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The Community Rating System: Assessing Indicators of Community Participation, A Dasymetric and Sovi Approach

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THE COMMUNITY RATING SYSTEM: ASSESSING INDICATORS OF COMMUNITY PARTICIPATION, A DASYMETRIC AND SOVI® APPROACH

by

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ABSTRACT

The National Flood Insurance Program (NFIP) was established to provide affordable insurance to property owners and encourage communities to adopt and enforce floodplain management, primarily through the Community Rating System (CRS). The CRS awards points to communities for adopting a variety of activities in support of floodplain management. One area of interest in the CRS program is understanding differences in the types of communities participating and the degree of their participation. Research on the NFIP's CRS tends to focus on community program participation in reducing flood losses and indicators of participation. Much of this research was performed prior to 2013 revisions to the CRS points system and considers the characteristics of the full CRS community, rather than just of the floodplain occupants, and uses single census factors. This study considers how robust these findings are given updates to the CRS points system and alternative methodological approaches.

This research asks three main questions. Do previously identified indicators of community CRS participation remain useful, for overall points and for points within each CRS series? Are there significant differences between the Social Vulnerability Index (SoVI®) (Cutter et al. 2003) and the individual factors (educational attainment, housing value, population density) in the correlation to the CRS points? How does the application of a dasymetric approach to identify populations and their characteristics within the 100-year floodplain compare to the correlations of SoVI® and individual factors (educational attainment, housing value, population density) with community CRS participation calculated at the community level? The analysis of indicator verification and potential was conducted using Pearson's *r* and compared using Fisher's *z* transformation. The comparison between the whole community and floodplain in the community was done through a paired t-test.

The results confirmed the strength of housing value and education attainment as strong indicators of CRS participation post-2013 revisions, but population density was not found to be significant. The SoVI® was found to have indicator strength comparable to both housing value and educational attainment for indicating CRS participation. The SoVI® finding indicated that the more vulnerable communities tend to have lower levels of CRS participation. The results indicated that a dasymetric approach has limited value in examining the CRS within this study region.

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INTRODUCTION

Flood-prone communities in the United States are experiencing increasing threats from flooding events associated with climate change. These threats are associated with both intensified storm events and changing long-term sea levels influencing tidal flooding (Sweet and Park 2014; Moftakhari et al. 2015). Homeowners with federally-backed mortgages within the 100-year floodplain of these communities must participate in the National Flood Insurance Program (NFIP), which provides flood insurance to aid in personal recovery after a flooding event. Incentives and policies within the NFIP help communities' recovery after a flooding event and place an emphasis on reducing and preventing flood losses. In recent years, the NFIP has come under some scrutiny due to mounting debt from large flooding events (e.g., Hurricanes Katrina and Ike, Super Storm Sandy). This attention encouraged efforts to make insurance premiums reflect actual risk exposure and reduce communities' exposure to flood risks (Bellomo et al. 1999; King 2013; Knowles and Kunreuther 2014; Kousky and Kunreuther 2014; Kousky and Shabman, Pricing Flood Insurance: How and Why the NFIP differs from a Private Insurance Company, unpublished report, 2014; Michel-Kerjan 2010; Michel-Kerjan et al. 2012; NRC 2015). The NFIP's untenable position has led researchers to examine other facets of the program to determine the best ways to improve the program (King 2013; Knowles and Kunreuther 2014; Kousky 2010; NRC 2015).

[1] Landis, Z. P. To be submitted to *Natural Hazards Review*.

1 .1 BACKGROUND

Within the NFIP exists the Community Rating System (CRS), which allows communities to earn reductions in NFIP insurance premiums through voluntary participation in hazard reduction activities. The CRS contains four series of activities: public information activities; mapping and regulations; flood damage reduction activities; and, warning and response. Each series contains several activities. Table 1.1 summarizes the CRS series, activities, maximum points per activity and presents descriptive statistics on the level of community participation by activity within the study region. For comparison, Table 1.2 provides the national statistics for CRS. Generalizing the comparison between the national CRS and the study area CRS, within the study area communities tend to have higher participation in all the activities but lower average scores for each activity.

Table 1.1 2013 to Present: Study Region CRS Points by Series and Activity.

Activity	Maximum Possible Points	GA, NC, SC Maximum Points Earned	GA, NC, SC Average Points Earned	GA, NC, SC Percentage of Communities Credited
300 Series: Public Information Activities				
310 Elevation Certificates	116	116	67	100%
320 Map Information Service	90	140	134	96%
330 Outreach Projects	350	310	158	91%
340 Hazard Disclosure	80	80	10	98%
350 Flood Protection Information	125	102	57	97%
360 Flood Protection	110	70	21	37%

Assistance				
370 Flood Insurance Promotion *	110	0	0	0%
400 Series: Mapping and Regulations				
410 Floodplain Mapping	802	115	25	94%
420 Open Space Preservation	2,020	454	93	80%
430 Higher Regulatory Standards	2,042	914	297	100%
440 Flood Data Maintenance	222	213	108	96%
450 Stormwater Management	755	370	65	93%
500 Series: Flood Damage Reduction Activities				
510 Floodplain Mgmt. Planning	622	310	107	66%
520 Acquisition and Relocation	2,250	300	13	14%
530 Flood Protection	1,600	482	13	11%
540 Drainage System Maintenance	570	330	167	93%
600 Series: Warning and Response				
610 Flood Warning and Response	395	205	74	61%
620 Levees *	235	0	0	0%
630 Dams *	160	64	50	100%

Note: * denotes new activity as of 2013 (based on FEMA 2013)

Table 1.2 2013 to present: National CRS Points by Series and Activity.

Activity	Maximum Possible Points	National Maximum Points Earned	National Average Points Earned	National Percentage of Communities Credited
300 Series: Public Information Activities				

310 Elevation Certificates	116	116	45	100%
320 Map Information Service	90	70	50	93%
330 Outreach Projects	350	175	72	89%
340 Hazard Disclosure	80	57	19	71%
350 Flood Protection Information	125	98	39	92%
360 Flood Protection Assistance	110	65	49	41%
370 Flood Insurance Promotion *	110	0	0	0%
400 Series: Mapping and Regulations				
410 Floodplain Mapping	802	585	64	50%
420 Open Space Preservation	2,020	1,548	463	70%
430 Higher Regulatory Standards	2,042	784	213	99%
440 Flood Data Maintenance	222	171	87	89%
450 Stormwater Management	755	540	107	84%
500 Series: Flood Damage Reduction Activities				
510 Floodplain Mgmt. Planning	622	273	167	46%
520 Acquisition and Relocation	2,250	1,701	165	24%
530 Flood Protection	1,600	632	45	12%
540 Drainage System Maintenance	570	449	212	77%
600 Series: Warning and Response				

610 Flood Warning and Response	395	353	129	37%
620 Levees *	235	0	0	0%
630 Dams *	160	0	0	0%

Note: * denotes new activity as of 2013 (based on FEMA 2013)

The CRS offers communities the opportunity to implement adaptive measures and build adaptive capacity in the community (A. Atreya, An Assessment of the National Flood Insurance Program's (NFIP) Community Rating System (CRS), presented at 2016 Fall Conference: The Role of Research in Making Government More Effective, 2016; Atreya and Kunreuther, Measuring Community Resilience: The Role of the Community Rating System (CRS), unpublished report, 2016; Highfield and Brody 2017; Smit and Wandel 2006). In terms of flooding, this means the CRS is able to help reduce flood losses in the community and increase the community's ability to respond to a flooding event (Kousky 2010). This loss-reduction and response-improvement potential makes the CRS a valuable program within the NFIP.

As Table 1.1 shows, there are differences in the degree of community participation in each activity and series. For some activities, most communities are able to access a large percentage of the total points available. In other activities, communities earn on average only a small portion of the points available (e.g., communities average for floodplain mapping is 25 out of 802 possible points or 3%). While this flexibility in the point strategy allows communities to participate in activities that appeal to their citizens, it can also limit loss-reduction of the CRS by allowing communities to select activities with limited loss-reduction benefits. Brody et al. (2009b) found this very effect in Florida communities who all tended to earn more points in public information activities, which have limited loss reduction potential. Many of the activities available under warning and response were not widely utilized because several of the activities are tied to state led programs (Brody 2009a).

In part to improve the incentive system, the CRS undergoes strategic revisions approximately every five years with the most recent change occurring in 2013. These revisions may add activities and change the points associated with activities (e.g., the points for activity 420 Open Space Preservation changed from 900 in the 2007 CRS Manual to 2020 in the 2013 CRS Manual). The 2013 point system (Table 1.1) delegated more points towards activities that demonstrated greater benefits in reducing flood losses and damages (FEMA 2007, 2013). The 2013 point system places communities within Special Flood Hazard Areas (SFHA) in classes 10 to 1, providing reductions of 5% per class from (0% to 45% correspondingly). Communities outside of SFHAs are eligible for a 5% reduction only. Table 1.3 outlines the insurance premium reductions and the points associated with each CRS class.

