Case Study

The Relationship between Climate Vulnerability and Disaster Declarations: A Case Study of Flood-Prone Indigenous Communities in Alaska

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Abstract: Using descriptive statistics, correlation analyses, one-way ANOVA, and an environmental justice lens, we considered the social and physical vulnerability factors associated with climate change and flood-related disaster declarations for Alaska Native Villages (ANVs), which are indigenous communities. We found that, on average, compared with communities not involved in disaster declarations, communities with disaster declarations between 1977 and 2014 had lower elevation, more exposure to erosion, less precipitation in summer and fall, larger populations, less population growth, a higher percentage of youth, larger household size, a higher percentage of Alaska Natives, more population below the poverty level, and lower per capita income. This finding is positive, because it suggests that, collectively, communities with greater vulnerability are getting more disaster declarations, which come with disaster aid. However, some of the most vulnerable communities may not be getting all the help they need. In particular, southwestern communities along the Yukon and Kuskokwim Rivers were statistically more likely to get disaster declarations than were ANVs that received attention in the media and the literature for their vulnerability. **DOI: 10.1061/(ASCE)NH.1527-6996.0000341.** © *2019 American Society of Civil Engineers.*

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Introduction

In Alaska and the Canadian Arctic, climate change has brought increased permafrost melt, loss of sea ice, and changes in flooding and erosion (deGrandpre 2015; Freymueller et al. 2008). Flooding and erosion may make current residences and settlements uninhabitable in the near future (Marino 2015, p. 2; Herrmann 2015; GAO 2009, p. 36). In 2009, the Government Accountability Office (GAO) called attention to 31 Alaska Native Villages (ANVs) that are imminently threatened by flooding and erosion, with four (Kivalina, Koyukuk, Newtok, and Shishmaref) in need of relocation (GAO 2009, p. 12). The vulnerability to flooding and erosion that many indigenous communities experience is not just physical—it is intertwined with social vulnerability related to colonization and other factors that raise environmental justice concerns (Cameron 2012; Walker and Burningham 2011; Wilson 2014). For example, the location of many Alaskan and Canadian Arctic communities reflects colonial efforts to sedentarize indigenous groups, without regard to whether the particular settlement would withstand erosion (Berardi 1999; Ford et al. 2010). In Alaska, this stationary lifestyle combines with dependence on subsistence resources that move, dependence on imported Western goods, and limited control over these resources (Marino 2012, pp. 375–378; Thomas et al. 2016, p. 290; Loring et al. 2016, p. 122; Lynch and Brunner 2007, p. 97; Huntington et al. 2005, p. 91).

A number of studies attempted to rank the vulnerability of Alaskan and other communities, largely based on physical factors (Alessa et al. 2008; Gorokhovich et al. 2014; Himes-Cornell and Kasperski 2015). The authors are concerned that there is no prize (i.e., award of assistance) for the winner of these beauty-pageant-like rankings. In other words, there is no clear political pathway forward to decrease vulnerability and to achieve environmental justice objectives. In this paper, the authors sought to not only outline the physical and social vulnerability of ANVs, but also to understand which ANVs are getting assistance for the flooding and erosion that they face. In the absence of a coordinated effort to address climate change–related flooding and erosion, state and federal responses to climate change impacts often come only after a disaster and an official federal disaster declaration (Bronen 2011; Flatt 2012; GAO 2009). These declarations provide important funding and assistance for a community to recover, rebuild, and even relocate. Without federal or state assistance, responding to these climatic challenges is difficult, particularly for physically and socially vulnerable communities (Bronen 2011; Iverson 2013).

Although some ANVs vulnerable to flooding and erosion have been able to obtain disaster relief and even relocate, many have not. To date, there has not been a systematic attempt to identify which communities in Alaska are getting disaster declarations and the associated funding and which are not. This paper considered the social and physical vulnerability factors that may be associated with the number of flood-related disaster declarations a community receives. The following section provides a literature review that outlines factors relevant to community vulnerability and adaptive capacity and discusses the challenges in conducting vulnerability assessments in Alaska. Before examining the case study, the paper provides background on how disaster declarations can be a tool for responding to flooding, although they do not proactively reduce vulnerability.

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Definition and Measurement of Vulnerability to Climate Change

Climate change vulnerability is "a function of the character, magnitude, and rate of climate variations to which a system is exposed, its sensitivity, and its adaptive capacity" (Bierbaum et al. 2014, p. 672). Here, adaptive capacity means the potential of a system to adjust to climate change, take advantage of opportunities, and cope with the consequences (Bierbaum et al. 2014, p. 672). For most communities, adaptive capacity is based on financial capital (Abel et al. 2006; Walker et al. 2006), social capital (Moser and Ekstrom 2010, p. 22,030; Norris et al. 2008, p. 136; Munaretto and Klostermann 2011, p. 248; Walker et al. 2006, p. 20), natural capital (Magis 2010, p. 410; Cutter et al. 2008, p. 601; Abate and Kronk 2013, p. 13; McNeeley 2009, p. 46; Wildcat 2009, p. 30), physical capital or infrastructure (Cutter et al. 2008, pp. 601–604; Nilsson et al. 2016, p. 170), and community knowledge (Arctic Council 2017; McNeeley 2009; Nilsson et al. 2016; Norris et al. 2008). Additional sources of adaptive capacity that are important for ANVs and indigenous communities include cultural capital (Houkamau and Sibley 2011; Kofinas 2009; Nilsson et al. 2016; Wexler 2013), the ability to navigate and influence Western laws and institutions that control access to various types of capital (Wuttunee 2004, pp. 5, 6, and 15), and the flexibility to draw on the resources most readily available and tailor them to the community's particular needs (Arctic Council 2017; Brunner and Lynch 2010; Chapin et al. 2006, 2009). Adaptive capacity is important because some communities with high exposure to climate risk are highly adapted to it or have resources that provide for adaptive capacity (Ford and Smit 2004; Nelson et al. 2010). Community vulnerability and adaptive capacity can be measured by a variety of physical and social indicators (Adger and Kelly 1999, p. 256). Tables 1–3 outline the physical and social indicators recognized as relevant in the literature. Table 1 summarizes indicators for physical vulnerability. Tables 2 and 3 summarize the household-level and community-level indicators related to social vulnerability and adaptive capacity. The social factors are as important as the physical factors because some communities with high exposure to climate risk are highly adapted to it or have resources that provide for adaptive capacity (Nelson et al. 2010, p. 20; Ford and Smit 2004, p. 396). Likewise, some communities may be more sensitive for social, economic, and cultural reasons. This may be the result of social inequalities as well as place inequalities—characteristics of communities and the built environment such as the level of urbanization, growth rates, and economic vitality (Cutter et al. 2003, p. 243).

The identified indicators guided the selection of variables in our study. Table 4 describes the type of indicators we selected for this study based on the literature and data availability. We classified the physical vulnerability indicators into location, exposure, and meteorological factors, and included demographic, economic, political, and community resource–related factors to capture the social vulnerability and adaptive capacity. We were limited by the lack of consistent, community-level information on these factors for Alaskan and other rural communities (e.g., Lyons et al. 2016, p. 9). This is partially due to the remote nature of these communities and their lack of baseline information. Another challenge

Table 1. Physical factors assessed in select studies of vulnerability

	Studies							
Physical factors	Alessa et al. (2008)	Gorokhovich et al. (2014)	Hahn et al. (2009)	Himes-Cornell and Kasperski (2015)	Lyons et al. (2016)	Nelson et al. (2010)	Pandey and Jha (2012)	Pendleton et al. (2010)
Sea level rise	—	×	—	—	—	—	—	×
Shoreline change rate	—	×	—	×	—	—	—	×
Slope, elevation	—	×	—	×	—	—	—	×
Ice cover	—	—	—	×	—	—	—	×
Tidal range and wave height	—	×	—	—	—	—	—	×
Terrain type, landcover	—	×	—	×	×	×	—	×
Temperature	—	—	×	—	—	—	×	—
Permafrost	×	×	—	×	—	—	—	—
Precipitation	×	—	×	—	—	×	×	—
Disasters	—	—	×	—	—	—	×	—
Subsistence/food availability	×	×	×	×	—	—	×	—
Water quality, drinking water	×	—	×	—	—	—	×	—

