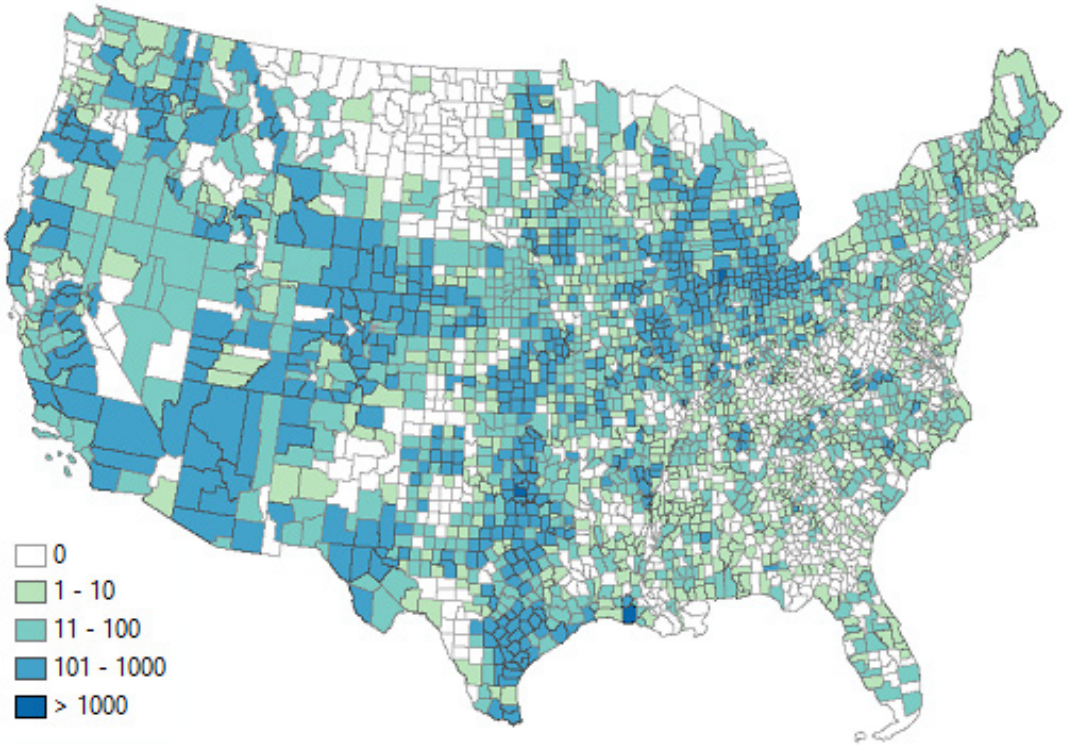

Figure 61: Number of active rural CBSDs by county for CONUS on 1/1/2023.

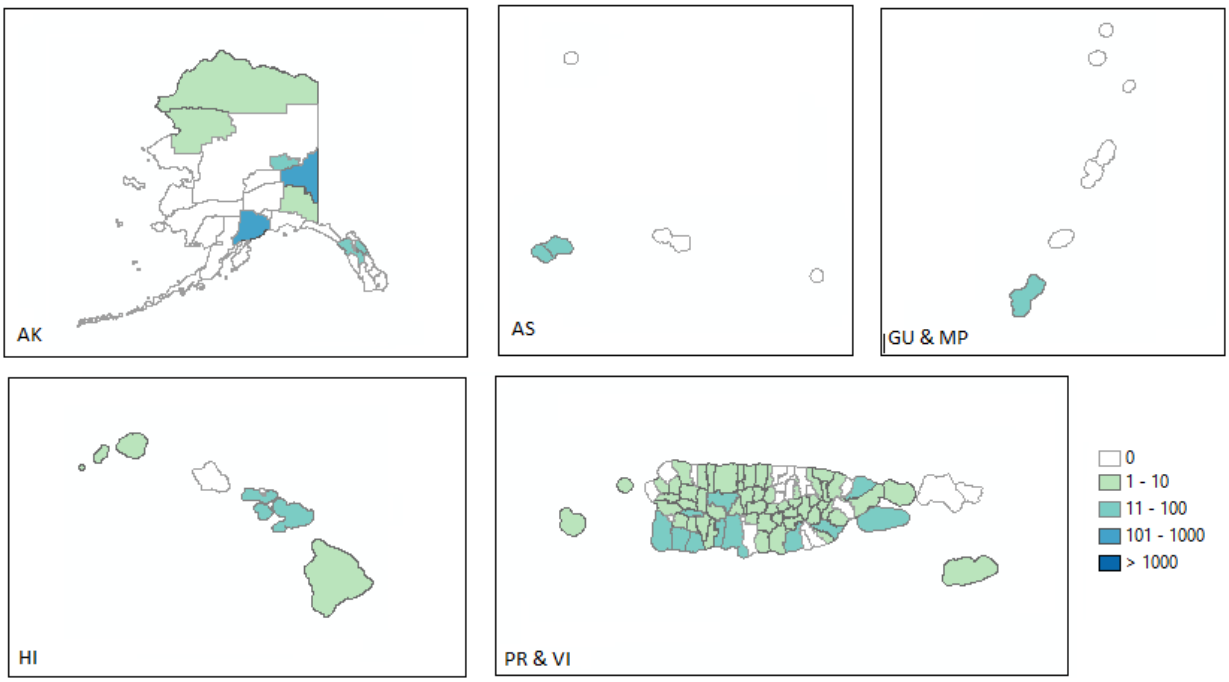

Figure 62: Number of active rural CBSDs by county for OCONUS on 1/1/2023.