Table 1.3 CRS Classes

CRS Class	**CRS Credit Points**	**Premium Reduction**	
		In SFHA	**Outside SFHA**
1	4,500+	45%	5%
2	4,000 – 4,499	40%	5%
3	3,500 – 3,999	35%	5%
4	3,000 – 3,499	30%	5%
5	2,500 – 2,999	25%	5%
6	2,000 – 2,499	20%	5%
7	1,500 – 1,999	15%	5%
8	1,000 – 1,499	10%	5%
9	500 – 999	5%	5%
10	0 – 499	0	0

Source: FEMA 2013

In 2013, there were several major revisions to the CRS. Within the 400 series the total points stayed nearly the same, but the allocation of points within the series changed significantly. Open space preservation (activity 420) jumped from a maximum of 900 points pre-2013 to 2020 points in the 2013 version (FEMA 2007, 2013). This change is important as that specific activity is credited with significantly reducing flood losses in communities (Brody 2012). The 300, 500, and 600 series also experienced changes, with the largest change affecting the 600 series. The change to the 600 series dropped its total possible points from 1330 pre-2013 to 790 points in the 2013 version (FEMA 2007, 2013). This change may be less significant within the program due to the limited number of communities accessing points within the 600 series (Table 1.2). These changes in the point system could influence which socioeconomic variables are the strongest correlates to higher levels of CRS participation.

Although the CRS program is receiving considerable interest, the level of participation among communities is uneven. Research to investigate which community characteristics correspond most closely with higher levels of participation has begun. However, research to date has not fully explored various methods and approaches to verify findings. In addition, changes to census areas (i.e., incorporated towns annexing lands), advances in GIS (Geographic Information System) technology, and changes to the CRS point system could affect previous findings. This research uses updated community participation information, incorporates the use of an index, rather than a single value, and employs a dasymetric approach to identify the population and their characteristics within the floodplain validate previously identified indicators of CRS participation.

1.2 RESEARCH QUESTIONS

This research aims to answer three questions regarding community CRS participation. In light of revisions to the CRS in 2013, 1) do previously identified indicators of community CRS participation remain useful, for overall points and for points within each CRS series? 2) Are there significant differences between SoVI® and single community factors (educational attainment, housing value, population density) in the correlation to the CRS points? 3) How does the application of a dasymetric approach to identify population characteristics within the 100-year floodplain compare to the correlations of SoVI® and individual factors (educational attainment, housing value, population density) with community CRS participation calculated at the community level?

CHAPTER 2

LITERATURE REVIEW

Researchers have focused on different programmatic aspects, areas, and community types in their CRS examinations. There are two common questions and methods in the current body of research (Brody et al. 2009b; Brody and Highfield 2013; Highfield and Brody 2012; Landry and Li 2012; Posey 2009; Sadiq and Noonan 2015a, b; Zahran et al. 2008a, b, 2010). The first common question investigates socio-economic factors associated with greater levels of overall CRS participation and the second considers factors associated with greater participation in each individual CRS activity (Table 1.1).

Investigations of these questions generally share two methodological practices. They examine correlations of single census variables with CRS class, total points scores, and series points scores. The analyses also rely on data representing the entire community, as designated in CRS participation. The majority of these studies offer insight into community participation in the CRS program prior to the 2013 revisions to the point system, leaving open the question of how changes to the point system may have influenced patterns of community participation.

Researchers have drawn from census variables to identify individual socio-economic factors that indicate higher participation in the CRS overall and within each of the CRS series. Researchers relied on correlation analyses to conduct these studies, using specific techniques appropriate to the nature of their data (Brody et al. 2009b; Brody and

Highfield 2013; Highfield and Brody 2012; Landry and Li 2012; Posey 2009; Sadiq and Noonan 2015a, b; Zahran et al. 2010). In these analyses, researchers examined correlations with CRS classes or CRS points (Table 1.3). The total CRS points approach is stronger than examining CRS participation using the CRS classes because it fully captures the degree of participation. There are potentially points and related actions not captured by using CRS class (i.e., a community may earn up to 499 points over the threshold for given class, but still remain within that class), but it does increase the overall total CRS score. Using Pearson's *r*, instead of Logit, Probit or Cragg models, provides an easily replicated method for future researchers to examine.

The four major studies engaging community CRS participation identified socio-economic factors that correlate to different measures of community CRS participation. The methods, regions and community types in these studies differ slightly. There are both some consistencies and differences among the findings. Following brief descriptions of each, Table 2.1 summarizes key aspects of these studies.

Brody et al. (2009b) aimed to determine how Florida counties participated in each of the CRS series. They determined educational attainment had a positive correlation with community participation in each of the CRS series while population density had no correlation. This study did not assess housing value (Brody et al. 2009b). This study provides the only insights into specific CRS series, illuminating the importance for examining specific CRS series.

Landry and Li (2012) examined CRS participation in North Carolina for counties only, examining if competing factors (e.g. crimes rates, educational system) limited some counties' CRS participation. Their study found population density and housing value to have positive correlations with CRS participation. They also identified a negative correlation between educational attainment and CRS participation.

Posey (2009) aimed to determine adaptive capacity of municipalities throughout the US and used the CRS class as a proxy to measure adaptive capacity. He identified both educational attainment and housing value to have statically significant positive correlations to CRS participation. There was not a population density factor included in this analysis.

Sadiq and Noonan (2015b) examined all CRS communities in the US attempting to provide definitive indicators nationally for both CRS participation and CRS score, foregoing examining each CRS series or activity. They identified both educational attainment and housing value to have positive correlations to CRS participation, educational attainment to have a positive correlation to CRS score and no correlation to either participation or score for population density.

Table 2.1 Summary of Related Research

Study	Time	Region	Enum Unit	N	Stat Method	Independ. Variables	Dependent Variables
Brody et al. (2009b)	1999 – 2005	Florida	Counties	48-51	Multivariate stat models	Census Variables	CRS Series and Activities
Landry and Li (2012)	1991 – 2002	North Carolina	Counties	100	Logit and Probit Models	Census Variables	CRS Participation
Posey (2009)	1978 - 2007	National	Munici-palities	10,916	Probit and OLS Models	Census Variables	CRS Participation
Sadiq and Noonan (2015)	2012	National	All CRS Commun ities	1,182	Two-stage Cragg model	Census Variables	CRS Participation and Score

Note: Enum Unit = Enumeration Unit; N = sample size; Stat Method = Statistical Method Used

Using these methods, research identified educational attainment, home value, and population density as indicators of higher CRS participation; however, findings were not consistent across studies (Brody et al. 2009b; Posey 2009; Landry and Li 2012; Sadiq and Noonan 2015b). Educational attainment is defined as percentage of the population (25 and older) with a bachelor degree or higher; home value is represented by median home value; population density refers to population per square mile. Landry found no correlation between CRS and educational attainment while Brody et al., Posey, and Sadiq and Noonan identified educational attainment as a correlate. Landry and Li's (2012) investigation of counties in North Carolina was the only study to identify population density as a strong indicator of higher participation.

Table 2.2 summarizes the findings of these studies relating selected census variables to CRS participation. These specific variables were chosen for several reasons: educational attainment has consistently some of the highest correlations to CRS scores, educational attainment and housing value were consistently found to have significant correlation. Only one study found population density as a correlate.

Table 2.2 Studies Showing Census Factor Correlation to Aspects of the CRS.

	Educational Attainment	**Housing Value**	**Population Density**
Brody et al. (2009b)	+	N/A	≠
Landry and Li (2012)	≠	+	+
Posey (2009)	+	+	N/A
Sadiq and Noonan (2015b)	+	+	≠

A significant difference in these studies lies in their spatial extent and region examined. The Posey (2009) and Sadiq and Noonan (2015b) studies are national studies examining CRS communities while Brody et al.'s (2009b) study focused on communities in Florida. Landry and Li (2012) examined communities in North Carolina. Sadiq and Noonan (2015b) examine all CRS communities (counties and incorporated towns, riverine and coastal) within their study region, while Brody et al. (2009b) and Landry and Li (2012) examined only counties in their study areas. Posey (2009) focused on municipalities (incorporated places smaller than county). These differences in community type (e.g., county or smaller municipality) and region (e.g., Colorado or Georgia) offer one potential explanation for the differences among findings.

Another issue relevant to understanding community CRS participation is that communities' participation differs across series and for each activity of the series. Sadiq and Noonan (2015b) call for an examination of these correlations to each CRS series to determine if overall CRS predictors show similar patterns for each of the CRS series. Brody et al. (2009b) and Brody and Highfield (2013) highlight the importance of investigating differences in participation within each series. Communities in Florida are more likely to participate in informational campaigns (i.e. 300 series activities) than in other CRS series, which require more effort from the community (Brody et al. 2009b). Brody and Highfield (2013) also demonstrates how open space preservation (an activity in the 400 series) is linked to flood loss reduction. These findings are important distinctions within the CRS, demonstrating the activities that result in the greatest reduction of losses and the activities communities elect to pursue are not always aligned. One caveat for the CRS series and activity evidentiary basis for this research is that is much of it is based in the efforts of a few researchers collaborating with Brody in many studies.