Table 2. Household level social variables assessed in select studies of vulnerability

	Studies								
Household level social variables	Alessa et al. (2008)	Baum et al. (2008)	Bergstrand et al. (2015)	Cutter et al. (2003)	Hahn et al. (2009)	Himes-Cornell and Kasperski (2015)	Nelson et al. (2010)	Pandey and Jha (2012)	Vincent (2004)
Wealth/income	×	×	×	×	—	×	×	—	×
Employment/occupation	—	×	×	×	×	—	—	×	—
Education/knowledge	×	×	×	×	×	—	×	—	—
Health and health insurance	—	—	×	—	×	—	×	×	×
Language proficiency	—	×	×	—	—	—	—	—	—
Gender	—	—	×	×	—	×	—	×	—
Age	×	×	×	×	×	×	—	×	×
Household and family structure	—	×	×	×	×	×	—	×	—
Race/ethnicity	—	—	×	×	—	—	—	—	—

Table 3. Community level social variables assessed in select studies of vulnerability

Community level social variables	Studies: Alessa et al. (2008)	Baum et al. (2008)	Bergstrand et al. (2015)	Cutter et al. (2003)	Hahn et al. (2009)	Himes-Cornell and Kasperski (2015)	Lyons et al. (2016)	Nelson et al. (2010)	Pandey and Jha (2012)	Vincent (2004)
Economic development and diversity, resource dependence	×	—	×	×	×	×	—	—	—	—
Special needs populations	—	×	×	×	—	×	—	—	—	—
Infrastructure quality and density	—	×	×	×	—	—	×	×	—	—
Housing quality	—	—	×	×	—	—	—	—	—	—
Rural/urban status	—	—	×	×	—	—	—	—	—	×
Population growth	—	×	×	×	—	—	—	—	—	×
Health care access	—	—	×	×	—	—	—	—	—	×
financial assistance	—	—	×	×	×	×	—	—	×	—
Social networks	—	—	—	—	—	—	×	×	—	—
Presence of plan	×	—	—	—	—	×	—	—	—	—

Table 4. Structure of vulnerability indicators used in data collection

Category	Indicator	Description	Level of measurement
Physical			
Location	Region	Geographic and cultural regions of Alaska (12 regions total)	Nominal
	Flood type	Predominant flood type (i.e., storm surge, ice jams)	Nominal
	Coastal	On coast, on river, or not on a water body at all	Nominal
Exposure	Elevation	Elevation of community in relation to sea level	Interval
	Erosion	General erosion threat level between 0 and 3, where 0 = not affected, and 3 = most affected	Ordinal
	Sea level rise	Sea level rise exposure (1 = exposed to sea level rise, and 0 = otherwise)	Nominal
	Area	Exact number of square miles used for incorporated municipalities; for tribal/unincorporated communities, 1 mi^2 used as estimate	Ratio
Meteorological	Temperature	Historical average September maximum temperature (°C)	Interval
	Precipitation summer	Historical average September maximum precipitation (mm)	Ratio
	Precipitation, fall	Historical average November maximum precipitation (mm)	Ratio
Social			
Demographic	Population	2014 Population	Ratio
	Population change	Population increase (%/year) 1990–2010	Ratio
	Youth	Percentage 2010 population 19 and under	Ratio
	Elderly	Percentage 2010 population 65 and older	Ratio
	Household size	Average household size, 2010	Ratio
	Native	Percentage Native, alone or in combination with another race, 2010	Ratio
Economic	Poverty	Percentage of population below poverty level in 2010	Ratio
	Income	Average income per capita in 2014	Ratio
	Wages	Resident wages per community in 2014	Ratio
	Employment	Percentage of employment in 2014	Ratio
	Public assistance	Percentage of households receiving public assistance income	Ratio
	Subsistence	Subsistence participation (1 = participated, 0 = otherwise)	Nominal
Community resources	Communication	Communication access in terms of internet and cell phones (1 = either internet or cell access, 0 = no broadband or cell access)	Nominal
	Road	Possible to access community by road (i.e., 3 = year-round road, 2 = seasonal road, 1 = marine highway access, 0 = not on Alaska State Highway or Marine Highway System)	Ordinal
	Distance to city	Shortest air distance to major urban center	Ratio
	Hazard mitigation plan	Covered by some kind of hazard mitigation plan as of 2016 (1 = yes, 0 = otherwise)	Nominal
Political	Tribe	Federally recognized tribe (1 = yes, 0 = no)	Nominal
	City type	Municipal administration: 1 = unincorporated census-designated place, i.e., with significant population; 2 = second-class city; 3 = first-class city; and 4 = home-rule city)	Nominal
	Village corporation	Presence of a Native Village Corporation (0 = no; 1 = yes; 2 = village corporation merged with regional corporation; 3 = village corporations merged together)	Nominal
	Borough	Within borough (county) or larger municipality (0 = not in borough, 1 = within borough)	Nominal
	NFIP	Participation in national flood insurance program as of 2016 (0 = no, 1 = yes)	Nominal

is the government structure of Alaska. About 70 communities have no municipal government at all (only a small tribal government), so they lack administrative resources. On the other hand, many communities are part of a county-level borough which may be vast in size—the North Slope Borough is the size of Wyoming. These county-level governments have more resources but are challenged to administer such large and diverse areas. In their principal component analysis, Cutter et al. (2003, p. 251) used zero for missing values pertaining to Alaskan and other communities, resulting in an underestimate of vulnerability for these communities. Bergstrand et al. (2015), using median values in place of zeros, found higher social vulnerability values for Alaska than did Cutter et al. (2003).

In addition to the lack of comprehensive community-level information, there is difficulty quantifying important factors. Alessa et al. (2008) addressed this challenge using proxy indicators (e.g., the number of indigenous people 50 or older as a proxy for traditional knowledge) (Alessa et al. 2008, p. 533). Himes-Cornell and Kasperski's (2015) study of physical vulnerability and adaptive capacity in 315 Alaskan communities compensated for a lack of erosion rate data by using communities' self-assessments of erosion vulnerability as documented by GAO (2009) and USACE (2009). Lyons et al. (2016) criticized this study, noting that qualitative factors suggest that some communities are much better off than those with higher quantitative assessments of vulnerability. They suggested that it is difficult to quantify intangible sources of vulnerability such as colonization (Lyons et al. 2016, p. 9).

Aside from criticisms directed at quantitative vulnerability assessments, there is concern that labeling communities as vulnerable can pave the way for greater Western interference in communities, thus perpetuating Western colonial institutions that bypass indigenous values and knowledge (Howitt et al. 2013, p. 321). This may result in greater dependencies on Western institutions, moving indigenous communities further from self-sufficiency and autonomy (Haalboom and Natcher 2013, p. 368). The use of the term vulnerability in this paper is shorthand for the various risks that these communities face. It is not meant to imply that they are somehow helpless or unable to actively adapt, as they have done for thousands of years (Nakashima et al. 2012; Theriault 2012).

Flooding, Erosion, Disasters, and Disaster Declarations in Alaska

Flooding and Erosion Hazards in Alaska

Flooding is the most common disaster in Alaska (Department of Military and Veterans Affairs and Division of Homeland Security and Emergency Management 2013), the United States (Downton and Pielke 2001; GAO 2013), and perhaps around the world (Guha-Sapir et al. 2012). In Alaska, major floods traditionally have occurred along rivers during spring break-up (when ice creates dams that overflow) and during heavy late-summer rains. More recently, autumn sea storms and storm surge have caused major floods and episodic erosion in communities along Alaska's north and northwestern coasts (Lynch and Brunner 2007; USACE 2006). This flooding relates to the later formation of shorefast ice, which traditionally protected coastlines from flooding (Field et al. 2014, p. 32). Storm surge and heavy rains also can threaten other parts of Alaska, particularly across the coastal south. Apart from the north and northwestern coasts, potential climate change impacts on flooding in other parts of Alaska are not well understood. Although there is some indication that the severity of riverine ice-jam floods may decrease if climate change brings less snow and earlier breakups (Beltaos and Prowse 2001; Johnson 2017; C. Van Breukelen, personal communication, 2015), coastal flooding may increase with less sea ice and more severe storms (Field et al. 2014, p. 32).

