Good Fences:

The Importance of Setting Boundaries for Peaceful Coexistence

Alex Rutherford, Dion Harmon, Justin Werfel*,

Shlomiya Bar-Yam, Alexander Gard-Murray, Andreas Gros, and Yaneer Bar-Yam

New England Complex Systems Institute

238 Main St., Suite 319, Cambridge, MA 02142

(Dated: May 15, 2011; released October 6, 2011)

Abstract

We consider the conditions of peace and violence among ethnic groups, testing a theory designed to predict the locations of violence and interventions that can promote peace. Characterizing the model's success in predicting peace requires examples where peace prevails despite diversity. Switzerland is recognized as a country of peace, stability and prosperity. This is surprising because of its linguistic and religious diversity that in other parts of the world lead to conflict and violence. Here we analyze how peaceful stability is maintained. Our analysis shows that peace does not depend on integrated coexistence, but rather on well defined topographical and political boundaries separating groups. Mountains and lakes are an important part of the boundaries between sharply defined linguistic areas. Political canton and circle (sub-canton) boundaries often separate religious groups. Where such boundaries do not appear to be sufficient, we find that specific aspects of the population distribution either guarantee sufficient separation or sufficient mixing to inhibit intergroup violence according to the quantitative theory of conflict. In exactly one region, a porous mountain range does not adequately separate linguistic groups and violent conflict has led to the recent creation of the canton of Jura. Our analysis supports the hypothesis that violence between groups can be inhibited by physical and political boundaries. A similar analysis of the area of the former Yugoslavia shows that during widespread ethnic violence existing political boundaries did not coincide with the boundaries of distinct groups, but peace prevailed in specific areas where they did coincide. The success of peace in Switzerland may serve as a model to resolve conflict in other ethnically diverse countries and regions of the world.

---

* current address Wyss Institute, 60 Oxford St, Cambridge, MA 02138

Achieving peace requires a vision of what it looks like. How we imagine peace affects the steps we take and our ability to implement it in diverse locations around the world. Does peace in one place look the same as in another? Is knowledge of the specifics of each conflict necessary to negotiate peace between ethnic groups in conflict? Even if specifics are important, there are broad frameworks that guide our thinking. Recently, we introduced a complex systems theory of ethnic conflict that describes the conflicts in areas of the former Yugoslavia and India with high accuracy [1]. In this theory, specific details of history, social and economic conditions are not the primary conditions for peace or conflict. Instead the geographic arrangement of populations is key. Significantly, it points to two distinct conditions that are conducive to peace—well mixed and well separated. The first corresponds to the most commonly striven for framework of an integrated society [2]. The second corresponds to spatial separation, partition and self determination—a historically used but often reviled approach [3]. Here we consider a more subtle third approach, that of within-state boundaries in which cooperation and separation are both necessary. The success of this approach is of particular importance as the world becomes more connected. As illustrated by the European Union, the role of borders as boundaries is changing.

In order to evaluate the role of within-state boundaries in peace, we considered the coexistence of groups in Switzerland. Switzerland is known as a country of great stability, without major internal conflict despite multiple languages and religions [4,5]. Switzerland is not a well-mixed society, it is heterogeneous geographically in both language and religion (Fig. 1). The alpine topography and the federal system of strong cantons have been noted as being relevant to coexistence; their importance can be seen in Napoleon's statement, after the failure of his centralized Helvetic Republic, that "nature" had made Switzerland a federation [6–8]. But the existence of both alpine and non-alpine boundaries between groups and the presence of multiple languages and religions within individual cantons suggest partition is not essential for peaceful coexistence in Switzerland. In identifying the causes of peace, the literature has focused on socio-economic and political conditions including a long tradition of mediation and accommodation, social cleavages that "cross-cut" the population rather than coincide with each other, unwritten and written rights of proportionality (fairness) and cultural protectionism, a federal system with strong sub-national units, a civil society that fosters unity, direct democracy through frequent referenda, small size, historical time difference between cleavage in language and religion, neutrality in international warfare, and
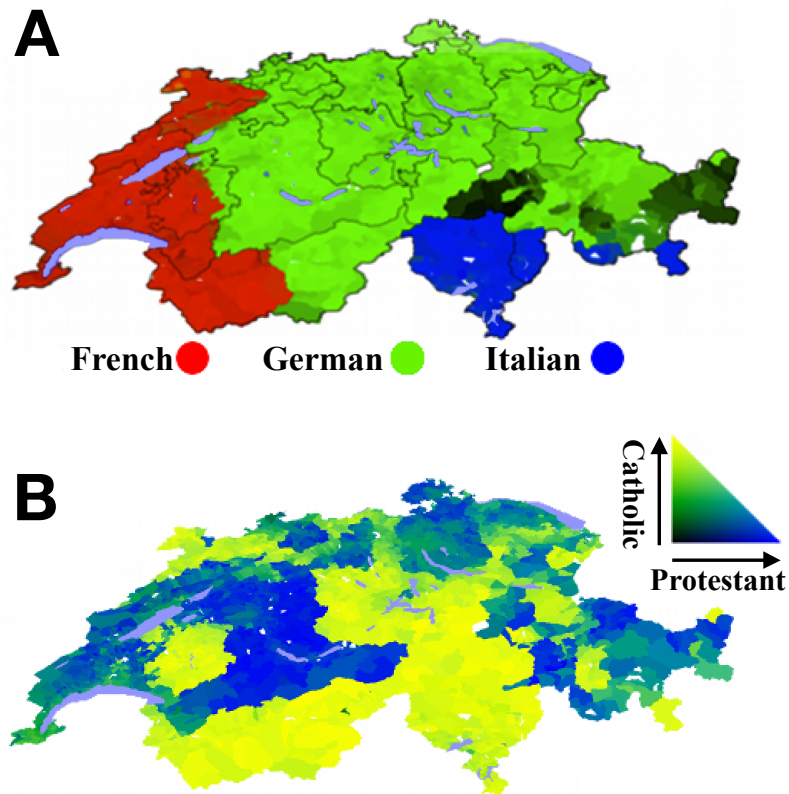
FIG. 1: Maps of Switzerland showing the 2000 census proportion of (**A**) linguistic groups, (**B**) Catholic and Protestant (Mercator projection).

economic prosperity [4–6,9–13]. Geography plays an unclear, presumably supporting, role in these frameworks. The analysis of coexistence in Switzerland is also part of a broader debate about whether social and geographical aspects of federalism promote peace or conflict [15].

In this paper we analyze the geographical distribution of groups in Switzerland based solely upon the hypothesis that spatial patterns formed by ethnic groups are predictive of unrest and violence among them [1]. The theory asserts that highly mixed regions or well-segregated groups are peaceful, while groups of a certain intermediate geographical size are likely to engage in violence. While effective separation may be achieved when group areas are large enough, the model also allows that topographic or political boundaries may serve as separations to promote peace [1,16]. Using the case of Switzerland, we test the ability of the theory to predict peaceful coexistence in the context of internal country boundaries. Where explicit boundaries do not exist, such as in mixed cantons where alpine boundaries

are absent, violence might be expected, and the results of the model in these areas serve as a particularly stringent test of the theory. In most cases violence is not predicted, consistent with what is found. In one area a significant level of violence is predicted, and violence is actually observed. The analysis sheds light on the example of Switzerland as a model for peaceful coexistence. The former Yugoslavia serves as a contrasting example of widespread violence. The theory correctly identifies areas of conflict and areas of peace also in the former Yugoslavia. The precision of the results provides some assurance of the usefulness of the theory in planning interventions that might promote peace in many areas of the world.

The geographical distribution theory [1] considers type separation into geographical domains independent of the specification of the individual types—a universality of type behavior in collective violence. Violence arises due to the structure of boundaries between groups rather than as a result of inherent conflicts between the groups themselves. In this approach, diverse social and economic causal factors trigger violence when the spatial population structure creates a propensity to conflict, so that spatial heterogeneity itself is predictive of local violence. The local ethnic patch size serves as an "order parameter," a measure of the degree of order of collective action, to which other aspects of behavior are coupled. The importance of collective behavior implies that ethnic violence can be studied in the universal context of collective dynamics, where models can identify how individual and collective behavior are related.

The analysis is applicable to communal violence and not to criminal activity or interstate warfare. In highly mixed regions, groups of the same type are not large enough to develop strong collective identities, or to identify public spaces as associated with one or another cultural group. They are neither imposed upon nor impose upon other groups, and are not perceived as a threat to the cultural values or social/political self-determination of other groups. Partial separation with poorly defined boundaries fosters conflict. Violence arises when groups are of a geographical size that they are able to impose cultural norms on public spaces, but where there are still intermittent violations of these rules due to the overlap of cultural domains. When groups are larger than the critical size, they typically form self-sufficient entities that enjoy local sovereignty. Hence, we expect violence to arise when groups of a certain characteristic size are formed, and not when groups are much smaller or larger than this size. The model of violence depends on the distribution of the population and not on the specific mechanism by which the population achieves this structure, which may include

internally or externally directed migrations. By focusing on the geographic distribution of the population, the model seeks a predictor of conflict that can easily be determined by census. This may work well because geography is an important aspect of the dimensions of social space, and other aspects of social behavior (e.g., isolationism, conformity, as well as violence) are correlated to it.

Physical boundaries such as mountain ranges and lakes or national and subnational political boundaries that establish local autonomy may prevent the violations of cultural norms and enable self-determination, inhibiting the triggers of violence. By creating autonomous domains of activity and authority, the boundaries shield groups of the characteristic size from each other when they correspond with their geographical domains.

Mathematically, evaluation of the model begins by mapping census data onto a spatial grid. We included the fraction of every population type on each site. The expected violence is determined by detecting patches consisting of islands or peninsulas of one type surrounded by populations of other types. These features are detected by pattern recognition using the correlation of the population for each population type with a template that has a positive center and a negative surround. The template used is based on a wavelet filter [1,17,18]. Wavelets are designed to obtain a local measure of the degree to which a certain scale of variation (wavelength) is present. Outcomes are highly robust, and other templates give similar results. The diameter of the positive region of the wavelet, i.e., the size of the local population patches that are likely to experience violence, is the only essential parameter of the model. The parameter is to be determined by agreement of the model with reports of violence, and results were robust to varying the parameter across a wide range of values. To model the effect of boundaries, we assume that separate autonomous regions can be analyzed by including only the populations within each of the autonomous areas to determine the expected violence. Where boundaries are incomplete, as might be the case for mountains, lakes and convoluted political boundaries, we include only the populations that are in line of sight through gaps or past ends of boundaries to determine the expected violence within a region. An effective map of populations at each site is constructed, determined by the orientation of any boundaries relative to that site. Populations past boundaries of the line of sight are replaced by neutral populations. The result of the correlation of population with the wavelet filter is a single value at every location, the theoretical "propensity to violence," and the locations of expected violence are obtained by applying a threshold to that value.

The location of groups of a certain size is indicative of a violence-prone group, but the precise location of violence is not determined. The proximity of these violence-prone groups to actual violence is tested by constructing proximity maps. The proximity to reported violence is correlated to the proximity to violence prone groups. The model was validated without boundaries [1] by applying it to the former Yugoslavia, yielding correlations of up to 0.89. The results were robust to varying the characteristic length between 18–60 km. Our revised method with fractional population values on every site gave similar results with correlations of up to 0.87. (Methods are further described in the Appendix.)

We now consider the linguistic (Fig. 2) and religious (Fig. 3) groups in Switzerland, each in turn. Initial analyses and the sequence of historical boundary formation suggested considering topographical barriers when discussing language groups, and political barriers when considering religious groups. The geography of languages primarily reflects the extent of invasions prior to the existence of current political boundaries and has remained stable in most areas for over a thousand years [5]. The modern state was established afterwards, and religious conflict played a role in establishing the internal political boundaries [5–7]. Census data were obtained for 2634 municipalities (communes) in Switzerland (bfs.admin.ch), yielding a high spatial resolution.

