Modeling Scenarios for Flood Loss Reduction in Escambia County, FL

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Introduction

Increasing physical risk combined with rapid land use change and development in flood-prone areas has amplified the adverse impacts of flooding in the United States (U.S.). Never before have the repercussions from both surge and rainfall-based storm events been so damaging to the economic vitality of local communities. Losses from both acute and chronic flood events are especially problematic in low-lying coastal areas, where development has accelerated in recent decades. The average annual property damage caused by floods has increased approximately 54 times over the last four decades (Brody et al., 2011). From 2003 to 2013 alone, property owners in the U.S. claimed over $3.5 billion per year in insured flood losses. Counties/parishes along the Gulf of Mexico coastline reported almost $21.5 billion of this total. These property damage estimates help solidify what has been generally understood for years: that floods pose a major risk to communities and with increasing development in coastal areas the problem is growing worse.

In an effort to counteract mounting flood losses, FEMA introduced the Community Rating System (CRS) in 1990 as a way to encourage local jurisdictions to exceed the National Flood Insurance Program's (NFIP) minimum standard for floodplain management. The program has grown since its inception and now includes over 1,200 participating communities, including Escambia County. While some previous research has been conducted on the effects of the CRS at the regional and national levels (Brody et al., 2007; Brody et al., 2008; Landry and Jingyuan, 2012; Highfield and Brody, 2013; Brody and Highfield, 2013), little work has been done to understand the degree to which specific mitigation activities under the CRS can reduce observed flood losses for a specific community.

This study addresses the lack of local-level knowledge about the effectiveness of the CRS and associated mitigation techniques by quantitatively examining flood losses in Escambia County, Florida. Escambia as a whole has long been considered a national hotspot for flooding due to its vulnerability to precipitation and hurricane-based events. For example, from 1996 to 2007, Escambia incurred over $308 million in insured flood losses, the second-most loss out of every county in the state (Brody et al., 2011). In recognition of the mounting flood losses in Escambia County and the lack of knowledge about which mitigation techniques offer the greatest benefit in loss reduction, this study pursues the following research objectives:

1) Catalogue and spatially analyze insured flood losses for unincorporated Escambia County;
2) Leverage a national dataset and corresponding statistical model to "down-scale" the effects of the most significant CRS activities to Escambia County.
3) Estimate the percent reduction in insured flood losses based on the implementation of certain CRS activities for Escambia County; and

4) Conduct "what if scenarios" based on changing contextual conditions within the County to estimate future flood losses.

The Community Rating System

In 1990, to counteract the growing problem of flood losses, FEMA introduced the CRS as a way to encourage local jurisdictions to exceed the NFIP's minimum standards for floodplain management. Participating communities adopt primarily non-structural flood mitigation measures in exchange for an NFIP premium discount of up to 45 percent. The CRS program categorizes planning and management activities into four "series" containing 18 mitigation "activities" (see Table 1).

Public information (Series 300) activities indicate the ability of a local jurisdiction to inform its residents about flood hazards, insurance, and household protection measures. Six public information activities comprise this series: *310 elevation certificates; 320 map information service; 330 outreach projects; 340 hazard disclosure; 350 flood protection information;* and *360 flood protection assistance*. Mapping and regulation (Series 400) activities involve both critical data needs and regulations that exceed NFIP minimum standards. Activities that make up Series 400 include: *410 additional flood data; 420 open space preservation; 430 higher regulatory standards; 440 flood data maintenance;* and *450 stormwater management*. Damage reduction (Series 500) activities require specific mitigation techniques, such as acquiring, relocating, or retrofitting existing buildings. This series is composed of four activities: *510 floodplain management planning; 520 acquisition and relocation; 530 flood protection;* and *540 drainage system maintenance.* Finally, flood preparedness (Series 600) entails coordinating local agencies and their programs to minimize the adverse effects of floods. Specific activities in series 600 are: *610 flood warning program; 620 levee safety;* and *630 dam safety* (for more information see: http://training.fema.gov/EMIWeb/CRS/).