In addition to rapid flooding, Alaska's coastal and riverine communities also face gradual erosion (Field et al. 2014, p. 17). Gradual erosion of Alaska's northern and western coastlines relates to sea level rise and permafrost thaw (Jones et al. 2009). Sea-level rise along the northern and northwestern coasts may weaken permafrost-rich coastal bluffs, increasing the rate of thawing (Chapin et al. 2014, p. 20; Jones et al. 2009). When permafrost thaws, episodic erosion tends to be irreversible, because the lost sediments do not accrete back in the same place (R. Carter, personal communication, 2017). Riverine erosion tends to be more gradual and easier to measure than coastal erosion (R. Carter, personal communication, 2017).

Importance of Disaster Declarations and Obstacles to Getting Them

As discussed in the Introduction, the lack of a coordinated governmental effort to proactively address climate change means that many communities must wait until after a disaster strikes to get large amounts of federal funding. Payouts for disasters can be substantial. Congress provided roughly $120 billion for Hurricane Katrina and $60 billion for Hurricane Sandy recovery in Public Assistance and Individual Assistance (Lindsay 2014). The average annual appropriated funding level for disaster relief for from 2001 to 2010 (excluding the highest and lowest years) was $11.5 billion (Lew 2011). Nearly $6.9 million in federal assistance to individuals was provided after an Interior Alaska riverine flooding disaster in 2009 (FEMA 2009). Disaster declarations also pave the way for additional funding during the year after the disaster in the form of a Hazard Mitigation Grant Program, which is based on a percentage of funding allocated through disaster assistance [42 U.S.C. 5170c; 44 C.F.R. §§ 206.432(b) and 206.436].

An ANV seeking a federal disaster declaration and postdisaster grant funding (i.e., Public Assistance and Individual Assistance provided by FEMA) faces several obstacles. The community first must advocate for the declaration of a state disaster. For a state disaster to reach the status of a federal disaster, the state must prove that federal response is merited [42 U.S.C. §5170(b)]. The Sandy Recovery Improvement Act of 2013, Public Law 113-2, 127 Stat. 4 (2013), amended the Stafford Act to allow tribes, including ANVs, to apply directly to the federal government for disaster declarations and aid [42 U.S.C. § 5170(b)]. However, if this option is exercised, tribes may have to pay a state-level cost share [unless this is waived under 42 U.S.C. § 5170(c)] and also must have the capacity to administer funding, which has not been feasible for ANVs thus far.

The Federal Emergency Management Act advises the President to declare a federal disaster only when the disaster is "of such severity and magnitude that effective response is beyond the capabilities of the State and the affected local governments and that Federal assistance is necessary" [42 U.S.C. § 5170(a)]. Although there are criteria for how much funding a disaster merits, there are no clear criteria for whether a disaster is beyond the capacity of state and local governments. Many articles have been written about how the president's decision does not necessarily correlate with the vulnerability and need of the affected communities (Cutter et al. 2003, p. 256; Daniels 2013, pp. 669–689; Garrett and Sobel 2003, p. 508; US Congress and Senate Bipartisan Task Force on Funding Disaster Relief 1995; Reeves 2011, p. 1147; Cutter and Emrich 2005; Schmidtlein et al. 2008, p. 13; Salkowe and Chakraborty 2009, p. 15; Downton and Pielke 2001, p. 163; Sylves and Búzás 2016, p. 5; Gasper 2015, p. 2; Vogel 2012, p. 41).

The second obstacle for ANVs such as Newtok and Kivalina is that the slow-moving erosion they are experiencing does not fall within the federal government's definition of disaster (42 U.S.C. § 5122). Efforts of these two communities to seek a federal disaster declaration have failed.

The third obstacle relates to high costs (e.g., transportation and shipping) associated with remotely located ANVs, many of which have small populations and no road access (Cochran et al. 2013; McNeeley 2009). When FEMA considers the ratio of benefits to costs for grant projects outside of disaster relief, the benefits seem low compared with more centrally located, urban communities (GAO 2009, p. 22). The low population, high cost of living, and remoteness also impede obtaining and retaining personnel who can navigate the complex FEMA grant process. Furthermore, ANVs that lack municipal governments and flood maps are excluded from participating in FEMA grants related to the National Flood Insurance Program (NFIP) (GAO 2013).

A fourth obstacle relates to hazard mitigation plans (HMPs). These plans are not required for disaster declarations, but are required for other FEMA grants (i.e., Pre-Disaster Mitigation and the Hazard Mitigation Grant Program) and certain types of Public Assistance (42 U.S.C. §5133; FEMA 2018b, c). At the time of this research, many ANVs lacked HMPs. The State of Alaska more recently has worked to provide ANVs with HMPs, though these are often externally developed and many not adequately reflect community hazards (Ristroph 2018).

With these obstacles (among others), some ANVs have been more successful than others at obtaining federal disaster assistance and other FEMA grants. Shishmaref, often cited among the most vulnerable villages to flooding and gradual erosion (GAO 2009; Marino 2015; Herrmann 2015), received only a single state disaster declaration and no federal disaster declaration between 1977 and 2014. The seemingly less-threatened community of Alakanuk (GAO 2009; Himes-Cornell and Kasperski 2015) obtained eight state and five federal disaster declarations during the same period.

In the last few decades, no ANV has been able to relocate in the absence of a federal disaster declaration. The Native Village of Alatna received sufficient funding and assistance after a 1994 flooding disaster declaration to enable it move to higher ground to relocate. The Native Village of Eagle similarly relocated following a 2009 flood. The Native Villages of Galena and Circle, both of which were nearly destroyed by the same flood of 2009, were able to completely rebuild in their existing locations. Yet villages such as Kivalina, despite repeated flooding, have been unable to relocate, because they have never received a presidential disaster declaration (Bronen and Chapin 2013; Shearer 2011; USACE 2006).

Given the importance of disaster declarations in assisting Alaskan communities to respond and adapt to flooding and erosion problems in the face of climate change, the authors sought to identify which communities in Alaska were getting state and federal disaster declarations and which were not, and to determine how those receiving more declarations differ from those without declarations.

Methodology

Data Collection

The unit of analysis in this study was Alaskan communities, including municipalities, ANVs, and census data points in the State of Alaska. The authors gathered data on every community in the State of Alaska, excluding those communities that had missing values for many variables (Himes-Cornell and Kasperski 2015, p. 4). All or most Alaskan communities (not just ANVs or those with a disaster declaration) were included to help explain variation between communities that have obtained disaster declarations and those that have not (Kerlinger 1986, p. 287).

The selection of vulnerability indicators took place through both a deductive and an inductive process. The deductive aspect was based on variables cited in the literature (Tables 1–3) regarding physical and social vulnerability and adaptive capacity. The inductive aspect involved selecting a broad range of publicly available factors without knowing whether they would have any relationship to disaster declarations.

To determine the number of disasters experienced by each Alaskan community, the State of Alaska's record of state-issued disaster declarations related to flooding and erosion from the initiation of state declarations under the Alaska Disaster Act (June 10, 1977) through the end of 2014 (Cavallo 2015) was reviewed. This document indicates the nature of the disaster (for some but not all declarations), which communities or areas were included in each disaster declaration issued by the Alaska governor during this period, and which of these state declarations resulted in the issuance of a federal disaster declaration.

