Supplemental Appendix:
"Denial and Punishment in the North Caucasus"

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Contents

1 Conflict Diffusion Literature List

Tables 1-3 show a list of 90 most widely-cited articles on conflict diffusion, mentioned in Footnote 1 of the manuscript. To be included, the articles had to be published in a major peer-reviewed political science journal between 1980 and 2011 and listed in the Web of Science, Social Science Citation Index and/or Google Scholar. For each article, we indicate its level of analysis (cross-national or subnational) and the type of conflict analyzed (interstate war, civil war and insurgency, terrorism, revolutions and protests). The list excludes disaggregated studies of conflict, which do not directly address the question of how violence spreads (e.g. Kalyvas 2006, Lyall 2009).

Of the 90 articles, 77 are on the cross-national level and only indirectly address the dynamics of state responses to insurgency. Of 13 subnational studies on the list, 7 disaggregate conflict events by combatant (Saxton 2005; Saxton and Benson 2008; Townsley et al. 2008; O'Loughlin and Witmer 2011; O'Loughlin et al. 2010a, b, O'Loughlin et al. 2011). None explores state coercion directly.

Table 1: **Conflict Diffusion Literature** (part 1 of 3)

Year	Article	Level of Analysis	Type of Conflict
2011	De Groot (2011)	Cross-National	Ethnic Conflict
2011	Kathman (2011)	Cross-National	Civil War and Insurgency
2011	Murdie and Bhasin (2011)	Cross-National	Revolutions and Protests
2011	O'Loughlin et al. (2011)	Sub-National	Civil War and Insurgency
2011	O'Loughlin and Witmer (2011)	Sub-National	Civil War and Insurgency
2011	Rasler and Thompson (2011)	Cross-National	Interstate War
2011	Schutte and Weidmann (2011)	Sub-National	Civil War and Insurgency
2011	Vasquez et al. (2011)	Cross-National	Interstate War
2010	Braithwaite (2010b)	Cross-National	Civil War and Insurgency
2010	Braithwaite (2010a)	Cross-National	Interstate War
2010	Bunce and Wolchik (2010)	Cross-National	Revolutions and Protests
2010	Kathman (2010)	Cross-National	Civil War and Insurgency
2010	Neumayer and Plumper (2010)	Cross-National	Terrorism
2010	O'Loughlin et al. (2010)a	Sub-National	Civil War and Insurgency
2010	O'Loughlin et al. (2010)b	Sub-National	Civil War and Insurgency
2010	Raleigh et al. (2010)	Sub-National	Civil War and Insurgency
2010	Reed and Chiba (2010)	Cross-National	Interstate War
2010	Weidmann and Toft (2010)	Sub-National	Civil War and Insurgency
2010	Weidmann and Ward (2010)	Sub-National	Civil War and Insurgency
2010	Weyland (2010)	Cross-National	Revolutions and Protests
2009	Cederman et al. (2009)	Cross-National	Ethnic Conflict
2009	Cederman et al. (2009)	Cross-National	Ethnic Conflict
2009	Gartzke and Jo (2009)	Cross-National	Interstate War
2009	Raleigh and Hegre (2009)	Sub-National	Civil War and Insurgency
2009	Weidmann (2009)	Cross-National	Ethnic Conflict
2009	Weyland (2009)	Cross-National	Revolutions and Protests
2009	Wimmer et al. (2009)	Cross-National	Ethnic Conflict

Table 2: **Conflict Diffusion Literature** (part 2 of 3)