Table 1 Nationwide Summary of CRS Activity Points

Activity	Maximum Possible Points	Average Points Earned	Maximum Points Earned	Percentage of Communities Credited
300 Public Information Activities				
310 Elevation Certificates	162	69	142	100%
320 Map Information Service	140	138	140	95%
330 Outreach Projects	380	90	290	86%
340 Hazard Disclosure	81	19	81	61%
350 Flood Protection Information	102	24	66	87%

360 Flood Protection Assistance	71	53	71	48%
400 Mapping & Regulatory Activities				
410 Additional Flood Data	1,346	86	521	29%
420 Open Space Preservation	900	191	734	83%
430 Higher Regulatory Standards	2,740	166	1,041	85%
440 Flood Data Maintenance	239	79	218	68%
450 Stormwater Management	670	98	490	74%
500 Flood Damage Reduction Activities				
510 Floodplain Management Planning	359	115	270	20%
520 Acquisition and Relocation	3,200	213	2,084	13%
530 Flood Protection	2,800	93	813	6%
540 Drainage System Maintenance	330	232	330	69%
600 Flood Preparedness Activities				
610 Flood Warning Program	255	93	200	30%
620 Levee Safety	900	198	198	1%
630 Dam Safety	175	66	87	81%

Source: FEMA, 2007. National Flood Insurance Program Community Rating System Coordinator's Manual.

Credit points are assigned for the different flood mitigation activities falling within designated series, but activities do not carry the same amount of credit. As shown in Table 1, more points are available to communities that implement what should be more effective flood mitigation actions. For example, under series 400 most of the available credit points (2,740) are found in *Higher Regulatory Standards,* which includes "elements" such as requiring freeboard on structures built in floodplains, preserving natural and beneficial functions, lowering the substantial improvement threshold, and protecting the storage capacity of floodplains from fill and construction. In contrast, only 239 points are available for *Flood Data Maintenance.* The same imbalance can be seen in series 500, where the most points (3,200) are available for acquiring and relocating insurable buildings in the floodplain. Conversely, only 359 points are available for *Floodplain Management Planning* and 330 points for *Drainage System Maintenance.* Thus, the points are generally weighted more toward non-structural activities perceived as effective.

Table 2 CRS Flood Insurance Premium Discounts by Class

Credit Points	Class	SFHA Discount	Non-SFHA Discount
4,500 +	1	45%	5%
4,000 – 4,499	2	40%	5%
3,500 – 3,999	3	35%	5%
3,000 – 3,499	4	30%	5%
2,500 – 2,999	5	25%	5%
2,000 – 2,499	6	20%	5%
1,500 – 1,999	7	15%	5%
1,000 – 1,499	8	10%	5%
500 – 999	9	5%	5%
0 – 499	10	0%	0%

Source: FEMA, 2007. National Flood Insurance Program Community Rating System Coordinator's Manual.

The total number of credit points obtained by a participating locality is used to determine the extent of insurance premium discounts. Credit points are aggregated into “classes,” from 9 (lowest) to 1(highest). Communities awarded a higher CRS class will have implemented a greater number of the 18 flood mitigation measures and therefore receive a higher premium discount for insurance coverage. Discounts range from 5 (class 9) to 45 percent (class 1), depending on the degree to which a community plans for the adverse impacts of floods (see Table 2 for more detail). While the local jurisdiction takes responsibility for implementing each activity, the individual homeowner receives the discount on their national flood insurance premium. The CRS program is also revenue neutral: as premium discounts are applied to communities practicing better floodplain management, base flood insurance rates are scaled upward. Since 1990 community participation in the CRS has increased steadily and has included some communities with the highest numbers of flood insurance policies – and highest risk - in the nation. As of May 2013, 1,249 communities participate in the CRS, a small proportion of the 24,000+ NFIP communities. However, approximately 66% of all flood insurance policies are in CRS participating communities.

Analyzing Specific CRS Activities Using a National Sample of Communities

The first step in this study is to identify which specific CRS flood mitigation activities significantly reduce observed flood losses and how much, on average, are they saving local communities. To accomplish this aim, we select 450 CRS-participating communities as a nationally representative sample with which to statistically assess the performance of specific CRS activities and their elements. For each selected community, we track CRS point totals on a yearly basis over an eleven-year study period from 1999 to 2009 and test their impacts on insured loss claim payments. To better isolate the effect of each CRS activity/element, we statistically control for multiple hydrological, socioeconomic, and risk-based variables. In total, we select for analysis 9 CRS activities and 11 individual elements within these activities. Through this research approach, we are able to identify the CRS activities/elements that have the greatest effect on reducing property damage caused by floods and quantify in dollar amounts their expected savings.

Selecting the Study Sample

Study findings are based on an analysis of a simple random sample of 450 communities participating in the CRS. Findings of the study should be considered representative of all CRS communities in the U.S. such that results can be extended to a national programmatic level. Forty-Five percent of selected communities are coastally located and 21 percent are counties or county equivalent. The average population for communities in the sample was 122,000 (with a median of 40,781). As shown in Table 3, the communities selected for analysis reflect the distribution of NFIP policies nationwide, where Florida contains the largest number. Finally, the sample was very "balanced" in that 96 percent of the communities were present for the entire 11-year study period.