Each series in the CRS has a different focus and each requires varying amounts of political and fiscal capital and other resources to enact. The 300 series tends to contain informational campaign activities; the 400 series contains data archiving, regulatory changes, and mapping; the 500 series focuses on flood reduction activities; the 600 series addresses warning systems and dam and levee maintenance. The two right columns of Table 1.1 demonstrates the varying participation in each series and shows the average achievement communities attain in that activity within the study region.

One of the most consistent approaches across these studies is the use of single socio-economic variables as a correlation to CRS scores (Brody et al. 2009a, b; Brody and Highfield 2013; Highfield and Brody 2012; Landry and Li 2012, Landry and Jahn-Parvar 2011; Sadiq and Noonan 2015a, b; Zahran et al. 2008a, 2010). However, the use of composite measures, such as indices and scales, practiced in other fields, could consolidate several socio-economic factors to provide a better correlation than a single factor (Babbie 2013). Capturing the combined influence of multiple variables through the use of an index may provide greater explanatory power in understanding the relationships between community characteristics and CRS participation. In the area of hazard management, understanding vulnerability of a community is a particularly important component in understanding overall risk.

Cutter et al. (2003) provides just such a hazard relevant index through the Social Vulnerability Index (SoVI®). SoVI® reduced 42 socio-economic variables through principal components analysis into 11 factors, which explained 76% of the variance in the single factors. Educational attainment and housing value may each capture some aspect of vulnerability, so testing SoVI® as a possible indicator for CRS score could provide greater insights into participation among CRS communities as it represents a more holistic measure of vulnerability.

The second consistent research approach is utilizing data summarizing the entire community's socio-economic background (Brody et al. 2009a, b; Brody and Highfield 2013; Highfield and Brody 2012; Landry and Li 2012, Landry and Jahn-Parvar 2011; Sadiq and Noonan 2015a, b; Zahran et al. 2008a, 2010). These researchers examined the community as a whole, rather than examining only individuals who live in the floodplain and are thus more affected by changes in CRS score (e.g., increased flood protection and decreased insurance rates).

Communities participating in the CRS vary in both population and land area. Differences in residential patterns in these communities include the level of floodplain occupancy. For example, Hilton Head, SC (pop. 37,000 and 37 sq. mi.) is almost entirely in the 100-year floodplain, while Jacksonville, NC (pop. 70,000 and 46 sq. mi.) only has small sections of the community in the 100-year floodplain. This variation in the occupancy in the floodplain could potentially produce significant changes in CRS involvement in the community.

In situations, where the precise location of residences with respect to some boundary is critical to the analysis, researchers have frequently applied a dasymetric approach (Langford and Higgs 2006). Briefly, a dasymetric approach takes into account the changing densities of population within the boundaries of the map. Given the potential for population characteristics to influence patterns of investment within a community, it is possible that a dasymmetric approach may reveal different relationships between indicators and CRS scores.

CHAPTER 3

METHODS

This study includes all CRS communities in the coastal counties (as each state defines them under the Coastal Zone Management Act) of North Carolina, South Carolina, and Georgia (n=88) (Appendix A). Figure 3.1 shows the study region for this research. Each state has slightly different definition of their coastal counties. North Carolina's definition is the most unlike South Carolina or Georgia. North Carolina coastal counties are only those counties that border coast or coastal sound, while both South Carolina and Georgia include counties effected by tidal waters. This research did not identify any communities in this region which were eligible for the CRS but chose not to participate. There were no communities identified that had opted out of the NFIP.

Figure 3.1 Study Region (Outlined in black). The study region is 20 counties from North Carolina, 8 counties from South Carolina and 11 counties from Georgia.

The presentation of methodology begins with a description and justification of data sources and associated caveats for analysis. A discussion of statistical techniques employed follows. Details of the dasymetric approach used are addressed in the final section.

This research uses floodplain data from the 2016 National Flood Hazard Layer, CRS score data from 2014 FEMA State profiles, census data from the 2013 ACS 5-year estimates, and 2000 SoVI® data from NOAA's Digital Coast (FEMA 2016; Census 2013; NOAA 2000). The 2016 National Flood Hazard Layer contains all floodplains within the United States. This research used the 100-year floodplain as designated by the National Flood Hazards Layer. The CRS score data was provided from the 2014 FEMA State profiles. This data (Appendix B) included every CRS community in North Carolina, South Carolina and Georgia with the CRS class each community attained as well as the community's overall score, score for each series and score for each activity.

The assessment of the characteristics of floodplain occupancy relied on community block group data from the 2013 ACS 5-year estimate (2009-2013). These data provided the lowest margin of error at the block group level. For assessments of the entire community, 2013 ACS 5-year estimates (2009-2013) for census place (county or incorporated town) were used as the margins of error associated with these data were much lower than the block group data for 1-year and 3-year estimates. The margin of error for the census place was under 10% of the mean where the margin of error for the block groups ranged from under 10% of the mean to 60% of the mean. Educational attainment is defined as percentage of the population (25 and older) with a bachelor degree or higher; home value is represented by median home value; population density refers to population per square mile. NOAA's Digital Coast provided year 2000 SoVI® data at the block group level. Using these data allows for the analysis of the SoVI® at the scale of the floodplain in each community.

Two caveats apply to the data used. The margin of error associated with the block group data could be an item of concern. However, as the results of this analysis show, there is no statistical difference between the floodplain data and the community data meaning examination of just the population within the floodplain provides no additional insight to CRS score participation. If the results had demonstrated a statistical difference indicating the floodplain provided more accurate representation of the community more attention to the influence of the margin of error would be warranted. The SoVI® data is from year 2000, which does not provide the most accurate picture of communities in 2013. This data is the most recent available at the smallest census unit because this research was unable to more recent SoVI® data. While not a close match in the time period, it is sufficient to provide preliminary insights into the use of an index in examining CRS communities.

In order to compare single census factors-CRS point score correlations with one another, the correlations are examined using Pearson's *r* and transformed using Fisher's *z* transformation. Pearson's *r* is a measure of linear correlation with values ranging from total negative to total positive correlation, -1 to 1 respectively. Fisher's *z* transformation changes the values from *r* to normally distributed *z*-scores allowing for a more accurate comparison of correlation values (Mudholkar 2004). All reported Pearson's *r* values in the results are compared using Fisher's *z* transformation. The following example demonstrates the value in Fisher's *z* transformation, if you compare the *r* values of .95 to .90 and .55 to .50, they seem to have the same difference .05 however, Pearson's *r* only has a range of -1 to 1, so as you approach either end of the value range small changes are statistically significant. Taking the *r* values provided above, there is a significant statistical difference between *r* values of .95 to .90 where there is no statistical difference between the *r* values of .55 to .50. The linear approach is acceptable because the correlation is to continuous CRS points score, rather than ordinal CRS classes.

Using the three socio-economic factors identified from the literature (educational attainment, housing value, and population density), this research uses the same correlation analyses, described in the previous paragraph, to examine which variables have the highest correlations with CRS series. This analysis follows Brody (2009b, 2013) to determine if the CRS changes in 2013 brought about changes in the type of community that attempts to access each CRS series and Sadiq and Noonan's (2015b) recommendations for determining which indicators are strongest for each CRS series.

Using an index allows for the consolidation of several factors into one component, these components tend to group around factors that have similar high and low correlations. The assessment of the index value rather than a single factor is conducted using the SoVI® (Cutter et al. 2003). The reduction of single variables into an index allows for a better understanding of specific communities by aligning factors under similar themes. For example, the index could place housing value, educational attainment, and median income into a single factor that the researcher could then call their level of affluence factor. The SoVI® is widely used in hazards research applications (Lam et al. 2016; Posey 2009). Because of the broad application and focus on hazards, SoVI® is a good choice for investigation of the potential for indices.

This research employs a dasymetric approach to increase the spatial accuracy of population data relative to the floodplain. Previous CRS research used an equal distribution method, where the data is evenly distributed throughout the spatial unit

(Brody et al. 2009b, b; Brody and Highfield 2013; Highfield and Brody 2012; Landry and Li 2012, Landry and Jahn-Parvar 2011; Sadiq and Noonan 2015a, b; Zahran et al. 2008a, 2010). In contrast, dasymetric mapping places the data points as close to their real-world location as possible. Figure 3.2 provides a general visualization of the difference between using a single point (left), what previous research has done (center), and what this research does (right).

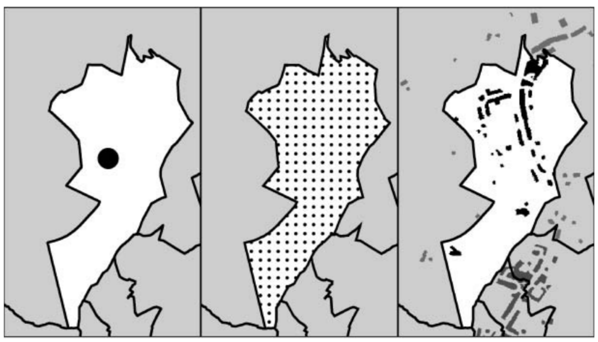

Figure 3.2 Dasymetric Example. The three alternative representations of population used in accessibility modeling: using a single representative point (left), evenly distributed throughout a census zone (center), and a dasymetrically distributed model (right) (Langford and Higgs 2006).

