Final 700 MHZ General Use Narrow Band Allotment Pool

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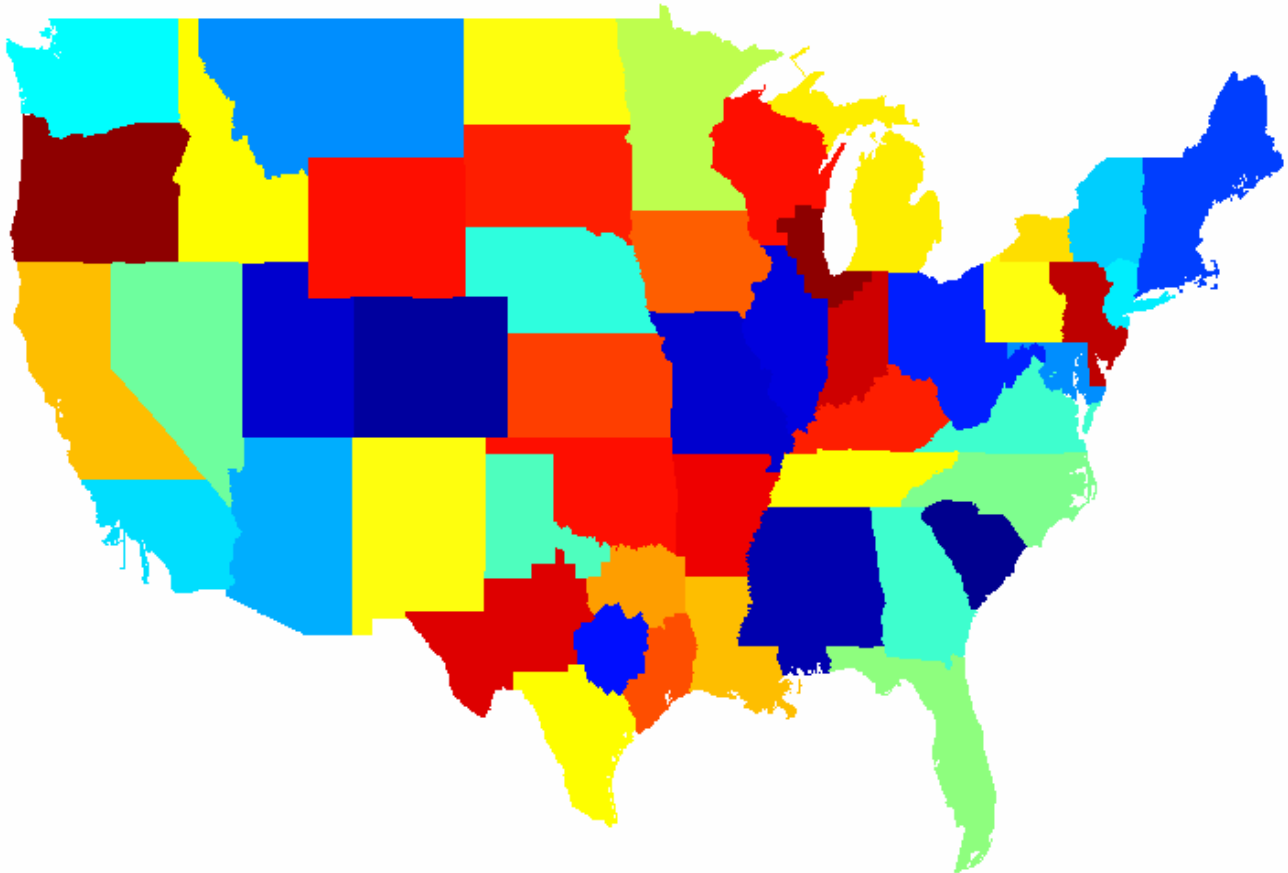
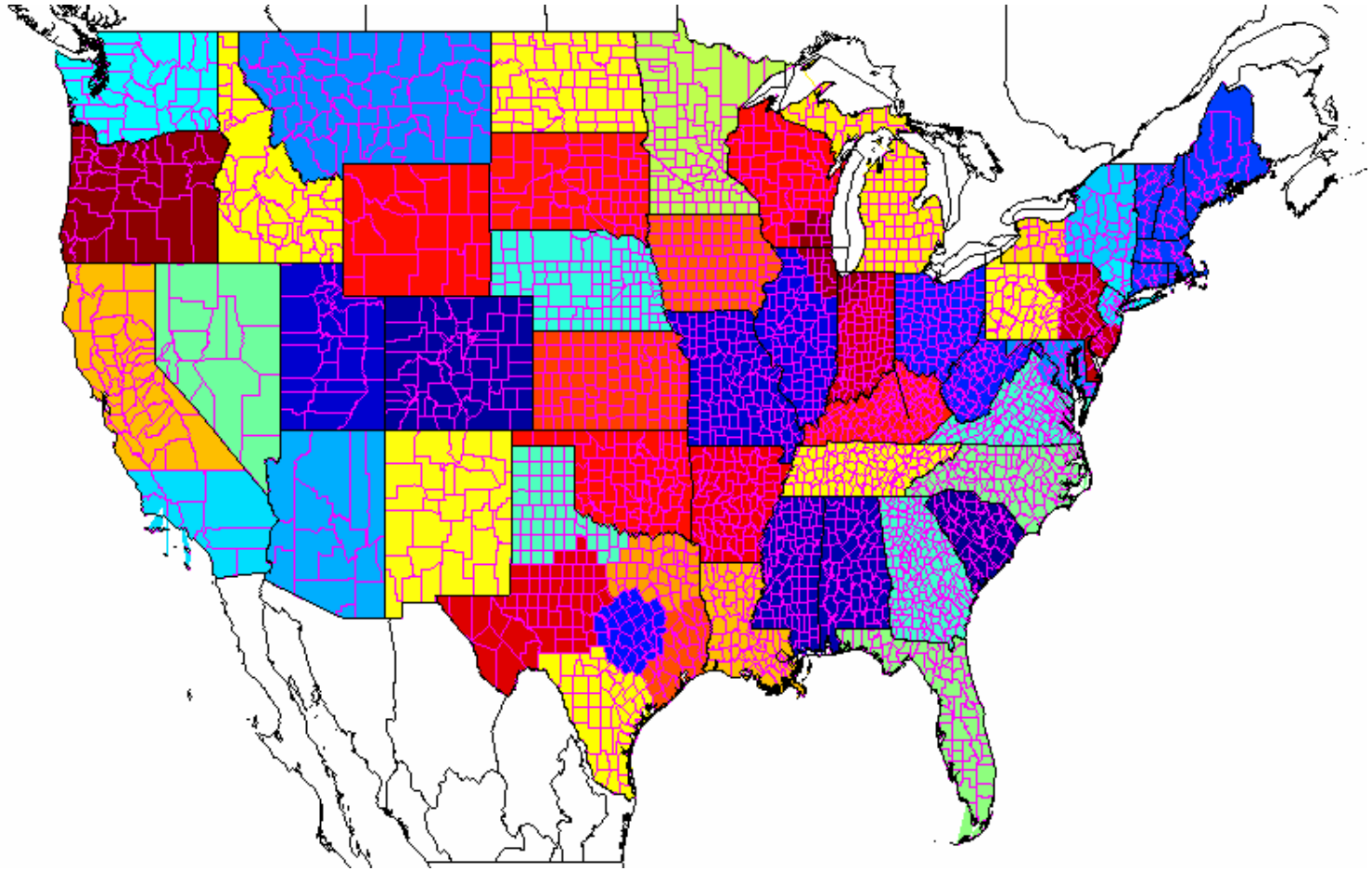
What Are the "Allotments"?

- Each County allotment:
  - is a contiguous 25-kHz Block
    - (4) 6.25 kHz channels, or
    - (2) 12.5 kHz channels
  - maintains at least 250 kHz separation with all other allotments within each county
- Each County (except PR/VI) received a minimum of 5 of these 25-kHz blocks
  - The remainder were allotted according to the capacity model, and reuse constraints
  - Terrain and US Borders do affect availability

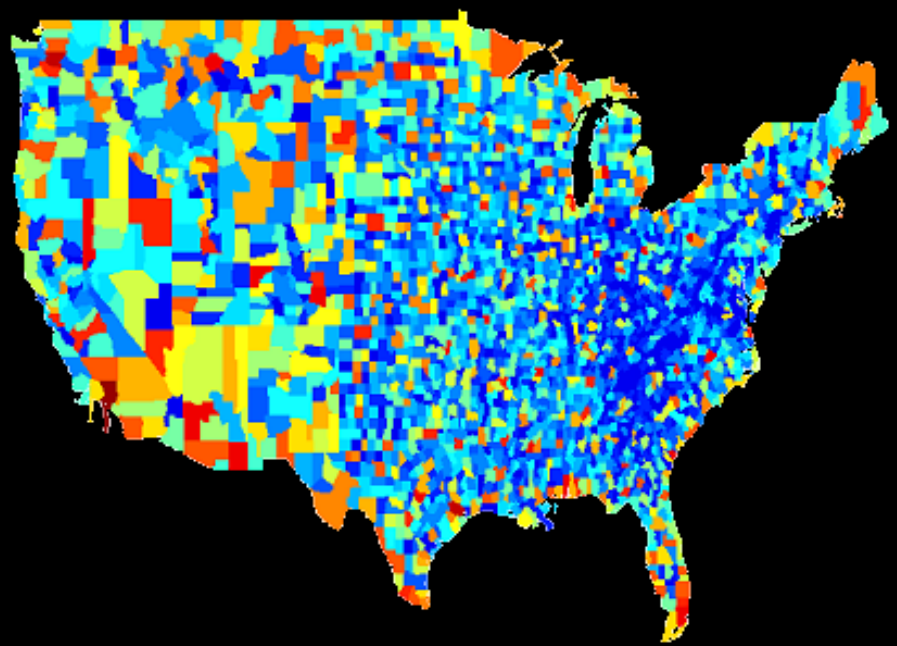
700 MHZ RPC Regions



700 MHZ RPC Regions



Overall Results



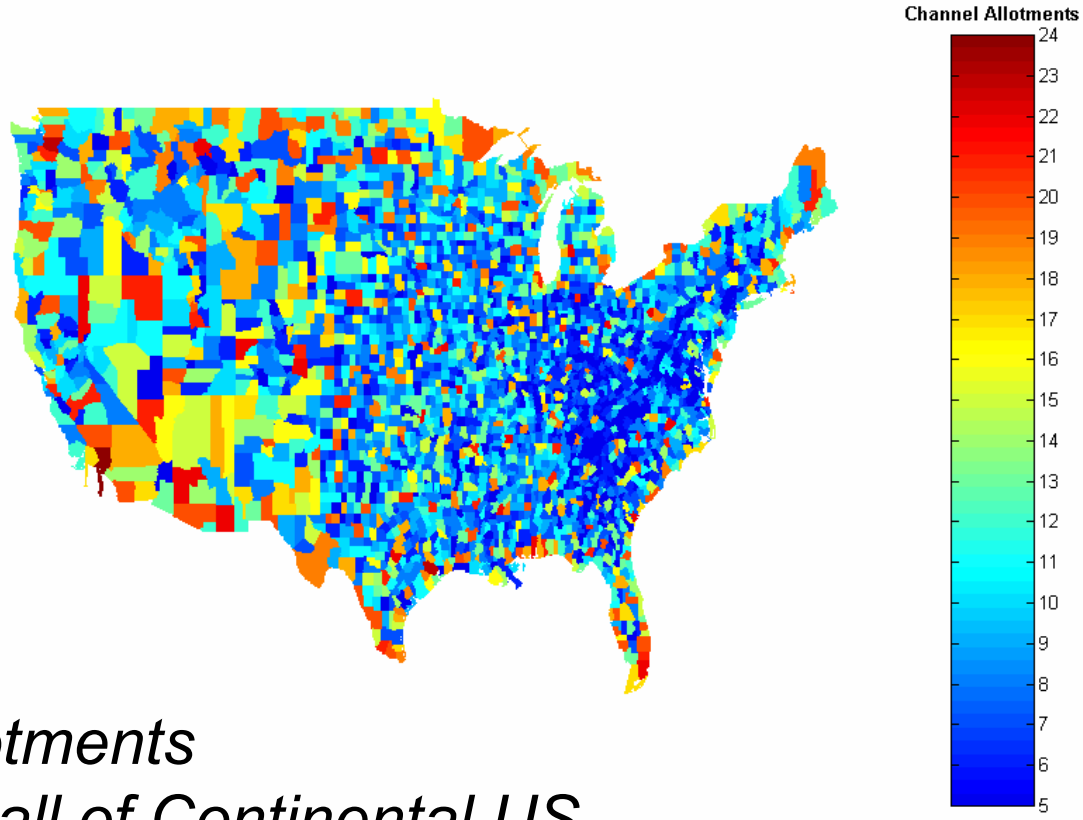
Pool Assignment Method

- The Frequency Assignment Problem (FAP) is **Very** Complex:
  - No “computable” solution, only “Good Methods”,(we used a hybrid of these)
  - Our solution also utilized forward and reverse refinement
- The optimization or “packing” is a dependent on many variables
  - Individual and global capacity needs, global and local terrain, past and “future” assignments
  - It is very difficult to visualize the “Problem Space” and “Objective Function” values
- Hard Constraints used, but soft are available
  - Method is very powerful, can handle much more complex problems

Pool Assignment Method

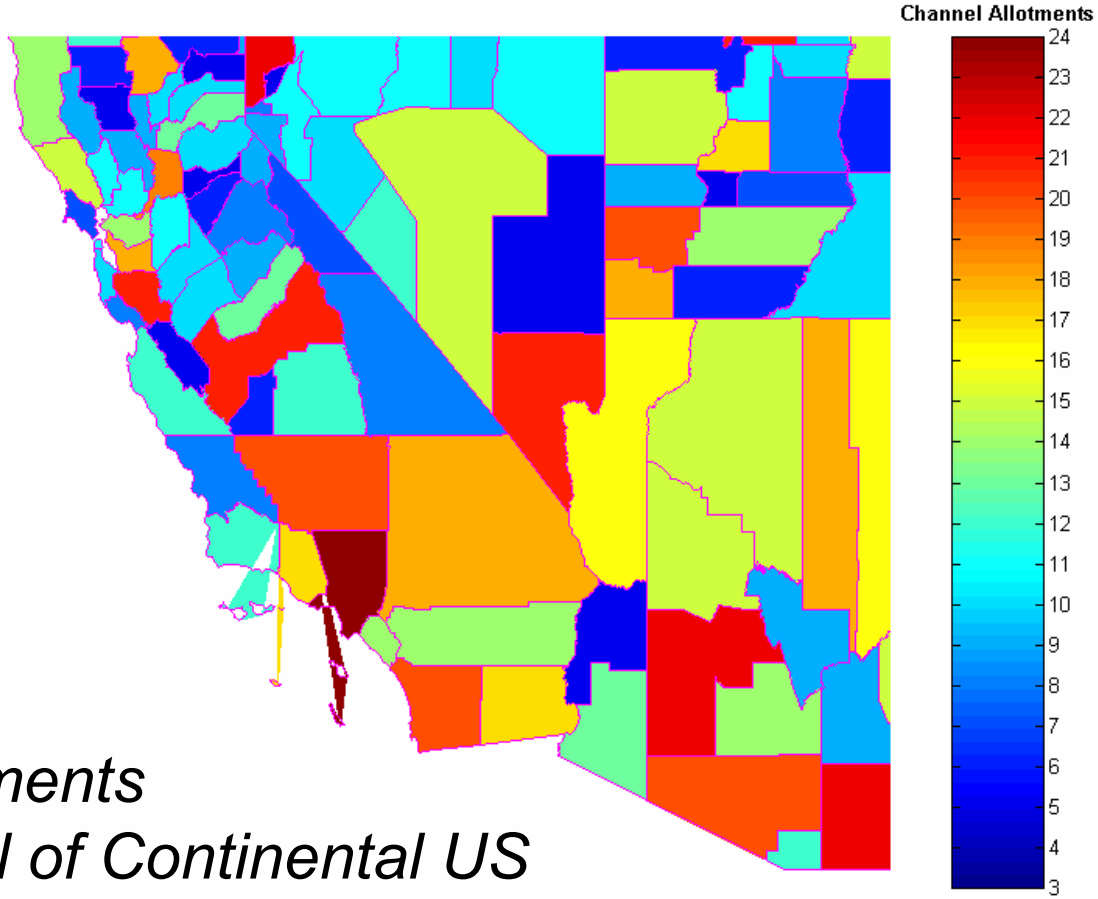
- The Frequency Assignment Problem (FAP) is **very** complex:
- The optimization or “packing” is a dependent on many variables
- Hard constraints (rules) were used, but soft are available
  - Method is very powerful, can handle much more complex problems
  - Method aspects had to be generalized, more information will yield even greater efficiency

700 MHZ Pre-Allotment Pool - Continental US



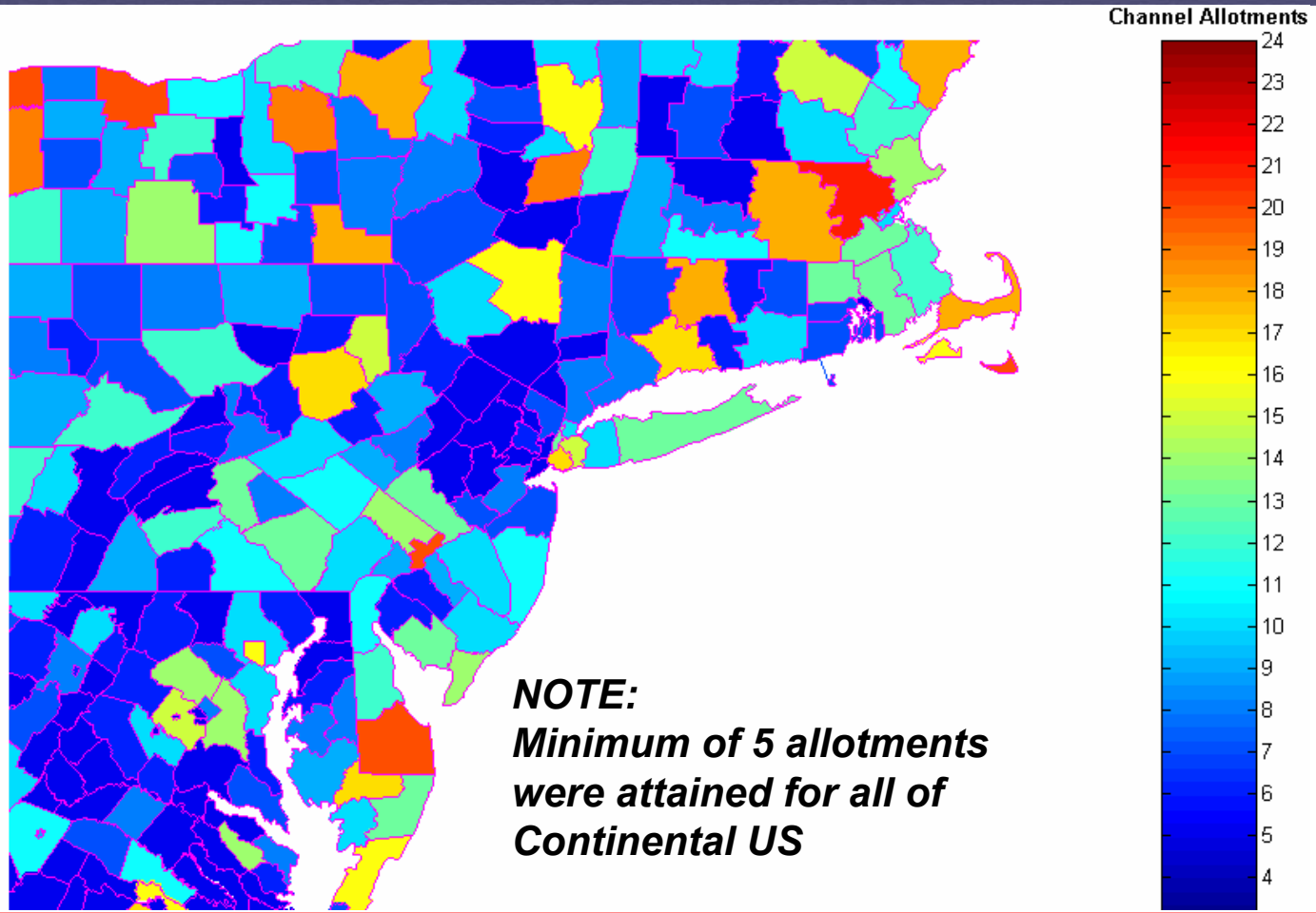
***NOTE**:*
Minimum of 5 allotments were attained for all of Continental US

700 MHZ Pre-Allotment Pool - Southern California Area



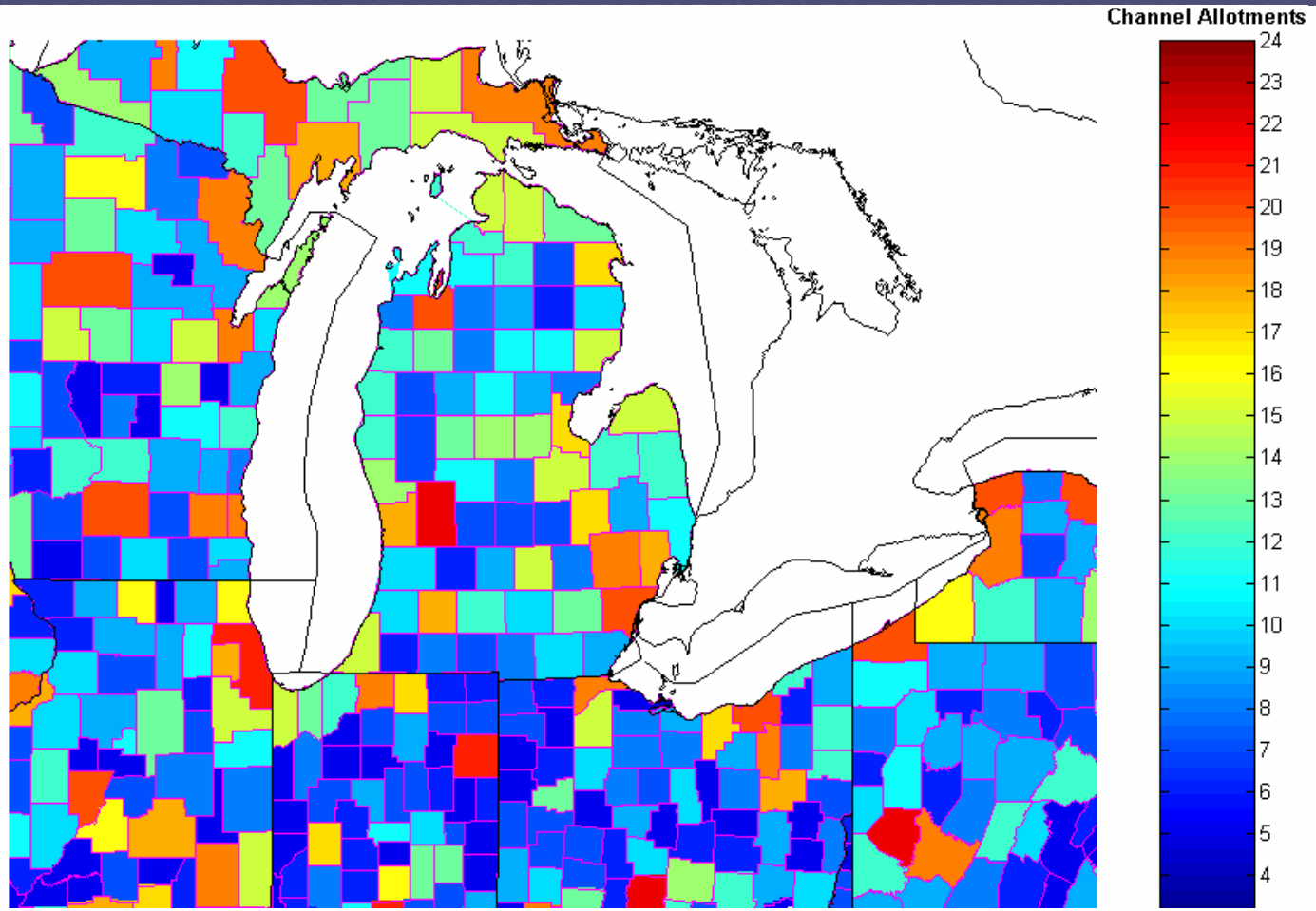
***NOTE**:*
Minimum of 5 allotments were attained for all of Continental US

