Patterns of violence in the Bosnian civil war.

Andreas Beger*
Florida State University

10 December 2008

Are there patterns in the location of violence during the Bosnian civil war from 1992 to 1995? Existing theories of civil war do not have direct implications for where violence should have been observed, and more recent work on civil war using GIS is based on grid cells that are inappropriate to answer this question. Using an inductive approach, this project maps data on violent events to demographic data for Bosnia and Herzegovina's 109 pre-war municipalities to identify potential relationships between ethnic demographics and violence. Subsequent regression analysis confirms that violence was clustered predominantly in Muslim inhabited areas. The results suggest that measures capturing how diverse an area is, or how exposed it is to ethnic cleansing, could be useful for predicting the location of violence in other conflicts.

Submitted to Dr. Lisa Jordan for Social Applications of Geographic Information Systems, Fall 2008.

* Ph.D. Student, Department of Political Science, Florida State University, 113 Collegiate Loop, Tallahassee, FL 32306-2230. abeger@fsu.edu.

1 Introduction

Most existing work on civil wars allows one to broadly identify which countries are at risk for conflict, but it provides limited information on where violence will be located in countries at war (Buhaug and Lujala 2005). The goal of this project is to identify patters in the location of violence during the Bosnian civil war. As such, it is descriptive in nature and not driven by a solid theoretical expectations. This is because, as I will argue below, while existing theories of civil war have some implications for the location of violence within countries, they are not specific enough to clearly identify where violence should be located. Ultimately, the aim of this project is to inductively identify patterns in the location of violence to develop specific theoretical arguments on the spatial location of violence in countries experiencing civil war that could then be used for deductive research using data from other conflicts for empirical analysis.

Traditional research on civil wars is conducted at the country level, and concentrates on the onset of civil war (e.g. Fearon and Laitin 2003, Collier and Hoeffler 2004). Although theoretical arguments associated with this research are tested only at the country level, they do have some important general implications for patterns of violence within countries. In response, more recent research based on the use of GIS has sought to disaggregate civil wars by using smaller units of observation (e.g. Buhaug and Rød 2006, Raleigh and Urdal 2007). The first section in this paper provides a rough and short overview of traditional research on civil war, along with its critiques from a geographic perspective, and recent developments to address these issues. In light of theoretical issues in moving from aggregate theories to specific implications for the location of violence however, this project proceeds in an inductive manner with the goal of locating patterns in the location of violence during the Bosnian civil war. Moreover, the focus is not on the onset or incidence of conflict (which is inherently dichotomous in nature), but rather the number of violent events in a given area. Due to difficulties in obtaining detailed data below the country level, the empirical analysis here focuses on the Bosnian civil war from 1992 to 1995, with data on the location of violent events drawn from the Armed Conflict Location and Event Dataset (ACLED; Raleigh and Hegre 2005).

The immediate goal of this project is to identify patterns in the location of violence during the Bosnian civil war that ultimately could be extended to other conflicts to see if they hold. A lot has been written on the Bosnian war, so the results, that most violence was related to ethnic cleansing, are by no means innovative, but then, that is not the goal at this stage. Although it might be easy to predict that ethnic cleansing will be a major factor in a war, that in and of itself does not provide specific prescriptions for the location of actual violence. By literally confronting the data, this project forces a clear and explicit statement of how violence relates to various factors. Because this project is inductive in nature, a true hypothesis test for implications drawn from the conclusions in this paper requires extending this research project to other conflicts.

After a brief background on the Bosnian civil war, I discuss the data and methods used in this paper. The first step in the empirical analysis was to visually map violent events relative to various factors of concern, such as the ethnic makeup of Bosnia's municipalities prior to the war. This suggested two patterns in the location of violence which are subsequently confirmed in a statistical analysis using bootstrapped negative binomial regression analysis. Overall, the next part of this research project is to verify the patterns identified here by drawing out additional implications and conducting empirical analyses in other conflicts as well. Doing so would provide a proper evaluation, with the potential for falsification, for the findings presented here.

2 Insurgency, ethnicity, and violence.

At least since the 1990's, a significant amount of attention has been paid in political science to the causes and consequences of civil war. The focus has predominantly been on explaining the onset of civil war, and the following section will outline some of the major arguments in that area. However, among the criticisms leveled against this work is that it uses country-years as the basic unit of observation and hence is vulnerable to issues arising from overaggregation. As a result, and partly driven by the availability of better conflict data, more recently there is an increasing number of GIS-based work that builds on smaller geographical units.

2.1 Traditional studies of civil war

In the wake of the civil wars following the breakup of Yugoslavia in the early 1990's, there was much anecdotal evidence for the existence of brutal "ethnic" wars in which opposing ethnic groups, typically thought to be driven by "ancient hatreds" that were reignited after communist regimes fell from power, engaged in mutual genocide and ethnic cleansing in order to build homogeneous nation-states (for example Kaplan 1993).[1] Political scientists built on these arguments by looking for empirical evidence to support some type of link between ethnicity and civil war. To date, there is mixed support, at best, for various incarnations of such a link, but many alternative arguments to explain civil war have emerged instead.

Going back a step, it is useful to first look at how civil war has been studied in political science. Conceptually, a civil war is a conflict fought within the boundaries of an internationally recognized state by organized political or military actors, where the state or party representing the state is one of the principal combatants. Although there are various nuances on specific op-

[1] RANDOM: To be honest, being half Yugoslavian myself, I think that all of these ancient hatreds arguments are highly questionable at best. Pick any two groups that have lived in close proximity, go back far enough, and you will find some past conflict. Unfortunately, the ancient hatreds argument is very common anywhere you look in reference to groups other than your own (e.g. American journalists will write about ancient hatreds between Sunni and Shia Arabs in Iraq, but not about ancient hatreds between White and Black Americans…if slavery is not a cause for ancient hatreds I don't know what would be).

erational definitions of civil war (Gleditsch et al. 2002, Harbom, Melander and Wallensteen 2008, Sambanis 2004, Sarkees 2000), the most common additions are various clauses related to fatalities that identify when a conflict passes the threshold from a conflict to "proper" war. The most common clauses are that (a) a civil war starts in the year in which battle-related fatalities surpass some threshold, typically 1,000, and (b) there must be effective resistance, i.e. all parties must sustain some relative or absolute number of fatalities(for more detail see Sambanis 2004).[2] The unit of observation underlying actual coding and most research is the country-year, i.e. observations consisting of a given year for a given country. Typically data cover all countries with a population above 500,000 from 1946 to the near present.

Substantively, the focus of most research has been to explain the onset of civil war. There are two major, substantiated arguments that have developed out of this literature. The first argument focuses on the opportunity to wage an insurgency as the main explanation for civil war onset (Fearon and Laitin 2003). Essentially, certain structural conditions are thought to favor conflict, and prime amongst them are a weak central government as well as states that have remote and/or inaccessible terrain that favors insurgency warfare, such as jungles or mountainous areas. The second argument focuses on easily lootable resources such as diamonds and precious metals that can make rebellion a lucrative undertaking (Collier 2000, Collier and Hoeffler 2004)—i.e. rebellion is motivated by greed. Both assume that grievances to motivate rebellion are either always present and/or irrelevant. Aside from these two arguments, a multitude of other research explores various factors that may also be related to civil war onset. With a few exceptions, the duration of civil wars (Fearon 2004) or their fatalities (Lacina and Gleditsch 2005, Lacina 2006) are not studied (yet?).