Figure 3.3 displays the specific manner in which this research applied the dasymetric approach. The large box represents the whole community and the grey shaded area represents the floodplain within the community. The checkered boxes within the whole community represent smaller census units (block groups). As the graphic depicts, there are still some inaccuracies with this approach. The census units do not perfectly line up with the floodplain, meaning census units were used to describe the demographics of the floodplain that were partially outside the floodplain and some census units were not used that were partially inside the floodplain.

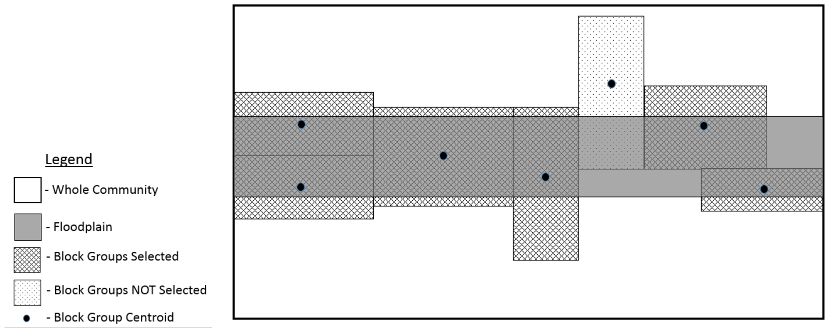

Figure 3.3 Dasymetric Method Applied. Example of the dasymetric approach used in this research. Outer box is the entire community, grey shaded area is the floodplain in the community, and checkered boxes are census block groups with their areal centroid in the floodplain.

Figure 3.4 demonstrates the specific manner block groups were selected for the dasymetric approach. This research evaluated three different methods for selecting block groups in the community's floodplain. The first was selecting block groups that intersected the community's floodplain. This resulted in overestimation as several communities had larger populations and land area included in the floodplain. The second method selected block groups completely contained within the community's floodplain. This method resulted in underestimations and some of the smaller communities had no demographic information for floodplain areas. The last method considered and the one used for this research was selecting block groups with the centriod within the floodplain. Figure 3.4 represents the flow of this block group selection process.

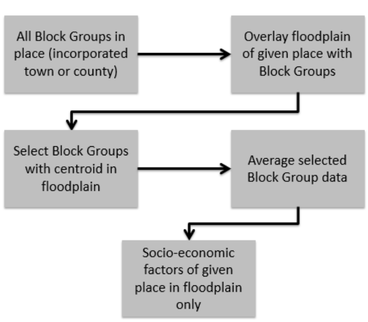

Figure 3.4 Block Group Selection Flow Diagram. This figure demonstrates the workflow of block group selection for the dasymetric approach applied.

Utilizing more precise location data can change results (Landford and Higgs 2006; Openshaw 1983). Using this dasymetric approach in examining a community's CRS score allows the research to focus more closely on the population in the floodplain and largely remove those population in the community unaffected by changes in the CRS. This research used paired t-tests to determine if there was a significant difference between the data at the whole community and the floodplain levels (Hsu and Lachenbruch 2008). The specific application of the dasymetric method was accomplished through ArcGIS, selecting census data by location (inside the community and inside the floodplain). There are still limits to this dasymetric approach, which encounters the modifiable areal unit problem (MAUP), albeit on a smaller scale than previous studies. With improved data representation this problem could be overcome completely (Holt et al. 2004, Manntay et al. 2007).

CHAPTER 4

RESULTS

The results from this study provide insights into CRS participation by confirming previous findings, applying SoVI® to examine CRS communities, examining CRS series participation, and evaluating influence of community socio-economic composition through dasymetric analysis. The results help resolve some differences in past research on CRS participation indicators and offer preliminary insights into examining data dasymetrically.

4.1 TOTAL CRS SCORE AND DEMOGRAPHIC ASSOCIATIONS

Consistent with the findings from previous research, housing value and educational attainment remain strong indictors of overall CRS score. Table 4.1 lists the results of the Pearson's *r* analysis for the factors and locations studied. North Carolina communities are included in Table 4.1 to facilitate comparison with Landry and Li (2012). The positive correlation between housing value and CRS score and educational attainment and CRS score demonstrates that as housing values and education attainment in a community increase the communities CRS score will likely increase. Table 4.2 lists the specific significance levels for *r* values of with sample sizes of 48 and 88. The values in Table 4.2 demonstrate that housing value, educational attainment and SoVI® score are significant correlations above 99% confidence. The table shows this same significance demonstrated in the whole study region applies for North Carolina communities and demonstrates no correlation between CRS scores and population density.

Table 4.1 Correlation Values (Pearson's *r*) Between Indicator and Total CRS Point Scores.

	NC Coastal Communities (N=48)	**NC, SC, GA Communities (N=88)**	**NC, SC, GA Floodplains (N=88)**
Median Housing Value	0.59***	0.44***	0.43***
Educational Attainment	0.54***	0.47***	0.46***
Population Density	0.14	0.01	-0.01
SoVI® Score	-0.49***	-0.39***	-0.43***

Note: *** statistically significant at p<0.01

Table 4.2 Statistically Significant *r* Values.

N	***df***	**0.1 (90%)**	**0.05 (95%)**	**0.02 (98%)**	**0.01 (99%)**
3	1	0.997	0.999	1.000	1.000
4	2	0.950	0.975	0.990	0.995
5	3	0.878	0.924	0.959	0.974
6	4	0.811	0.868	0.917	0.942
…	…				
48	46	0.285	0.323	0.368	0.399
…	…				
88	86	0.210	0.239	0.273	0.297

Note: α level for two-tailed test (Rogerson 2001)

Interestingly, the SoVI® score proved to be an indicator of total CRS score as well. The SoVI® score includes measures of educational attainment and household income as well as other variables, such as renter and elderly populations, that capture more dimensions of community vulnerability. A SoVI® score of -5 would mean the area has very low social vulnerability. This correlation means the lower the social vulnerability in an area the higher the CRS score. It also means that locations with higher social vulnerability appear to not participate as much in a program that would help lower their exposure to flooding events.

Unlike Landry and Li's (2012) findings, this research did not find population density to be a indicator to overall CRS points scores (Table 4.1). The difference between the findings likely stems from the difference in types of communities included in the studies. Landry and Li only examined counties in North Carolina, leaving out smaller CRS communities. This study examined all CRS communities in the coastal zones of three states, including the municipalities below county level. However, when North Carolina communities were isolated (n=48), this study was still unable to reproduce Landry and Li's findings. While the correlation value for population density did increase, using Fisher's *z* transformation to test the statistical difference between population density and the other indicators showed that these are significantly different above a 95% confidence threshold. That analysis indicates that housing value, educational attainment, and SoVI® score are all statistically better indicators of CRS participation than population density in both the whole study area and in North Carolina. Furthermore, Table 4.2 shows the r value associated with 90% certainty is 0.285, substantially above the r value for North Carolina's population density (r = .14), indicating that population density does not indicate CRS participation.

The dasymetric mapping approach facilitates a more precise location of population in a study area. This approach allows determination of statistical difference between the floodplain and the entire community. When conducting a paired t-test between the floodplain and whole community, housing value and population density are shown to have a significant statistical difference (Table 4.3). Since population density is shown not to correlate with CRS score, the statistical difference only demonstrates how values can differ when located specifically. Similarly, the difference between housing value in the floodplain and the whole community shows a statistical difference; however, when comparing the *r* values (using Fisher's *z* transformation), there is no statistical difference between the floodplain and the whole community. This analysis means the applied dasymetric approach adds limited value to further understanding CRS communities in this study area. This dasymetric approach did not provide a distinction between the floodplain and the whole community. The aim of this dasymetric approach was to demonstrate that those living in the floodplain would have more of an impact on CRS score indicators than the whole community.

Table 4.3 Paired T-Test between Floodplain and Whole Community

	Mean Floodplain Value	**Mean Community Value**	**Two-tail T-test p Value**
Median Housing Value	297,001	279,413	0.00008***
Educational Attainment	33.8%	33.3%	0.34479
Population Density	434	628	0.0000002***
SoVI® Score	-1.12	-1.08	0.74652

Note: * Statistical difference p value = 0.01

4.2 SERIES CRS SCORE AND DEMOGRAPHIC ASSOCIATIONS

Brody et al. (2009b) and Brody and Highfield (2013) examined community participation to specific series within the CRS. They demonstrated how communities choose to participate in CRS series and which series reduce flood losses. These results examine indicators of CRS participation by series, highlighting the difference between the floodplain and the whole community (Table 4.4). Fisher's *z* transformation demonstrates the only statistical differences are those between population density and the other variables, meaning while educational attainment in the community consistently has the highest *r* values across the CRS series, those *r* values are not statistically larger than housing value or SoVI® score. This means, statistically speaking, housing value and SoVI® score are as good as educational attainment at indicating CRS participation by series.

Table 4.4 Pearson's *r* value for each CRS Series (n=88). Highlighted values show the highest correlation to each series.