Year	**Article**	**Level of Analysis**	**Type of Conflict**
2008	Buhaug and Gleditsch (2008)	Cross-National	Civil War and Insurgency
2008	De Soysa and Neumayer (2008)	Cross-National	Civil War and Insurgency
2008	Forsberg (2008)	Cross-National	Ethnic Conflict
2008	Iqbal and Starr (2008)	Cross-National	Civil War and Insurgency
2008	Salehyan (2008b)	Cross-National	Civil War and Insurgency
2008	Salehyan (2008a)	Cross-National	Civil War and Insurgency
2008	Saxton and Benson (2008)	Cross-National	Revolutions and Protests
2008	Townsley et al. (2008)	Sub-National	Civil War and Insurgency
2008	Urdal (2008)	Sub-National	Civil War and Insurgency
2008	Way (2008)	Cross-National	Revolutions and Protests
2007	Beissinger (2007)	Cross-National	Revolutions and Protests
2007	Braithwaite and Li (2007)	Cross-National	Terrorism
2007	Gleditsch (2007)	Cross-National	Civil War and Insurgency
2007	Ward et al. (2007)	Cross-National	Interstate War
2007	Ward and Hoff (2007)	Cross-National	Interstate War
2006	Beck et al. (2006)	Cross-National	Interstate War
2006	Braithwaite (2006)	Cross-National	Interstate War
2006	Braumoeller (2006)	Cross-National	Interstate War
2006	Dorussen (2006)	Cross-National	Interstate War
2006	Furlong et al. (2006)	Cross-National	Interstate War
2006	Hegre and Sambanis (2006)	Cross-National	Civil War and Insurgency
2006	Salehyan and Gleditsch (2006)	Cross-National	Civil War and Insurgency
2005	Braithwaite (2005)	Cross-National	Interstate War
2005	Saxton (2005)	Sub-National	Revolutions and Protests
2005	Senese (2005)	Cross-National	Interstate War
2005	Starr (2005)	Cross-National	Interstate War
2005	Starr and Thomas (2005)	Cross-National	Interstate War
2005	Tir (2005)	Cross-National	Interstate War
2004	Fox (2004)	Cross-National	Ethnic Conflict
2003	Furlong and Gleditsch (2003)	Cross-National	Interstate War
2003	Leeds (2003b)	Cross-National	Interstate War
2003	Leeds (2003a)	Cross-National	Interstate War
2003	Starr (2003)	Cross-National	Interstate War

Table 3: **Conflict Diffusion Literature** (part 3 of 3)

Year	Article	Level of Analysis	Type of Conflict
2002	Hammarstrom and Heldt (2002)	Cross-National	Interstate War
2002	Starr (2002)	Cross-National	Interstate War
2002	Starr and Thomas (2002)	Cross-National	Interstate War
2002	Ward and Gleditsch (2002)	Cross-National	Interstate War
2001	Cederman (2001)	Cross-National	Interstate War
2001	Gleditsch and Ward (2001)	Cross-National	Interstate War
2001	Hegre et al. (2001)	Cross-National	Civil War and Insurgency
2001	Oneal and Russett (2001)	Cross-National	Interstate War
2000	Bonneuil and Auriat (2000)	Cross-National	Revolutions and Protests
2000	Gleditsch and Ward (2000)	Cross-National	Interstate War
2000	Rasler and Thompson (2000)	Cross-National	Interstate War
1999	Reising (1999)	Cross-National	Revolutions and Protests
1998	Dudley and Miller (1998)	Cross-National	Revolutions and Protests
1998	Enterline (1998a)	Cross-National	Interstate War
1998	Enterline (1998b)	Cross-National	Interstate War
1998	Kadera (1998)	Cross-National	Civil War and Insurgency
1998	Simowitz (1998)	Cross-National	Interstate War
1998	Simowitz and Sheffer (1998)	Cross-National	Interstate War
1998	Starr and Siverson (1998)	Cross-National	Interstate War
1997	Raknerud and Hegre (1997)	Cross-National	Interstate War
1995	Carment and James (1995)	Cross-National	Ethnic Conflict
1994	Hammarstrom (1994)	Cross-National	Interstate War
1993	Gurr (1993)	Cross-National	Civil War and Insurgency
1991	O'Loughlin and Anselin (1991)	Cross-National	Interstate War
1990	Most and Starr (1990)	Cross-National	Interstate War
1990	Siverson and Starr (1990)	Cross-National	Interstate War
1985	Starr and Most (1985)	Cross-National	Interstate War
1983	Starr and Most (1983)	Cross-National	Interstate War
1982	Bremer (1982)	Cross-National	Interstate War
1980	Most and Starr (1980)	Cross-National	Interstate War

2 The Epidemic Model

2.1 Proof of the stability of equilibrium solutions

Recall that the epidemic model of conflict diffusion and containment is represented by the following system of differential equations:

$$\dot{V} = (\beta - d)VC - (\alpha + p)V \tag{1}$$
$$\dot{C} = -(\beta - d)VC + (\alpha + p)V \tag{2}$$

where

- V = proportion of units experiencing insurgent violence at t,
- C = proportion of units experiencing no violence at t,
- $\dot{V}, \dot{C}$ = time derivatives of V, C,
- β = rate of transmissibility in the absence of denial,
- α = rate of recovery in the absence of punishment,
- d = offsetting impact of denial on transmissibility,
- p = offsetting impact of punishment on recovery.