The role of ethnicity in civil war is much less clear than colloquial opinion (from journalists, politicians, etc.) would make it out to be. Partly this may be because quantitative research faces the challenge of explicitly specifying measures related to ethnicity, rather than being able to rely on case-specific observations in which members of different ethnic groups fought each other. The standard solution to this measurement problem has been to construct country-level indices of ethnic diversity or some other aspect of the distribution of a country's population among different ethnic groups. The most common index is the ethnolinguistic fractionalization index (ELF; Taylor and Hudson 1972), originally calculated using data on ethnic groups from a Soviet atlas (Bruck and Apanchenko 1964), but since then updated with more recent demographic data (for example Reynal-Querol 2002, Fearon 2003). The ELF more or less measures the probability that two randomly picked individuals will *not* belong to the same ethnic group. Because there is no theoretical link between ethnic diversity in that sense and civil war, various other, more theoretically motivated indices have also been proposed (Montalvo and Reynal-Querol 2005). Regardless of the index used however, there are no consistent findings about the relationship

[2] The latter clause is to distinguish civil war from genocide or other forms of one-sided killing.

between ethnic diversity and civil war (for example Hegre and Sambanis 2006).

2.2 Disaggregating civil war

Branching off from these "traditional" studies of civil war, a new stream of work that leverages GIS to study civil wars has emerged to supplant extant work. Among the questions that motivate it is the potential for making arguments subject to ecological fallacy (Buhaug and Lujala 2005, 403–404). Although most existing arguments relating to civil war are not very explicit about what happens within a country that experiences civil war, they do have some clear implications. For example, if civil wars are fought primarily because the opportunity for doing so is high (e.g. weak state and structural conditions that favor rebellion), then we should probably expect to see that rebel groups are based in areas that meet these conditions. Rebel groups in Colombia should be based in the jungles and mountains, where government control is weak, not in urban areas, where government control is typically strong. By only examining country-level data, most existing research cannot identify whether such implications are met within countries that experience civil war. Using GIS to develop smaller units of observation is thus useful to ensure that lower-level implications are empirically reasonable.

Another motivation for moving to lower units of observation is simply that it allows research to focus on the location of violence within countries, not only across countries (Buhaug and Gates 2002, Buhaug and Lujala 2005). Being able to understand why violence occurs in certain areas during a conflict and not others is theoretically interesting, but ultimately, it is also practically useful. In an extreme example, accurately forecasting that a large country like Russia or Brazil will experience civil war in 2020 in an of itself is not completely satisfying—knowing where violence during such a conflict will likely be located provides much more information on who will be involved in such a conflict, how to respond to it, etc.

Because data on civil violence is hardly available below the country level, early work in this stream of the literature focused on identifying the location and extent of conflict zones within countries that experienced civil war (Buhaug and Gates 2002, Buhaug and Lujala 2005). This presents new problems in using geographically disaggregated data on various explanatory variables in a consistent manner, and limits the ability of statistical models to predict specific conflict locations within a country. Thus with the advent of new data on the geographic location of specific violent events in countries experiencing civil war (Raleigh and Hegre 2005), more recent research has turned to the use of grid cells as a basic unit of observation in statistical analyses of civil war violence (Buhaug and Rød 2006, Raleigh and Urdal 2007). These studies use arbitrary grid cells with a size of 100km by 100km (at the equator), to which all other data are merged into, in conjunction with regression analysis, to model the relationships between various factors and the incidence of conflict in the area bound by a grid cell.

2.3 Violence in Bosnia

This particular project, although motivated by the above-mentioned work, by necessity deviates in some respects. First, there are minor data management issues when converting data from it's natural format to the grid cells used in those studies. Demographic data are usually collected at the level of local administrative units, and using grid cells would require transplanting demographic data to the appropriate format. In large cross-national studies this is unlikely to affect the overall validity of these studies, and using more "natural" administrative units instead of grid cells would only improve reliability. In fact, using arbitrary grid cells is more desirable as administrative units might be too fine-grained when studying whole continents (Buhaug and Rød 2006). Changes in administrative boundaries, as occurred in Bosnia *after* the war also pose data problems when time-series data are used. This project is focused on one, fairly small country and demographic data is drawn from census data with only 109 data points, one for each pre-war municipality. As a result, transforming demographic data from municipalities to grids is much more likely to be a problem as far as validity is concerned, and thus I simply use municipalities as the unit of observation.[3]

Additionally, while 100km × 100km grid cells are adequate in cross-national studies, they are still fairly large areas. Bosnia only has an area slightly larger than 50,000km^2, and thus would only constitute a few cells. This would prevent statistical analysis. Furthermore, one could argue that in some situations a finer-grained unit of observation than large grid cells might be desirable.[4] Of course the consequent drawback is that the work here is not directly comparable to existing work that relies on grid cells.

Second, rather than focus on the incidence of armed conflict, I also examine the number of violent events in any given area during the Bosnian civil war. Given the question at hand this seems theoretically more appealing, but there are also concrete measurement problems that justify this approach. On one hand, studying the incidence of violence is preferable in cross-national research because there are likely to be strong differences in the amount of measurement error across different conflicts. For example, the civil wars in former Yugoslavia were probably much better covered than the average African civil war, and thus there is more data on specific violent events in the former than in the latter, regardless of the actual intensity of the conflicts. On the other hand, this cross-national issue is not of concern here because I focus on Bosnia, and, more importantly, almost every municipality in Bosnia experienced at least one violent event during the war. As a result incidence alone becomes practically meaningless in the Bosnian civil

[3] Ultimately all research will have to convert data at some point, e.g. when converting elevation data in raster format for use with whatever unit is at hand.

[4] For example, some NGOs like Amnesty International have started projects to remotely monitor human rights violations, genocide, and ethnic cleansing using remote sensing with satellites. Because satellite coverage is limited and expensive to finance, knowing where best to look could greatly aid these efforts. Military forces that rely on unmanned aerial vehicles or reconnaissance planes to some extent could similarly benefit.

war.

The last major deviation from previous work is that this project is inductive in nature. Part of the goal of disaggregating the data used to study civil wars ultimately is to better evaluate current theoretical arguments about civil war. The transition from country-level arguments to lower level implications is not quite straightforward however. For example, assuming that lootable resources are related to conflict, and given data on the location of lootable resources in a country, there still is no clear implication for where violence will occur. If the central government is relatively strong, fighting might occur right in resource areas, but if the government is fairly weak, rebel groups might have a consolidated hold on resources areas and fighting will occur elsewhere. Most extant arguments about civil war share this ambiguity about lower level implications for the location of violence. Empirical research to date that does have clear predictions relies on the extent to which either side in a civil war controls a given area to make arguments about the location of selective violence only (Kalyvas 2006). Data on zones of control are hard to collect however and do not exist with a few exceptions (one being Kalyvas and Kocher 2007).[5] Thus existing theoretical arguments are limited in how accurate their implications for the location of violence are. This is less of an issue for extant research that relies on grid cells or battle areas because these typically still cover a relatively large area. With existing grid cells, the distance between the center of each unit of observation is roughly 100km—one can probably safely presume that rebel groups will typically not venture that far astray from areas they control. In the case of Bosnia however, the distance between the centers of different municipalities is a matter of a few kilometers. For practical purposes, there are no existing theoretical arguments that have direct implications for the location of violence at such a small scale.

In light of this problem, this paper is very much an explorative and descriptive effort. The goal is to identify patterns in the location of violence in the Bosnian civil war. Although ethnic violence and cleansing offers itself as an immediate explanation for much of the violence during this conflict, these claims themselves do not suggest much in the way of where violence should have been located. This project confronts the data to develop clear and explicit statements on how violence relates to various factors of interest and how these influence the location of violence. Thus what is presented here is only a first step in further research that is needed to properly test the resulting implications using data from other conflicts.

Before proceeding to the actual empirical analysis, below is a quick overview of the Bosnian civil war.

[5]The prime exception is the Vietnam War, in which the United States for a few years collected systematic data on insurgent/government control through the Hamlet Evaluation System and other projects (Kalyvas and Kocher 2007). Once declassified, similar data will probably be also available for the current Iraq and Afghanistan Wars.