700 MHZ Pre-Allotment Pool - East Coast Area

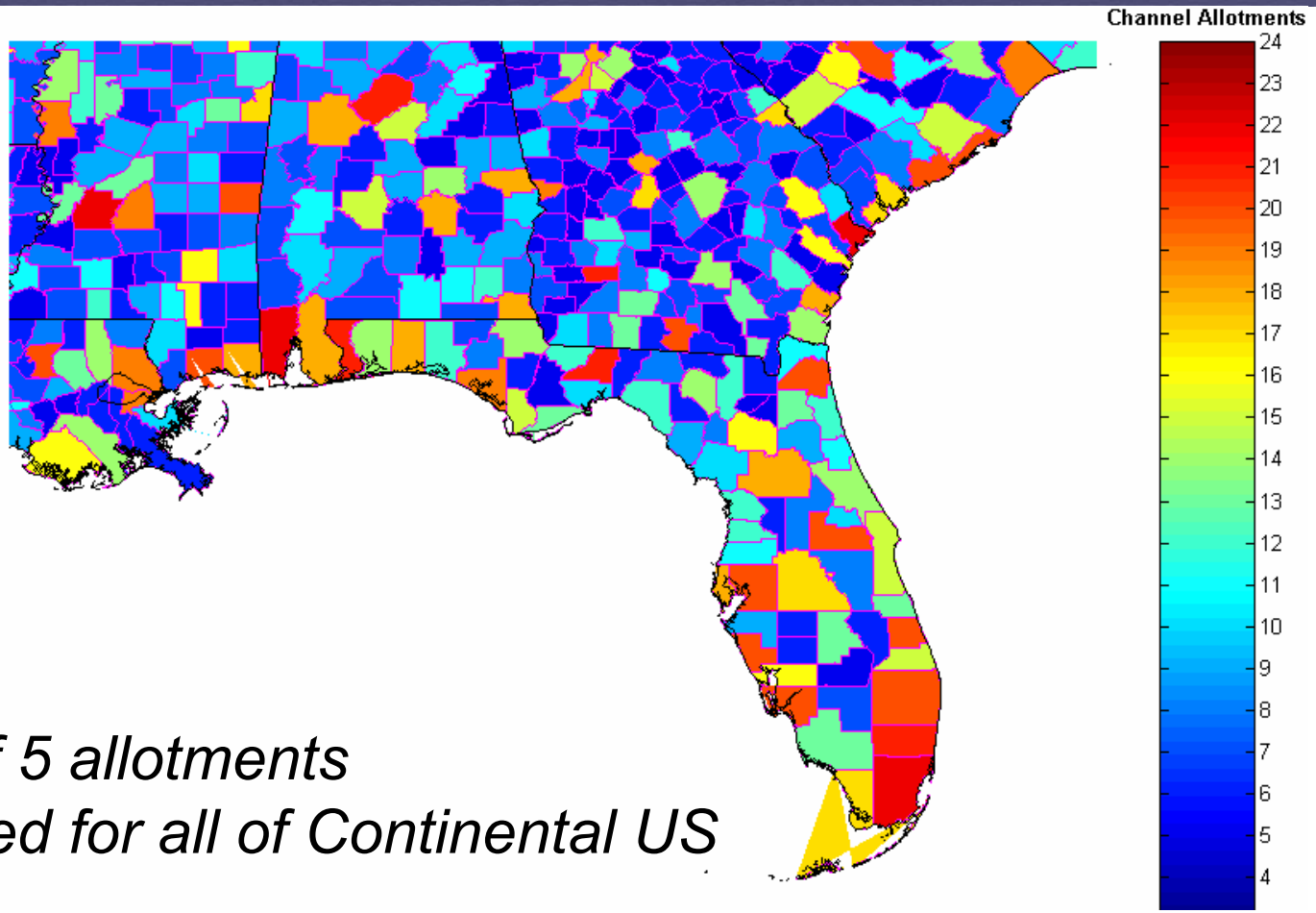


NOTE:
Minimum of 5 allotments were attained for all of Continental US

700 MHZ Pre-Allotment Pool - Chicago and Detroit Areas

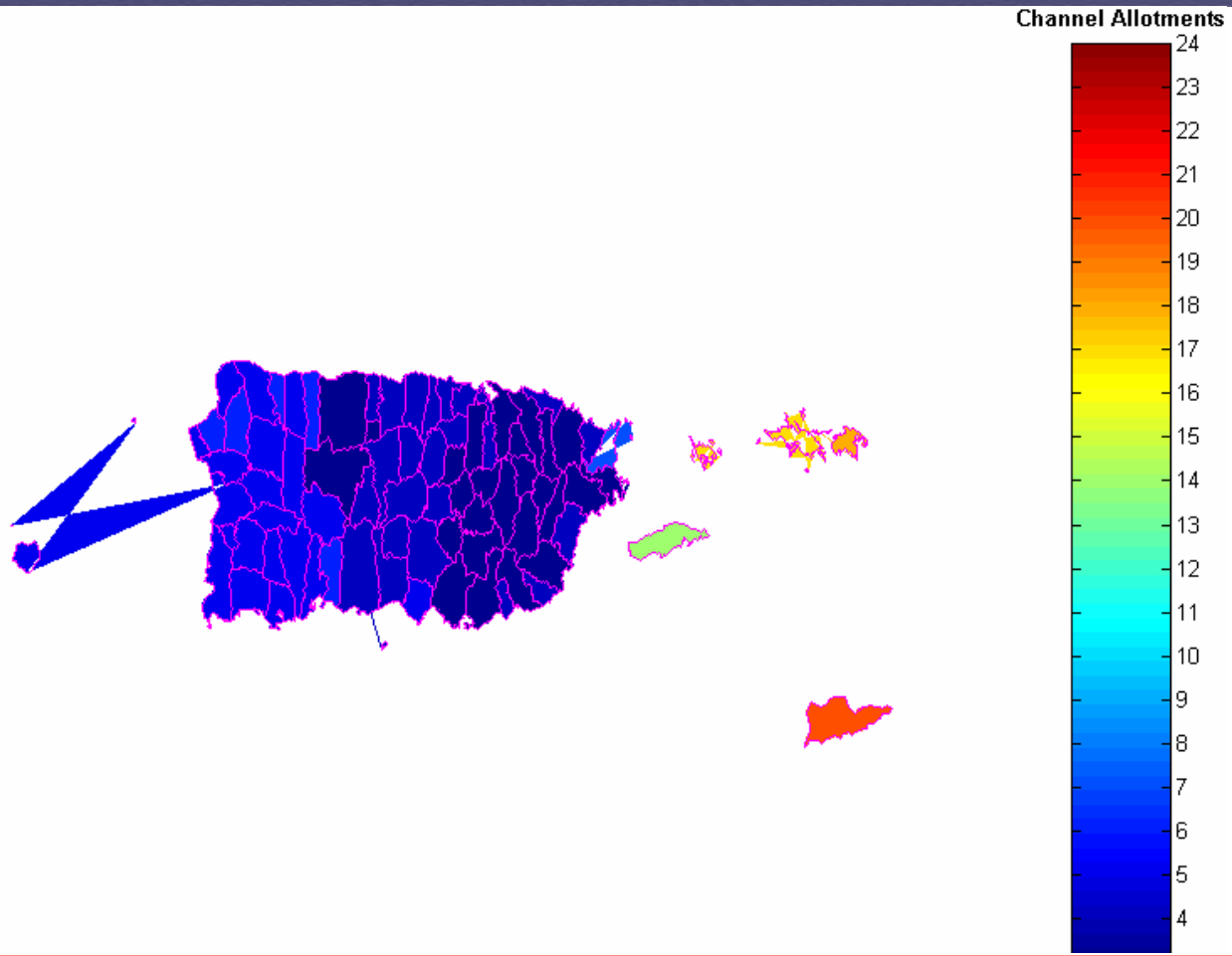


700 MHZ Pre-Allotment Pool - Florida and SE US

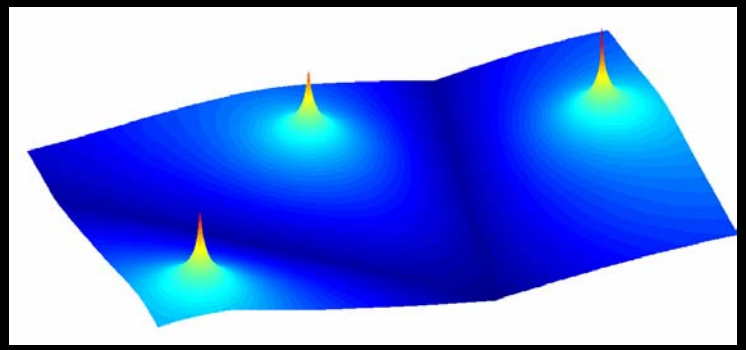


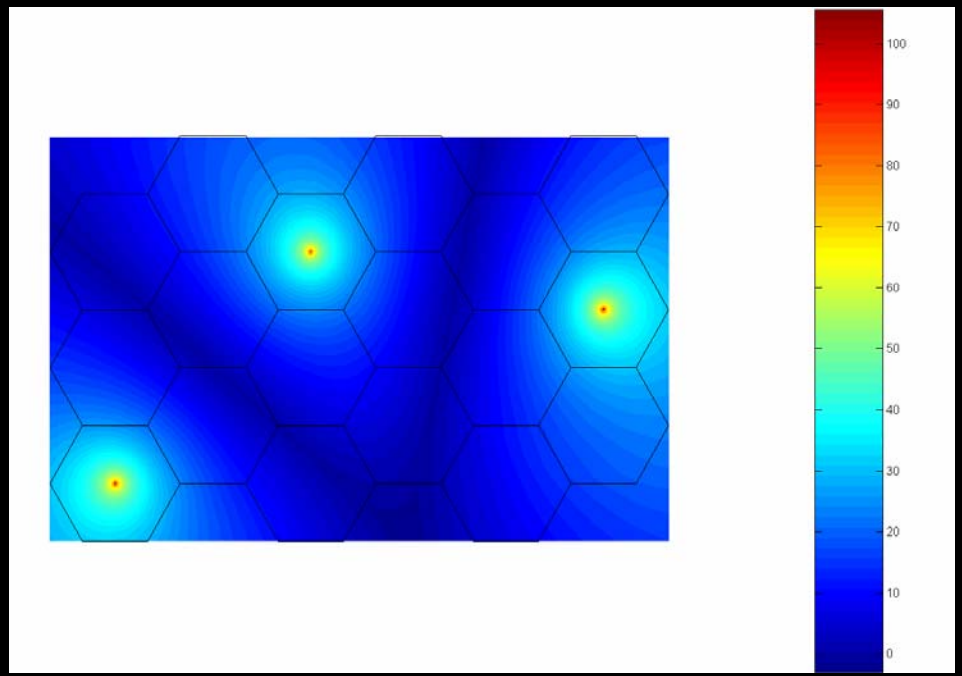
***NOTE**:*
Minimum of 5 allotments were attained for all of Continental US

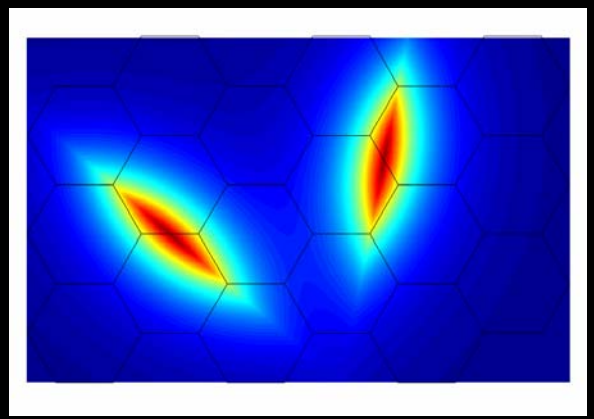
700 MHZ Pre-Allotment Pool - Puerto Rico



Technology Considerations

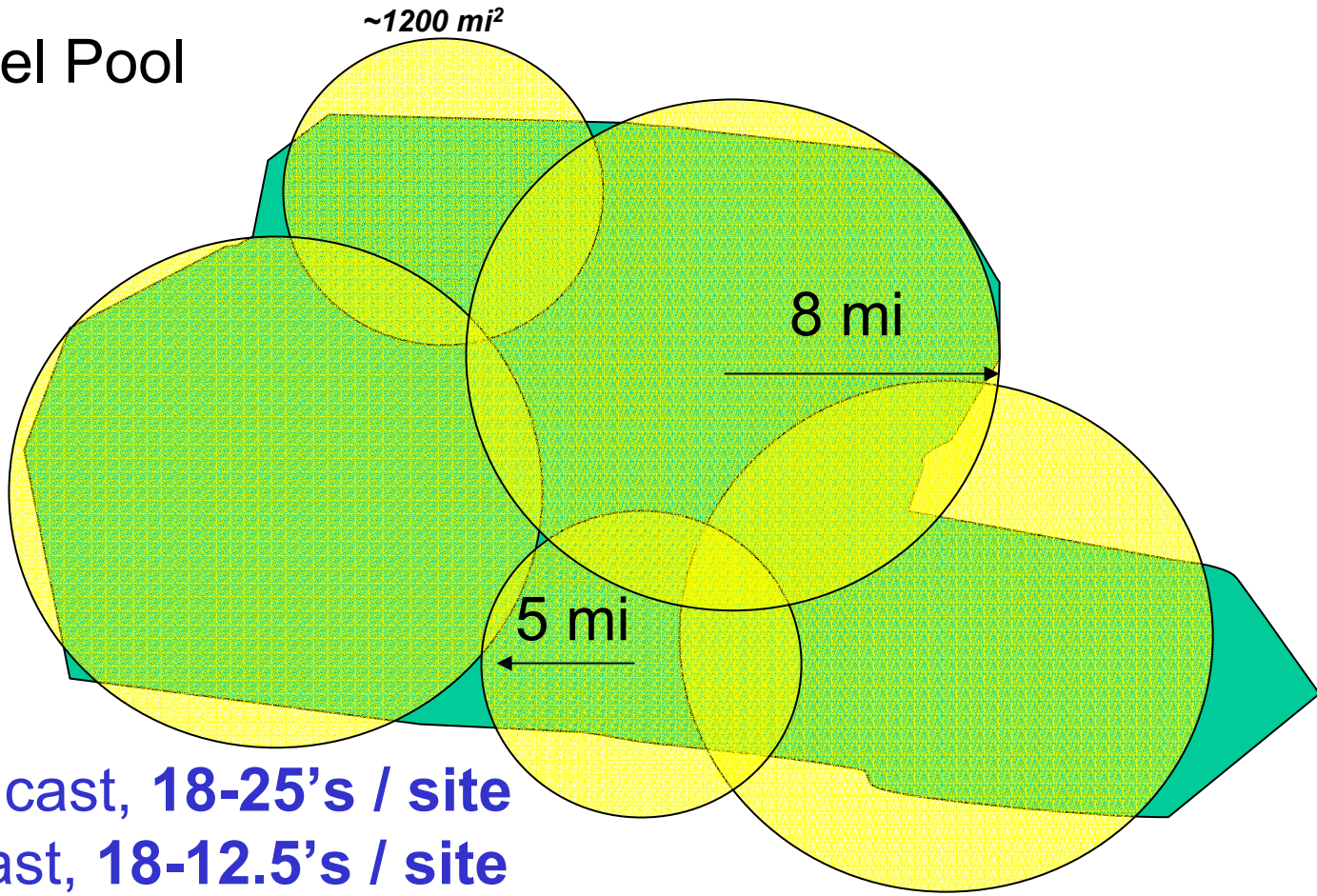






Technology and Design Considerations

18-25 kHz Channel Pool
High Site Design
5 Sites

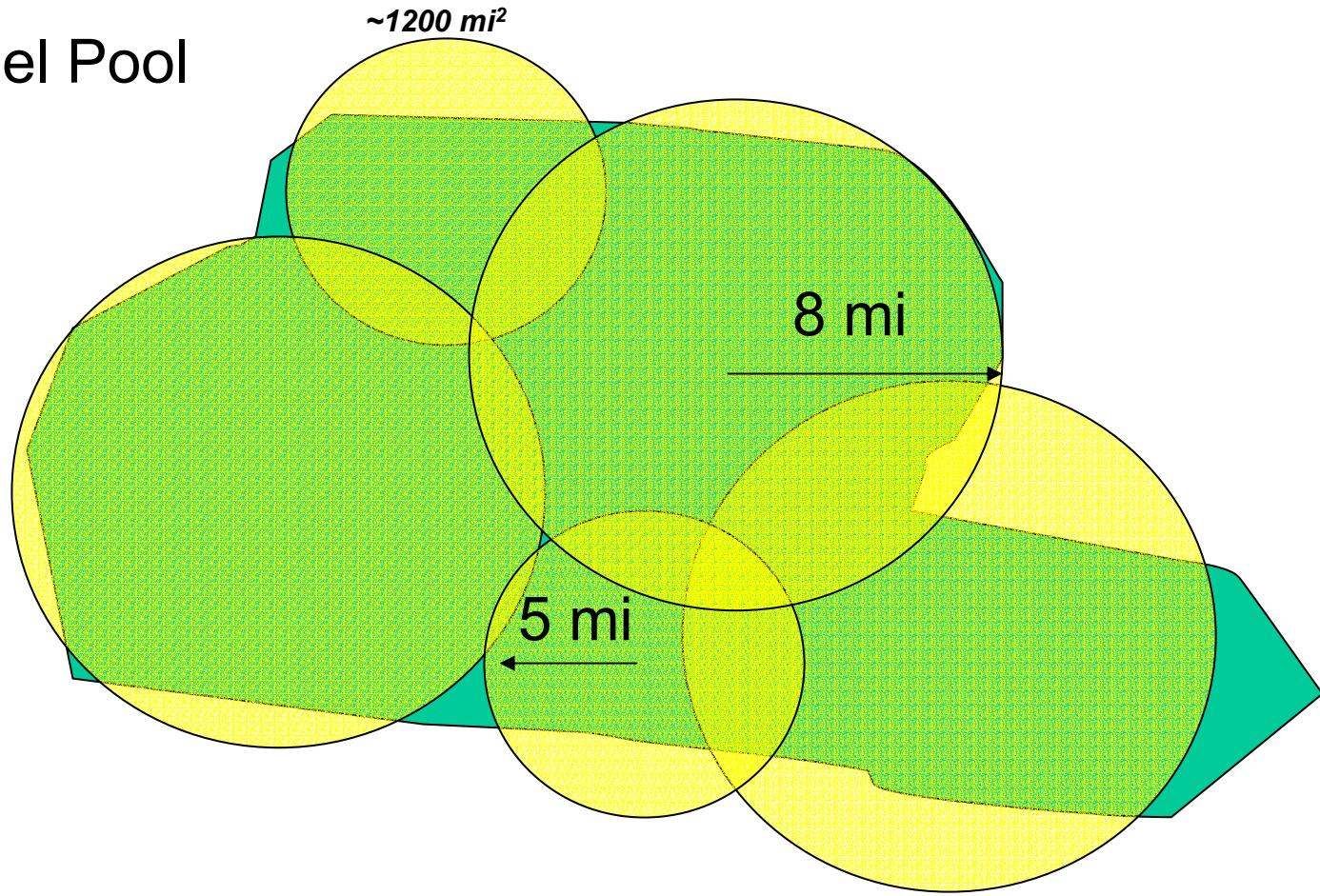


Multicast:
7-12.5's / site
14-6.25's / site
(TDMA or FDMA)
No Reuse

Single Zone Simulcast, **18-25's / site**
Two Zone Simulcast, **18-12.5's / site**

