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Taking 'Geography' Seriously:

Disaggregating the Study of Civil Wars.

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Two parallel developments in the past decade have combined to push the detailed consideration of a renewed effort to rethink the *geography of* and *geographic effects* in civil wars. Within the discipline of geography, especially in the quantitative study of human behavior, there has been a significant turn to the "local". Partly responding to the criticism by other human geographers, spatial analysts have increasingly shifted their focus from trying to develop global models in which relationships are expected to hold across all places and contexts to contextual models in which general relationships are modified to take account of local circumstances. Within the discipline of political science, models of civil wars distributions and effects now routinely include "geographic" variables, though usually in the form of controls with emphasis still on the effects of political and economic variables such as income inequality, the scale of democracy or ethnic differentiation. The purpose of this paper is to make linkages between these still-separated but parallel interests by pointing to some methods that would allow political scientists to examine the geographic factor in civil wars more effectively and allow political geographers to link their spatial perspective to the burgeoning literature on civil conflicts in the post-Cold War world.

In a recent paper advocating closer attention to the spatial analysis of conflicts, Harvey Starr advocates study that contextualizes behavior but recognizes that a key obstacle to the study of the agent-structure problem (entity-environment relationship) is to "find enough cases where the different structural or environmental conditions necessary to evaluate a model exist" (Starr 2003, 15). There are two obvious ways to accommodate this difficulty. The first is to collect more disaggregated data on civil wars. As noted by Buhaug and Gates (2002, 418), we have little systematic knowledge of the fighting of civil wars "Territory and resources are never lost and gained" (See also the paper at this conference by Raleigh and Hegre (2005) and the forthcoming work by Buhaug and Lujala (2005)). Detailed locational data will help to undermine the national-scale dominance of current civil war study and help to explain the extent to which local geographic elements such as terrain, land cover, topography, and relative location are instrumental in setting the conditions for war initiation or war extent in time and space. The second way to address Starr's concern is to take "geography" more seriously in existing approaches to civil war study. By this, we mean to use the approaches and the methods of quantitative geography within the framework of the dominant national-scale examinations. Though some consideration of geographic factors have found their way into the literature (de Rouen and Sobek 2004; Fearon and Laitin 2003; Gates 2002a; Ghobarah, Huth, and Russett 2003; Ross 2004a), the basic critique of the international relations field by Agnew (1994) is still valid. Agnew distinguishes between two views of space – the territorial view dominant in IR where space is a series of blocks defined by state territorial boundaries whilst other scales (local and regional) are effectively ignored, and the second view, preferred by geographers, where space is a structural construct where geographical entities of all sorts (nodes, regions etc) have spatial effects that result from interaction with one another. Most of the attempts to add a geographic dimension to civil war research have continued to use state-level data and have thus been unable to break out of the "territorial trap" (using Agnew's lexicon). The recent trends towards fixing the locational coordinates of conflicts as evidenced in the Uppsala data (see Buhaug and Gates (2002) and Eriksson and Wallensteen (2004)) are welcome developments to move the scale of analysis away from the exclusivity of national boundaries and categories.

In this paper, we present two examples of possible research trajectories that match what we see as the two current attempts to respond to the kinds of challenges of Starr (2003) and of political geographers such as Agnew that urge greater attention to the contexts of conflicts. Remaining within the bounds of the "territorial trap", we show how the civil war work that finds global-level parameters can be disaggregated so that local parameters can be developed for spatially-varying relationships to emerge using the GWR (geographically weighted regression) software (Fotheringham, Brunsdon, and Charlton 2002). We apply the method to the recent data from the World Health Organization (2000) on disability adjusted life years (DALYs) that were also analyzed by (Ghobarah, Huth, and Russett 2003, 2004b) in their study that showed that civil wars have long-term effects through both domestic and neighbor conflicts.

In the second analysis, continuing the disaggregating effort, we look at point data (the geographic coordinates of war locations) and ask if the usual assumption that wars are clustered geographically across the world holds when the data are examined using some of the geo-statistical methods found in geographic analysis. Specifically, we ask if the apparent clustering from the maps of the war locational coordinates (see the maps in Buhaug and Gates (2002) or O'Loughlin (2004)) is statistically significant when compared to the distributions of the "populations at risk". Recourse to GAM (the Geographical Analysis Machine) allows a more nuanced analysis than the simple a-contextual point pattern methods (Openshaw, Charlton, Craft, and Birch 1988; Openshaw, Charlton, Wymr, and Craft 1987).

Geography in Civil Wars

Civil war is ultimately created by interplay of domestic structures and domestic contexts. However, geographers contend that the effects (identified by political scientists) of domestic structures, such as GDP, government structure, and ethnic makeup, and domestic contexts, such as population growth, terrain, weak state institutions, and resources, are influenced by geographic context. A lack of territorial sovereignty and an inability to form a national identity conspire to keep weak states vulnerable to volatile domestic circumstances. The spatial clustering of weakened states, and the subsequent clustering of conflict in weak states, allows for conflict to cross borders, infecting already vulnerable states. Therefore, the location of a state (and its civil wars) is not simply an attribute, but another potential cause of conflict. States with high risk are subject to increased risk because 1) neighboring wars exacerbate volatile domestic conditions inside bordering states, and 2) neighboring wars can (and frequently do) spread into nearby states. Weak states cannot mitigate conflict diffusion and escalation from outside state borders.

The literature on civil war has a long legacy and is characterized by an approach that is best described as piecemeal. For example, there is a considerable literature that separately examines the onset, escalation, and termination of civil wars, each taken as separate phases, disconnected from one another (see the extensive and annotated bibliography in Collier *et al.* (2003). At the same time, most of the literature has also looked at civil wars as self-contained and homogenous phenomena, ignoring the connections of civil wars to both regional and local conditions. Civil wars have largely been studied as related to a country's domestic attributes. As a result, almost all the extant data on civil war are collected and collated at the country level. The question of whether there is a larger (regional or global) or smaller (local) scale in which the wars are embedded has, heretofore, largely been ignored. In briefly reviewing these threads, we illustrate some of the shortcomings that result from geographical aggregation of local processes to national attributes in existing cross-national studies. We also suggest how studying the micro-level processes can contribute to our understandings of the dynamics and consequences of civil war.

Causes of Civil Wars - A Geographic Focus on the Literature: Grievance is usually thought to be the root cause of civil conflict. Civil wars are more common in societies with low income (See, for example, Fearon and Laitin, 2003). Poverty itself cannot provide a reasonable explanation of why groups resort to violent conflict. Economic misery and poverty are ubiquitous, but only a few countries see violent conflict. Relative deprivation and economic inequality are common in poor societies that experience civil war (Gurr 1970). In his review of the causes of civil war, Gates (2002a) says (p. 13) that the "quantitative conflict community for the most part agrees *that poverty and lack of economic opportunities, conflict history, ethnic dominance, and political instability* are important factors for understanding international conflict. We have good reason to believe that the following set of factors are associated with a greater risk of civil war, but for some reason or another, there is some doubt: *dependence on natural resources, ethnic diasporas, total population and geographical dispersion of the population, rough terrain, political institutional structure, and state strength*." The results of many studies, though, are quite mixed for many of these purported latter causal factors.

Even civil violence requires some organization, and the role of mobilization is also thought to be important. Entrepreneurs and group characteristics that stimulate and facilitate collective action are critical determinants of whether grievances and inequalities actually lead to violent conflict (De Figueredo and Weingast 1999; Gates 2002b). Geography, ethnicity and ideology play important roles in determining military success of the rebels, deterring defection within the group, and helping recruitment (Gates 2002b). Much of the recent work on civil war has emphasized the role of private incentives and rent-seeking activities as predictors of civil war onset. Individuals are more likely to take up arms when they can benefit materially from war though looting, extracting valuable commodities, and extortion (Collier 2000; Collier, Hoeffler, and Soderbom 2004; Mueller 2003; Murshed 2002; Tullock 1971).

Geographic work stressing the diffusion of conflict and the locational attributes of civil war has primarily focused on three different themes -- absolute location of wars, relative location of wars, and territory as a “container” of salient explanatory features. Some arguments do not stray far from environmental deterministic assertions, but the majority implies that certain geographic circumstances influence the onset and proliferation of war. Absolute location perspectives contend that civil war prone states are located in particular geographical locations and disproportionately occupy the periphery of the world economy. Decolonization, superpower proxy wars, and impoverished conditions have created an environment of endemic poverty, poor governance, and a fundamental disjoint of state ideology and nation (O'Loughlin 1989), which in turn has fostered discontent and violent conflict. Strategic geopolitics—the relationships fostered by resource and strategic location dependence—have continued to create “Shatterbelt” regions well past the end of the Cold War (Klare 2001). Shatterbelt regions, such as the Caucasus, are defined as areas with a precious natural resource, ethnic diversity, external intervention and a history of conflict (Cohen 2003). However, a failure of development policies is also blamed for the proliferation of failed states, which in turn are clustered in failed regions. These failed states within the third world are often deemed as forgotten by the West (Kaplan 2000) but the state-centric nature of absolute location perspectives tends to undermine domestic circumstance in civil war onset and proliferation.

Relative location work focuses on the position and process of both the state and the internal conflict. Similar work on interstate conflict stresses the relationships of alliances and borders as explanations of conflict diffusion and proliferation (Siverson and Starr 1991). Countering the atomistic nature of the usually type of study, Ward and Gleditsch (2002), Sambanis (2001) and Salehyan and Gleditsch (2004) show that regional conditions in neighboring communities also influence the eruption of civil violence. Territoriality--the social construction of spaces by political processes (such as war) to express power (Sack 1986) - is the prime concept driving relative location studies. Challenges to central rule are assumed to come from areas with a distinct local character who have been ignored in weakened or failed states (Herbst 2000), yet conflict location relative to state capitals, borders, communities, and resources often provide tacit explanations of intent and positionality (Buhaug and Gates 2002). Ideological distance, directly associated with territory and space, is employed as a measure of ethnic or national group distance from others which Gates (2002a) finds as directly related to an organizational structure within rebel groups. The involvement of outside players into a civil war has recently prompted speculations of "aggressive symbiosis" (Le Billon 2001), a context where the conflict has become beneficial to certain criminal elements of war torn societies. The creation of spaces and networks of illegal activity is redrawing political boundaries and overtaking governance in failed states (Keen 1998; Ó Tuathail 2000), presenting local, national, and possibly global risks.

"Geography as Container" involves work focusing on salient features of the environment (human or physical) which may be associated with war in a particular territory. This environmental perspective is dominated by resource arguments, which contends that features of particular resources, especially the use of resources by rebels as funds for their cause, make conflict more feasible. Research on resource scarcity (Homer-Dixon 1999) as conflict encouraging has been challenged by a growing body of research focusing on the proliferation of conflict in resource abundant areas (Auty 2004; de Soysa 2000). De Rouen and Sobek (2004) conclude that "borders, war type, Africa, UN intervention, forest cover, and mountain cover" all contribute to civil war outcomes but that the effects are varied and contradictory. Thus, forest cover helps the government cause whilst mountainous terrain helps the rebels and hurts the government cause. Whereas Fearon and Laitin (2003) find evidence for the influence of terrain in conflict onset, Collier and Hoeffler (2001) and Buhaug and Gates (2002) dismiss this argument preferring an economic explanation as incentive to rebellion. However, terrain is considered a contributing factor in conflict proliferation (Collier *et al.* 2003; Fearon and Laitin 2003). Studies detailing the role of terrain are useful, but inconclusive, partly because of uncertainties in definitions and measurements of rough terrain. Mapping insurgencies and rebel movements is a way to understand this correlation.