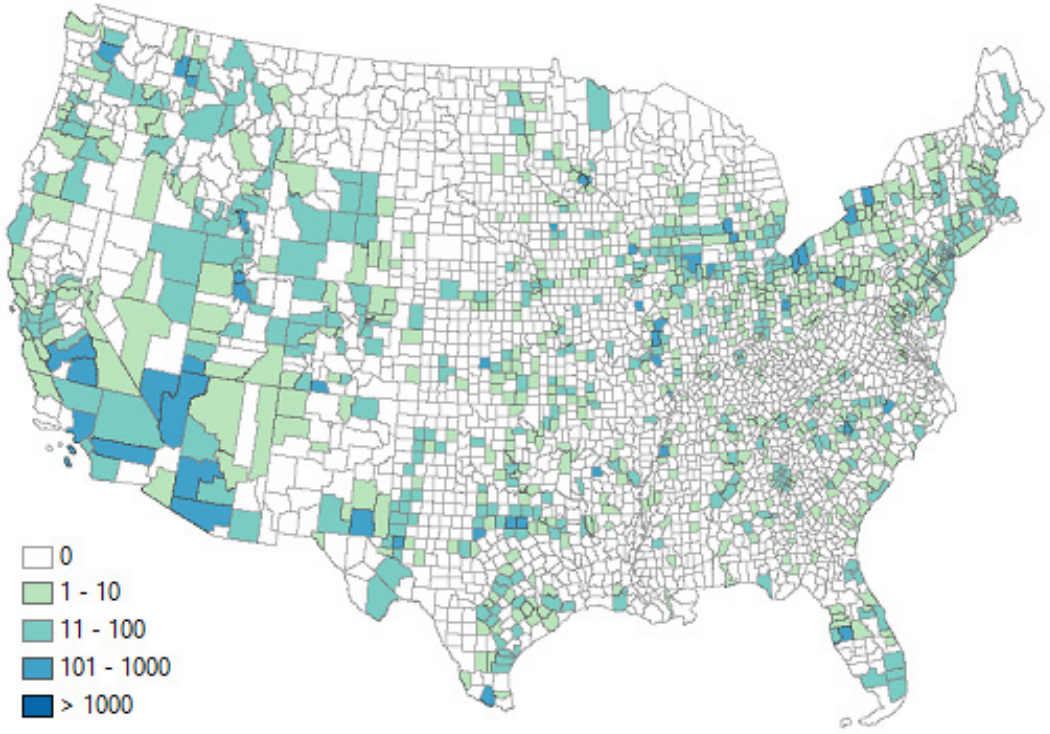

Figure 63: Number of active urban CBSDs by county for CONUS on 4/1/2021.

Figure 64: Number of active urban CBSDs by county for OCONUS on 4/1/2021.

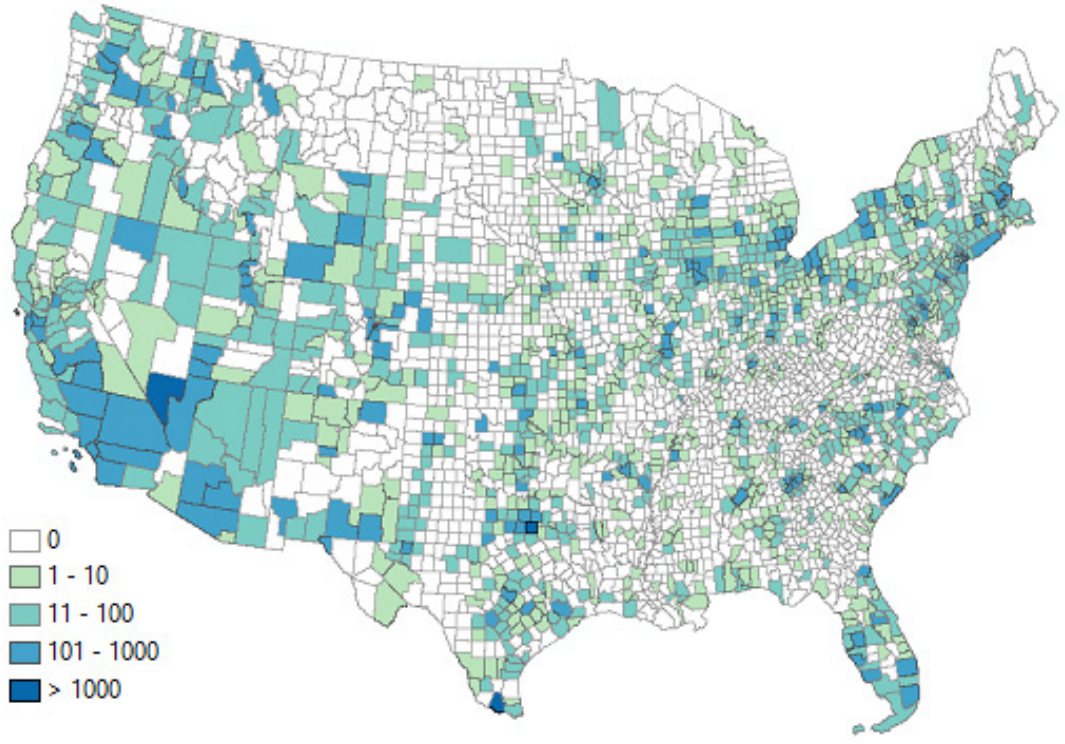

Figure 65: Number of active urban CBSDs by county for CONUS on 1/1/2023.

Figure 66: Number of active urban CBSDs by county for OCONUS on 1/1/2023.