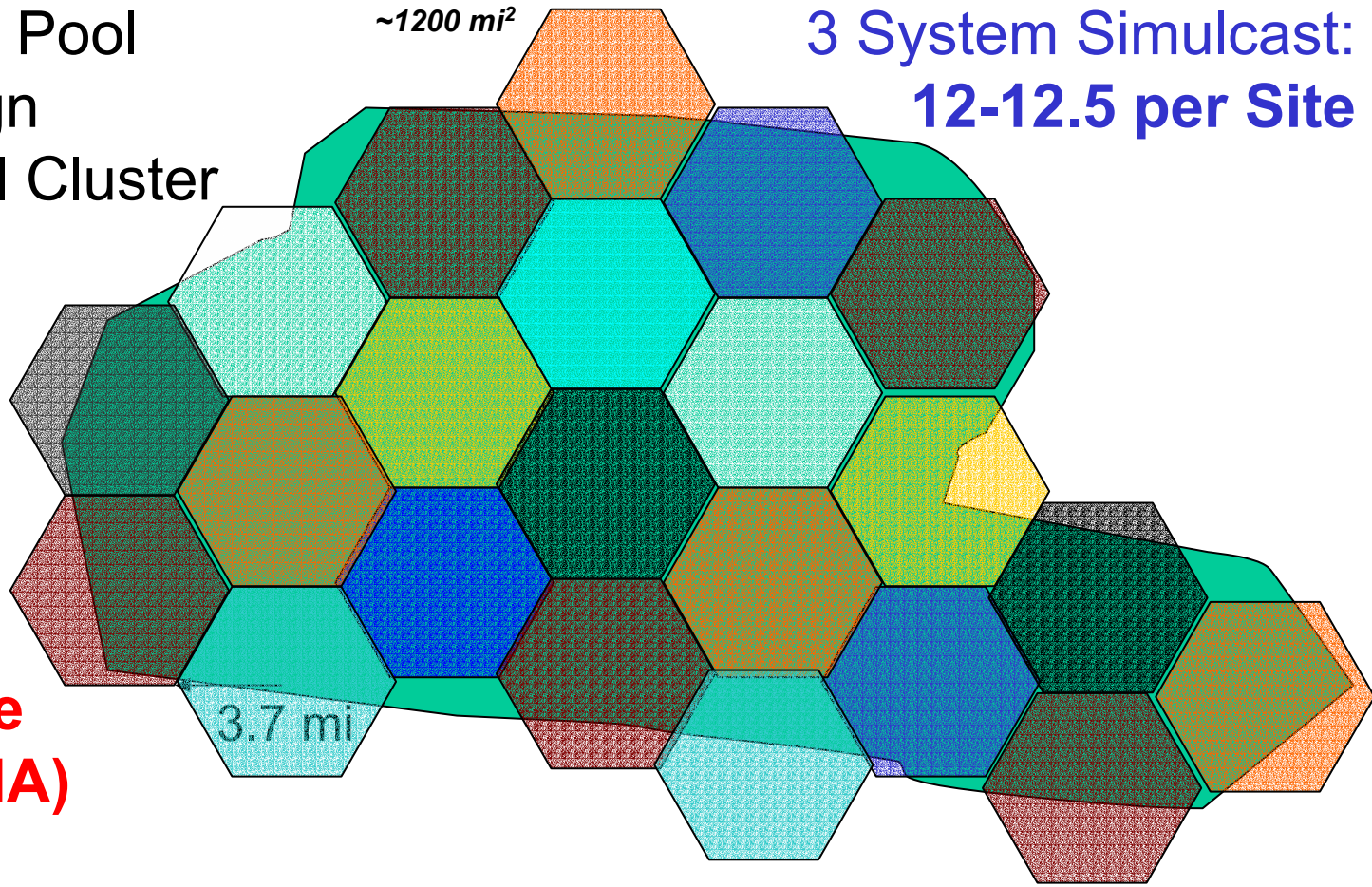
Technology and Design Considerations

18-25 kHz Channel Pool
High Site Design
5 Sites



Technology and Design Considerations

18-25 Channel Pool
Low Site Design
22 Sites, 7 Cell Cluster
~18 dB C/I

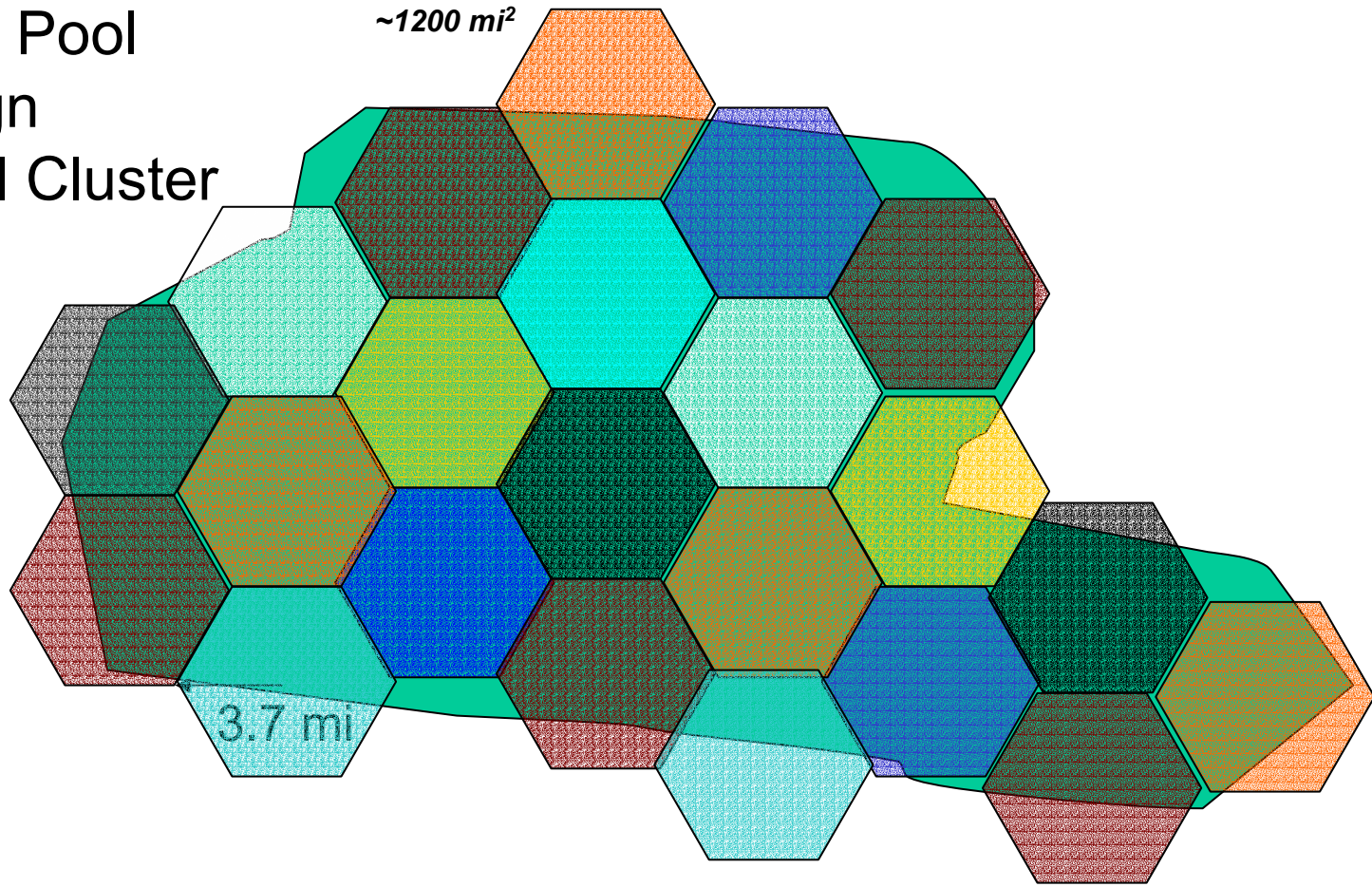


3 System Simulcast:
12-12.5 per Site

Multicast:
5-12.5 per site
10-6.25 per site
(TDMA or FDMA)
3.1X Reuse

Technology and Design Considerations

18-25 Channel Pool
Low Site Design
22 Sites, 7 Cell Cluster
~18 dB C/I



6.25 kHz FDMA Multicast

Block				
1	1	4	2	5
2	2	5	3	1
3	3	1	4	2
4	4	2	5	3
5	5	3	1	4
6	1	4	2	5
7	2	5	3	1
8	3	1	4	2
9	4	2	5	3
10	5	3	1	4
11	1	4	2	5
12	2	5	3	1
13	3	1	4	2
14	4	2	5	3
15	5	3	1	4
16	1	4	2	5
17	2	5	3	1
18	3	1	4	2

Site	#	Min Site Sep
1	15 Chans	>225 kHz
2	15 Chans	>225 kHz
3	14 Chans	>225 kHz
4	14 Chans	>225 kHz
5	14 Chans	>225 kHz

14-15 Voice Paths/Site

72 Total

12.5 kHz TDMA/FDMA Multicast

Block		
1	1	4
2	2	5
3	3	1
4	4	2
5	5	3
6	1	4
7	2	5
8	3	1
9	4	2
10	5	3
11	1	4
12	2	5
13	3	1
14	4	2
15	5	3
16	1	4
17	2	5
18	3	1

Site	#	Min Site Sep
1	8 Chans	>500 kHz
2	7 Chans	>500 kHz
3	7 Chans	>500 kHz
4	7 Chans	>500 kHz
5	7 Chans	>500 kHz

FDMA: 7-8 Voice Paths/Site

36 Total

TDMA: 14-16 Voice Paths/Site

72 Total

6.25 kHz FDMA Multicast Cellular

Block				
1	1	5	2	6
2	2	6	3	7
3	3	7	4	1
4	4	1	5	2
5	5	2	6	3
6	6	3	7	4
7	7	4	1	5
8	1	5	2	6
9	2	6	3	7
10	3	7	4	1
11	4	1	5	2
12	5	2	6	3
13	6	3	7	4
14	7	4	1	5
15	1	5	2	6
16	2	6	3	7
17	3	7	4	1
18	4	1	5	2

Site	#	Min Site Sep
1	11 Chans	>225 kHz
2	11 Chans	>225 kHz
3	10 Chans	>225 kHz
4	10 Chans	>225 kHz
5	10 Chans	>225 kHz
6	10 Chans	>225 kHz
7	10 Chans	>225 kHz

10-11 Voice Paths/Site

72 Total

12.5 kHz FDMA/TDMA Multicast Cellular

Block		
1	1	5
2	2	6
3	3	7
4	4	1
5	5	2
6	6	3
7	7	4
8	1	5
9	2	6
10	3	7
11	4	1
12	5	2
13	6	3
14	7	4
15	1	5
16	2	6
17	3	7
18	4	1

Site	#	Min Site Sep
1	6 Chans	>1MHz
2	5 Chans	>1MHz
3	5 Chans	>1MHz
4	5 Chans	>1MHz
5	5 Chans	>1MHz
6	5 Chans	>1MHz
7	5 Chans	>1MHz

FDMA: 5-6 Voice Paths/Site

36 Total

TDMA: 10-12 Voice Paths/Site

72 Total

Single-Zone
12.5 and 25 kHz Simulcast

Block	
1	1
2	1
3	1
4	1
5	1
6	1
7	1
8	1
9	1
10	1
11	1
12	1
13	1
14	1
15	1
16	1
17	1
18	1

Site	#	Min Site Sep
1	18 Chans	250 kHz

FDMA: 18 Voice Paths
TDMA: 36-72 Voice Paths

Multi-Zone Simulcast

Block	
1	1
2	1
3	1
4	1
5	1
6	1
7	1
8	1
9	1
10	2
11	2
12	2
13	2
14	2
15	2
16	2
17	2
18	2

Site	#	Min Site Sep
1	9 Chans	250 kHz
2	9 Chans	

FDMA: 9 Voice Paths/Site

18 Total

TDMA: 18-36 Voice Paths/Site

36-72 Total

Block	
1	1
2	1
3	1
4	1
5	1
6	1
7	2
8	2
9	2
10	2
11	2
12	2
13	3
14	3
15	3
16	3
17	3
18	3

Site	#	Min Site Sep
1	6 Chans	250 kHz
2	6 Chans	250 kHz
3	6 Chans	250 kHz

FDMA: 6 Voice Paths/Site

18 Total

TDMA:12-24 Voice Paths/Site

36-72 Total

Block		
1	1	2
2	2	1
3	1	2
4	2	1
5	1	2
6	2	1
7	1	2
8	2	1
9	1	2
10	2	1
11	1	2
12	2	1
13	1	2
14	2	1
15	1	2
16	2	1
17	1	2
18	2	1

Site	#	Min Site Sep
1	18 Chans	250 kHz
2	18 Chans	250 kHz

FDMA: 18 Voice Paths/Site

36 Total

TDMA: 36 Voice Paths/Site

72 Total

Block		
1	1	3
2	2	1
3	3	2
4	1	3
5	2	1
6	3	2
7	1	3
8	2	1
9	3	2
10	1	3
11	2	1
12	3	2
13	1	3
14	2	1
15	3	2
16	1	3
17	2	1
18	3	2

Site	#	Min Site Sep
1	12 Chans	>500 kHz
2	12 Chans	>500 kHz
3	12 Chans	>500 kHz

FDMA: 12 Voice Paths/Site

36 Total

TDMA: 24 Voice Paths/Site

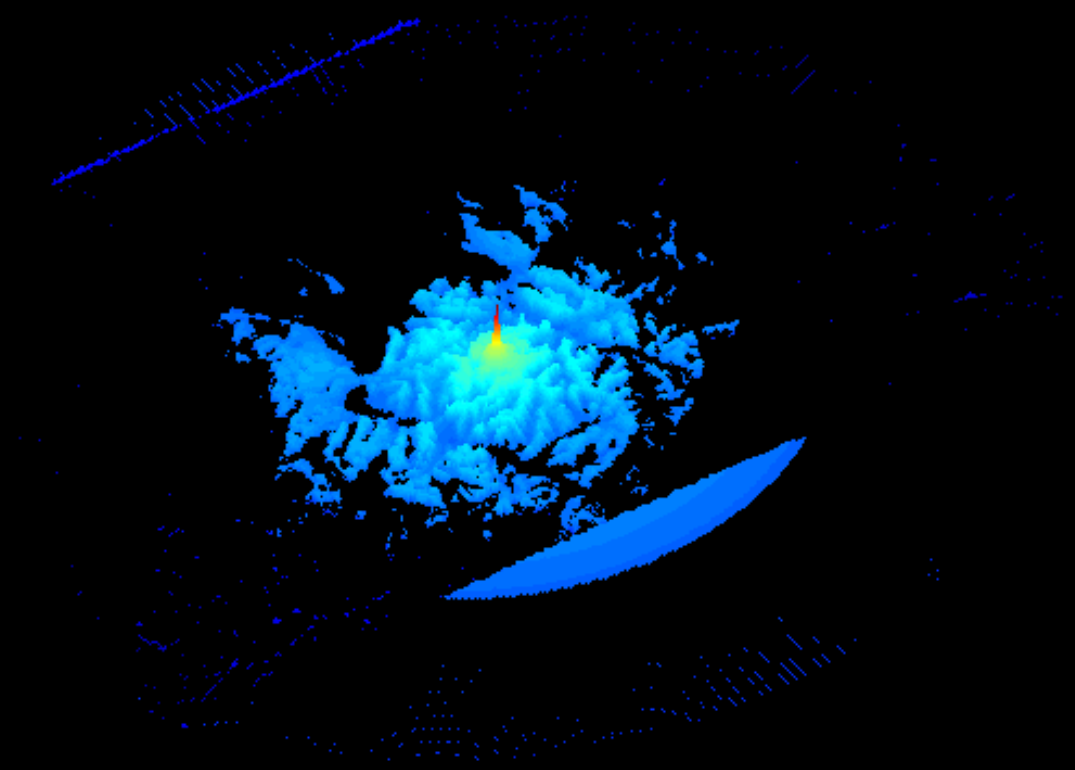
72 Total

Summary of Example:

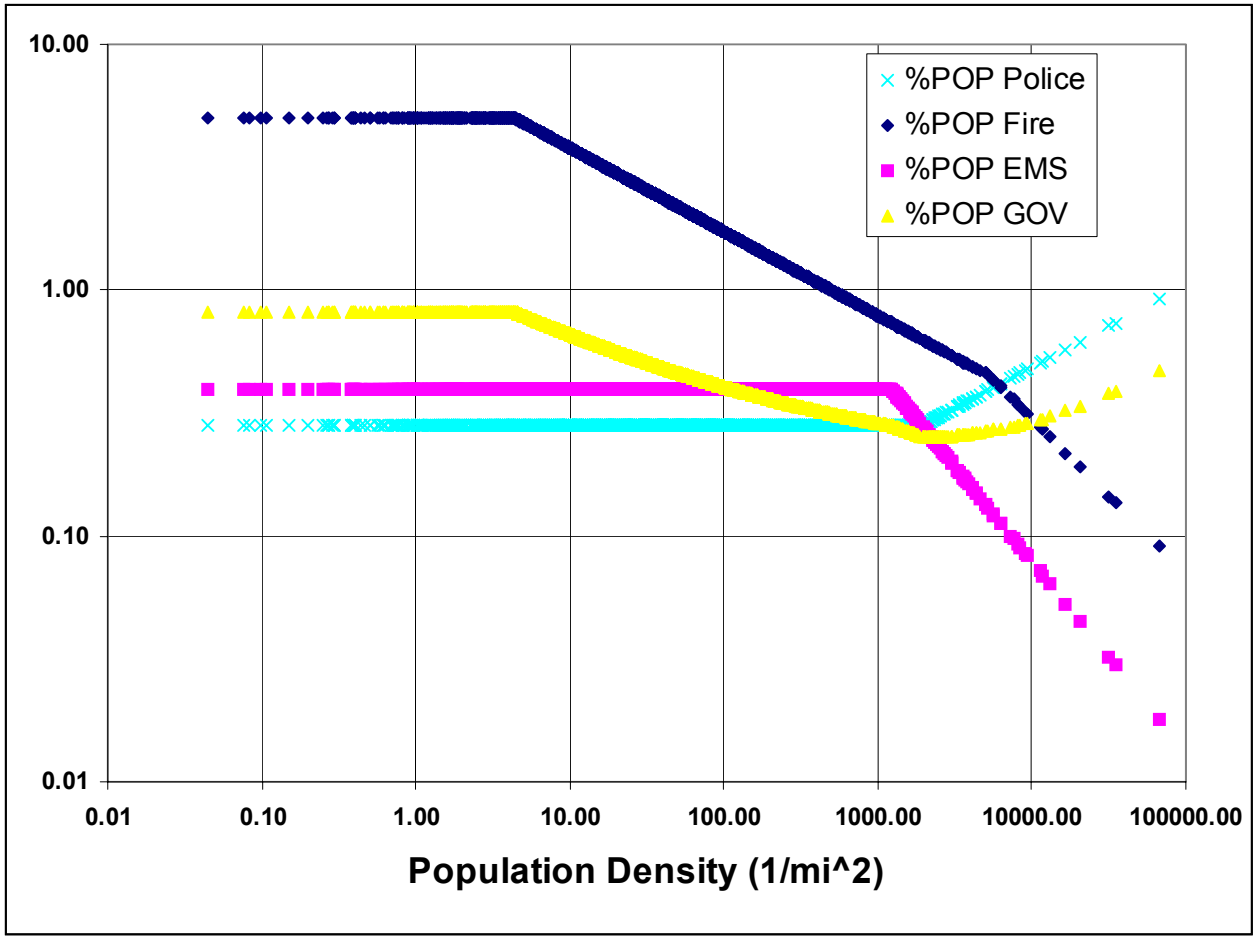
Possible Utilization of Allotment Pool of 18-25 kHz Blocks

	Technology	Sites	Zones	Min Voice Paths/Site	Total Voice Paths	Min Site Separation (kHz)	Full Efficiency Achived?	Min Voice Paths/Site >12?
P25	FDMA - 6.25 kHz Multicast	5	1	14	72	225	Yes	Yes
	FDMA - 12.5 kHz Multicast	5	1	7	36	500		
	FDMA - 12.5 kHz Single Zone Simulcast	5	1	18	18	275		Yes
	FDMA - 12.5 kHz Dual-Zone Simulcast	5	2	18	36	250		Yes
	FDMA - 12.5 kHz Tri-Zone Simulcast	22	3	12	36	500		Yes
	FDMA - 6.25 kHz Multicast Cellular	22	1	10	72	225	Yes	
	FDMA - 12.5 kHz Multicast Cellular	22	1	5	36	1,000		
	TDMA - 12.5 kHz, 2 Slot, Multicast	5	1	14	72	500	Yes	Yes
	TDMA - 12.5 kHz, 2 Slot, Multicast Cellular	22	1	10	72	1,000	Yes	
	TDMA - 12.5 kHz, 2 Slot, Single Zone Simulcast	5	1	36	36	250		Yes
	TDMA - 12.5 kHz, 2 Slot, Dual-Zone Simulcast	5	2	36	72	250	Yes	Yes
P25	TDMA - 12.5 kHz, 2 Slot, Tri-Zone Simulcast	22	3	24	72	500	Yes	Yes
OpenSky	TDMA - 25 kHz, 2 Slot, Multicast	5	1	6	36	1,000		
OpenSky	TDMA - 25 kHz, 2 Slot, Multicast Cellular	22	1	4	36	1,500		
	TDMA - 25 kHz, 2 Slot, Single Zone Simulcast	5	1	36	36	250		Yes
	TDMA - 25 kHz, 2 Slot, Dual-Zone Simulcast	5	2	18	36	250		Yes
	TDMA - 25 kHz, 2 Slot, Tri-Zone Simulcast	22	3	12	36	250		Yes
TETRA	TDMA - 25 kHz, 4 Slot, Multicast	5	1	12	72	1,000	Yes	Yes
TETRA	TDMA - 25 kHz, 4 Slot, Multicast Cellular	22	1	8	72	1,500	Yes	
	TDMA - 25 kHz, 4 Slot, Single Zone Simulcast	5	1	72	72	250	Yes	Yes
	TDMA - 25 kHz, 4 Slot, Dual-Zone Simulcast	5	2	36	72	250	Yes	Yes
	TDMA - 25 kHz, 4 Slot, Tri-Zone Simulcast	22	3	18	72	250	Yes	Yes