Natural resource endowment is linked to poor economic growth and governance - "resource rents provide political leaders with a classic means of staying in power by establishing a regime organized through a system of patronage….such regimes can divert themselves of the need for popular legitimacy by eliminating the need for broad based taxation, … (and) financing a repressive security apparatus" (Le Billon 2001, 567). Arguments often detail the dual nature of resources—the revenue of precious materials support corrupt governments but also provide conflict incentives and a well-needed source of income for rebel groups (Collier, 2000). While oil has received the most attention as a war inducing resource (Collier 2000; Fearon and

Laitin 2003; Le Billon 2004); other resources including diamonds (West and Central Africa), timber (Cambodia), minerals (Congo), and drugs (Colombia, Afghanistan) have been implicated in civil war proliferation (Auty 2004). The spatial dispersion of resources (diffused throughout the state or in certain point locations) is incorporated into theories of relative conflict location as discussed above (Buhaug and Gates 2002; Le Billon 2001). Ross (2004b) concludes that some of the most widely-cited causal mechanisms involving oil, non fuel minerals and drugs, appear to be validly related to civil conflict but legal agricultural commodities are not. In general, resources and civil war are related by a variety of mechanisms and we need to separate them by group and regional context before we can make a conclusion that the "resource curse" holds (that resources increase the risk of civil war). The linkage of the environment and security began in the 1980s, and was followed by extensive studies in the 1990s by Homer-Dixon and the Toronto group into identifying the role of environmental scarcity in conflict. Focusing particularly on scarcity of resources--water, forests, fish—and violent domestic and international conflict, researchers were able to construct a causal pathway. These case studies expanded to understand the role of resource abundance in encouraging conflict and the 'third generation' of environment and security work now integrates environmental factors with socio-economic considerations

The essential relationship of increasing income lessening the risk of civil war onset remains undisputed (Collier *et al.* 2003; Fearon and Laitin 2003). But how does poverty cause civil war? Poverty is considered both an economic development and political development failure. It represents the inability of a government to properly provide and sustain a livelihood for its people. At higher rates of initial per capita income, a government's ability to retain control increases. In countries with lower GDPs, by contrast, securing power and order become government priorities. The percentage of government monies on military spending doubles during conflict (Collier *et al.* 2003), which can produce a cycle of conflict as societal spending (education, health, development aid) is cut, and income further declines. Elbadawi and Sambanis (2002, 2) find that conflict is "disruptive to capital or transaction-intensive activities (such as roads, production of manufactures, or financial services); it can divert expenditure and the societies resources from economic services (growth enhancing activities) to war efforts; and it can divert portfolios from domestic investment into capital flight". Fearon and Laitin (2003, 80) note that a higher income is associated with a more developed infrastructure, and therefore better control of the state and its people. Collier and Hoeffler (2001) note that neighboring war has a considerably larger impact on a bordering countries' GDP than on domestic GDP (presumably, domestic GDP was very low to start). In later work, Collier, Hoeffler, and Soderbom (2004) assert that low per capita income, high inequality and a moderate degree of ethnic division lengthen conflict whilst a decline in primary commodity shortens it.

Two intersecting paradigms exist to explain the role of political factors in civil war. Weak state literature focuses on the legitimacy and sovereignty of the state as contributing to the outbreak of war (Herbst 2000; Holsti 1996). Forms of governance (autocracies, democracies, and anocracies) theory looks for associations between political structure and rebellion (Hegre, Ellingsen, Gates, and Gleditsch 2001). Weak state literature is theoretically well-informed and work on forms of governance is empirically sound. Yet, control is the underlying assumption in both of these literatures. If states and governments have a complex of control, either through the validation of the government as the voice of the state or, as in an autocracy, a well-structured infrastructure of fear and domination, the probability of civil war is assumed to be low.

Ethnic diversity as a cause of conflict is based on the assumption that increased fractionalization makes it difficult to create a unified community, due to people having alternative allegiances. Power relations are not assumed to be equal in fractionalized societies. Ethnicity's relationship to conflict is quite variable, as noted by a number of studies finding diversity linked to conflict (Connor 1973; Horowitz 1985), diversity not linked to conflict (Collier and Hoeffler 1998; Fearon and Laitin 2003), diversity lessening conflict (Collier *et al.* 2003), ethnic dominance exacerbating conflict (Collier et al. 2003; Gates 2002a) , religious affiliation causing conflict (Huntington 1996; Reynal- Queron 2004) and ethnic elites are a catalyst for conflict (Brown 2001; Lake and Rothschild 1998).

Recent studies have found that ethnic diversity does not create an increased risk of conflict onset. However, ethnic fragmentation's relationship to conflict proliferation is more varied (Gurr 1993; Horowitz 1985). Ethnic dominance (typically 45-90% of the population) can increase the risk of rebellion. This argument is based on the "predicted effects of ethnic diversity as dependent upon the opportunities for predation of primary commodity exports and taxation of diasporas" (Collier and Hoeffler 2001, 7). A dominant group may also have a considerable number of potential recruits and hence the chance of success may be greater. Ethnic ties with related ethnic grievances lessen the costs of recruiting and sustaining a fighting force. The costs are essentially lessened due to perceived benefits being shared throughout the ethnic group. This new perspective on the non-ethnic nature of ethnic wars has detractors who regard conflict as the interplay of diversity and grievance. Grievances (based on the distribution of resources) and ethnic identification as a basis for rebellion are grounded in the impression that modernity does not lead to a more democratic system (Ellingson 2000, 237). Elbadawi and Sambanis (2002) find similar results to Collier and Hoeffler (2001)-- economic and political underdevelopment are the root causes of conflict (specifically in Africa)--but they also find that ethnic fragmentation may lead to poor economic health in the form of bad economic policies.

Many studies of civil war perpetuate the same mismatch between the national level at which data are collected and the regional, as well as local, aspects of the actual conflict. Buhaug and Gates (2002), on the other hand, show that the geographic location of a civil war within any particular country is fundamental for understanding conflict dynamics. Civil wars that take place in the periphery of countries tend to last much longer than those occurring close to national capitals, for example. Moreover, governmental capabilities are not homogenous, but neither are they geographically fungible. Extensive state power may be present in some locales, but virtually absent a few kilometers away. Geographically-disaggregated conflict-specific measures of resources yield much better predictions of civil war duration than national level data (Buhaug and Lujala 2005). However, disaggregated data beyond the level of the nation state have not yet been widely explored in this context. Although such data presently do not yet exist in a manner that easily allows cross-national comparisons, it is already clear that a disaggregated, spatial perspective on civil wars will augment our understanding of their causes.

The diffusion of conflict, or the escalation of parallel conflicts, is rooted in the illegitimacy of state borders and the inability to control both territory and the people in it. Domestic conflict spreads in the same way people and services cross borders the Third World. Diffusion and escalation are important and understudied features of civil war because entire regions can escalate into a series of civil wars feeding off each other (e.g. West Africa in the late 1990s). Regional conflict formations are evident in interstate war (O'Loughlin and Anselin 1991; Väyrynen 1984), and are speculated to exist for civil war (Kaplan 2000). It is also clear that within regions, particular states are more prone to civil conflict than others. Why states devolve into conflict and how the presence of a violent neighbor influences a state's conflict risk is a question addressed in this paper. The "location of states, their proximity to one another, and especially whether or not they share borders, emerges time and again as key variables in studies of international conflict phenomena: from major power general war to the diffusion of international conflict, to the analysis of peace between pairs of democracies" (Starr and Thomas 2002, 244).

A lack of territorial sovereignty within weak states allows for conflict to spread over borders. Border regions can also be used to assess the spread of domestic conflict, as they have been used in international conflict analysis (Siverson and Starr 1991). The salience of borders highlights the mismatch of nation and state (Englebert, Tarango, and Carter 2002). Borders serve two purposes- 1) a legal borderline which separates territories and joins states and 2) a zone where people negotiate meanings associated with their identity such as membership in a nation or state (Wilson and Donnan 1998). Border formations can thus have a tremendous influence on nation and state sovereignty. If neither territory nor identity is structured and protected by the state, there seems no conceivable reason why conflict, like people and services, cannot pass through porous boundaries, contributing to the diffusion and escalation of civil wars.

Faced with the high risk of war endemic to developing states, weak states are in a position of 'double jeopardy'- they are both domestically suited to civil war outbreaks and internationally surrounded by high risk weak states which allow for conflict to spread across borders. Therefore, the location of a state can be an underlying cause in domestic conflict outbreak and duration

Why Geography matters!

Most analyses of social science data have proceeded apace with an implicit assumption that all the data are generated by a random process that results in the data being independently, identically, distributed (aka i.i.d).

Geographers, on the other hand, have been advocating a SISS (spatially integrated social science) which views space as integrating social processes and sees social science dynamics as processes in place (Goodchild, Anselin, Applebaum, and Harthorn 2000; Griffith and Layne 1999). This approach uses GIS (Geographic Information Systems) to integrate data by geo-referenced location and applies spatial statistical analysis to integrate multidisciplinary approaches. Reviewing the status of this perspective, Goodchild *et al.* (2000, 139) conclude that "in the mainstream of the social sciences, attention to the spatial (and space-time) dimension of phenomena is much less apparent (compared to geography), although a revival of sorts is occurring." It is time to revisit the decades-old notion of the "ecological triad" (social entity or actor, environment, and entity-environment relationship) from the Sprouts (Sprout and Sprout 1965). Careful consideration of each element can disabuse us of ideas that certain global regions, such as the Middle East, are intrinsically "conflict-prone". As Sørli *et al.* (2005) show, economic growth and development, ethnic dominance and regime type explain the distribution of conflict in the Middle East, but not oil nor Islam so that a general model fits and there is no reason to resort to exceptionalist explanations.

Growing attention is given to the number and distribution of refugees and forced migrants near conflict zones and the potential for destabilization of neighboring regions (Okamoto and Wilkes 2003; Salehyan and Gleditsch 2004). Human geographic considerations such as population distributions, flows and concentrations have also been correlated to increased conflict risk (Collier and Hoeffler 2001). Although the relationships between demography and conflict are under-theorized, high and diverse populations in poor countries can be involved in a struggle over power, representation and resources (education, health care, food, employment). High populations may also (by sheer number) assist in support for disparate groups and hence, prolong rebellion. Refugee flows are believed to exacerbate the risk and proliferation of conflict through a process of diffusion, wherein refugees alter the balance of power (through ethnic populations or resource exploitation), or escalation, an occurrence when refugee flows bring new combatants into a contentious situation (Lake and Rothschild 1998; Whitaker 2003). The impact of a refugee flow is contingent upon the political and military cohesion amongst the refugees, the stability of the host state, and the extent of external intervention (Whitaker 2003).

From the economic perspective, Collier (1999) has demonstrated that at the country level, the economic growth rate is reduced by 2% per annum during civil wars**.** Further, civil wars in neighboring states (within a 300 km distance) negatively affects the economy of the domestic state.(Lischer 2002; Murdoch and Sandler 2004) Moreover, recently Ghobarah, Huth and Russett (2003; 2004b) show that public health consequences of civil wars persist beyond the span of the actual conflict by estimating the additional burden of death and disability. The health outcome in 1999, from the indirect and lingering effects of civil wars in the years 1991–97, was approximately equal to that incurred directly and immediately from all wars in 1999. Further*,* the public health consequences of civil wars are disproportionately borne by women and children.

Regional conflicts are a mixture of intra-national, intra-regional, and extra regional conflicts. Considering that most conflict is currently intra-state, and the strength of regions is based on actors (states) at the bottom of this hierarchy, regional systems in the periphery experience a double risk on conflict. Regional conglomerations of states are at internal risk because of conflict diffusion, and international interests exacerbate tensions and power relationships inside regions which result in shatterbelt-like scenarios.