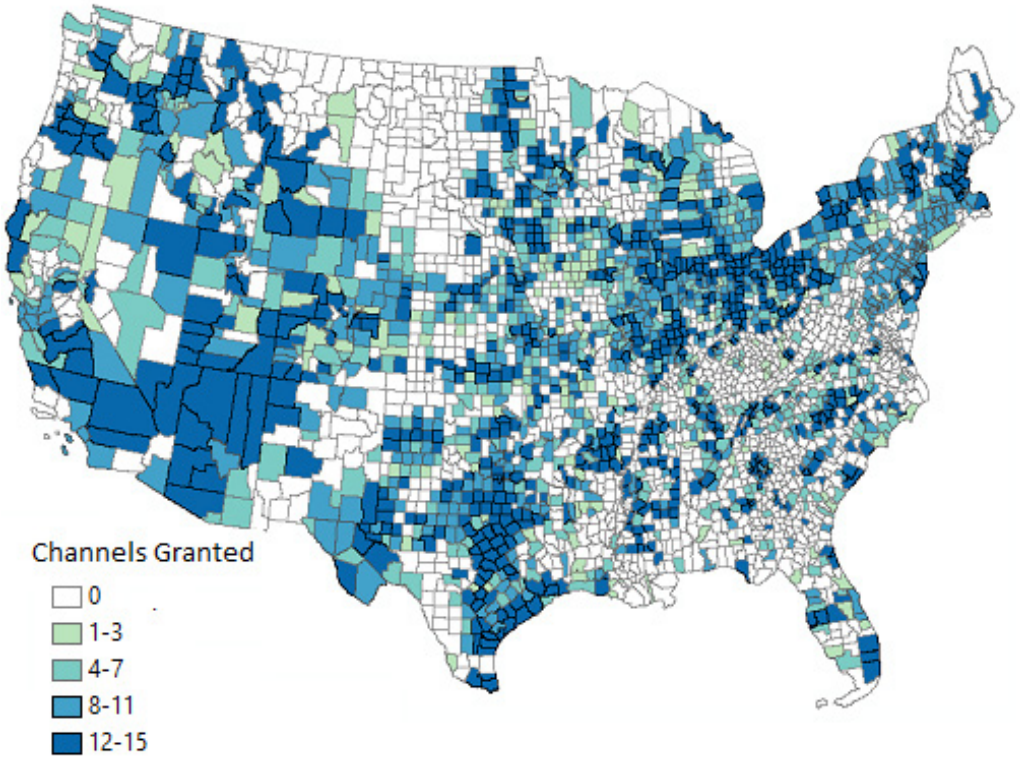

Figure 67: Number of channels granted within each county for CONUS on 4/1/2021.

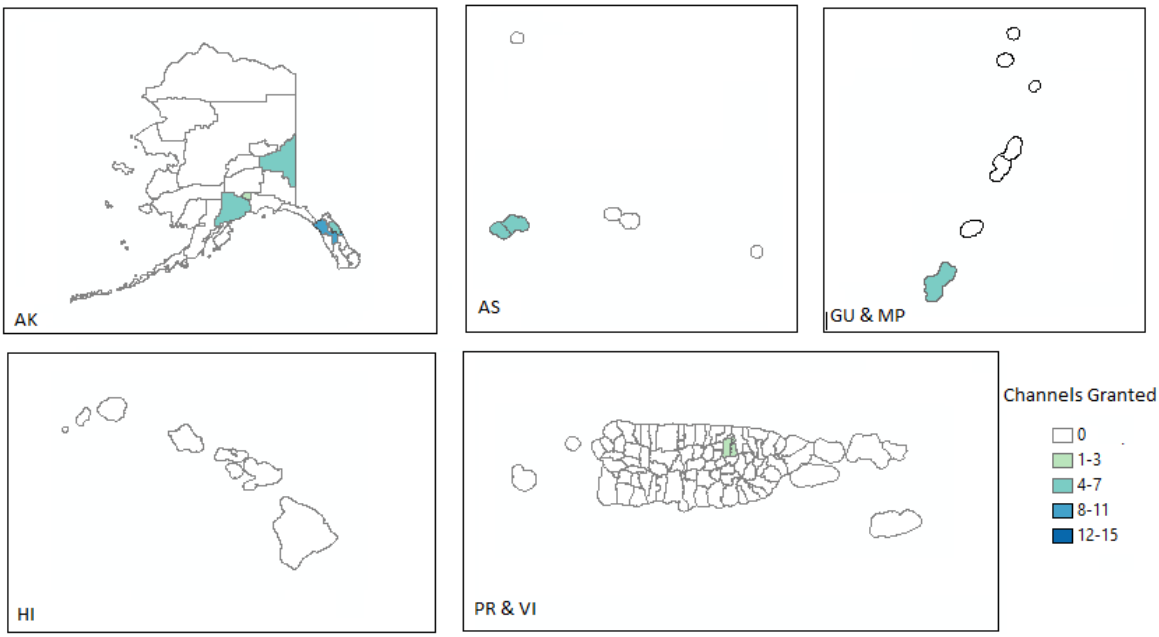

Figure 68: Number of channels granted within each county for OCONUS on 4/1/2021.

