OPPORTUNITY, WILLINGNESS AND GEOGRAPHIC INFORMATION SYSTEMS (GIS): RECONCEPTUALIZING BORDERS IN INTERNATIONAL RELATIONS[1]

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ABSTRACT
This paper continues a project which has developed a major reconceptualization and revision of how borders may be seen and measured through the use of GIS by allowing us to talk about the specific qualities of borders in terms of opportunity and willingness: ease of interaction and salience, respectively. This reconceptualization has also lead to the creation of a dataset which lets us go beyond simply observing the number of borders a state possesses, whether or not a border existed between two states, or the length of that border.

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GEOPOLITICS, BORDERS AND IR: A BRIEF INTRODUCTION

A review of the literature on war, militarized disputes, enduring rivalries, and alliances, indicates that over the past 20 years there has been a renewed attention to the role and impact of geography in the study of international relations. Much of this is related to the "new geopolitics" which treats geography as an essential part of the context of possibilities and constraints that face foreign policy decision makers (see Starr 1991a; Ward 1992; Goertz and Diehl 1992; and even Goertz 1994). Studies of the diffusion of behavioral phenomena as well as the investigation of the relationships between proximity, contiguity, location and territory to international interactions, have burgeoned. These activities by students of international relations have paralleled those of geographers who are focusing on a "new geopolitics" based on the possibilities that the geopolitical environment provide to human decision makers.

Much of my own work has addressed questions which fit within this broad geopolitical perspective. Beginning with the development of the opportunity and willingness framework (Starr 1978), I have engaged in collaborative research which has sought both to refine the theoretical basis of these concepts as well as to specify the relationships between them (e.g. Most and Starr 1989; Cioffi-Revilla and Starr 1995; Friedman and Starr 1997). These concepts have also been clarified through efforts to operationalize them in the study of international political phenomena. The latter investigations include the study of the diffusion of international phenomena: violent conflict (e.g. Most and Starr 1980; Siverson and Starr 1991), and democracy (e.g. Starr 1991b, 1999). The central feature of the analyses has been a focus on the nature and effects of spatial proximity as operationalized by international borders. One major aim of the present project can be seen as a concept clarification exercise-- to revise and reconceptualize how we think about borders and how they should be measured.

While there are many facets to a geopolitical approach to international relations, borders have been of primary interest to, and the main focus of, geopolitical scholarship. For example, as one important component in the mapping of factors related to the onset of war, the Correlates of War project has developed the most extensive and complete dataset on borders available for international systemic actors since 1816 (e.g. see Gochman 1992, for a description of the COW measurement rules; see also Starr and Most 1976). Borders have been studied as part of the analysis of many of the central concerns of international relations. A brief list of these concerns would include: the number and types of interactions among states; interdependence among states, within regional groupings and the level of interdependence within the international system as a whole; regional integration; the probability of war among states; the diffusion of war and other forms of international conflict; the diffusion of additional international phenomena, such as the spread of democracy; understanding why and how territory affects the onset of war; the processes underlying the lack of war between pairs of democracies; the effects of alliances; the question of international regions and the structure of the international system.

CONCEPTUALIZING (AND RE-CONCEPTUALIZING) BORDERS

Thus, 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. From Boulding's (1962) ideas of "behavior space," "loss-of-strength gradient" and "critical boundary" to the simple but profound concern of geographers that humans interact most with those to whom they are closest, there are powerful theoretical reasons to be interested in borders, and how they affect international relations. But *how* exactly do borders affect international interaction?

Clearly, a key dimension for many researchers is *proximity* (see for example, Gochman's 1992 discussion of borders as they relate to the overall COW project). My own diffusion research moved to the study of borders after concluding that the diffusion of certain phenomena could only be studied by looking at units that were "relevant" to one another-- and that such relevance could be indicated by geographical proximity (see also the work of Lemke-- 1995, 1996). Proximity, in turn, could be operationalized through "borders." Borders were seen as important indicators of proximity because they had important relationships to both the opportunity and willingness of state actors as conceptualized by Most and Starr (1976). One key aspect of borders is that they affect the *interaction opportunities* of states, constraining or expanding the *possibilities* of interaction that are available to them. States that share borders will tend to have a greater *ease* of interaction with one another, and thus will tend to have greater number of interactions. This idea developed from multidisciplinary sources, such as economist Kenneth Boulding's (1962) concept of the loss-of-strength gradient; or geographer G.K. Zipf's (1949) "law of least effort." The important issue raised here is that borders create the opportunity for interaction (see Starr and Most 1976, Most and Starr 1980, and Siverson and Starr 1991 for a full discussion of geographic opportunity).

Such opportunity might be seen in terms of the *number* of other countries with which any single state has interaction opportunities. It might also be seen in the degree to which such opportunity exists between any particular pair of states. So, for example, Wesley (1962) argues that the length of a common border between two countries is a better measure of "geographic opportunity" than simply the number of borders. And, presaging the GIS discussion to be presented, he goes on to suggest than length should be measured not in "actual physical length" but in terms of population units. I have argued that the opportunities for interaction view of borders gets at the important conceptual core of proximity in a way that other measures of "distance" do not. Such measures have included the use of the air mileage between the capitals of states to measure distance (e.g. Gleditsch and Singer 1975, Garnham 1976). One purpose of the present project would be to test the utility of different conceptions of proximity as interaction opportunties.

Secondly, borders also have an impact on the willingness of decision makers to choose certain policy options, in that they act as indicators of *areas of great importance or salience*. Because other states are close, having greater ease of interaction and the ability to bring military capabilities to bear, they are also key areas of external cues (or diffusion). Accordingly, activities in these areas are particularly worrisome, can create uncertainty, and thus deserve attention. The notion that changes in bordering areas create uncertainty because of their proximity was based on arguments developed by Midlarsky (e.g. 1970, 1975), and applied in Most and Starr (1980).

Starr and Most (1976:10) were also particularly concerned with the "roles that different types of borders appear to play" in war involvement. Different types of border might have differential impacts on both opportunity and willingness. Thus, borders were differentiated in terms of homeland borders and borders generated by colonial territories. This differentiation allowed us to test whether all territory was seen as equally important, or whether homeland territory generated greater willingness than more distantly held colonial/imperial territories. Implicitly tested in such analyses was the notion that it was homeland territory *per se*, that was important: that the proximity of *any* homeland territory of one state to *any* homeland territory of another state was the important factor. While some of our diffusion analyses indicated that this was probably the case, other analyses also demonstrated the strong impact of colonial territorial borders on the diffusion of war. Simply, colonial territories were responsible for creating a greater number of *opportunities* for conflictual interaction (in a way that is usefully complementary to Choucri and North's [1975] notion of lateral pressure "intersections"). Thus, we were correct in the inclusion of colonial borders (a twist unique to international relations research of the 1970s, as found in our original border dataset). Starr and Most (1976) also distinguished between land-based contiguity and across-water proximity. Again, such a distinction *implicitly* dealt with possible variations in ease of interaction and salience.

The present project seeks to build upon these two dimensions of borders as indicators of proximity, to revise and reconceptualize how borders may be seen and measured. The use of GIS (Geographic Information Systems) will permit a much fuller and clearer specification of borders by allowing us to talk about the *specific qualities* of borders in terms of opportunity and willingness. The reconceptualization will permit us to go beyond simply observing the number of borders a state possesses, whether or not a border existed between two states, or the length of that border. By so doing, a number of questions raised in studying the issues noted above can now be more fully addressed.