Language and topographical barriers - We study the three main language groups—German, French and Italian (Fig. 3A)—which together comprise 91% of the total population in the 2000 census (Romansh, the fourth official language, accounts for less than 2%). We considered only the effect of physical boundaries due to lakes and mountain ranges (Fig. 3, B and C). We determined the presence of topographical boundaries using an edge detection algorithm on topographical heights (Fig. 3D). This process identifies where there is a sharp change in height, i.e., a cliff, or steep incline, that runs for a significant distance forming a natural boundary. Elevation data with a spatial resolution of approximately 91m [19] was coarsened to pixels of size 9.1×9.1 km. Edges were identified where there was an increase of more than 1.8 km in height over a distance of 9.1 km ($11.5°$) using a discretized Laplacian differential operator [20] with a mask size of a single pixel. The conclusions are robust to variations in the elevation angle (Appendix). Calculations of the propensity to violence are reported here (Fig. 3, E and F) for the characteristic length of 24 km and in the Appendix for a range of characteristic lengths. Without boundaries, the correlation of the wavelet filter
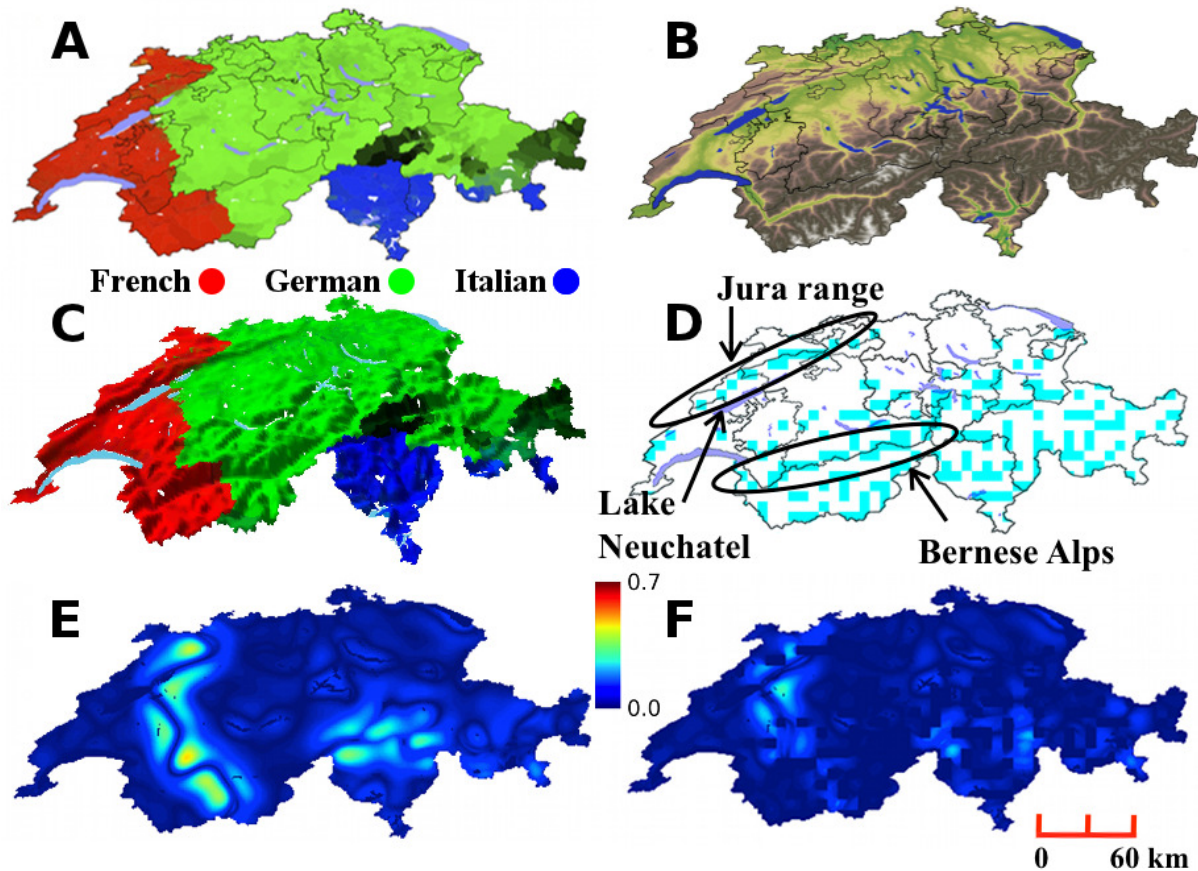
FIG. 2: Maps of Switzerland showing **(A)** proportion of linguistic groups according to the 2000 census, **(B)** elevation within Switzerland, **(C)** overlay of linguistic groups onto a digital elevation model, and **(D)** topographical features including lakes (blue) and ridges extracted using edge detection (cyan). Comparison of calculated propensity (color bar) to violence between linguistic groups without **(E)** and with **(F)** the inclusion of topographical features as boundaries using a characteristic length scale of 24 km. Mercator projection, except C which is the Europe Albers projection. The distance scale is approximate.

yields a maximum propensity to violence value of 0.48. With topographical boundaries the maximum propensity is reduced to 0.30. Between the German and French-speaking areas to the northwest, the Jura mountain range and Lake Neuchatel, and to the south, the Bernese Alps, are mitigating boundaries. The interface between Lake Neuchatel and the Bernese Alps through the canton of Fribourg has no mitigating boundary, but is almost straight—neither side is surrounded by the other, so the propensity is low. Between the Italian and German-speaking areas, the Lepontine Alps dramatically reduce the calculated propensity.

7

The Jura range is, however, a porous boundary, and the highest residual propensity is adjacent to it in the northwest of the canton of Bern, which, unique in Switzerland, is historically known to be an area of "intense" linguistically-based conflict, including arson, bombings and other terrorist tactics [13,21]. We obtained a correlation higher than 0.95 between predicted and reported violence (Appendix), consistent with the hypothesis of the model. Manifesting Swiss willingness to create political boundaries, the conflict led to a referendum, and in 1978 the modern-day canton of Jura was created out of part of the north of what was then the canton of Bern [7]. While the conflict underlying the unrest was linguistic, local votes led to separation by majority religion. However, conflict did not end, and a proposal to shift the French-speaking Protestant areas of Bern to join French-speaking Catholic Jura is currently being considered [22]. Our results suggest that a calculated propensity to violence of 0.3 should be considered just at the threshold for actual violence, even under the social and political conditions prevailing in Switzerland. Remarkably, at this threshold high correlations (above 0.8) also are found in the former Yugoslavia. Thus, similar propensities for violence in different social contexts result in violence.

Religious Groups and Political Barriers - The two main religious groups of Switzerland are Protestant and Catholic. The Swiss federal political system separates the country into 26 "cantons" and "half-cantons" considered as semi-autonomous political units (Fig. 3). Moreover, this schema is repeated within the largest canton by area, Graubünden, whose sub-cantonal divisions called circles (*kreise*) have a distinctive political autonomy [4,12]. We obtained canton boundaries from mapping resources (`www.gadm.org`, `www.toposhop.admin.ch`). Circles boundaries were identified by district lists (`www.gis.gr.ch`). In the 2000 census, Roman Catholic and Protestant affiliations account for 77% of the total population. Less than 8% subscribe to other religions, and the remainder have no religious affiliation or did not specify one. Without boundaries, the maximum calculated propensity to violence is very high (0.57), and with political borders it is only 0.20. Without Graubünden circles, the propensity increases to a quite high 0.42, still well above the threshold. Because of a 10% decline in religious affiliation in recent years, we considered also the 1990 census, with similar conclusions (Appendix).

The separation of religions by canton is apparent geographically and historically. In some cases the area of a canton includes small enclaves embedded in another canton whose
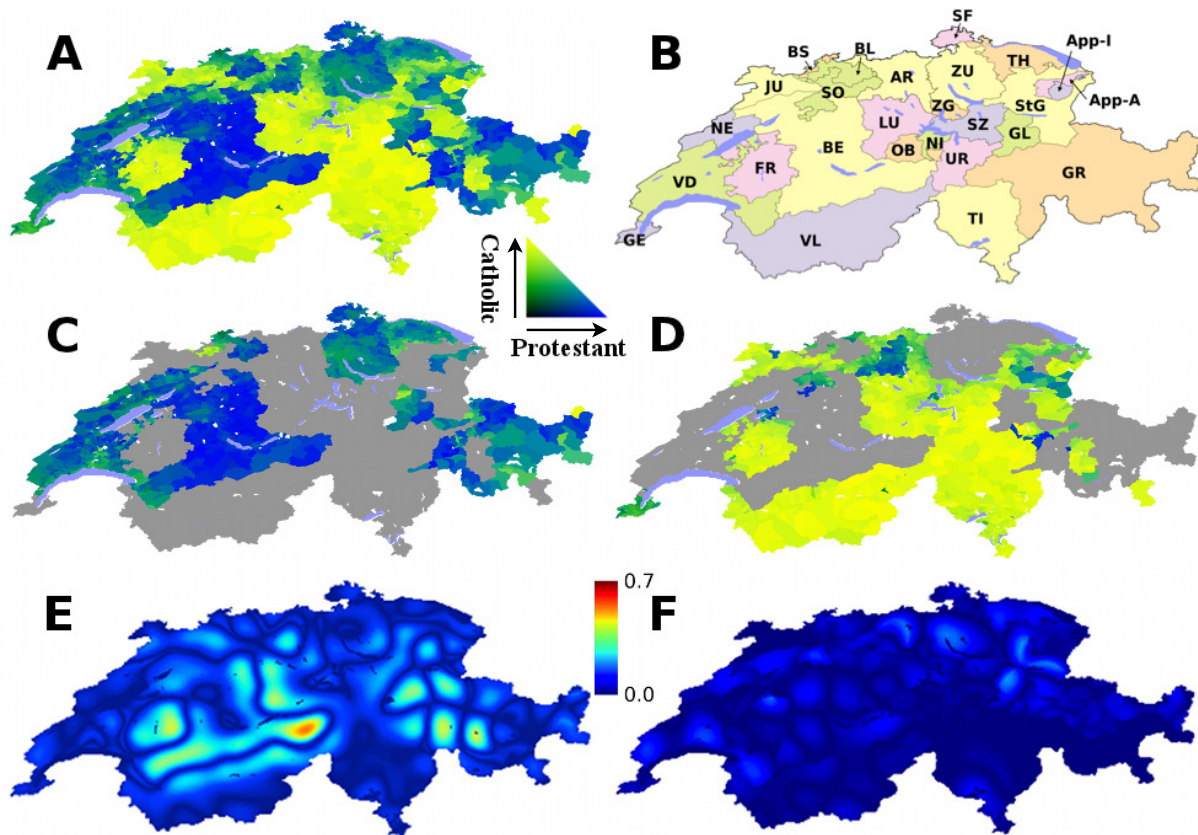
FIG. 3: Maps of Switzerland (Mercator projection) showing **(A)** proportion of Catholic (yellow) and Protestant (blue) according to the 2000 census, **(B)** cantons, **(C)** and **(D)** cantons (and Graubünden circles) that are majority Protestant and Catholic respectively, using the same color map as A. Comparison of propensity to violence between religious groups without **(E)** and with **(F)** the inclusion of administrative boundaries using a characteristic length scale of 24 km. Propensity value scale is shown by color bar. Canton abbreviations are GE: Genève, SO: Solothurn, ZG: Zug,VL: Valais, BS: Basel-Stadt, GL: Glarus, VD: Vaud, BL: Basel-Landschaft, TI: Ticino, NE: Neuchatel, AR: Aargau, GR: Graubünden, FR: Fribourg, LU: Lucerne, App-A: Appenzell-Ausserhoden, BE: Bern, OB: Obwalden, App-I: Appenzell-Innerrhoden, JU: Jura, NI: Nidwalden, StG: St. Gallen, UR: Uri, SF: Schaffhausen, TH: Thurgau, SZ: Schwyz, ZU: Zurich.

majority religion corresponds to the canton to which they belong. Still, there are exceptions to the separation of religions by canton. In each case the geography is sufficient to limit the propensity to violence. For example, there is an area of Protestant majority in the far north of the Catholic canton of Fribourg. It is, however on a long appendage and therefore

9

is not surrounded by Catholic areas, and so has a low propensity to violence according to the analysis. Historical evidence is found in conflict in the 1500s [7]. The Reformation led to cantons adopting a Protestant or retaining a Catholic identity. A brief war resulted in a peace treaty that established religious freedom by canton. The canton Appenzell was split by religious differences into two "half-cantons" Innerrhoden and Ausserrhoden. The political independence of circles (*kreise*) in Graubünden also provided religious autonomy [12]. The intentional formation of political boundaries in regions that would have violence according to the model, and the subsequent model propensity below the threshold associated to a lack of actual violence are consistent with the hypothesis on the role of boundaries in peaceful coexistence.

Yugoslavia - Our modified method including boundaries was tested on the previous case study of Yugoslavia, consisting of the combined area of Croatia, Bosnia, Serbia and Montenegro. Topographical boundaries reduce the maximum propensity from 0.63 to 0.57, and administrative borders to 0.56. The correlations of predicted and reported violence changes were insignificantly lower, with correlations of 0.86 and 0.85, respectively. That political boundaries do not have a greater impact on the calculated violence implies that they do not align with the geographical boundaries between groups. We also extended the area to include Macedonia and Slovenia, parts of the Socialist Federal Republic of Yugoslavia before gaining independence (Fig. 4). With the political boundaries the correlation is still 0.85; however, when political boundaries are not included, the correlation is reduced considerably to 0.72. The lower correlation is specifically due to a high calculated propensity to violence along the borders of Slovenia with Croatia, and of Macedonia with Serbia and Kosovo. These areas, however, were peaceful—consistent with the predictions when boundaries are included. Our results suggest that these political borders were instrumental in reducing ethnic violence, whereas the violence in other areas of Yugoslavia was not prevented because of poor alignment of borders with population groups.