Of course, the opposite is also true. Systems that experience a great degree of stability are at a lesser risk of internal conflict because of the stability of the larger region. The European Union is an example of where a commitment to peace, a stable economic environment and a location in the core of the world-economy allowed for the pursuit of change through peaceful measures as opposed to violence

Methods

This review above was not designed to be comprehensive but to highlight the geography of civil wars. The main foci of researchers remain the state-level geography characteristics that can be entered into regression models with the usual economic, political and social data. Thus, ratios of mountainous and forested terrain by country, number of bordering states with civil strife measured either by distance or contiguity, population density and distribution, and resources figure prominently as the geographic factors in civil war research. What is generally missing is any precise locational analysis and disaggregation of global level estimates to regional or local scales. Recent emphases and innovations in quantitative geography offer new insights that should be attractive to political scientists that are trying to develop contextual models.

Within the scope of spatial analysis, research usually proceeds from ESDA (exploratory spatial data analysis) techniques and cartographic exploration with attribute and locational data (latitude/longitude) organized in a GIS (Geographic Information System). Within the past decade, there has been a welcome integration of cartographic display and spatial statistical analysis within the same software packages. (The latest version of ArcMap version 9 from ESRI, for example, includes routines for geo-statistical analysis). While cartographic display can offer some possible hypotheses about the geographic association of the variable of interest (the location of civil wars), the analyst must be cautious to also consider the other map layers that display the predictors such as income, ethnicity, political development, etc. Until these effects are filtered out, the simple statistic of clustering or randomness from a point pattern analysis cannot be conclusive. From physical geography, there are many point pattern analyses that are uni-variate since they are suggested by physical processes (e.g. the spread of a beetle infestation in trees). In human geography, such simple extrapolations cannot be supported because of the complexity of human spatial processes.

The identification of "hot spots", locations and clusters where the variable of interest is disproportionately found is the *sine qua non* of spatial analysis. Local indicators of spatial correlation (e.g., *LISA – Local Indicators of Spatial Association*) or the G*i index are simply descriptive statistics that are helpful in pointing to some contexts where further attention can be directed (see Anselin (1995) and Ord and Getis (1995)). Neither approach flows from a specified probability model nor have they especially enduring statistical properties. Moreover, development of these methods for polygon data (areal data) parallel developments in geo-statistical analysis for points (see Bailey and Gattrell, 1995 and Diggle (2003)). Both developments reflect the recent switch towards more disaggregated measures of distribution and display of the local effects. While the still heavily-used global measures of distribution (Morans I and Geary's c) were introduced about 50 years ago and were the only measures of clustering commonly used till a decade ago, the "turn to the local" (Fotheringham 1997) has seen a renewed interest in pushing the consideration of contextual effects in overall spatial patterns across the field of geography. A rejection of general laws and relationships that hold across all environments in favor of contextually-nuanced models is now the dominant feature of geographic work.

Fotheringham, Brunsdon and Charlton (2002, 6) summarize the differences between local and global statistics in the following table. While global models are rooted in the positivist tradition of science, local approaches recognize the complexity of human behavior and especially the potentially-important effects of local contexts, that are derived from tradition, historical memory, group identification and mobilization, and the legacy of inter-group interactions (Agnew 2002; Johnston 1991).

Global Statistics	**Local Statistics**
Summarize data for whole region (e.g. Morans I)	Local disaggregations of global statistics (e.g. G*i)
Single-valued statistic	Multi-valued statistic
Non-mappable	Mappable
GIS-unfriendly	GIS –friendly
Aspatial or spatially limited	Spatial
Emphasize similarities across space	Emphasize differences across space
Search for regularities or 'laws'	Search for exceptions or "local hot spots'
Example – classic regression	Example – GWR geog. weighted regression

The recent interest in disaggregation of general relationships is not confined to geography as is evidenced by growing attention to disaggregated and local statistics such as LOESS (Cleveland 1993) and disaggregated methods of graphical display (Cleveland 1994).

Common to both point and polygon analysis in geography is the concept of spatial non-stationarity, that the measurement of a relationship depends in part on where the measurement is taken. The implication is that the process that we are studying might not be consistent over space, due perhaps to sampling errors, but more importantly, an issue for the validity of global models. It is fair to state that most human geographers expect sort level of non-stationarity since we generally expect contextual effects. Unlike (some) political scientists who think that the remaining presence of pattern in error terms of regression models reflects poor statistical analyses (King 1996), geographers tend to give these effects a substantive meaning and resort to claims about the importance of "place" in their accounts (Agnew 1996; O'Loughlin 2001, 2003). Methods that test for the presence of non-stationarity and (if found), which use it to model the relationships under consideration have thus found an eager audience in geography. While there is no room to go into detail here, it must be pointed out that spatial dependence and spatial heterogeneity are the key concepts that drive the concern with spatial non-stationarity and context (Anselin 1988). Spatial dependence refers to the neighbor effects generated by contiguity or short distance and can usually be seen in the display of the error terms from a regression while spatial heterogeneity refers to the larger-scale or regional differences that are evident in most expressions of human processes.

Four approaches are available for examination of possible significant geographic differences (non-staationarity) in social, political and economic predictions of civil war involvement in states. Anselin's GeoDA program (Anselin, Syabri, and Kho 2005) offers a spatial econometric approach that combines exploratory spatial data analysis and models that mix structural predictors and spatial (geographically-weighted) elements. One important option in this approach allows the calculation of spatial regime-specific models for regions when there is evidence that the relationship has a non-stationary form. This spatial econometric approach has been used (ineffectively) in a study of the distribution of terrorism (Braithwaite and Li 2004). A second approach called the spatial expansion method has not really taken hold despite its evident appeal of disaggregating the global parameters by allowing the parameter estimates to be functions of other attributes, such as latitude and longitude (Jones and Cassetti 1992). One key reason for the relative lack of interest in this method is that it is restricted to displaying trends in relationships over space with the complexity of the measured trends being dependent upon the complexity of the expansion equation, thus possibly covering up some important local variation (Fotheringham, Brunsdon, and Charlton 2002, 17). A third option, multi-level modeling, has achieved less attention in geography than might have been expected given its ability to combine multiple scales in one analysis. While most applications have been for examining individual behaviors and attitudes in nested settings (precincts, cities, counties), some applications are now available for aggregate data (Subramanian, Duncan, and Jones 2001) with a recent re-analysis of the Fearon and Laitin (2003) data and approach completed using a multi-level approach (Raleigh 2004).

In this paper, we present a re-analysis of the recent work that attributes long-term health effects in the form of shortened years of life (measured by DALYs – Disability Adjusted Life Years) from civil wars, both domestically and in neighbors (Ghobarah, Huth, and Russett 2003, 2004b). Geographically-weighted regression (GWR) has received growing attention because of its ability to disaggregate the usual global parameters (such as those reported in these two studies) into local estimates that can be mapped and examined further in both cartographic and modeling extensions. The availability of the software and the ability to export the estimates to GIS packages such as ArcMap has promoted further interest in this approach (Charlton, Fotheringham, and Brunsdon 2003); it is also available in ***R***. One big advantage of this method is that it is based on the familiar traditional regression approach and includes the local emphasis in an intuitive and explicit way (Fotheringham, Brunsdon, and Charlton 2002, 27). It has evolved from the spatial expansion method summarized above, and incorporates both spatial dependence and spatial heterogeneity in its estimations.

GWR takes the usual regression model and extends it; compare equations (1) and (2).

$$y = b_0 + \Sigma_k b_k x_{ij} + e_i \tag{1}$$

$$y_i = b_0(u_i , v_i) + \Sigma_k \beta_k (u_i , v_i) x_{ij} + \varepsilon_i \tag{2}$$

where (u_i , v_i) denote the coordinates of the *i*th point in space and $\beta_k (u_i , v_i)$ is a realization of the continuous function surface $\beta_k (u_i , v_i)$ at point *i*. GWR permits the parameter estimates to vary locally where (g) indicates that the parameters are to be estimated at a location whose coordinates are given by the vector g. The parameter estimates for GWR may be solved using a weighting scheme

$$\hat{\beta} (u_i , v_i) = (\mathbf{X}^{\mathbf{T}} \mathbf{W} (u_i , v_i) \mathbf{X})^{-1} \mathbf{X}^{-T} \mathbf{W} (u_i , v_i)\mathbf{y} \tag{3}$$

where the bold type denotes a matrix, $\hat{\beta}$ represents an estimate of $\boldsymbol{\beta}$, and $\mathbf{W} (u_i , v_i)$ is an *n* x *n* matrix whose diagonal elements are the geographical weighting for each of the n observed data for regression point *i*. (Fotheringham, Brunsdon, and Charlton 2002, 53). The weights are chosen such that those observations near the point for which parameter estimates are needed have more influence on the result than observations further away.

The issue of a choice of weights in spatial analysis is a complex and potentially critical one (Getis and Aldstadt 2004). The weights are usually obtained through a spatial kernel function. Two types of spatial kernels are often used, i.e., fixed and adaptive kernels. In a fixed kernel function, an optimum spatial kernel (bandwidth) will be obtained and applied over the study area. This approach is usually less computationally intensive but can lead to odd results when there are isolated points with no neighbors by producing large local estimation variance in areas where data are sparse, and may mask subtle local variations in areas where data are dense (Fotheringham, Brunsdon, and Charlton 2002). On the other hand, the adaptive kernel function seeks a certain number of nearest neighbors to adapt the spatial kernel to ensure a constant size of local samples. This kernel might present more reasonable means in representing the degree of spatial non-stationarity in the study area. In this study, we use both fixed and adaptive kernel functions for comparison of results.

Within the discipline of geography, point pattern analysis has tended to focus on "hot spots" or clusters of points of interest. Here, the methods of detecting clusters are many and varied with recent development of commercial software (ClusterSeer; www.terraseer.com) and numerous routines in ***R*** for this specific purpose. There exist a number of techniques for dealing with 'simple' cluster analysis where the objective is simply to find occurrences of a phenomena, in addition to the clusters to be found there is some noise in the data. Virtually all techniques however fail or at least struggle when faced with a background population from which to find the clusters. Here the problem is not just to find clusters, but to find clusters that stand out in relation to their surrounding population (McGill and Openshaw 1998). The rapid advances in computer power and detection has made possible extensive and comprehensive computer searches of the large data-rich human and physical environments. Many of these data are geographically referenced, such as zipcode or centroids.

The GAM (Geographical Analysis Machine) was developed to explore large databases for evidence of patterns **if** the analyst has no good ideas of where to look for the patterns and what characteristics they may have. Thus, it suggests places to look for further insights into the processes that are producing the spatial patterns rather than acting as a hypothesis testing approach (Openshaw, Charlton, Craft, and Birch 1988; Openshaw, Charlton, Wymr, and Craft 1987)). For this reason, it has been criticized by Besag and Newell (1991) but as an exploratory technique, it has received widespread attention and use in epidemiology, biogeography and criminology. We use the GAM in this paper to examine the Uppsala locational data on the occurrence of civil wars since 1945 to see if there is any patterning or clustering, when one controls for the distribution of the population at risk.