METHODOLOGY: ARC/INFO AND THE CONCEPTUALIZATION-OPERATIONALIZATION OF BORDERS

Geographic information systems, developed through the early to mid-1960s, are now the focus of a large literature produced by geographers and regional scientists (see a brief review in Starr and Bain 1995). As could be expected, there are many approaches and perspectives on GIS. It is important to understand that a GIS is a *tool*, founded on a variety of computer technologies, that permits the integration of data about the spatiality of phenomena along with data about other characteristics of those phenomena.[2] It is important to note that GIS is more than mere computer mapping. According to Cowen (1990, 57), the heart of a GIS system is its ability to overlay various layers or coverages of data so that the GIS would have "*created new information* rather than just have retrieved previously encoded information" (emphasis added). The reconceptualization of borders using GIS derives from the ability to generate new measures-- or new information-- about the nature of borders.

The GIS system utilized in this study is ARC/INFO, developed and supplied by Environmental Systems Research Institute, Inc. (ESRI). It is one of the most widespread commercial GISs in use globally. Its strengths, in part, reside in its ability to integrate many kinds of data, as well as "an open architecture which allows it to be linked to a number of relational database management systems" (Peuquet and Marble 1990, 91). ARC/INFO employs a "georelational" approach, which abstracts "geographic information into a series of independently defined layers or coverages, each representing a selected set of closely associated geographic features (e.g., roads, streams, and forest stands)" (ESRI 1992, 14).[3] The large scale database consists of the sixteen layers of data. These layers contain data ranging from physical characteristics such as drainage networks, hypsography (elevation and topographic relief), and land cover, to man-made features such as road networks, railroad networks, and aeronautical data.[4]

Starr and Bain (1995) describe how various coverages within the ARC/INFO system were used to revisit the opportunity and willingness dimensions of borders.[5] In subsequent work (with the research assistance of Deb Thomas and Richard Deal), the specific methodology used for extracting and combining the border data from the various ARC/INFO coverages has changed substantially (see the Technical Appendix referred to in note 5). However, the data sources, coverages, and overall criteria for determining the opportunity for interaction and salience did not vary.

The GIS methodology, however, must be driven by theoretical considerations. The various layers of the ARC/INFO GIS contain a great number of variables, and the key question must be *which* of these variables should be selected to create valid indexes to represent opportunity and willingness (ease of interaction and salience). There is a large literature on the nature of boundaries produced by geographers; (and by geopoliticians writing earlier this century). This literature often focuses on the meaning of boundaries for group formation, group identity, and group maintenance; (e.g. see Falah and Newman 1995, as well as such seminal works as Prescott 1987 or Glassner 1992). As noted, the mere existence of a border can tell us many things and generate research hypotheses.

Yet, "a border is not a border is not a border." Borders serve many functions, and obviously take on different meanings in different specific contexts (e.g. see such discussions as Giddens 1984, or Goertz 1994). No single operationalization of border, and no dataset based on such an operationalization, will be able to provide the total historical-political context for all pairs of states. Nevertheless, drawing on two decades of attention to these idea, I argue that the opportunity and willingness conceptualization does tap key elements of the proximity-border concept, and constitutes a progressive step in the more general conceptualization of borders, context, and the analysis of international interaction.

Opportunity for Interaction (Ease of Interaction)
Regarding opportunity, the variable selection decisions were based on theoretical considerations presented by both geographers and IR scholars. The notion of ease of interaction derives from Boulding's (1962) concern with the "loss-of-strength gradient," and the ability to project conventional military power. Out of the welter of possible variables (and taking various technical/analytic constraints into account), three central factors for the movement of land-based military capability were selected– the existence of roads, railroads, and the steepness of terrain. This project draws from Wesley (1962), who suggests that scholars should use cross-border roads to operationalize geographic opportunity. Similarly, Lemke (1996), using Bueno de Mesquita's (1981) operationalization of the loss-of-strength gradient, is concerned with the distance over which military forces can move in specific periods of time, and how this relates to the propensity for wars or MIDs (militarized disputes). Lemke is specifically concerned with paved roads and railroads in attempting to estimate the loss-of-strength gradient, and those countries that make up "relevant" dyads/neighborhoods for African states. Based on the work of Boulding, Bueno de Mesquita, and Lemke, an index created from these three factors both reflects ease of interaction, and is applicable (valid) across a large set of international dyadic boundaries.

Using data available in the DCW's data layers an index was constructed for ease of interaction which aggregates values generated from ARC/INFO. It can be used to characterize *any* border (termed an "arc" in ARC/INFO) or *border segment* on the globe. After reviewing all the variables within all of the layers, the following were selected to create an "ease of interaction" index. The first variable looked for the presence or absence of roads within the locations being studied. Roads included multi-lane divided roads, as well as primary and secondary roads (Layer 4, Road Layer, RDLINE). The second variable was the presence or absence of railroads (Layer 3, Railroad Layer, RRLINE). The third variable involved the slope of an area, which was based on the elevation values of contour lines (in mean feet above sea level; Layer 8, Hypsography Layer, HYNET), and was derived from a digital terrain model by converting the hypsography into a triangulated irregular network. Each of these values was investigated for a *buffer* area of 10,000 meters on each side of all international borders.[6]

The methodology used by Starr and Bain involved the use of hexagons, and the combined density of the different coverages for roads, railroads and hypsography produced by a polygon attribute table for each hexagon. This generated a metric (an ease of interaction index running from 0 to 373) whereby high "saturation" or density indicated the greatest ease of interaction. The least saturated hexagons are those which are most difficult to move across; the most heavily saturated hexagons are the most easily traversed.

[Figures 1 and 2 here]

However, despite several advantages to the use of hexagons, this methodology increased both the computing capacity and time required for generating the data from ARC/INFO. A methodology using the vector data directly was developed which appeared to simplify the generation of the data considerably, while producing roughly analogous results.[7] The revised color map of opportunity for interaction for Israel is seen in Figure 1; a similar representation of the Iran-Iraq border is presented in Figure 2. With this formulation we simply note the presence or absence of roads and railroads (rather than the saturation of a hexagon), and represented the hypsography or slope as follows: coded 1 if the slope was 0-5 degrees, coded 2 if the slope was 5-20 degrees, and coded 3 if it was greater than 20. This created a simple combined 1 to 4 index, with 4 (red in the color maps) representing the *greatest* ease of interaction, and 1 (dark green in the color maps) the most difficult areas to move across.[8]

Note that the revised procedures described here were specifically developed to generate a *four*-category scheme. This was purposely done in order to facilitate the translation of the color maps into black and white representations (as found in Starr 1998). While maps are an important medium for the *presentation* of results, it must be stressed that any section of any border can now be represented by a value from 1 to 4: values that can be used in data analyses within the GIS, both with other GIS variables or any other data sets that are imported into the ARC/INFO GIS. Such a dataset will be described below.

Figures 1 and 2 are important in demonstrating that the ease of interaction *can vary* along any single border that a state might have with a contiguous neighbor (the values, as represented by different colors, vary). The opportunity for interaction variable can be used to indicate this variation along any single border (or "arc", for example Israel's border with Lebanon). This would capture the variation that might occur on a very long border– *any* particular portion of a border can be thus be characterized as to its degree of permeability. Thus, we are now able to go beyond the simple idea that in some way contiguity provides the possibility for interaction– while some parts of some borders would make this highly likely or possible, other parts would make interaction much less likely. We could make such judgments irregardless of the length of a border, or the number of different borders that a state might have.