The system can be solved for the following equilibria

$$\text{(non-violent equilibrium)} \quad V_{eq} = 0 \qquad C_{eq} = 1 \tag{3}$$
$$\text{(violent equilibrium)} \quad V_{eq} = 1 - \frac{\alpha + p}{\beta - d} \qquad C_{eq} = \frac{\alpha + p}{\beta - d} \tag{4}$$

The Jacobian matrix of the system is

$$\mathbf{J} = \begin{pmatrix} -(\alpha + p) + (\beta - d)C & (\beta - d)V \\ (\alpha + p) - (\beta - d)C & -(\beta - d)V \end{pmatrix} \tag{5}$$

We also define the basic reproduction number R_0

$$R_0 = \frac{\beta - d}{\alpha + p} \tag{6}$$

The equilibria in (3, 4) are neutrally stable if $det(\mathbf{J}) \geq 0$ and $tr(\mathbf{J}) \leq 0$, when $\mathbf{J}$ is evaluated at the corresponding equilibrium values of V and C. The stability condition holds for the non-violent equilibrium as long as $\alpha + p > \beta - d$ (or $R_0 < 1$), and for the violent equilibrium as long as $\alpha + p < \beta - d$ (or $R_0 > 1$).

2.2 Derivation of empirical R_0 statistic

We now derive an empirical estimate for the basic reproduction number in (6). Consider a stochastic version of the epidemic model in (1,2). As before, units transition between two mutually exclusive states: violence (V) and non-violence (C). At each time step, a non-violent unit becomes violent with probability $Pr(V|C)$ or remains non-violent with probability $Pr(C|C) = 1 - Pr(V|C)$; a violent unit will experience renewed hostilities with probability $Pr(V|V)$ or transition to non-violence with probability $Pr(C|V) = 1 - Pr(V|V)$.[1]

These probabilities can be used to find a discrete-time approximation to the transmissibility and recovery parameters β, α and the offsetting impact of government countermeasures d, p. Following Mode and Sleeman (2000), we assume that the time length a unit spends in each state is exponentially distributed, with rates specific to each state. The probability of staying in the non-violent state C depends on the transmissibility rate β, the denial actions taken by the government d and the initial proportion of violent units in the system V_0 (a scalar), while the probability of staying in a violent state depends only on the recovery rate α and punishment actions p.

$$\begin{aligned} Pr_{it}(V|V) &= \exp\big(-(\alpha_{it} + p_{it})\big) \quad Pr_{it}(C|V) = 1 - \exp\big(-(\alpha_{it} + p_{it})\big) \\ Pr_{it}(V|C) &= 1 - \exp\big(-(\beta_{it} - d_{it})V_0\big) \quad Pr_{it}(C|V) = 1 - \exp\big(-(\beta_{it} - d_{it})V_0\big) \end{aligned} \tag{7}$$

These equations are solved to find an estimate of the reproduction number R_0,

$$\begin{aligned} \hat{R}_0 &= V_0^{-1} \frac{\ln\big(Pr(C|C)\big)}{\ln\big(Pr(V|V)\big)} \\ &\propto \log_{Pr(V|V)} Pr(C|C) \end{aligned} \tag{8}$$

where Pr(C|C) is the mean predicted probability of continuing non-violence and Pr(V|V) is the mean predicted probability of continuing insurgent violence.

2.3 Empirical model: Markov Chain with spatial spline

We now describe the statistical model used to fit the regressions and calculate the transition probabilities in (7) and (8). Following Amemiya (1985) and Jackman (2000), a logit link function was used to estimate the transition probabilities reported in the paper. The probability that a peaceful village i transitions to violence between times t and $t+1$ is expressed as

$$Pr_{i,t}(C|V) = Pr(y_{i,t+1} = 1 | y_{i,t} = 0, \mathbf{x}_{i,t}) = \text{logit}^{-1}(\mathbf{x}_{i,t}\theta_C) \tag{9}$$

and the probability that a violent village remains violent is

$$Pr_{i,t}(V|V) = Pr(y_{i,t+1} = 1 | y_{i,t} = 1, \mathbf{x}_{i,t}) = \text{logit}^{-1}(\mathbf{x}_{i,t}\theta_V) \tag{10}$$