Table 3: Distribution of Study Sample

State	Freq.	Percent	State	Freq.	Percent
AL	4	0.89	**MS**	7	1.56
AR	4	0.89	**MT**	4	0.89
AZ	14	3.11	**NC**	43	9.56
CA	29	6.44	**NE**	1	0.22
CO	19	4.22	**NJ**	19	4.22
CT	2	0.44	**NM**	5	1.11
DE	3	0.67	**NV**	2	0.44
FL	100	22.22	**NY**	12	2.67
GA	10	2.22	**OH**	3	0.67
IA	1	0.22	**OK**	7	1.56
ID	13	2.89	**OR**	7	1.56
IL	12	2.67	**PA**	7	1.56
IN	9	2	**RI**	2	0.44
KS	2	0.44	**SC**	12	2.67
KY	7	1.56	**TN**	4	0.89
LA	20	4.44	**TX**	19	4.22
MA	2	0.44	**UT**	4	0.89
MD	2	0.44	**VA**	9	2
ME	9	2	**VT**	1	0.22
MI	3	0.67	**WA**	8	1.78
MN	2	0.44	**WI**	6	1.33
MO	1	0.22			

Measurement of Variables

Flood impacts were measured based on NFIP insured loss claim payments, which were broken down into nine different categories. As shown in Table 4, property damage was evaluated separately according to Total, Contents, and Building-related losses. Within each of these designations, damages were further divided by A-V FEMA flood zones and B, C, and X zones. Overall, the study captured approximately $11 billion in total NFIP losses, 80 percent of which occurred in the A-Z flood zones. The percentage of damage in the B, C, and X zones was substantially higher among coastal communities.

Table 4: Measurement of Insured Losses

Damage Category	Mean	Std. Dev.	Min	Max
Total Damage	2,247,526	97,900,000	0	6,720,000,000
A-V Zone	1,853,905	84,800,000	0	5,840,000,000
B-C-X	387,395	13,100,000	0	869,000,000
Total Contents	421,932	17,200,000	0	1,170,000,000
A-V Zone Contents	324,610	13,900,000	0	949,000,000
B-C-X Contents	93,713	3,227,415	0	212,000,000
Total Building	1,825,594	80,700,000	0	5,550,000,000
A-V Zone Building	1,529,295	70,900,000	0	4,890,000,000
B-C-X Building	293,682	9,858,951	0	658,000,000

Nine CRS activities and 11 elements were measured and analyzed to test their impact on insured flood losses (see Table 5). Activities and elements were selected based on the CRS Project Team. Activities were not analyzed if they had nearly 100 percent or less than 1 percent participation rate due to lack of variation to explain flood losses. The CRS credit score for each activity and element examined in the study was tracked on a yearly basis from 1999 to 2009. Most variables increased their scores over time, but several actually decreased in intensity over the study period.

Table 5: Activities and Elements Analyzed

Activity	Element
410 – Additional Flood Data	Floodway Standards (FWS) All w/o Floodway Standards (410 Reduced)
420 – Open Space Preservation	Entire Activity
430 – Higher Regulatory Standards	Freeboard (FRB) Cumulative Substantial Improvement (CSI/LSI) BCEGS (separate analysis) All w/o the above elements (430 Reduced)
450 – Stormwater Management	Stormwater Management Regulations (SMR) Freeboard in X Zones (FRX - X zone claims only) Erosion and Sedimentation Controls (ESC) + Water Quality Regulations (WQ)
510 – Floodplain Management Planning	Floodplain Management Plan (FMP)
520 – Acquisition and Relocation	Entire Activity
530 – Flood Protection	Entire Activity
540 – Drainage System Maintenance	Channel & Debris Removal (CDR)

610 – Flood Warning Program	Entire Activity

Table 6 shows descriptive statistics for CRS variables analyzed in the study, including average, minimum, and maximum number of credit points. Because there are communities in the sample that had 0 credit points for some activities or elements, the average scored are fairly low considering the maximum number of point attainable. For example, on average, communities in the study sample received only .8 percent of the total possible points for acquisition and relocation (activity 520) of buildings in the SFHA. This result is due in part because almost 85 percent of the sample had no credit for activity 520. In contrast, adoption of channel and debris removal (element CDR) was more common, and as a result, sample communities were accredited on average almost 60 percent of the available points. Over 20 communities received the highest possible score for this element.