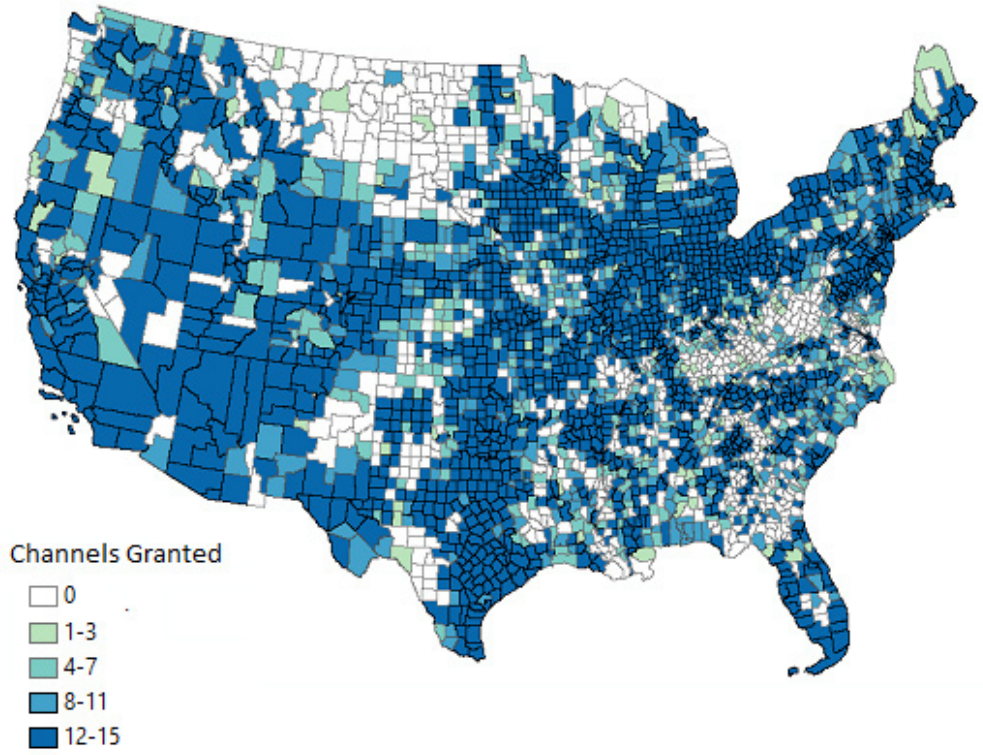

Figure 69: Number of channels granted within each county for CONUS on 1/1/2023.

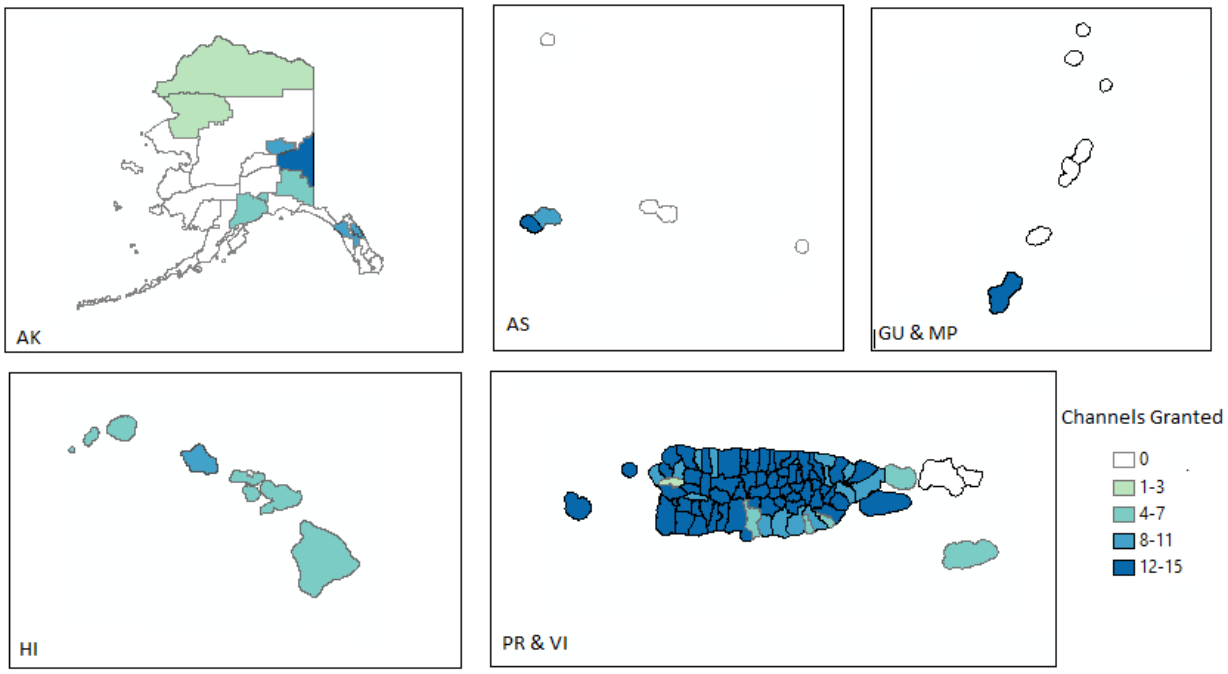

Figure 70: Number of channels granted within each county for OCONUS on 1/1/2023.

5.3 Band Utilization

In this report, band utilization is defined as the number of actively granted 10 MHz channels in each county. Band utilization represents the maximum usage because grants reflect what the CBSDs are authorized to use. The county basis for this analysis was chosen to match the county basis on which PALs were auctioned. In calculating band utilization, a 10 MHz channel is considered actively granted even if its entire bandwidth is not used, e.g., in the case of 5 MHz grants. This is the result of anonymization of the FAD data as described in Section 2. County level maps of the band utilization on April 1, 2021 and January 1, 2023 are provided in Figures 67, 68, 69, and 70.

For each possible value from 1 to 15 channels granted, Figure 71 provides the percent of counties that had at least that many channels actively granted in each quarterly dataset. In each subsequent quarter, more counties used CBRS and counties using CBRS tended to increase the number of channels they used. On April 1, 2021, 56.4% of counties had at least one channel granted while 10% had all 15 channels granted. On January 1, 2023, 78.1% of all counties used at least 1 channel and 32.9% used all 15 channels.