Replicating and Disaggregating the Effects of Civil Wars on Health Outcomes

In a series of papers, Ghobarah, Huth and Russett have recently made the argument that civil wars kill people long after the war is over or settled through the secondary effects on health care networks, shifted government expenditures away from educational and other basic needs provisions, slowed economic growth and other war-related costs (Ghobarah, Huth, and Russett 2003, 2004a, b). In their studies, civil wars both at home and in contiguous states have independent significant effects on DALYs (Disability Adjusted Life Years), often of a sizeable magnitude. Thus, they estimate that "the impact in 1999 of living in a country that had experienced an intense civil war a few years earlier (such as Bosnia, with 6.8 civil war deaths per 100 people) rather than in a median country with no war at all is a loss of about 28.5 healthy years for only one disease of 23; the misery accumulates with each of the other 22 categories of disease." (Ghobarah, Huth, and Russett 2003, 197). They report the coefficients and the estimates for the whole world with no disaggregation for region or country, though one of the key controls in the studies is whether a country is located in a tropical zone or not. Using the data made available through their website (http://www.yale.edu/unsy/civilwars/data.htm), we replicated these studies and extended them by disaggregating the regression parameters to each of the 180 states. Our inquiry is designed to see if there are significant variations across the globe and whether these variations are geographically clustered, which, in turn, might generate further hypotheses on the factors causing the distribution. The results are reported in Tables 1 and 2 and Figures 1-6.

Rather than replicating the dozens of age-sex group/disease combinations that are reported by Ghobarah, Huth and Russett, we examined the same age group (15-44) for both sexes and for all disease causes (the cumulative effect of all illnesses) and for AIDS, one of the diseases on which the presence of civil war has a strong impact. We also re-calibrated the models with different weights matrices since it is well-known that spatial analysis tends to produce variable results for different weights, the Achilles heel of this kind of work. One of the key issues, then, is to ascertain how stable the results are for different measures of the key conceptions of contiguity. While variable results might lead to some consideration of the substantive consideration of their meaning (e.g. if the values were significant at 800kms radius but not 500 kms), the usual emphasis is on their stability across models. As well as fixed radii using both state capital coordinates and geographic centroids, we also used an adaptive kernel for both sets of coordinates. The parameters for the different bands and centroids can be compared in Tables 1 and 2 for the same models.

Ghobarah, Huth and Russett (2003) have nine predictors as well as the constant in their models and we were able to replicate their results for males and females (all causes) closely with GWR's global model option. Ghobarah, Huth and Russett (2003) do not report the coefficients for the AIDS subset).[1] As in the original study, civil wars at home and in the neighboring states, as well as urbanization and income inequalities, have strong and consistent (across the diseases and spatial weights) effects on the DALYs score (Tables 1 and 2). The interpretation of parameters in GWR models is somewhat different from the usual regression presentation. While the coefficients have the same interpretation as OLS, there are as many coefficients as cases in the study. Thus, in Tables 1 and 2, the median coefficient is presented and the number of cases beyond the "fences" (plus or minus one standard deviation) is also given as a measure of dispersal. Thus, in the model for Males 15-44 (all diseases) the global estimate for both the GWR global

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[1] There is one significant difference. Ghobarah, Huth and Russett (2003, 196) report an estimate of 2.99 for the civil wars1991-97 effect for the Females 15-44 (all diseases) model but our estimate (re-checked) is 0.299; similarly, our estimate for the Males 15-44 (all diseases) for this variable is 0.215, not the 2.15 reported in the APSR article. These might be typographical errors in the original paper.

model and the Ghobarah, Huth and Russett estimate for contiguous civil wars is about 52 DALYs but the GWR median value is 35.42 DALYs. It is not appropriate to compare the median GWR estimate directly to the OLS estimates, though the values are generally of the same sign. The number of countries outside the "fences" varies greatly from model to model and from predictor to predictor, thus suggesting large instability in the results and sizeable differences across the globe.

A comparison of the adjusted R^2 values (the comparison of the predicted values of the different models at each regression point and the observed values) of the two types of models gives some insight into the nature of the GWR procedure. Dramatic increases in the adjusted R^2 are the norm for GWR models given the difference in the degrees of freedom. ANOVA (testing the null hypothesis that the GWR offers no improvement over the global model) and an AIC test (Aikake Information Criterion) are used to compare the global and the GWR models; the values are reported in the last two lines of the tables. The F-tests indicate that 5 of the 9 GWR show that the local models in general offer a better account for variations in the DALYs than the comparative global models of Ghobarah, Huth and Russett.

The most interesting information from the GWR diagnostics in a study that focuses on disaggregation is the geographic variability in the local parameter estimates. We can examine the significance of their variability by conducting a Monte Carlo test developed by Hope (1968). As can be seen in Tables 1 and 2, few of the predictor coefficients show significant non-stationarity, or stated another way, the vast majority of the local parameters could be distributed in this manner by chance. Of the predictors, civil war deaths 1991-97 and civil wars in contiguous states (the key independent variables in the argument of the original study) show most non-stationarity, occurring four times in the GWR models.

Comparison of the parameters across the models using different spatial weight measures does not suggest any consistent conclusion. In Table 1, six GWR models with different coordinate centroids and weights are presented. While the estimates for the individual predictors are in the same range and generally have the same sign in each of the models, there are some clear patterns. The shorter fixed range kernel at 500 kms produces models that are no significant improvement over the global model (see the F-ratios and the adjusted R^2 values in Table 1); by contrast, the adaptive kernel models and the fixed 800 km radius models generates the largest F-ratios, high R^2 values and large decreases in the AIC scores. While it is hard to pick one 'best" model, it appears that either the adaptive kernel or the fixed 800 km radius weighting options produce valuable insights into the distribution of the local parameter values.

Some comparative distributions are presented in Figure 1 to 6. (All maps use the natural breaks option in ArcMap to fix the display categories). The map of the parameter values for the civil war deaths 1991-97 variable in Figure 1 shows a dramatic clustering of highest estimates (more than 0.33) in South and South-east Asia (including Australia) and a grouping of high values in tropical Africa and in Latin America. Similarly, Figure 2 for the civil war in contiguous states parameter shows a tight clustering of the highest values (more than 22.32 DALYs lost) in sub-Equatorial Africa (extending to Australia which, in adaptive kernels, becomes a neighbor of states in the Indian Ocean and South - Southeast Asia). The tropical country location variable generated a geographically non-stationary set of parameter values and their display in Figure 3 shows a contiguous group of Middle Eastern states surrounded by high values in a concentric manner. In Figure 4, the adjusted R^2 values displays a weak pattern of clustering across the globe with highest model fits in Latin America and Southeast Asia with other high values in parts of the Middle East and southern Africa. The model generates the poorest fits in China and adjoining Central Asia, as well as in North America and in west-central Africa. There are no obvious geographic correlates with this pattern. The map of the residuals from the GWR model for Males All-causes with an adaptive weighting option (Figure 5) shows moderate clustering in southern and eastern Africa; this pattern and the African clusters on the other maps suggest that the "African factor" in the models of Ghobarah, Huth and Russett is under-specified. It would seem that the effects of civil war on the DALY values are most dramatic in the African context. A further map of dramatic impact is that for the estimate for contiguous civil wars on females 15-44 DALYs affected through AIDS (Figure 6). The zone of highest AIDS intensity in east and south Africa appear dramatically, with values above 25 years. The rest of sub-Equatorial Africa shows values greater than 8 years.

The re-analysis of the data that show a significant effect of civil war involvement at home and in neighboring states from Ghobarah, Huth, and Russett (2003) using geographically-weighted regression has identified some important spatial patterns in the distribution of the localized parameters. Not all of the original analyses need to be disaggregated and the choice of weighting (adaptive or fixed kernels), and of the centroids for each country are important considerations in the approach. However, the appearance of clusters in Africa (especially in southern and eastern Africa) of the local parameter values for many of the models suggests that greater attention be paid to the specific African context and consideration of a re-calibrated model that would substitute an African location for the 'tropical location" that was present in the original models.

Point Pattern Analysis of Civil War Locations

Point pattern analysis is most often found in the fields of biology, epidemiology, and criminal analysis. The goal of such analyses is to gain insight into the underlying process or processes that generated the points. In the case of conflict studies, spatial arrangement of the conflict locations can be used to assess the degree to which diffusion processes may be influencing the onset of conflict versus other processes such as population expansion, resource depletion, ethnic division, or poverty.

The more simplistic point pattern analyses view point data with scant regard for the underlying context of the study region. A typical first approach is to view the data in a scatterplot form and make a qualitative assessment of the pattern. While such an exploratory technique can be effective for data that exhibit extreme spatial clustering or regularity over a uniform or controlled study area, it is difficult to have confidence in the conclusions for less obvious point patterns or for what appear to be obvious patterns occurring over a variable population at risk. Other exploratory approaches such as quadrat methods, kernel estimation, and the *K* function attempt to quantify point patterns (Fotheringham, Brunsdon, and Charlton 2000). Though these types of analyses can improve the understanding of the point distributions, they still struggle to account for underlying populations that may be influencing the pattern (Bailey and Gattrell 1995).

Though the population at risk parameter is a common problem in analyzing point patterns, methods that control for the spatial variations in the underlying population are often given short shrift (Bailey and Gattrell 1995; Fotheringham, Brunsdon, and Charlton 2000). One approach is to apply a kernel estimate to both the points under study as well as the population at risk and take the ratio to normalize the point pattern density. This may yield a more appropriate density map of the event distribution but provides no way of identifying statistically significant clusters. To statistically evaluate the possibility of civil war clusters against a background population at risk, we turn to the Geographical Analysis Machine (GAM) (Openshaw, Charlton, Wymr, and Craft 1987) . This method analyzes point data by overlaying a two-dimensional regular grid of points on the study area and comparing the number of observed data within a given radius of each grid point against the population at risk. The original GAM used a Monte Carlo computation to determine the statistical significance if each grid point with respect to clustering. More recent versions of the GAM calculate the probabilities by comparing the observed event data against a Poisson distribution based on the population at risk.[2] Characteristics of GAM, from Fotheringham and Zhan (1996) include a) a method for defining sub-regions of the data; b) a means of describing the point pattern in the data, c) a procedure for assessing the statistical significance of the observed point pattern, within each subregion considered independently, and d) a procedure for displaying the sub-regions in which there are significant patterns.

The GAM proceeds as follows (from Fotheringham, Brunsdon, and Charlton (2002). Begin with random selection of a location and then of a radius of a circle to be centered at that location. Within this random circle, the number of points is counted and this observed value compared with an expected value based on an assumption about a process generating the point pattern (in our analysis, we assume it to be random). The population at risk in each circle is then used as a basis for generating an expected number of points which is compared to the actual number. (We use both an even population distribution, all areas with more than one person per square kilometer, and a weighted population distribution). The circle is then drawn on the map if it contains a statistically interesting count (higher or lower than expected). The process is

[2] This is the method used here as implemented by the DCluster Package for the *R* language and environment. (Gómez-Rubio, Ferrándiz, and López 2004). The Besag and Newell (1991) method for cluster detection was also tested but produced nonsensical results due to its estimation procedure. Instead of specifying a search radius, the user sets the number of expected events per cluster. The procedure then expands its radius for each point in the grid until that number is met and compares the population size inside the search radius to the expected value. For our conflict data set, this produced a map showing significant clustering in the Atlantic Ocean off the west coast of Africa due to the perceived high rate of conflict against an extremely low expected value (zero over water).

repeated many times so that the map is produced which contains a set of circles centered on parts of the map where interesting patterns appear.