This work is part of a broader effort to use new methods for quantitative analysis of patterns of violence and their prevention [23–31]. There is also interest in ethnic group interactions across national borders [32-34]. We have shown that groups that are not well-mixed but are geographically separated by natural or political boundaries into autonomous domains are peaceful in both Switzerland and the former Yugoslavia. Our work clarifies
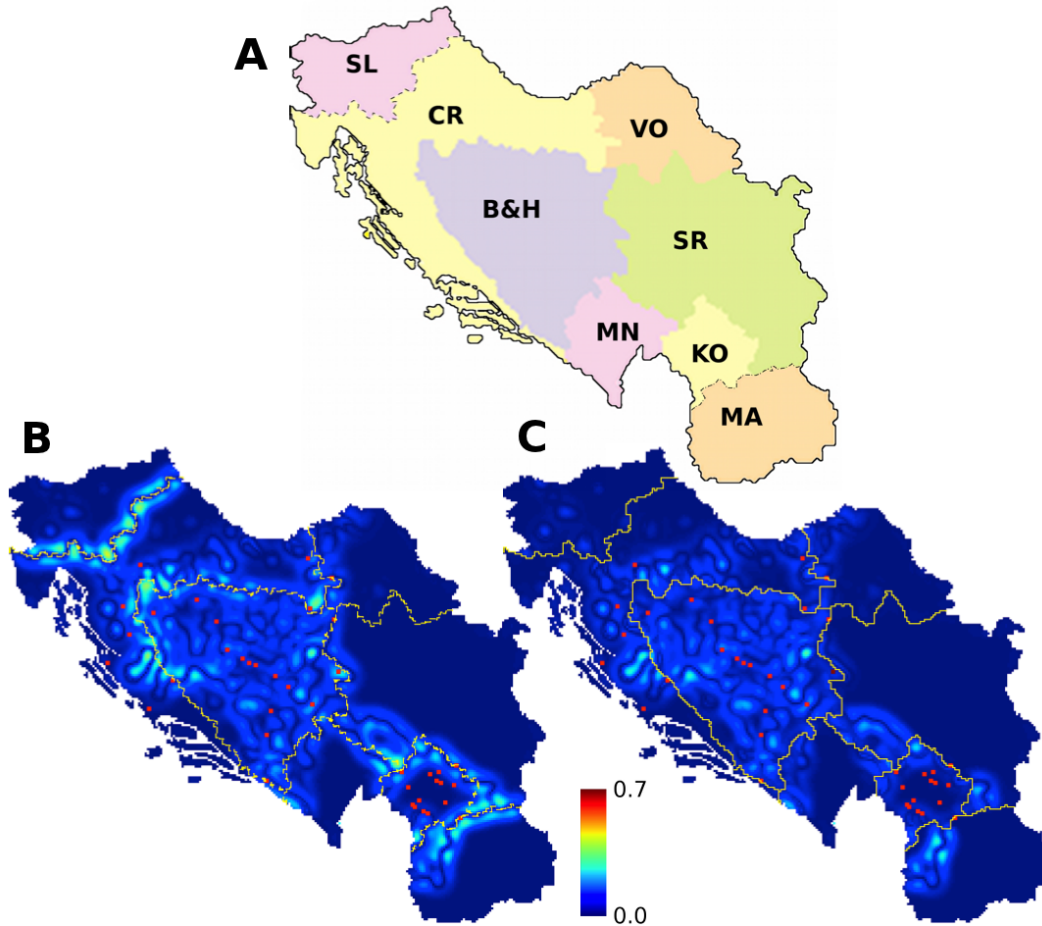
FIG. 4: **(A)** Map of the area of the former Yugoslavia showing administrative provinces. Propensity to violence calculated without **(B)** and with **(C)** administrative boundaries, using a characteristic length of 21 km. Locations of boundaries are shown on both plots as solid and dashed yellow lines respectively. Sites of reported violence are shown as red dots [18]. Spurious violence is predicted along the borders of Slovenia and Macedonia when boundaries are not included. Province labels are: SL: Slovenia, CR: Croatia, VO: Vojvodina*, B&H: Bosnia & Herzegovina, SR: Serbia, MN: Montenegro, KO: Kosovo*, MA: Macedonia. (*Autonomous administrative provinces of Serbia.)

the ambiguities of mixed language and religion Swiss cantons by showing that in most cases the natural geography of the populations conspires to lead to a low level of violence, so that additional boundaries were not necessary; where they were needed, as in Graubünden, they were established. The highest calculated propensity to violence is between linguistic groups in the northern part of the canton of Bern, where historically unresolved real world

11

tensions actually exist. Our analysis indicates that both administrative and natural barriers can play a significant role in mitigating conflict between religious and linguistic groups. Historical evidence suggests that for religious groups the boundaries in Switzerland were created to provide autonomy to a group with a shared identity and avoid conflict among multiple groups. Ongoing efforts to reduce tensions in Bern include introducing new political boundaries. The many political, social and economic factors that play roles in reducing violence [4–6,9–14] build on a strong foundation of geographical borders. Our analysis suggests that when partition within a country is viewed as an acceptable form of conflict mitigation, such partition can give rise to highly stable coexistence and peace.

References:

[1] M. Lim, R. Metzler, Y. Bar-Yam, Global pattern formation and ethnic/cultural violence. Science 317, 1540 (2007).

[2] Imagine Coexistence: Restoring humanity after violent ethnic conflict, A. Chayes, M. L. Minow eds., (Jossey-Bass, San Francisco, 2003)

[3] C. Kaufmann, When all else fails: Ethnic population transfers and partitions in the Twentieth Century. Int. Secur. 23, 120 (1998).

[4] A. Lijphart, Democracy in Plural Societies: A Comparative Exploration (Yale University Press, New Haven, 1977).

[5] C. L. Schmid, Conflict and Consensus in Switzerland (University of California Press, Berkeley, 1981).

[6] W. Martin, A History of Switzerland: An Essay on the Formation of a Confederation of States (G. Richards, London, 1931).

[7] U. Im Hof, Geschichte der Schweiz, vol. 188 of Kohlhammer Urban-Taschenbücher (Kohlhammer, Stuttgart, 1991).

[8] N. Bonaparte, Proclamation de St. Cloud, 30 septembre 1802 in Bonaparte et la Suisse: Travaux Preparatoires de l'Acte de Mediation (1803), V. Monnier, Ed. (Helbing & Lichtenhahn, Geneva, 2002).

[9] J. Steiner, Amicable Agreement Versus Majority Rule: Conflict Resolution in Switzerland (University of North Carolina Press, Chapel Hill, 1974).

[10] H. E. Glass, Ethnic diversity, elite accommodation and federalism in Switzerland. Publius 7, 31 (1977).

[11] W. Linder, Swiss Democracy: Possible Solutions to Conflict in Multicultural Societies (Palgrave Macmillan, New York, ed. 3, 2010).

[12] R. C. Head, Early Modern Democracy in the Grisons: Social Order and Political Language in a Swiss Mountain Canton: 1470–1620 (Cambridge University Press, Cambridge, 2002).

[13] K. D. McRae, Conflict and Compromise in Multilingual Societies: Switzerland (Wilfrid Laurier University Press, Waterloo, Ontario, 1983).

[14] C. H. Church, The Politics and Government of Switzerland (Palgrave MacMillian, New York, 2004).

[15] T. Christin, S. Hug, Federalism, the geographic location of groups, and conflict, CIS Working Paper No. 23, Center for Comparative and International Studies, ETH Zurich and University of Zurich (2006).

[16] W. Shearer, Determine Indicators for Conflict Avoidance, Science (2008)

[17] P. Ch. Ivanov et al., Nature 383, 323 (1996).

[18] I. Daubechies, Ten Lectures on Wavelets, (SIAM, Philadelphia, 1992).

[19] A. Jarvis, H. I. Reuter, A. Nelson, E. Guevara, Hole-filled SRTM Version 4: http://srtm.csi.cgiar.org (2008).

[20] A. Bovik, Essential Guide to Image Processing (Academic Press, Burlington, 2009).

[21] W. R. Keech, Linguistic diversity and political conflict: Some observations based on four Swiss cantons. Comp. Politics 4, 387 (1972).

[22] "Citizens to settle territorial Jura conflict," Swissinfo, May 4, 2009 (http://www.swissinfo.ch/eng/politics/Citizens_to_settle_territorial_Jura_conflict.html?cid=7377228, Accessed Feb. 21, 2011).

[23] D. L. Horowitz, Ethnic Groups in Conflict (University of California Press, Berkeley, ed. 2, 2000).

[24] B. Harff, T. R. Gurr, Ethnic Conflict in World Politics (Westview, Boulder, ed. 2, 2004).

[25] M. Reynal-Querol, Ethnicity, Political Systems, and Civil Wars. J. Conflict Res. 46,

29 (2002).

[26] J. Fox, Religion, Civilization, and Civil War: 1945 Through the New Millennium (Lexington Books, Lanham, MD, 2004).

[27] I. S. Lustick, D. Miodownik, R. J. Eidelson, Secessionism in multicultural states: Does sharing power prevent or encourage it? Am. Pol. Sci. Rev. 98, 209 (2004).

[28] T. R. Gulden, Spatial and temporal patterns in civil violence: Guatemala, 1977-1986. Politics Life Sciences 21, 26 (2002).

[29] L. E. Cederman, K. S. Gleditsch, Introduction to special issue on "Disaggregating Civil War." J. Conflict Res. 53, 487 (2009).

[30] H. Buhaug, S. Gates, The geography of civil war. J. Peace Res. 39, 417 (2002).

[31] J. C. Bohorquez, S. Gourley, A. R. Dixon, M. Spagat, N. F. Johnson, Common ecology quantifies human insurgency. Nature 462, 911 (2009).

[32] African Boundaries: Barriers, Conduits and Opportunities, P. Nugent, A. I. Asiwaju, eds. (Pinter, London, 1996).

[33] K. Mitchell, Transnational discourse: bringing geography back in, Antipode 29, 101 (1997).

[34] M. Silberfein, A. Conteh, Boundaries and conflict in the Mano River region of West Africa, Conflict Management and Peace Science 23, 343 (2006).

Appendices for: Good Fences:

The Importance of Setting Boundaries for Peaceful Coexistence

Contents

Appendix A: Methods

1.   Identifying the propensity to violence using a wavelet filter

The potential for conflict is quantified in our model using a wavelet filter [A.1–A.3]. In essence, the filter evaluates the extent of the presence of a type in a circular area with a specified radius and subtracts from this the presence of the same type in a surrounding area. This results in cancellation if the same type is located in the surrounding area. Other types

are all treated with the opposite sign causing cancellation if there are mixed populations of the first type with the others. Thus, the largest values are obtained for an island of one type surrounded by other types. Large values are also obtained for a peninsula of one type into a sea of other types. To evaluate the likelihood of violence at a particular location, we apply the filter, centered at that location, for each of the types. The likelihood of violence in that region is the maximum over all types. Unlike the earlier method [A.4], we included all population types on each site of a grid rather than basing calculations on an agent model. Mathematically the expression for the filter applied at a location (x, y), with the maximum taken over all types, is

$$c(x, y) = \max_s \sum_{x', y'} m(x - x', y - y') \left(p_s(x', y') - \sum_{s' \neq s} p_{s'}(x', y') \right), \tag{A1}$$

which is a convolution of the fraction of the population of one type, $p_s(x, y)$ minus the fractional population of other types, with a wavelet,

$$m(x, y) = (1 - \rho(x, y)^2) e^{-\rho(x,y)^2}, \tag{A2}$$

where the scaled distance from the center is given by

$$\rho(x, y) = \frac{\sqrt{x^2 + y^2}}{r_c}, \tag{A3}$$

the Euclidean distance divided by the radius of the wavelet, r_c, which is half of the diameter, l_c, the model parameter identifying the size of groups that are likely to engage in conflict. The value of $c(x, y)$ serves as a measure of the likelihood of violence in the vicinity of the location (x, y). When performing statistical tests on the prediction of violence, we specify a threshold that distinguishes regions of violence from regions of non-violence according to whether $c(x, y)$ exceeds the specified threshold.

2. Boundaries

We model both topographical and administrative boundaries within a country as preventing intergroup violence across them, similar to national boundaries in the earlier method [A.4]. A cliff separating a plateau from a plain is considered to be a barrier to movement between the upper and lower areas and thus serves as a boundary.

We generalize the previous method for incorporating boundaries to allow for partial boundaries and boundaries with gaps. Partial boundaries between areas within the country can arise due to mountains, lakes, or at convoluted political borders. For such boundaries, we consider the line of sight from a given location to identify the populations which impact on the propensity for violence at that location. Populations outside of the line of sight are not included as contributing to violence. Thus an effective map of populations as experienced at each site is constructed, determined by the specific orientation of any boundaries relative to that site. The areas which are blocked from sight are populated with a neutral population, the existing local proportions of the population. This better matches both the mixed and single type local populations than a single type. The local proportions were measured within a range of two characteristic lengths (wavelet diameters) of each site, considering only sites that are in a line of sight.

3. Empty sites

Some small areas are unpopulated. These and lake areas were treated as other sites, but the violence at these sites was set to zero. Only small differences arise if these unpopulated areas are treated differently.

There are two types of unpopulated areas, land and water. Unpopulated land areas are treated as other land areas for the purpose of the calculations. After the calculation we set the propensity to violence in those locations to zero. The results were not affected significantly (Fig. A.1). Water areas were treated similarly, with the exception that bodies of water that are large were considered to be topographical barriers, similar to mountains and cliffs. Specifically, we included the two largest lakes, Leman and Neuchatel, both of which have a length above 10 km, which is comparable to the range of characteristic length scales used to detect a propensity to violence.

References:

[A.1] I. Daubechies, Ten Lectures on Wavelets, (SIAM, Philadelphia, 1992).

[A.2] A. Arneodo, E. Bacry, P.V. Graves, J.F. Muzy, Phys. Rev. Lett. 74, 3293 (1995).