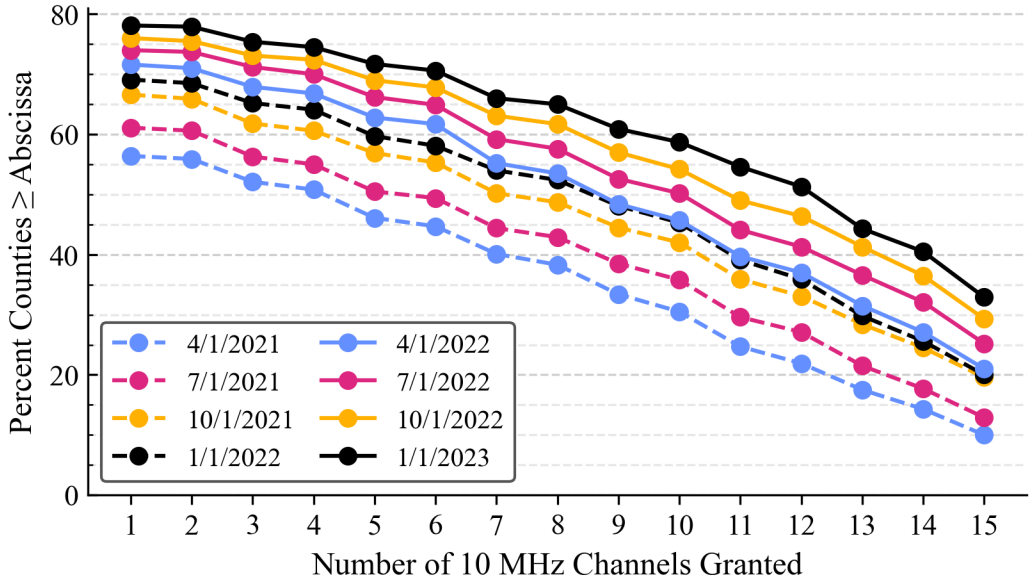

Figure 71: Band utilization for each quarterly dataset from 4/1/2021 to 1/1/2023.

Figure 72 shows the same metrics but excludes all counties in each dataset which have zero active CBSDs. Therefore, in Figure 72, each series indicates that 100% of counties have at least one channel granted. This view of the data also shows that higher utilization has become more common over the analysis period. On April 1, 2021, only 17.7% of counties with at least one active CBSD had all 15 channels granted. This number increased to 42.1% on January 1, 2023.

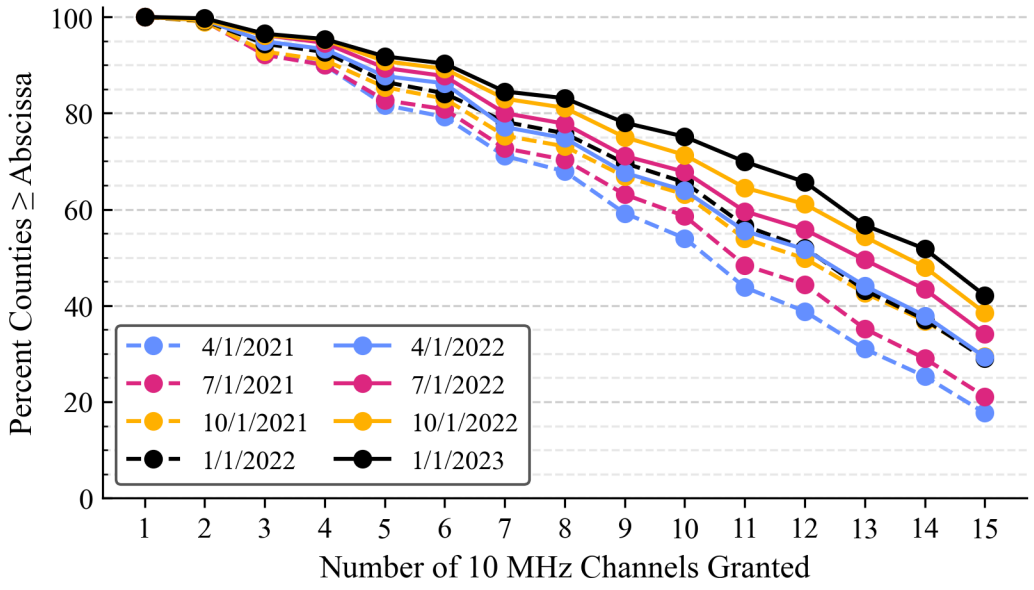

Figure 72: Band utilization for counties with at least one active CBSD for each quarterly dataset from 4/1/2021 to 1/1/2023.

Mean band utilization, i.e., mean number of 10-MHz channels granted per county, provides a summary of the band utilization within a set of counties. Figure 73 illustrates the mean band utilization for all counties and for only counties with at least one active CBSD. As shown, the mean number of 10 MHz channels granted rose from 5.4 to 9.2 across all counties. The mean number of channels granted in counties with at least one active CBSD rose from 9.5 on April 1, 2021 to 11.8 on January 1, 2023.