FEMA's record of federal disaster declarations that corresponded to these state declarations also was reviewed (FEMA 2018a). There were far fewer federal declarations, because these require a higher threshold than do state declarations. FEMA's record indicated the disaster type, the type of assistance issued, and the county or borough for which the declaration was issued. Based on both the federal and state records, the types of disasters for which declarations were issued and what communities or locations received declarations were analyzed.

Data Analysis

The study was simplified by removing 10 communities without population data, 69 communities with no population in 2014, and 17 communities with fewer than 10 people in 2014, leaving 350 communities. Although community income is relevant to vulnerability, gross annual revenue was removed because this information was missing for 57.4% of the communities. For the remaining records, 193 communities had no missing data, and 157 had some missing data. Pearson correlation analyses, point-biserial correlation analyses, ANOVA, Kruskal–Wallis tests, and post hoc analyses were used to show the relationship between disaster declarations and the communities' physical and social vulnerability. The Pearson correlation is used to test the strength of linear association between two continuous variables. Point-biserial correlation is used to test the strength of association between a continuous-level variable (ratio or interval data) and a binary variable. ANOVA is used to test the differences among group means. The Kruskal–Wallis test is a nonparametric test to determine if there are statistically significant differences of an ordinal or continuous variable between two or more groups when the normality and equal variance assumptions of ANOVA test are not met. Post hoc analysis is conducted to reveal which groups differ significantly by making pairwise multiple comparisons if ANOVA or the Kruskal–Wallis test is significant. To explore the relationship between a community's physical vulnerability and the number of disaster declarations, we used correlation analyses and one-way ANOVA. The dependent variable was the number of state or federal disaster declarations, and the independent variables were the physical and social vulnerability indicators. The levels of measurement of the vulnerability indicators are listed in Table 4. The statistical tests used to test the relationship between disaster declarations and these vulnerability indicators are summarized in Table 5. An alpha level of 0.05 was used for all analyses.

Limitations of Analysis

Given the information available, it was not possible to make a reliable comparison of the severity of climate change impacts across all Alaska settlements, nor was it possible to evaluate the degree of damage or disaster magnitude across all events. The count of disaster declarations within a given community may be an underestimate, because some communities may have been included in a disaster declaration without specifically being named in a declaration.

Table 5. Statistical tests

Dependent variable	Independent variables	Statistical test
Number of state declaration	Physical vulnerability indicators	
	Sea level rise exposure	Point-biserial correlation
	Elevation, area, summer temperature, summer precipitation, fall precipitation	Pearson correlation
	Region, flood type, coastal location, degree of erosion	One-way ANOVA, Kruskal–Wallis test, and post hoc analyses
	Social vulnerability indicators	
	Subsistence, communication, tribe, borough, NFIP, hazard mitigation plan	Point-biserial correlation
	Population size, population change, youth, elderly, household size, Native, poverty, income, wages, employment, public assistance, distance to city	Pearson correlation
	Road access, city type, village corporation	One-way ANOVA, Kruskal–Wallis test, and post hoc analyses
Number of federal declaration	Physical vulnerability indicators	
	Sea level rise exposure	Point-biserial correlation
	Elevation, area, summer temperature, summer precipitation, fall precipitation	Pearson correlation
	Region, flood type, coastal location, degree of erosion	One-way ANOVA, Kruskal–Wallis test, and post hoc analyses
	Social vulnerability indicators	
	Subsistence, communication, tribe, borough, NFIP, hazard mitigation plan	Point-biserial correlation
	Population size, population change, youth, elderly, household size, Native, poverty, income, wages, employment, public assistance, distance to city	Pearson correlation
	Road access, city type, village corporation	One-way ANOVA, Kruskal–Wallis test, and post hoc analyses

Information from the Alaska Department of Commerce and Regional Affairs was used for most of the independent variables, although this information may be incomplete (particularly the list of which communities have plans in place). Finally, many variables that influence disaster declarations (such as politics) are difficult to quantify.

Results

Overview of Communities with Disaster Declarations

According to the current disaster cost index provided by State of Alaska in 2015, 30.7% of the 350 Alaskan communities in this study were involved in at least one state disaster declaration related to flooding for which they received public assistance or a categorical grant between 1977 and 2014 (Cavallo 2015); 22.3% of the communities were included in at least one federal disaster declaration related to flooding for which they received public assistance between 1977 and 2014 (FEMA 2018a) (Fig. 1).

Descriptive statistics were used to compare the physical vulnerability and social vulnerability of communities with and without disaster declarations. Tables 6 and 7 detail the results of our descriptive statistical analysis. Table 5 focuses on physical vulnerability indicators, whereas Table 6 focuses on social vulnerability indicators. The results suggested that, compared with communities lacking disaster declarations, communities involved in disaster declarations generally have the following characteristics:

- physical charactersitics include lower elevation, more exposure to erosion, and less precipitation in summer and fall;
- built environment charactersitics include less road access and greater distance from urban centers;
- demographic charactersitics include larger populations, less population growth, higher percentage of youth, larger household size, and a higher percentage of Alaska Natives;
- economic charactersitics include more population below poverty levels, lower per capita income, higher employment rate, higher rate of public assistance, less communication access, and higher rate of subsistence participation; and
- political charactersitics include being more likely to be federally recognized tribes and ANCSA Village Corporations, being less likely to be incorporated in boroughs or larger municipalities, being less likely to participate in the National Flood Insurance Program, and being more likely to be covered by hazard mitigation plans.

Disaster Declarations and Physical Vulnerability

To explore the relationship between a community's physical vulnerability and the number of disaster declarations, correlation analyses and one-way ANOVA were used. The correlation analysis statistics for disaster declarations and physical vulnerability are summarized in Table 8. The point-biserial correlation coefficients suggest significant correlations between the erosion exposure and the number of state and federal disaster declarations a community received. However, there was no significant correlation between the exposure to sea level rise and the number of state disaster declarations a community received ($r_{pb} = 0.030$, $p > 0.05$) or the number of federal disaster declarations ($r_{pb} = 0.036$, $p > 0.05$). The Pearson correlation coefficient indicated significant negative correlations between the number of state disaster declarations and a community's elevation ($r = -0.147$, $p < 0.05$), the number of federal disaster declarations and a community's elevation ($r = -0.155$, $p < 0.05$), and the historical average September maximum temperature and the number of federal disaster declarations ($r = -0.119$, $p < 0.05$).

To explore the differences in disaster declarations received by communities with different predominant types of flooding (i.e., rain-induced, ice jams, or storm surge), regions, and coastal or riverine locations, one-way ANOVA, Kruskal–Wallis tests, and post hoc analyses were conducted. Because of the violation of the ANOVA test assumption of normality and equal variance (Appendix, Table 12), Kruskal–Wallis tests were conducted. The results are shown in Table 9. The mean ranks of state and federal disaster declarations were statistically different between communities with different predominant types of flooding (i.e., rain-induced, ice jams, or storm surge), in different regions, or at different coastal or riverine locations.