Salience (Willingness)

The salience dimension of proximity/borders is concerned with the importance or value of territory along or behind a border. Again, the question is how importance/value is to be measured. Below I will discuss an alternative hypothesis that it is territory *per se* which is important. However, here we must be concerned with indicators which would discriminate the level of value or concern over territory (as Most and Starr did by differentiating between homeland territory and colonial possessions; and between contiguous land borders and across-water borders). Drawing once more on geographers, demographics are seen as important: the territory on which a state's population lives. This was to be operationalized by areas of population concentration. A capital city, the locus of governmental activity and the symbol of the state, should also be used to indicate the importance of territory. While I disagree that distance between capital cities should be considered a primary indicator of proximity, such studies (e.g. Gleditsch and Singer 1975) do highlight the central importance of capital cities. Note that in selecting areas of population concentration and the seats of government we have now captured all three of the central elements of the state found in the international relations literature: territory, population, and government. Areas of urban concentration including urbanized areas and capital cities were extracted from the Populated Place Layer, Layer 2 (PPPOLY and PPPOINT).

Other coverages provided the location of items that would indicate the importance of an area. For instance, from Layer 13, the Aeronautical Layer, active civil and military airports were identified (AEPOINT). The Cultural Landmark Layer (Layer 14) provides a catalogue of such items, including: military camps, forts, oil wells and refineries, power plants of various kinds, water tanks, factories, industrial complexes, hospitals, telecommunications stations, etc. The wide variety of items found in Layer 14 was used because the *substantive* importance of any single type of installation could vary considerably across states. By identifying the location of key aspects of a state's transportation, communication, energy production, industrial, agricultural, and security infrastructures, we have items that tap "importance" in a manner generally relevant to all states.

[Figures 3 and 4 here]

The salience index was developed in much the same fashion as the index for opportunity for interaction. After reviewing the various coverages, the salience or importance of a border area was determined by places of population concentration, state capitals, airfields, and selected cultural features located within a 50,000 meter buffer of the region's borders. One rule that was used across methodologies, was that a capital city was automatically coded with the highest value found in any of the units of analysis. The revised, vector approach to salience is described thusly: "The willingness for interaction component of the study provided more of a challenge in using a vector approach because the hexagons were used to 'count' the number of cultural features, number of population centers, and number of airports within each one. Using the POINTDISTANCE command in combination with a FREQUENCY command allowed each feature to be

given a value based on the number of other features that were within 4 kilometers. These could then be mapped based on the value, showing where clusters arose" (NSF Technical Report #2 by Thomas; see also Deal, Technical Report #3 on how the salience indexes were constructuted). The results of these revised analyses are shown in Figures 3 and 4, which display the clustering of point coverages indicating the importance of an area, with graphics representing the numbers of points that overlap within four kilometer ranges. Note that while reducing the time and capacity requirements for analysis, the vector-based datasets/methods also produce more graphically pleasing and interpretable results. While the data-generating strengths of GIS have been stressed, it would be useful here to emphasize as well the *visual* utility of GIS-- its ability to generate maps which help investigators to look at data differently, and provide heuristics for generating hypotheses and model specification.

Thus, while color map representations of salience are useful, remember that any area in a buffer around a border can now be characterized by a value from 1 to 4, which can be utilized in data analyses. A four value scale was created to indicate areas with one important feature up through those with four or more. The size of the circles also helps indicate the level of salience.And, again, Figures 3 and 4 are important by demonstrating how borders may differ in their importance-- in terms of where people live, where the capital city is located, where significant elements of the transportation, military, or economic systems are situated. Portions of borders where more of these items are located, (within a 50,000 meter buffer of the border), could be seen as more important or salient (the areas in red or orange) than segments without population centers, or economic, military or transportation facilities. As with opportunity for interaction, this representation of the salience of borders permits us to differentiate whole borders, to differentiate portions of long borders, and to make sense as to why some borders might be seen as more important than others; why changes or events across some borders might generate more uncertainty than occurrences across other borders.

[Figure 5 here]

Vital Borders

The use of a GIS dataset, then, permits a new mechanism for operationalizing a state's borders. A GIS system has been used to create new data. Through the indexes generated, we can attach values to a single dyadic border or border segment. These values will indicate the ease of interaction provided by that border, and/or the importance of any particular border or border segment. These two dimensions can be used separately or combined. Recall that Most and Starr (1989) argue that opportunity and willingness are *jointly* necessary conditions for certain types of behavior, and that they are related to each other in complex ways (see also Cioffi-Revilla and Starr 1995). For want of a better term, I have suggested that a border with high values on both could be considered a "vital border," (as presented in Figures 5). The core of this concept is that an arc or a border segment may combine high or low values reflecting *both* opportunity and willingness. There may indeed be some military/security aspects of borders which are not captured by the scheme presented here, or confound it: e.g. because a border is strategically important, roads and railways may *not* be built![9]

Figure 5 indicates that four categories have been used in combining opportunity for interaction and salience. Given that both opportunity for interaction and salience were presented as 4-point scales, their joint combined value can run from 2-8. For a border to be considered "vital" it must have a joint value of 7 or 8-- demanding a value of either 3 or 4 on *each* dimension (again represented as red areas on the color maps). On the color maps dark green areas represent border segments which are the "least vital." Vital borders thus represent areas that are both highly permeable-- easy to cross-- and also encompass population centers and/or featues of economic, political or social importance. Once more, they are represented by values that can be used in statistical analyses or represented on maps.

[Table 1 here]

A NEW DATASET ON THE "NATURE" OF BORDERS

As shown in Table 1, the GIS-generated maps can be reduced to a relatively compact dataset useful for quantitative analysis. For each of the 301 contiguous land borders between states 17 variables have been developed, which can be transformed into a variety of nominal, ordinal, and interval measures. For any dyad border (see the example of Israel's border used in Table 1) we can present the length of that border in kilometers, and the area under the buffers created from that border. From these two variables we can present the percentage of each border that falls into categories 4 through 1 (or, red through dark green in the color figures). This can be done for ease of interaction, saliency, or vitalness. Knowing the length of the arc, the area under the buffer along it, and the percentage of each category, permits the analyst to use interval data (as noted below) or broadly based categories such as high-salience or low-salience. Note also that Table 1 provides a weighted average for each border in terms of ease of interaction, salience, or vitalness, showing the average value across the whole border.

[Table 2 here]

This dataset includes 151 states with land borders, which generate 301 separate contiguous land borders between states. The states in this group thus average almost four borders each. Table 2 provides descriptive data on the total set of borders, using the weighted averages. For example, we see that the average salience is quite low, barely getting above 1.000 (with a maximum value of 1.369 on the 4.000 scale). This means that although we find many "red" areas (scale of 4.000) on the maps, they constitute only very small portions of the total border. The values for ease of interaction are much higher (thus , so are the values for vitalness). Interestingly, the border with the highest salience score exists between Moldova and the Ukraine. In many ways this should not be surprising since until less than a decade ago, this was only an *internal* border, or the equivalent of the border between Connecticut and Massachusetts. With a weighted average of 1.342, the German-Dutch border is the next highest. A cluster of relatively high salience borders are found among the original members of the EEC. And, because of a high density of road and rail facilities, they also have among the highest weighted averages in terms of ease of interaction. That is– the borders of the original core countries of the EU also have borders that look like the *internal* jurisdictional boundaries of states.