[A.3] P. Ch. Ivanov, M. G. Rosenblum, C-K. Peng, J. Mietus, S. Havlin, H.E. Stanley, A.L. Goldberger, Nature 383, 323 (1996)
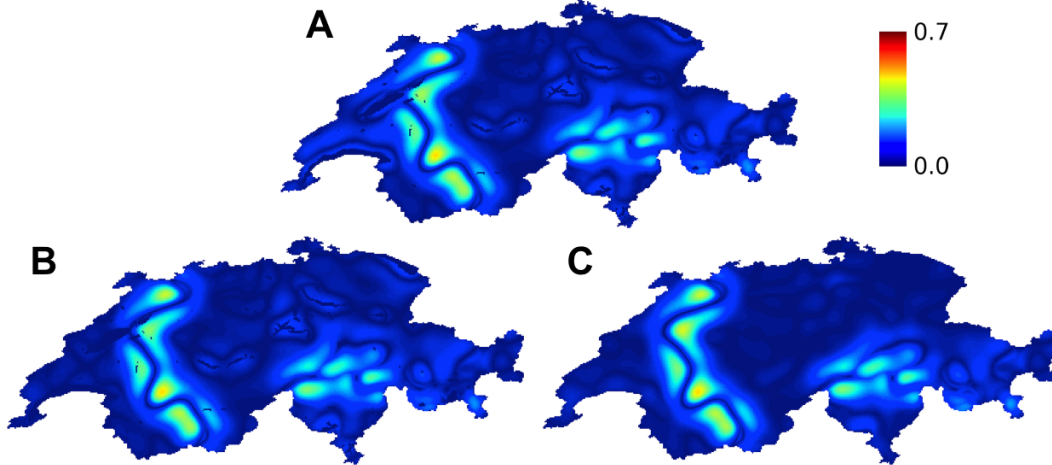
FIG. A.1: Level of predicted violence between linguistic groups in Switzerland using a characteristic length scale of 24 km. Each panel represents results for a different treatment of lakes and unpopulated land areas: **(A)** including lakes and unpopulated land areas as empty sites; **(B)** including as barriers the lakes of Leman and Neuchatel; **(C)** interpolating a composition for all unpopulated sites from neighboring sites.

[A.4] M. Lim, R. Metzler, Y. Bar-Yam, Global pattern formation and ethnic/cultural violence. Science 317, 1540 (2007).

Appendix B: Census data

The commune composition used in our calculations was based on the census of 2000 and 1990 published by the Swiss Statistical Office. Where municipalities have merged, an aggregate of their previous constituent municipalities was taken. Three official languages we considered are French, German and Italian, which comprise 91% of the total population. The fourth official language, Romansch, is 2%. The religions considered are Roman Catholic and Protestant accounting for 77% of the total with less than 8% belonging to other religious groups and the remainder not subscribing to a religion or not specifying one. The 1990 census data is only readily available on a cantonal level. As described in Section G, we estimated the commune composition using the 2000 value and the change in the parent canton between 1990 and 2000.

Appendix C: Summary of model comparisons with the data

We briefly summarize the comparisons between model predictions and the observed data reported in the main section of the paper.

Our examination of linguistic and religious groups in Switzerland highlighted cases where violence is predicted without the presence of boundaries, but is mitigated by the consideration of topographical and political boundaries appropriate to linguistic and religious groups, respectively.

(1) Topographical boundaries reduced violence between linguistic groups. This occurred along (a) Alpine boundaries of the Swiss Alps between German-speaking and Italian-speaking populations, (b) Alpine boundaries between German-speaking and French-speaking populations, and (c) Jura range boundaries between German-speaking and French-speaking populations.

(2) Political boundaries reduced violence between religious groups. This is the case both for (a) canton boundaries and for (b) circle boundaries in the canton of Graubünden.

Our analysis also identified locations in which our model does not predict violence despite linguistic or religious heterogeneity and no explicit boundaries.

(3) The straightness of the boundary prevents violence between linguistic groups in Fribourg/Freiburg.

(4) Isolation of a Protestant population on an appendage from the Catholic majority prevents violence in Fribourg/Freiburg.

We also identified one area at the highest level of calculated residual propensity to violence and it corresponds to an area of unresolved historical conflict.

(5) The northeastern part of the canton of Bern is the location of both the highest prediction of propensity to violence, and a real-world history of intergroup tension. The unique condition of the conflict in this part of Switzerland and its correspondence to the prediction by the model provides additional confirmation of the model.

Considering the predicted and reported violence in the former Yugoslavia also demonstrated the importance of the boundaries which coincide with ethnic divisions.

(6) Political boundaries between Slovenia and Macedonia and the other countries of the former Yugoslavia prevent violence along their borders.

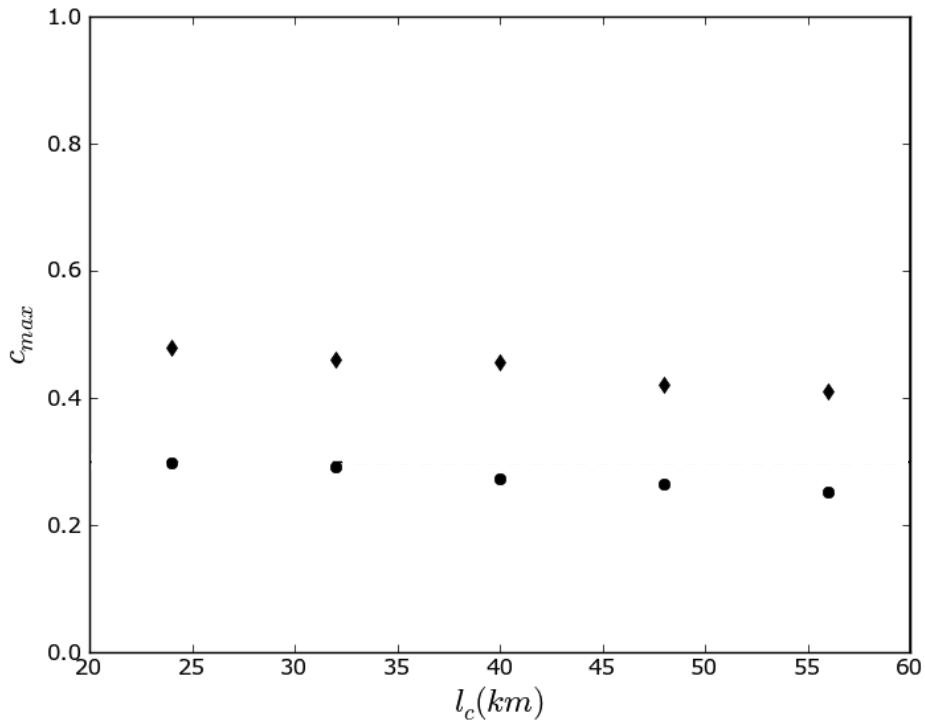(7) The borders between the countries of Croatia, Bosnia, Serbia and Montenegro were

FIG. D.1: Maximum level of the propensity to violence between linguistic groups in Switzerland as calculated in the model as a function of the characteristic length scale. The calculation is performed with effect of topographical boundaries ($\bullet$) and without effect of topographical boundaries ($\Diamond$).

not aligned with the boundaries between ethnic groups and so were ineffective at reducing violence.

Appendix D: Languages

Here we describe in greater detail the results of the calculation of the propensity to violence between linguistic groups in Switzerland with and without the effect of topographical boundaries. In the main text we described the calculation of propensity for violence for a characteristic length scale of $24\,\mathrm{km}$. Here we provide it for the length scales 24, 32, 40, 48 and $56\,\mathrm{km}$. Figs. D.1–D.3 show that, at all values of the characteristic length scale, the propensity for violence is high for calculations without topographical boundaries and is dramatically reduced by their inclusion.
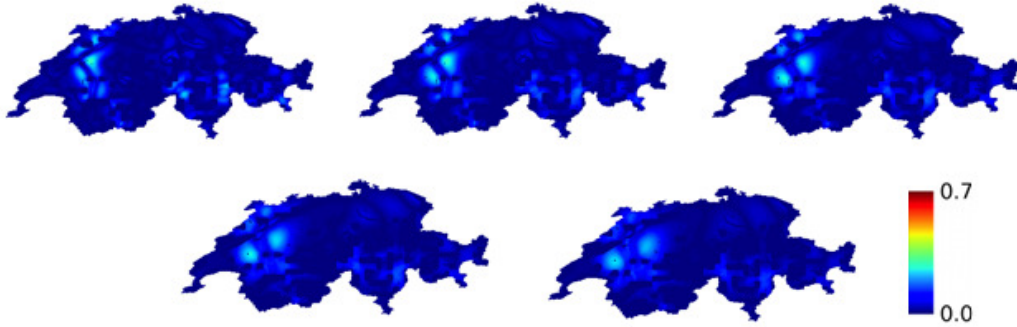
FIG. D.2: Level of propensity to violence between linguistic groups in Switzerland including the effect of topographical boundaries. Characteristic lengths increases from left to right, top to bottom with the values 24, 32, 40, 48, 56 km.
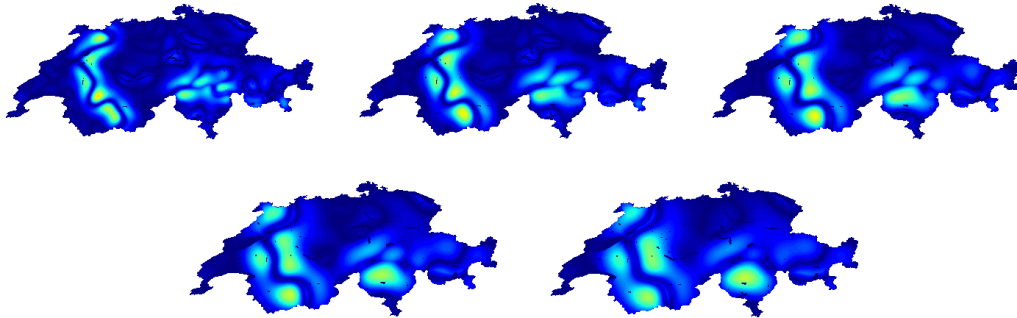

FIG. D.3: As in Fig. D.2 without the effect of topographical boundaries.

Appendix E: Elevation edges

Here we investigate the robustness of our analysis to variation of the calculation of topographical barriers extracted from the elevation data. We vary the gradient threshold that determines the presence of a boundary and compare the results for linguistic groups in Switzerland. We also include here a similar comparison of the calculation of the impact of topographical edges on the conflict between ethnic groups within the former Yugoslavia. Figure E.1 shows the variation of the maximum propensity to violence in Switzerland as the threshold gradient for geographical barriers varies. The propensity is robust to the variation across a range of angles. Still, as the gradient increases and barriers are removed the propensity to violence increases. The model results are consistent with the expectation that it is necessary to include geographical features as barriers in order to achieve agreement
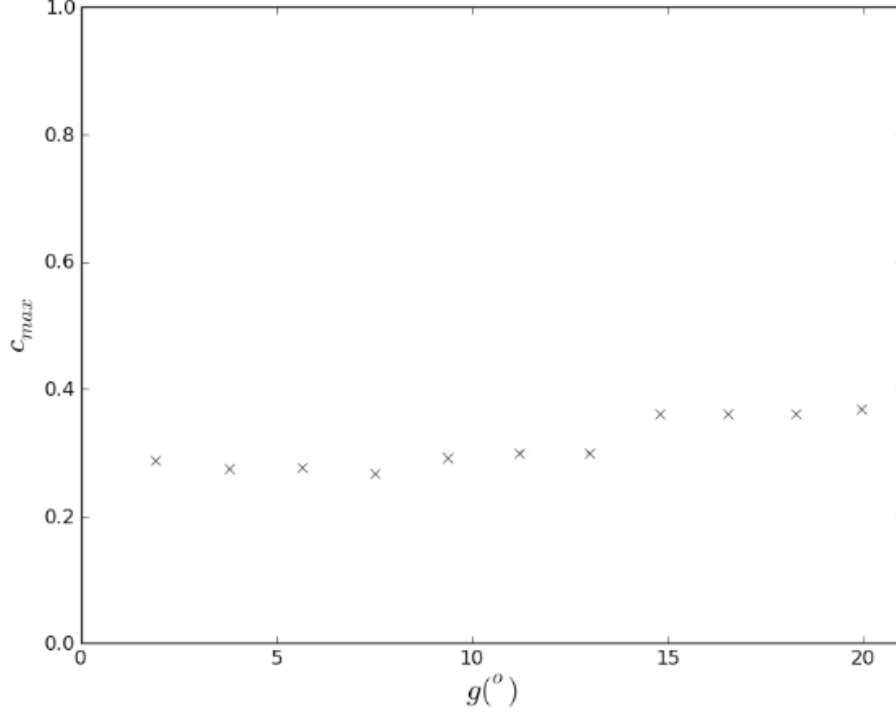
FIG. E.1: The maximum propensity to violence between linguistic groups in Switzerland as the threshold gradient for topographical barriers varies.

with the locations of actual reports of violence, and is consistent with the hypothesis that such barriers are effective in mitigating outbreaks of violence. Figure E.2 shows the maximum propensity to violence calculated for the former Yugoslavia as a function of changes in the gradient threshold, and the resulting correlation of predicted and reported violence. The results show that while some variation in the maximum value of the predicted violence propensity occurs, it remains above the threshold for expected violence. The correlation with observed violence is not very sensitive to the gradient of the edges in elevation. This indicates that areas of predicted violence continue to be proximate to the areas of reported violence. Topographical features are not sufficiently steep or aligned with the boundaries of population groups to inhibit violence.
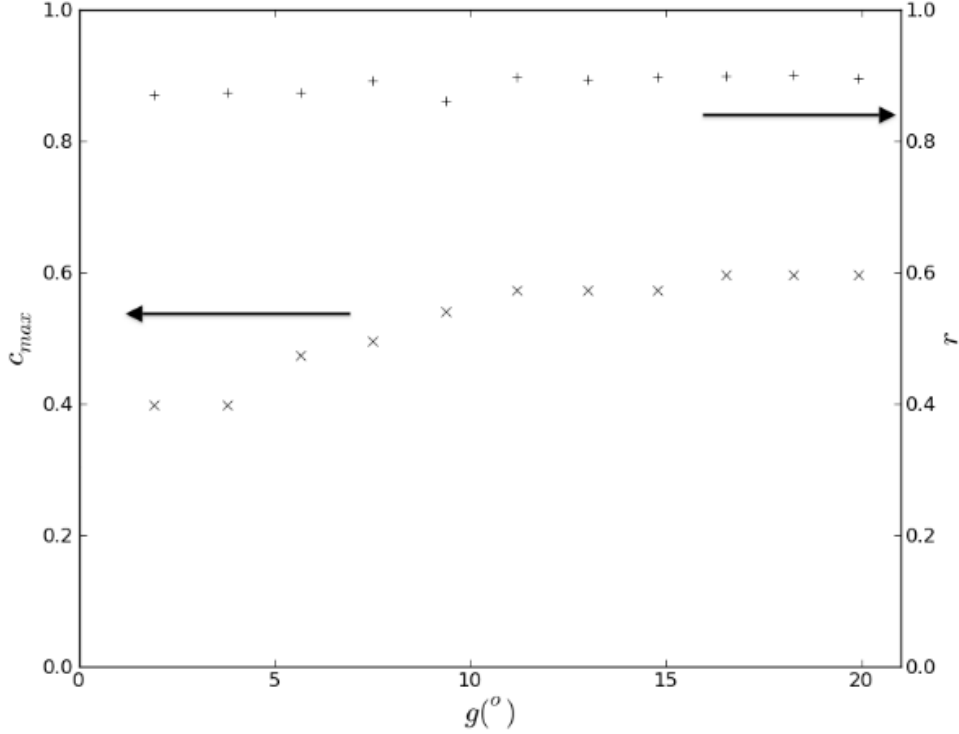
FIG. E.2: Maximum propensity to violence ($\times$, left axis) and correlation of predicted with reported violence ($+$, right axis) in the former Yugoslavia as the threshold gradient for topographical barriers g varies.