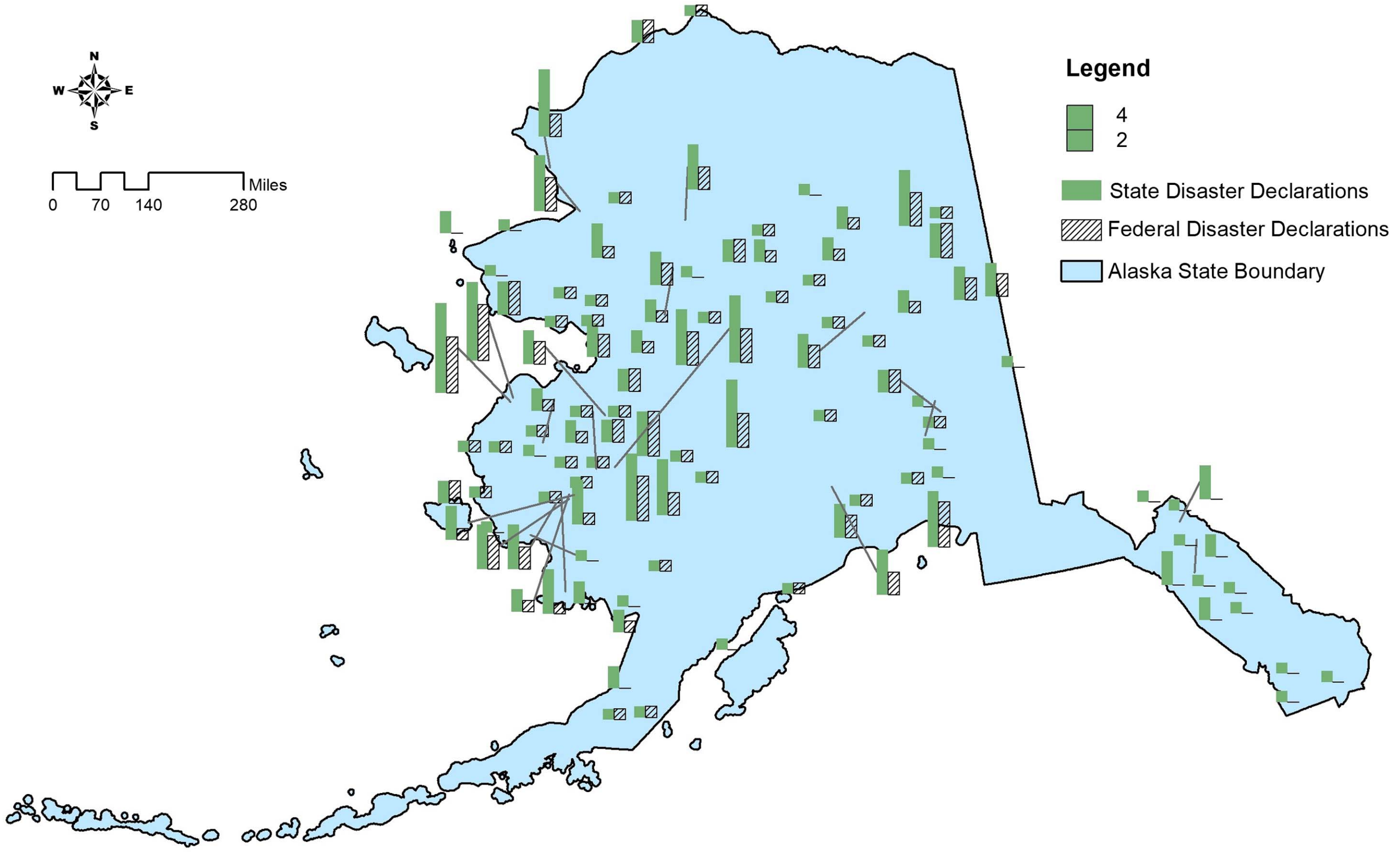

Fig. 1. State and federal disaster declarations for Alaskan communities. (Data from US Census Bureau 2017; FEMA 2018a; Cavallo 2015.)

Table 6. Physical vulnerability overview for communities with and without disaster declarations

Physical factors	Communities with disaster declarations	Communities without disaster declarations
Dominant region	Interior Alaska as a region has the greatest number of communities that received disaster declarations.	The south-central region around Anchorage has the greatest number of communities without disaster declarations.
Dominant flood pattern	Noncoastal north, northwest, Interior, and southwest along Yukon and Kuskokwim Rivers, where flooding is due to ice jams in spring and rain in late summer/early fall	South coastal, including Aleutians, south central, and southeast, where flooding is due to rain in fall and some sea storms
Adjacent to river or coast (%)	100% of communities with disaster declarations are adjacent to river or coast.	92.2% of communities without disaster declarations are adjacent to river or coast.
Mean elevation (m)	107.4	161.1
Communities with erosion problems (%)	73.8% of communities with disaster declarations have erosion problems.	35.4% of communities without disaster declarations have erosion problems.
Communities exposed to sea level rise (%)	24.3% of communities with disaster declarations are exposed to sea level rise.	22.2% of communities without disaster declarations are exposed to sea level rise.
Mean area (mi^2)	56.3	60.6
Mean September maximum temperature (°C)	9.5	9.6
Mean September maximum precipitation (mm)	183.1	198.3
Mean November maximum precipitation (mm)	166.4	205.0

To further assess which groups were significantly different from each other, pairwise comparisons with Dunn's (1964) procedure were made using a Bonferroni correction for multiple comparisons. The Bonferroni correction is a method used to counteract the problem of multiple comparisons by adjusting the significance α for each pairwise test so that the probability of observing at least one significant result by chance remains below a desired significance level (0.05) (Dunn 1964). Therefore, adjusted p-values were used to draw conclusions. First, for state disaster declarations in communities with different predominant types of flooding, the post hoc analysis revealed no statistically significant differences in the number of state disaster declarations between communities in the noncoastal south, where flooding is primarily due to rainfall (mean rank = 132.71), and communities in the coastal south, including the Aleutians, the south-central coastline, and the southeast, where flooding is due to rain in autumn and some sea storms

Nat. Hazards Rev., 2020, 21(1): 05019004

Table 7. Social vulnerability overview for communities with and without disaster declarations

Social factors	Communities with disaster declarations	Communities without disaster declarations
Average population, 2014	4,187	1,382
Average population change, 1990–2010 (%)	0.4	3.2
Average percentage of youths 19 and under, 2010 (%)	32.9	28.7
Average percentage of elderly 65 and older, 2010	9.2	9.9
Average household size, 2010	3.0	2.7
Average percentage Native Alaskan, 2010 (%)	70.7	38.2
Average percentage of persons below poverty level, 2010 (%)	25.0	19.1
Average per capita income, 2014	$19,993.20	$25,068.4
Average total resident wages in 2014 (million $)	77.6	20.1
Average percentage of employment, 2014 (%)	64.0	56.2
Average percentage of households receiving public assistance income, 2010 (%)	15.4	13.8
Communities with subsistence participation (%)	92.5	81.5
Communities with communication access (%)	89.7	95.1
Communities with road access (%)	31.8	58.0
Average distance to major city (mi)	283.6	224.0
Communities covered by local hazard mitigation plan (%)	72.9	44.0
Federally recognized tribe (%)	86	44.4
Dominant city type	Second-class city	Unincorporated census-designated place, i.e., with a significant population
ANCSA Village Corporation (%)	83.2	42.8
Within borough or larger municipality (%)	19.6	60.5
National Flood Insurance Program participant (%)	31.8	42.8

Table 8. Correlations between disaster declarations and physical vulnerability indicators

Physical factors	Correlation test statistics	State disaster declarations	Federal disaster declarations
Sea level rise exposure	Point-biserial correlation	0.030	0.036
	Significance (two-tailed)	0.579	0.499
Erosion exposure	Point-biserial correlation	0.346[a]	0.318[a]
	Significance (two-tailed)	0.000	0.000
Elevation	Pearson correlation	−0.147[a]	−0.155[a]
	Significance (two-tailed)	0.006	0.004
Area	Pearson correlation	0.008	−0.020
	Significance (two-tailed)	0.887	0.705
Temperature	Pearson correlation	−0.052	−0.119[a]
	Significance (two-tailed)	0.381	0.046
Summer precipitation	Pearson correlation	−0.040	−0.064
	Significance (two-tailed)	0.508	0.284
Fall precipitation	Pearson correlation	−0.076	−0.080
	Significance (two-tailed)	0.206	0.182

[a]Correlation significant at 0.05 level (two-tailed).

(mean rank = 161.69) ($p = 0.173$). Likewise, there was no significant difference between communities in the noncoastal north, northwest, Interior, and southwest along the Yukon and Kuskokwim Rivers, where flooding is due to ice jams in spring and rain in late summer/early fall (mean rank = 197.83), and communities along the northern and northwestern coastline, where flooding is based on sea storms related to later formation of sea ice along shorelines (mean rank = 219.89) ($p = 0.99$). However, there were significantly more state disaster declarations in the latter groups than in the former groups ($p < 0.05$).