3 The Bosnian civil war

Yugoslavia was reestablished in the wake of World War 2 as a socialist federal state consisting of six republics (see figure 2).[6] Bosnia and Herzegovina (BiH) was somewhat unique among them as the only republic without a clear ethnic majority. In 1991, the three major ethnic groups, Bosnian Muslims, Serbs, and Croats, constituted 43.48%, 31.21%, and 17.38% of the population respectively. As the communist regimes in Eastern Europe and Yugoslavia started to weaken and eventually fall in the late 1980's and early 1990's, BiH was as a result in a somewhat precarious positions within Yugoslavia. Nationalist leaders in the republics of Slovenia, Croatia, and Serbia started to call for more decentralization or centralization respectively, and the federal government of Yugoslavia was increasingly paralyzed. By 1991, after free multiparty elections that generally strengthened nationalist leaders in the republics, a confrontation over the issue of federalism between Serbia on one side, and Croatia and Slovenia on the other, was quite obvious. In case of secession, BiH's territorial integrity was threatened by demands from its Serb and Croat populations to join their parent republics/states, while staying in a Yugoslavia without Slovenia and Croatia practically meant domination by Serbia.

Following several months of uncertainty, Slovenia *de facto* gained independence in July 1991 after a short conflict in which the Serb-dominated federal army (JNA) fought skirmishes against local Slovenian territorial defense units (TO). A few months earlier in Croatia, police and territorial defence units had begun to effectively stake out separate states for Croats and Serbs. The Serb minority in Croatia gained control over the Krajina and Western Slavonia and declared a separate republic (Republika Sprska Krajina, or RSK). By August of 1991 full-scale fighting broke out between the Croatian proto-Army on one side, and Croatian Serbs and the JNA on the other. A UN ceasefire in January 1992 effectively froze frontlines for the next three years. By now the new Federal Republic of Yugoslavia consisted of BiH, Serbia, and Montenegro. In Bosnia, both Croats and Serbs had established ethnic counter-states, and Muslims were left in control of the nominal government of BiH. With Serbs boycotting the government, BiH declared independence in March 1992 and immediately plunged into full-scale violence.

Bosnian Serbs, with support from JNA units in Bosnia that effectively became the army of the new Republika Sprska (RS), gained control over the majority of Bosnia's territory and encircled the capital Sarajevo in a siege that was to last until the end of the war. At this point Bosnian Croats and Muslims fought jointly against the RS. From the very beginning, the war included widespread ethnic cleansing, predominantly but not exclusively perpetrated by military and paramilitary units associated with the RS. By 1993 Serbian frontlines were more or less static, but Croats and Muslims began to fight each other (this included the Croat siege of Mostar in Herzegovina). At this point all frontlines became fairly static, and the situation for all of Yu-

[6] This overview draws on several histories: Gilbert and Large (2002), Glenny (1999), Judah (2000), Tanner (2001), and Woodward (1995).

goslavia in 1993 in shown in figure 1.[7]

Over the course of the conflict, in response to continuing violence against civilians, the UN and NATO became increasingly involved in the conflict. The Federal Republic of Yugoslavia was subjected to sanctions for its role in fueling the conflicts in Croatia and Bosnia, and the Serb breakaway republics in Croatia (RSK) and Bosnia (RS) began to stagnate. After the Croatian Army overran the RSK in 1995 and began to advance into Bosnia, and under pressure from NATO air attacks on Bosnian Serb positions, the parties to the Bosnian civil war signed the Dayton Agreement to end the war. The Dayton Agreement also established the post-war order. BiH was divided into Serb and Muslim-Croat parts by the Interentity Boundary Line, with a key city in the north, Brćko, becoming autonomous. A NATO peacekeeping force, IFOR (Implementation Force, subsequently SFOR or Stabilization Force), was deployed to ensure the agreement is followed, in addition to a civilian Office of the High Representative that enjoyed extensive powers over the new government of BiH. Western military forces and the High Representative have remained in BiH to this day.

4 Data and methods

The next subsection describes the data used and its sources. All data are open-source and readily available on the internet. The second subsection describes the methods used in this project. At a basic level, this project is inductive: I explore the data to look for apparent patters in the location of violence, without strong theoretical prior beliefs. The initial step in doing this is visual, by looking at relevant maps, but I also used regression analysis to substantiate visual impressions.

4.1 Data

The main limitation in studying civil wars below the country-level is a lack of fine-grained data on the location of violence in civil wars. The two major data collection efforts for civil wars, the Correlates of War Project (Sarkees 2000) and the Armed Conflict Dataset (Gleditsch et al. 2002, Harbom, Melander and Wallensteen 2008), both measure civil wars at a country-year level, i.e. they indicate whether a country experienced civil war in a given year. Additionally, these datasets, or extensions to them (Lacina and Gleditsch 2005), also provide information on the total number of deaths in a civil war, but neither provides information on the location of violent incidents during a conflict. The Armed Conflict Dataset includes geographic information identifying the center and extent of areas within a country in which violence took place, but they do not identify individual episodes of violence and the area subject to violence is recorded as a circle rather than a more exact polygon (Buhaug and Gates 2002, 423–424). The Armed Conflict Location Event Dataset (ACLED; Raleigh and Hegre 2005) is a more recent project that is in the

[7] This map is from wikipedia, at http://commons.wikimedia.org/wiki/Image:Former_Yugoslavia_wartime_1.PNG.

process of identifying and coding the location of specific violent episodes in various civil conflicts in the world. Although not complete, the data do cover the Bosnian war. The raw ACLED data for Bosnia consist of 544 reports of violent episodes related to the civil war, with geographic coordinates to located them. After dropping events that occurred after the end of the war in 1995, there are 518 events. The map in figure 4 shows a plot of violent episodes. Because several events are coded as having occurred in the same location, this map slightly obscures the actual number of events in a given municipality, which are shown in figure 5. This map shows there there is a clear clustering in events: (1) around Bihać in the west, (2) Mostar in the south, (3) Sarajevo in the center, (4) Brčko in the north, and (5) a wide swath of territory in eastern Bosnia.

The unit of observation in the statistical analyses consists of the pre-war municipalities in Bosnia and Herzegovina. Since the census data used here is aggregated to municipalities, they provides a natural starting point as the unit of observation. Obtaining geographic data on the pre-war municipalities was somewhat difficult for two main reasons. First, the administrative structure of Bosnia and Herzegovina has changed significantly as a result of the war. In 1991, Bosnia and Herzegovina consisted of 109 municipalities, including several that formed the capital, Sarajevo. Today BiH consists of 138 municipalities, including the autonomous Brčko District.[8] The boundaries for the post-war municipalities roughly correspond to the pre-war municipalities, except that where the Interentity Boundary Line that divides the Serb and Muslim-Croat parts of BiH crosses old municipalities, they have been split into corresponding new municipalities. Data for the new municipalities is not freely available, but the National Geophysical Data Center Coastline Extractor has data from the World Data Bank II that includes old (i.e. pre-war) municipal boundaries.[9] The data are in a old format, and thus it was necessary to code municipality names by hand.[10] Four municipalities in Sarajevo were combined in the data into two larger entities, and rather than split them I aggregated other data by combining the relevant municipalities. As a result there are 107 entities in the dataset. The map in figure 2 shows the republics that made up Yugoslavia and the municipalities in Bosnia and Herzegovina.

Additional data for the demographic characteristics of each municipality come from the 1991 census.[11] This includes the total population size of the municipality, as well as the population belonging to each of the three major ethnic groups, the number who identified themselves

[8] As a result of the Dayton Agreement in 1995, Bosnia and Herzegovina today has a three-tiered administrative structure. At the highest level, the Interentity Boundary Line divides the country into three parts: the Serb Republika Srpska, the Muslim-Croat Federation of Bosnia and Herzegovina (FBiH), and the autonomous Brčko District. At the second level, the FBiH is further divided into several cantons, and at the lowest level each entity consists of numerous municipalities.

[9] Available online at http://rimmer.ngdc.noaa.gov/.