THE SCIENTIFIC UTILITY OF A GIS-GENERATED BORDER DATA BASE

One basic point raised in Most and Starr (1989) was that researchers needed to be much clearer as to the broader concepts which were really under investigation, so that their models and the resulting research designs could be more logically and fully specified. Perhaps "borders" can be used in some research for reasons that are innate to "borderness"– that they *separate* entities from one another. However, as discussed above, most uses of borders involve their representation of proximity– that is, entities are *close* to one another, *important* to one another, and have an *enhanced ability to interact* with one another. But, does the existence of a border actually respresent these notions? Borders that are difficult to traverse, either commercially or militarily may not fit this idea of proximity. Borders which are "buffered" by empty and meaningless spaces may not fit this idea of proximity. Conversely, legal borders in the contemporary world may be meaningless in terms of full permeability and high levels of transactions– as in the European Union. The concept of a vital border– with its two subcomponents– specifies more completely and precisely how a border might represent "proximity" and allows us to investigate the *meaning* of a border, traditional or transnational.

Revisiting IR Hypotheses with More Fullt Specified Borders

A wide array of research questions based on the assumption that borders indicate proximity, salience, and ease of interaction may be addressed by a vital borders dataset. For example, which types of borders are most or least related to spatial diffusion? In the Most and Starr analyses of the diffusion of conflict (e.g. 1980), they

investigated whether states which were subjected to the "treatment" of having a Warring Border Nation (WBN) were more likely to become involved in conflict than those without such a treatment. Is it the *nature* of the border rather than *numbers* of borders that affect conflict behavior? Boulding (1962) also introduced the concept of critical boundaries, as part of his concern with the viability of states in regard to neighbors.[10] One suggestive analysis in Starr and Bain (1995) was that the GIS-generated maps of salience and opportunity for interaction, indicated that in 1967 Israel had changed its legal borders with Jordan and Syria to match what could be considered to be its critical boundaries. What is the relationship between vital borders and critical boundaries? Are attempts to match the two behind the events listed in the MIDs dataset? causes of war in general? causes of wars over territory in particular?

One finding of Siverson and Starr (1991, 54-55) is that the relationship between joining an ongoing war and being subjected to WBNs and WAPs is one of "loose necessity." Many states have treatments, but do not join wars. In fact, having only *one* treatment (only one WBN and/or WAP) appeared to have almost no effect on the behavior of states. Thus, one potential research project using the new Vital Border dataset would be to investigate the *nature of the borders* that separate the state from its WBN. If the border is a vital border, does it increase the probability of the diffusion of war/conflict. That is, both sets of studies were concerned with "treatments." A new null hypothesis could be that *any* WBN treatment enhances the probability of war diffusion. More fully specified hypotheses would propose that vital border WBNs have a greater probability of enhancing diffusion; (or that a border needs to score high on *either* salience or opportunity for interaction). Is it simply "borderness" in some vague sense, or these more specific qualities that are involved? Lemke (1995, 1996) raises the same question. As with Most and Starr, Lemke is concerned with the key question of identifying "relevant dyads." Indeed, he goes beyond this to try to identify "relevant neighborhoods." Using this project's newly created opportunity for interaction index, Lemke's questions can be specified even more closely. Another research project could involve the comparison of Lemke's findings to those based on GIS generated border data on opportunity for interaction.

Further refinement of the procedures used (particularly the size of the buffers employed) for generating vital borders are clearly needed, as is an independent operationalization for critical boundary. But even setting aside the question of critical boundaries– do states (especially those with large numbers of borders) demonstrate a higher incidence of conflict along vital borders? along salient borders? along borders with greatest ease of movement?

Revisiting Borders as Part of *The War Puzzle*

Part of the considerable research devoted to borders and territory (e.g. Starr and Most 1976, 1978; Vasquez 1993) suggests that territorial contiguity is a major determinant of whether or not a state will go to war with another state. Indeed, as a significant piece of the war puzzle, Vasquez suggests that territorial contiguity is the "source of conflict most likely to result in war" (Vasquez 1993, 307). However, perhaps simple contiguity may not be the critical factor. Dropping one level of analysis lower, Vasquez (1993) also hypothesizes that the nature of the border between two states also affects the probability that states will go to war. Specifically, he hypothesizes that borders that coincide with natural frontiers or that traverse uninhabited regions or are seen as having little value are much less likely to provoke wars than dissimilar borders and border areas (this is a theme picked up later by Lemke).

The dataset generated by the GIS project provides an ideal way to test this latter hypothesis regarding the nature of borders. Three different groups of conflict dyads were selected for this analysis: enduring rivalries (Goertz and Diehl 1993; 1995), territorial disputes (Huth 1996), and militarized interstate disputes (using the 1996 of the MIDS dataset). These cases were selected for pairs of states that shared a contiguous land border, and where the conflict (or series of conflicts) involved fell into the broad temporal band covered by the GIS data (refer to endnote #3). For a list of the conflict dyads identified by these data sets and that are used in this analysis please refer to the appendix.

In order to test the null hypothesis that borders coinciding with natural frontiers (a greater difficulty in interaction) have either no effect on the likelihood that states will go to war with neighbors or make states more likely to go to war, one must compare the nature of borders where conflict has occurred with those where conflict has not occurred. The same is true for the effect of the perceived importance (salience) of a border area. One strategy would be to compare the nature of conflict borders with all other borders in the system. However, this strategy is flawed since it fails to account for differences in government and for differences in the propensity of individual states to enter into wars. Instead, we employ a more conservative strategy that can take these differences into account; we test for statistically significant differences between conflict dyad borders (the shared conitguous homeland border between two states) and the remaining borders of the two states which form the conflict dyad. An alternative hypothesis is also examined; it posits that rather than the nature of the border being important, the length of the border is the primary distinguishing factor between conflict borders and non-conflict borders. The longer a border is, the greater the opportunity for interaction and, therefore, conflict.

As stated earlier, each border has been measured in terms of ease of interaction, salience, and a joint measure of the two, vitalness. Border areas have been assigned to one of four categories–category one being the most difficult for interaction or least important and category four being the easiest for interaction and the most important. Similarly, vitalness is also measured in four categories with category one being the least vital and category four being the most vital. These measures are then given as percentages of the total border length (ease of interaction) and area (salience). They have also been calculated in absolute terms of kilometers and kilometers squared for each of the four categories. Finally, a weighted average for ease of interaction, salience, and vitalness is given for each border.

The results of the analysis of enduring rivalry dyads (N=22 dyads) are given in Table 3. The means for enduring rivalry borders are compared to the remaining borders of states in the enduring rivalry. Specifically, a test of independent means has been conducted for each category both in relative terms (percentage) and absolute terms (kilometers or kilometers squared). The choice of a test of independent means is appropriate since the nature of any state border is independent of the nature of the remaining borders for that state. Surprisingly, not a single category measuring the nature of the border shows a statistically significant (á = .10) difference in means. On this basis, one can conclude that the nature of the borders of a state engaged in an enduring rivalry does not significantly improve our chances of predicting which neighboring state will be the enduring rival. On the other hand, the alternative null hypothesis that no statistical difference exists between the mean border length for enduring rivalry conflict dyads and the mean length of remaining enduring rival borders can be rejected. The probability of seeing a sample difference this large (520.81 KM), if the difference in the population equals zero is p = .09. This suggests that based solely on the knowledge of the *length of the borders* of a state engaged in an enduring rivalry, we can confidently predict which state will be the enduring rivalry conflict dyad partner.