[1] At the unit level, these probabilities take the form of individual Bernoulli trials, which most conventional stochastic epidemic models like Greenwood and Reed-Frost assume to be independent and identical for all units and time periods. We loosen these assumptions here due to the interdependent and highly variable nature of political violence – some villages may be more likely to transition than others due to a host of regional and local risk factors. The quantities of interest thus change from population-level transition probabilities $Pr(\cdot)$ to $Pr_{it}(\cdot)$, where i indexes the spatial unit and t indexes the time step.

where $y_{i,t} = 1$ indicates that location i is experiencing insurgent violence at time t, and $y_{i,t} = 0$ otherwise. θ_C and θ_V are sets of regression coefficients that capture the conditional effects of the covariates $\mathbf{x}$ under the two possible current states. These equations are reduced to

$$Pr_{i,t}(V) = Pr(y_{i,t+1} = 1|\mathbf{x}_{i,t}) = \text{logit}^{-1}(\mathbf{x}_{i,t}\theta_C + y_{i,t}\mathbf{x}_{i,t}\gamma) \tag{11}$$

where $\theta_V = \theta_C + \gamma$. Finally, the expression in (5) is used as the parametric portion of a GAM model

$$Pr_{i,t}(V) = \text{logit}^{-1}\big(\mathbf{x}_{i,t}\theta_C + y_{i,t}\mathbf{x}_{i,t}\gamma + f(\text{Long}_i, \text{Lat}_i)\big) \tag{12}$$

where $f(\text{Long}_i, \text{Lat}_i)$ is a thin-plate regression spline of the geographic coordinates of village i.

GAMs assume that the mean of the dependent variable ($E[Y_{i,t}] = \mu_{i,t}$) depends on an additive predictor through a link function $g(\mu_{i,t})$, and that the linear predictor can include parametric model components and an unknown nonparametric smooth function $f()$:

$$E[\text{Y}_{i,t}] = \mu_{i,t} = g^{-1}(X^{*\prime}_{i,t}\beta + f(\text{Long}_i, \text{Lat}_i)\big) \tag{13}$$

where $X^*_{i,t}$ is the i,tth row of the model matrix for the strictly parametric model components, and $f(\text{Long}_i, \text{Lat}_i)$ is a thin-plate regression spline of the geographic coordinates of village i.

Thin-plate splines (Duchon, 1977; Wood, 2003) estimate f by minimizing

$$||\mathbf{y} - \mathbf{f}|| + \lambda J_{md}(f) \tag{14}$$

where $\mathbf{y}$ is a vector of y_i's, $\mathbf{f} = |f(\mathbf{x}_1), \ldots, f(\mathbf{x}_n)|'$, $\mathbf{x}$ is an $n \times d$ matrix of predictors (in this case, longitude and latitude), $||.||$ is the Euclidean norm, λ is a smoothing parameter, and J_{md} is a "wiggliness penalty" for f, defined as

$$J_{md} = \int \cdots \int_{\mathcal{R}_d} \sum_{\nu_1 + \cdots + \nu_d = m} \frac{m!}{\nu_1! \ldots \nu_d!} \left(\frac{\partial^m f}{\partial x_1^{\nu_1} \ldots \partial x_d^{\nu_d}} \right)^2 dx_1 \ldots dx_d \tag{15}$$

where m is the order of differentiation, satisfying $2m > d$. In the two predictor case, the wiggliness penalty becomes

$$J_{22} = \int \int \Big(\frac{\partial^2 f}{\partial \text{Long}^2} \Big)^2 + 2 \Big(\frac{\partial^2 f}{\partial \text{Long}^2 \partial \text{Lat}^2} \Big)^2 + \Big(\frac{\partial^2 f}{\partial \text{Lat}^2} \Big)^2 d\text{Long} d\text{Lat} \tag{16}$$

When $\lambda = 0$, the expression in (2) can be treated as a pure regression spline. When $\lambda \neq 0$, the expression becomes a penalized regression spline. λ also governs the model degrees of freedom, and can be selected with criteria like generalized cross-validation or the Akaike information criterion (AIC).

The advantage of thin-plate regression splines is that they avoid the knot placement problems of conventional regression spline modeling, thus reducing the subjectivity of the model fitting process. They also nest smooths of lower rank within smooths of higher rank. GAM models can be estimated in `R` using the `mgcv` package developed by Simon Wood. See Wood (2006) for a detailed discussion of this class of models.