[10] The format is Arc/Info Ungenerate and contains polylines defining municipal boundaries. I combined these polylines with those for the BiH republic boundaries to create polygons corresponding to municipalities. The boundary for BiH does not entirely match other data, and visually it seems that the municipal boundaries are somewhat inaccurate.

[11] Unfortunately I could not locate a print copy of the official census results, so instead I rely on a list on wikipedia at http://en.wikipedia.org/wiki/1991_population_census_in_Bosnia_and_Herzegovina.

as being of Yugoslav nationality, and a category for the remainder consisting of various other groups. The main interest in using these data is to identify areas that were primarily inhabited by members of one the three major ethnic groups. Figure 6 shows this visually. The municipalities are colored by which ethnic groups has a relative population majority in it, with red denoting Serbs, green denoting Bosnian Muslims, and blue denoting Croats. Furthermore, the shade of the color indicates whether the majority was relative (i.e. below 50 percent), absolute (above 50 percent), or whether a group had a supermajority of 60 percent or more.

Due to the common argument that rough terrain is associated with civil war, I also include a measure that captures the percentage of a municipality's terrain with a slope above 15 degrees. The original digital elevation model data are from the Shuttle Radar Topography Mission 90 meter data.[12] A topographic map from these data, with interpolated missing raster values, is shown in figure 3. After calculating the slope for each grid cell, I reduced the resolution by a factor of 10 to make the data more manageable, and calculated the percentage of grid cells within each municipality that had a slope higher than 15 degrees. As is evident in the topographic map, central and east-central Bosnia consists of very mountainous and rough terrain, while the northern part of the country adjacent to the Sava river is fairly flat.

Finally, I calculated the area for each municipality in order to be able to calculate population densities, as well as ethnolinguistic fractionalization index values for each municipality, based on the above-mentioned census data. The ELF index is the standard measure of ethnic diversity at a country level, but can just as easily be calculated for municipalities.[13] It ranges from 0 to 1, with higher values indicating higher levels of diversity. Substantively, its value roughly indicates the probability that two randomly picked individuals from a municipality will *not* be members of the same ethnic group. Table 1 shows summary statistics for all variables.

4.2 Methods

This project is essentially a descriptive/inductive exercise. After collecting the data described above, I created a series of maps in an attempt to visually identify possible relationships or patterns. Subsequent statistical analyses were used to further evaluate those potential patterns. Because the arguments in this project are inductive, further empirical analyses in other civil wars are necessary before reaching conclusions about their external validity.

The statistical analyses use the number of violent events in a municipality as the dependent variable. The number of violent events reasonably constitutes event count data, although overdispersion suggests a negative binomial rather than poisson regression model (Long 1997, 217–250). Because the sample size is small with 107 municipalities, all coefficient estimates are

[12] SRTM 90 from the U.S. Geological Survey, available at http://edc.usgs.gov/products/elevation/.

[13] Calculated as ELF $= 1 - \sum_{i=1}^{N} p_i^2$, where p_i is the population share of the i-th group in a municipality and N is the total number of groups in the municipality.

bootstrapped. Significance levels are determined using bias-corrected accelerated confidence intervals (DiCiccio and Efron 1996). This allows for asymmetric confidence intervals in case the coefficients do not follow a normal distribution.

5 Patters of violence

The first thing that would reasonably come to mind as a pattern for violence in the Bosnian war is ethnic cleansing. The analyses below substantiate that intuition—most of the violence seems to have taken place in Bosnian Muslim inhabited areas adjacent to areas under the control of Serbs or Croats. However, the analyses also suggest ways to measure which areas will be the most likely subjects of ethnic cleansing campaign, and this should allow for the construction of measures that can be further evaluated in other conflicts.

5.1 General overview

Figure 6 shows the largest groups in each of the 107 municipalities in the data. In terms of municipalities, the map shows that Serbs had a more concentrated population than either Croats or Muslims: out of the 37 municipalities in which Serbs were the largest group, in only 5 (13.5 percent) did Serbs not also constitute at least 50 percent of the population. Croats and Muslims both had less than an absolute majority in 30 percent of the municipalities in which they were the largest group (20 and 50 municipalities respectively). Overall however, all three ethnic groups appear to be fairly heterogenous, with no single group inhabiting just one contiguous area. The Serb population was split between two large swathes of territory in the east and west respectively, Croats lived predominantly in the south with some exclaves in the center and north, and Bosnian Muslims were scattered over the center, with an exclave in western Bosnia around the town of Bihać.

Plotting the location of violent events over this map produces the map in figure 7. Visually, two stark patterns seems to stand out. First, almost all violence seems to have occurred in Bosnian Muslim dominated municipalities. Indeed, although Bosnian Muslims made up 43.48% of the prewar population of 4.38 million, and were the largest group in 50 out of 107 municipalities (46.73%), overall 408 of the total 518 violent events, or 78.76%, occurred in Muslim-dominated municipalities. Considering the wider context of the Bosnian war, there is much cause to suppose that this would have been the case. Both Croats and Serbs had their own republics in Yugoslavia, and by the time Bosnia and Herzegovina declared independence in March 1992, the Serb and Croat populations in BiH could turn to their own states for material support. Bosnian Muslims had no state to turn to except what was left of Bosnia and Herzegovina's government. Indeed, there is evidence to suggest that Tuđman and Milošević at least tacitly sought to divide Bosnia between themselves without regard for the Muslim population. More generally

one could argue that ethnic groups with ties to a bordering state are less prone to experience violence on their territory.

The second pattern that seems apparent is that within Bosnian-dominated municipalities and otherwise, violence tended to concentrate on the fringes of ethnic areas. Considering areas outside of Bosnia as well, the Muslim inhabited areas of western Bosnia and eastern Bosnia were all completely or almost completely surrounded by Serb-populated and held areas (the new Yugoslavia and Republika Srpska in the east, Republika Srpska and Republika Sprska Krajina in the west), while Sarajevo itself was encircled by Serb-held areas for much of the war. If one's goal was to consolidate ethnic states, for the Republika Srspka these areas would have been the most obvious candidates for ethnic cleansing. This suggests that ethnically unconsolidated areas generally should see a relatively higher level of violence.

5.2 Statistical analysis

Thus there are two candidates for patterns in the location of violence: (1) that violence was concentrated in Bosnian Muslim held areas, and (2) that violence was higher in ethnically unconsolidated areas. To evaluate these candidate patterns, I estimated negative binomial regression models with appropriate measures for each candidate pattern, as well as three control variables. The first control variable is the total population in a municipality, drawn from the 1991 census. Second is population density, which should roughly take account of the fact that some municipalities were home to major cities and presumably valuable targets. Based on arguments about the role of rough terrain in insurgency warfare (Fearon and Laitin 2003) the third control variable measures the percentage of a municipalities terrain that exceeded a slope of 15 degrees. Because coefficient estimates are bootstrapped, the results for each model list coefficients and 90% confidence intervals rather than standard errors. Those coefficients that are significant also include a incidence rate ratio, which shows the factor change in the expected number of violent events when the associated variable is increased by one unit.

To evaluate the first pattern, I estimated a model which included a dummy variable indicating whether Bosnia Muslims were the largest group in the municipality. The results, presented in table 2, show that when controlling for confounding factors, Muslim-dominated municipalities still experienced more violent events than other municipalities. On average, a Muslim-dominated municipality could expect to have more than twice as many (2.33 times) violent events than a similar non-Muslim municipality.

Turning to the next pattern, an initial problem was that measuring what constitutes a consolidated area and what does not is not straightforward. I use two sets of variables in a preliminary attempt to do so. The first is a series of three dummy variables indicating whether any of the three major ethnic groups help a supermajority of 60 percent or more of a municipality's population. The second is the standard ELF measure of ethnic diversity, calculated for each mu-

nicipality. Looking at the supermajority variables first, municipalities with a Serbian and Croatian supermajority both experienced less violent events, *ceteris paribus*, whereas municipalities with a Muslim municipality were no more nor less likely to experience violence. This extends the previous finding in the sense that Muslim-dominated areas were not only more likely to experience violence in general, but it also does not appear to matter how large, in relative terms, their Muslim population was. On the other hand, areas with a heavy Serb or Croat population concentration were less likely to experience violence.