Fotheringham and Zhan (1996) compare Openshaw's GAM, Besag and Newell's method, and their own version of cluster analysis. Their version is similar to Openshaw's but differs in two ways. They (i) allow both the location and circle size to vary randomly within specified ranges and (ii) use the Poisson probability distribution to directly assess significance. The GAM method used here is therefore a mix of Openshaw's original algorithm with Fotheringham and Zhan's approach where a grid and circle size are specified as fixed parameters and significance testing performed using the Poisson probability distribution. In their analysis, Fotheringham & Zhan found that all three methods performed well in identifying geographically interesting clusters against a given underlying population at risk. They found their method easier to apply than Besag and Newell's technique and independent of setting a minimum cluster size. When tested on random point patterns, the Openshaw and Fotheringham methods performed best (least number of false positives) at high significance levels (i.e. $\alpha < 0.005$)

For this study, the GAM was applied to the Uppsala conflict data from Strand, Wilhelmsen and Gleditsch (2004) and tested against two versions of population at risk. The conflict data used for this portion of the analysis is from the Armed Conflict Dataset, version 2.1. Only Type 3 data, internal armed conflicts (303 conflicts since 1946) were used in our analysis. The first version of the population data assumed an equal chance of conflict anywhere in the inhabited world. This translated into a threshold of 1 person/km^2 and was applied to control for the expectation that conflict cannot occur in oceans and uninhabited land. The other version assumed that as population density increases, so does the risk of conflict as competition for resources also increases (Collier *et al.* 2003). Data for these model parameters were obtained from CIESIN(2000) Gridded Population of the World dataset for the year 1995. Prior to running the analysis, all data were converted to the equidistant cylindrical projection to help limit the effects of the Earth's curvature on distance calculations. These conflicts were then summed according to their geographical reference point to yield 204 unique map coordinates. Though most points record just a single conflict, Iraq, for instance, experienced the most (13) internal conflicts over the last half century.

The GPW population density data used were at the 30 arc-minute (1/2 degree) spatial resolution. This translated into 43,471 grid cells with at least 1 person/km^2. The GAM implementation used here required an expected value for the number of conflicts. For the uniform population at risk analyses, we assume that the probability of the 393 conflicts is uniform over the inhabited surface, yielding a constant expected conflict value of 0.009 (393/43,471). For the population density analyses, the expected conflict value was weighted according to the population density at each grid cell such that the mean expected conflict remained 0.009

For each of the population risk densities, the GAM was run using a 100km grid of points where clusters were tested for each point on the grid at 100km, 500km, and 800km radii. These radii were chosen based on previous work on conflict that suggests that an influence threshold for civil wars lies somewhere in the 300-800 km range (Murdoch and Sandler 2004). Results for the 100km radius only succeeded in detecting the observed conflict locations and are not reported here.

Maps for the 500km and 800km search radii are presented in Figures 7-11. Figure 7 shows how Figures 8-11 are constructed; it is based on the uniform population at risk and a search radius of 500km. For each map, purple points are the GAM grid points that tested positive for spatial clustering at $\alpha = 0.1$ level. Similarly, green and red points indicate clustering at the $\alpha = 0.01$ and $\alpha = 0.001$ level, respectively (Similar levels of significance and similar results in terms of numbers of clusters can be seen in Fotheringham and Zhan (1996). The bottom right overlay map of Figure 7 shows all three levels of significant clustering in one map and is reproduced in Figure 8 at a larger scale. The larger maps in Figures 8-11 have an additional set of red points that mark the observed conflict coordinates.

Examining the detected clusters against a uniform population distribution (Figures 8-9) shows a strong equatorial belt of internal civil conflicts. The 500km and 800km maps are quite similar, with the main difference visible in the larger clusters detected using the 800km search radius. Both maps show an ocean edge effect where offshore grid points whose search radius includes onshore observed conflicts tend to demonstrate higher levels of clustering due to the unusually low population at risk over oceans. The points off the coast of Ireland, for instance, clearly demonstrate this ocean effect.

For the clusters generated using a population density surface (Figures 10-11), the same differences between the 500km and 800km search radius are visible, as are similar ocean edge effects. The geographic distribution of clusters, however, differs substantially when population density variations are taken into account in contrast to the uniform population risk of Figures 7-9. The most obvious shift occurs in Africa, where much more significant clustering is detected. This is accompanied by a decrease in clustering in Southeast Asia. Since population densities are relatively lower in Africa than in Southeast Asia, this shift in detected clusters is not unexpected. The Balkans region also loses its significance as a conflict cluster when the underlying population distribution is controlled.

Though the analysis conducted here only used two variations of a population at risk, it is important to recognize that other variations are possible. Given existing theories of civil war outbreaks and diffusion, (see for example the list in Gates (2002a)), it would also be worth testing for clusters against a measure of minorities at risk (ethnic distributions), level and trends of per capita income, environmental stress, income inequality, urbanization, and migration. Incorporating such data pose additional challenges due to the study area's global scale.

Conclusions

Over a decade ago, in the early 1990s, one of the authors intended to "bring back geography to the study of international relations" (O'Loughlin and Anselin 1991, 31). The authors had modeled a state's war behavior as "related to a) their domestic attributes, b) spatial dependence (neighboring effect), and c) spatial heterogeneity (regional effect)". In this project, domestic, international, and interregional factors will be analyzed for their impact on civil wars. Our continued justification for a political geographic examination of countries and regions in conflict analysis is twofold- first, conflict does not happen in a vacuum, and it seems logical to account for surrounding context and secondly, evidence from the spread of international conflict has emphasized the role of neighbors and regions (Siverson and Starr 1991).

Most research in contemporary political geography is highly descriptive and increasingly ideological (see the review in Mamadouh (2004). Meanwhile, within quantitative geography, important developments and innovations are being pushed for both polygon and point pattern analysis, usually within a GIS framework. Descriptive political geographic work takes a place-based approach, like a case study in comparative politics that has a strong historical foundation and a policy-oriented focus. Most applications of the techniques of spatial analysis are in physical geography and in data-rich specialties such as climatology, environmental analysis, and remote sensing image analysis. A merging of the interests of political geographers interested in war and peace study and spatial analysts is long past due.

Our intention in this paper was to point to some of the ways in which the local turn in quantitative geography, complemented with an array of methods that disaggregate global-level measures, can offer insights into the nature of civil war. Specific methods have been developed for point and areal analyses and in the absence of theory-driven hypotheses, most of the approaches are (correctly) of an exploratory nature. Thus, assumptions of randomness are made rather than specific expectations of certain types of pattern (clustering, regular etc). Hundreds of studies have tackled the causes of civil wars, their locations and durations, their settlements, and the potential for long-term effects. Now it is time to disaggregate general, country-based study and with the collection of more locationally-specific data, the possibility of application of the methods of spatial analysis has finally opened up.

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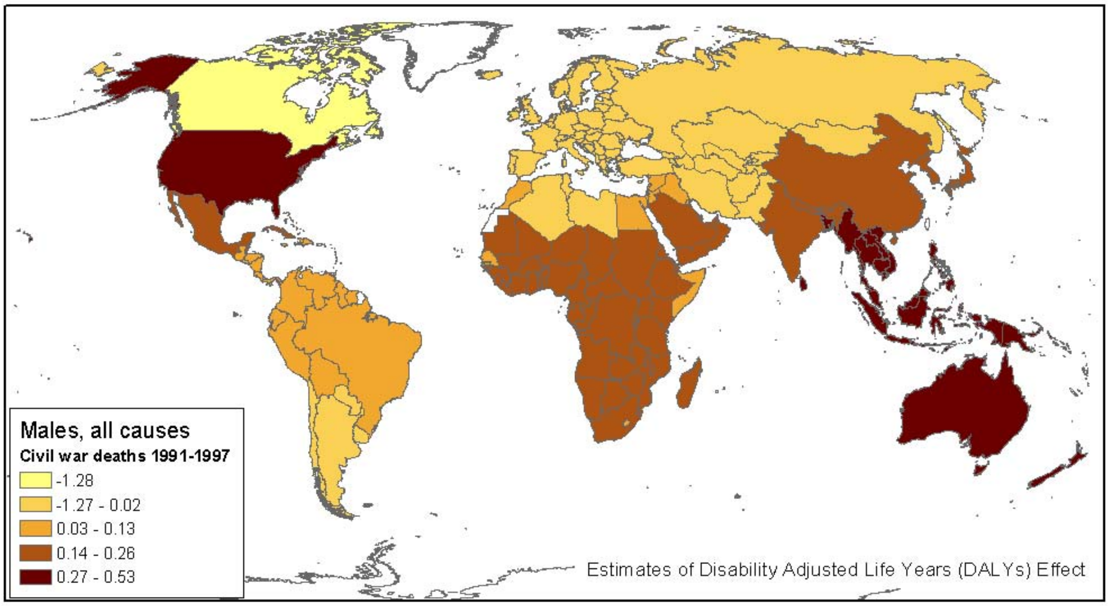

Figure 1: Distribution of parameter values for the predictor "civil war deaths 1991-97" for males all-causes data ; adaptive kernel weighting with the capitals as centroids. Categorization is by natural breaks.

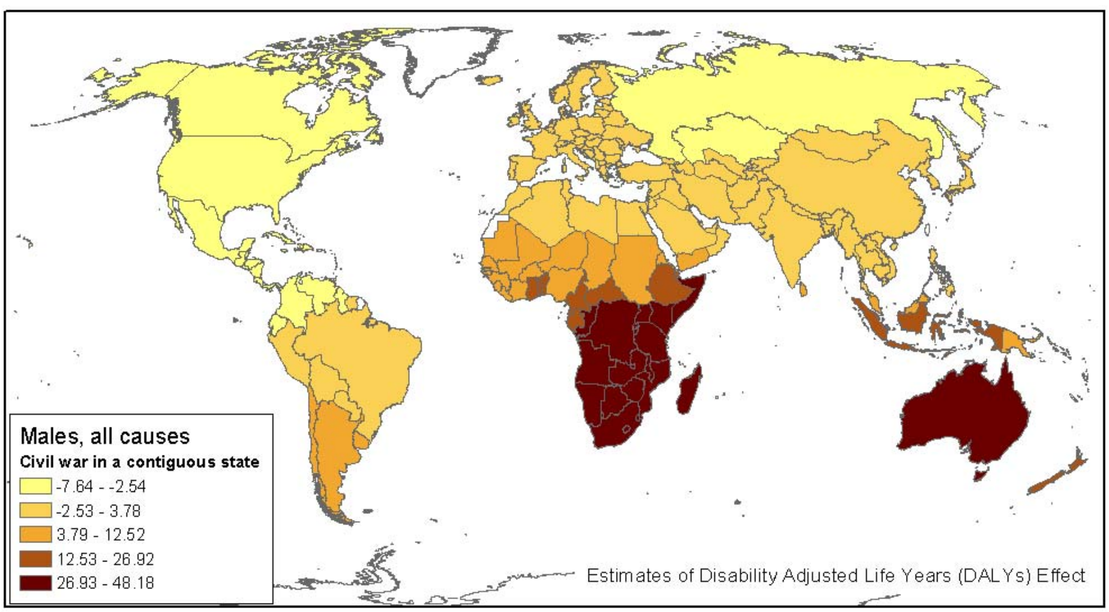

Figure 2: Distribution of parameter values for the predictor "civil war in contiguous state" for males all0-causes data ; adaptive kernel weighting with the capitals as centroids. Categorization is by natural breaks.