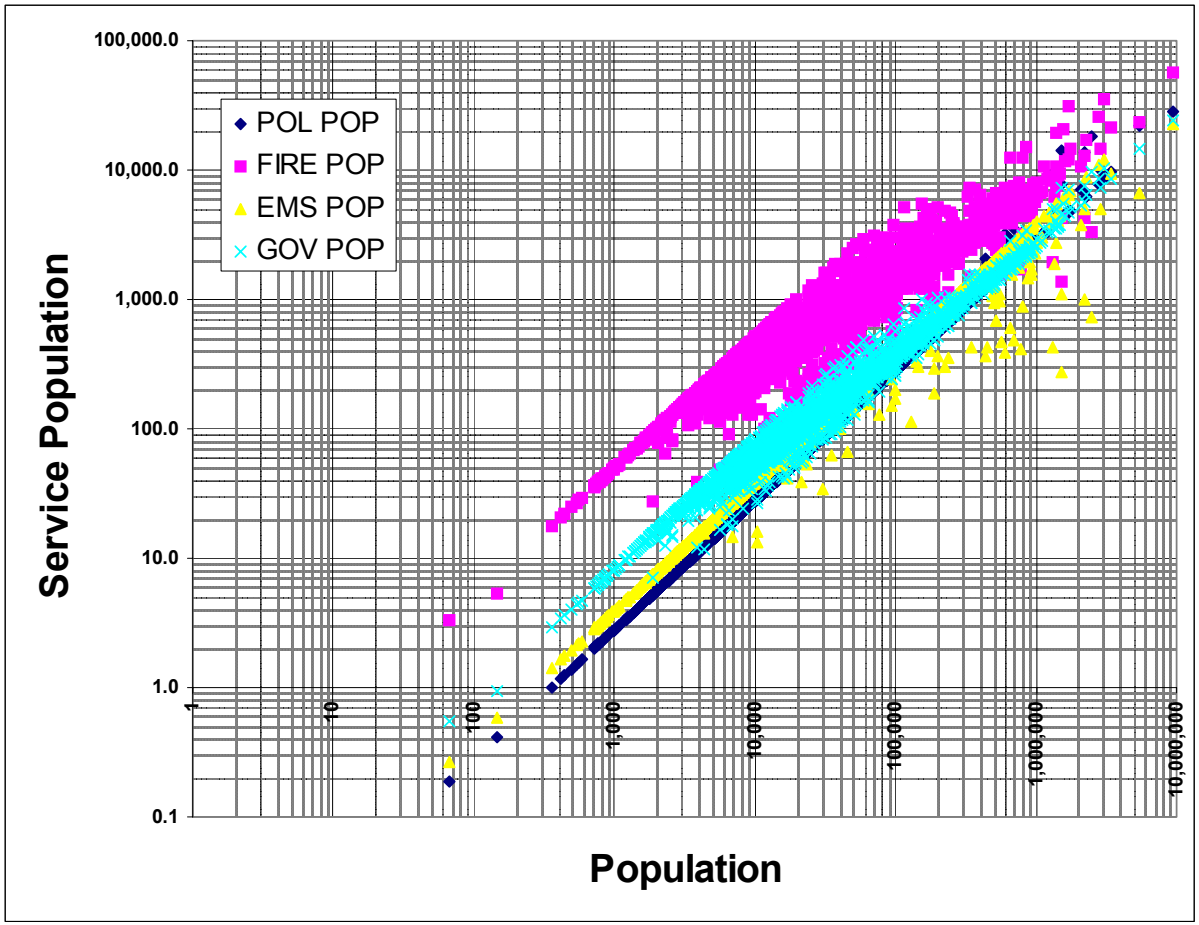
Final Methodology and Models



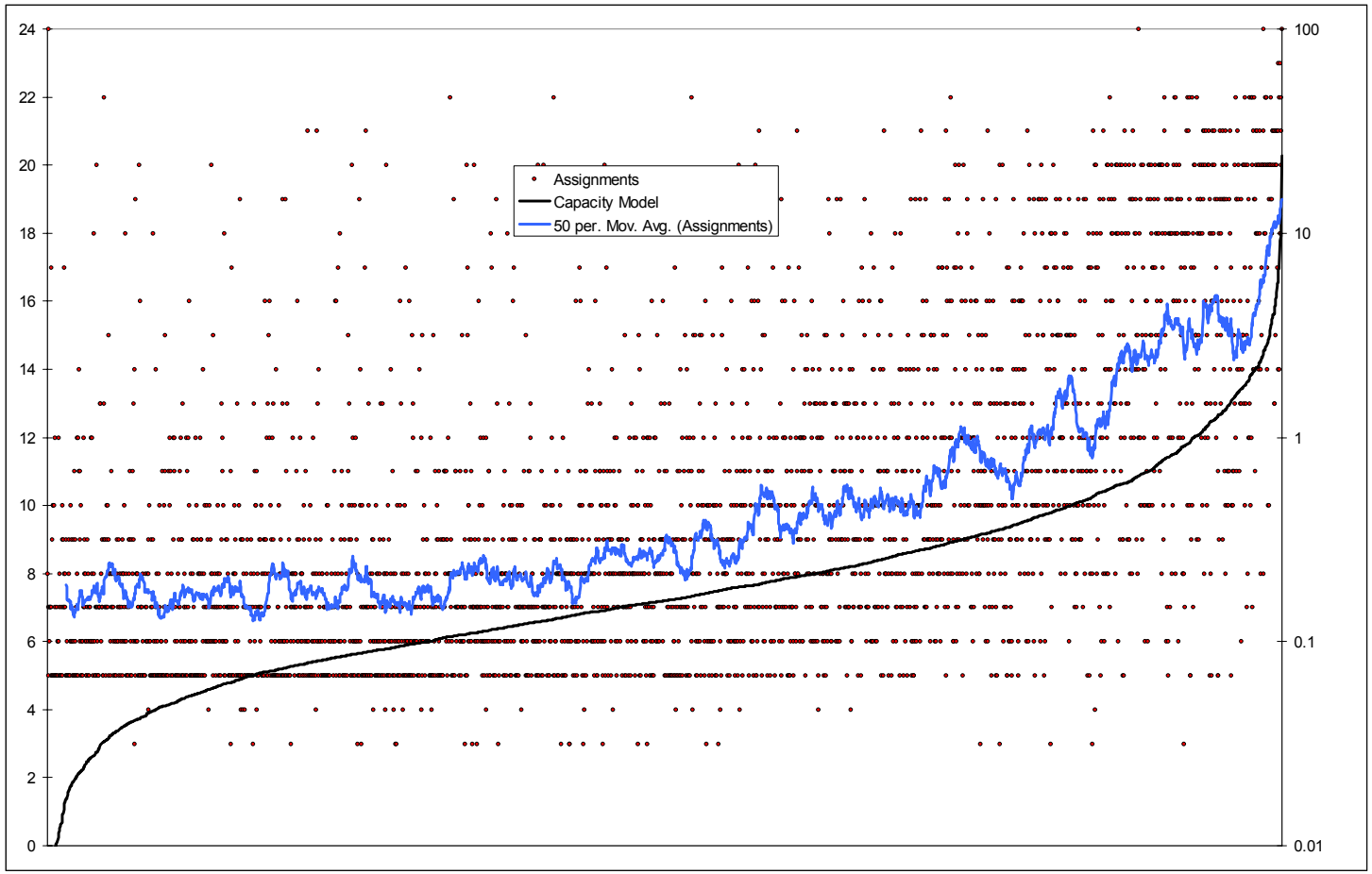
Final Service Population Models vs. Population Density



Final Service Population Models vs. Population



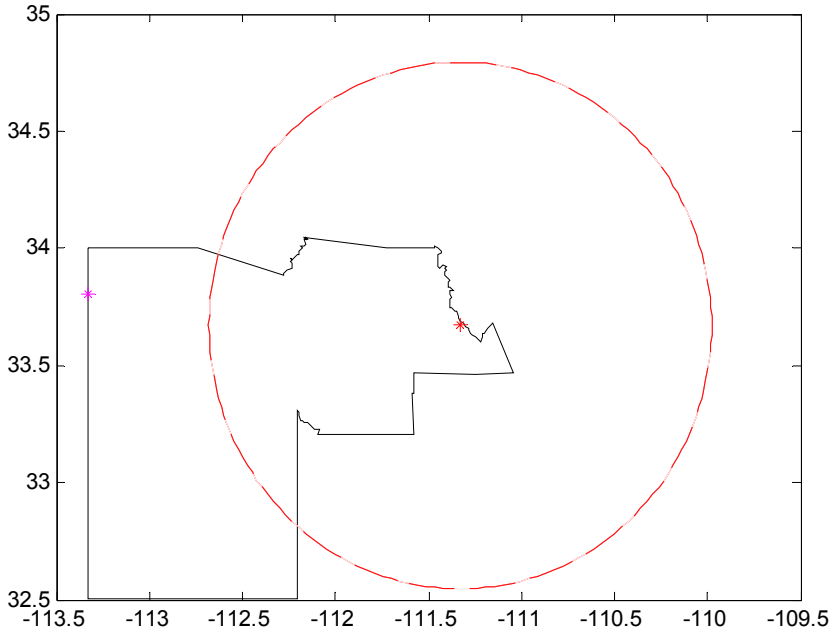
National Capacity Model and Pool Size Results



Top 30 Capacity Requirements

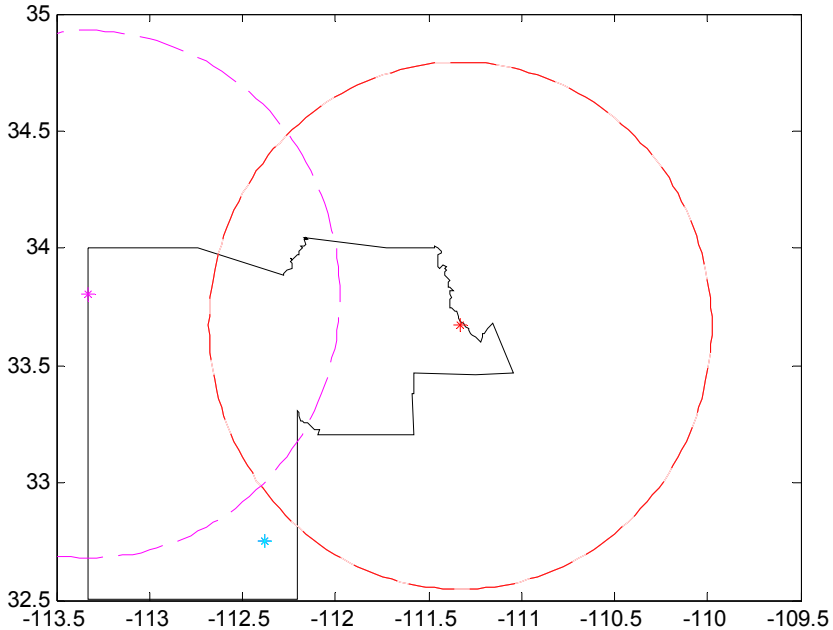
#	County	State	#	County	State
1	Los Angeles County	CA	16	FL	Broward County
2	Maricopa County	AZ	17	NY	Queens County
3	Cook County	IL	18	AZ	Pima County
4	San Diego County	CA	19	TX	Bexar County
5	San Bernardino County	CA	20	NY	New York County
6	Harris County	TX	21	NY	Suffolk County
7	Miami-Dade County	FL	22	FL	Palm Beach County
8	Riverside County	CA	23	TX	Tarrant County
9	Orange County	CA	24	MA	Middlesex County
10	Clark County	NV	25	CA	Fresno County
11	King County	WA	26	CA	Alameda County
12	Kings County	NY	27	CA	Sacramento County
13	Dallas County	TX	28	CA	Kern County
14	Santa Clara County	CA	29	MI	Oakland County
15	Wayne County	MI	30	PA	Allegheny County

Transmitter Location Selection and Contour Generation



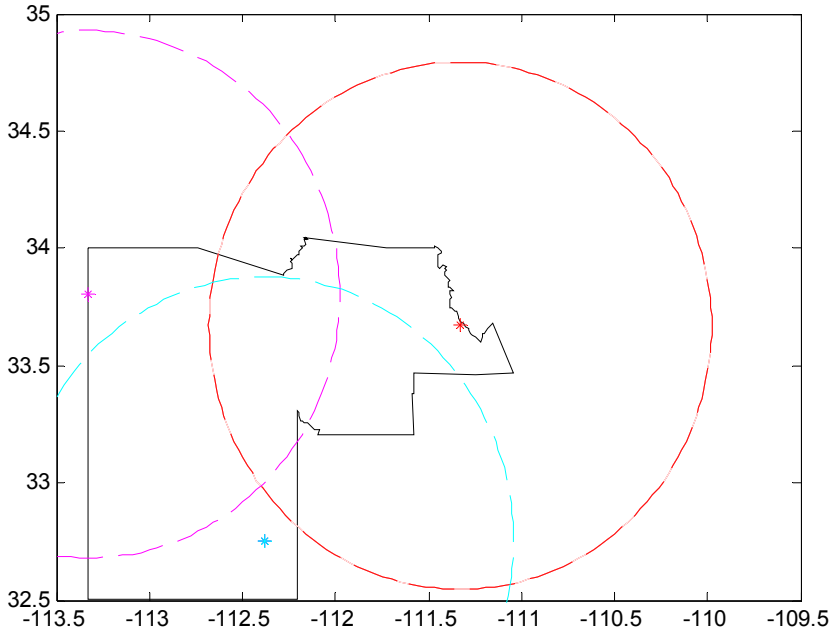
The Highest Point (red) in Maricopa County, AZ

Transmitter Location Selection and Contour Generation



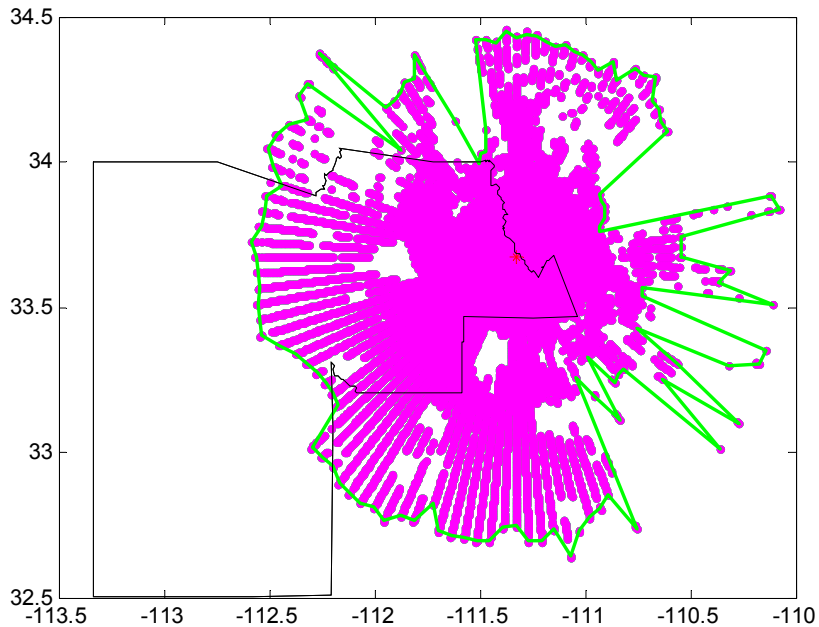
The Next Highest Point in Maricopa County, AZ (separated by 125 km)

Transmitter Location Selection and Contour Generation



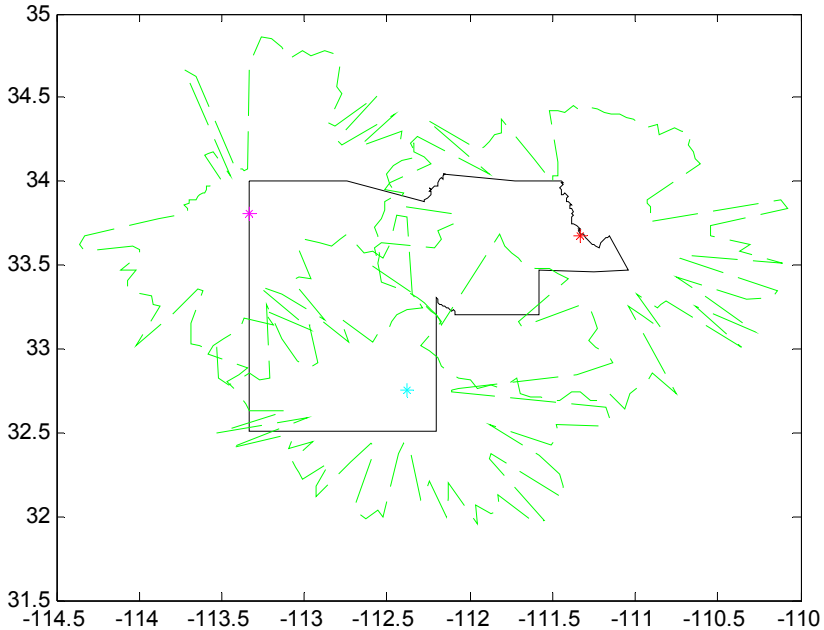
The Three Highest Points in Maricopa County, AZ (separated by 125 km)

Transmitter Location Selection and Contour Generation



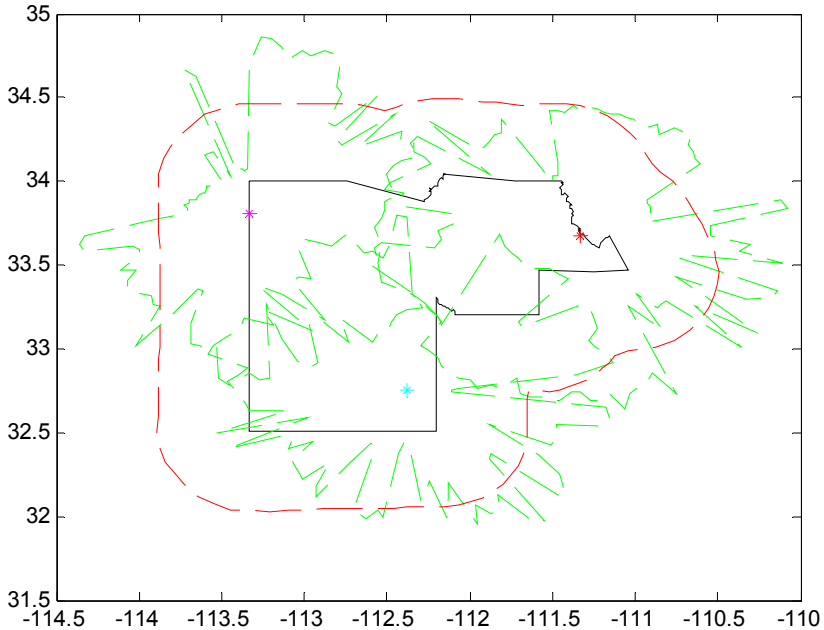
Closing the Interference Polygon for this Transmitter

Transmitter Location Selection and Contour Generation



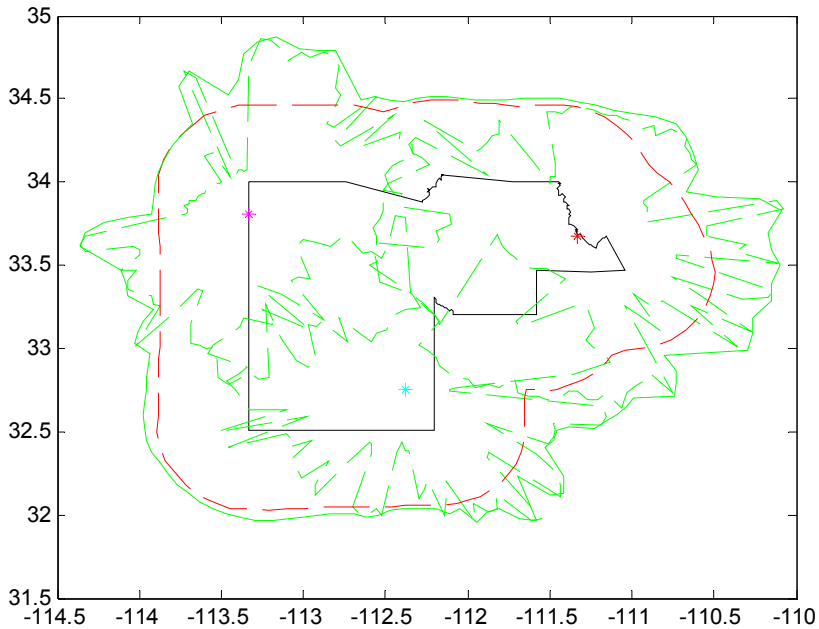
Interference Counters for the Three Representative Transmitters

Transmitter Location Selection and Contour Generation



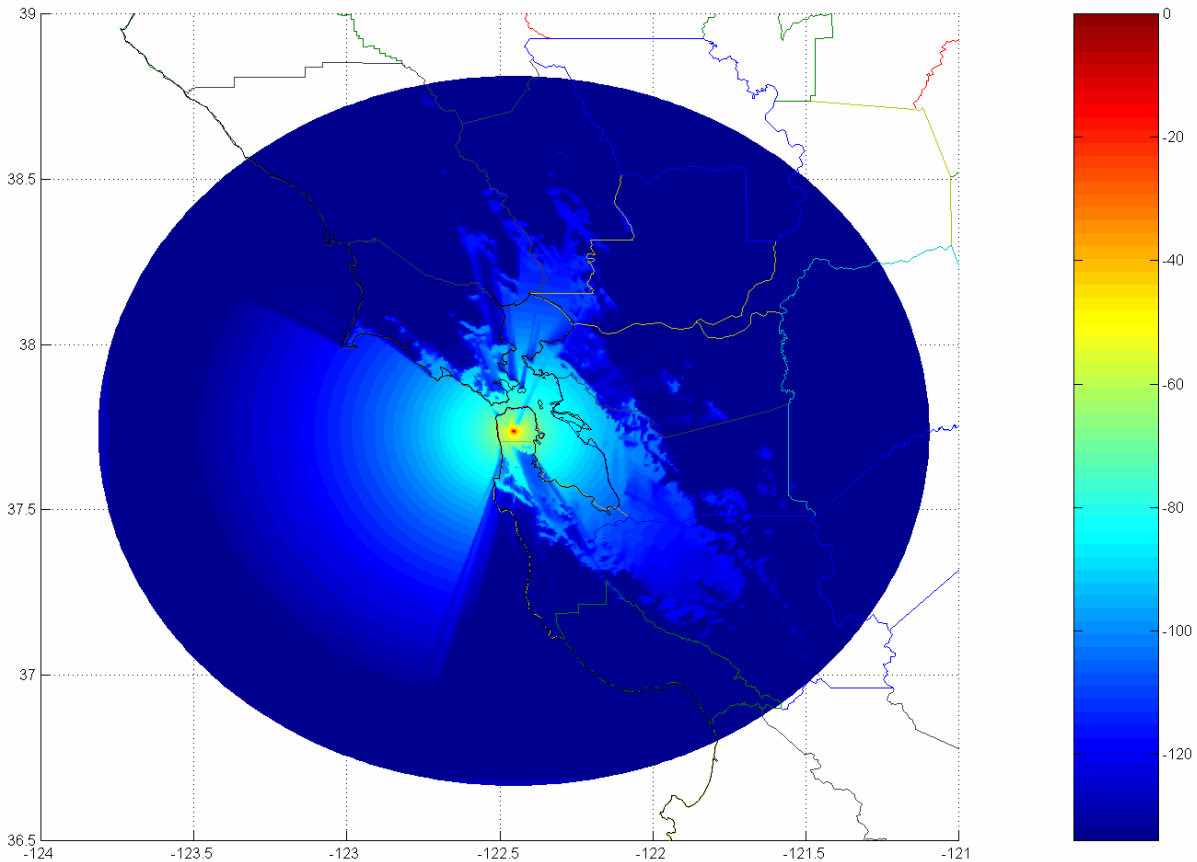
Interference Counters for the Representative Transmitters, and the 50-km Buffer

Transmitter Location Selection and Contour Generation

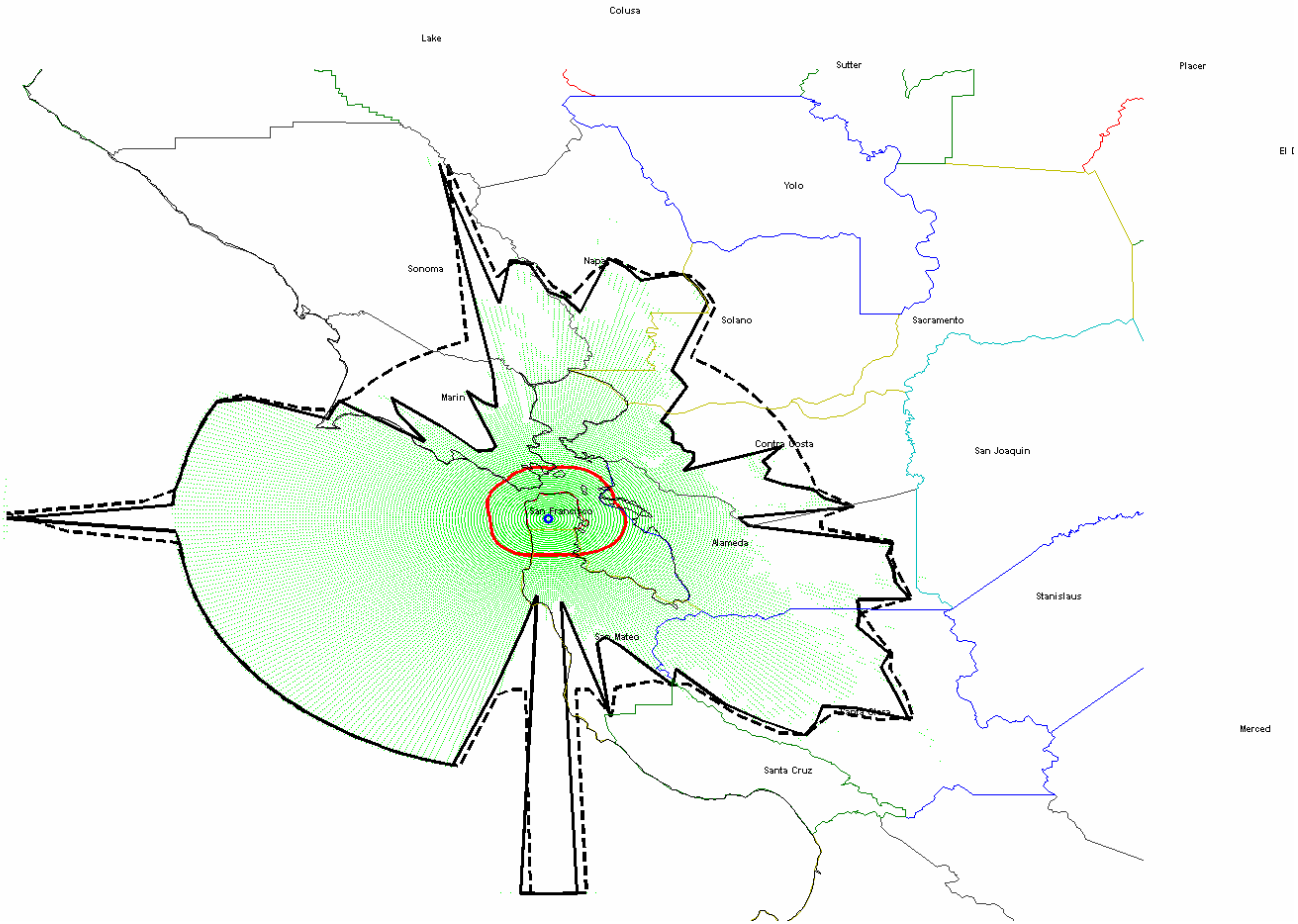


Final Contour (solid green) with its Constituent Parts (dotted green and red)