The last model uses the ELF to measure consolidation at a municipality level—in a sense this is the obverse of the previous model. Rather than evaluating whether municipalities that were clearly dominated by one ethnic group experienced less violence, using the ELF allows one to answer the question whether ethnically diverse municipalities were more likely to experience violence. Indeed, the coefficient estimate indicates that a perfectly heterogeneous municipality (ELF=1) would on average have experienced more than four times (4.29) as many violent events as a perfectly homogeneous municipality (ELF=0). This is somewhat unusual as the ELF measure typically is not statistically significant in country-level analysis, whereas here it is significant and fairly robust to different model specifications (not shown here).

6 Discussion and conclusion

The goal of this project was to identify patterns in the location of violence during the Bosnian civil war, and with this in mind, there are two main findings:

1. Violence was concentrated in Bosnian Muslim inhabited areas, and more generally it might be the case that ethnic groups with "ethnic" ties to foreign governments will experience less violence on their territory.

2. In the process of consolidating ethnic states, outlying and heterogeneous areas in Bosnia experienced the highest level of violence. More generally, violence in ethnic wars may be most likely located in border areas and ethnic enclaves/exclaves that are the first targets of ethnic cleansing.

Of course these findings are entirely inductive and can only suggest potential explanations for the location of violence in (ethnic) wars. The next step would be to test the implications in other conflicts to ascertain whether they still hold. With future developments of this projects, there are three major issues that need to be addressed.

First, the regression analyses do not take potential spatial dependence into account. It seems reasonable to presume that municipalities close to areas with heavy fighting will experience a higher number of significant events as well. For example, the city of Sarajevo spanned

several municipalities, so fighting over control of the city produced high event counts for multiple adjacent municipalities. Including a spatial lag of violent events in future research might mitigate that problem.

Second, both of the measures of consolidation used here are municipality-specific, rather than taking the geographic location of a municipality into account as well. For example, most of eastern Bosnia, although it had a large Muslim population, was almost entirely surrounded by Serb-populated and held areas, including Serbia and Montenegro proper to the east. Neither of the measures I use here capture something like that. A relatively straightforward alternative might be to measure the proportion of a municipality's border that is adjacent to municipalities in which members of another ethnic group form the plurality. An ultimate measure of this would also take into account how "strong" the surrounding areas are. For example, while the Muslim enclave in western Bosnia, around Bihać, was surrounded by Serb-populated areas on all sides, these happened to belong to two separate and relatively weak states, the Republika Srpska Krajina in Croatia and the Republika Srpska in BiH. The Muslim inhabited areas in eastern Bosnia on the other hand bordered Serbia proper, and additionally were in the way of direct communication between the Republika Srpska and Serbia.

Third, the data on the location of violence events potentially suffer from systematic selection bias. They are based largely on (Western) press reports, yet in many conflicts press access is in practice limited by very high levels of violence, and sometimes also restricted due to political considerations. The former implies that data will be limited in areas of very high violence, but still accurate in other areas. The latter is probably more worrisome: some regimes/powers restrict press access while other encourage it, and this can create systematic bias in the reporting of violence across political boundaries. During the Bosnian war, the Muslim-Croat government of BiH was much more facilitating to Western press, while press access in Bosnian Serb held areas was arbitrary and often restricted (Judah 2000). In this particular case, the most devastating consequence of this could be that the results indicating that violence was most likely in Muslim-inhabited areas are entirely spurious and an artifact of reporting bias. In actuality, most of the areas in eastern Bosnia with high levels of violent events fell under Bosnian Serb control during the war, so the reporting bias might not be as stark as in a worst-case scenario. The issue of systematic sample selection due to reporting bias still deserves further attention though.

References

Bruck, S.I. and V.S. Apanchenko. 1964. *Atlas Narodov Mira*. Moscow: Glavnoe Upravlenie Geodezii i Kartografii.

Buhaug, Halvard and Jan Ketil Rød. 2006. "Local determinants of African civil wars, 1970-2001." *Political Geography* 25(3):315–335.

Buhaug, Halvard and Päivi Lujala. 2005. "Accounting for scale: Measuring geography in quantitative studies of civil war." *Political Geography* 24:399–418.

Buhaug, Halvard and Scott Gates. 2002. "The Geography of Civil War." *Journal of Peace Research* 39(4):417–433.

Collier, Paul. 2000. "Rebellions as a Quasi-Criminal Activity." *Journal of Conflict Resolution* 44(6): 839–853.

Collier, Paul and Anke Hoeffler. 2004. "Greed and grievance in civil war." *Oxford Economic Papers* 56: 563–595.

DiCiccio, Thomas J. and Bradley Efron. 1996. "Bootstrap Confidence Intervals." *Statistical Science* 11(3): 189–211.

Fearon, James D. 2003. "Ethnic and Cultural Diversity by Country." *Journal of Economic Growth* 8: 195–222.

Fearon, James D. 2004. "Why Do Some Civil Wars Last So Much Longer Than Others?" *Journal of Peace Research* 41(3): 275–301.

Fearon, James D. and David D. Laitin. 2003. "Ethnicity, Insurgency, and Civil War." *American Political Science Review* 97(1).

Gilbert, Felix and David Clay Large. 2002. *The End of the European Era: 1890 to the Present*. 5th ed. New York: W.W. Norton & Company.

Gleditsch, Nils Petter, Peter Wallensteen, Mikael Eriksson, Margareta Sollenberge and Håvard Strand. 2002. "Armed Conflict 1946-2001: A New Dataset." *Journal of Peace Research* 39(5): 615–631.

Glenny, Misha. 1999. *The Balkans: Nationalism, War, and the Great Powers, 1804–1999*. New York: Penguin Books.

Harbom, Lotta, Erik Melander and Peter Wallensteen. 2008. "Dyadic Dimensions of Armed Conflict, 1946-2007." *Journal of Peace Research* 45(5):697–710.

Hegre, Håvard and Nicholas Sambanis. 2006. "Sensitivity Analysis of Empirical Results on Civil War Onset." *Journal of Conflict Resolution* 50(4): 508–535.

Judah, Tim. 2000. *The Serbs: History, Myth and the Destruction of Yugoslavia*. 2nd ed. New Haven, CT: Yale Nota Bene.

Kalyvas, Stathis N. 2006. *The Logic of Violence in Civil War.* Cambridge: Cambridge University Press.

Kalyvas, Stathis N. and Matthew Adam Kocher. 2007. "Ethnic Cleavages and Irregular War: Iraq and Vietnam." *Politics & Society* 35(2): 183–223.

Kaplan, Robert D. 1993. *Balkan Ghosts: A Journey Through History.* New York: St. Martin's.

Lacina, Bethany. 2006. "Explaining the Severity of Civil Wars." *Journal of Conflict Resolution* 50(2): 276–289.

Lacina, Bethany and Nils Petter Gleditsch. 2005. "Monitoring Trends in Global Combat: A New Dataset of Battle Deaths." *European Journal of Population* 21: 145–166.

Long, J. Scott. 1997. *Regression Models for Categorical and Limited Dependent Variables.* London: Sage Publications.

Montalvo, José G. and Marta Reynal-Querol. 2005. "Ethnic polarization, potential conflict and civil war." *American Economic Review* 95: 796–816.

Raleigh, Clionadh and Håvard Hegre. 2005. "Introducing ACLED: An Armed Conflict Location and Event Dataset." Paper presented to the conference on "Disaggregating the Study of Civil War and Transnational Violence", University of California Institute of Global Conflict and Cooperation, San Diego, CA, 7-8 March. Online at http://www.prio.no/CSCW/Datasets/Armed-Conflict/Armed-Conflict-Location-and-Event-Data/.