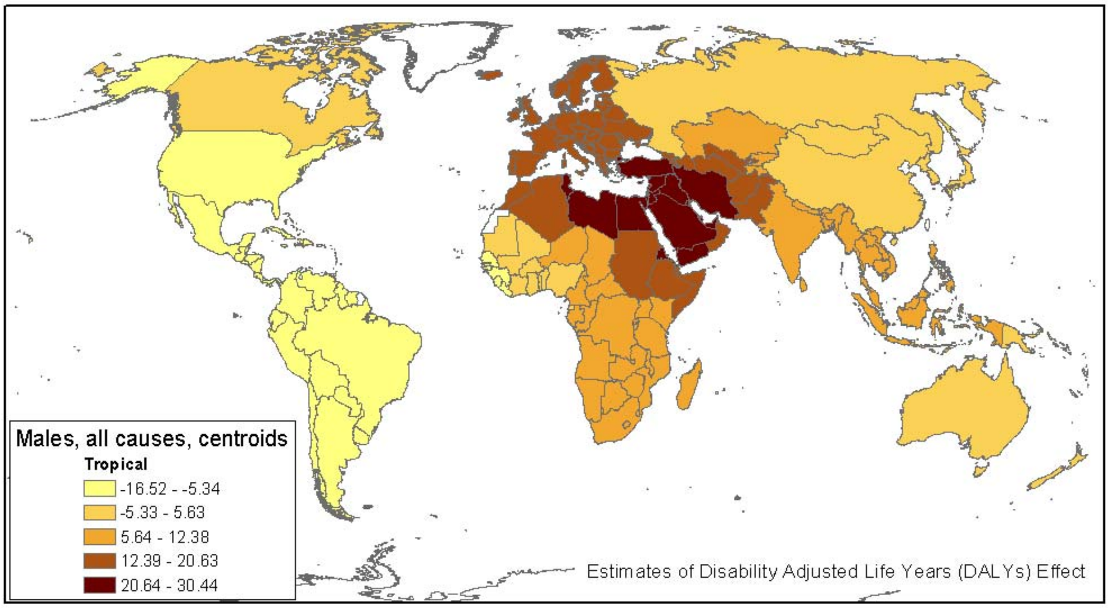

Figure 3: Distribution of parameter values for the predictor "location in a tropical country" for males all-causes data ; adaptive kernel weighting with the capitals as centroids. Categorization is by natural breaks.

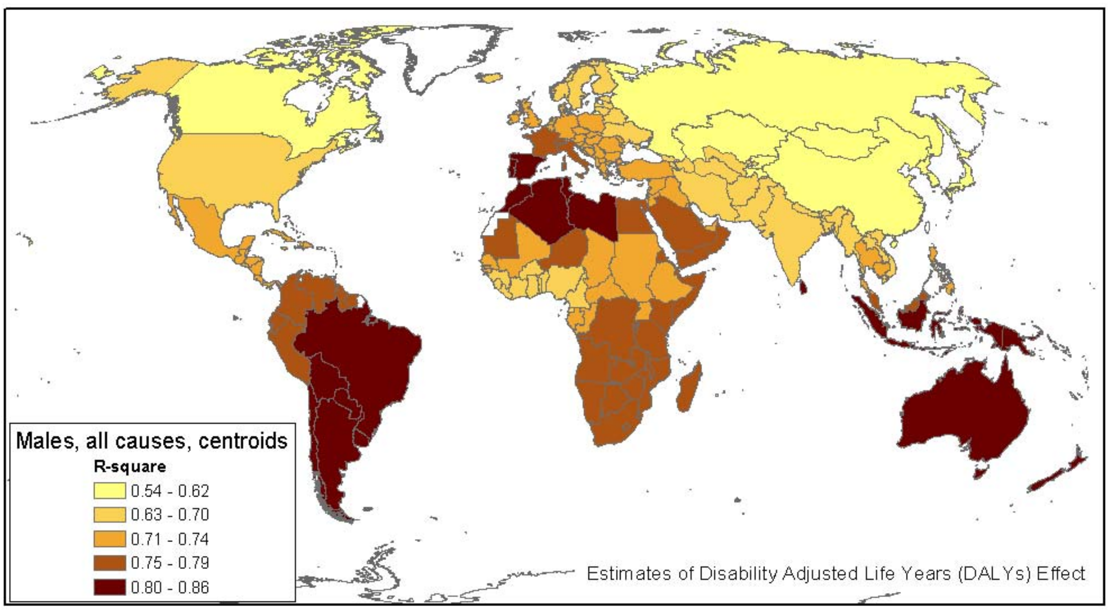

Figure 4: Distribution of the adjusted R^2 values for the GWR model using Ghobarah et (2003) predictors for males all-causes data ; adaptive kernel weighting with capitals as centroids. Categorization is by natural breaks.

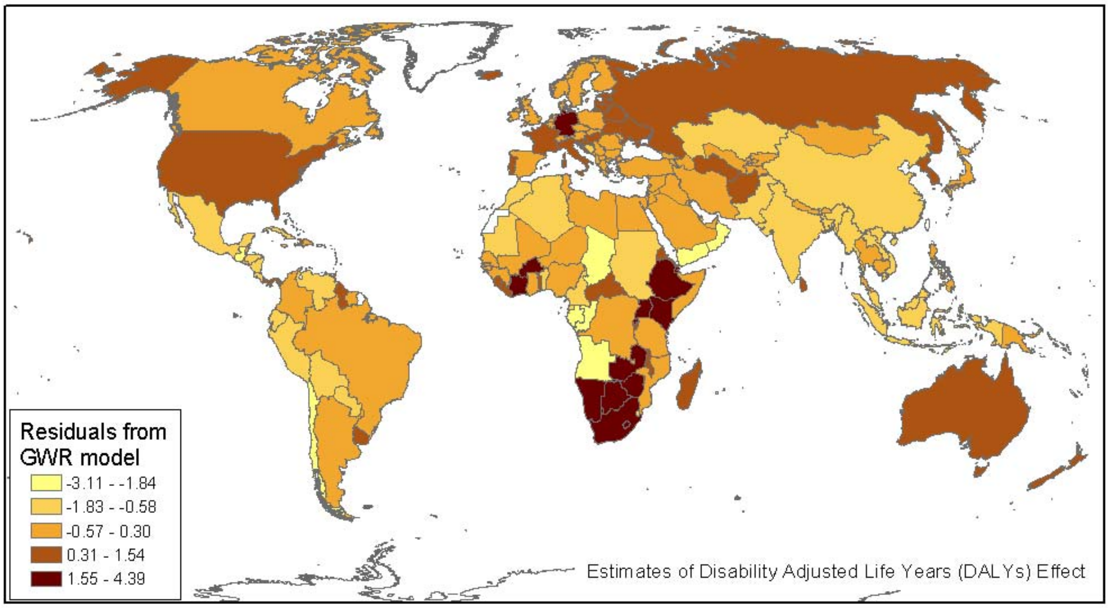

Figure 5: Distribution of residual values for the Ghobarah *et al* (2003) model using a GWR approach; weighting is adaptive kernel with the capitals as centroids. Categorization is by natural breaks.

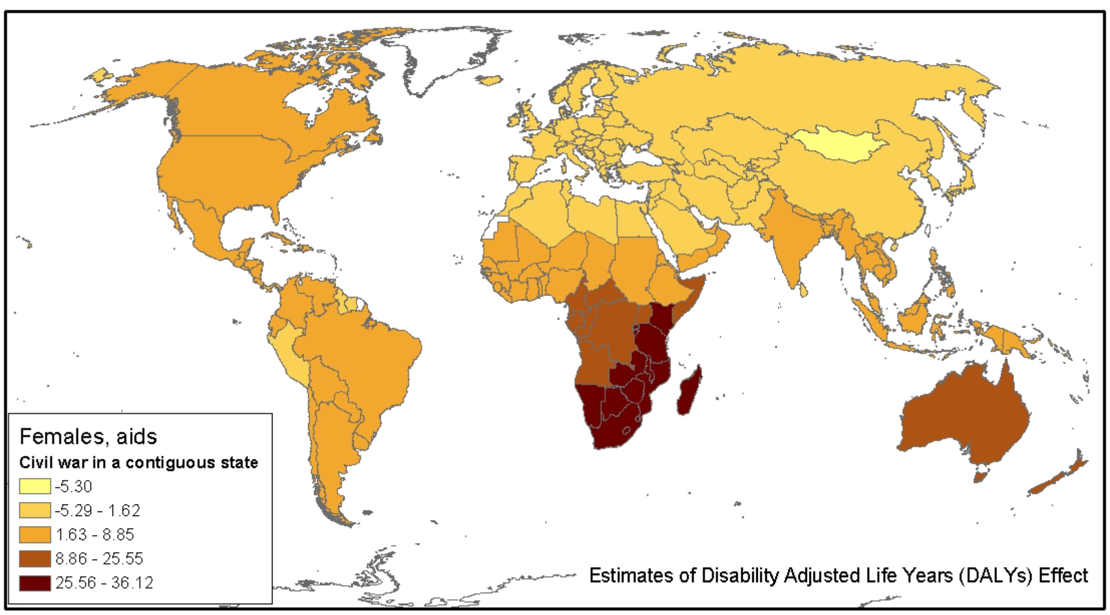

Figure 6: Distribution of parameter values for the predictor "civil war in contiguous state" for the females AIDS data; weighting is adaptive kernel with the capitals as centroids. Categorization is by natural breaks

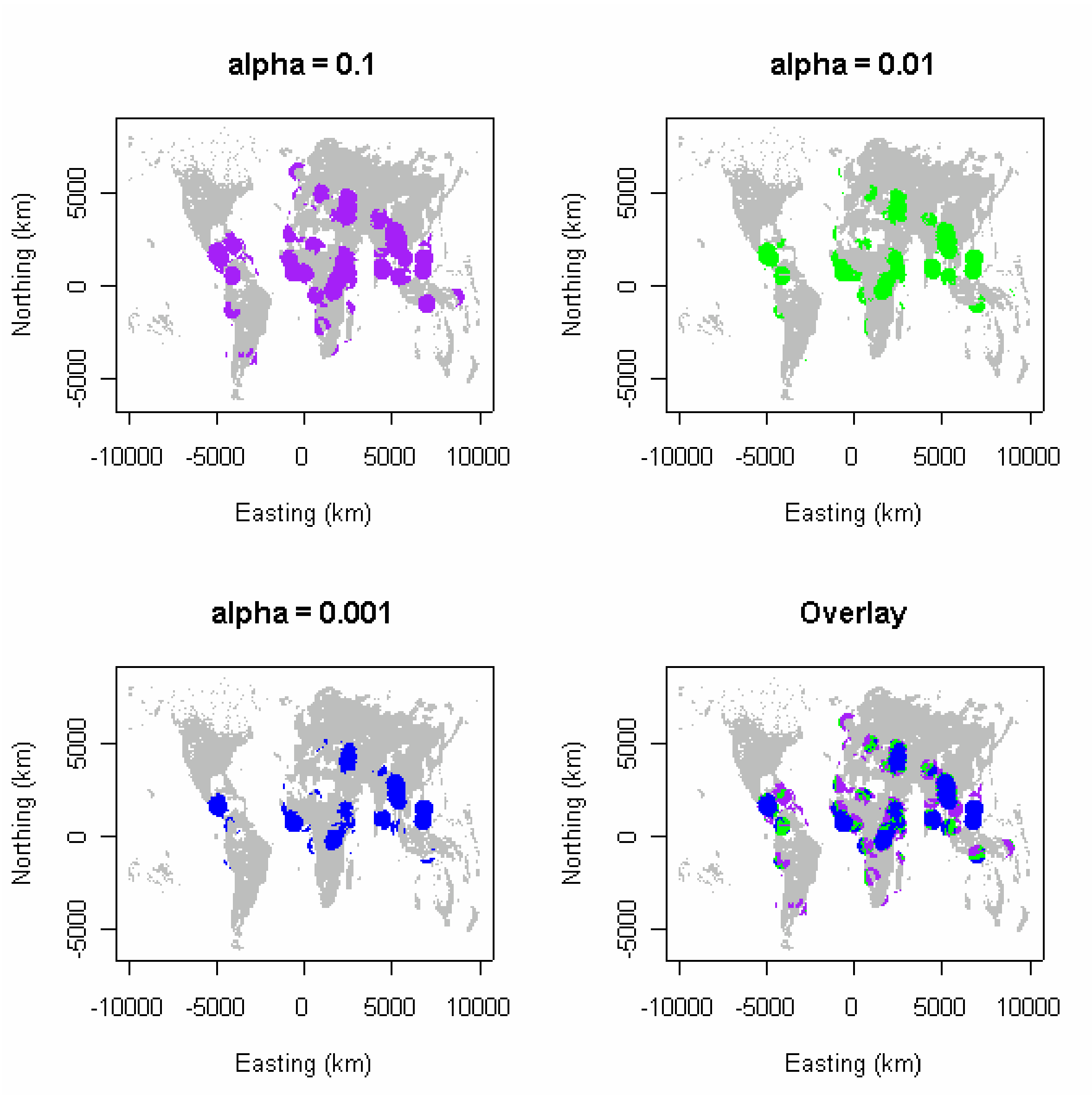

Figure 7. Significant clusters of civil war locations, given a uniform population and 500km search radius.