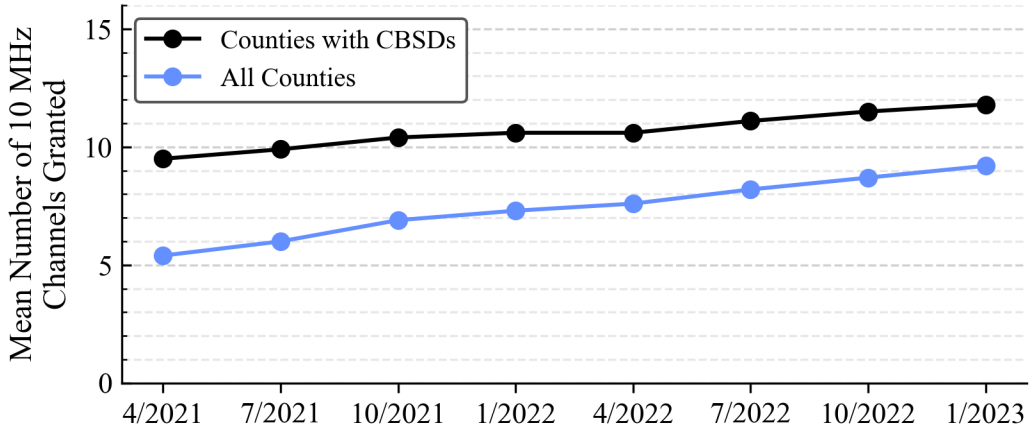

Figure 73: Mean band utilization in each quarterly dataset from 4/1/2021 to 1/1/2023.

5.4 Dynamic Protection Area Neighborhoods

DPAs allow commercial entities to share the spectrum with the incumbents. This subsection investigates the impact of DPAs by examining the increase in the number of active CBSDs and band utilization for DPA-impacted versus non-impacted counties, where a county is considered DPA-impacted if it intersects with any DPA neighborhood. All other counties are considered non-impacted.

Table 8 provides nationwide counts of active CBSDs in DPA-impacted and non-impacted counties, and Figure 74(a) illustrates these numbers. Both county types experienced significant and steady increases in CBSD deployments. Over the analysis period, the number of CBSDs in non-impacted counties increased by 81,173 (11,596 per quarter, on average) compared to an increase of 76,060 in DPA-impacted counties (10,866 per quarter, on average). Figure 74(b) illustrates these CBSD counts as a percentage of the total number of active CBSDs on each date. CBSDs in DPA-impacted counties increased as a percentage of the total, from 40.3% on April 1, 2021 to 44.7% on January 1, 2023. On that date, there were 128,351 CBSDs in DPA-impacted counties with a total population of 232,348,897 residents. Had DPA neighborhoods been designated as exclusion zones, those CBSDs could not have been deployed.

Table 8: Nationwide counts of active CBSDs in DPA-impacted and non-impacted counties.

County Type	4/1/2021	7/1/2021	10/1/2021	1/1/2022	4/1/2022	7/1/2022	10/1/2022	1/1/2023
DPA-impacted	52,291	61,569	72,116	80,438	90,203	99,278	113,253	128,351
Non-impacted	77,473	89,721	102,179	110,867	123,306	135,003	147,228	158,646
Unknown	18	27	31	36	36	37	37	36

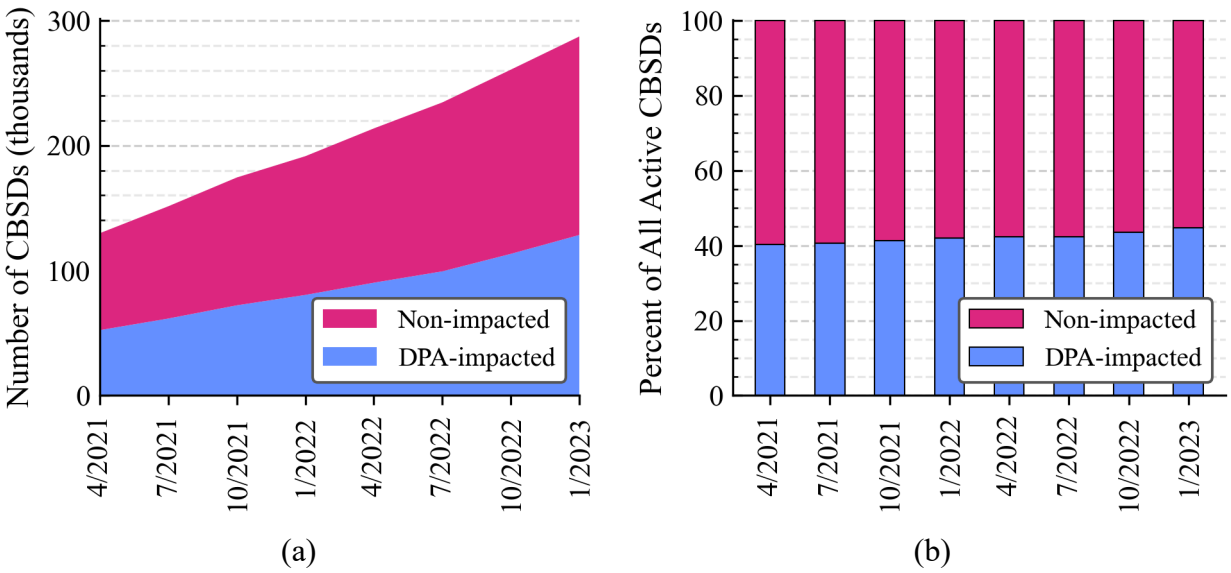

Figure 74: Nationwide number (a) and percentage (b) of CBSDs in DPA-impacted and non-impacted counties from 4/1/2021 to 1/1/2023.

Figure 75 provides the percent of DPA-impacted and non-impacted counties in which the number of CBSDs is equal to or greater than the value on the x-axis (abscissa) on April 1, 2021, and January 1, 2023. During the early stages of CBRS deployment, there was a greater likelihood that non-impacted counties were using CBRS, compared to DPA-impacted counties. On April 1, 2021, 62.5% of non-impacted counties contained at least one active CBSD, compared to 49.8% of DPA-impacted counties. Over the analysis period, this gap narrowed. On January 1, 2023, 79% of non-impacted counties had at least one active CBSD, compared to 77.2% of DPA-impacted counties. While non-impacted counties tended to have more active CBSDs than DPA-impacted counties, growth occurred in both categories, and the county with the most CBSDs is within a DPA neighborhood.