Second, for state disaster declarations in communities in different regions, post hoc analysis revealed statistically significant differences in state disaster declarations between communities in the Aleutians (mean rank = 121.50) and the southwest (mean rank = 227.10) ($p = 0.004$), the southwest and the Anchorage area (mean rank = 129.23) ($p < 0.001$), the Anchorage area and Interior Alaska (mean rank = 190.78) ($p = 0.001$), and the Anchorage area and the Bering Strait region (mean rank = 214.28) ($p = 0.013$), and no significant differences between any other combinations ($p > 0.05$).

Third, regarding the state disaster declarations received by coastal communities and riverine communities, the post hoc analysis

Table 9. Kruskal–Wallis test results for physical vulnerability factors

		Similar distribution across groups (Boxplot)		Test of differences in mean ranks between groups	
Dependent variable	Factor	Yes	No	Accept H_0: no difference ($p > 0.05$)	Reject H_0: significant difference ($p < 0.05$)
State disaster declarations	Predominant types of flood	—	x	—	χ^2 (3) = 34.942 ($p < 0.001$)
	Region	—	x	—	χ^2 (11) = 57.681 ($p < 0.001$)
	Location to coast or river	—	x	—	χ^2 (2) = 11.995 ($p = 0.002$)
Federal disaster declarations	Predominant types of flood	—	x	—	χ^2 (3) = 43.028 ($p < 0.001$)
	Region	—	x	—	χ^2 (11) = 74.435 ($p < 0.001$)
	Location to coast or river	—	x	—	χ^2 (2) = 17.154 ($p < 0.001$)

revealed statistically significant differences in state disaster declarations between riverine communities (mean rank = 186.15) and communities not on the coast or a river (mean rank = 121.50) ($p = 0.003$), but no significant differences between riverine communities and coastal communities (mean rank = 169.30) ($p = 0.188$) or between coastal communities and communities not on the coast or a river ($p = 0.05$).

The post hoc analysis revealed no statistically significant differences in the number of federal disaster declarations between communities in the non-coastal south (mean rank = 142.00) and communities in the coastal south (mean rank = 156.14) ($p = 0.99$), or between communities in the noncoastal north, northwest, Interior, and southwest along the Yukon and Kuskokwim Rivers (mean rank = 201.04) and communities along the northern and northwestern coastlines (mean rank = 213.33) ($p = 0.99$). However, as with state disaster declarations, there were significantly more federal disaster declarations in the latter groups than in the former groups ($p < 0.05$).

Furthermore, post hoc analysis revealed significant differences in federal disaster declarations between communities in the southeast (mean rank = 136.00) and Interior Alaska (mean rank = 197.01) ($p = 0.001$), the southeast and the southwest (mean rank = 230.41) ($p < 0.001$), Kodiak (mean rank = 136.00) and the southwest ($p = 0.008$), the Aleutians (mean rank = 136.00) and the southwest ($p = 0.004$), the Anchorage area (mean rank = 143.72) and Interior Alaska ($p = 0.001$), the Anchorage area and the southwest ($p < 0.001$), inland southcentral (mean rank = 151.93) and the southwest ($p = 0.002$), and the Bristol Bay region (mean rank = 159.56) and the southwest ($p = 0.004$), and no significant differences between any other combinations ($p > 0.05$). In summary, the southwest received significantly more state and federal disasters compared with other regions.

Finally, the post hoc analysis revealed statistically significant differences in federal disaster declarations between riverine communities (mean rank = 190.37) and communities not on coast or river (mean rank = 136.00) ($p = 0.007$), and between riverine communities and coastal communities (mean rank = 162.96) ($p = 0.002$), but no significant differences between coastal communities and communities not on a coast or river ($p = 0.391$).

Disaster Declarations and Social Vulnerability

To explore the relationship between a community's social vulnerability and the number of disaster declarations, correlation analyses and ANOVA were used. The correlation analysis results for disaster declarations and social vulnerability are summarized in Table 10. The point-biserial correlation coefficients revealed significant correlations between the number of state disaster declarations and association with a federally recognized tribe ($r_{pb} = 0.310$, $p < 0.05$), incorporation within a borough or larger municipality ($r_{pb} = -0.263$, $p < 0.05$), and the presence of some kind of hazard mitigation plan as of 2016 ($r_{pb} = 0.281$, $p < 0.05$. There were no significant correlations between the number of state disaster declarations and subsistence participation, communication access, or participation in the NFIP. The point-biserial correlation coefficients displayed significant correlations between the number of federal disaster declarations and association with a federally recognized tribe ($r_{pb} = 0.286$, $p < 0.05$), incorporation within a borough or larger municipality ($r_{pb} = -0.260$, $p < 0.05$) and coverage by some kind of hazard mitigation plan as of 2016 ($r_{pb} = 0.260$, $p < 0.05$). No significant correlations were found between the number of federal disaster declarations and subsistence participation, communication access, or participation in the NFIP.

The Pearson correlation coefficient indicated significant positive correlations between the number of state disaster declarations and the community population size in 2014 ($r = 0.139$, $p < 0.05$), percentage of population 19 or under in 2010 ($r = 0.125$, $p < 0.05$), average household size in 2010 ($r = 0.130$, $p < 0.05$), percentage of native population ($r = 0.298$, $p < 0.05$), total resident wages in 2014 ($r = 0.138$, $p < 0.05$), employment rate in 2014 ($r = 0.201$, $p < 0.05$), and distance to major urban centers ($r = 0.130$, $p < 0.05$). There was a significant negative correlation between the number of state disaster declarations and per capita income in 2014 ($r = -0.115$, $p < 0.05$). No significant correlations were found between state disaster declarations and population change during 1990–2010, percentage of population 65 or older in 2010, percentage of population below poverty level, or percentage of households receiving public assistance.

The Pearson correlation coefficients also disclosed significant positive correlations between the number of federal disaster declarations and the percentage of population 19 or under in 2010 ($r = 0.128$, $p < 0.05$), average household size in 2010 ($r = 0.146$, $p < 0.05$), percentage of native population ($r = 0.295$, $p < 0.05$), percentage of population below the poverty level ($r = 0.130$, $p < 0.05$), employment rate in 2014 ($r = 0.207$, $p < 0.05$), and distance to major urban centers ($r = 0.141$, $p < 0.05$). There was a significant negative correlation between the number of federal disaster declarations and per capita income in 2014 ($r = -0.121$, $p < 0.05$). No significant correlations were found between federal disaster declarations and the community population size in 2014, population change during 1990–2010, percentage of population 65 and older in 2010, total resident wages in 2014, or percentage of household receiving public assistance.

ANOVA, Kruskal–Wallis tests, and post hoc analyses were used to explore the differences in disaster declarations received by communities with different levels of road access, different city administration, and different village corporation types. Because of the violation of the ANOVA test assumption of normality and equal variance (Appendix, Table 13), Kruskal–Wallis tests were conducted. The results are shown in Table 11. The mean ranks of state and federal disaster declarations were statistically different between communities with different levels of road access, different city administration, and different village corporation types.