Appendix F: Religion (2000 census)

Here we describe in greater detail the calculation of violence between religious groups in Switzerland. In the main text we described the calculation of propensity for violence for a characteristic length scale of 24 km. Here we provide the results for the length scales 24, 32, 40, 48 and 56 km.

Figure F.1 plots the maximum propensity to violence with canton and Graubünden circle boundaries, with canton boundaries only, and without political boundaries. The corresponding maps are shown in Figs. F.2–F.4. Autonomy within cantons and Graubünden circles has been established to prevent conflict. Consistent with the historical experience, the model results imply that without these boundaries violence would be expected, but with them it is not. The effect of canton boundaries is important across all length scales, that of the circles in Graubünden is important at the smaller length scales. This result specifically suggests
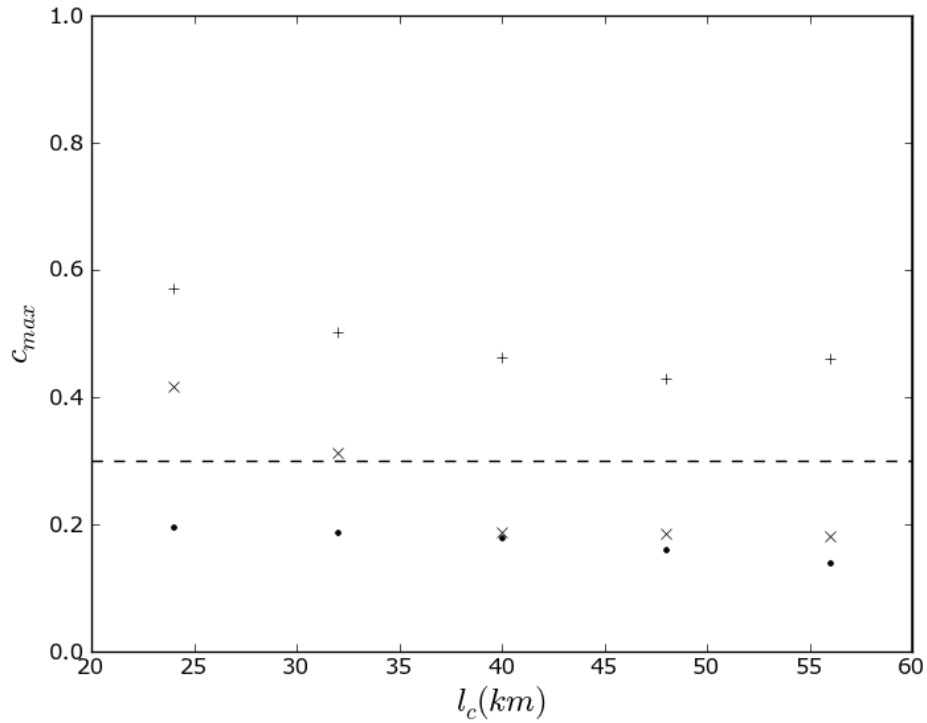
FIG. F.1: Maximum level of the propensity to violence between religious groups in Switzerland as a function of characteristic length scale according to the model. Calculations are shown including the effect of canton boundaries and Graubünden circle boundaries ($\bullet$), including the effect of canton boundaries only ($\times$), and without the effect of political boundaries ($+$). The dashed line represents the inferred threshold of propensity of violence in order for violence to occur.

that length scales of 24–32 km correspond to a geographical group size that is susceptible to violence.
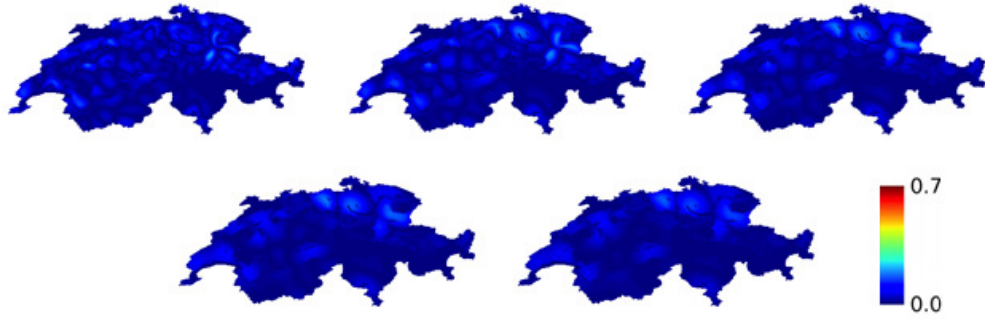
FIG. F.2: Level of predicted violence between religious groups in Switzerland with political boundaries, including both cantons and Graubünden circles (2000 census). Characteristic length increases from left to right, top to bottom for the values 24, 32, 40, 48, 56 km.
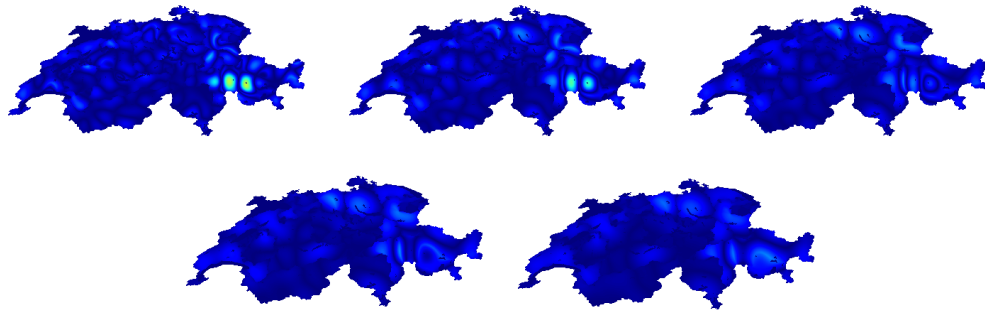

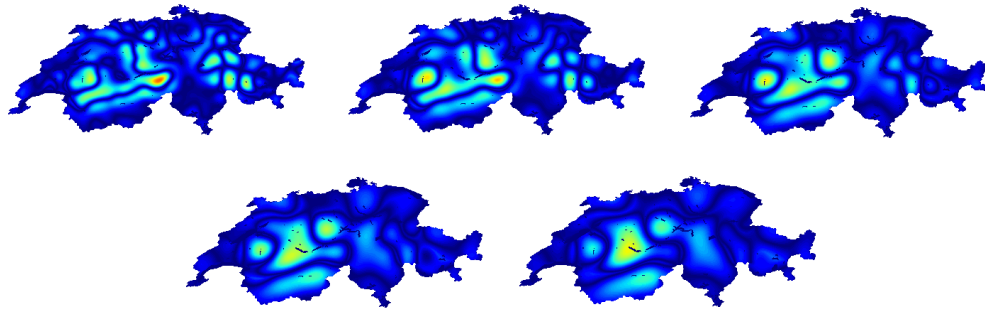FIG. F.3: As in Fig. F.2 but including only the effect of canton boundaries.

FIG. F.4: As in Fig. F.2 but without the effects of political boundaries.

Appendix G: Religion (1990 census)

In the main paper we reported the propensity for violence between religious groups for the 2000 census for the characteristic length of 24 km. During the 1990s there was a significant reduction in religious affiliation. We therefore considered also the 1990 census. The results are very similar to those of the 2000 census with maximum propensity without boundaries of 0.59 (compared to 0.57) reduced to 0.23 when including the political boundaries (compared to 0.20).

In 2000 Roman Catholicism and Protestantism accounted for 87% of the population, 10% more than in 2000, and with only 9.5% identifying themselves as atheist or not specifying religious affiliation. The census for religions in Switzerland in 1990 is readily available only at a canton level resolution rather than the municipality level used in our calculations. We used the reduction of religious affiliation in the entire canton to estimate religious composition for each municipality in 1990. Explicitly:

$$p = p' \times \frac{1.0 - \beta a'}{1.0 - a'}, \tag{G1}$$

where p and p' are the value of the municipal Catholic or Protestant proportion of the population estimated for 1990 and given for 2000, a' is the unaffiliated municipality population proportion in 2000, and

$$\beta = \frac{A}{A'} \tag{G2}$$

is the ratio of unaffiliated canton population proportions, A and A', in 1990 and 2000. Fig. G.1 is a map of the resulting religious affiliation. Figs. G.2–G.5 show the calculations of the propensity for violence for the 1990 census corresponding to the results for the 2000 census results shown in Fig. F.1–F.4.
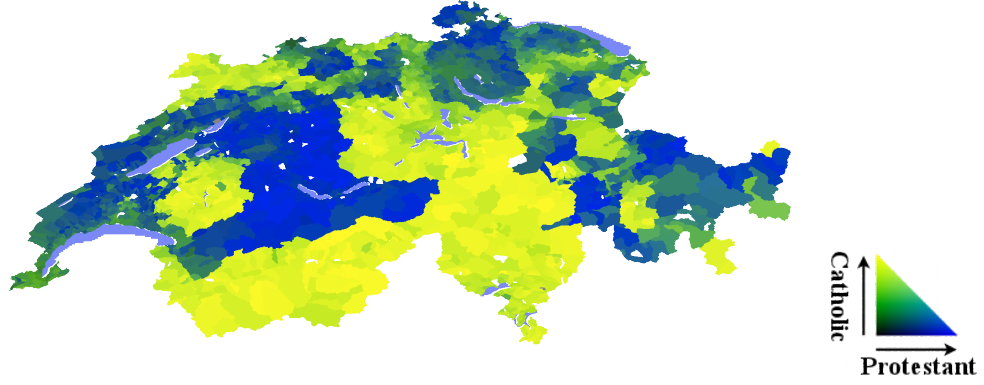
26

FIG. G.1: Proportion of religious groups according to interpolated 1990 census. Communes are colored according to proportion of Protestant (blue) and Catholic (yellow) as shown by color triangle.
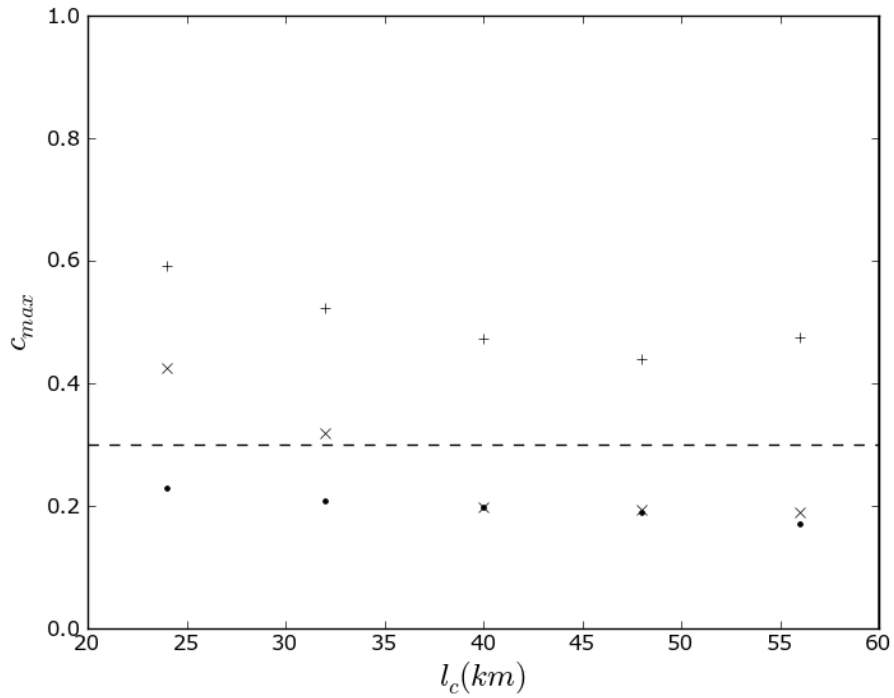