3 North Caucasus Violence Dataset

We use a new dataset of violent incidents in the Russian North Caucasus. The panel dataset is based on monthly observations across 7,584 municipalities in the seven autonomous republics of the North Caucasus, and two adjacent regions (oblasts).[2] The sample of villages and towns is universal, encompassing all populated places within these regions, as listed in the National Geospatial-Intelligence Agency's GEOnet Names Server (GNS). For each month between July 2000 and December 2008, the incidence and number of violent events in each village were measured through automated text mining of the independent Memorial Group's "Hronika nasiliya [Chronicle of Violence]" event summaries (Memorial, 2009). Fuzzy string matching was used to geocode these violent events to the municipalities in sample, so as to account for alternate spellings in Russian and a host of local languages. The dataset includes micro-level information on the dates, geographic coordinates, participants, and casualties of episodes of political violence and other forms of unrest distributed across these villages and towns. To capture the connective topology of the study region, a dynamic network dataset was created, with individual villages as the units (or nodes, in network analysis terms), and road distances as the connections (or edges) between them. The following appendix provides a description of the data collection strategy, coding rules, dynamic road network estimation, aggregation and summary statistics.

3.1 Automated event coding

A few words are in order about the data collection strategy and selection criteria used in support of our analysis. Since the original Memorial data are in raw text format, automated text analysis was used to mine the Memorial timeline for the dates, locations, actors involved, casualty tolls, and types of incidents. The data extraction strategy we employed differs from traditional automated approaches in several ways. First, dictionary-based event coding algorithms typically use parsing techniques or pattern recognition to code incidents in a "who-does-what-to-whom" format, of which category typologies like VRA and TABARI are prime examples (Schrodt and Gerner, 1994; Schrodt, 2001; Gerner et al., 2002; King and Lowe, 2003; Shellman, 2008). We opted for a somewhat simpler approach based on Boolean association rules and indexing algorithms (Han and Kamber 2001, 230-236; Kim et al. 2001). While not appropriate for all applications, this approach is far more efficient for data-mining highly structured event summaries of the sort that comprise the Memorial timeline – where all entries are of approximately the same length (1-2 sentences) and content (date, location, what happenned, who was involved). Second, while various studies have shown that reliance on a single news source in events data analysis can mask important inferences and differences in media reporting, most previous uses of events data have relied on only one news source (Reeves et al., 2006; Davenport and Stam, 2006; Davenport and Ball, 2002). The advantage of Memorial's event summaries is that they compile daily reports from international news wires, Russian state and local newspapers, news websites, radio and television broadcasts, and independent reporters, permitting a diverse approach to corpus building which reduces the risk of reporting bias.[3]

[2] In alphabetical order, the republics are Adygea, Chechnya, Dagestan, Ingushetia, Kabardino-Balkaria, Karachaevo-Cherkessiya, and North Ossetia. The two oblasts are Krasnodar Kray and Stavropol Kray. The dataset includes 7,584 villages $\times 102$ months $= 773{,}568$ village-month observations.

[3] A natural concern with this, like all disaggregated events datasets, is that media are more likely to report incidents located in accessible areas (Raleigh and Hegre, 2009, 234). This problem is addressed somewhat by Memorial's reliance on reports from human rights observers and local independent sources – who benefit from greater access to isolated areas than mass media organization with relatively few local ties.

From these raw data, the Text Mining (`tm`) package in the R statistical language was used to assemble a corpus of 38,789 text documents, perform natural language processing (removing word order and Russian stop words) and create a document-term matrix (Feinerer, 2008; Feinerer et al., 2008). Two custom dictionaries were used to code events and automatically georeference them against the U.S. National Geospatial Intelligence Agency's database of 7,584 municipalities (i.e. cities, towns, villages, and populated places) in the seven North Caucasus Republics (Dagestan, Chechnya, Ingushetia, North Ossetia, Kabardino-Balkaria, Karachaevo-Cherkesiya, Adygea) and two adjacent majority Russian regions (Stavropol'skiy Kray and Krasnodarskiy Kray).