	Housing	**Education**	**PopDen**	**SoVI®**	**H-FP**	**E-FP**	**P-FP**	**S-FP**
300	0.392 ***	0.357 ***	-0.058	-0.235	0.370 ***	0.379 ***	-0.054	-0.302 **
400	0.279 **	0.347 ***	-0.018	-0.384 ***	0.297 ***	0.347 ***	-0.089	-0.401 **
500	0.303 ***	0.321 ***	0.133	-0.133	0.282 **	0.323 ***	0.161	-0.144
600	0.336 ***	0.322 ***	0.042	-0.242 *	0.309	0.298 ***	-0.046	-0.293 **

Note: H = Housing Value; E = Educational Attainment; P = Population Density; S = SoVI®; FP = Floodplain. * $p<0.05$; ** $p<0.02$; *** $p<0.01$

These correlations to CRS series suggest that, despite Brody and Highfield's 2012 findings demonstrating activities in the 400 series perform best at reducing flood losses, communities continue to pursue 300 series more heavily. Table 4.4 demonstrates this by the higher correlation values for 300 series, these results taken in tandem with the results for total CRS score (Table 4.1) demonstrate the more points received from a specific series the higher the *r* value for that series. Brody et al. (2009b) also found communities participating at higher levels in the 300 series. There are several possible implications for this pattern: one is that communities will pursue the less resource-intensive points first (300 series) and build consensus to address more resource-intensive activities in the 400 and 500 series. Table 1.1 shows 300 series has high participation and high awarding of possible points; the 400 series has high participation and lower awarding of possible points; and, the 500 series has lower participation and lower awarding of points. A second possibility is that communities do not necessarily prioritize reducing flood losses, and focus on the more accessible activities to reduce their insurance premiums.

CHAPTER 5

DISCUSSION

The results from this research provide three key insights into understanding community participation in the CRS. The major takeaway from this research is the correlation of the SoVI® scores to CRS participation. This research demonstrates that overall vulnerability is associated with CRS participation; the lower the vulnerability the higher the participation and vice versa. Possibly the most troubling finding from this investigation of SoVI® is the indication that the more social vulnerability a community experiences, the less likely it is to participate at higher classes of CRS. Meaning, the most vulnerable populations are not participating equally in measures that could lower their vulnerability to flooding hazards.

The SoVI® provides a conceptually stronger approach for representing the relationship between vulnerability and CRS scores. Despite SoVI® having slightly lower r values than both housing value and educational attainment, the Fisher's z transformation indicates that the correlations are not significantly different (two tailed p-value between SoVI® and housing value is .69 and two tailed p-value between SoVI® and educational attainment is .52). This strength stems from the multiple factors SoVI® considers versus only the single factors. This multi-factored approach provides a more complex understanding of the vulnerability of participating communities by accounting for more of the demographic characteristics associated with community vulnerability. In more practical terms, this means that while the single factor only says one thing about the community, SoVI® suggests that communities who participate more in CRS tend to have a combination of variables associated with lower vulnerability, such as higher housing values, higher mean incomes, larger Asian populations, higher educational attainment, and lower renter populations. This previous illustration is only for practical understanding of SoVI®, as this research only used total SoVI® scores and not the individual drivers to SoVI® it cannot make claims regarding individual drivers.

These findings also show that despite changes to the CRS in 2013, housing value and educational attainment continue to correlate with higher levels of CRS participation. The persistence of the correlations between CRS scores, educational attainment and housing value suggests that regardless of changes to the CRS program, communities who are participating in the program will continue to be involved. This finding may indicate the need to consider a programmatic shift that better incentivizes all types of communities to participate in the CRS. Landy and Li's (2012) finding that population density is an indicator of CRS participation is not confirmed by this study. Based on these correlations, coupled with the findings about SoVI®, the CRS appears to be a program with less engagement from less affluent and more socially vulnerable communities. In other words, communities which, arguably, could benefit the most from the CRS appear to be participating the least.

The final point is that a dasymetric approach provides limited value for understanding CRS communities in these NC, SC, and GA coastal zones. While the dasymetric approach demonstrated a better correlation in determining 400 series participation, the difference between the floodplain and the whole community was not statistically significant. A possible reason for the limited benefits of examining CRS communities dasymetrically is the selected study region. Most of the communities in the study region had sections that were not in the floodplain; over half of the communities had more than 50% of the community in the floodplain. With such a large portion of the community in the floodplain it is likely that the community as a whole is interested in changes to their community CRS score. A more definitive approach for examining CRS communities dasymetrically may be to study CRS communities in riverine floodplains where larger sections of the community will be outside the floodplain or by using parcel-level data to further refine the population's location.

CHAPTER 6

CONCLUSION

The NFIP is designed to reduce community members' exposure to flood losses, allowing individuals to receive flood insurance. Within the NFIP the CRS allows communities to take collective loss-reducing actions, which in turn lower the communities' insurance premiums and protect the community from flooding events. Understanding which communities participate in the CRS can assist program administrators in refining the CRS to reduce adaptation barriers some communities may experience in participating in the CRS (Klein et al. 2014). Increasing community participation in the CRS would assist in reducing flood losses, which could also reduce post-flood recovery time. The alternative methods for examining CRS communities examined in this research allows for researchers to understand CRS communities through a new lens.

This research demonstrated the value SoVI® in indicating community CRS points score, providing a more structurally sound indicator over the previous single-factors. The SoVI® proves to be an alternate indicator for researchers studying CRS communities, providing correlation coefficients consistent with the best single-factor indicators. This finding should encourage researchers to further examine this and other indices for their ability to provide additional insights into communities' socio-economic standing and ability to respond to hazardous events.

While previous research examined the whole CRS community, this research examined CRS communities through a different approach considering the characteristics of floodplain residents. Past studies determined that flood risk exposure increased communities' involvement in the CRS. This research followed those findings to determine if who specifically was exposed to that risk in the community affected how the community participated. This research showed there was no statistical difference between the whole community and the floodplain, suggesting that perhaps the community perception of flood risk exposure applies to the whole community and not just those in the floodplain. However, the limitations of the dasymetric approach applied here and the lack of information on flood risk perceptions require further research to explore that possibility.

6.1 FUTURE DIRECTIONS

The CRS is a government program which truly addresses the purpose for which is was created: reducing flood losses in communities. The CRS needs to continue to reform to further address flood losses in communities and facilitate for a broader base of communities participating in the CRS. Two items come to mind for future revision to the CRS, the first is tiered requirements based on the number of years a community has been in the CRS. Over time, increasing the number of points required to maintain insurance discounts could push communities towards the more flood reducing activities in the CRS and further increase the effectiveness of the program. The second item to include is a socio-economic multiplier for communities. This socio-economic multiplier could be factored by considering the median income for the community, or the tax revenue for the community and if those are below a certain threshold the community would receive the multiplier. This multiplier would take the community's overall score and multiply it by the multiplier value (whatever that value is determined to be). While this would not initially reduce flood losses, it could encourage communities which do not have many resources to participate in the program. However, even with this multiplier, it would be important for communities to meet the tiered requirements described above after so many years in the CRS. This approach could allow less advantaged communities to access the CRS benefits without fundamentally changing the CRS to a social program. This access to the program could build consensus in the community allowing the community to build participation gradually.

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APPENDIX A – LIST OF CRS COMMUNITIES STUDIED

North Carolina	
	Alliance
	Atlantic Beach
	Bayboro
	Beaufort
	Belhaven
	Cape Carteret
	Carolina Beach
	Carteret County
	Caswell Beach
	Cedar Point
	Craven County
	Creswell
	Currituck County
	Dare County
	Duck
	Edenton
	Emerald Isle
	Havelock
	Holden Beach
	Hyde County
	Jacksonville
	Kill Devils Hill
	Kitty Hawk
	Manteo
	Minnesott Beach
	Morehead City
	Nags Head

	New Hanover County
	Newport
	North Topsail Beachtown
	Oak Island
	Ocean Isle Beach
	Oriental
	Pamlico County
	Pine Knoll Shores
	Plymouth
	River Bend
	Roper
	Southern Shores
	Southport
	Stonewall
	Sunset Beach
	Topsail Beach
	Vandemere
	Washington County
	Washington Park
	Washington
	Wrightsville Beach
South Carolina	
	Awendaw
	Beaufort County
	Beaufort
	Berkeley County
	Charleston
	Charleston County
	Colleton County
	Edisto Beach
	Florence County
	Florence
	Folly Beach
	Georgetown County
	Georgetown
	Hilton Head Island
	Hollywood
	Horry County

	Isle of Palms
	Kiawah Islandtown
	Mcclellanville
	Meggett
	Mount Pleasant
	Myrtle Beach
	North Charleston
	North Myrtle Beach
	Pawleys Island
	Port Royal
	Ravenel
	Rockville
	Seabrook Island
	Sullivans Island
	Surfside Beach
Georgia	
	Brunswick
	Camden County
	Chatham County
	Effingham County
	Glynn County
	Hinesville
	Pooler
	Savannah
	Tybee Island