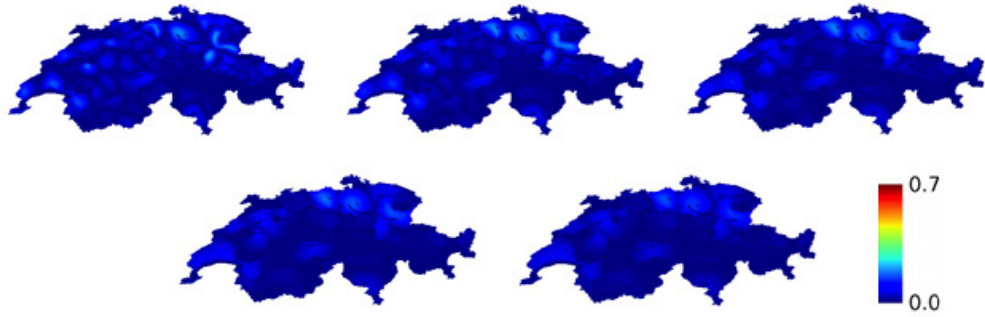FIG. G.2: As in Fig. F.1 for the 1990 census.
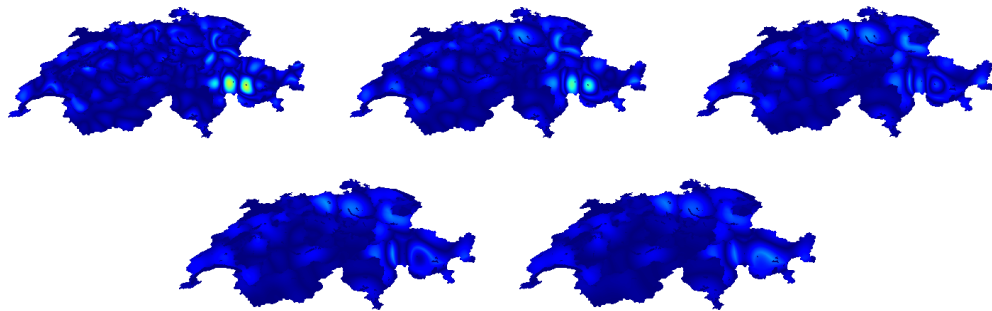
FIG. G.3:   As in Fig. F.2 for the 1990 census.
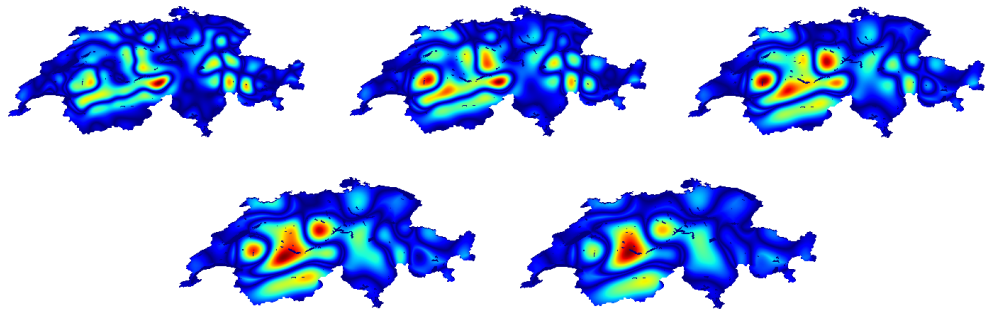

FIG. G.4:   As in Fig. F.3 for the 1990 census.

FIG. G.5:   As in Fig. F.4 for the 1990 census.

28

Appendix H: Bern/Jura violence

Unique in Switzerland in recent decades, the violence in the area of Bern/Jura based on linguistic conflict included targeted arson and bombings and a violent encounter between demonstrators. We performed an analysis of the correlation of reported violence with the location of highest propensity calculated by the theory, which is reduced by local geography compared to what would be expected without it. The resulting correlation is greater than 0.95. We note that the difficulty in relieving the conflict in the northern area of Bern is consistent with an expectation that political boundaries are used for inter-religious rather than inter-lingual conflict, for which purpose they may not be as well adapted.

Specific events, listed by location:

Glovelier - March 24, 1961, arson against a military arsenal. [H:1]; July 16, 1972, explosion of a military arsenal. [H:2] (`http://www.bijube.ch/page-7207.html`)

Les Auges - October 21, 1962, arson against a military barracks. [H:3] (`http://www.bijube.ch/page-6210.html`)

Bourrignon - March 26, 1963, arson against a military barracks. [H:3] (`http://www.bijube.ch/page-6303.html`)

Genevez - April 28, 1963, arson against a farm. [H:3] (`http://www.bijube.ch/page-6304.html`)

Montfaucon - July 18, 1963, arson against a farm. [H:3] (`http://www.bijube.ch/page-6307.html`)

Mont-Soleil - October 5, 1963, a house bombing against a leader of an anti-separatist group. [H:3,4] (`http://www.bijube.ch/page-6310.html`)

Malleray - December 23, 1963, a bombing of a property of an anti-separatist group leader. [H:3]; October 20, 1987, arson against a shooting range. [H:5] (`http://www.bijube.ch/page-6312.html`, `http://www.bijube.ch/page-8509.html`)

Studen - February 27, 1964, bombing of a railway line. [H:3,S8:6] (`http://www.bijube.ch/page-6402.html`)

Delemont - March 12, 1964, bombing of a branch of the Cantonal Bank of Berne. [H:3] ; March 4, 1966, government administration building attacked. [H:1] (`http://www.bijube.ch/page-6403.html`)

Saignelégier - November 20, 1965, arson against a hotel. [H:1]; On October 1, 1987,

explosion of a munitions depot. [H:7] (http://www.bijube.ch/page-6511.html, http://www.bijube.ch/page-8710.html)

Mont-Crosin - May 29, 1966, arson against a hotel. [H:1] (http://www.bijube.ch/page-6605.html)

Cortébert - March 16, 1980, violent fighting between separatists and anti-separatists with stones, firecrackers, and flare guns. Demonstrators on both sides were injured. [H:8] (http://www.bijube.ch/page-8003.html)

Moutier - September 4, 1985 bombing of the district court. [H:9] (http://www.bijube.ch/page-8509.html)

Reussilles - September 11 and 23, 1993, arson against a munitions depot. [H:7,H:5]

Perrefitte - October 21, 1987, bombing of a shooting range. [H:5] (http://www.bijube.ch/page-8710.html)

Büren - April 5, 1989, arson against a historic wooden bridge. [H:10] (http://www.bijube.ch/page-8509.html)

Montbautier - May 24, 1992, arson against a German-language school, previously vandalized. [H:11]

Courtelary - January 7, 1993, bombing of a house of an anti-separatist. [H:12,S8:13] (http://www.bijube.ch/page-9301.html

Berne - January 7, 1993, premature explosion of a bomb in a car killing one person. [H:13] (http://www.bijube.ch/page-9301.html)

References:

[H:1] "Les incendiaires ont avoué," Journal de Genve, July 6, 1966.

[H:2] "Le FLJ fait sauter un dépôt de munitions de l'armée," Journal de Genve, July 17, 1972.

[H:3] "De l'incendie à l'explosion en passant par les menaces," Gazette de Lausanne, October 13, 1965.

[H:4] "Plastic contre la villa d'un dirigeant UPJ," Gazette de Lausanne, October 7, 1963.

[H:5] "La série des attentats s'allonge," Journal de Genve, October 22, 1987.

[H:6] "Le Sabotage du FLJ serait confirmé," Gazette de Lausanne, March 4, 1964.

[H:7] "Dépôt de munitions détruit à Saignelégier," Journal de Genve, October 2, 1987.

[H:8] "Cortébert: violents incidents entre séparatists et pro-bernois," Gazette de Lausanne, March 17, 1980.

[H:9] "Enormes dégâts à Moutier," Gazette de Lausanne, September 4, 1985.

[H:10] "Le pont historique de Büren incendié," Gazette de Lausanne, April 6, 1989.

[H:11] "Les flammes ravagent une école du Jura bernois,"Le Nouveau Quotidien, May 26, 1992.

[H:12] "Deux explosions, dont une mortelle dans le canton de Berne," Gazette de Lausanne, January 8, 1993.

[H:13] "Retour tragique des poseurs de bombes jurassiens," Le Nouveau Quotidien, January 8, 1993.

Appendix I: Yugoslavia

Figures showing the correlation of predicted and reported violence for the former Yugoslavia without administrative or topographical boundaries (Fig. I.1) with administrative boundaries (Fig. I.2) and with topographical boundaries (Fig. I.3).

We also provide a similar analysis of the former Yugoslavia including Macedonia and Slovenia, without (Fig. I.4) and with (Fig. I.5) political boundaries. Without political boundaries the agreement of predicted and reported violence is dramatically reduced.
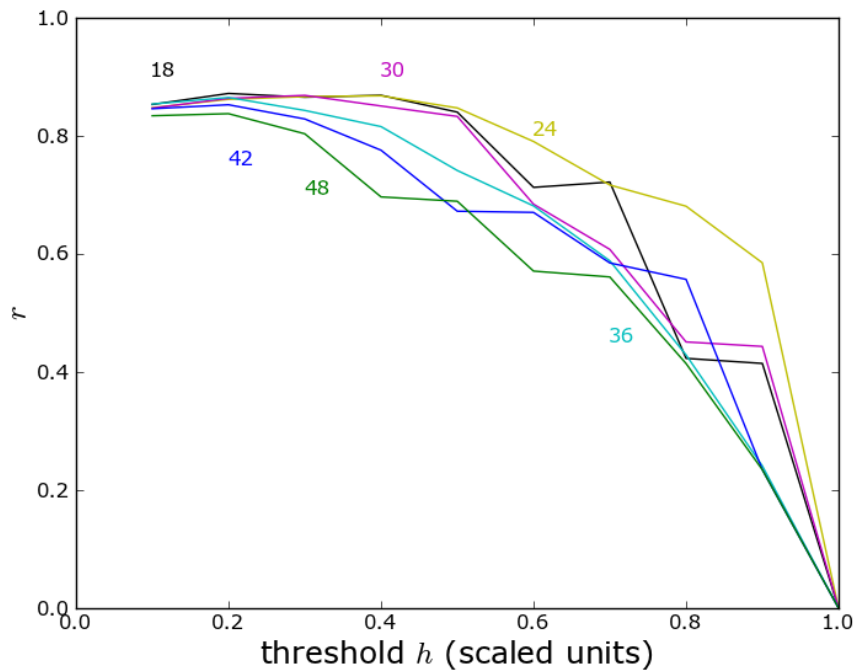

FIG. I.1: Correlation of proximity maps of predicted and reported violence in Yugoslavia without topographical or political boundaries, as a function of threshold for violence divided by the maximum propensity for violence. Each curve is labelled by the characteristic length (km). (Compare with Figure S4.3 in Ref. [14].)
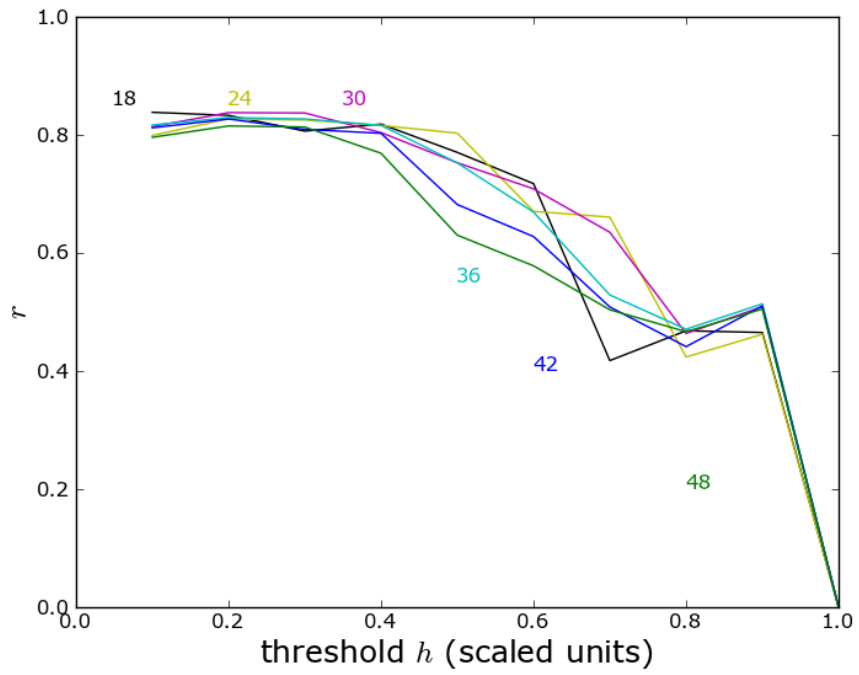
FIG. I.2: As in Fig. I.1 but including the effects of administrative boundaries.
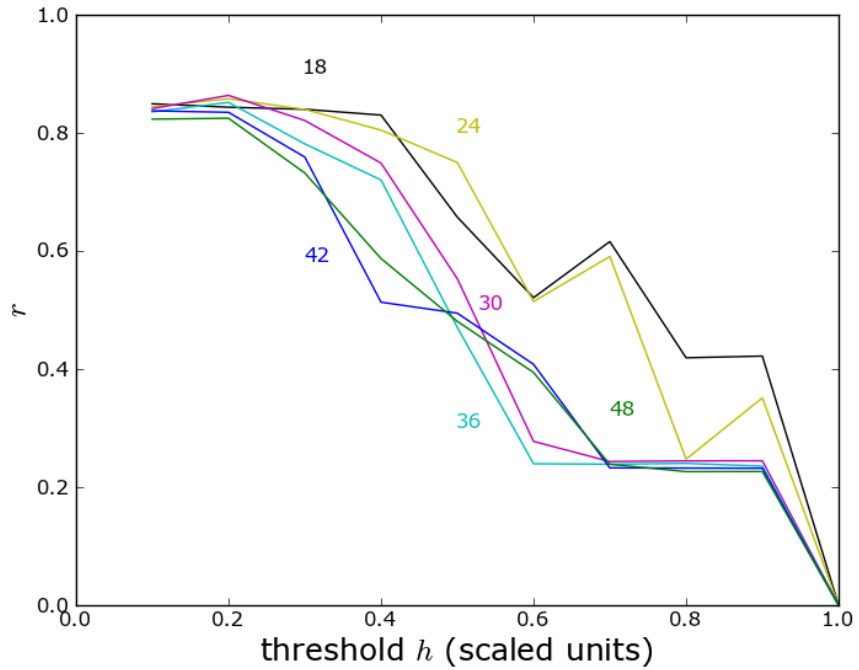