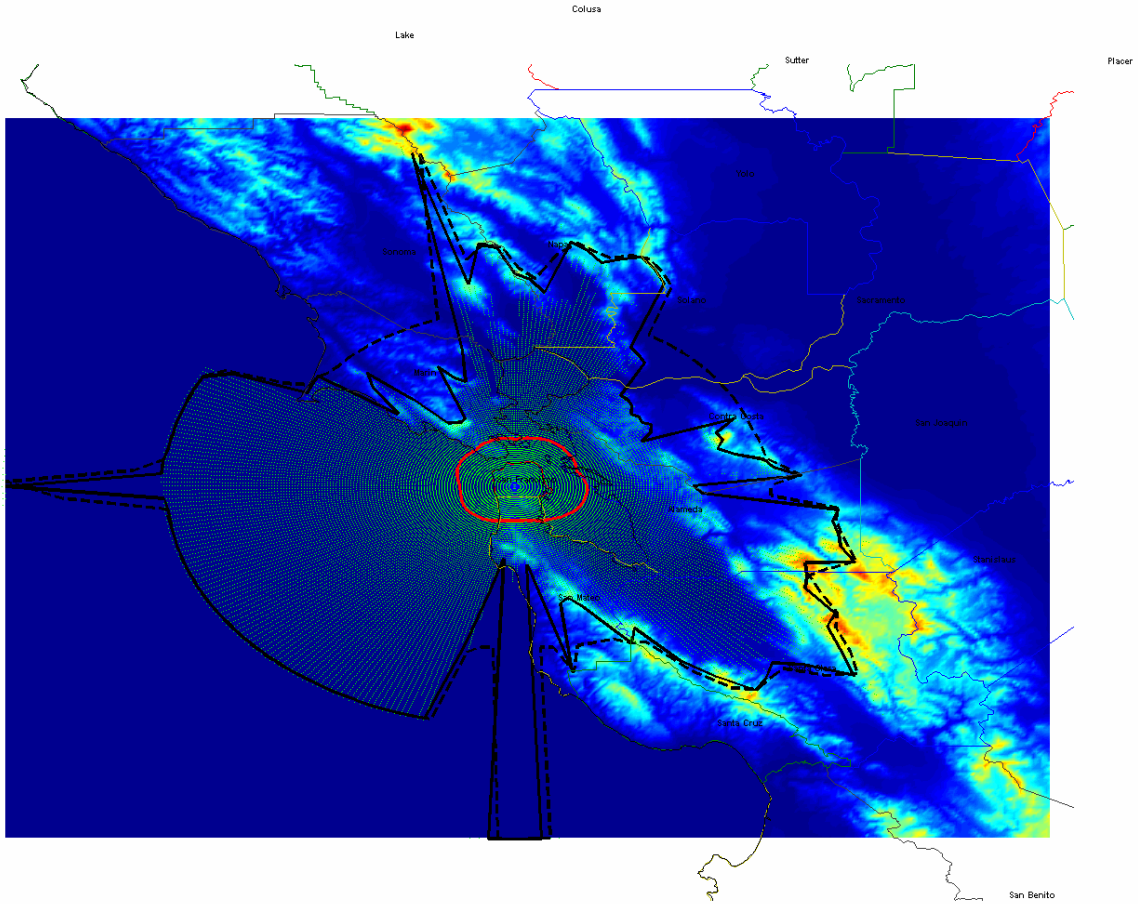
San Francisco County (CA), Propagation Model Levels (dBm)



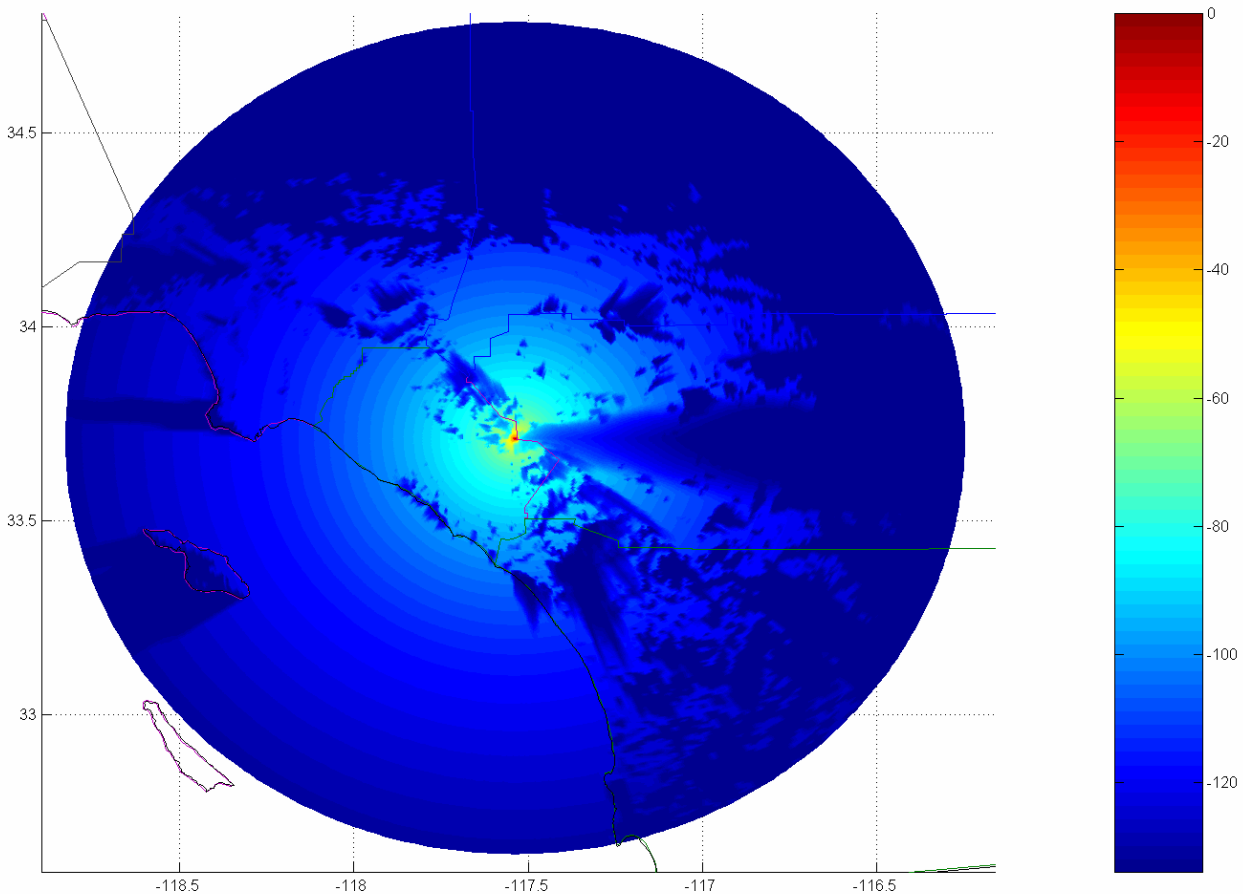
San Francisco County (CA), Propagation-Based Interference Contour and Buffer



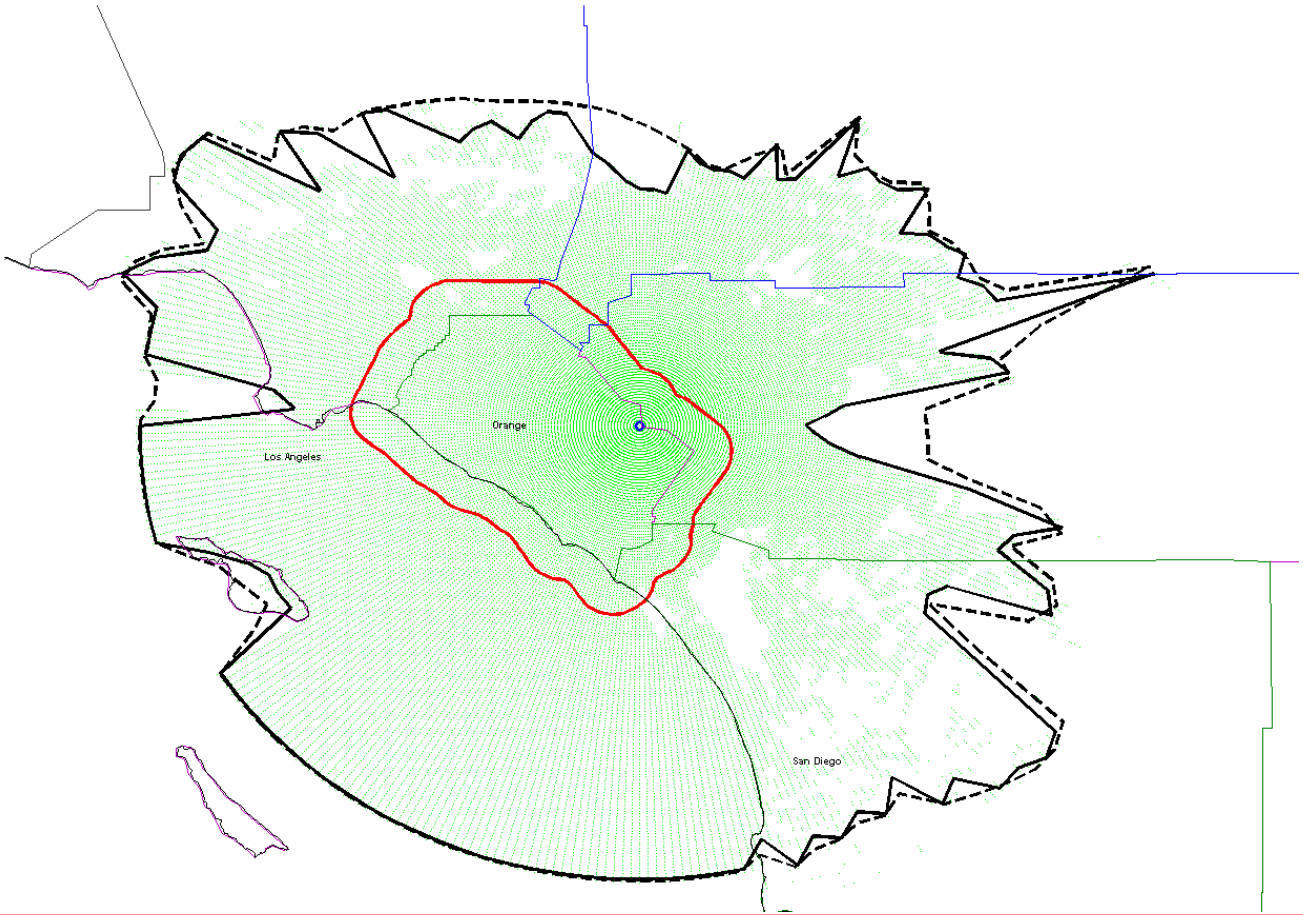
San Francisco County (CA), Interference Contours w/Terrain Underlay



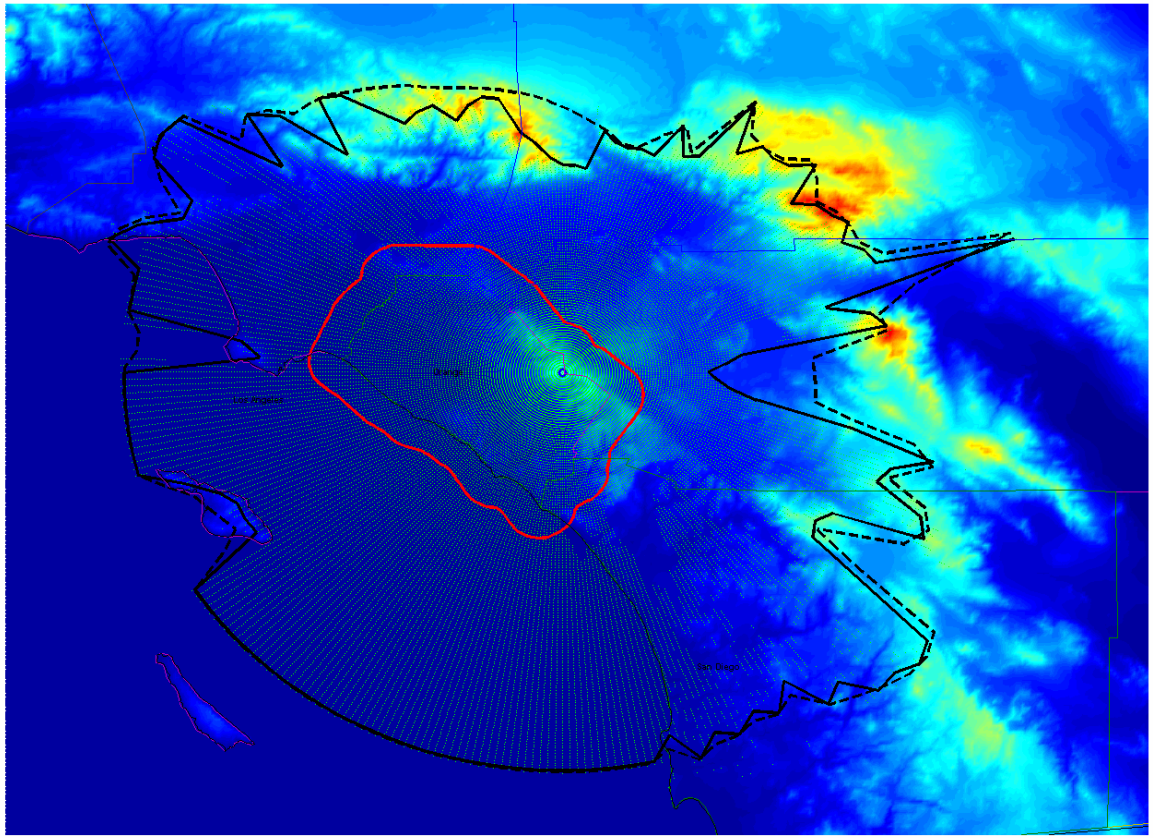
Orange County (CA), Propagation Model Levels (dBm)



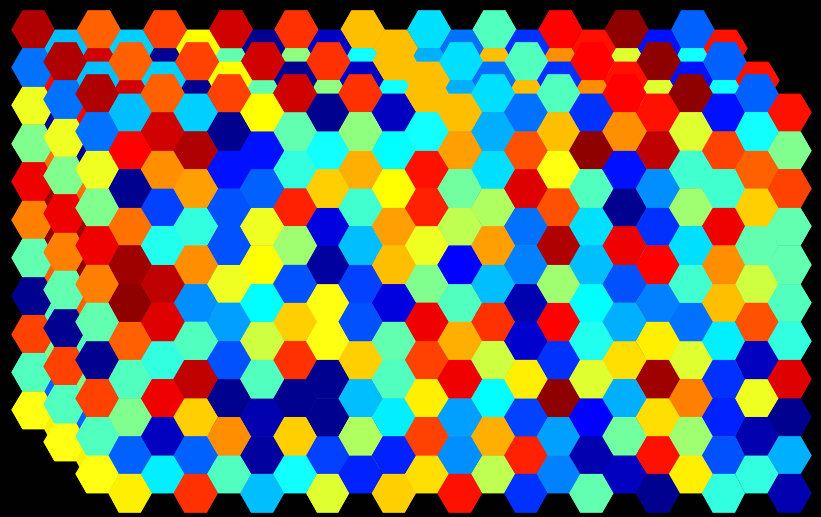
Orange County (CA), Propagation-Based Interference Contour and Buffer



Orange County (CA), Interference Contours w/Terrain Underlay

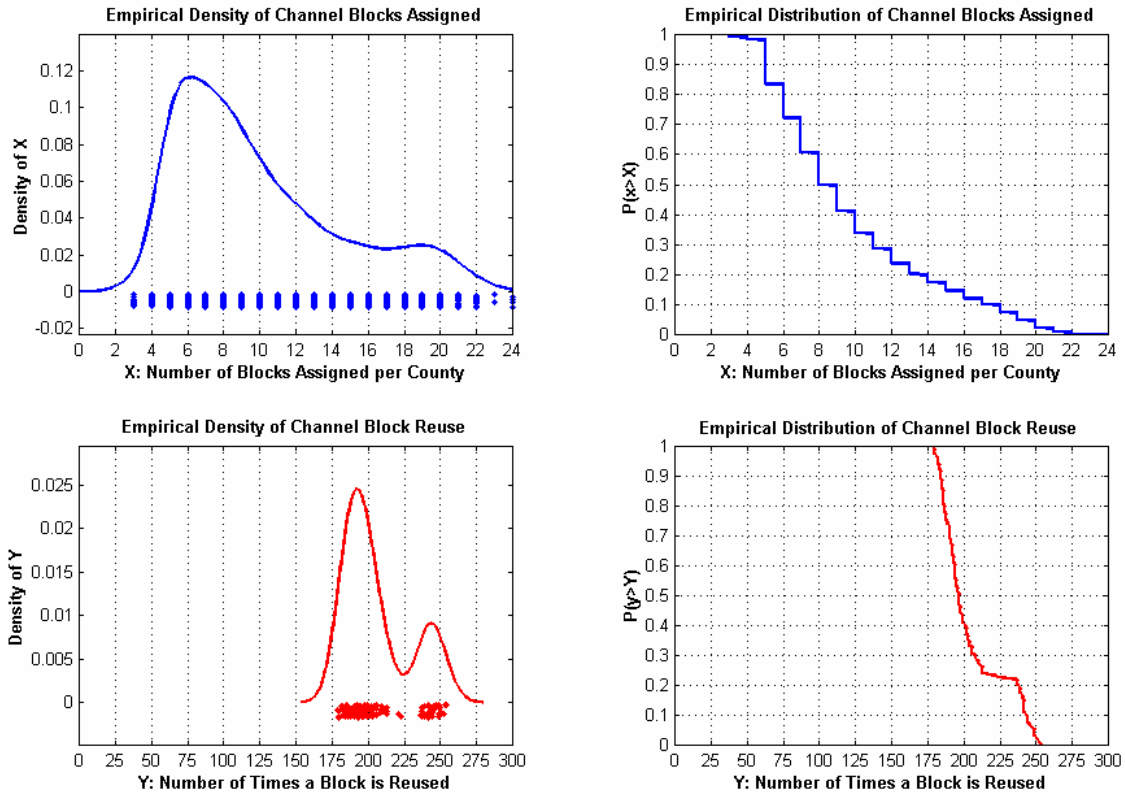


Reuse Characteristics

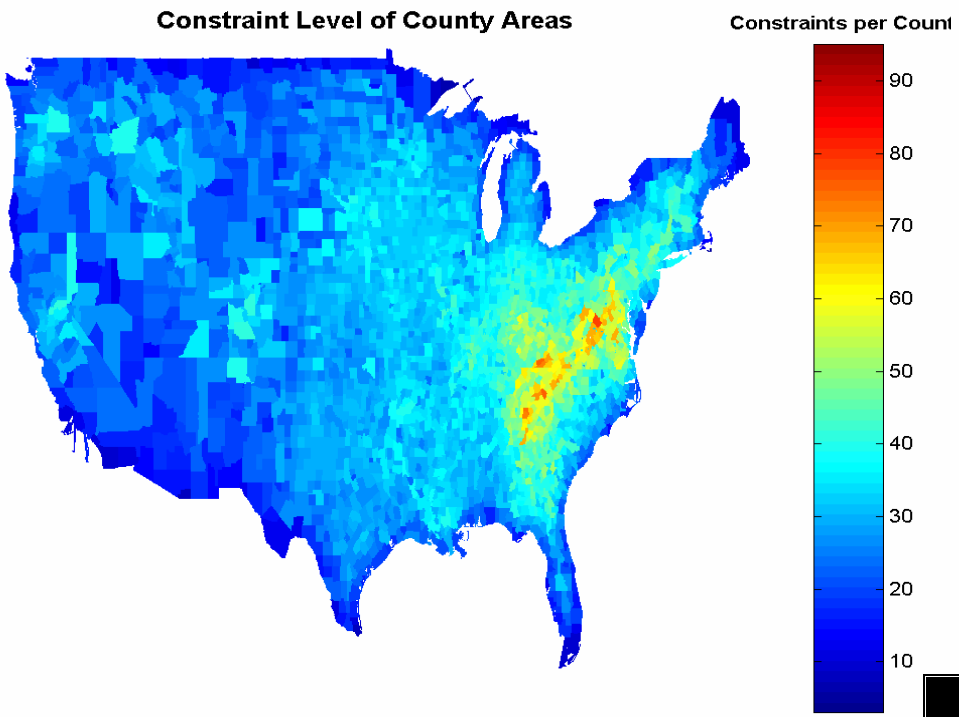


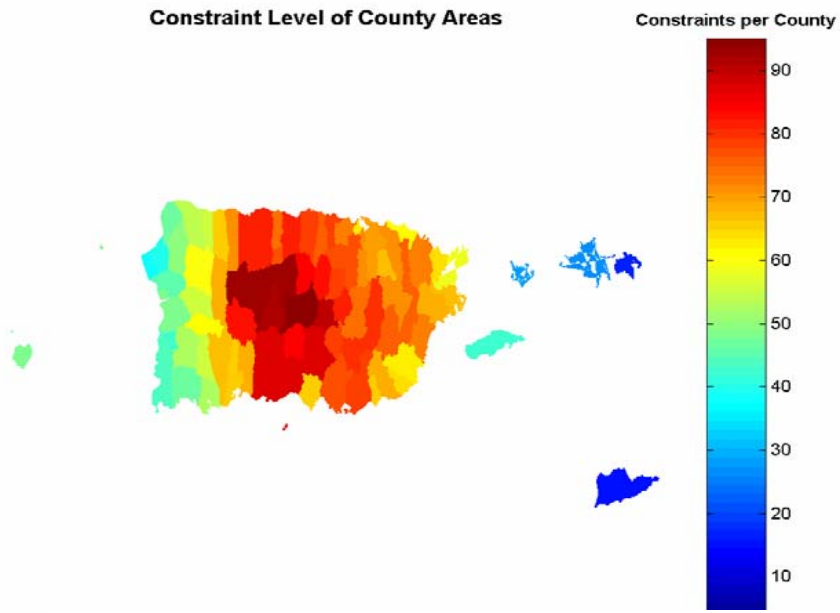
Results
-Statistics and Distributions

mean(sum(A')) = 9.8166
median(sum(A')) = 8
mean(sum(A)) = 205.45
median(sum(A)) = 197