Table 6: Descriptive Statistics for CRS Variables

Variable	Observation	Mean	Std. Dev.	Min	Max
410 Reduced	4395	17.41701	48.18503	0	600
FWS	4395	12.04602	40.46038	0	400
420	4842	132.7784	153.7663	0	725
430 Reduced	4395	84.47223	110.3485	0	758
FRB	4395	46.25884	61.32668	0	300
CSI/LSI	4395	14.77172	28.61078	0	133
BECGs Residential	3302	4.41126	1.655364	1	10
450	4842	86.53201	79.63544	0	490
SMR/SMP	4395	37.7959	61.55587	0	370
FRX	4395	12.96496	21.33399	0	150
ESC/WQ	4395	35.65484	24.88439	0	70
510	4842	22.82693	52.48154	0	265
520	4842	26.48038	151.0337	0	2364
530	4842	5.778397	54.37717	0	1053
610	4842	32.37836	55.81445	0	20

To isolate the effect of each CRS activity/element on insured flood losses and reduce the possibility of finding spurious relationships, an array of variables were included in the models as statistical controls. As shown in Table 7, variables were arranged into the following four major categories: Flood Risk, Inundation, Socioeconomic/Built Environment, and Other.

Under flood risk variables, we measured for each jurisdiction in the sample floodplain area, soil permeability, and slope. Floodplain area was measured as the proportion of each locality containing land within the 100-year floodplain. The average percentage of floodplain area among all study locations was just over 27 percent. It is presumed that larger areas of floodplain will lead to more flooding and associated property damages.

Soil permeability relates to the degree to which precipitation and runoff infiltrate into the ground. Porous soils, such as those with high sand content drain much more quickly than low porosity soils, making them a potentially more resilient substrate for development. We expect that communities containing soils with higher levels of porosity will incur significantly lower amounts of property damage from floods. Soil permeability data was collected from the Soil Survey Geographic Database (SSURGO) and measured as an infiltration rate in inches per hour.

Slope was measured using 30 meter Digital Elevation Models (DEMs) to calculate the average percent elevation across each jurisdiction in the sample. Generally, steeper slopes increase rainfall concentration, causing faster and higher stream peaks as well as mean annual flows (Stuckey, 2006). Because this study analyzed a nationally-representative sample, including low-lying coastal areas and mountainous terrain, the slope variable had a large range and standard deviation (see Table 7).

Two variables were measured for the water inundation category. Precipitation is an essential control variable as it is usually considered the most important factor contributing to local flooding and associated property damage. Generally, the more rainfall, the greater the likelihood streams and rivers will overflow due to excessive runoff. We calculated precipitation based on annual rainfall amounts from the PRISM Climate Group dataset reported in inches per hour. Annual precipitation data for the five year period was mapped at a scale of 30 arc second normals and then averaged annually in hundredths of millimeters for each jurisdiction. The average rainfall for the study sample was approximately 41 inches per year. Another type of flooding originates from storm surge events, representing an important control variable for coastal localities. We measured this variable as the number of surge events occurring each year. Coastal communities in the sample recorded up to 7 separate events during the study period.

Three control variables were measured and analyzed under the socioeconomic/built environment category. Population estimates were calculated based on U.S. Census data and imputed for each year in study period. Rapid urban and suburban development in flood-prone areas has placed more people in harm's way, resulting in greater losses to property. The average population for the study sample was approximately 122,000, but included a wide range from 281 to 4,348,353 people (with a median of 40,781). The number of housing units in each study location was also analyzed using a similar logic. We expect that jurisdictions with a greater number of housing units are more likely to report higher amounts of flood-related property loss. Housing units were measured using U.S. Census data and estimated on a yearly basis. On average, there were approximately 51,800 units per community across all years of the study period.

Using the same data source, we included median household income as a control measure for wealth. Generally, the degree of wealth in a community frequently relates to the impact of a flood. Wealthier communities often have the financial capacity, both at the budgetary and household levels, to effectively mitigate flooding through various structural and nonstructural techniques. Wealthier households are more apt to buy insurance, so the claims numbers should be higher in wealthier communities. At the same time, however, these communities have greater financial capital (e.g. more expensive houses) that could be lost to damaging floods. The average median household income for the sample across all years was approximately $47,000 with a range from $21,000 to $168,000.