Raleigh, Clionadh and Henrik Urdal. 2007. "Climate change, environmental degradation and armed conflict." *Political Geography* 26(6):674–694.

Reynal-Querol, Marta. 2002. "Ethnicity, Political Systems and Civil War." *Journal of Conflict Resolution* 46: 29–54.

Sambanis, Nicholas. 2004. "What Is Civil War? Conceptual and Empirical Complexities of an Operational Definition." *Journal of Conflict Resolution* 48(6): 814–858.

Sarkees, Meredith Reid. 2000. "The Correlates of War Data on War: An Update to 1997." *Conflict Management and Peace Science* 18(1): 123–144.

Tanner, Marcus. 2001. *Croatia: A Nation Forged in War.* 2nd ed. New Haven, CT: Yale Nota Bene.

Taylor, C. and M. C. Hudson. 1972. *The World Handbook of Political and Social Indicators.* 2nd ed. New Haven, CT: Yale University Press.

Woodward, Susan L. 1995. *Balkan Tragedy: Chaos and Dissolution after the Cold War.* Washington, D.C.: The Brookings Institution.

7 Tables and Figures

Figure 1: Yugoslavia in 1993

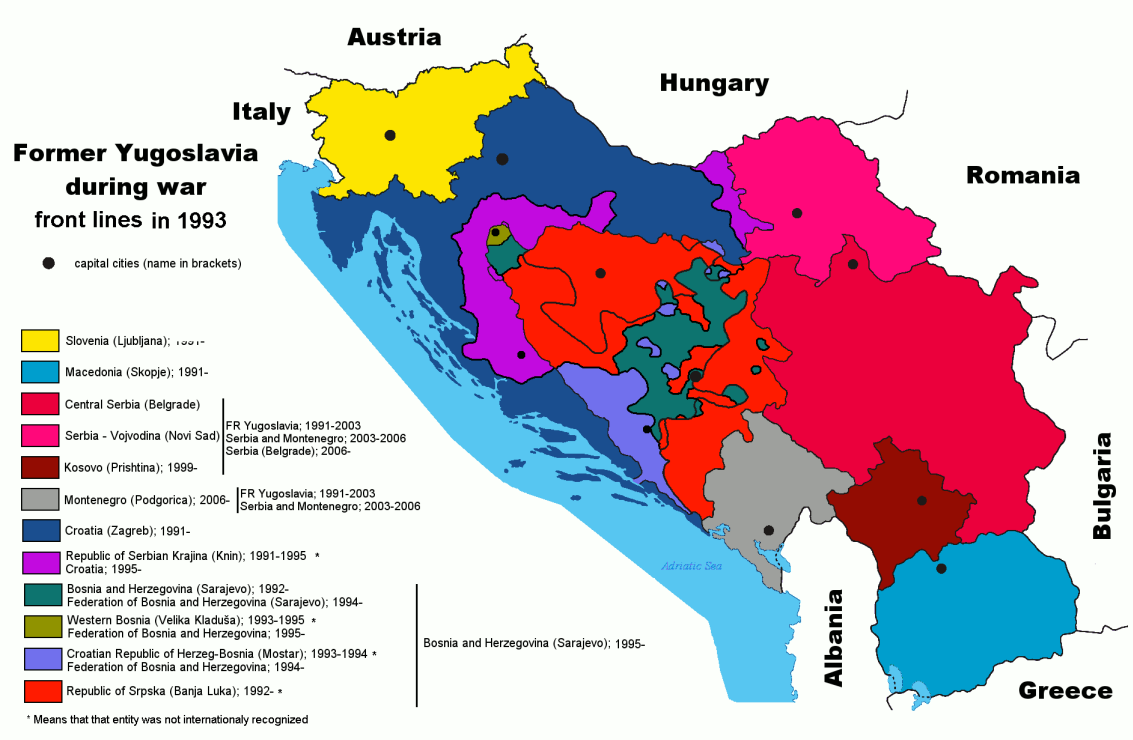

Table 1: Summary statistics

Variable	Type	Mean	Min	Max
Events	count	4.84	0	56
Population[a]		40.91	4.17	231.71
Pop.density[b]		0.13	0.01	2.31
Rough terrain	0 to 1	0.20	0	0.74
ELF	0 to 1	0.47	0.02	0.72
Muslim-dominated	0 or 1	0.47		
Supermajority:				
Muslim	0 or 1	0.22		
Serb	0 or 1	0.21		
Croat	0 or 1	0.10		

Notes: $N = 107$. [a] thousands. [b] 1000ppl/km^2.