APPENDIX B – DATA USED

B.1 WHOLE COMMUNITY DATA

North Carolina	Median Housing Value ($)	Educational Attainment (Percent Bachelors or higher 25 and over)	Population Density (per Sq Mi)	SoVI® Score
Alliance	128800	14.6	371.974243	2.36
Atlantic Beach	301600	30.3	642.7446929	-5.51
Bayboro	78100	6.1	681.7074889	2.36
Beaufort	196500	24	871.4456733	-3.95
Belhaven	86000	10.8	1060.697428	2.9
Cape Carteret	260300	33.8	762.4955332	-1.94
Carolina Beach	258700	36.4	2326.992668	-5.03
Carteret County	199200	23.9	130.9404778	-0.9
Caswell Beach	462300	51.3	135.4766843	-3.17
Cedar Point	335800	39	579.6553681	-1.61
Craven County	152400	21	146.4631885	0.19
Creswell	85700	10.9	487.6778419	2.58
Currituck County	223800	18.4	89.89538272	-2.15
Dare County	293900	30.6	88.51434466	-2.84
Duck	573400	58.3	152.7606505	-5.1
Edenton	111100	20.7	931.8533665	2.3
Emerald Isle	390600	46.5	733.2082145	-4.41
Havelock	137600	12.5	1230.674105	-3.18
Holden Beach	481500	55.3	212.1848841	-3.02
Hyde County	76400	10.7	9.488310847	1.04
Jacksonville	153600	23.1	1507.298829	-2.7
Kill Devils Hill	260900	34.3	1189.587161	-3.74
Kitty Hawk	321100	28.2	403.3210281	-4.66

Manteo	400000	32.3	757.5013891	-1.63
Minnesott Beach	194400	35.8	126.7253444	0.32
Morehead City	191300	27.5	1227.840426	-0.02
Nags Head	326200	38.6	418.8732251	-3.12
New Hanover County	215200	36.6	1056.178366	-0.87
Newport	158700	9.2	563.9604527	-0.19
North Topsail Beachtown	286800	41.7	116.965718	-5.86
Oak Island	243200	31.7	363.7030916	-2.96
Ocean Isle Beach	538700	47.4	149.1255163	-0.44
Oriental	322800	51.5	639.1437728	0.04
Pamlico County	157500	18.7	39.05977182	0.47
Pine Knoll Shores	393800	51.3	603.0076493	-3.62
Plymouth	91400	18.4	962.4804039	4.91
River Bend	193400	28.2	1243.330464	4.49
Roper	81800	6.6	713.3875951	2.59
Southern Shores	455200	49.3	687.5470208	-5.1
Southport	245800	36.7	730.2992474	5.05
Stonewall	57300	5.2	164.6569072	0.81
Sunset Beach	273100	45.2	529.0322387	-0.53
Topsail Beach	391500	58.9	83.81335855	-5.72
Vandemere	75300	6.6	166.8561274	2.36
Washington County	89000	11.7	38.17496908	2.8
Washington Park	236600	52.4	1707.75354	1.52
Washington	159900	23.5	1189.826864	2.25
Wrightsville Beach	844700	66.8	1749.23281	-3.08
South Carolina				
Awendaw	149000	17	136.6435059	-1.3
Beaufort County	275500	37.6	281.5246485	-1.43
Beaufort	252700	40.7	441.328357	-1.3
Berkeley County	150400	21.3	161.8328844	-0.83
Charleston	253800	48.9	1101.429065	-2.15
Charleston County	236100	39.4	381.7203746	-1.89
Colleton County	89900	14.7	36.81241837	1.31
Edisto Beach	509000	58.1	194.6532604	-0.37
Florence County	114900	21.3	171.1141592	1.73
Florence	148700	29.8	1708.09841	0.75
Folly Beach	607700	54.8	209.2477609	-4.62
Georgetown County	158800	22.7	73.94159158	1.39
Georgetown	114500	17.7	1320.371469	3.16

Hilton Head Island	447900	48.5	896.9107079	-1.72
Hollywood	200600	28.4	203.7830872	0.12
Horry County	159600	22.7	237.4861052	-0.9
Isle of Palms	792200	65.8	931.7097566	-7.16
Kiawah Islandtown	1000000	80.4	147.9513863	-6.45
Mcclellanville	323300	60.6	223.2002234	0.42
Meggett	360800	32.2	67.31594177	1.37
Mount Pleasant	349200	59.5	1503.349026	-2.97
Myrtle Beach	167100	27.3	1146.031891	-3.77
North Charleston	138300	19	1323.053682	-0.55
North Myrtle Beach	248000	31.9	669.4293444	-2.85
Pawleys Island	1000000	69.1	146.8626322	-4.05
Port Royal	197100	34.6	562.3643219	-3.94
Ravenel	109500	10.1	194.9837121	0.39
Rockville	347500	38.7	316.2914699	0.18
Seabrook Island	705800	68.7	286.6616795	-5.39
Sullivans Island	1000000	75	716.9649675	-7.17
Surfside Beach	246100	31.9	1986.237614	-2.88
Georgia				
Brunswick	94700	12.3	900.3370068	2.97
Camden County	154500	19.5	82.37652825	-1.34
Chatham County	174500	31.3	617.9283562	0.16
Effingham County	155400	16.8	109.3773321	-0.66
Glynn County	162900	26.1	189.6768047	0.29
Hinesville	125800	22.6	1843.184584	-0.04
Pooler	176100	39.4	645.6974236	-1.4
Savannah	145900	26.1	1315.521404	0.59
Tybee Island	351700	37.6	1021.786465	-0.69

B.2 FLOODPLAIN COMMUNITY DATA

North Carolina	**FP Median Housing Value**	**FP Educational Attainment**	**FP Population Density**	**FP SoVI**
Alliance	128800	14.6	371.974243	2.36
Atlantic Beach	238733	25.72062084	556.6289014	-5.45
Bayboro	78100	6.1	681.7074889	2.36

Beaufort	247240	24.98063517	432.4881485	-0.95
Belhaven	86000	10.8	1060.697428	2.9
Cape Carteret	283300	40.76923077	271.9748713	-1.53
Carolina Beach	277525	37.24241289	837.110163	-4.47
Carteret County	251758	26.44636502	56.85040984	-0.43
Caswell Beach	423100	50.45731707	175.0793714	-3.17
Cedar Point	288800	33.00153139	389.1929822	-1.61
Craven County	166220	26.48597398	136.7495952	0.53
Creswell	85700	10.9	487.6778419	2.58
Currituck County	245758	18.81460549	62.18362035	-2.08
Dare County	312292	31.22674349	46.55903261	-2.57
Duck	573400	58.3	152.7606505	-5.1
Edenton	206050	28.42424242	259.1329631	6.12
Emerald Isle	466266	39.15391539	500.7756712	-4.69
Havelock	121088	12.5	115.5850911	-6.28
Holden Beach	469200	55.28455285	272.6338658	-3.02
Hyde County	154300	10.68775461	6.81492619	1.04
Jacksonville	107285	23.16021288	746.5617972	-2.11
Kill Devils Hill	260075	35.79608423	844.8753807	-4.67
Kitty Hawk	332700	28.0390417	250.3139602	-3.89
Manteo	400000	32.3	757.5013891	-1.63
Minnesott Beach	176000	19.81799798	61.40189916	0.32
Morehead City	228300	31.0802139	631.0251775	-0.12
Nags Head	262950	36.35676493	110.0469974	-1.87
New Hanover County	350230	40.57978385	465.1683359	-2.52
Newport	230050	12.6142596	400.2573489	1.74
North Topsail Beachtown	286800	41.7	116.965718	-5.86
Oak Island	248866	39.6589659	408.6095606	-1.92
Ocean Isle Beach	547433	47.36842105	248.8096146	-3.9
Oriental	322800	51.5	639.1437728	0.04
Pamlico County	192100	23.75259875	28.70489066	1.01
Pine Knoll Shores	393800	51.3	603.0076493	-3.62
Plymouth	81400	23.29032258	261.7946765	4.91
River Bend	210100	34.49408673	1496.213087	4.49
Roper	79200	8.268330733	85.3061709	2.58
Southern Shores	461900	48.66180049	568.1002484	-5.1
Southport	254866	31.38564274	560.4272201	3.71
Stonewall	235400	19.3220339	22.05247921	-0.24
Sunset Beach	279550	23.3974359	319.751808	0.09