Conflict dyads taken from Huth's (1996) territorial disputes dataset (N=27 dyads) show similar results. See Table 4. Whereas with the enduring rivalry data set, no statistically significant differences existed between the conflict dyad borders and the other borders of enduring rivals in terms of ease of interaction, salience, or vitalness, two different categories of salience show statistically significant differences. These are the number square kilometers ranked category one and the percentage of the border ranked category three. Oddly, the difference between the territorial dispute dyads and the remaining borders of the disputants has the opposite sign from which the original hypothesis would suggest. The conflict dyads from Huth's territorial dispute data set actually have more kilometers of low importance border area than do their corresponding non-conflict border areas. Similarly, the hypothesis would lead one to expect that conflict dyads would have a larger percentage of high importance areas than corresponding non conflict dyads; however, this is also shown to be false. Therefore, one cannot reject the null hypotheses that natural borders and low importance border areas do not reduce the likelihood that states will go to war. Nonetheless, the null hypothesis associated with border length can be easily rejected-- the probability of seeing this large of a mean difference (465.19 KM) in the sample if the population difference is actually zero is very small ($p = .03$). Thus, support for the argument that the longer a border is the more likely that concerned states will go to war appears to be growing stronger.

The final set of analyses uses the militarized interstate dispute (MIDS) data (N=61 dyads). Similar tests regarding the differences between the means of conflict dyads and the remaining borders of conflict parties have been conducted and the results are shown in Table 5. The MIDS data is much more inclusive than that of either Goertz and Diehl (1993; 1995) or Huth (1996). Consequently, 61 usable conflict dyads have been identified as opposed to the 27 for Huth and 22 for Goertz and Diehl. Nevertheless, a phenomenon similar to that found in the Huth territorial dispute data exists in the MIDS data. Several categories show statistically significant differences (á = .05), but in every case the sign of the difference is opposite of that suggested by the hypotheses. One is forced once again to accept the null hypotheses that more difficult to cross borders and less important border areas do not lower the likelihood that states will go to war with that neighbor. However, differences in the mean length of borders for conflict dyads and non-conflict borders for conflict parties remain statistically significant ($p = .03$).

Consequently, this analysis substantially undermines the Vasquez (1993) hypotheses that the nature of a border in terms of ease of interaction and importance affects whether or not states are more likely to fight across it. Statistically significant differences with the expected sign do not appear in an examination of twenty three categories measuring the nature of borders. Nonetheless, the alternative hypothesis that the nature of the border doesn't matter but that what does matter is the length of the border receives broad support from an analysis of three major conflict data sets.

CONCLUSION

These initial analyses do not support Vasquez's notion that dropping to lower levels of "interaction opportunity" increases the ability to explain war. The finding that the length of the border matters, however, does suggest that the general concern by Most and Starr with "opportunities for interaction" (e.g. 1980) was generally correct in terms of territorial contiguity (and that Wesley [1962] was on the right track). It also supports other analyses by Vasquez in which he demonstrates the importance of *any* territory to states. Territory appears to be important; the opportunities for territory to become part of conflict are increases by the length of contiguous territory, and not by more specific measures of opportunity and willingness.

These analyses provide some indication of the utility of the GIS-based conceptualization and dataset. They demonstrate that such a dataset can be used to investigate a number of related questions, for example: What sorts of borders can be found between states in enduring rivalries? What is the nature of the territory over which conflicts arise? Goertz and Diehl (1992), Holsti (1991), Huth (1996), for example, focus on territory *per se* as a *cause* of war; as both the issue over which war breaks out, and as a factor which increases the stakes of a war. Such analyses provide us with a very important *alternative hypothesis*: it is territory-- any territory-- which creates an opportunity for conflict, which serves as the issue for war, and which makes the stakes worth fighting over. The GIS-based dataset now permits analysts to test these competing hypotheses.

In sum, both theoretically and substantively geopolitical factors are important to a wide range of issues in the study of international relations. One key aspect of borders is that they affect the interaction opportunities of states, constraining or expanding the possibilities of interaction that are available to states. States that share borders will tend to have a greater ease of interaction with one another. Secondly, borders also have an impact on the willingness of decision makers to choose certain policy options, in that they act as indicators of areas of great importance or salience. The ARC/INFO GIS permits us to operationalize and investigate these two dimensions-- opportunity as ease of interaction, and willingness as salience/importance. Using data available in the different data layers found in ARC/INFO's Digital Chart of the World, we have constructed indexes of both ease of interaction and of salience. They can be used to characterize any border (or arc) or border segment on the globe. The use of a GIS dataset, then, permits a new mechanism for operationalizing a state's borders. We can now go beyond simply noting the existence of a border, or its length. Through the indexes generated, we can attach values to the ease of interaction a border or border segment provides, and/or the importance of any particular border or border segment. These two dimensions can be used separately or combined. A border with high values on both could be considered a "vital border." The GIS generated indexes permit us to tap both dimensions, and to use them singly or combined given the research question under consideration.

APPENDIX

Recent Enduring Rivalry Dyads **(Goertz and Diehl 1993;1995)**

Afghanistan	Pakistan
Algeria	Morocco
Argentina	Chile
Cambodia	Thailand
China	India
China	Russia
Congo	Zaire
Egypt	Israel
Ethiopia	Somalia
Ethiopia	Sudan
Greece	Turkey
India	Pakistan
Iran	Iraq
Iraq	Kuwait
Israel	Jordan
Israel	Syria
Jordan	Syria
Kenya	Uganda
Laos	Thailand
Norway	Russia
North Korea	South Korea
Saudi Arabia	Yemen

Recent Territorial Disputes **(Huth 1996)**

Afghanistan	Pakistan
Argentina	Chile
Argentina	Uruguay
Bukina Faso	Mali
Bhutan	China
Bangladesh	India
Bolivia	Chile
Brazil	Uruguay
Cambodia	Vietnam
Chad	Libya
China	Vietnam
China	India
China	Russia
Egypt	Sudan
Ethiopia	Somalia
Ghana	Togo
Ghana	Togo
Guinea-Bissau	Senegal
Greece	Turkey
Georgia	Russia
Guyana	Venezuela
Honduras	Nicaragua
Honduras	El Salvador
Guyana	Surinam
Guyana	Venezuela
Honduras	Nicaragua
Honduras	El Salvador
India	Pakistan
Ireland	United Kingdom
Iraq	Saudi Arabia
Laos	Thailand
Lesotho	South Africa
Oman	United Arab Emirates
North Korea	South Korea

Recent Militarized Interstate Disputes **(1996)**

Afghanistan	Pakistan
Algeria	Morocco
Argentina	Chile
Armenia	Azerbaijan
Bukina Faso	Mali
Bangladesh	India
Bangladesh	Myanmar
Bosnia	Yugoslavia
Botswana	South Africa
Cambodia	Thailand
Cameroon	Nigeria
Chad	Libya
Chad	Nigeria
China	Vietnam
China	India
China	Russia
Columbia	Venezuela
Congo	Zaire
Costa Rica	Nicaragua
Croatia	Yugoslavia
Czech Republic	Germany
Ecuador	Peru
Egypt	Israel
Egypt	Libya
Estonia	Russia
Ethiopia	Somalia
Ethiopia	Sudan
Hungary	Yugoslavia
India	Pakistan
Indonesia	Papua New Guinea
Iran	Iraq
Iran	Turkey
Iraq	Kuwait
Iraq	Saudi Arabia

Iraq	**Syria**
Iraq	**Turkey**
Israel	**Jordan**
Israel	**Syria**
Jordan	**Syria**
Kenya	**Somalia**
Kenya	**Uganda**
Laos	**Thailand**
Libya	**Sudan**
Libya	**Tunisia**
Mauritania	**Morocco**
Mauritania	**Senegal**
Myanmar	**Thailand**
Mozambique	**South Africa**
NorwayRussia	
North Korea	**South Korea**
Rwanda	**Uganda**
Sudan	**Uganda**
UgandaZaire	
Zaire	**Zambia**

NOTES

REFERENCES

Boulding, Kenneth E. 1962. *Conflict and Defense*. New York: Harper & Row.