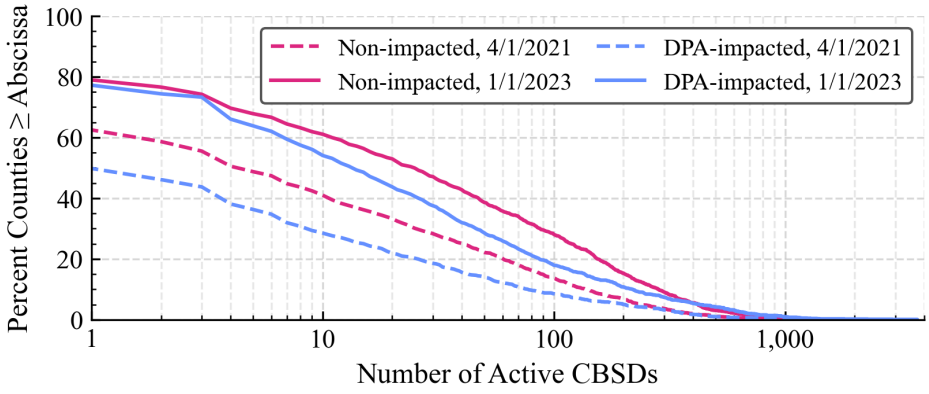

Figure 75: Percent of DPA-impacted and non-impacted counties in which the number of CBSDs is equal to or greater than the value on the x-axis on 4/1/2021 and 1/1/2023.

Figure 76 illustrates the mean number of active CBSDs per county for DPA-impacted counties and non-impacted counties. As shown, there is a small difference in the mean number of active CBSDs per county between these two categories. In each quarterly dataset, non-impacted counties had a slightly higher mean number of active CBSDs with the difference ranging from 11 to 16. While non-impacted counties maintained a slightly higher mean active CBSD count, the mean increased for both DPA-impacted and non-impacted counties.

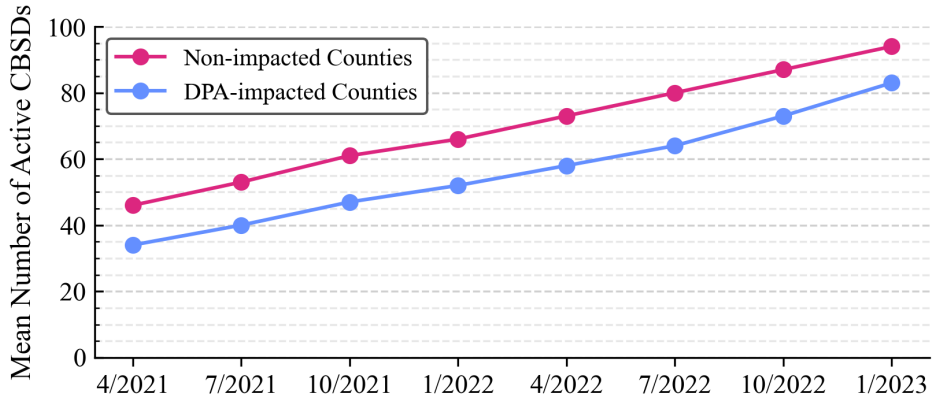

Figure 76: Mean CBSDs per county for DPA-impacted and non-impacted counties from 4/1/2021 to 1/1/2023.

Figure 77 illustrates mean band utilization for CBSDs in DPA-impacted and non-impacted counties. Non-impacted counties are shown to have slightly more 10 MHz channels granted on average in every quarterly dataset. The mean number of channels granted increased for both categories every quarter and the slight difference between the two decreased over time. On April 1, 2021, on average, non-impacted counties had 1.2 more channels granted in a county. The most recent dataset indicates the smallest difference observed over the analysis period, with non-impacted counties having only 0.35 more 10 MHz channels granted, on average.

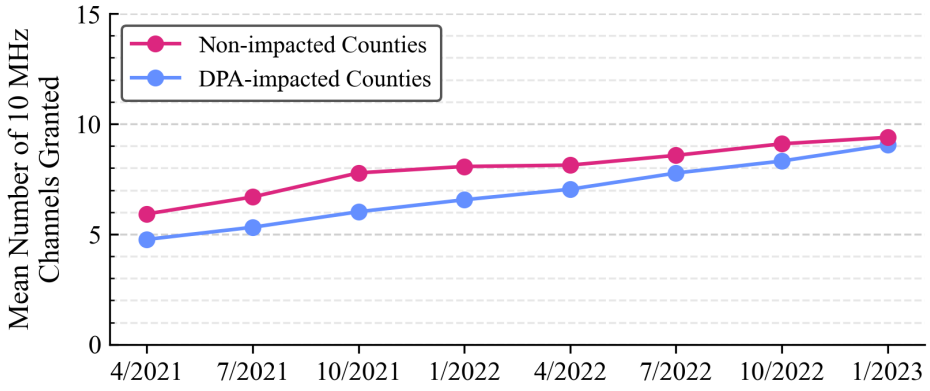

Figure 77: Mean band utilization in DPA-impacted and non-impacted counties from 4/1/2021 to 1/1/2023.