Of the 38,789 records in Memorial's timeline, 9,953 were reports of a historical nature, press statements, and other entries not addressing specific incidents of violence or their geographical locations. Of the remaining 28,836, we were able to geocode 73% at the municipality level, 6% at the rayon (district) level and 21% at the oblast (province) level. In all, 21,050 unique events were geocoded for 7,584 municipalities between January 2000 and September 2009, representing as close to a universal sample of state and nonstate violence in Russia as open sources currently permit – compared with just 925 Russian events for the entire post-Soviet period in the Global Terrorism Database (LaFree and Dugan, 2007) and 14,177 events in the North Caucasus data collected by **?** and O'Loughlin et al. (2011). The near-universal coverage of the data permits a "whole" network design, with boundary specification defined only by the administrative borders of the nine southern Russian regions. Because the Memorial event summaries are updated both in real time and retroactively, we narrowed the period of observation to the months for which the journalistic record is relatively complete: July 2000 - December 2008.

3.2 Event coding rules

Insurgent violence: Event must involve at least one of the following *actors*: nonstate armed groups (NVF), defined by Russian law as any armed group, militia, guerilla or terrorist organization, formed outside the frameworks of existing laws and operating outside the command and control structure of the Russian state; **and** at least one of the following *actions*: terrorist attack, hostage-taking, firefight, bombing, ambush, hit and run attack. Definition does not include events initiated by government forces and non-political acts of violence – such as those resulting from unambiguously criminal activity like burglary and armed robbery.

> *Example:* В ночь на 29 июня в с. Елистанжи Веденского района Чеченской Республики вошел отряд боевиков до 70 человек. Они обстреляли место дислокации роты батальона Юг, а так же место дислокации ПОМ поселкового отдела милиции, который состоит из сотрудников милиции, прикомандированных из других регионов РФ. Боевики убили водителя главы администрации Веденского района, местного жителя. Его вывели из дома и застрелили на улице. Также была обстреляна машина с сотрудниками батальона Юг, которые ехали из с. Агишбатой в с. Елистанжи. В резултате погиб сотрудник батальона. К утру боевики ушли из села.

> *Translation*: On the night of 29 July a detachment of up to 70 insurgents entered the village of Elistanzhi, Venedo district, Chechen Republic. They opened fire on the positions of a company of the "Yug" Battalion, as well as the positions of the municipal police department, which consists of police officers dispatched from other

regions of the Russian Federation. The insurgents killed the driver of the head of Vedeno District, a local resident. He was taken from his home and shot on the street. A car with "Yug" Battalion personnel also came under fire, as it was driving from Agishbatoy village to Elistanzhi. As a result one serviceman was killed. By morning the insurgents had left the village. [Event ID: 34117; Date: 20080629]

Kinetic Operations (punishment): Event must involve at least one of the following *actors*: Russian Armed Forces, Federal Security Services, Special Forces, Ministry of Internal Affairs, local police, local administration, federal administration; **and** at least one of the following *actions*: search and destroy missions, artillery strikes, air strikes, raids, any incidents of government violence that took place as part of a "counterterrorist operation" (KTO), defined in Russian law as a "combination of special-purpose combat operations and other measures involving military hardware, weapons and special means to prevent terrorist acts, neutralize terrorists, provide physical security to persons and facilities, as well as to minimize the consequences of terrorist actions."

Example: 5 февраля после 9.00 по с. Алхан-Кала Грозненского района нанесен артиллерийский удар. С различной степенью интенсивности снаряды рвались на территории населенного пункта не менее двух часов. В результате артобстрела ранены шесть человек. В восточной части села, непосредственно примыкаюшхей к г. Грозному, были повреждены более десяти домов.

Translation: On 5 February after 9:00 an artillery strike was carried out on the village Alkhan-Kala, Groznenskiy district. With varying degrees of intensity, munitions continued to explode over the population center for no less than two hours. As a result of the artillery strike, six people were wounded. In the eastern section of the village, immediately adjacent to the city of Grozny, over ten homes were damaged. [Event ID: 1075; Date: 20010205]

Cordon Operations (denial): Event must involve at least one of the following *actors*: Russian Armed Forces, Federal Security Services, Special Forces, Ministry of Internal Affairs, local police, local administration, federal administration; **and** at least one of the following *actions*: efforts to physically disrupt lines of communication connecting a municipality to other locations in the region. This definition goes beyond routine road obstructions like vehicle checkpoints; it includes only larger-scale operations such as government efforts to establish a cordon around a whole village or town.

Example: Группа боевиков блокирована в городе Дагестанские Огни, сообщил оперативный дежурный МВД республики.