Finally, we incorporated a measure of impervious surface into the statistical analysis. Conversion of agricultural and forest lands, wetlands, and open space to urban areas can compromise a hydrological systems' ability to absorb, store, and slowly release water. The result of widespread hardened surfaces is often increased flood intensity (Tourbier and Westmacott, 1981). Greater areas of impervious surface coverage correspond to a decrease in rainfall infiltration and an increase in surface runoff (Paul and Meyer, 2001) and peak discharges (Brezonik and Stadelmann, 2002). These conditions set the stage for more regular flood hazards and resulting losses. In a previous study focusing on coastal counties in Texas, we found that every square meter of additional impervious surface translated into approximately $3,602 of added property damage caused by floods per year (Brody et al., 2008). Percent impervious surface was measured in a GIS using Landsat Thematic Mapper satellite imagery of land cover. Communities in the sample, on average, contained approximately 17 percent impervious surface, with a range from 0-58%.

Lastly, several variables were included in the statistical models falling under the “other” category. In addition to the area or size of each jurisdiction, we measured their distance to the coastline to account for variations in hydrological and geophysical characteristics. We also measured the mean year a residential structure was built. We expected that newer structures would be erected under more stringent building codes and flood mitigation practices, resulting in lower relative amounts of property damage. The average year built of the housing stock for the sample was 1973. The age range of these structures covered a 74 year period. Finally, we measured and analyzed the number of NFIP policies in the SFHA as a key factor explaining insured flood claims. On average, communities in the sample generated over 1,800 claims from flood zone locations. It is important to note that it was not possible to include all variables described here in the final statistical models due to high levels of inter-correlation.

Table 7: Descriptive Statistics for Contextual Control Variables

Variable	**Measurement**	**Source**	**Mean**	**Std. Dev.**	**Range**
Flood Risk					
Floodplain	Proportion of jurisdiction containing 100-yr floodplain	AECom, Inc.	.271	.296	0 – 1
Soil Permeability	Average soil permeability in inches per hour	Soil Survey Geographic Database	4.570	3.836	.1 – 16.7
Slope	Average percent slope	National Elevation Dataset	75.801	130.480	0 – 826.2
Inundation					
Precipitation	Hundredths of millimeters per year	PRISM Climate Group	105593.6	42562.42	2415 – 254584
Surge Event	Number of storm surge events per jurisdiction during the study period	SHELDUS v8.0	.0930	.4530	0 – 7
Socioeconomic/Built Environment					
Housing Units	Number of housing units	U.S. Census/ Geolytics, Inc.	51796.85	115280.6	335407 – 1567323
Population	Number of people	U.S. Census/ Geolytics, Inc.	122095.1	289293.1	281 – 4348353
Income	Median household income level	U.S. Census/ Geolytics, Inc.	47306.77	17322.64	21229.67 – 168386.7
Impervious Surface	Proportion of jurisdiction covered by impervious surfaces based on summing 30 sq. meter pixels from remote sensing imagery.	Landsat Imagery	17.34	14.27	.008 – 57.99
Other					
Area of Jurisdiction	Number of square miles	GIS	385.78	1384.45	.0625 – 18244
Coastal Location	Distance from coastline	GIS	180501.2	316625	0 – 1302182

	in meters				
Year Built	Year structure was built	FEMA	1973	11.09	1924 - 1997
NFIP Policies	Total count of insurance policies within a FEMA flood zone	FEMA	1886.28	7976.81	0 - 155092

*Note that statistics for variables are collapsed over all 11 years of the study period.

To statistically identify the impact of CRS activities and elements on insured flood losses, we analyzed the data using Linear, Random Effects Panel Models. This analytical approach enabled us to evaluate the average linear effect of a one-point change in credit points while accounting for yearly variations among all variables. A sample of 450 communities over an 11-year time step provided 4,848 observations for analysis.

It is important to note that these models assume a linear relationship between CRS activities and flood losses. They report expected averages based on past performance. Results should be used as guidelines for assessing relative impacts of different policy alternatives, not exact predictions of future flood losses.