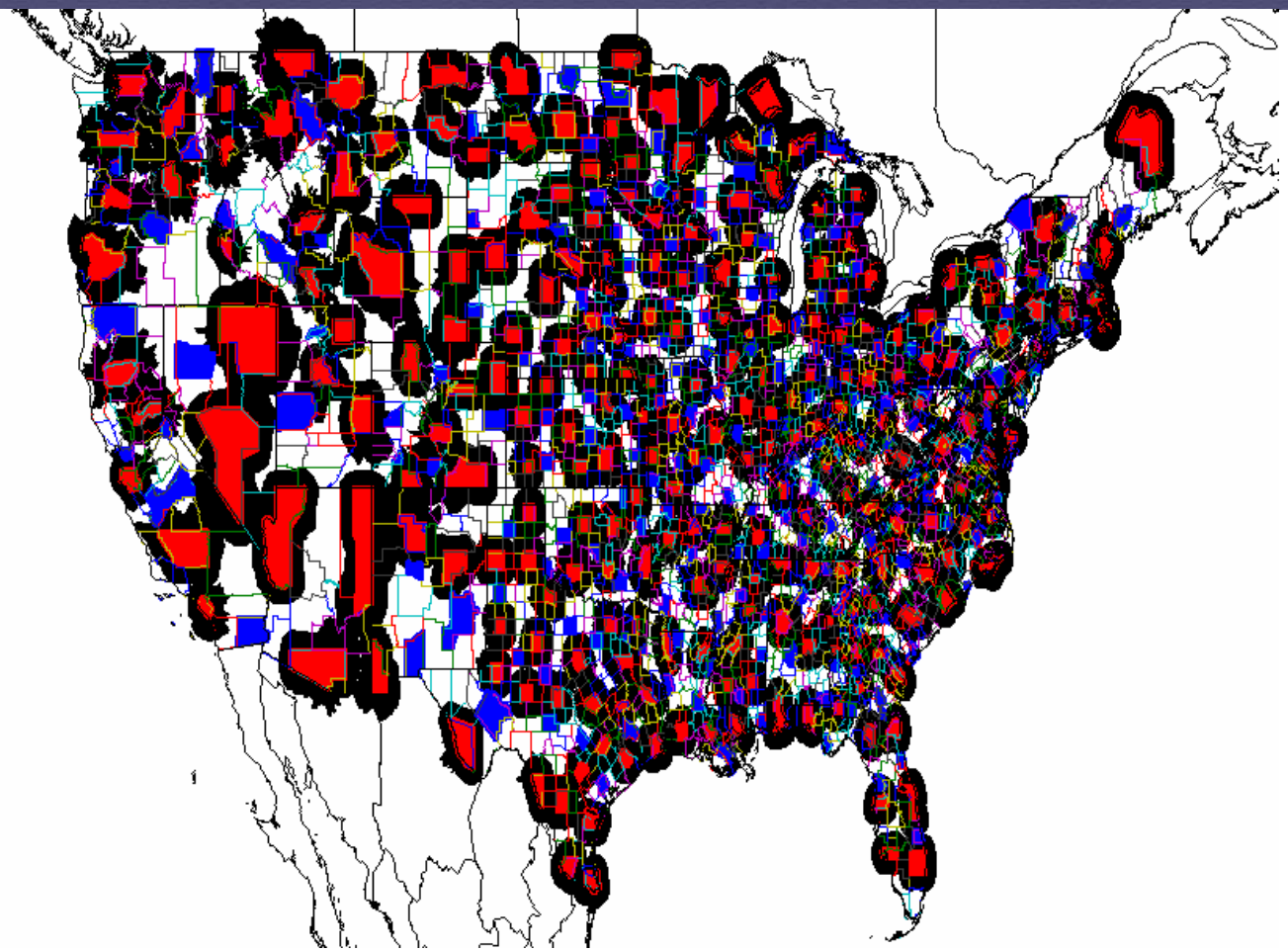
Overall Constraint Levels, and Minimum Map Coloring



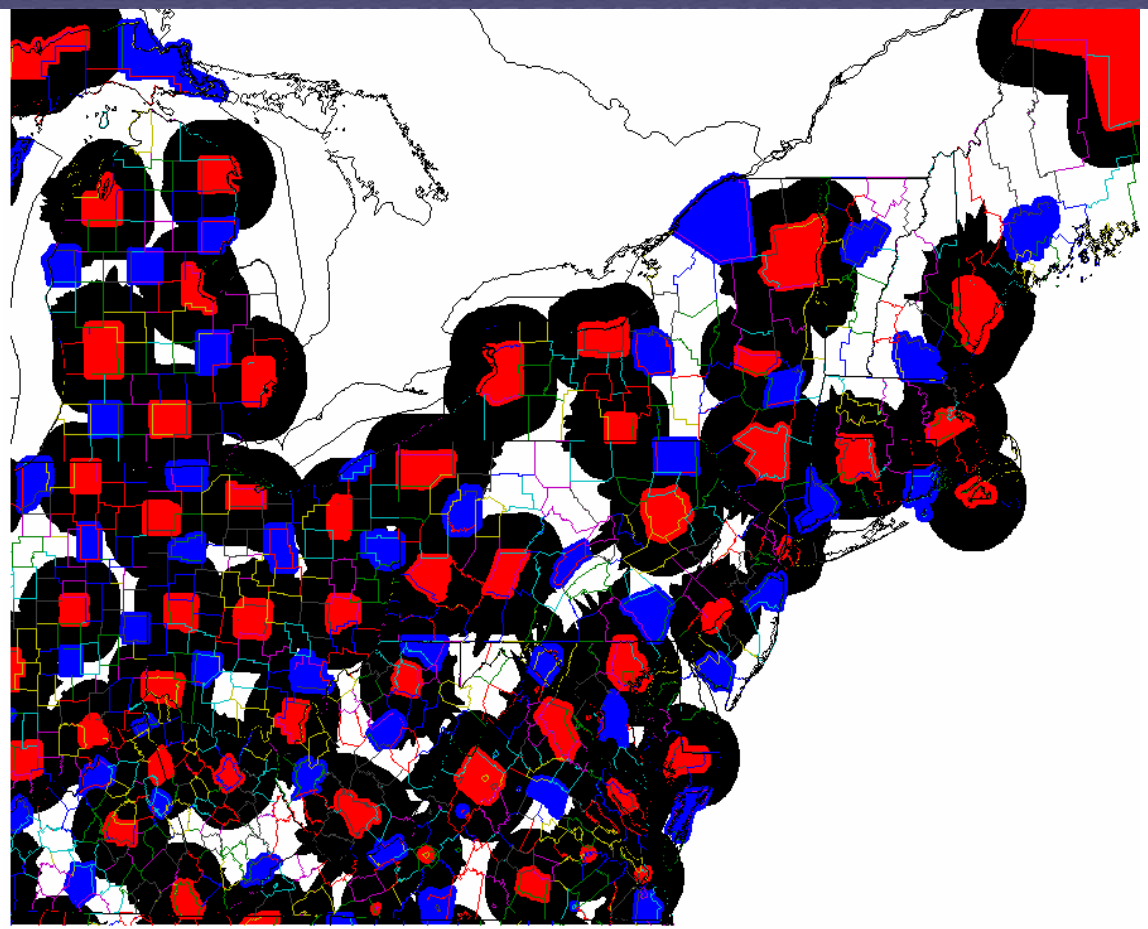


Region	Number of Sites	Number of Colors
Continental U. S.	3110	26
Puerto Rico and Virgin Islands	81	44
Alaska	27	5
Hawaii	5	3

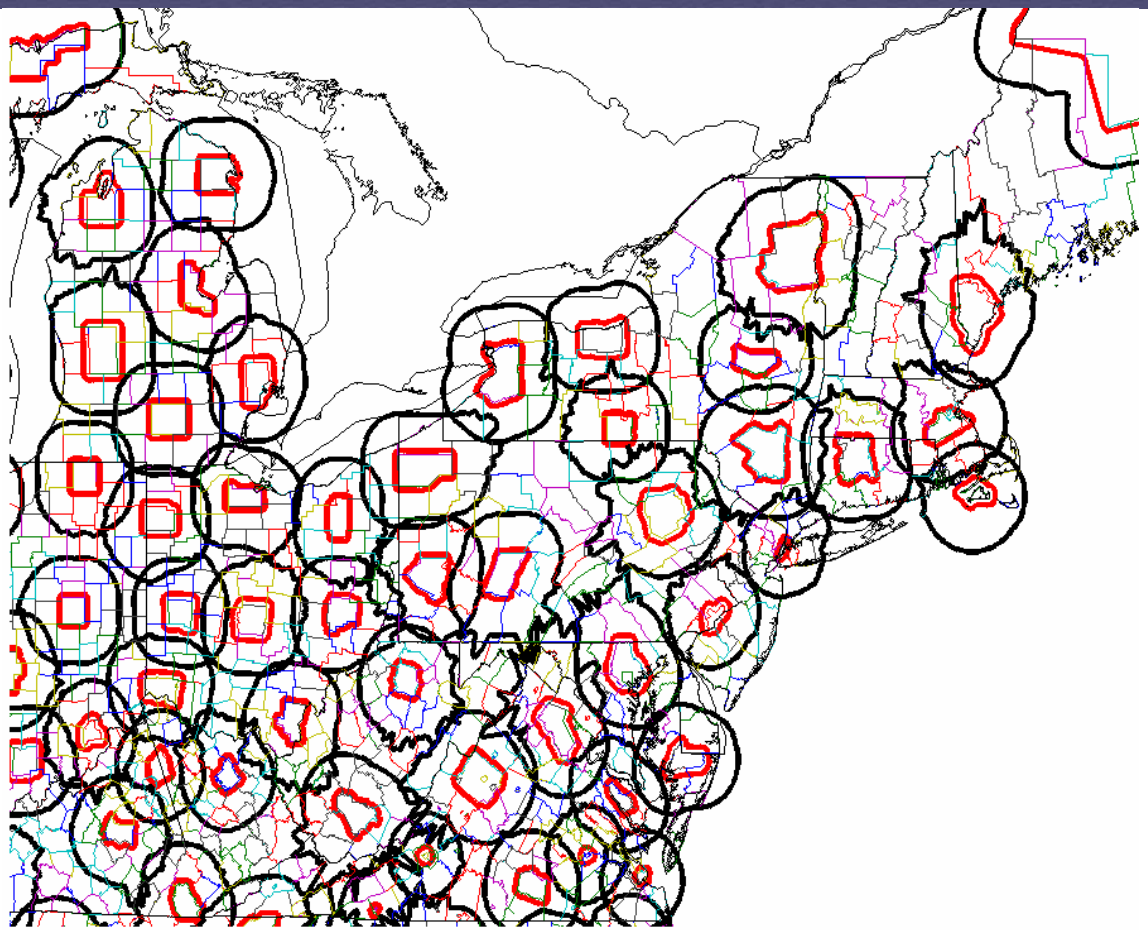
Example of Reuse, Channel Block 142



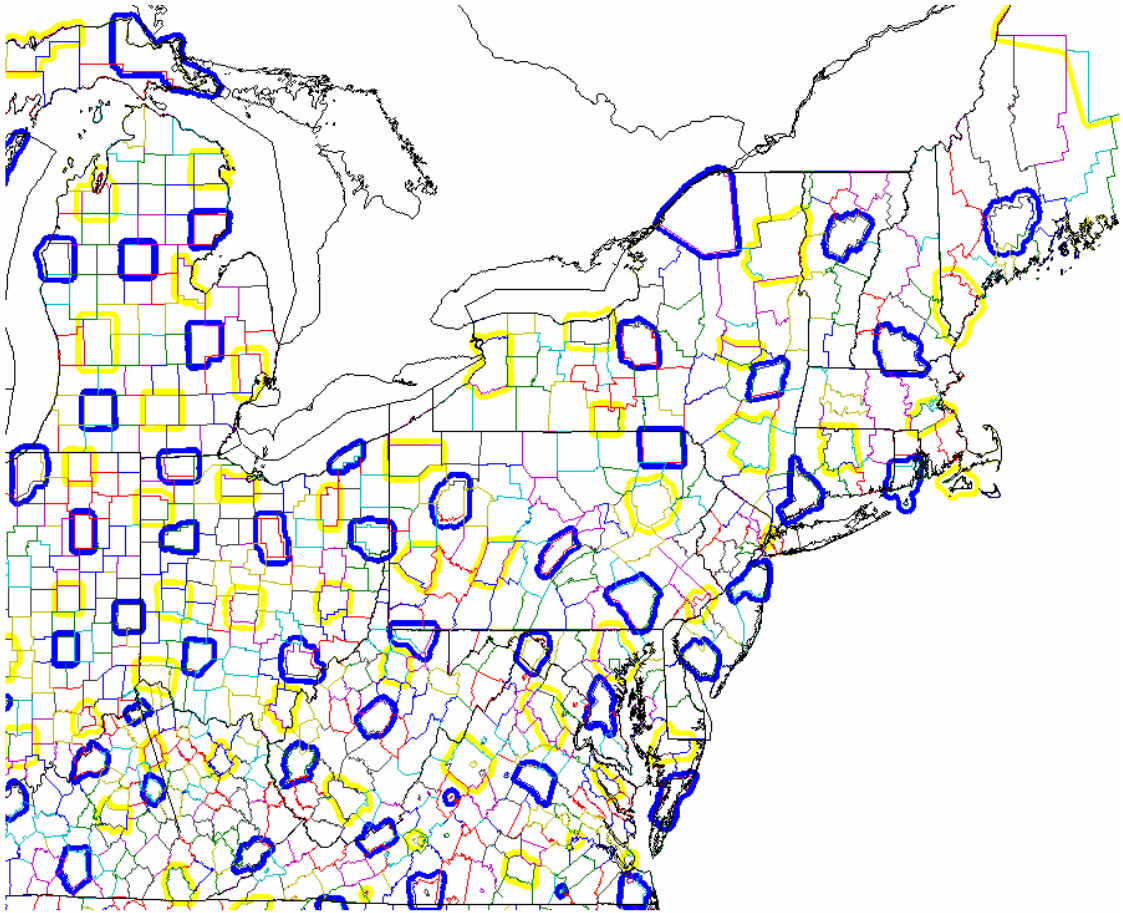
Example of Reuse - NE United States, Channel Block 142



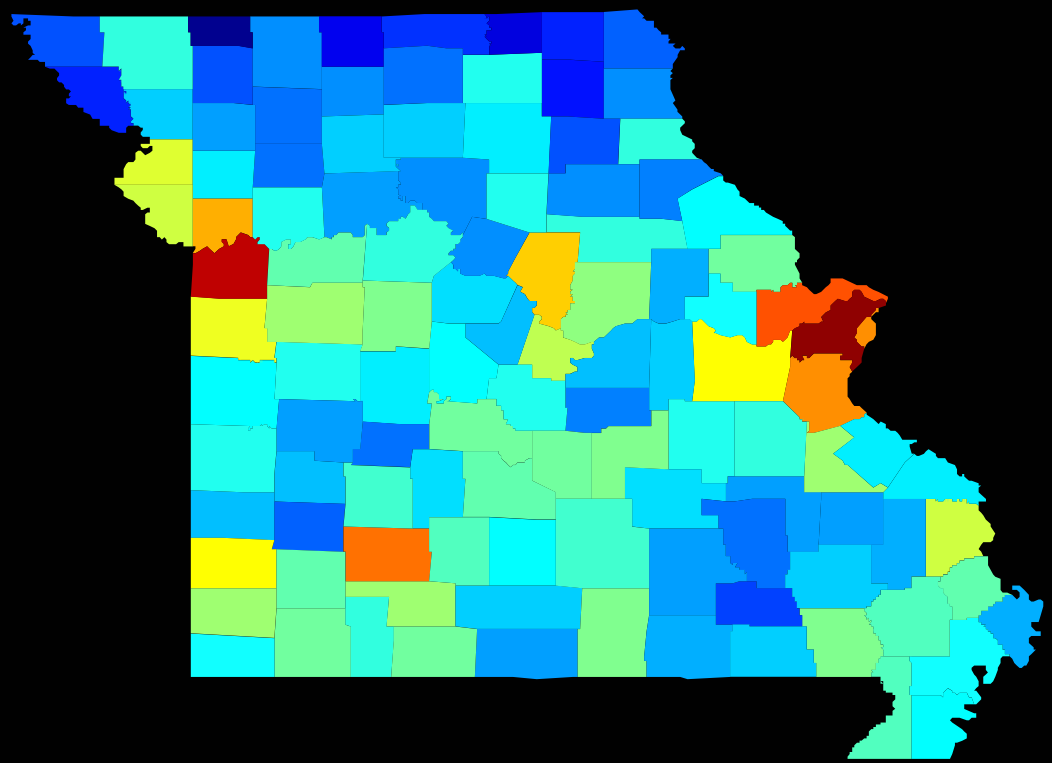
Example of Reuse - NE United States, Channel Block 142 (On-Channel Allotments)



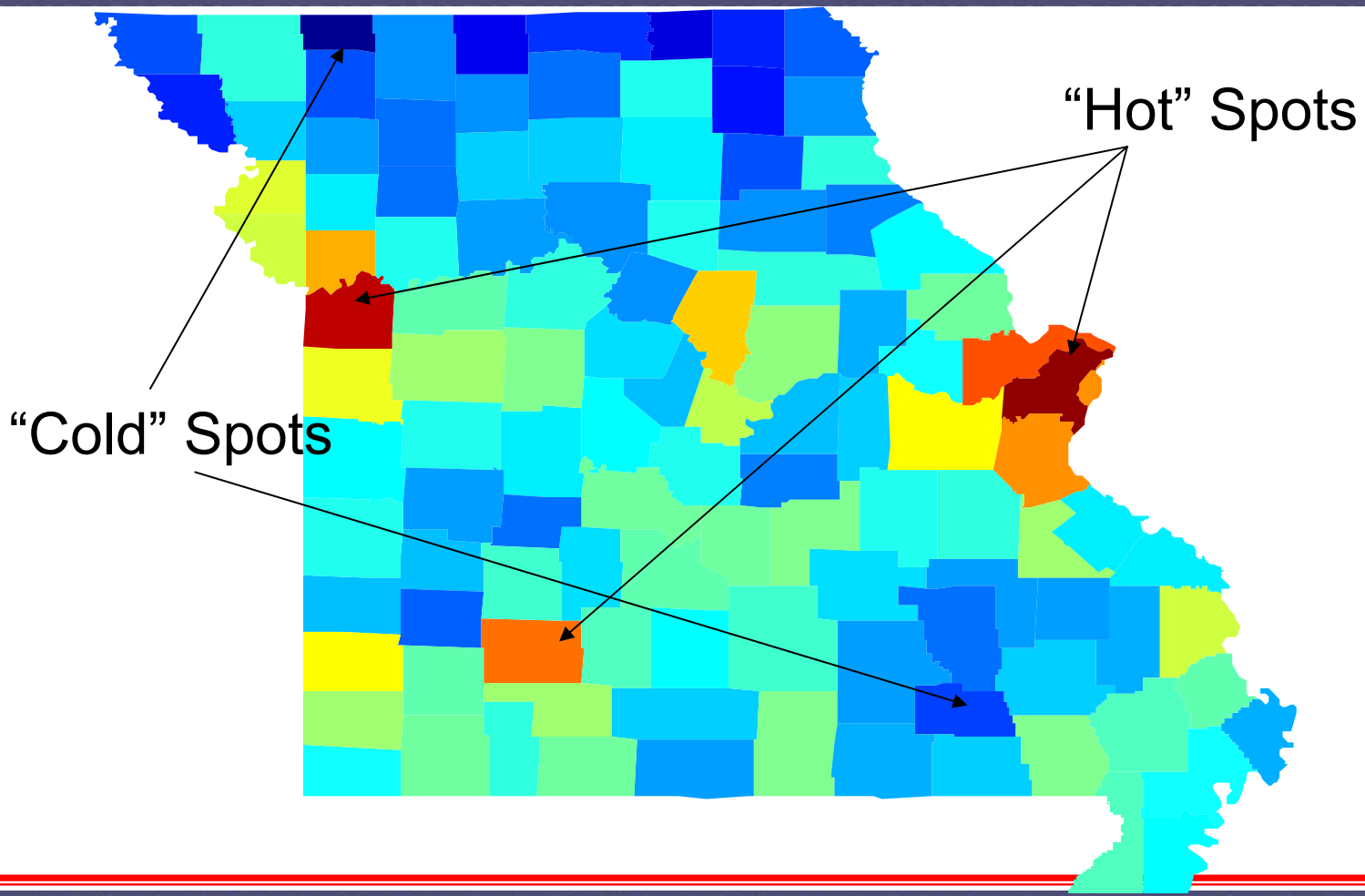
Example of Reuse - NE United States, Channel Block 142 (Adjacent Allotments)