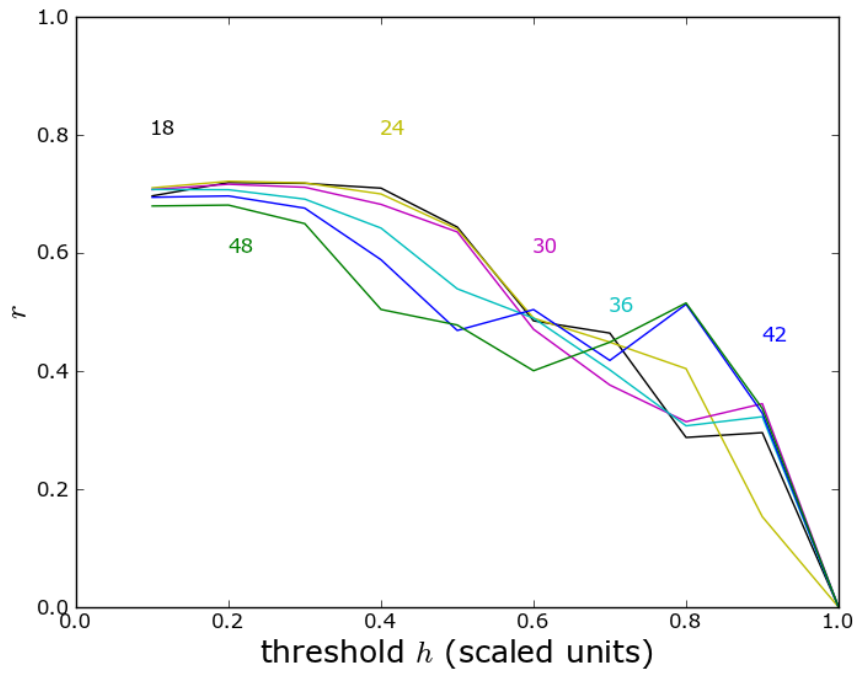FIG. I.3: As in Fig. I.1 but including topographical boundaries.

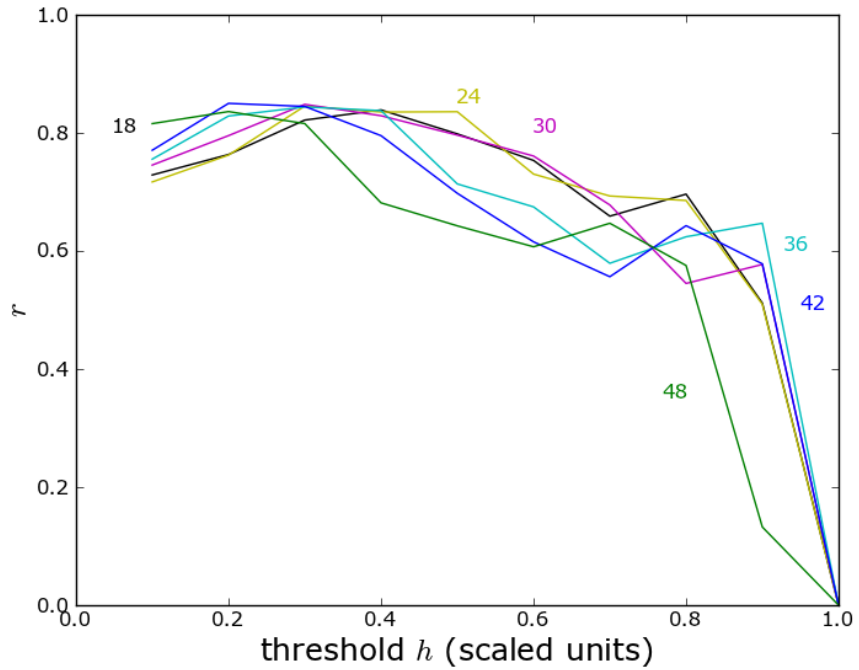FIG. I.4: As in Fig. I.1, but including Slovenia and Macedonia.

FIG. I.5: As in Fig. I.4 but including the effect of political boundaries.

Appendix J: Expanded bibliography on ethnic conflict

In recent years there have been increasing efforts to understand the causes and enabling conditions for civil war and ethnic conflict. The attached bibliography [J:1–118] expands on citations included in the main text and in supplementary materials of Ref. [14]. These efforts include examinations of geography and other structures within countries [J:18–50] as well as the effects of transnational geography [J:51–67]. Extensive analysis explores the role of political structures, particularly federalism, in enabling or preventing civil and ethnic conflict [J:68–89]. Research has begun to include quantitative studies and modeling to understand human behavior and conflict [J:90–94]. A body of research examines Switzerland regarding the presence or absence of tensions and possible causes [J:95–118].

References:

[J:1] P. Collier, A. Hoeffler, "Greed and grievance in civil war," Policy Research Working Paper 2355, The World Bank Development Research Group (2000).

[J:2] P. Collier, A. Hoeffler, D. Rohner, Beyond greed and grievance: feasibility and civil war. Oxford Econ. Papers 61, 1, 1–27 (2009).

[J:3] P. Collier, D. Rohner, Democracy, Development, and Conflict. J. European Econ. Assoc. 6, 2–3, 531–540 (2008).

[J:4] K. Eck, L. Hultman, One-sided violence against civilians in war: Insights from new fatality data. J. Peace Res. 44, 2, 233–246 (2007).

[J:5] J. Esteban, D. Ray, Polarization, fractionalization and conflict. J. Peace Res. 45, 2, 163–182 (2008).

[J:6] J. Esteban, G. Schneider, Polarization and conflict: Theoretical and empirical issues. J. Peace Res. 45, 2, 131–141 (2008).

[J:7] T. R. Gurr, Ethnic warfare on the wane. Foreign Affairs 79, 3, 52–64 (2000).

[J:8] J. G. Kellas, The Politics of Nationalism and Ethnicity (St. Martin's Press, New York, NY, ed. 2, 1998).

[J:9] I. Lustick, Stability in deeply divided societies: Consociationalism versus control. World Politics 31, 3, 325–344 (1979).

[J:10] J. McGarry, B. O'Leary, Eds., The Politics of Ethnic Conflict Regulation: Case Studies of Protracted Ethnic Conflicts (Routledge, New York, NY, 1993).

[J:11] A. Rabushka, K. A. Shepsle, Politics in Plural Societies: A Theory of Democratic Instability (Merrill, Columbus, OH, 1972).

[J:12] N. Rost, G. Schneider, J. Kleibl, A global risk assessment model for civil wars. Social Sci. Res. 38, 4, 921–933 (2009).

[J:13] S. M. Saideman, D. J. Lanoue, M. Campenni, S. Stanton, Democratization, political institutions, and ethnic conflict: A pooled time-series analysis, 1985–1998. Comparative Political Studies 35, 1, 103–129 (2002).

[J:14] N. Sambanis, What is civil war? Conceptual and empirical complexities of an operational definition. J. Conflict Res. 48, 6, 814–858 (2004).

[J:15] J. Snyder, From Voting to Violence: Democratization and Nationalist Conflict (Norton, New York, NY, 2000).

[J:16] E. Spolaore, Civil conflict and secessions. Economics of Governance 9, 1, 45–63 (2008).

[J:17] A. Wimmer, Who owns the state? Understanding ethnic conflict in post-colonial societies. Nations and Nationalism 3, 4, 631–665 (1997).

[J:18] A. Alesina, R. Baqir, C. Hoxby, Political jurisdictions in heterogeneous communities. J. Political Economy 112, 2 (2004).

[J:19] R. Bhavnani, D. Miodownik, Ethnic polarization, ethnic salience, and civil war. J. Conflict Res. 53, 1, 30–49 (2009).

[J:20] R. Bhavnani, D. Miodownik, J. Nart, REsCape: An Agent-Based Framework for Modeling Resources, Ethnicity, and Conflict. J. Artif. Societies and Social Sim. 11, 27, (2008).

[J:21] R. J. Blimes, The indirect effect of ethnic heterogeneity on the likelihood of civil war onset. J. Conflict Res. 50, 4, 536–547 (2006).

[J:22] A. Braithwaite, MIDLOC: Introducing the Militarized Interstate Dispute Location dataset. J. Peace Res. 47, 1, 91–98 (2010).

[J:23] H. Buhaug, L. E. Cederman, J. K. Rd, "Modeling Ethnic Conflict in Center-Periphery Dyads," Paper prepared for presentation at the workshop on "Polarization and Conflict," Nicosia, Cyprus, April 26–29, 2006.

[J:24] H. Buhaug, S. Gates, The Geography of Civil War. J. Peace Res. 39, 4, 417–433 (2002).

[J:25] H. Buhaug, J. K. Rd, Local determinants of African civil wars, 1970–2001. Polit.

Geog. 25, 3, 315–335 (2006).

[J:26] L. E. Cederman, "Articulating the geo-cultural logic of nationalist insurgency," in Order, Conflict, and Violence, S. N. Kalyvas, I. Shapiro, T. Masoud, Eds. (Cambridge University Press, Cambridge, 2008) pp. 242–270.

[J:27] L. E. Cederman, L. Girardin, Beyond fractionalization: Mapping ethnicity onto nationalist insurgencies. Am. Pol. Sci. Rev. 101, 1, 173–185 (2007).

[J:28] L. E. Cederman, L. Girardin, "Toward realistic computational models of civil wars," Paper prepared for presentation at the Annual Meeting of the American Political Science Association, held in Chicago, August 30–September 2, 2007.

[J:29] L. E. Cederman, L. Girardin, K. S. Gleditsch, Ethnonationalist triads: Assessing the influence of kin groups on civil wars. World Politics 61, 3, 403–437 (2009).

[J:30] L. E. Cederman, K. S. Gleditsch, Introduction to Special Issue on "Disaggregating Civil War." J. Conflict Res. 53, 4, 487–495 (2009).

[J:31] L. E. Cederman, J. K. Rd, N. B. Weidmann, "Geo-referencing of ethnic groups: Creating a new dataset," Prepared and presented at the GROW Workshop, Peace Research Institute Oslo (PRIO), February 10–11, 2006.

[J:32] L. E. Cederman, A. Wimmer, B. Min, Why do ethnic groups rebel? New data and analysis. World Politics 62, 1, 87–119 (2010).

[J:33] S. Chojnacki, N. Metternich, "Event Data Project on Conflict and Security (EDACS) in Areas of Limited Statehood," Coding Manual Version 1.3. (published 2007, download: http://www.polsoz.fu-berlin.de/polwiss/forschung/international/ frieden/publikationen/C4_Coding_Manual_1_3.pdf, November 9, 2010).

[J:34] C. Cioffi-Revilla, M. Rouleau, MASON RebeLand: An Agent-Based Model of Politics, Environment, and Insurgency. International Stud. Rev. 12, 1, 31–52 (2010).

[J:35] D. Cunningham, K. S. Gleditsch, I. Salehyan, It takes two: A dyadic analysis of civil war duration and outcome. J. Conflict Res. 53, 4, 570–597 (2009).

[J:36] H. Dorussen, "Introducing PKOLED: A peacekeeping operations location and event dataset," Paper presented at the conference Disaggregating the Study of Civil War and Transnational Violence, University of Essex, November 24–25, 2007.

[J:37] M. Findley, P. Rudloff, "Combatant fragmentation and the dynamics of civil wars," American Political Science Association 2009 Toronto Annual Meeting Paper (published 2009, download: http://ssrn.com/abstract=1450036, November 9, 2010).

[J:38] M. Findley, J. K. Young, S. M. Shellman, "Modeling Dynamic Violence: Integrating Events, Data Analysis and Agent-Based Modeling," American Political Science Association 2010 Annual Meeting paper (published 2010, download: http://ssrn.com/abstract=1642577, November 9, 2010).

[J:39] A. Geller, S. Moss, Growing qawm: An evidence-driven declarative model of Afghan power structures. Adv. Complex Syst. 11, 2, 321–335 (2008).

[J:40] A. S. Mahmud, The creation of multi-ethnic nations with or without a core region. Public Choice (2010, download: http://www.springerlink.com/content/vg13k3264q21362r/, January 18, 2011).

[J:41] H. Meadwell, Spatial models of secession-proofness and equilibrium size. Quality & Quantity (2010, download: http://www.springerlink.com/content/0m1kw18015265504/, January 18, 2011).

[J:42] C. Raleigh, H. Hegre, Population size, concentration, and civil war. A geographically disaggregated analysis. Polit. Geog. 28, 4, 224–238 (2009).

[J:43] J. K. Rd, H. Buhaug, "Civil Wars: Prospects and Problems with the Use of Local Indicators," Proceedings, ScanGIS 2007, 212–225 (2007).