Results

Descriptive Statistical Patterns of Losses

Table 8: Total Insured Flood Losses per Year

Year	Building Damage	Content Damage
1999	$187,000,000	$46,300,000
2000	$95,200,000	$44,400,000
2001	$116,000,000	$38,000,000
2002	$69,900,000	$23,300,000
2003	$148,000,000	$23,000,000
2004	$595,000,000	$105,000,000
2005	$7,200,000,000	$1,660,000,000
2006	$60,400,000	$11,900,000
2007	$52,900,000	$12,000,000
2008	$221,000,000	$67,300,000
2009	$110,000,000	$18,500,000

As shown in Table 8, the approximately $11 billion in losses captured by the study period was comprised primarily of building-related damages for which insurance coverage is usually targeted. Total insured flood losses varied greatly from year to year, depending on the intensity of flood events among communities in the sample. For example, in the year 2000 communities in the study sample claimed approximately $95,000 in building-related losses. In contrast, in 2005, with the landfalls of hurricanes Katrina and Rita, sample communities generated over $7 billion for the same category of losses.

The variation of losses within each year also varied greatly. In 2008, for example, the average amount of building-related losses in sample communities was approximately $509,000. But, the damage throughout the year ranged from $0 to $54 million. Similarly, in 2004 contents-related losses average over $238,000, but ranged from $0 to nearly $48 million. The seemingly wild swings in damages between and within years are typical of the way floods impact local communities across the U.S. Losses stemming from severe storms that affect concentrated areas tend to stand out among the baseline of chronic flood damages. By evaluating flood losses on a yearly basis, we are able to capture variations in damages and better account for the factors that lead to adverse impacts.

Explanatory Statistical Models

Statistical models were run for each of the nine damage categories and for each CRS activity/element by series. Contextual control variables behaved as expected across all model runs. As previously mentioned, it was not statistically possible to include all control variables within the same model because some were so highly correlated with each other. Therefore, we selected variables that explained the most variance in insured flood losses. As shown in Table 9, larger proportions of floodplain area led to significantly higher flood losses (p<.05). In contrast, greater soil permeability resulted in significantly lower amounts of flood damages as measured over the study period (p<.01). That is, communities with well-drained, sandy soils experienced lower amounts of flood loss. Increasing degrees of average slope within a community had a positive effect on losses, but this variable was not statistically significant.

On the other hand, as expected, inundation measures were the most powerful predictors of flood losses among communities in the study sample. Both the amount of precipitation and number of coastal surge events, on average, had a large statistically significant impact on the amount of property damage caused by floods (p<.01). Increasing population levels within a community also resulted in significantly higher amounts of flood losses. More people living in a CRS community translates into a greater opportunity for property damage to occur during a flood event.

The number of flood insurance policies is another important control variable due to the fact that they directly relate to the amount of claims filed in a flood event. On average, for every additional policy holder in the study sample, we observed a statistically significant increase in the dollar amount of insured losses ($p<.01$). Finally, newer structures within a community were generally associated with reduced flood losses, but this variable performed somewhat sporadically across models in terms of statistical significance. The average year built of structures was most likely to have a significant impact on lower damage occurring in B, C, and X flood zones.

Table 9: Impact of Contextual Control Variables on Insured Flood Losses

Variable	Effect on Flood Losses
Proportion in Floodplain	+**
Soil Permeability	– ***
Slope	+
Precipitation	+***
Coastal Surge Events	+***
Population	+***
Policies in Floodplain	+***
Year Built	–

** indicates statistically significant where P<.05

*** indicates statistically significant where P<.01

The inclusion of contextual control variables enabled us to effectively isolate and quantify the effects of specific CRS activities and elements chosen for the study. Each activity or element listed in Table 6 was examined for its impacts on flood losses in a fully-specified statistical model, which included the contextual control variables described above. Variables were analyzed within their respective series. Among all CRS variables analyzed, two emerged as statistically significant predictors of reduced insured losses.

1) Open space protection (activity 420) significantly reduced losses for buildings and contents combined. A one-point increase in this activity resulted in a statistically significant decrease (based on a 99% level of confidence) in the average amount of insured flood claims per year. The open space variable was particularly effective for flood loss reduction in the A-V zones where the activity is focused.

2) Freeboard requirements under activity 430 had the largest statistical effect among all CRS variable analyzed in the study. Communities adopting this CRS element saw major reductions in flood damage associated with both buildings and contents. Each additional point for freeboard led to a statistically significant decrease (based on a 99% level of confidence) in the average amount of insured flood claims per year.

Although one CRS credit point reflects a very subtle shift in mitigation policy, it can result in substantial savings in flood damage. Table 10 reports the average dollars saved for each community per one-point increase for the four significant CRS variables. For example, the total dollar savings of a one-point increase in the Freeboard element was equivalent to, on average, $10,114 per community, per year. The majority of these savings come from elevated buildings in the A-V flood zones, which is where this element is targeted. When buildings in the Special Flood Hazard Area (SFHA) conform to freeboard requirements, communities saved, on average, $5,658 per year based on a one point increase in the element. Protecting open space in the SFHA also resulted in major savings per CRS credit. The dollar savings of a one-point increase in activity 420 was equivalent to, on average, $3,147 per community per year. Again, buildings located in the A-V flood zones realized the largest damage reductions.