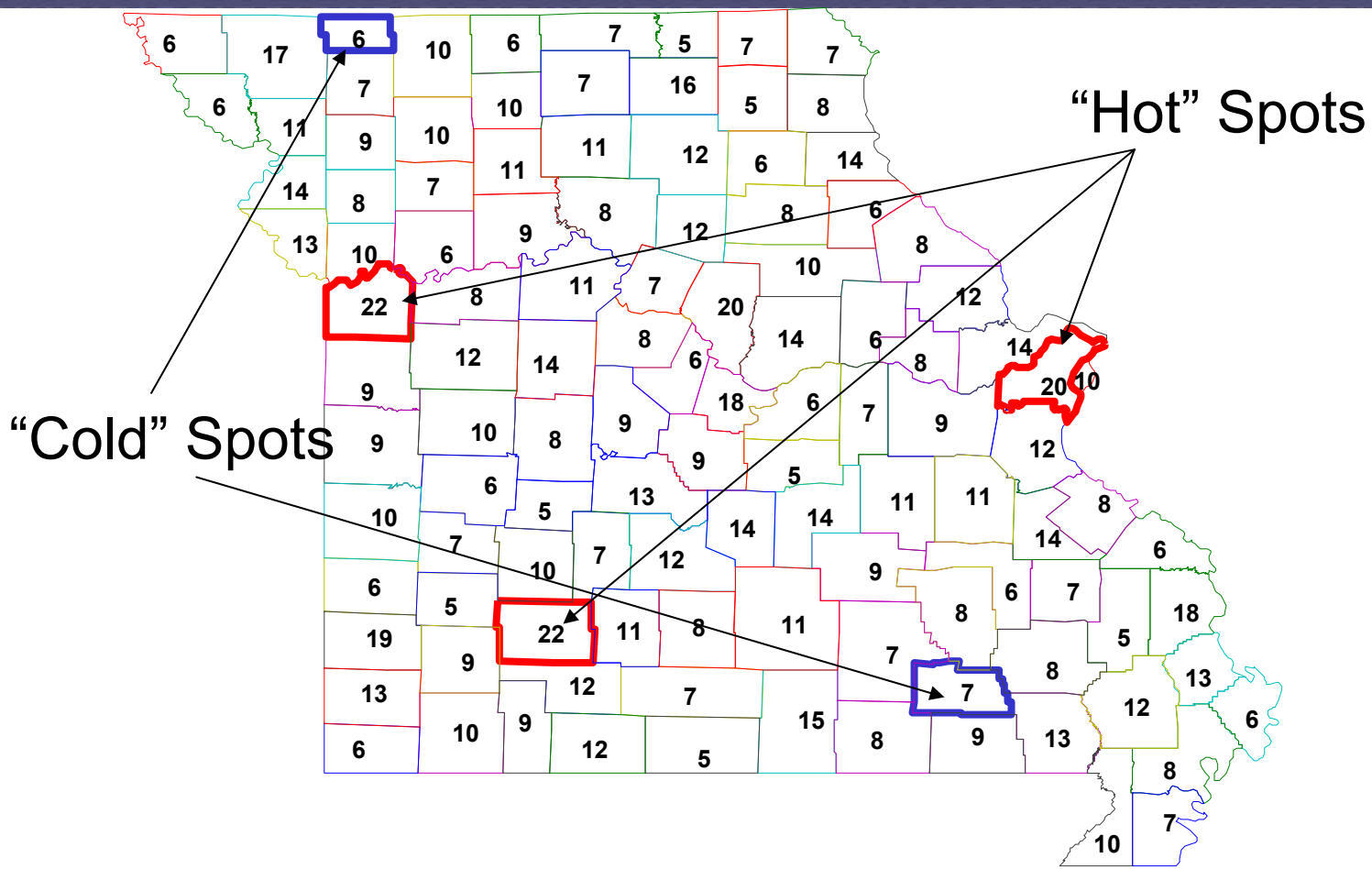
Regional Examples



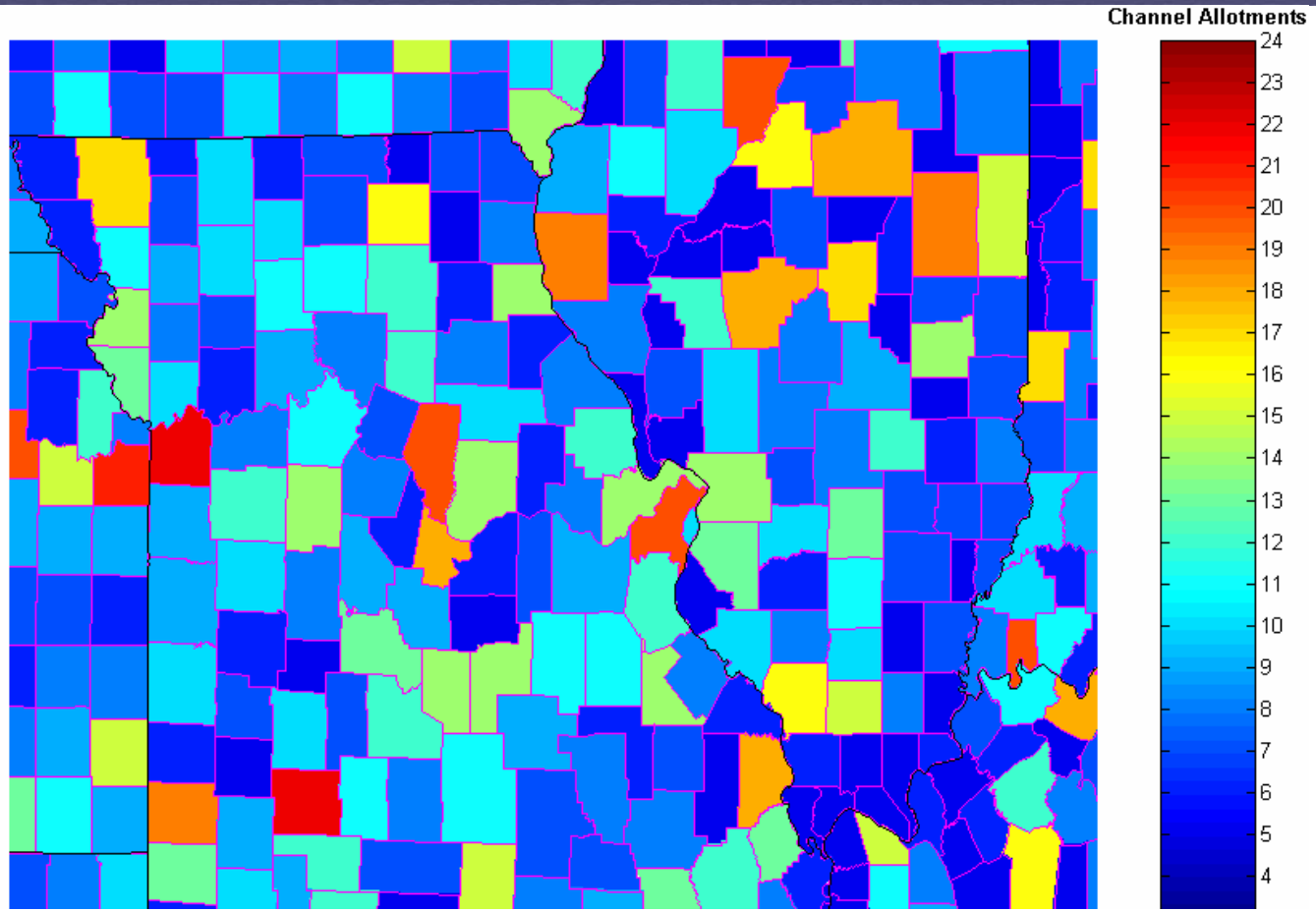
Capacity Model - Region 24



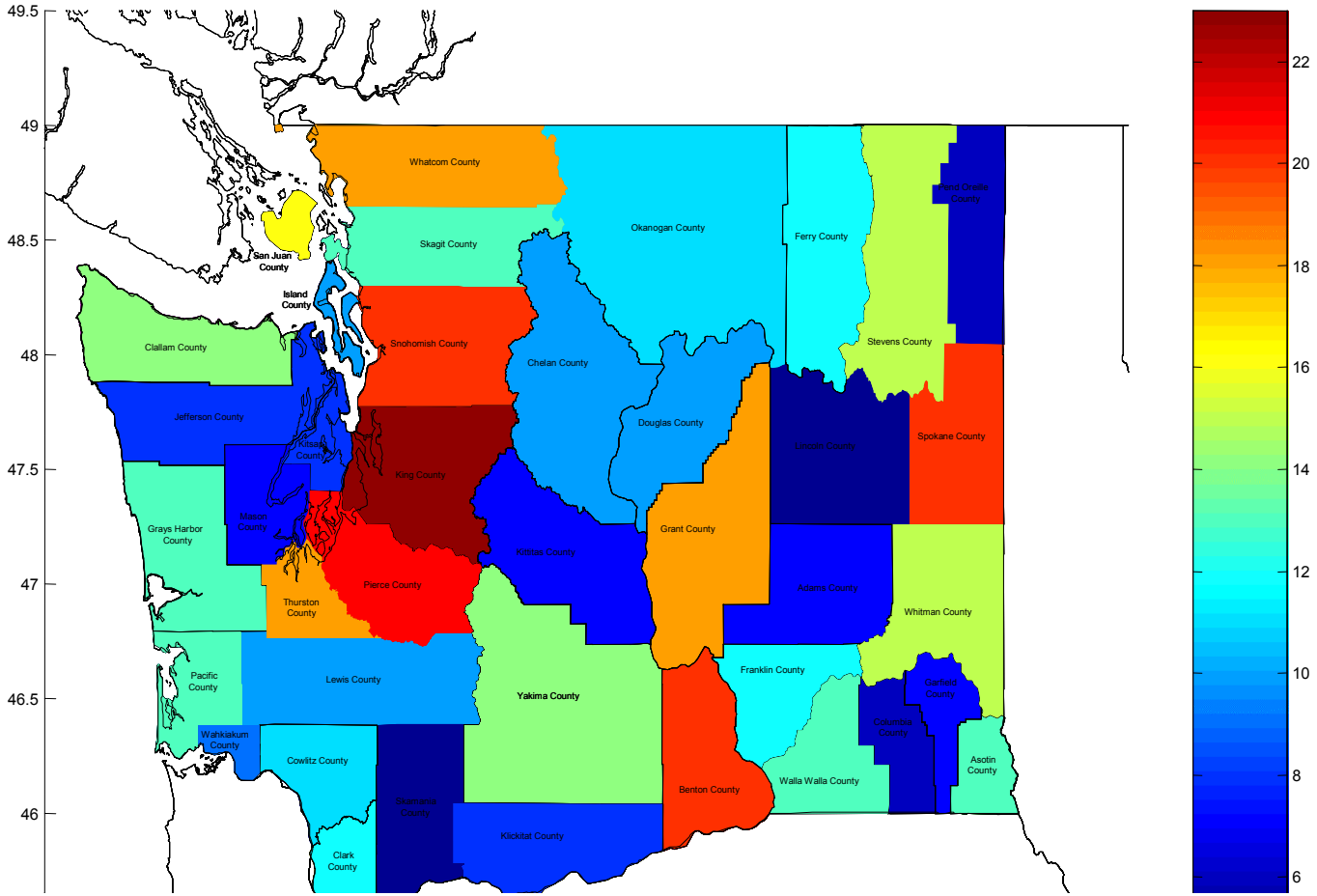
Region 24 Allotment Count



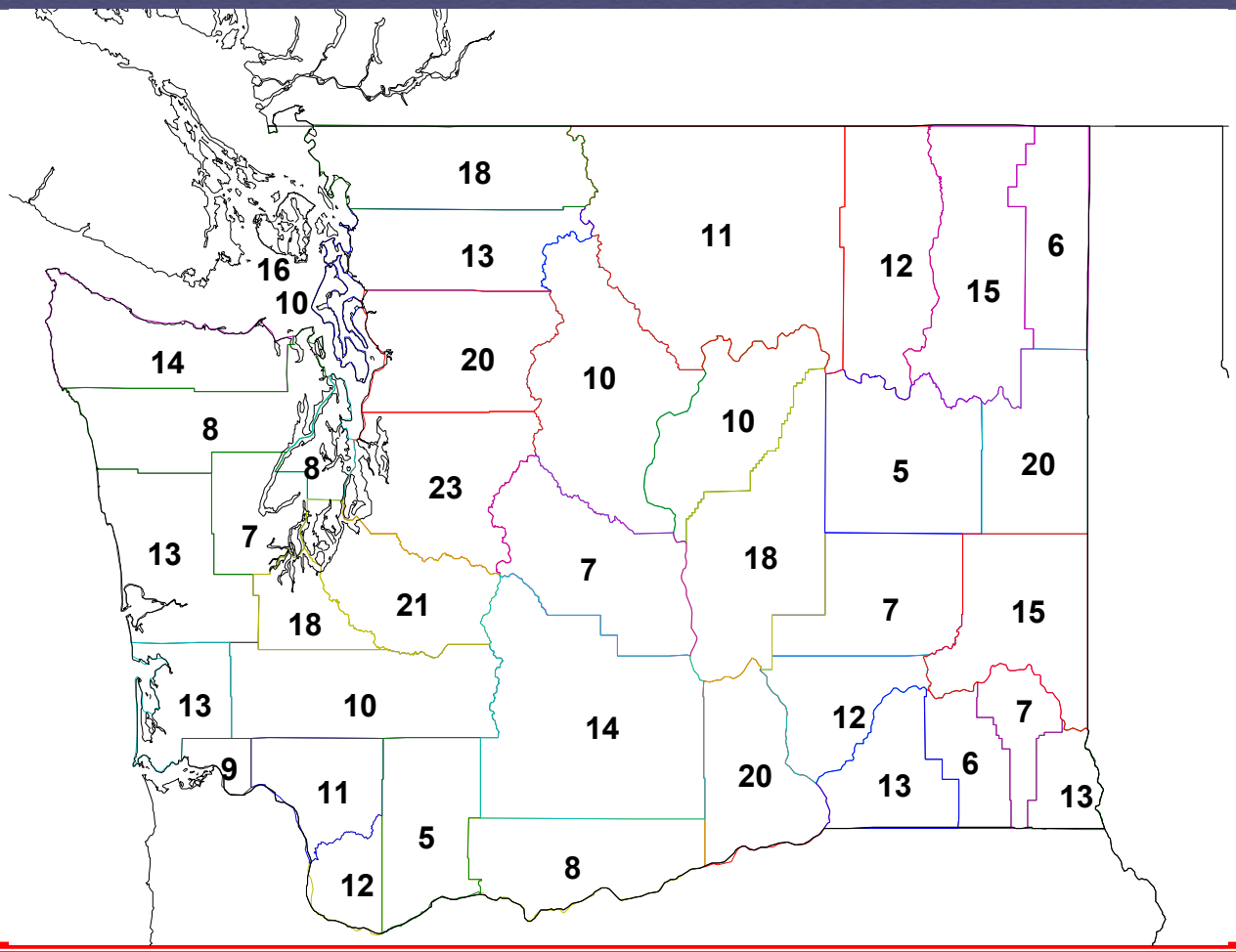
700 MHZ Pre-Allotment Pool - Region 24 Area