To further assess which groups were significantly different from each other, pairwise comparisons with Dunn's (1964) procedure were conducted using a Bonferroni correction for multiple comparisons. Adjusted p-values were used to draw conclusions. For state disaster declarations in communities with different levels of road access, the post hoc analysis revealed statistically significant fewer state disaster declarations for communities on the Alaska State Highway System that can obtain supplies by road throughout the year (mean rank = 144.40) compared with communities not on the Alaska State Highway or Marine Highway System (mean rank = 195.92) ($p < 0.001$), or communities on the Alaska State Highway System that can obtain supplies by road except when roads are closed in winter (mean rank = 325.00) ($p < 0.001$). Second, regarding municipal administration, the post hoc analysis revealed statistically significant fewer state disaster declarations for communities that are unincorporated census-designated places (mean rank = 149.58) compared with the other communities, namely communities that are second-class cities (mean rank = 203.34) ($p < 0.001$), communities that are first-class cities (mean rank = 228.98) ($p < 0.001$), and communities that are home-rule cities (mean rank = 225.16) ($p = 0.002$). Third, the post hoc analysis revealed that communities whose village corporations had merged received significantly more state disaster declarations (mean rank = 260.76) compared with other communities, i.e., communities not associated with village

Nat. Hazards Rev., 2020, 21(1): 05019004

Table 10. Correlations between disaster declarations and social vulnerability indicators

Social factors	Correlation test statistics	State disaster declarations	Federal disaster declarations
Subsistence participation	Point-biserial correlation	0.104	0.089
	Significance (two-tailed)	0.052	0.096
Communication access	Point-biserial correlation	−0.061	−0.076
	Significance (two-tailed)	0.253	0.155
Association with federally recognized tribe	Point-biserial correlation	0.310[a]	0.286[a]
	Significance (two-tailed)	0.000	0.000
Incorporation in borough or larger municipality	Point-biserial correlation	−0.263[a]	−0.260[a]
	Significance (two-tailed)	0.000	0.000
Participation in NFIP	Point-biserial correlation	0.048	0.021
	Significance (two-tailed)	0.367	0.695
Coverage by hazard mitigation plan	Point-biserial correlation	0.281[a]	0.260[a]
	Significance (two-tailed)	0.000	0.000
Population size 2014	Pearson correlation	0.139[a]	0.100
	Significance (two-tailed)	0.009	0.061
Population change 1990–2010	Pearson correlation	−0.067	−0.058
	Significance (two-tailed)	0.259	0.325
Percentage of youth (19 or under)	Pearson correlation	0.125[a]	0.128[a]
	Significance (two-tailed)	0.026	0.023
Percentage of elders (65 or older)	Pearson correlation	−0.020	−0.033
	Significance (two-tailed)	0.724	0.554
Household size 2010	Pearson correlation	0.130[a]	0.146[a]
	Significance (two-tailed)	0.018	0.008
Percent of native population	Pearson correlation	0.298[a]	0.295[a]
	Significance (two-tailed)	0.000	0.000
Percentage of population below poverty level 2010	Pearson correlation	0.111	0.130[a]
	Significance (two-tailed)	0.053	0.023
Per capita income 2014	Pearson correlation	−0.115[a]	−0.121[a]
	Significance (two-tailed)	0.041	0.030
Total resident wages 2014	Pearson correlation	0.138[a]	0.099
	Significance (two-tailed)	0.012	0.072
Employment rate 2014	Pearson correlation	0.201[a]	0.207[a]
	Significance (two-tailed)	0.000	0.000
Percentage of household receiving public assistance	Pearson correlation	0.013	0.028
	Significance (two-tailed)	0.839	0.662
Distance to major urban centers	Pearson correlation	0.130[a]	0.141[a]
	Significance (two-tailed)	0.016	0.009

[a]Correlation significant at 0.05 level (two-tailed).

Table 11. Kruskal–Wallis test results for social vulnerability factors

		Similar distribution across groups (boxplot)		Test of differences in mean ranks between groups	
Dependent variable	Factor	Yes	No	Accept H_0: no difference ($p > 0.05$)	Reject H_0: significant difference ($p < 0.05$)
State disaster declarations	Road access	—	x	—	χ^2 (3) = 37.749 ($p < 0.001$)
	City administration	—	x	—	χ^2 (3) = 47.242 ($p < 0.001$)
	Village corporation type	—	x	—	χ^2 (3) = 62.434 ($p < 0.001$)
Federal disaster declarations	Road access	—	x	—	χ^2 (3) = 41.639 ($p < 0.001$)
	City administration	—	x	—	χ^2 (3) = 32.586 ($p < 0.001$)
	Village corporation type	—	x	—	χ^2 (3) = 57.157 ($p < 0.001$)

Nat. Hazards Rev., 2020, 21(1): 05019004

corporations (mean rank = 140.64) ($p < 0.001$), communities with regular village corporations (mean rank = 195.25) ($p = 0.002$), or communities whose village corporations merged with a regional corporation (mean rank = 192.22) ($p = 0.048$). Furthermore, communities with regular village corporations had significantly more state disaster declarations compared with communities not associated with village corporations ($p < 0.001$) (the latter generally correspond to nontribal communities).

Regarding federal disaster declarations, the post hoc analysis disclosed significant differences in federal disaster declarations between the following groups: communities on the Alaska State Highway System that can obtain supplies by road throughout the year (mean rank = 149.85) and communities not on the Alaska State Highway or Marine Highway System (mean rank = 196.32) ($p < 0.001$), communities on the Alaska State Highway System that can obtain supplies by road throughout the year and communities on the Alaska State Highway System that can obtain supplies by road except when roads are closed in winter (mean rank = 327.50) ($p = 0.004$), communities on the Alaska Marine Highway System that can obtain supplies by ship year-round (mean rank = 157.47) and communities not on the Alaska State Highway or Marine Highway System ($p = 0.035$), and communities on the Alaska Marine Highway System that can obtain supplies by ship year-round and communities on the Alaska State Highway System that can obtain supplies by road except when roads are closed in winter ($p = 0.009$). In summary, communities that are on the Alaska State Highway System and can obtain supplies by road except when roads are closed in winter, along with communities not on the Alaska State Highway or Marine Highway System at all, received significantly more federal disasters than communities on the Alaska Marine Highway System that can obtain supplies by ship year-round or communities on the Alaska State Highway System that can obtain supplies by road throughout the year. Second, regarding municipal administration, the post hoc analysis showed there were statistically significant fewer federal disaster declarations for communities that are unincorporated census-designated places (mean rank = 115.67) compared with the communities that are second-class cities (mean rank = 201.51) ($p < 0.001$). Finally, the post hoc analysis indicated that communities whose village corporations had merged had significantly more federal disaster declarations (mean rank = 254.30) compared with other communities, i.e., communities without village corporations (mean rank = 146.82) ($p < 0.001$), communities with regular village corporations (mean rank = 190.67) ($p = 0.001$), or communities whose village corporations merged with a regional corporation (mean rank = 185.58) ($p = 0.018$). Furthermore, communities with regular village corporations had significantly more federal disaster declarations compared with communities without village corporations ($p < 0.001$).

Discussion and Conclusions

Many Alaska Native Villages, particularly those in remote areas along shorelines with few economic resources, are vulnerable to flooding disasters. Climate change likely has exacerbated flooding disasters in northern and northwestern coastal communities where ice is melting, and flooding disasters are continuing to occur as they have for some time in more interior riverine communities. The results suggest that many ANVs tend to be more vulnerable to flooding disasters than urban centers such as Anchorage and Fairbanks. These ANVs tend to have more erosion, no road connection to urban centers, larger household sizes, more Alaska Native residents, greater poverty, less incorporation in boroughs or larger municipalities, and less participation in the National Flood Insurance Program than their urban counterparts. Many are off the road system, making disaster assistance more complicated. This is an environmental justice issue, because the most vulnerable communities are primarily Alaska Native and inhabited by populations that historically were forced to settle in places not meant for permanent habitation.

A number of studies have sought to quantify the vulnerability of Alaskan communities to climate change and disasters, but few have considered how the most vulnerable communities could reduce their vulnerability. State and federal disaster declarations have provided some postdisaster relief to vulnerable Alaskan communities, but to date there has been little research about whether the most vulnerable Alaskan communities are getting these disaster declarations. This research suggests that, on average, both state and federal disaster declarations are more likely to occur in these remote areas with greater physical and social vulnerability than in urban areas with less vulnerability and more resources to protect from and respond to disaster.