Bueno de Mesquita, Bruce. 1981. *The War Trap*. New Haven: Yale University Press.

Choucri, Nazli and Robert C. North. 1975. *Nations in Conflict*. San Francisco: W.H. Freeman.

Cioffi-Revilla, Claudio and Harvey Starr. 1995. "Opportunity, Willingness, and Political Uncertainty: Theoretical Foundations of Politics." *Journal of Theoretical Politics* 7 (January):447-476.

Cowen, David J. 1990. "GIS versus CAD versus DBMS: What are the Differences." In *Introductory Readings in Geographic Information Systems*, eds. Donna J. Peuquet and Duane F. Marble. London: Taylor and Francis.

Environmental Systems Research Institute. 1992. *ARC/INFO: GIS Today and Tomorrow*. New York: ESRI.

Falah, Ghazi and David Newman. 1995. "The Spatial Manifestation of Threat: Israelis and Palestinians Seek a 'Good' Border." *Political Geography* 14 (8):689-706.

Friedman, Gil and Harvey Starr. 1997. *Agency, Structure and International Politics: From Ontology to Empirical Inquiry*. London: Routledge.

Garnham, David. 1976. "Dyadic International War, 1816-1965: The Role of Power Parity and Geographic Proximity." *Western Political Quarterly* 29 (2):231-242.

Giddens, Anthony. 1984. *The Constitution of Society*. Berkeley: University of California Press.

Glassner, M.J. 1992. *Political Geography*. New York: Wiley.

Gleditsch, Nils Petter and J. David Singer. 1975. "Distance and International War, 1816-1965." Proceedings of the IPRA 5th Conference, IPRA Studies in Peace Research. Oslo: International Peace Research Association.

Gochman, Charles S. 1992. "Interstate Metrics: Conceptualizing, Operationalizing and Measuring the Geographic Proximity of States Since the Congress of Vienna." In *The New Geopolitics*, ed. Michael D. Ward. Philadelphia: Gordon and Breach.

Goertz, Gary. 1994. *Contexts of International Politics*. Cambridge: Cambridge University Press.

Goertz, Gary and Paul F. Diehl. 1992. *Territorial Changes and International Conflict*. London: Routledge.

Goertz, Gary and Paul F. Diehl. 1993. "Enduring Rivalries: Theoretical Constructs and Empirical Patterns." *International Studies Quarterly* 37 (2):147-171.

Goertz, Gary and Paul F. Diehl. 1995. "Taking 'Enduring' Out of Enduring Rivalry: The Rivalry Approach to war and Peace." *International Interactions* 21 (3):291-308.

Holsti, K.J. 1991. *Peace and War: Armed Conflicts and International Order 1648-1989*. Cambridge: Cambridge University Press.

Huth, Paul K. 1996. *Standing Your Ground: Territorial Disputes and International Conflict*. Ann Arbor: University of Michigan Press.

Lemke, Douglas. 1995. "The Tyranny of Distance: Redefining Relevant Dyads." *International Interactions* 17 (1):113-126.

Lemke, Douglas. 1996. "Why So Much Peace?: Interstate War in Africa." Presented at the Annual Meeting of the American Political Science Association, San Francisco, CA.

Marble, Duane F. 1990. "Geographic Information Systems: An Overview," In *Introductory Readings in Geographic Information Systems*, eds. Donna J. Peuquet and Duane F. Marble. London: Taylor and Francis.

Midlarsky, Manus I. 1970. "Mathematical Models of Instability and a Theory of Diffusion." *International Studies Quarterly* 14:60-84.

Midlarsky, Manus I. 1975. *On War*. New York: Free Press.

Most, Benjamin A. and Harvey Starr. 1980. "Diffusion, Reinforcement, Geopolitics, and the Spread of War." *American Political Science Review* 74 (December):932-946.

Most, Benjamin A. and Harvey Starr. 1989. *Inquiry, Logic and International Politics*. Columbia, SC: University of South Carolina Press.

Peuquet, Donna J. and Duane F. Marble. 1990. "ARC/INFO: An Example of a Contemporary Geographic Information System." In *Introductory Readings in Geographic Information Systems*, eds. Donna J. Peuquet and Duane F. Marble. London: Taylor and Francis.

Prescott, J.R.V. 1987. *Political Frontiers and Boundaries*. London: Allen and Unwin.

Siverson Randolph M. and Harvey Starr. 1991. *The Diffusion of War*. Ann Arbor: University of Michigan Press.

Starr, Harvey. 1978. "'Opportunity' and 'Willingness' as Ordering Concepts in the Study of War." *International Interactions* 4 (4):363-387.

Starr, Harvey. 1991a. "Joining Political and Geographic Perspectives: Geopolitics and InternationalRelations." *International Interactions* 17 (1):1-9.

Starr, Harvey. 1991b. "Democratic Dominoes: Diffusion Approaches to the Spread of Democracy in the International System." *Journal of Conflict Resolution* 35 (2):356-381.

Starr, Harvey. 1998. "Geographic Information Systems (GIS) and the Study of Borders in International Relations." Presented at the Annual Meeting of the International Studies Association, Minneapolis.

Starr, Harvey. 1999. "Democratic Dominoes Revisited: Democratic Diffusion, 1974-1996." Presented at the Annual Meeting of the International Studies Association, Washington, DC.

Starr, Harvey and Will Bain. 1995. "The Application of Geographic Information Systems (GIS) to International Studies." *International Studies Notes* 20 (2):1-8.

Starr, Harvey and Benjamin A. Most. 1976. "The Substance and Study of Borders in International Relations Research." *International Studies Quarterly* **20 (December):581-620.**

Vasquez, John. 1993. *The War Puzzle*. **Cambridge: Cambridge University Press.**

Ward, Michael D., ed. 1992. *The New Geopolitics*. **Philadelphia: Gordon and Breach.**

Wesley, James P. 1962. "Frequency of Wars and Geographical Opportunity." *Journal of Conflict Resolution* **6 (4):387-389.**

Zipf, G.K. 1949. *Human Behavior and the Principle of Least Effort*. **Cambridge, MA: Addison-Wesley.**

TABLE 1. Components of a New Dataset: The Example of Israel's Borders

Israel's Border With:	Egypt	Jordan	Lebanon	Syria
Length (km)	220	410	110	92
Area (sq km)	21,108	39,282	8,944	10,184
Per cent Ease of Interaction Category:				
1	7.41	28.97	29.58	19.06
2	4.44	18.13	24.78	12.43
3	86.03	50.24	42.56	61.55
4	2.12	2.67	3.08	6.96
Per cent Salience Category:				
1	91.62	92.34	81.50	90.23
2	6.18	6.31	11.48	7.22
3	2.20	1.35	6.13	2.56
4	0.00	0.00	0.88	0.00
Per cent Vital Border Category:				
1	10.80	45.60	49.30	29.90
2	80.50	46.70	36.80	56.80
3	8.56	7.49	11.90	12.90
4	0.90	0.22	2.03	3.76
Weighted Average of Ease of Interaction	2.83	2.27	2.19	2.56
Weighted Average of Salience	1.11	1.09	1.26	1.12
Weighted Average of Vital Border	**1.98**	**1.62**	**1.67**	**1.84**