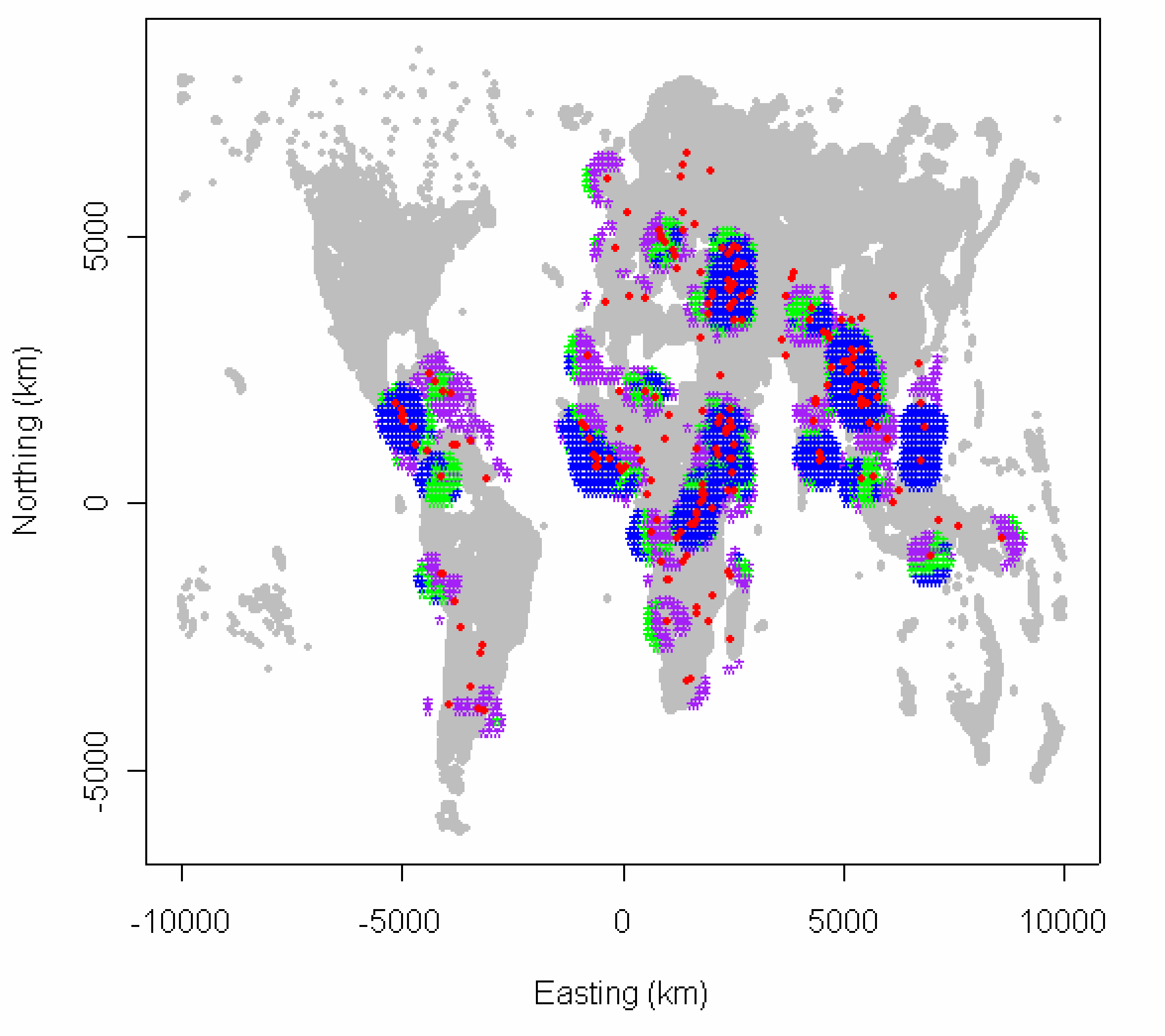

Figure 8. Significant clusters of civil war locations, given a uniform population and 500km search radius.

Purple clusters, $\alpha = 0.1$, are comprised of 6,225 points; green clusters, $\alpha = 0.01$, are comprised of 2,275 points; blue clusters, $\alpha = 0.001$, are comprised of 1,115 points; red dots are the original conflict locations.

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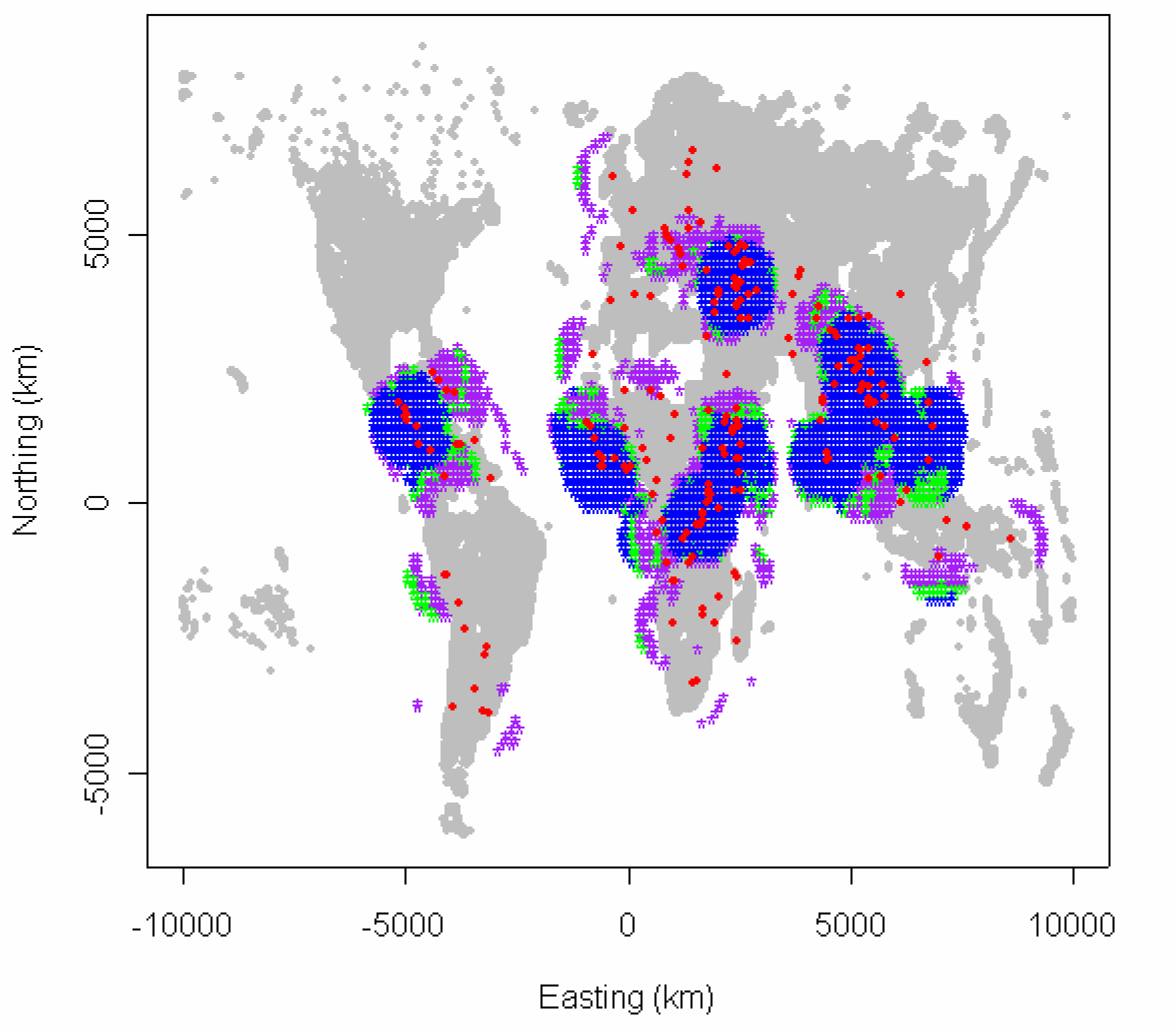

Figure 9. Significant clusters of civil wars locations, given a uniform population and 800km search radius

Purple clusters, α = 0.1, are comprised of 6,055 points; green clusters, α = 0.01, are comprised of 2,894 points; blue clusters, α = 0.001, are comprised of 1,836 points; red dots are the original conflict locations.

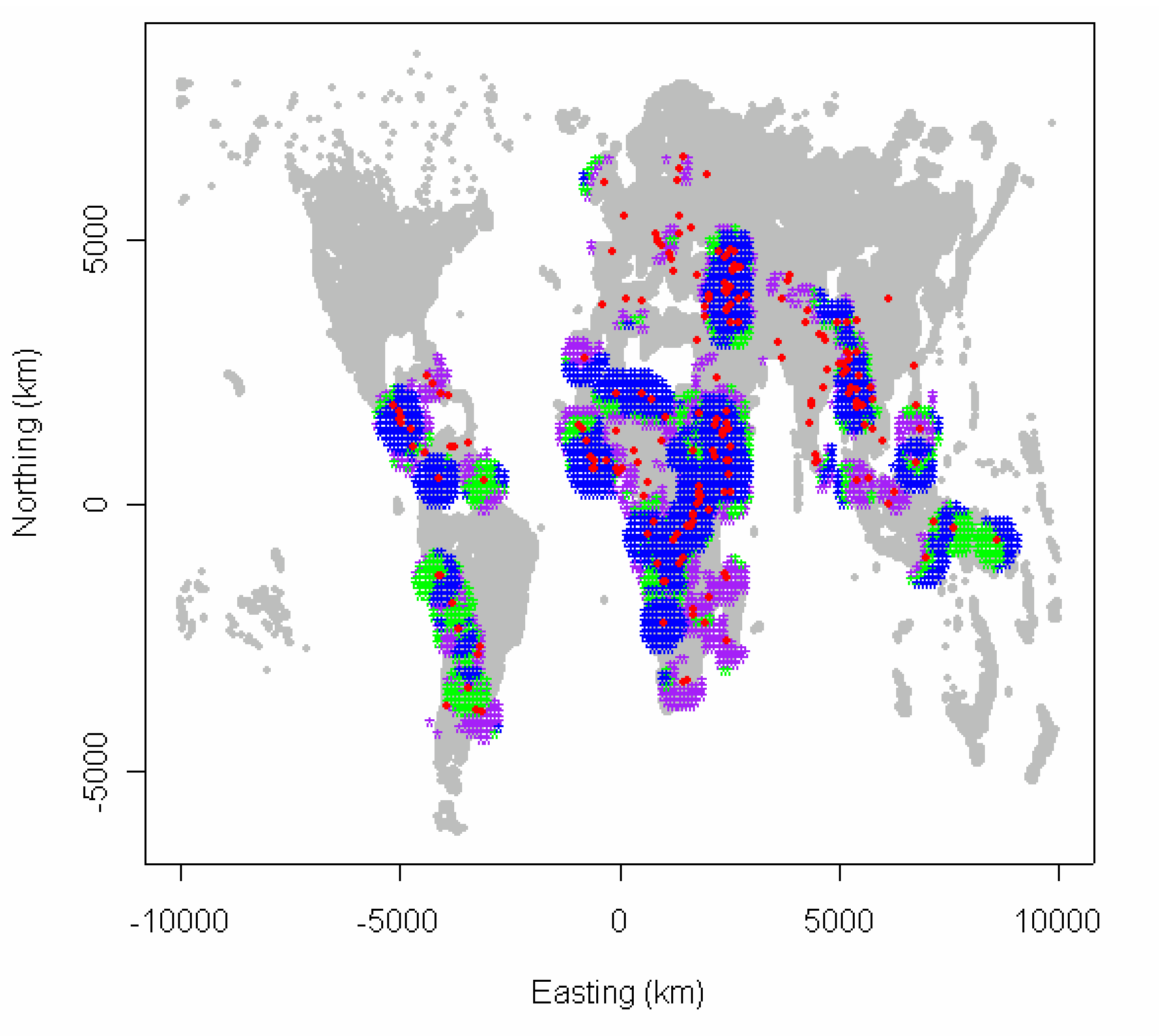

Figure 10. Significant clusters of civil war locations, given the population density and 500km search radius.