This finding is positive, because it suggests that, collectively, communities with greater vulnerability are receiving more state and federal disaster declarations, which come with disaster aid. However, some of the most vulnerable communities may not be getting all the help they need. As mentioned in the "Introduction," ANVs that appear to be extremely prone to flooding disasters (such as Shishmaref) are not necessarily getting more disaster declarations. Interior Alaska as a region has the greatest number of communities that have received both state and federal disaster declarations based on descriptive statistics, but inferential statistics suggest that southwest Alaskan communities tend to get more state and federal disaster declarations per community, on average.

There are two possible explanations for this finding. First, it may be that southwest communities are experiencing more disaster events, but are not getting as much attention in the literature and media as communities seeking to relocate (such as Shishmaref). This explanation may be consistent with GAO (2009, p. 14), which suggested that most of the imminently threatened communities are located in the southwest (although most of these are on the coast).

Whereas northern and northwestern coastal Alaska Native Villages are beginning to receive needed attention for flooding and erosion related to melting sea ice and climate change (GAO 2009; Bronen 2011; Brown et al. 2015; Wolsko and Marino 2016; Chapin et al. 2014), flooding and erosion that has occurred for many years in inland communities along the Yukon and Kuskokwim Rivers has received relatively little attention. This research suggests that noncoastal riverine flooding is an important phenomenon that is perhaps overlooked by peer reviewed and popular articles, because riverine communities actually have received more federal disaster declarations and assistance than the more recently impacted coastal communities.

Second, these findings regarding more state and federal disaster declarations for southwest communities also could mean that factors other than physical vulnerability, such as political power and organization, may influence disaster declarations (Cutter et al. 2014, p. 70; Rubin et al. 1985, p. 42; Garrett and Sobel 2003; Salkowe and Chakraborty 2009; Shearer 2012). Just because disaster strikes does not mean that a community will receive a disaster declaration. Rather, better community organization and more resources (including capacity and social capital) are correlated with disaster declarations. For example, communities whose tribally associated corporations had merged with other village corporations were associated with more state and federal disaster declarations. Communities that were covered by a hazard mitigation plan (which is not required for disaster aid but enables postdisaster grants) were associated with more state and federal disaster declarations. Finally, communities that were part of a county-level government (a borough) were associated with fewer state and federal disaster declarations. These findings suggest that communities with higher levels of organizational capacity, i.e., those that are able to collaborate at a local level and obtain planning services, may be more successful advocates for a disaster declaration. There remain in Alaska a number of communities that have no publicly available, written plan to address hazard mitigation or other community goals, so they may be at a disadvantage in getting disaster-related assistance. Likewise, a number of communities (including 70 ANVs) have no local government other than their tribal government, so they are not eligible for grant opportunities that are open to municipalities. Although being part of a borough seemingly shows higher levels of organization, inclusion can mean that an ANV lacks its own hazard mitigation plan and that it must seek a disaster declaration first by going through the borough. It also may be that the most physically vulnerable ANVs happen to be located outside of boroughs, which do not cover the entire state.

Aside from the location of disaster declarations, an interesting outcome of this study is that erosion happens to be closely correlated with disaster declarations, even though erosion alone cannot garner a state or federal disaster declaration. Therefore, because disaster declarations and FEMA aid are mainly geared toward postdisaster elevation and relocation of buildings, they may not be addressing erosion that is contributing to future disasters. Further study should explore the relationship between efforts to mitigate erosion and disaster risk reduction.

Unless Congress shifts funding toward more proactive predisaster programs such as FEMA's predisaster mitigation program (42 U.S.C. §5133), ANVs will rely on whatever funding they can obtain from after-the-fact disaster declarations. Although these declarations are a valuable source of aid, they are a reaction to a disaster and do little to proactively address problems that contribute to vulnerability, such as erosion. Additionally, there is a need to build social capital and to bolster local adaptation, hazard mitigation, and disaster response capacity.

Appendix. Analysis Procedures

To explore the differences in disaster declarations received by communities with different predominant types of flooding (i.e., rain-induced, ice jams, and storm surge), regions, coastal or riverine locations, we conducted one-way ANOVA. To examine the outlier, normality, and heterogeneity of variance assumptions of ANOVA tests, boxplots, Shapiro–Wilk tests, and Levene's tests of homogeneity of variances were conducted. The results are summarized in Table 12. Due to the existence of outliers as assessed by inspection of a boxplot, violation of normality assumption as assessed by a Shapiro–Wilk test, and heterogeneity of variances as assessed by Levene's test of homogeneity of variances, we conducted Kruskal–Wallis tests to determine if there were differences in disaster declarations between communities with different predominant types of flooding, region, and locations.

We used one-way ANOVA to explore the differences in disaster declarations received by communities with different levels of road access, different city administration, and different village corporation types. The Alaska Native Claims Settlement Act (ANCSA) created village and regional corporations out of tribal members (43 U.S.C. §§ 1606, 1607) and gave these corporations a portion of the land that the tribes traditionally occupied (43 U.S.C. §§ 1611, 1613, 1618). Almost every ANV is associated with an ANCSA Village Corporation, although some ANVs merged their Village Corporations with other Village Corporations or their Regional Corporation. To examine the outliner, the normality, and heterogeneity of variance assumptions of ANOVA test, boxplots, Shapiro–Wilk tests, and Levene's tests of homogeneity of variances

Table 12. Test of assumptions for physical vulnerability ANOVA analysis

Dependent variable	Factor	Existence of outlier (boxplot): Yes	No	Shapiro–Wilk normality test: Accept H_0 ($p > 0.05$)	Reject H_0 ($p < 0.05$)	Levene's tests of homogeneity of variances: Accept H_0 ($p > 0.05$)	Reject H_0 ($p < 0.05$)
State disaster declarations	Predominant types of flood	x	—	—	$p < 0.05$	—	$F(3, 345) = 16.877$ ($p < 0.001$)
	Region	x	—	—	$p < 0.05$	—	$F(11, 337) = 15.425$ ($p < 0.001$)
	Location to coast or river	x	—	—	$p < 0.001$	—	$F(2, 346) = 10.222$ ($p < 0.001$)
Federal disaster declarations	Predominant types of flood	x	—	—	$p < 0.05$	—	$F(3, 345) = 23.399$ ($p < 0.001$)
	Region	x	—	—	$p < 0.01$	—	$F(11, 337) = 15.291$ ($p < 0.001$)
	Location to coast or river	x	—	—	$p < 0.001$	—	$F(2, 346) = 12.769$ ($p < 0.001$)

Table 13. Test of assumptions for social vulnerability ANOVA analysis

Dependent variable	Factor	Existence of outlier (boxplot): Yes	No	Shapiro–Wilk normality test: Accept H_0 ($p > 0.05$)	Reject H_0 ($p < 0.05$)	Levene's tests of homogeneity of variances: Accept H_0 ($p > 0.05$)	Reject H_0 ($p < 0.05$)
State disaster declarations	Road access	x	—	—	$p < 0.001$	—	$F(3, 345) = 16.808$ ($p < 0.001$)
	City administration	x	—	—	$p < 0.05$	—	$F(3, 345) = 22.623$ ($p < 0.001$)
	Village corporation type	x	—	—	$p < 0.05$	—	$F(3, 345) = 28.995$ ($p < 0.001$)
Federal disaster declarations	Road access	x	—	—	$p < 0.001$	—	$F(3, 345) = 23.722$ ($p < 0.001$)
	City administration	x	—	—	$p < 0.001$	—	$F(3, 345) = 21.325$ ($p < 0.001$)
	Village corporation type	x	—	—	$p < 0.001$	—	$F(3, 345) = 41.424$ ($p < 0.001$)

were conducted (Table 13). Due to the existence of outliers as assessed by inspection of a boxplot, violation of normality assumption as assessed by a Shapiro–Wilk test, and heterogeneity of variances assessed by Levene's test of homogeneity of variances, we conducted Kruskal–Wallis tests to determine if there were differences in disaster declarations between communities with different levels of road access, different city administration, and different village corporation types.

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