TABLE 2 **GIS-Based Dataset: Summary Statistics**

	Ease of Interaction	Salience	Vitalness	Length
Minimum	1.195	1.000	1.097	3.0
Maximum	3.296	1.369	2.462	6900.0
Median	2.800	1.013	1.918	520.0
Mean	2.597	1.044	1.818	792.8
Standard Deviation	0.500	0.071	0.299	863.8

N= 301 cases
Weighted Averages (except for length)

TABLE 3 Assessing the Borders of Enduring Rivals

Variable	Enduring Rivalry Border		All Other Borders for Enduring Rivalry States		Difference (Std. Error)	Observed Probability
	Mean	Standard Deviation	Mean	Standard Deviation		
% Interaction 1	20.30	19.806	24.00	24.219	-3.70 (4.83)#	p = .450
Interaction 1 KM	421.93	848.35	192.21	293.38	229.72 (183.12)#	p = .223
% Interaction 2	5.14	5.033	5.60	6.965	-.45 (1.57)	p = .772
Interaction 2 KM	74.63	136.60	34.61	46.37	40.02 (29.47)#	p = .188
% Interaction 3	72.91	23.172	68.80	29.097	4.11 (5.70)#	p = .475
Interaction 3 KM	894.14	806.017	643.67	821.52	250.47 (192.02)	p = .196
% Interaction 4	1.63	1.90	1.60	2.69	.03 (.60)	p = .963
Interaction 4 KM	12.03	19.38	11.56	24.58	.47 (5.58)	p = .933
Weighted Average Interaction	2.57	.439	2.49	.535	.08 (.107)#	p = .472
% Salience 1	97.14	3.18	97.75	3.59	-.61 (.826)	p = .460
Salience 1 KM^2	120439.59	109049.05	74929.90	74052.56	45509.69 (24346.62)#	p = .073
% Salience 2	1.9474	2.20	1.62	2.50	.32 (.575)	p = .571
Salience 2 KM^2	1421.58	1908.47	1057.63	2588.71	363.95 (583.25)	p = .534
% Salience 3	.80	1.47	.58	1.35	.22 (.32)	p = .498
Salience 3 KM^2	373.38	523.67	254.97	539.00	118.41 (125.78)	p = .348
% Salience 4	.11	.48	.05	.22	.06 (.06)	p = .347

TABLE 3 Continued (Assessing the Borders of Enduring Rivals)

Variable	Enduring Rivalry Border		All Other Borders for Enduring Rivalry States		Difference (Std. Error)	Observed Probability
	Mean	Standard Deviation	Mean	Standard Deviation		
Salience 4 KM^2	**32.48**	**112.16**	**15.46**	**55.25**	**17.02 (24.72)#**	**p = .498**
Weighted Average Salience	**1.04**	**.05**	**1.03**	**.05**	**.01 (.01)**	**p = .436**
% Vital 1	**25.16**	**23.11**	**29.38**	**29.17**	**-4.22 (5.691)#**	**p = .464**
% Vital 2	**71.09**	**22.86**	**67.37**	**28.72**	**3.72 (5.62)**	**p = .512**
% Vital 3	**3.56**	**3.61**	**3.12**	**4.30**	**.44 (.983)**	**p = .657**
% Vital 4	**.19**	**.57**	**.13**	**.34**	**.06 (.091)**	**p = .517**
Weighted Average Vital	**1.79**	**.245**	**1.74**	**.30**	**.05 (.06)#**	**p = .435**
Length	**1402.82**	**1316.70**	**882.01**	**943.15**	**520.81 (295.43)#**	**p = .090**

 # Unequal Variances (p > .95)

TABLE 4 Assessing the Borders of Huth's Territorial Disputes

Variable	Territorial Dispute Border: Mean	Territorial Dispute Border: Standard Deviation	All Other Borders for Territorial Dispute States: Mean	All Other Borders for Territorial Dispute States: Standard Deviation	Difference (Std. Error)	Observed Probability
% Interaction 1	23.82	24.59	19.17	24.30	4.65 (5.24)	p = .377
Interaction 1 KM	400.02	772.10	198.94	345.00	201.08 (152.26)#	p = .197
% Interaction 2	4.99	6.66	3.59	5.89	1.40 (1.30)	p = .284
Interaction 2 KM	68.44	125.60	27.19	44.85	41.26 (24.55)#	p = .104
% Interaction 3	69.89	28.46	76.03	27.83	-6.14 (6.02)	p = .309
Interaction 3 KM	895.16	748.43	680.24	794.65	214.91 (169.08)	p = .206
% Interaction 4	1.29	1.76	1.22	2.48	.08 (.51)	p = .878
Interaction 4 KM	15.86	29.83	8.14	20.52	7.72	p = .115
Weighted Average Interaction	2.49	.54	2.58	.52	-.10 (.11)	p = .399
% Salience 1	98.51	1.66	98.25	3.20	.27 (.64)	p = .677
Salience 1 KM^2	114743.93	95168.76	77705.44	74503.48	37038.48 (16991.58)	p = .031
% Salience 2	1.25	1.45	1.23	2.34	.03 (.47)	p = .954
Salience 2 KM^2	1286.37	1941.23	859.84	2534.27	426.53 (522.79)	p = .416
% Salience 3	.22	.25	.46	1.27	-.24 (.13)#	p = .064
Salience 3 KM^2	221.44	357.47	221.86	552.68	-.42 (111.95)	p = .997
% Salience 4	.02	.08	.06	.32	-.04 (.06)	p = .570

TABLE 4 Continued (Assessing the Borders of Huth's Territorial Disputes)

Variable	Territorial Dispute Border		All Other Borders for Territorial Dispute States		Difference (Std. Error)	Observed Probability
	Mean	Standard Deviation	Mean	Standard Deviation		
Salience 4 KM^2	**11.74**	**33.99**	**15.87**	**69.37**	**-4.13 (13.77)**	**p = .765**
Weighted Average Salience	**1.02**	**.02**	**1.02**	**.05**	**-.01 (.01)**	**p = .519**
% Vital 1	**28.66**	**28.69**	**22.62**	**27.88**	**6.04 (6.03)**	**p = .319**
% Vital 2	**69.01**	**28.19**	**74.83**	**27.43**	**-5.82 (5.93)**	**p = .329**
% Vital 3	**2.29**	**2.46**	**2.43**	**4.09**	**-.15 (.82)**	**p = .860**
% Vital 4	**.05**	**.09**	**.11**	**.38**	**-.07 (.07)**	**p = .372**
Weighted Average Vital	**1.74**	**.29**	**1.79**	**.29**	**-.06 (.062)**	**p = .363**
Length	**1379.63**	**1172.81**	**914.44**	**935.72**	**465.19 (212.27)**	**p = .030**