Table 10: Average Amount Saved per One-Point CRS Increase

	Building and Contents			Content Damage			Building Damage		
	Total	A-V	B-C-X	Total	A-V	B-C-X	Total	A-V	B-C-X
420	$3,147	$2,781		$549	$325		$2,556	$2,294	
FRB	$10,114	$7,045		$1,013	$747		$8,215	$5,658	$470

While estimating impact of per unit increases in CRS points is useful for determining the value of specific activities, it does not reflect the true savings communities in the sample accrued during the study period. Table 11 reports these savings based on the average amount of credit communities received in 2009 (the final year of the study period). Freeboard requirements produced the highest overall reduction in flood damages with an average of $960,817 per year. Taking into account the average amount of points accrued for open space protection among communities in the study sample, the total savings per year for this activity was equivalent to, on average, $547,497.

Table 11: Average Amount Saved per Jurisdiction

	Building and Contents			Content Damage			Building Damage		
	Total	A-V	B-C-D-X	Total	A-V	B-C-D-X	Total	A-V	B-C-D-X
420	$547,497	$483,869		$95,441	$56,482		$444,715	$399,146	
FRB	$960,817	$669,260		$96,200	$70,927		$780,441	$537,547	$44,640

Conclusions of National Analysis

Overall, freeboard requirements in the SFHA resulted in the largest savings per year at the community level, followed by the protection of open space, flood protection, and outreach projects. While it appears that freeboard saves a community, on average, twice as much as open space protection, it is important to note that these estimates are based on the current amount of credit points received rather than the potential for future savings. For example, if every community maximized their point totals for the freeboard requirement, the total average savings would be approximately $3 million. If every community were to maximize their point totals for activity 420, the average total savings would be approximately $2.8 million. Based on these projections, the total effect of each mitigation strategy is not that dissimilar.

Although this study enables policy makers to assess the relative strength of each individual CRS activity or element in terms of their ability to mitigate damages from floods, it is most likely the combination of multiple strategies working in concert that will lead to an effective flood management program. The significance of freeboard requirements suggests a protective strategy is preferable. The obvious value of open space protection, on the other hand, indicates that communities should pursue an avoidance approach to flood mitigation. Realistically, it will be a balance of different strategies selected by each participating community that, when implemented, will better safeguard residents from the adverse impacts of floods over the long term.

Down-Scaling Data to Escambia County

Using the parameter estimates from the nationally-derived statistical model described above, we could “down-scale” the results for each independent variable to Escambia County. By inserting the average values of each variable in the model during 2009 (Table 12), we generated the expected percent change in flood losses for each of the significant CRS activities (Freeboard and

420). Using this approach, we could also identify the influence of each contextual community characteristic (Table 9). Lastly, we predicted losses based on future “what if” scenarios by changing the values of local conditions. Predictions were made for total insured loss, losses within the SFHA and losses outside of the SFHA.

Table 12: Mean Values for Escambia County, FL

Variable	Mean 2009
Year Built	1987.32
Percent SFHA	0.18
Population (1K)	289.50
Soil Permeability	4.93
Slope	32.13
Precipitation	80.18
Surge Event	0
Policies in SFHA	3860
CRS 420	232
CRS Freeboard	0

For each of the three flood loss categories, we evaluated the following community scenarios:

1) What if Escambia County received the national average (55.5) of CRS points for Freeboard in 2009 (it had 0 at the time)?
2) How much does open space protection in the floodplain (Activity 420) reduce insured flood losses?
3) What if there were 2 coastal surge events before the year 2040 impacting Escambia County?
4) What if Escambia County reached its projected population for the year 2040 of 386,800 people?
5) What if Escambia County increased the number of NFIP policies within the SFHA from 3,869 to 5,000?

The results in Table 13 indicate that the implementation of several CRS activities in Escambia County result in significant reductions in insured flood losses. For example, if Escambia received the CRS national average for Freeboard during 2009, losses would have been reduced by over 20 percent overall and over 17 percent for structures within the SFHA. Also, open space protection efforts in 2009 reduced flood losses in Escambia County by almost 39 percent overall and over 40 percent for damage within the SFHA (Scenario 2).