Topsail Beach	391500	58.9	83.81335855	-5.27
Vandemere	75300	6.6	166.8561274	2.36
Washington County	87966	13.98392223	491.3425325	3.75
Washington Park	236600	52.4	1707.75354	1.52
Washington	111420	18.91288161	949.9070247	2.93
Wrightsville Beach	881800	66.8360864	195.4315933	-3.52
South Carolina				
Awendaw	163200	30.19145803	16.07785253	-1.92
Beaufort County	297278	39.19625588	116.9538274	-0.41
Beaufort	277175	32.05972066	280.325594	-4.56
Berkeley County	205221	31.67394038	89.60806965	-2.35
Charleston	341042	49.46492021	935.5505273	-2.79
Charleston County	336157	42.14602368	106.7365807	-1.42
Colleton County	108650	11.89631064	16.55604054	0.71
Edisto Beach	542400	60.10230179	113.9550223	-0.37
Florence County	121770	23.73154074	630.7546871	1.19
Florence	192057	40.88014981	843.2775245	-0.57
Folly Beach	607700	54.4	209.2477609	-4.62
Georgetown County	266915	21.73811197	35.57957432	1.3
Georgetown	176666	25.0363901	832.7478719	3.07
Hilton Head Island	503290	48.66669539	699.435466	-1.95
Hollywood	200600	28.4	203.7830872	0.12
Horry County	176747	19.6254446	118.1835074	-0.63
Isle of Palms	792200	65.8	931.7097566	-7.16
Kiawah Islandtown	1000000	80.4	147.9513863	-6.45
Mcclellanville	323300	60.6	223.2002234	0.42
Meggett	360800	32.2	67.31594177	1.37
Mount Pleasant	398241	60.47800763	782.4496679	-3.11
Myrtle Beach	220422	28.24911868	1139.701902	-3.87
North Charleston	116050	12.20435194	1140.7785	-0.03
North Myrtle Beach	264300	30.43606364	1022.254504	-0.03
Pawleys Island	1000000	69.1	146.8626322	-4.05
Port Royal	203766	39.70873786	401.4278888	-0.97
Ravenel	87600	0	234.5432974	-0.71
Rockville	347500	38.7	316.2914699	0.18
Seabrook Island	705800	68.7	286.6616795	-5.39
Sullivans Island	1000000	75	716.9649675	-7.17
Surfside Beach	291833	30.18469657	1552.821406	-2.47
Georgia				

Brunswick	105638	10.4534005	513.7495391	2.97
Camden County	165736	22.42713039	41.10875294	-1.37
Chatham County	248641	38.94578991	228.9979195	-1
Effingham County	164209	19.17926566	111.1566158	-0.59
Glynn County	203465	29.67148003	86.34539127	0.15
Hinesville	127683	22.56086399	908.4705488	0.14
Pooler	160540	39.4	376.7628506	-0.91
Savannah	134850	25.69787936	485.8635421	0.75
Tybee Island	366633	35.43478261	1051.932106	-0.69

B.3 300 SERIES CRS DATA – 2014

North Carolina	**310 Elevation Cert**	**320 Map Info Service**	**330 Outreach Projects**	**340 Hazard Disclosure**	**350 Flood Protection Info**	**360 Flood Protection Assist**	**300 Total**
Alliance	56	140	0	5	27	0	228
Atlantic Beach	45	140	217	5	62	0	469
Bayboro	56	140	68	5	27	0	296
Beaufort	56	140	86	5	28	0	315
Belhaven	56	140	168	5	66	0	435
Cape Carteret	48	140	104	5	71	0	368
Carolina Beach	56	140	250	10	70	0	526
Carteret County	90	140	176	10	70	0	486
Caswell Beach	79	140	184	5	28	35	471
Cedar Point	56	140	131	10	67	0	404
Craven County	112	140	163	10	64	0	489
Creswell	56	140	211	15	26	48	496
Currituck County	112	140	182	10	56	0	500
Dare County	56	140	131	5	54	0	386
Duck	70	140	153	10	69	0	442
Edenton	56	140	0	10	0	0	206
Emerald Isle	50	140	179	10	25	0	404
Havelock	56	140	207	5	59	0	467
Holden Beach	56	140	65	10	47	0	318
Hyde County	56	0	28	5	59	0	148
Jacksonville	112	140	36	15	56	0	359

Kill Devils Hill	56	140	212	15	84	59	566
Kitty Hawk	56	140	264	5	76	0	541
Manteo	56	140	213	5	69	0	483
Minnesott Beach	56	140	0	5	27	0	228
Morehead City	56	140	203	10	80	0	489
Nags Head	56	140	246	10	77	0	529
New Hanover County	70	140	105	10	53	0	378
Newport	56	140	182	10	32	0	420
North Topsail Beachtown	56	140	207	10	20	0	433
Oak Island	56	140	78	10	59	0	343
Ocean Isle Beach	56	140	129	10	73	62	470
Oriental	56	140	68	5	27	0	296
Pamlico County	56	140	68	5	27	0	296
Pine Knoll Shores	56	140	144	5	78	0	423
Plymouth	56	140	211	15	26	48	496
River Bend	74	140	177	5	49	0	445
Roper	56	140	211	15	26	48	496
Southern Shores	56	140	180	10	27	0	413
Southport	56	140	102	10	31	0	339
Stonewall	56	140	68	5	27	0	296
Sunset Beach	56	140	0	10	41	0	247
Topsail Beach	56	140	167	0	20	67	450
Vandemere	56	140	68	5	27	0	296
Washington County	56	140	211	15	71	48	541
Washington Park	56	140	105	5	55	49	410
Washington	54	140	74	5	51	59	383
Wrightsville Beach	56	140	187	15	73	0	471
South Carolina							
Awendaw	95	140	285	5	102	63	690
Beaufort County	102	140	167	10	83	0	502
Beaufort	80	140	173	66	92	0	551
Berkeley County	56	140	0	10	27	0	233
Charleston	46	140	297	5	66	45	599
Charleston County	70	140	296	5	95	68	674
Colleton County	70	140	154	5	58	0	427

Edisto Beach	112	140	213	10	65	0	540
Florence County	90	140	106	5	20	0	361
Florence	66	140	118	5	61	0	390
Folly Beach	84	140	171	10	79	0	484
Georgetown County	56	140	97	20	48	0	361
Georgetown	56	140	173	61	24	0	454
Hilton Head Island	116	140	140	81	90	68	635
Hollywood	95	140	285	5	102	59	686
Horry County	56	0	0	10	22	0	88
Isle of Palms	82	140	193	10	64	59	548
Kiawah Islandtown	95	140	291	5	102	59	692
Mcclellanville	51	140	285	15	102	59	652
Meggett	95	140	285	5	102	59	686
Mount Pleasant	66	140	180	10	58	67	521
Myrtle Beach	66	140	210	15	60	52	543
North Charleston	56	140	179	5	77	0	457
North Myrtle Beach	56	140	178	10	24	0	408
Pawleys Island	81	140	300	0	85	27	633
Port Royal	56	140	0	10	27	0	233
Ravenel	95	140	285	5	102	59	686
Rockville	95	140	285	5	102	59	686
Seabrook Island	95	140	310	5	102	59	711
Sullivans Island	95	140	284	5	76	63	663
Surfside Beach	56	0	12	10	24	0	102
Georgia							
Brunswick	56	70	81	5	0	0	212
Camden County	56	140	171	10	47	59	483
Chatham County	56	140	229	10	98	67	600
Effingham County	66	140	0	10	53	45	314
Glynn County	54	140	169	10	90	35	498
Hinesville	102	140	41	10	42	62	397
Pooler	56	140	243	10	61	0	510
Savannah	71	140	250	10	85	70	626
Tybee Island	56	140	207	10	83	54	550

B.4 400 SERIES CRS DATA – 2014

North Carolina	410 Additional Flood Data	420 Open Space Preserve	430 Higher Regu Standards	440 Flood Data Mainten	450 Storm water Managem	400 Total
Alliance	10	0	224	120	55	409
Atlantic Beach	60	74	284	115	30	563
Bayboro	10	0	224	105	55	394
Beaufort	10	342	101	105	30	588
Belhaven	10	36	151	50	30	277
Cape Carteret	10	0	206	105	30	351
Carolina Beach	60	74	258	115	65	572
Carteret County	60	81	186	105	30	462
Caswell Beach	60	81	409	74	30	654
Cedar Point	32	0	99	105	75	311
Craven County	10	36	271	162	30	509
Creswell	10	0	278	136	30	454
Currituck County	60	0	257	103	30	450
Dare County	82	91	237	93	55	558
Duck	60	74	333	129	45	641
Edenton	10	36	239	0	30	315
Emerald Isle	60	74	548	107	30	819
Havelock	32	36	95	96	75	334
Holden Beach	60	74	236	105	0	475
Hyde County	10	46	122	0	30	208
Jacksonville	10	46	360	77	30	523
Kill Devils Hill	60	84	387	103	60	694
Kitty Hawk	60	370	345	103	60	938
Manteo	10	36	90	100	30	266
Minnesott Beach	10	0	224	105	55	394
Morehead City	32	54	171	71	75	403
Nags Head	82	251	385	129	80	927
New Hanover County	60	84	453	121	30	748
Newport	32	0	226	97	75	430
North Topsail	60	91	523	95	30	799

Beachtown						
Oak Island	60	74	305	97	55	591
Ocean Isle Beach	60	74	515	133	90	872
Oriental	32	0	239	113	75	459
Pamlico County	32	46	230	105	75	488
Pine Knoll Shores	82	362	429	213	75	1161
Plymouth	10	0	278	136	30	454
River Bend	10	173	229	77	0	489
Roper	10	0	278	136	30	454
Southern Shores	60	248	480	113	30	931
Southport	10	36	270	105	30	451
Stonewall	10	0	224	105	55	394
Sunset Beach	60	74	312	115	30	591
Topsail Beach	50	415	200	89	70	824
Vandemere	32	0	239	105	75	451
Washington County	10	0	246	136	30	422
Washington Park	10	36	131	118	75	370
Washington	10	124	131	100	75	440
Wrightsville Beach	60	291	295	103	55	804
South Carolina						
Awendaw	10	61	351	120	60	602
Beaufort County	10	80	490	113	307	1000
Beaufort	10	44	231	113	220	618
Berkeley County	0	46	375	120	80	621
Charleston	10	36	169	96	40	351
Charleston County	115	46	914	133	370	1578
Colleton County	10	305	232	69	40	656
Edisto Beach	10	0	406	161	30	607
Florence County	10	0	45	55	40	150
Florence	10	454	224	105	75	868
Folly Beach	10	83	467	90	75	725
Georgetown County	0	46	202	113	75	436
Georgetown	0	36	48	60	70	214
Hilton Head Island	35	389	287	162	225	1098
Hollywood	10	36	351	143	60	600
Horry County	10	44	250	55	0	359