Figure 2: Republics in pre-war Yugoslavia

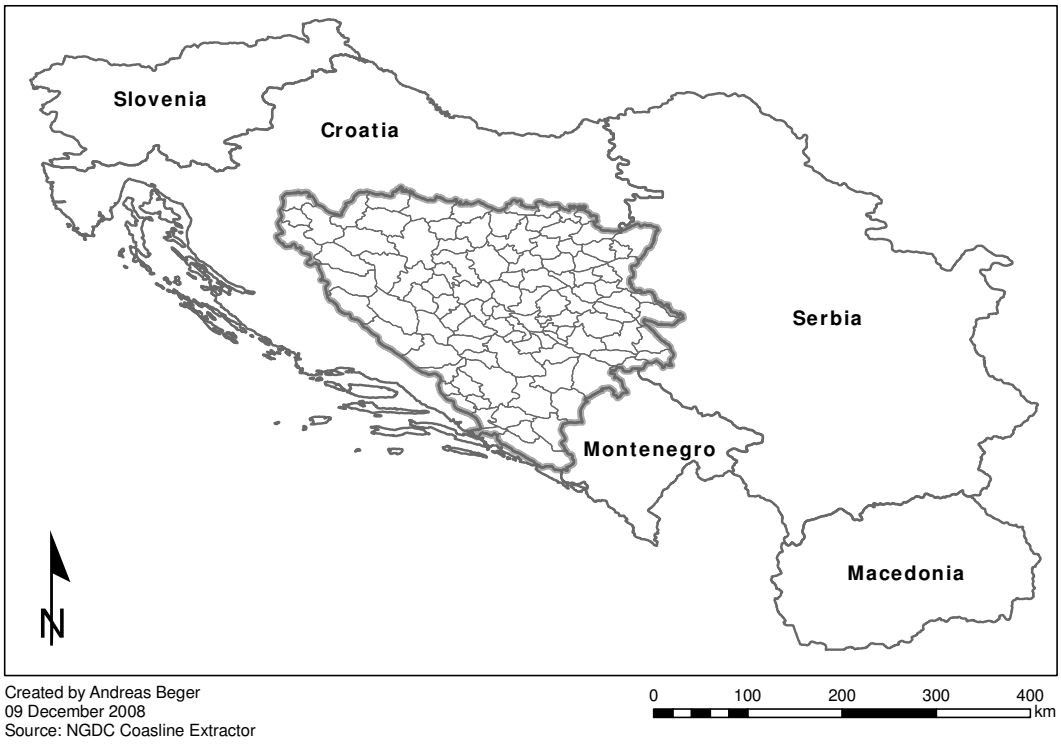

Figure 3: Topographic map of Bosnia and Herzegovina

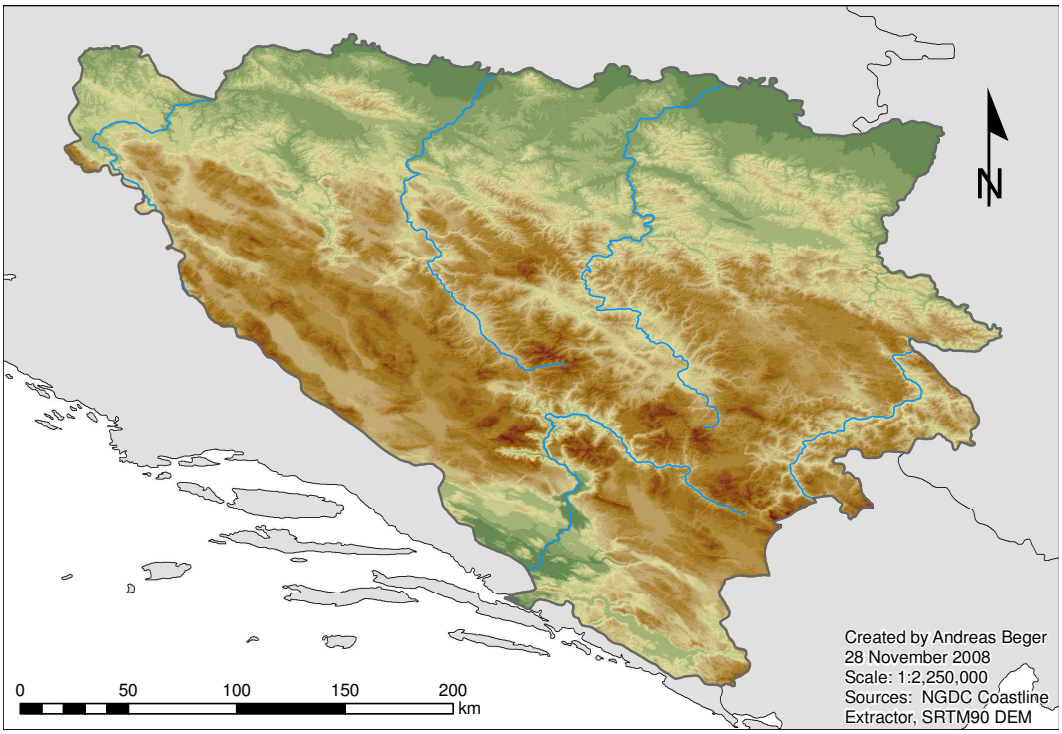

Figure 4: Location of violent events

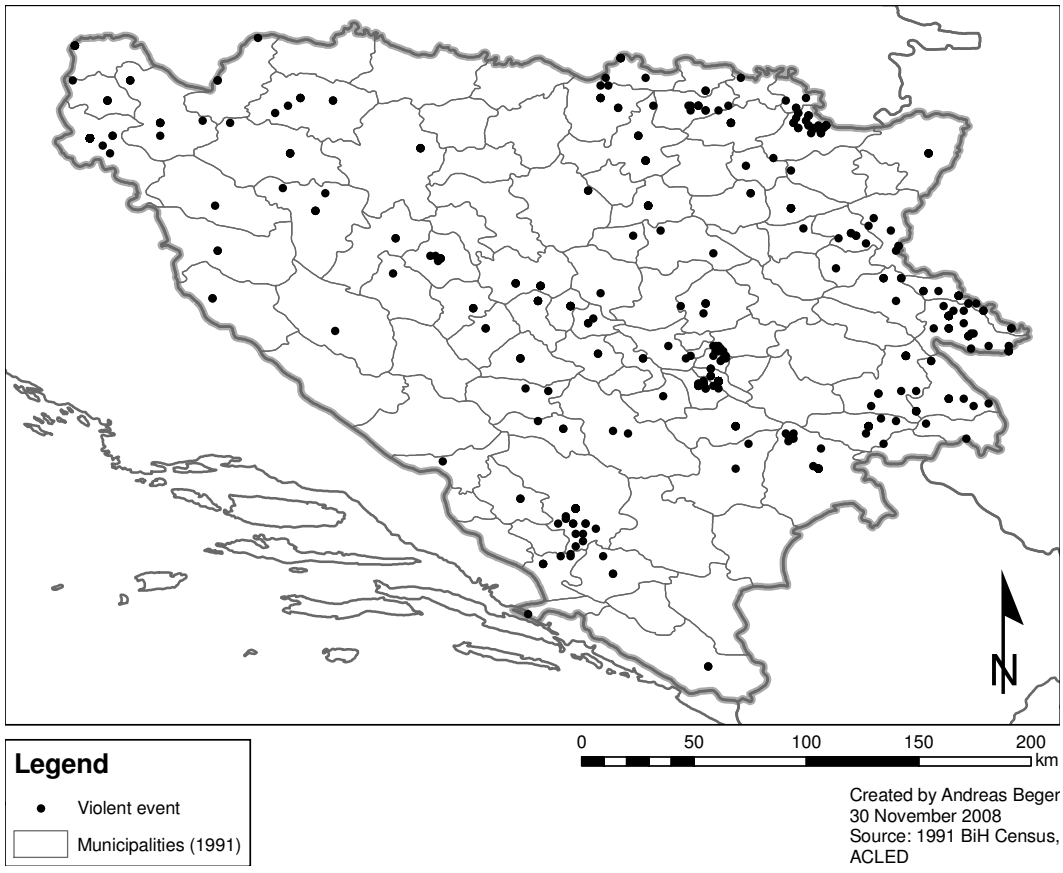

Figure 5: Number of violent events by municipality

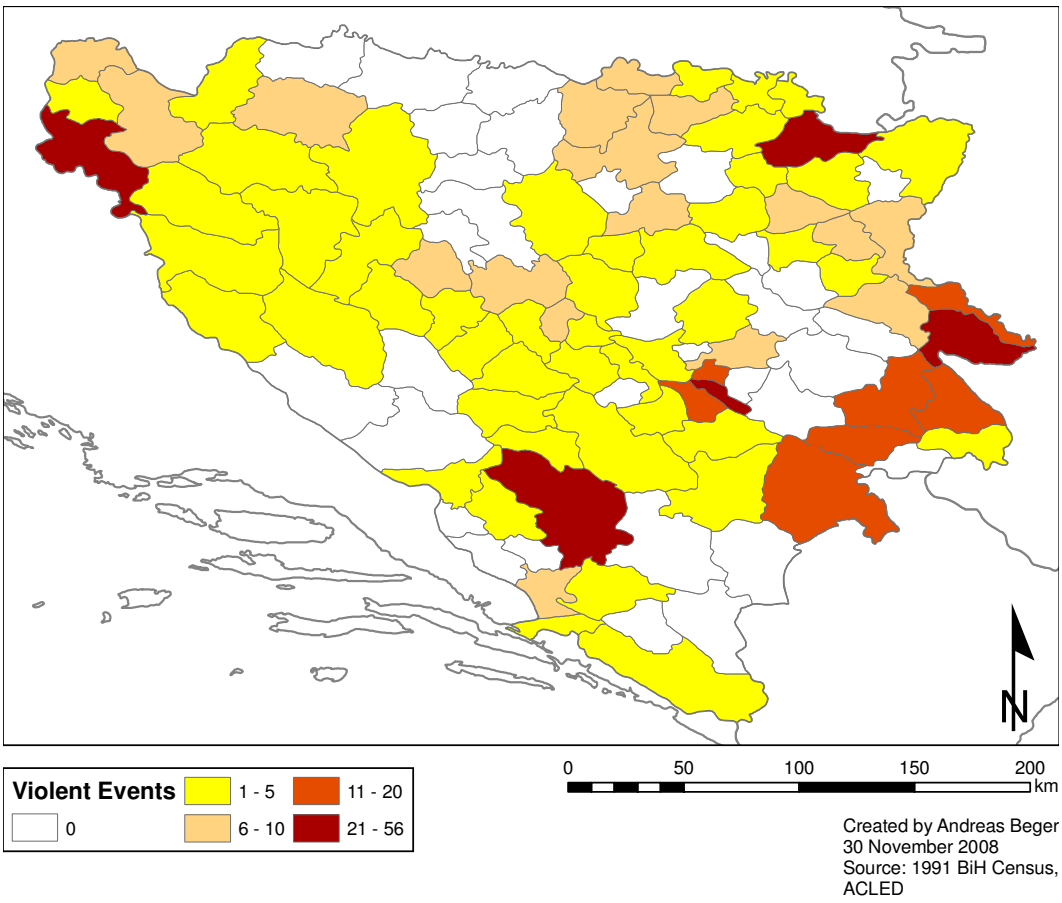

Figure 6: Ethnic majority by municipality

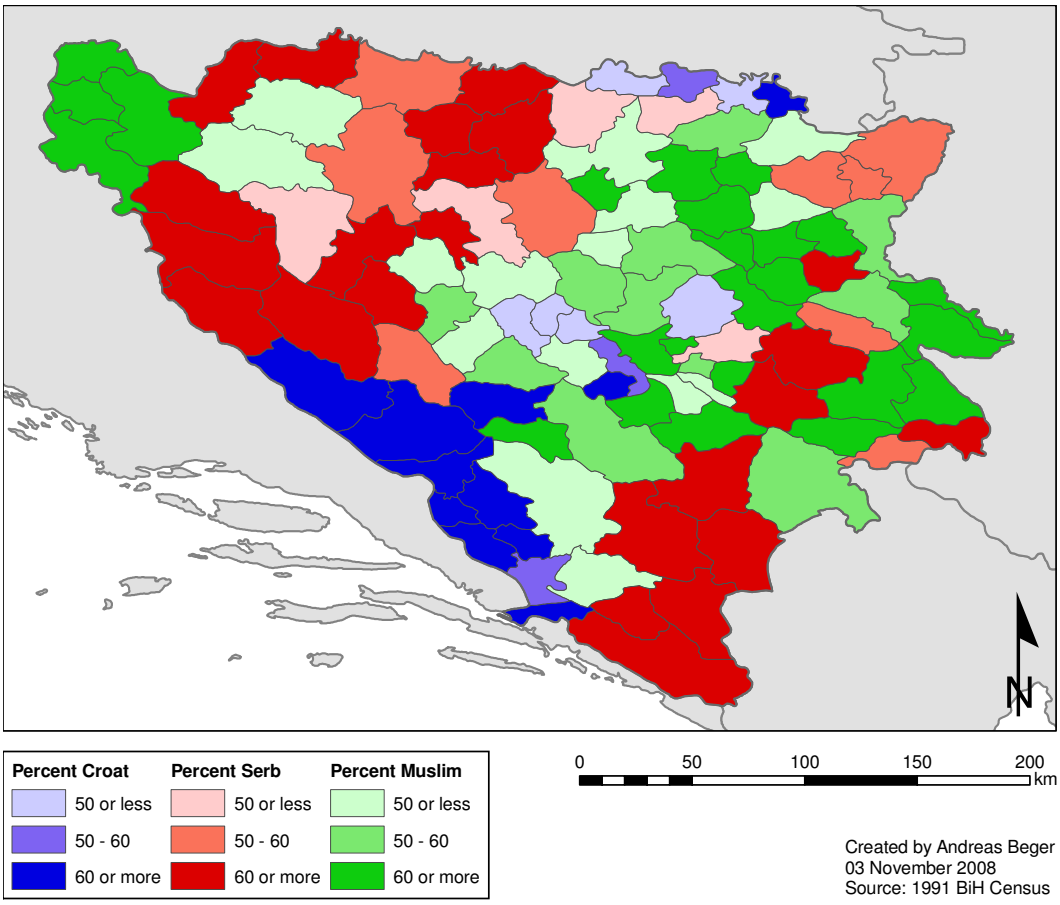

Figure 7: Ethnic majorities and violent events.

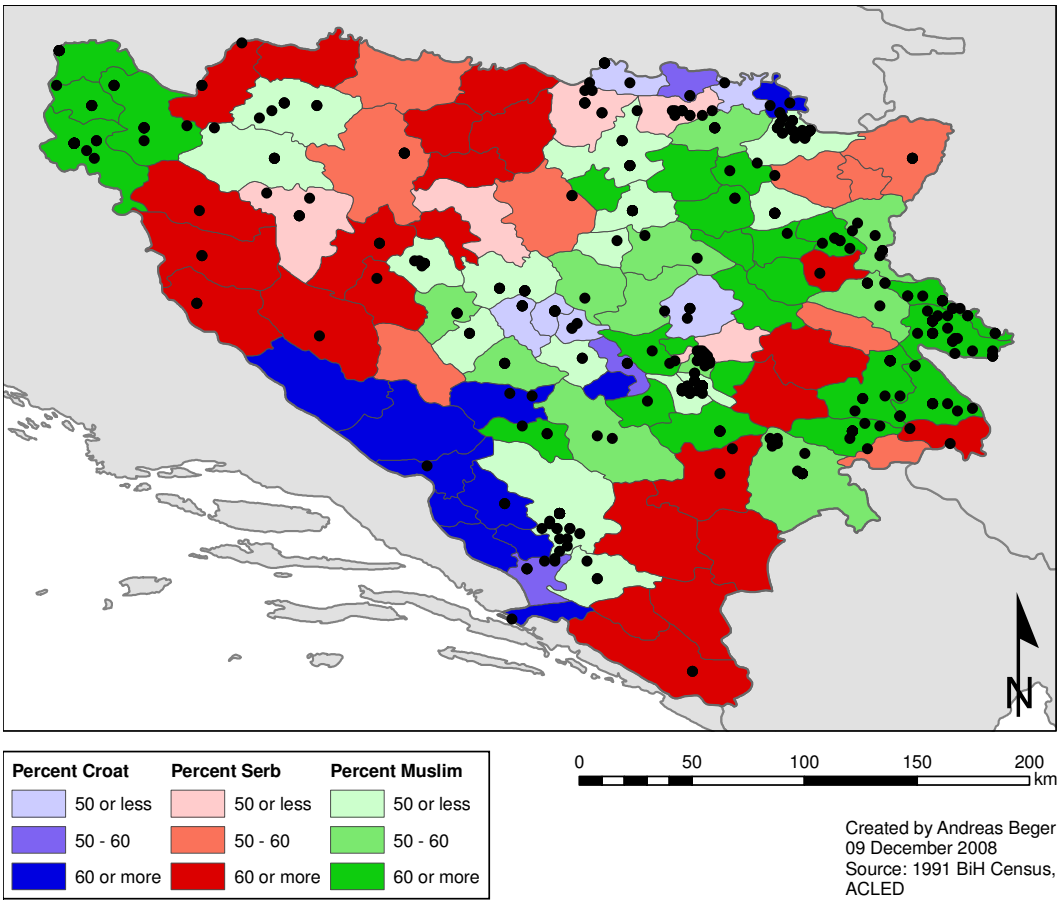

Table 2: Regression analysis of the number of violent events by municipality.

	Muslim areas		Consolidated		Consolidated—ELF	
Variable	β	90% CI	β	90% CI	β	90% CI
Population	0.02 (1.02)	0.01 – 0.03	0.02 (1.02)	0.005 – 0.03	0.02 (1.02)	0.01 – 0.04
Pop. density	-0.27	-1.50 – 1.01	-0.18	-1.74 – 0.87	-0.65	-2.54 – 0.59
Rough terrain	1.15	-0.12 – 2.31	1.10	-0.05 – 2.29	1.84 (6.30)	0.54 – 3.22
Muslim-dominated	0.86 (2.33)	0.39 – 1.33				
Supermajority:						
Serb			-1.27 (0.28)	-1.83 – -0.74		
Croat			-1.18 (0.31)	-1.97 – -0.30		
Muslim			0.40	-0.11 – 0.94		
ELF					1.46 (4.29)	0.24 – 2.75
Constant	0.01	-0.46 – 0.54	0.62	-0.05 – 1.30	-0.57	-1.15 – 0.04
α	1.18	0.92 – 1.73	1.03	0.79 – 1.59	1.29	1.00 – 1.98
lnL	-255.10		-249.54		-257.45	

Notes: $N = 107$. Negative binomial regression with bootstrapped bc_a confidence intervals. Incidence rate ratios shown in parentheses for significant coefficients.