The prospect of continued flood hazard events from both precipitation and hurricane storm surge also pose major threats in terms of potential property damage. For example, an additional two coastal surge events in the next 25 years would increase expected losses by over 756 percent county-wide (Scenario 3). Also, seemingly minor changes in the demographic composition of Escambia County could have a major impact on the amount of projected flood losses. For example, the Florida Bureau of Economic and Business Research projected the population for Escambia County to reach as much as 386,800 people by the year 2040. This population increase of 33 percent would result in a 38 percent increase in expected flood losses per year (Scenario 4). If only about 1,200 of these additional residents decide to live within the SFHA and purchase federal flood insurance (Scenario 5), flood losses within the SFHA would increase by an average of 29 percent per year.

Table 13: Percent Change in Insured Flood Losses Based on Five Scenarios

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Total Damage	-20.02%	-38.93%	756.12%	38.05%	----
SFHA Damage	-17.35%	-40.43%	804.10%	23.09%	29%
non-SFHA Damage	-5.44%	-29.62%	470.15%	30.06%	----

It is important to note that the five scenarios calculated in Table 13 are based on independent changes in specific parameters. In reality, changes will occur simultaneously for multiple variables. For example, as population increases, so too will the number of NFIP policies in the floodplain. At the same time, inundation from both rainfall and surge events will most likely play a role in increasing the amount of flood losses. Thus, the synergistic nature of changing community conditions make the estimates in Table 13 an underestimate of the actual percent change in flood losses we would expect over time.

Conclusion

This study demonstrates the effectiveness of specific mitigation activities implemented under FEMA's CRS for Escambia County, Florida. By leveraging a national dataset and corresponding statistical model predicting insured flood losses, we were able to quantify the impacts of mitigation efforts taking place in Escambia. We predicted expected flood losses for five "what-if" scenarios reflecting changes in environmental and demographic community conditions to illustrate expected flood losses in the future. These research methods and findings should provide valuable information to decision makers at the local level on how to effectively reduce the amount of property damage caused by floods county-wide.

How to Interpret the Research Findings

This study used representative samples of communities to statistically model and evaluate the performance of the CRS and specific activities and elements for their contributions to reducing observed insured flood losses. Using an empirical approach that involves the interpretation of probabilistic statistical models requires that the reader carefully interpret and qualify the findings contained in this report:

First, results should be qualified with the statement "on average, for the study sample, over the study period." Findings are based on averages for all CRS communities in the study sample. These reported averages of past or future expected flood damage savings cannot be downscaled to an individual community. This interpretation would help explain why freeboard requirements on average reduce losses by nearly $1 million, but a specific community in the sample may have only incurred $50,000 of total flood damage over the entire study period.

Second, the dollar effect of each CRS activity/element is influenced by the extent to which communities in the sample are accruing points. For some activities, communities in the sample are, on average, only receiving a small percentage of the total possible points allowed under the program. For example, for floodplain management planning (activity 510), communities in the study sample were receiving only 6 percent of the maximum number of points allowed. In this instance, communities as a whole may not be implementing this activity thoroughly enough to make a discernible difference when it comes to flood losses. There may be a point threshold (which was not investigated in this study) where an activity begins to have a significant impact.

Third, the expected overall savings in flood losses are influenced by the total amount of points available for each activity in the CRS program, which varies. This study evaluates the performance of CRS activities and elements based on past effort, not future expectations. As already mentioned above, freeboard requirements reduced property damages far more than open space protection. But, when savings are calculated based on the maximum amount of points available, the potential reduction in damages is almost the same. When weighting the relative value of activities, policy makers should consider the ramifications of what is possible in addition to the level of mitigation effort put forth in the past.

Fourth, results may be limited by the fact that there could be a lag between activity/element implementation and a measurable effect on flood losses. Some activities/elements have been in place for only a short time period and may not have had a chance to significantly reduce observed flood losses. It was not the objective of this study to identify how long an activity should be in place before it begins to show an impact on losses.

Fifth, the findings may also be influenced by a lack of implementation for specific CRS activities/elements. Even though a community receives credit, it may not be properly implementing the activity or element for which credit is received. For example, a community could draft and adopt a stellar floodplain management plan, but it never gets implemented or integrated into local development decisions where it will have a measurable effect.

Finally, CRS activities/elements are subtle policy-related events. Even given enough time and perfect implementation, it may be difficult to isolate and quantify the precise nature of their effects over an 11-year period. The large explanatory power of precipitation, soils, and other contextual characteristics may overshadow statistical signals from CRS-related variables.

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