[J:44] S. M. Shellman, Coding disaggregated intrastate conflict: Machine processing the behavior of substate actors over time and space. Polit. Anal. 16, 4, 464–477 (2008).

[J:45] J. Tir, Dividing countries to promote peace: Prospects for long-term success of partitions. J. Peace Res. 42, 5, 545–562 (2005).

[J:46] N. B. Weidmann, "From sparks to prairie fires: spatial mechanisms of group mobilization," Paper prepared for presentation at the Annual Meeting of the American Political Science Association in Chicago, August 30–September 2, 2007 and at the Sixth PanEuropean Conference on International Relations in Torino, September 12–15, 2007.

[J:47] N. B. Weidmann, "Geographic group fragmentation and civil peace," Paper presented at the conference Disaggregating the Study of Civil War and Transnational Violence, University of Essex, November 24–25, 2007.

[J:48] N. B. Weidmann, Geography as motivation and opportunity: Group concentration and ethnic conflict. J. Conflict Res. 53, 4, 526–543 (2009).

[J:49] N. B. Weidmann, D. Kuse, WarViews: Visualizing and animating geographic data on civil war. International Stud. Perspectives, 10, 1, 36–48 (2009).

[J:50] W. Yu, D. Helbing, "Game theoretical interactions of moving agents," in Simulating

Complex Systems by Cellular Automata, vol. 0/2010 of Understanding Complex Systems A. G. Hoekstra, et al. Eds. (Springer-Verlag, Berlin Heidelberg, 2010) ch. 10, 219–239.

[J:51] A. T. Bohlken, E. J. Sergenti, Economic growth and ethnic violence: An empirical investigation of Hindu–Muslim riots in India. J. Peace Res. 47, 5, 589–600 (2010).

[J:52] A. Braithwaite, Resisting infection: How state capacity conditions conflict contagion. J. Peace Res. 47, 3, 311–319 (2010).

[J:53] H. Buhaug, S. Gates, P. Lujala, Geography, rebel capability, and the duration of civil conflict. J. Conflict Res. 53, 4, 544–569 (2009).

[J:54] H. Buhaug, K. S. Gleditsch, Contagion or confusion? Why conflicts cluster in space. International Stud. Quarterly 52, 2, 215–233 (2008).

[J:55] N. F. Campos, V. S. Kuzeyev, On the dynamics of ethnic fractionalization. Am. J. of Pol. Sci. 51, 3, 620–639 (2007).

[J:56] J. D. Fearon, K. Kasara, D. D. Laitin, Ethnic minority rule and civil war onset. Am. Pol. Sci. Rev. 101, 1, 187–193 (2007).

[J:57] E. Forsberg, Polarization and ethnic conflict in a widened strategic setting. J. Peace Res. 45, 2, 283–300 (2008).

[J:58] D. Gerritsen, Unknown is unloved? Diversity and inter-population trust in Europe. European Union Politics 11, 2, 267–287 (2010).

[J:59] K. S. Gleditsch, Transnational dimensions of civil war. J. Peace Res. 44, 3, 293–309 (2007).

[J:60] H. Hegre, M. Nome, "Democracy, development, and armed conflict," APSA 2010 Annual Meeting Paper (2010).

[J:61] G. stby, Polarization, horizontal inequalities and violent civil conflict. J. Peace Res. 45, 2, 143–162 (2008).

[J:62] G. stby, R. Nords, J. K. Rd, "Regional inequalities and civil conflict in 21 subSaharan African countries, 1986–2004," Prepared for presentation at the workshop Polarization and Conflict, Nicosia, Cyprus, 26–29 April 2006.

[J:63] M. Ross, Michael, A closer look at oil, diamonds, and civil war. Annu. Rev. Poli. Sci. 9, 265–300 (2006).

[J:64] H. Strand, "Onset of armed conflict: A new list for the period 1946–2004, with applications," in Reassessing the Civil Democratic Peace, Ph.D. thesis, Department of Political Science, University of Oslo & Centre for the Study of Civil War, PRIO (2006).

[J:65] N. B. Weidmann, J. K. Rd, L. E. Cederman, Representing ethnic groups in space: A new dataset. J. Peace Res. 47, 4, 491–499 (2010).

[J:66] A. Wimmer, L. E. Cederman, B. Min, "Ethnic politics and violent conflicts, 1946–2005: A configurational approach," Paper presented at the conference Disaggregating the Study of Civil War and Transnational Violence, University of Essex, November 24–25, 2007.

[J:67] A. Wimmer, L. E. Cederman, B. Min, Ethnic politics and armed conflict: A configurational analysis of a new global data set. Am. Soc. Rev. 74, 2, 316–337 (2009).

[J:68] E. Aleman, D. Treisman, "Fiscal politics in ethnically mined,' developing, federal states: central strategies and secessionist violence," in Sustainable Peace: Power and Democracy After Civil Wars, P. G. Roeder, D. Rothchild, Eds. (Cornell University Press, Ithaca, 2005) 173–216.

[J:69] U. M. Amoretti, N. Bermeo, Eds. Federalism and Territorial Cleavages (Johns Hopkins University Press, Baltimore, MD, 2004).

[J:70] K. M. Bakke, "Peace-promoting versus peace-preserving federalism?" Paper presented at the annual meeting of the International Studies Association, San Diego, California, March 22, 2006.

[J:71] K. M. Bakke, E. Wibbels, Diversity, disparity, and civil conflict in federal states. World Politics 59, 1, 1–50 (2006).

[J:72] D. Brancati, Can federalism stabilize Iraq? The Washington Quarterly 27, 2, 7–21 (2004).

[J:73] D. Brancati, Decentralization: Fueling the fire or dampening the flames of ethnic conflict and secessionism? International Organization 60, 3, 651–685 (2006).

[J:74] T. Christin, S. Hug, "Federalism, the geographic location of groups, and conflict," Center for Comparative and International Studies, ETH Zurich and University of Zurich (2006).

[J:75] F. S. Cohen, Proportional versus majoritarian ethnic conflict management in democracies. Comp. Political Studies 30, 5, 607–630 (1997).

[J:76] R. D. Congleton, "A political efficiency case for federalism in multinational states: Controlling ethnic rent-seeking," in Competition and Structure: The Political Economy of Collective Decisions: Essays in Honor of Albert Breton, G. Galeotti, P. Slamon, R. Wintrobe, Eds. (Cambridge University Press, New York, NY, 2000), pp. 284–308.

[J:77] H. E. Hale, Divided we stand: Institutional sources of ethnofederal state survival

and collapse. World Politics 56, 2, 165–193 (2004).

[J:78] C. A. Hartzell, Explaining the stability of negotiated settlements to intrastate wars. J. Conflict Res. 43, 1, 3–22 (1999).

[J:79] S. Hug, "Conflict and federal arrangements," Paper presented at the annual meeting of the International Studies Association, San Diego, California, March 22, 2006.

[J:80] C. Johnson, "Federalism and secession under conditions of civil war," Paper presented at the annual meeting of the International Studies Association, San Diego, California, March 22, 2006.

[J:81] D. A. Lake, D. Rothchild, "Territorial decentralization and civil war settlements," in Sustainable Peace: Power and Democracy After Civil Wars, P. G. Roeder, D. Rothchild, Eds. (Cornell University Press, Ithaca, London, 2005) pp. 109–132.

[J:82] J. McGarry, B. O'Leary, "Federation as a method of ethnic conflict regulation," in From Power Sharing to Democracy: Post-Conflict Institutions in Ethnically Divided Societies, S. Noel, Ed. (McGill-Queen's University Press, Montreal, 2005) ch. 13, pp. 263–296.

[J:83] E. A. Nordlinger, Conflict Regulation in Divided Societies (Center for International Affairs, Harvard University, Cambridge, MA, 1972).

[J:84] A. Rabushka, K. A. Shepsle, Politics in Plural Societies: A Theory of Democratic Instability (Merrill, Columbus, OH, 1972).

[J:85] A. Schou, M. Haug, "Decentralisation in conflict and post-conflict situations," NIBR Working Paper: 2005:139.

[J:86] E. Spolaore, "Federalism, regional redistribution, and country stability," Prepared for the 5th Symposium on Fiscal Federalism "Regional fiscal flows, balance-sheet federalism, and the stability of federations," IEB-IEA, Barcelona, June 19–20, 2008.

[J:87] A. Stepan, Federalism and democracy: Beyond the U.S. model. J. Democracy 10, 4, 19–34 (1999).

[J:88] R. L. Watts, Federalism, federal political systems, and federations. Annu. Rev. Poli. Sci. 1, 117–137 (1998).

[J:89] E. Wibbels, Madison in Baghdad? Decentralization and federalism in comparative politics. Annu. Rev. Poli. Sci. 9, 165–188 (2006).

[J:90] J. C. Bohorquez, S. Gourley, A. R. Dixon, M. Spagat, N. F. Johnson, Common ecology quantifies human insurgency. Nature 462, 911–914 (2009).

[J:91] H. Hegre, N. Sambanis, Sensitivity analysis of empirical results on civil war onset. J. Conflict Res. 50, 4, 508–535 (2006).

[J:92] L. Luo, N. Chakraborty, K. Sycara, Modeling ethno-religious conflicts as prisoner's dilemma game in graphs. International Conference on Computational Science and Engineering 4, 442–449 (2009).

[J:93] I. S. Lustick, D. Miodownik, Abstractions, ensembles, and virtualizations: simplicity and complexity in agent-based modeling. Comparative Politics 41, 2, 223–244 (2009).

[J:94] D. R. White, "Dynamics of human behavior," in Encyclopedia of Complexity and Systems Science, R. A. Meyers, Ed.-in-chief (Springer-Verlag, Berlin, Heidelberg, 2009).

[J:95] C. H. Church, Switzerland: a paradigm in evolution. Parliam. Aff. 53, 1, 96–113 (2000).

[J:96] J. Dunn, "Consociational democracy" and language conflict: A comparison of the Belgian and Swiss experiences. Comparative Political Studies 5, 1 (1972).

[J:97] U. Dürmüller, Swiss multilingualism and intranational communication. Sociolinguistica 5, 111–159 (1991).

[J:98] M. J. Esman, Ed. Ethnic Conflict in the Western World (Cornell University Press, Ithaca, NY, 1977).

[J:99] H. E. Glass, Ethnic diversity, elite accommodation and federalism in Switzerland. Publius 7, 4, Federalism and Ethnicity 31–48 (1977).

[J:100] R. C. Head, Catholics and Protestants in Graubünden: Confessional discipline and confessional identities without an early modern state? German History 17, 3, 321–345 (1999).

[J:101] D. L. Horowitz, Ethnic Groups in Conflict (University of California Press, Berkeley, Los Angeles, CA, 1985).

[J:102] R. S. Katz, Dimensions of partisan conflict in Swiss cantons. Comp. Political Stud. 16, 4, 505–527 (1984).

[J:103] W. R. Keech, Linguistic diversity and political conflict: Some observations based on four Swiss cantons. Comp. Politics 4, 3, 387–404 (1972).

[J:104] A. Lijphart, Democracy in Plural Societies: A Comparative Exploration (Yale University Press, New Haven and London, 1977).

[J:105] W. Linder, Swiss Democracy: Possible Solutions to Conflict in Multicultural Societies (Macmillan Press, New York, ed. 2, 1998).

[J:106] K. D. McRae, Conflict and Compromise in Multilingual Societies: Switzerland (Wilfrid Laurier University Press, Waterloo, Ontario, Canada, 1983).

[J:107] L. Pap, The language situation in Switzerland: An updated survey. Lingua 80, 2–3, 109–148 (1990).

[J:108] W. E. Rappard, Federalism in Switzerland. Parliam. Aff. IV, 2, 236–244 (1950).

[J:109] L. Ruttan, M. Franzen, R. Bettinger, P. J. Richerson, "Ethnic Interactions: Analysis of a Sample of Boundaries," (2006, download: http://www.des.ucdavis.edu/faculty/Richerson/Ethnicity%208-11-06%20for%20pdf.pdf, November 11, 2010).

[J:110] C. L. Schmid, Conflict and Consensus in Switzerland (University of California Press, Berkeley and London, 1981).

[J:111] J. Steinberg, Why Switzerland? (Cambridge University Press, Cambridge, UK, ed. 2, 1996).

[J:112] P. Stevenson, Political Culture and Intergroup Relations in Plurilingual Switzerland. J. Multilingual and Multicultural Development 11, 3, 227–255 (1990).

[J:113] N. Stojanovic, "The idea of a Swiss nation: A critique of Will Kymlicka's account of multination states," M.A. Thesis, McGill University Department of Political Science (2000, download: http://www.nenadstojanovic.ch/testi%20scientifici/M.A.%20Thesis%20-%20final%20version.pdf, November 11, 2010).

[J:114] D. Welsh, Domestic politics and ethnic conflict. Survival 35, 1, 63–80 (1993).

[J:115] A. S. Wilner, The Swiss-ification of ethnic conflict: Historical lessons in nation-building from the Swiss example. Federal Governance 5/6, 2010).

[J:116] F. Rash, The German-Romance language borders in Switzerland. J. Multilingual and Multicultural Development 23, 1/2, 112–136 (2002).

[J:117] P. Stevenson, Political culture and intergroup relations in plurilingual Switzerland. J. Multilingual and Multicultural Development 11, 3, 227–255 (1990).

[J:118] O. Zimmer, A Contested Nation: History, Memory and Nationalism in Switzerland, 1761–1891 (Cambridge University Press, Cambridge and New York, 2007).