Purple clusters, α = 0.1, are comprised of 8,841 points; green clusters, α = 0.01, are comprised of 4,956 points; blue clusters, α = 0.001, are comprised of 2,369 points; red dots are the original conflict locations.

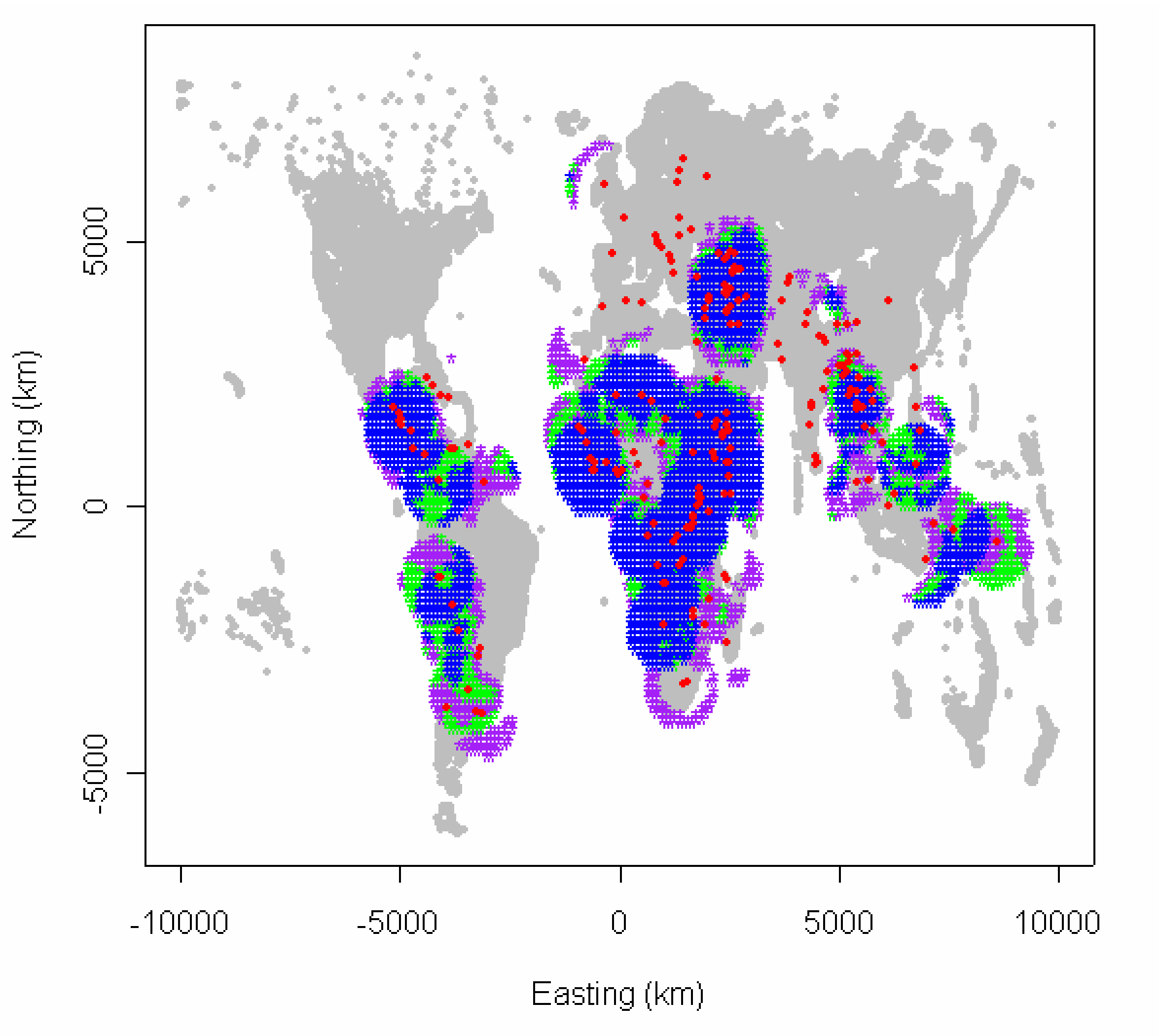

Figure 11. Significant clusters of civil war locations, given the population density and 800km search radius.

Purple clusters, α = 0.1, are comprised of 9,644 points; green clusters, α = 0.01, are comprised of 5,569 points; blue clusters, α = 0.001, are comprised of 2,733 points; red dots are the original conflict locations.

Table 1: Replication of Ghobarah et al (2003) results and Geographically-Weighted Regression extensions.

DALYs lost to All Disease Categories – Males aged 15-44.

Estimates (Coefficient and t-ratio; median for GWR)	Ghobarah et al. (2003) Estimates	Replication – Global Regression	GWR – Capitals Coord Adaptive	GWR – Capitals Fixed kernel-500kms	GWR – Capitals Fixed kernel – 800kms	GWR – Geog.centroids Adaptive	GWR – Geog.centroids Fixed kernels 500kms	GWR – Geog.centroid Fixed kernels 800kms
Intercept	6.65 (0.50)	7.84 (0.60)	10.31 (0)	9.65 (18)	10.75 (5)	27.25 (17)	27.51 (10)	33.51 (10)
Civil War Deaths 91-97	2.15 **(1.71)**	0.21 **(1.75)**	0.12** (0)	0.66 (10)	0.07 (15)	0.15 (2)	-0.11** (9)	0.09 (12)
Contiguous Civil Wars	7.84 **(2.74)**	7.75 **(2.72)**	0.45 (12)	-.09 (10)	-0.13 (4)	1.32 (14)	-0.78 (9)	-0.01 (6)
Health Spending	-2.12 (-1.35)	-1.98 (-1.27)	-3.19 (6)	-2.31 (7)	-3.29 (5)	-3.11 (2)	-2.32 (2)	-3.06 (10)
Education	-3.74 (-0.99)	-4.157 (-1.11)	2.45 (0)	2.81 (9)	3.01 (12)	-0.18 (17)	-1.17 (4)	1.35 (23)
Urban Growth	5.93 **(4.26)**	5.85 **(4.22)**	0.67 (0)	1.31 (2)	1.69 (1)	1.31 (17)	-0.30 (15)	1.29 (13)
Income Gini	52.24 **(2.88)**	51.61 **(2.83)**	35.42 (0)	36.08 (9)	22.37 (3)	48.89 (0)	27.22 (5)	24.63 (0)
Tropical Country	4.61 (1.29)	4.49 (1.29)	2.17** (0)	3.06 (3)	7.22 (0)	10.40 (0)	5.48 (2)	5.98 (0)
Polity Score	0.22 (0.98)	0.22 (0.99)	0.64 (6)	0.002 (9)	0.02 (7)	0.24 (27)	0.06 (22)	0.06 (9)
Ethnic Heterogeneity	0.62 (0.50)	0.41 (0.34)	0.49 (0)	0.70 (6)	0.24 (17)	0.55 (2)	0.24 (6)	-3.06 (6)
Adjusted R^2	**.46**	**.45**	**.82**	**.26**	**.91**	**.77**	**.43**	**.88**
F-ratio	**na**	**na**	**8.86#**	**0.69**	**9.77#**	**7.85#**	**0.96**	**6.72#**
AIC	**na**	**1537**	**1420**	**2871**	**1601**	**1439**	**2442**	**1737**

Median is the value for the GWR parameter estimates for all 180 countries; number of countries outside the inner and outer-fences is an indication of non-stationarity. The fences are at +/- 1 standard deviation from the mean.

(significant t-test) for the global regressions

** Significant Monte Carlo test for distribution of parameter values across the 180 countries

Significant F-ratio

Table 2: Geographically-Weighted Regression estimates for DALYs lost in different Disease Categories
– Females and Males aged 15-44.

Estimates (Coefficient and t-ratio; median –GWR)	Females Aged 15-44 All Diseases			Females Aged 15-44 AIDS		Males Aged 15-44 AIDS	
	Ghobarah et al. (2003) Estimates	**Global Estimates**	**GWR Capitals Adaptive**	**Global Estimates**	**GWR Capitals Adaptive**	**Global Estimates**	**GWR Capitals Adaptive**
Intercept	5.99 (0.34)	8.72 (0.50)	13.75 (7)	-9.92 (-1.07)	0.49 (2)	-11.96 (-1.00)	1.17 (8)
Civil War Deaths 91-97	2.99 **(1.78)**	0.30 **(1.78)**	0.15 (13)	0.06 (0.65)	.001 (13)	0.07 (0.64)	-0.30 (24)
Contiguous Civil Wars	12.52 **(3.27)**	12.42 **(3.24)**	1.90** (8)	3.59 **(3.37)**	1.87** (6)	9.30 **(3.52)**	-0.004 (7)
Health Spending	-1.56 (0.74)	-1.36 (-0.65)	-3.08 (0)	1.58 (1.41)	0.09 (3)	2.21 (1.54)	0.03 (19)
Education	-7.41 (-1.46)	-8.18 (-1.64)	-0.97 (28)	-4.10 (-1.54)	-.51 (25)	-6.07 **(-1.77)**	-0.13 (24)
Urban Growth	8.54 **(4.57)**	8.38 **(4.51)**	0.57 (7)	3.59 **(3.63)**	-.02 (14)	4.16 **(3.25)**	-0.02 (19)
Income Gini	50.10 **(2.06)**	48.47 **(1.98)**	26.89 (6)	13.26 (1.01)	0.84 (4)	16.40 (0.97)	.10 (7)
Tropical Country	4.34 (0.90)	4.17 (0.86)	2.26** (1)	3.63 (1.41)	0.28** (8)	4.40 (1.32)	.000 (7)
Polity Score	0.05 (0.18)	0.05 (0.20)	0.03 (3)	-0.04 (-0.27)	.001 (3)	-0.08 (-0.41)	.000 (6)
Ethnic Heterogeneity	0.59 (0.35)	0.18 (.11)	0.70 (22)	-0.16 (-0.18)	-0.13 (31)	-0.27 (-0.24)	-.01 (19)
Adjusted R^2	**.44**	**.44**	**.83**	**.25**	**.72**	**.24**	**.77**
F-ratio - GWR	**na**	**na**	**7.87#**	**na**	**6.42#**	**na**	**8.07**
AIC	**na**	**1643**	**1549**	**1417**	**1347**	**1509**	**1411**

Median is the value for the GWR parameter estimates for all 180 countries; number of countries outside the inner and outer-fences is an indication of non-stationarity. The fences are at +/- 1 standard deviation from the mean.
(significant t-test) for the global regressions; **# indicates significant F-ratio**
** Significant Monte Carlo test for distribution of parameter values across the 180 countries