6. SUMMARY

This report presents and analyzes aggregated and anonymized quarterly SAS FAD data from April 1, 2021 to January 1, 2023. The goal was to gain insight on the current state and growth of CBRS. Over 21 months, CBRS deployments grew at a steady rate. The total number of CBSDs with active grants increased by 157,251 CBSDs (121%), with a mean quarterly increase of 22,464 CBSDs per quarter (12%). On January 1, 2023, 78.1% of counties nationwide had at least one active CBSD, up from 56.4% on April 1, 2021. Both types of CBSDs, Category A and Category B, grew in number over the analysis period. In all quarterly datasets, Cat B CBSDs account for more than 95% of all active CBSDs. Additionally, the mean quarterly increase of 21,117 Cat B CBSDs far outpaced the mean quarterly increase of 1,347 Cat A CBSDs. Both indoor and outdoor deployments grew steadily, but over 95% of deployments were outdoors in all quarterly datasets. Despite being a minority use case overall, the majority of Cat A CBSDs are deployed indoors. E_UTRA rose from 37.1% of all active CBSDs on April 1, 2021 to 41.7% on January 1, 2023. NR did not appear in quarterly FAD data until January 1, 2022, and rose to 6.0% of all active CBSDs on January 1, 2023. In addition to growth in the number of active CBSDs, CBRS also demonstrates growth in band utilization at the county level. Across all counties, the mean band utilization increased over the analysis period from 5.4 to 9.2 10 MHz channels granted. While demonstrating significant growth in band utilization, the data suggest there is still room to grow.

A comparison of CBSD counts between DPA-impacted and non-impacted counties revealed that non-impacted counties tended to have a slightly higher number of active CBSDs; however, both groups experienced steady growth in the mean number of CBSDs per county. On April 1, 2021, non-impacted counties had 1.2 more channels granted, on average, than DPA-impacted counties. On January 1, 2023, this difference was reduced to 0.4 more channels granted, on average. On January 1, 2023, there were 128,351 active CBSDs in DPA-impacted counties with a total population of 232,348,897 residents.

Notably, Priority Access spectrum usage grew consistently, with a mean quarterly increase of 17% in the number of CBSDs with a PAL grant. However, GAA grants represented more than 85% of all active grants each quarter. GAA CBSDs dominated deployments; GAA-only CBSDs made up more than 80% of all CBSDs in every quarter. The GAA tier was also a popular supplement to PALs, with 66.7% of all active CBSDs using PAL grants also using at least one GAA grant on January 1, 2023.

Numbers of CBSDs in both urban and rural areas experienced steady increases. The majority of active CBSDs are deployed in rural areas, making up more than 70% of the total each quarter. Over the analysis period, rural CBSDs experienced approximately double the growth of urban CBSDs. Rural areas added 102,340 CBSDs (14,623 per quarter, on average), compared to the addition of 54,893 new CBSDs in urban areas (7,842 per quarter, on average) over the same period. Despite this, urban CBSDs increased from 20.0% of all active CBSDs on April 1, 2021, to 28.2% on January 1, 2023.

7. ACKNOWLEDGEMENTS

NTIA would like to thank the SAS Administrators and the FCC for facilitating the analysis provided in this report.

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NTIA FORM 29
(4-80)

U.S. DEPARTMENT OF COMMERCE
NATIONAL TELECOMMUNICATIONS AND INFORMATION ADMINISTRATION

BIBLIOGRAPHIC DATA SHEET

1. PUBLICATION NO.	2. Government Accession No.	3. Recipient's Accession No.
TR-23-567		

4. TITLE AND SUBTITLE	5. Publication Date
An Analysis of Aggregate CBRS SAS Data from April 2021 to January 2023	May 1, 2023
	6. Performing Organization Code NTIA/ITS.T

7. AUTHOR(S)	9. Project/Task/Work Unit No.
Douglas Boulware, Anthony Romaniello, Rebecca L. Dorch, and Michael G. Cotton	6505000-200
8. PERFORMING ORGANIZATION NAME AND ADDRESS Institute for Telecommunication Sciences National Telecommunications & Information Administration U.S. Department of Commerce 325 Broadway Boulder, CO 80305	10. Contract/Grant Number.

11. Sponsoring Organization Name and Address	12. Type of Report and Period Covered
National Telecommunications & Information Administration Herbert C. Hoover Building 14th & Constitution Ave., NW Washington, DC 20230	Technical Report

14. SUPPLEMENTARY NOTES

15. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)

This report presents an analysis of aggregate Citizens Broadband Radio Service (CBRS) Spectrum Access System (SAS) data reported quarterly from April 1, 2021, to January 1, 2023. The data provide valuable insights into the growth of CBRS, the impact of dynamic spectrum sharing, the role of General Authorized Access (GAA) spectrum usage, and CBRS's role in rural wireless connectivity. CBRS deployments grew at a steady rate with a mean quarterly increase of 12.0% and a total increase of 121% over the 21-month analysis period. On January 1, 2023, there were 128,351 active CBSDs (i.e., 45% of the total number of CBSDs) in Dynamic Protection Area (DPA)–impacted counties. The number of CBSDs with Priority Access License (PAL) grants grew consistently with a mean increase of 17% per quarter, but GAA CBSDs dominated deployments. On January 1, 2023, four out of five active CBSDs were GAA-only, 85% of the active grants were GAA, and 66.7% of the 56,529 CBSDs with a PAL also had at least one active GAA grant. Finally, on January 1, 2023, over 70% of all active CBSDs were deployed in rural census blocks.

16. Key Words (Alphabetical order, separated by semicolons)
3550–3700 MHz; 5G; cellular; Citizens Broadband Radio Service (CBRS); Citizens Broadband Radio Service Device (CBSD); rural connectivity; Spectrum Access System (SAS); spectrum management; spectrum sharing; spectrum utilization

17. AVAILABILITY STATEMENT	18. Security Class. (This report)	20. Number of pages
☒ UNLIMITED.	Unclassified	71
☐ FOR OFFICIAL DISTRIBUTION.	19. Security Class. (This page) Unclassified	21. Price: N/A

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