Isle of Palms	10	106	150	80	20	366
Kiawah Islandtown	10	86	302	118	60	576
Mcclellanville	10	36	312	130	60	548
Meggett	10	145	426	139	60	780
Mount Pleasant	10	44	588	77	75	794
Myrtle Beach	35	251	654	194	240	1374
North Charleston	10	36	330	113	92	581
North Myrtle Beach	10	46	264	113	225	658
Pawleys Island	0	190	395	207	0	792
Port Royal	10	0	99	88	40	237
Ravenel	10	36	408	105	60	619
Rockville	10	36	383	185	60	674
Seabrook Island	10	341	232	122	60	765
Sullivans Island	10	301	244	79	40	674
Surfside Beach	0	0	294	55	0	349
Georgia						
Brunswick	10	44	261	0	0	315
Camden County	10	36	218	103	80	447
Chatham County	10	198	278	195	55	736
Effingham County	10	46	569	89	129	843
Glynn County	10	36	291	113	75	525
Hinesville	10	54	457	136	210	867
Pooler	10	80	357	132	15	594
Savannah	10	44	473	146	15	688
Tybee Island	10	160	201	56	15	442

B.5 500 SERIES CRS DATA – 2014

North Carolina	**510 FP Managem Planning**	**520 Acquisition and Relocation**	**530 Flood Protection**	**540 Drainage System Maint**	**500 Total**
Alliance	0	0	0	15	15
Atlantic Beach	136	0	0	30	166
Bayboro	0	0	0	30	30
Beaufort	0	0	0	30	30

Belhaven	95	0	482	230	807
Cape Carteret	132	0	0	210	342
Carolina Beach	87	0	0	230	317
Carteret County	109	0	0	30	139
Caswell Beach	148	0	0	280	428
Cedar Point	109	0	0	30	139
Craven County	128	40	0	15	183
Creswell	0	0	0	230	230
Currituck County	134	0	0	30	164
Dare County	91	0	0	30	121
Duck	114	0	0	15	129
Edenton	0	0	0	240	240
Emerald Isle	111	0	0	268	379
Havelock	0	0	0	190	190
Holden Beach	121	0	0	30	151
Hyde County	127	0	21	15	163
Jacksonville	88	0	0	203	291
Kill Devils Hill	91	0	0	315	406
Kitty Hawk	91	55	0	30	176
Manteo	0	0	0	190	190
Minnesott Beach	0	0	0	15	15
Morehead City	118	0	0	170	288
Nags Head	91	0	34	300	425
New Hanover County	160	85	0	15	260
Newport	0	0	0	218	218
North Topsail Beachtown	110	80	0	30	220
Oak Island	115	0	42	30	187
Ocean Isle Beach	134	70	0	210	414
Oriental	177	0	0	30	207
Pamlico County	177	0	0	30	207
Pine Knoll Shores	0	0	0	230	230
Plymouth	0	0	0	230	230
River Bend	138	0	0	230	368
Roper	0	0	0	230	230
Southern Shores	0	0	0	30	30
Southport	0	0	0	15	15
Stonewall	0	0	0	30	30
Sunset Beach	0	0	0	135	135
Topsail Beach	108	100	28	218	454

Vandemere	177	0	0	30	207
Washington County	0	0	0	230	230
Washington Park	113	0	0	280	393
Washington	113	180	59	230	582
Wrightsville Beach	110	70	234	30	444
South Carolina					
Awendaw	260	0	0	315	575
Beaufort County	0	0	0	300	300
Beaufort	0	20	0	268	288
Berkeley County	0	0	0	15	15
Charleston	260	0	0	268	528
Charleston County	310	0	0	270	580
Colleton County	103	0	0	253	356
Edisto Beach	101	0	17	180	298
Florence County	0	0	0	0	0
Florence	0	0	0	243	243
Folly Beach	260	0	0	30	290
Georgetown County	151	0	0	0	151
Georgetown	0	0	0	265	265
Hilton Head Island	170	0	0	255	425
Hollywood	260	0	0	315	575
Horry County	105	0	0	0	105
Isle of Palms	260	0	84	315	659
Kiawah Islandtown	260	0	0	280	540
Mcclellanville	260	0	0	315	575
Meggett	260	0	0	315	575
Mount Pleasant	260	0	0	203	463
Myrtle Beach	80	25	0	147	252
North Charleston	260	0	0	210	470
North Myrtle Beach	252	0	155	280	687
Pawleys Island	151	0	0	280	431
Port Royal	0	0	0	0	0
Ravenel	260	0	0	315	575
Rockville	260	0	0	315	575
Seabrook Island	260	0	0	330	590
Sullivans Island	260	0	0	268	528
Surfside Beach	105	0	0	0	105
Georgia					
Brunswick	0	0	0	0	0

Camden County	0	0	0	268	268
Chatham County	178	130	0	218	526
Effingham County	0	0	0	250	250
Glynn County	95	0	0	230	325
Hinesville	0	0	0	288	288
Pooler	0	0	0	270	270
Savannah	250	300	0	230	780
Tybee Island	0	0	0	268	268

B.6 600 SERIES CRS DATA – 2014

North Carolina	**610 Flood Warning**	**620 Levee Safety**	**630 Dam Safety**	**600 Total**
Alliance	0	0	52	52
Atlantic Beach	0	0	58	58
Bayboro	0	0	52	52
Beaufort	0	0	52	52
Belhaven	80	0	58	138
Cape Carteret	0	0	58	58
Carolina Beach	120	0	58	178
Carteret County	0	0	52	52
Caswell Beach	130	0	58	188
Cedar Point	110	0	52	162
Craven County	0	0	52	52
Creswell	140	0	58	198
Currituck County	40	0	58	98
Dare County	155	0	52	207
Duck	120	0	52	172
Edenton	0	0	58	58
Emerald Isle	130	0	52	182
Havelock	108	0	52	160
Holden Beach	0	0	52	52
Hyde County	65	0	58	123
Jacksonville	0	0	52	52
Kill Devils Hill	130	0	52	182
Kitty Hawk	120	0	52	172
Manteo	120	0	52	172

Minnesott Beach	0	0	52	52
Morehead City	105	0	52	157
Nags Head	120	0	52	172
New Hanover County	0	0	52	52
Newport	0	0	52	52
North Topsail Beachtown	40	0	52	92
Oak Island	40	0	52	92
Ocean Isle Beach	110	0	58	168
Oriental	0	0	52	52
Pamlico County	0	0	52	52
Pine Knoll Shores	145	0	52	197
Plymouth	131	0	58	189
River Bend	0	0	52	52
Roper	140	0	58	198
Southern Shores	120	0	52	172
Southport	0	0	52	52
Stonewall	0	0	52	52
Sunset Beach	0	0	52	52
Topsail Beach	130	0	58	188
Vandemere	0	0	52	52
Washington County	111	0	58	169
Washington Park	0	0	52	52
Washington	60	0	52	112
Wrightsville Beach	130	0	58	188
South Carolina				
Awendaw	130	0	40	170
Beaufort County	67	0	40	107
Beaufort	60	0	40	100
Berkeley County	0	0	40	40
Charleston	180	0	40	220
Charleston County	205	0	40	245
Colleton County	75	0	40	115
Edisto Beach	125	0	40	165
Florence County	0	0	40	40
Florence	0	0	40	40
Folly Beach	0	0	40	40
Georgetown County	0	0	40	40
Georgetown	0	0	57	57
Hilton Head Island	100	0	40	140

Hollywood	130	0	40	170
Horry County	0	0	40	40
Isle of Palms	176	0	40	216
Kiawah Islandtown	130	0	40	170
Mcclellanville	130	0	40	170
Meggett	130	0	40	170
Mount Pleasant	180	0	40	220
Myrtle Beach	95	0	40	135
North Charleston	180	0	40	220
North Myrtle Beach	0	0	40	40
Pawleys Island	140	0	57	197
Port Royal	0	0	40	40
Ravenel	130	0	40	170
Rockville	130	0	40	170
Seabrook Island	130	0	40	170
Sullivans Island	130	0	40	170
Surfside Beach	0	0	40	40
Georgia				
Brunswick	90	0	62	152
Camden County	0	0	62	62
Chatham County	110	0	64	174
Effingham County	0	0	62	62
Glynn County	135	0	62	197
Hinesville	0	0	62	62
Pooler	150	0	62	212
Savannah	150	0	62	212
Tybee Island	165	0	62	227