 # Unequal Variances (p > .95)

TABLE 5 Assessing the Borders of Militarized Interstate Disputes

Variable	Militarized Interstate Dispute Border		All Other Borders for Militarized Interstate Dispute States		Difference (Std. Error)	Observed Probability
	Mean	Standard Deviation	Mean	Standard Deviation		
% Interaction 1	19.08	20.19	19.34	22.60	-.26 (3.28)	p = .937
Interaction 1 KM	255.18	551.99	149.56	280.00	105.62 (73.87)#	p = .157
% Interaction 2	5.27	7.13	4.55	6.30	.71 (.98)	p = .464
Interaction 2 KM	50.85	93.40	24.75	36.98	26.10 (12.29)#	p = .037
% Interaction 3	73.70	25.50	72.68	26.67	1.02 (3.94)	p = .795
Interaction 3 KM	733.86	676.47	568.36	681.20	165.50 (101.15)	p = .104
% Interaction 4	1.95	3.87	3.42	6.31	-1.47 (.69)#	p = .035
Interaction 4 KM	12.82	26.02	14.67	27.89	-1.85 (4.09)	p = .651
Weighted Average Interaction	2.58	.45	2.60	.51	-.02 (.07)	p = .771
% Salience 1	97.44	4.02	96.68	5.75	.76 (.68)#	p = .264
Salience 1 KM^2	88790.69	79684.61	63982.10	63710.58	24808.59 (11312.34)#	p = .031
% Salience 2	1.95	3.23	2.54	4.51	-.60 (.539)#	p = .269
Salience 2 KM^2	1097.79	1650.32	1039.14	2374.57	58.64 (329.53)	p = .859
% Salience 3	.55	1.10	.71	1.46	-.16 (.21)	p = .438
Salience 3 KM^2	269.60	452.48	239.52	507.01	30.08 (73.63)	p = .683
% Salience 4	.06	.29	.06	.21	-.00 (.04)	p = .990

TABLE 5 Continued (Assessing the Borders of Militarized Interstate Disputes)

Variable	Militarized Interstate Dispute Border		All Other Borders for Militarized Interstate Dispute States		Difference (Std. Error)	Observed Probability
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**		
Salience 4 KM^2	**22.53**	**74.30**	**16.52**	**53.22**	**6.01 (8.88)**	**p = .499**
Weighted Average Salience	**1.03**	**.05**	**1.04**	**.08**	**-.01 (.01)#**	**p = .185**
% Vital 1	**24.10**	**25.48**	**23.66**	**26.65**	**.44 (3.93)**	**p = .911**
% Vital 2	**72.23**	**25.50**	**70.83**	**26.81**	**1.40 (3.95)**	**p = .723**
% Vital 3	**3.51**	**5.84**	**5.24**	**8.55**	**-1.74 (.994)#**	**p = .083**
% Vital 4	**.17**	**.45**	**.26**	**.64**	**-.10 (.08)#**	**p = .207**
Weighted Average Vital	**1.79**	**.27**	**1.82**	**.30**	**-.03 (.04)**	**p = .504**
Length	**1052.74**	**973.54**	**757.33**	**785.95**	**295.40 (138.46)**	**p = .036**

 # Unequal Variances (p > .95)

1. This research project has been supported by a University of South Carolina Research & Productive Scholarship Award (#13570-E120), which in turn was instrumental in securing a National Science Foundation grant (SBR-9731056) to continue the project. I would also like to acknowledge the contribution of the research assistants who have so substantially contributed to this project through the excellence of their GIS programming: Will Bain, Deb Thomas, Richard Deal, and Guojing Shou. In addition, I would like to thank Dale Thomas for help in analyzing the data generated from this project. An earlier version of this paper was presented at the 1998 annual meeting of the International Studies Association.

2. According to Marble (1990, 10), to be considered a true GIS a system must include the following four major components:

1) A data input subsystem which collects and/or processes spatial data derived from existing maps, remote sensors, etc.
2) A data storage and retrieval susbsystem which organizes the spatial data in a form which permits it to be quickly retrived by the user for subsequent analysis.
3) A data manipulation and analysis subsystem which performs a variety of tasks such as changing the form of the data through user-defined aggregation rules or producing estimates of parameters and constraints for various space-time organization or simulation models.

4) A data reporting subsystem which is capable of displaying all or part of the original database as well as manipulated data and the output from spatial models in tabular or map form.

3. Data for this project is from the Digital Chart of the World (DCW), produced by ESRI for the Defense Mapping Agency in 1992. The data contained in the DCW was derived primarily from maps in the Defense Mapping Agency Operational Navigation Chart series that were used to generate a 1:1,000,000-scale vector database covering the entire surface of the earth. One major (perhaps "heroic") assumption of the project, is that the border data generated by the 1992 DCW can be usefully applied backward for 20-25 years, and forward for at least a decade. That is, the data retain validity as a rough surrogate for the ease of interaction and salience of areas for this time frame.

4. List of data layers in the ARC/INFO Digital Chart of the World: Political and Oceans; Populated Place; Railroads; Roads; Utilities; Drainage; Drainage Supplemental; Hypsography; Hypsography Supplemental; Ocean Features; Physiography; Aeronautical; Cultural Landmark; Transportation Structure; Vegetation; Land Cover. A seventeenth layer, the Data Quality layer, provides information on the particular source of data for a given tile and when that source was last updated.

5. A detailed description of the GIS programming has been set out in the Technical Appendix to the National Science Foundation grant (generated from the ongoing technical logs of the three research assistants). Readers interested in obtaining a copy of the Appendix should contact the author.

6. One of the more useful aspects of GIS systems is the ability to create any size "buffer" on either side of a border. It should be noted that the original tests and analyses were performed on Israel (see Starr and Bain 1995). Given Israel's size, a 10,000 meter buffer on each side of the border seemed appropiate. However, after test-case analyses on borders between Cambodia and Thailand and Ecuador and Peru, it was decided to use a 50,000 meter buffer; that size buffer had been employed for the salience dimension (as described below) even in the Israeli "pre-test." Analyses of other areas, such as Iran and Iraq, may lead us to employ buffers that are larger yet. Such buffers, covering most or all of a country, may be needed for those wishing to study internal conflict and the internal "boundaries" between groups.

7. We have estimated that the final data for Israel (as found in Figure 5 presenting Israel's Vital Border measures) required only one-tenth the computer space as the data required for Israel's Vital Borders using the hexagon methodology. *All* of the information, at all the stages required to construct the Vital Borders in Figure 5 required 2.5 to 3 megs. Using the earlier hexagon methodology, however, the figure was closer to 15 megs. The NSF Grant Technical Report of August 1996 by Deb Thomas, discusses the change in methodology, and presents the revised procedures for determining the opportunity for interaction.

8. The Opportunity for Interaction/Ease of Interaction index was developed as follows:

4=	presence of a road and the presence of railroad, and low slope
3=	a road or a railroad, and low slope
3=	a road and a railroad, and medium slope
3=	no road, no railroad, and low slope
2=	a road or a railroad, and medium slope
2=	a road and a railroad, and high slope
2=	a road or a railroad, and high slope
1=	no road, no railroad, and medium slope

1= no road, no railroad, and high slope

9. This point was made by one of the anonymous referees of the NSF grant proposal. However, as the same referee noted: "Starr has no apriori need to define what a 'vital border' is; rather his research should investigate how different elements in his proposed index relate to relevant dependent variables rather than trying, ex ante, to define the answer." This is, indeed, one of the purposes of the project, and addressed below in the discussion of IR hypotheses.

10. Boulding (1962, 265) notes:

> The legal boundary of a nation, however, is not always its most significant boundary. We need to develop a concept of a critical boundary, which may be the same as the legal boundary but which may lie either inside it or outside it...The penetration of an alien organization inside this critical boundary will produce grave disorganization... War, therefore is only useful as a defense of the national organism if it is carried on outside the critical boundary (emphasis in original).