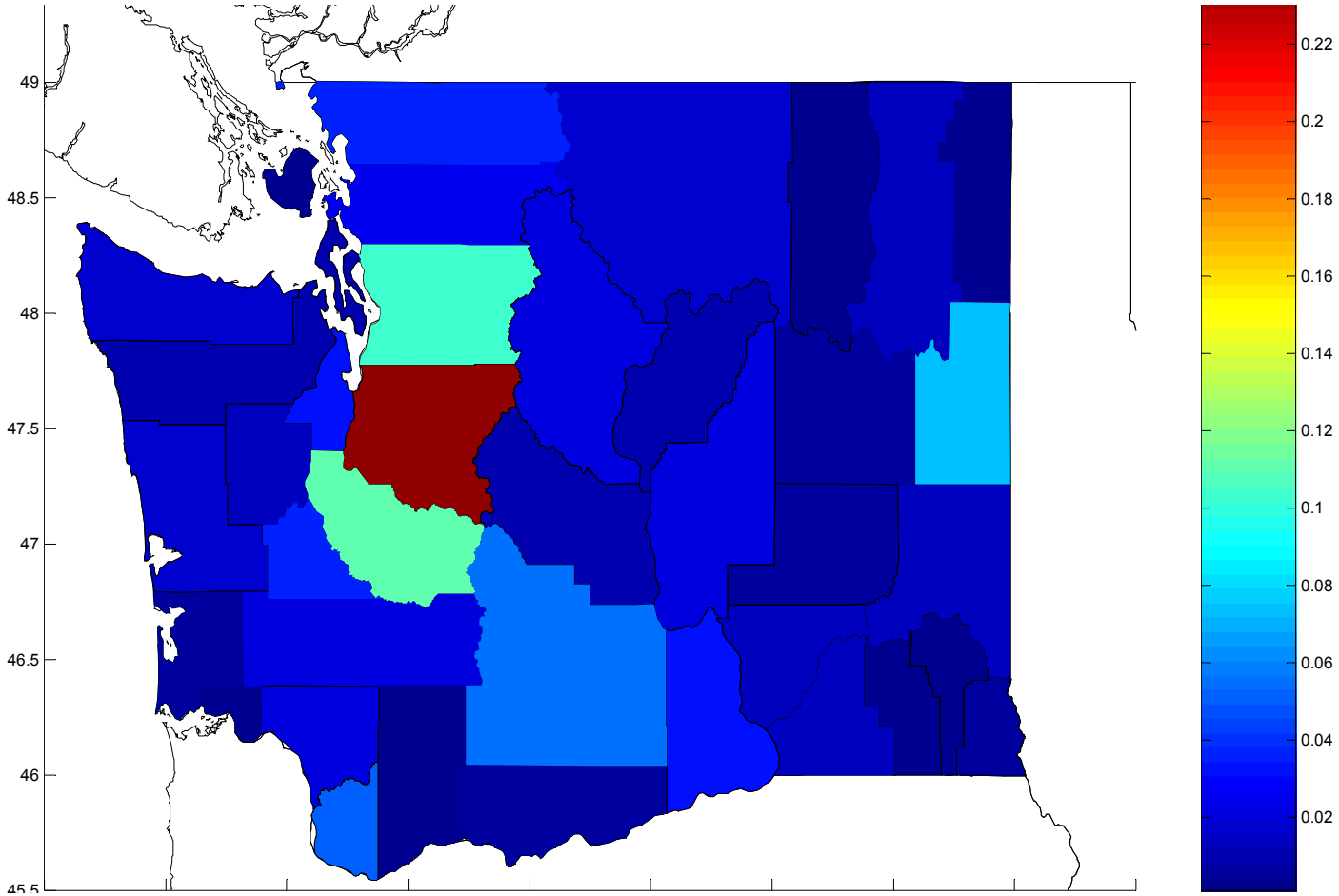
WA Pool Allotment Size



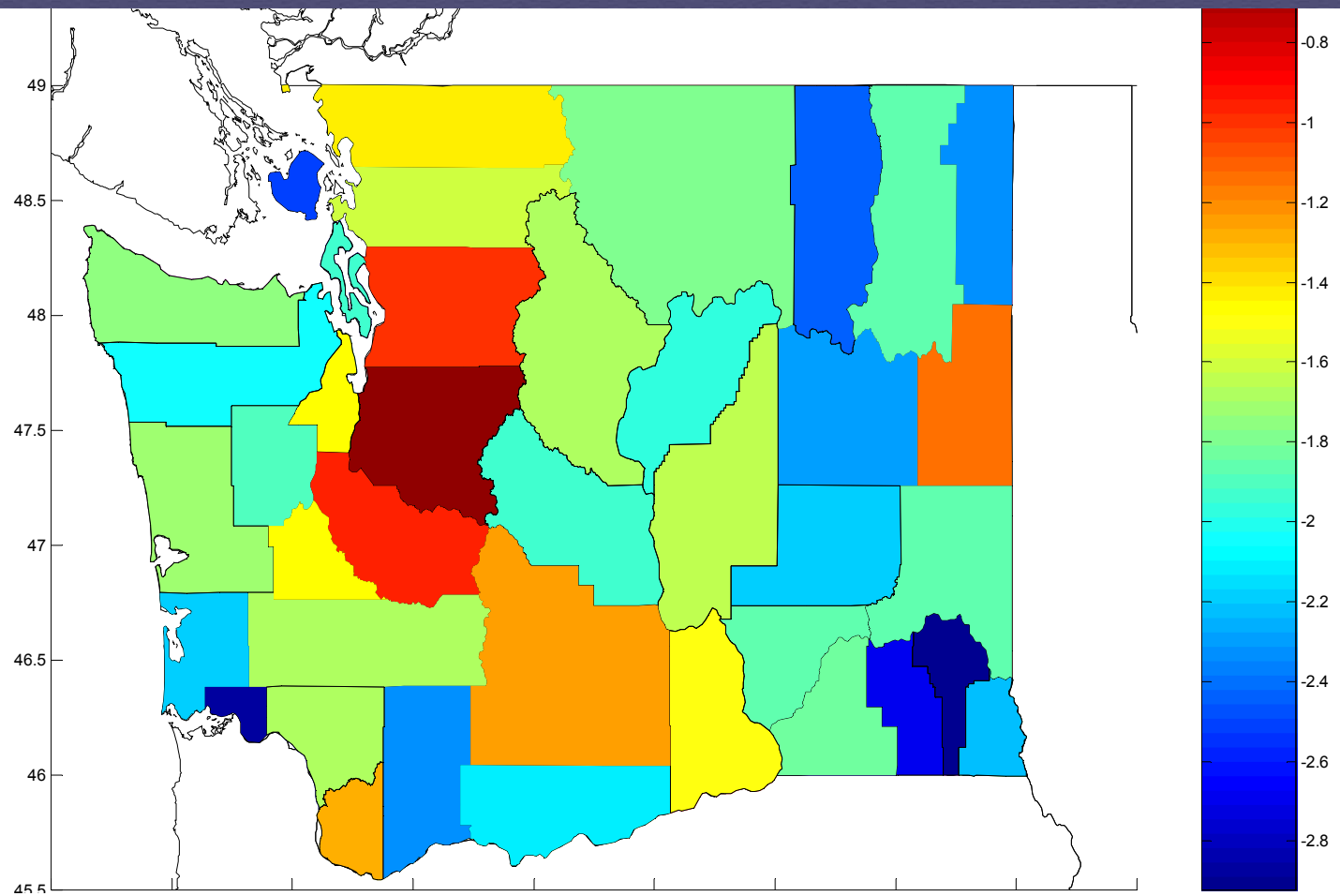
WA Pool Allotment Size



WA Capacity Model Requirements – Normalized Linear

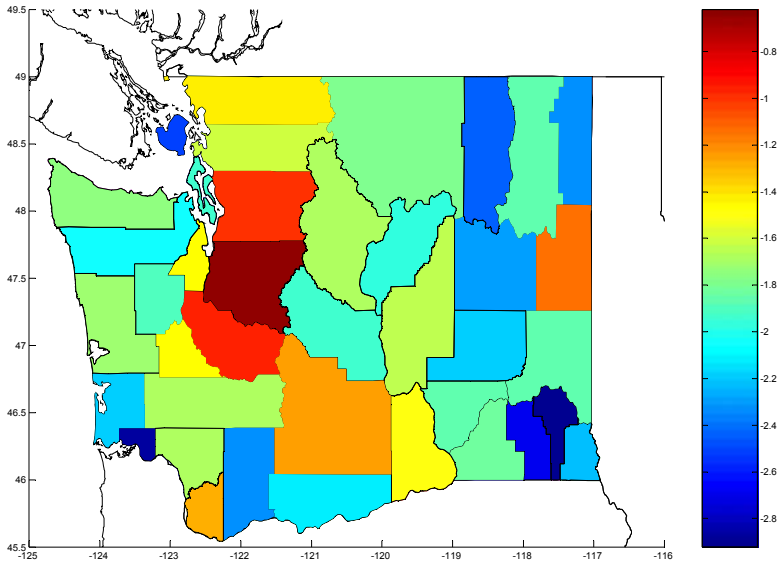


WA Capacity Model Requirements – Normalized Log

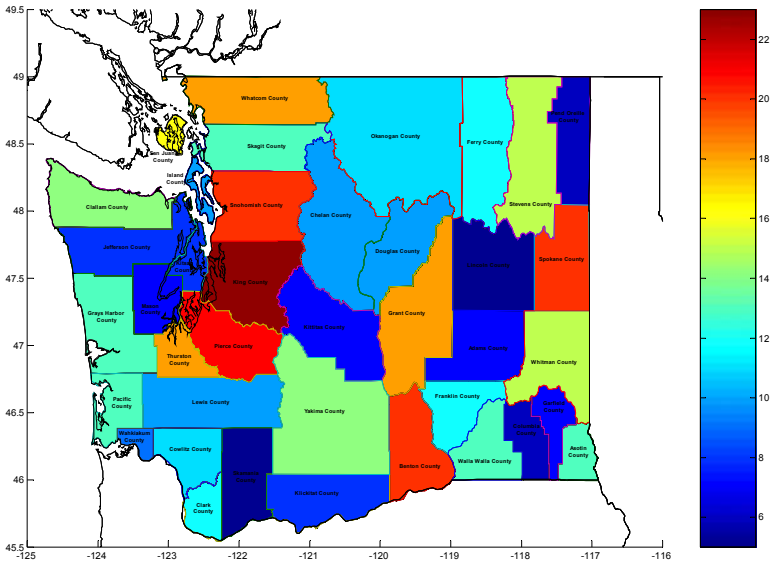


WA Results -Comparisons

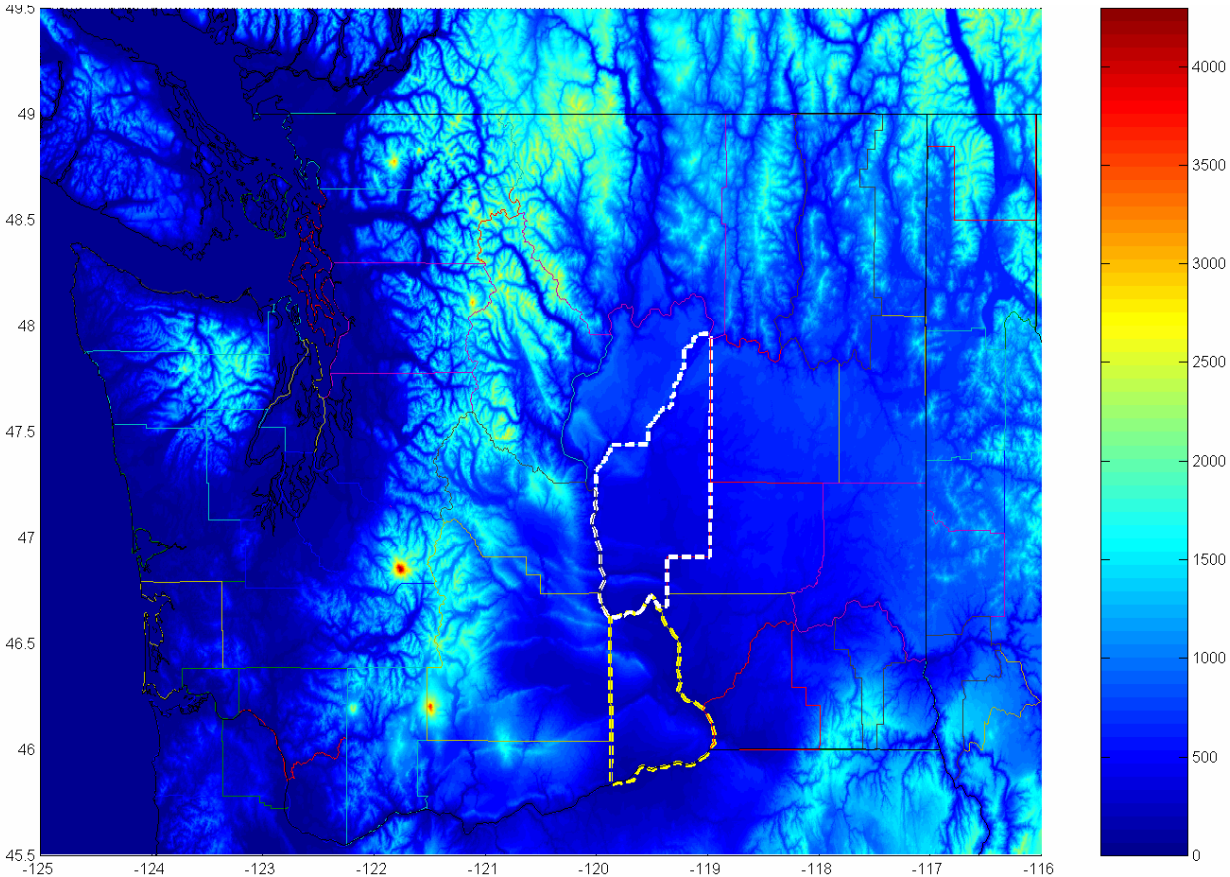
Capacity Model (Log)



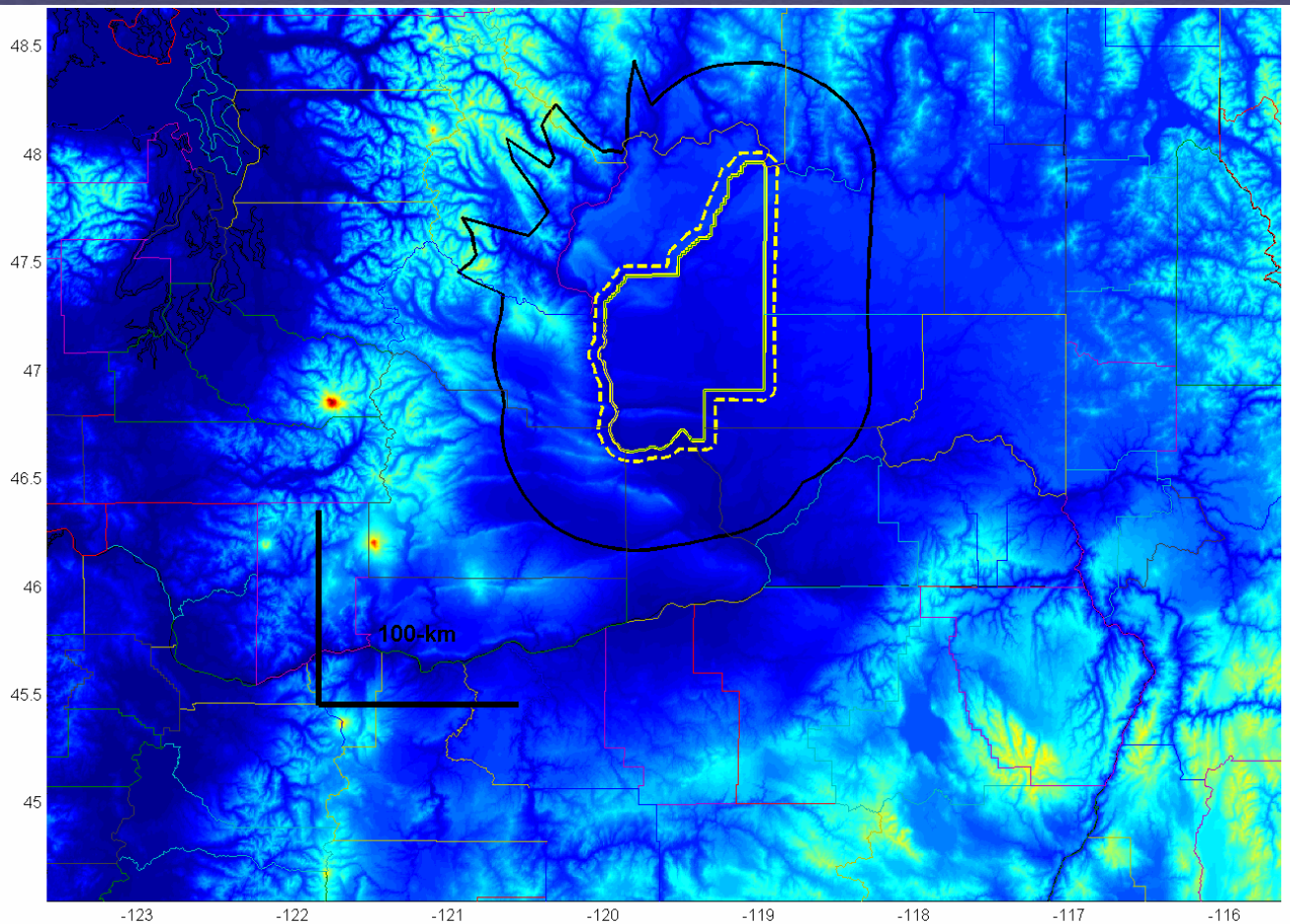
Pool Size



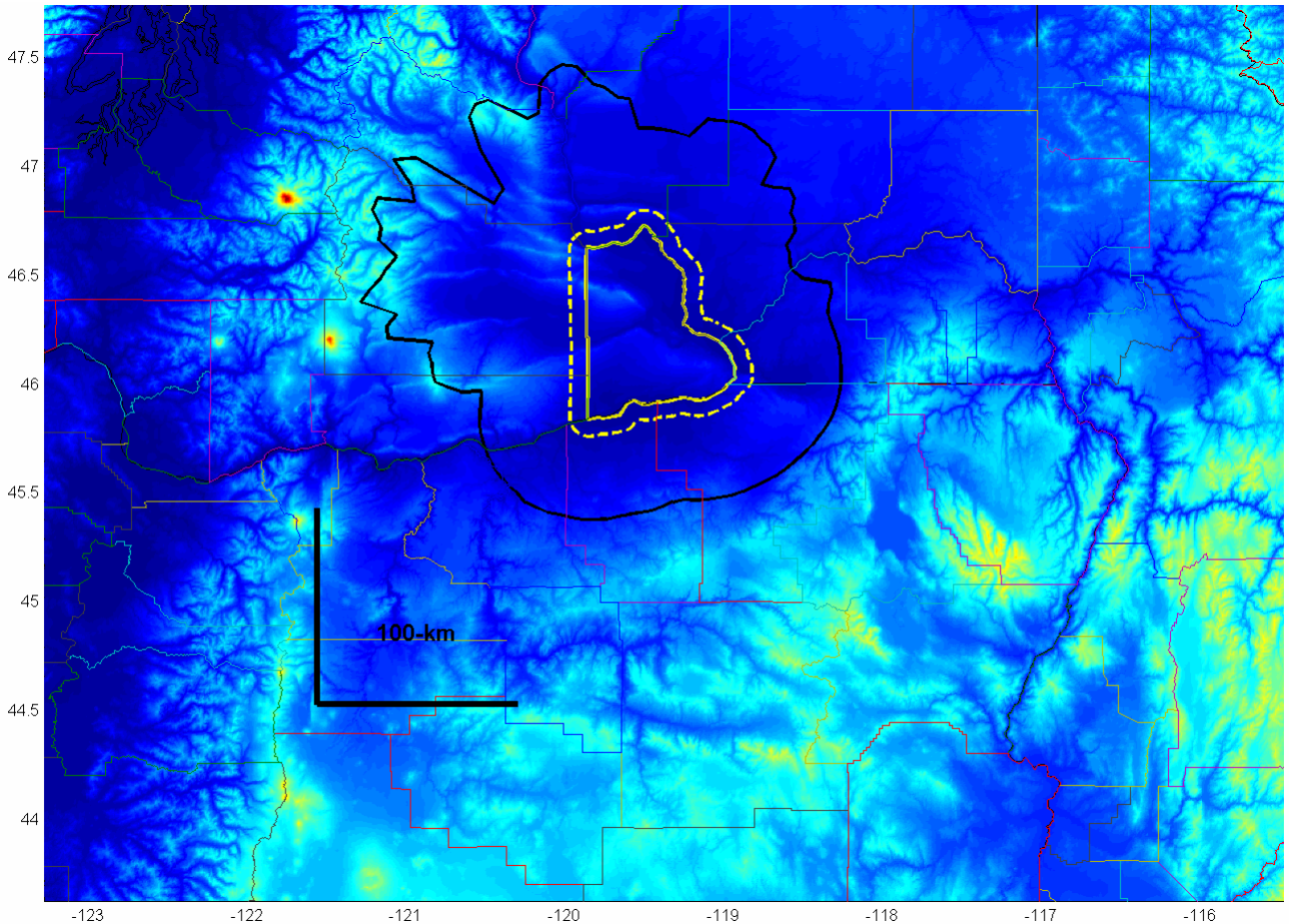
Ex. Terrain Isolated Counties



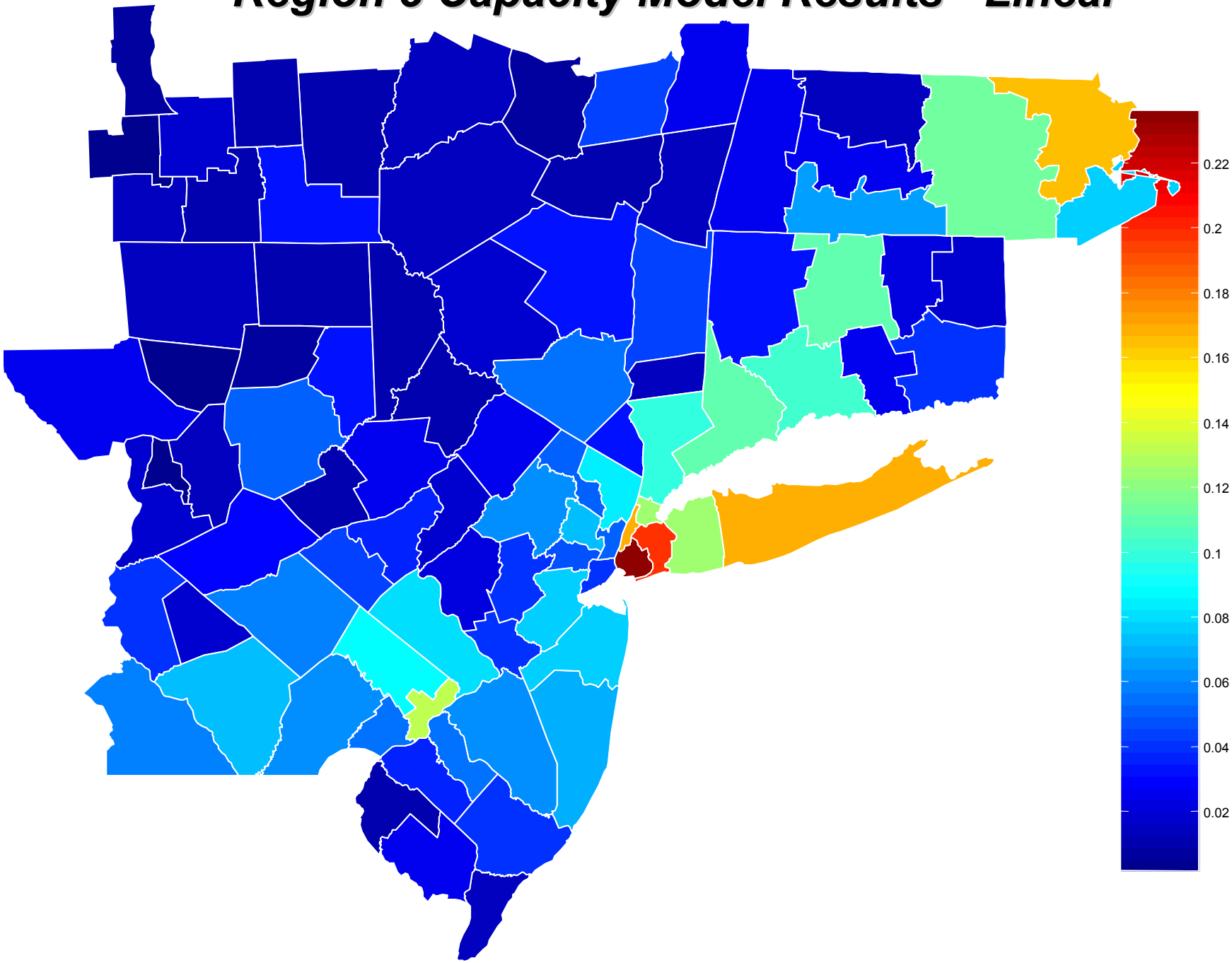
Ex. Terrain Isolated Counties



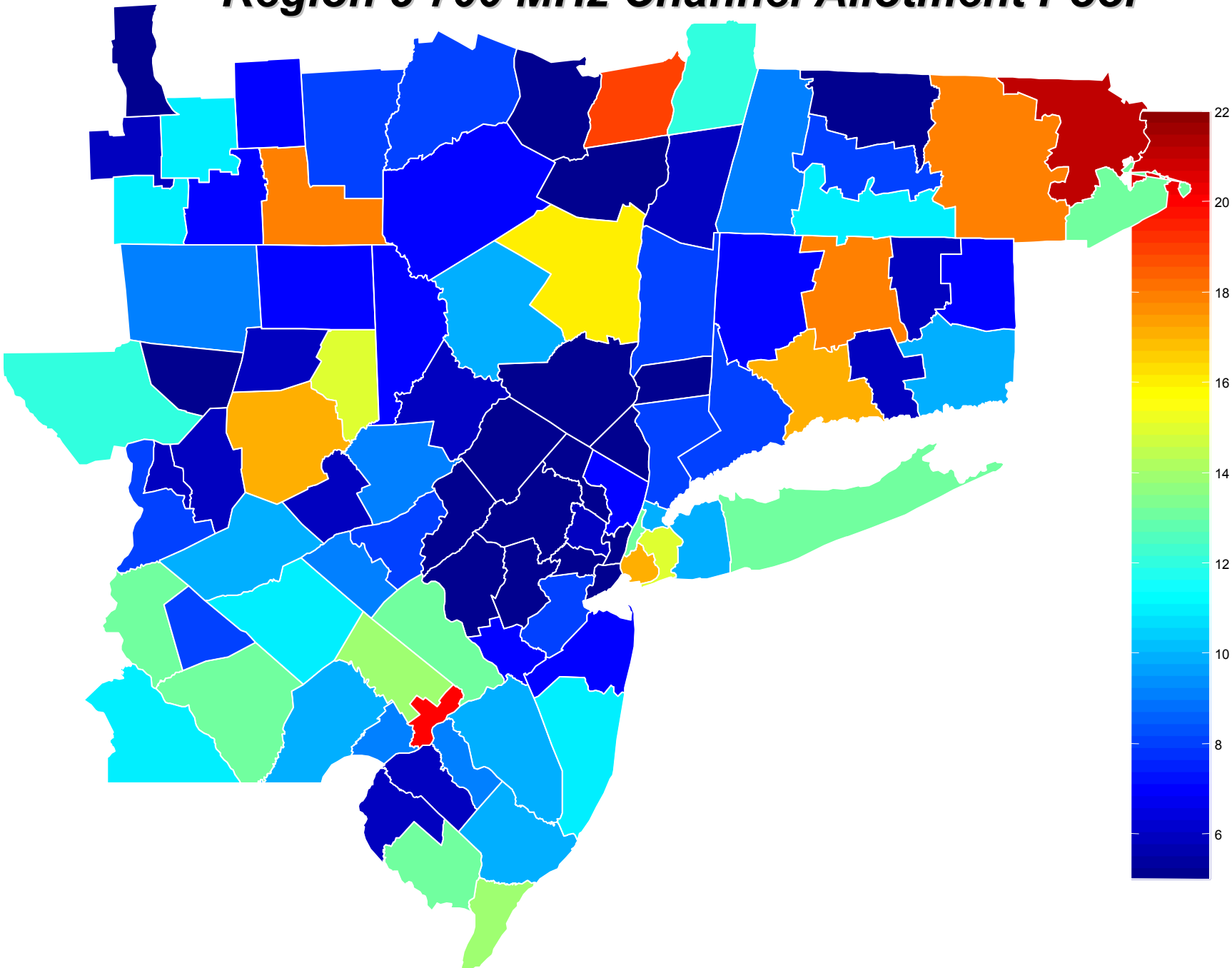
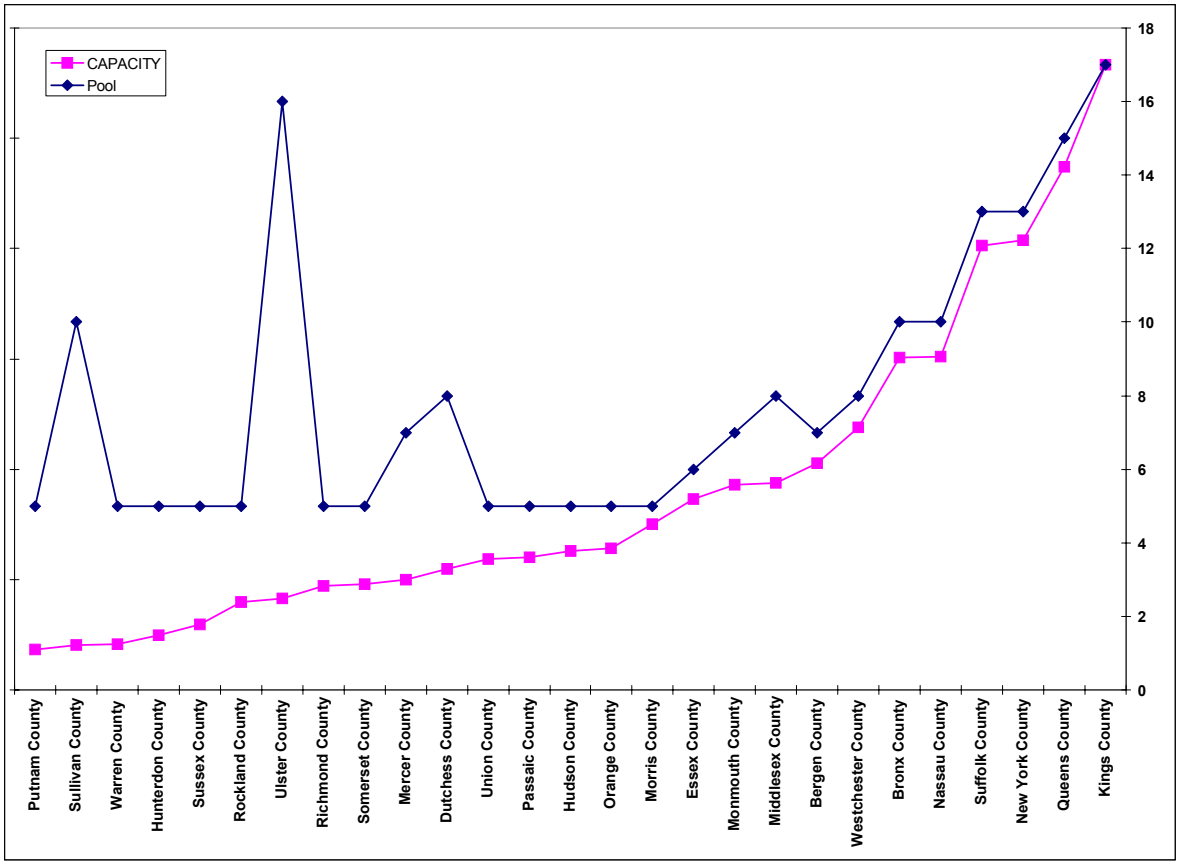
Ex. Terrain Isolated Counties



Region 8 Capacity Model Results - Linear



Region 8 700 MHz Channel Allotment Pool



Region 8 700 MHz Channel Allotment Pool and Capacity Model