Translation: A group of insurgents is blocked in the city of Dagestanskie Ogni, according to the republican Interior Ministry's operations duty officer. [Event ID: 31428; Date: 20080327]

Cordon and Search Operations (denial + punishment): At the event level, the "Kinetic" and "Cordon" variables were coded in a mutually exclusive way from, such that no denial event included an action where local kinetic operations were reported to have also taken place. If both types of events were observed, the resulting interaction between the two strategy choices was called *denial + punishment*.

> *Example:* Многочисленная группировка силовых структур, включая военнослужащих Министерства обороны, блокировала ст. Вознесеновская Малгобекского района Республики Ингушетия. В станице началась зачистка.
>
> *Translation:* A large grouping of security forces, including personnel from the Ministry of Defense, has blocked the village of Voznesenovskaya, Malgobek district, Republic of Ingushetia. A mop-up operation has begun in the village. [Event ID: 23472; Date: 20070422]

3.3 Reliability of automated event coding

The reliability of content analysis as a data collection method can be separated into three components: (1) consistency, (2) replicability, and (3) accuracy (Weber, 1990, 17). While previous events datasets for the North Caucasus have relied on hand-coding of newspaper articles and incident reports (Lyall, 2009, 2010), there are several advantages to the automated approach employed here. Foremost among these advantages are consistency and replicability – both of which will be critical if the epidemic model is to be meaningfully extended to other cases. Hand-coded event data collection is extremely labor-intensive, involving months of tedious and painstaking work by large teams of undergraduate research assistants (King and Lowe, 2003, 618). Even with experienced coders following well-defined tasks and classification rules, inter-coder reliability can be notoriously low (Mikhaylov and Benoit, 2008). Humans have limited working memories and tend to rely on heuristics, resulting in informal, subjective and ad hoc decisions, not to mention broader risks associated with fatigue, inattention and prior knowledge of hypotheses (Grimmer and King, 2009, 4-5).

Automated coding is no panacea; it also requires a deep working knowledge of the subject matter in the construction of coding rules, and a considerable – though nowhere near as onerous – time investment in data collection, pre-processing and programming. Once these coding rules are established, however, the consistency of machine coding becomes 100% since the program is executing a fixed algorithm (Schrodt and Gerner, 1994). The replicability of the codings across two or more machines – given the same set of rules, actor/action dictionary and corpus of texts – is similarly high. Further, automated coding is not subject to errors induced by the context of an event, political or cultural biases, fatigue or boredom.

Automated coding methods have been shown to produce results at least as accurate as hand coding but with complete consistency, replicability and more randomness in the errors (Schrodt and Gerner, 1994; King and Lowe, 2003). Whereas bias in the errors can create bias in the results, randomness in errors will tend to attenuate the results, not improve them. The Boolean matching approach uses in this paper capitalizes on the highly structured form of the coded texts – short, two-three sentence incident reports, which have a limited vocabulary and narrow substantive focus. Methods like TABARI and VRA Reader assume little to no structure in the text, thereby opening themselves to additional sources of error. If the assumptions about the nature of the texts are correct, the Boolean matching approach is likely not only to match the coding accuracy of TABARI and VRA Reader but actually exceed it.

The most common types of inaccurate codings in automated events extraction (i.e.: incorrect dates, geocodings or event types) usually occur due to unusually-structured sentences, unrecognized terms not included in the dictionary, or references to historical events (Schrodt, 2001). The first of these was addressed in part by selecting the highly-structured Memorial event summaries as the text corpus (see examples above). The second problem, usually induced through the use of off-the-shelf coding dictionaries, was addressed in the dictionary design phase. Rather than use a pre-existing list of terms that may or may not be in the text, we adopted an *ex-post* dictionary construction technique, in which the system generated a list of most-frequent terms (and permutations thereof) included in the Memorial summaries, and the dictionary lists of relevant political actors, actions, targets and place names were constructed based on this list.[4] This approach enables the fine-tuning of coding rules to the substantive domain of the texts, informed by prior knowledge of what sorts of events can be coded accurately.

While the approach taken here was designed to avoid many of the systematic sources of bias and error common to human coding and certain categories of automated coding, we performed a series of checks to assess the accuracy of the automated event codings and matchings to geographic place names and dates. The first of these was to examine the face validity of the data: does the spatio-temporal distribution of the coded events align with narrative accounts of the evolution of the Caucasus conflict during the period in question (2000-2008). Most analysts of the region – Russian and Western, qualitative and quantitative – have described an increasingly diffuse pattern of violence. A conflict which, until the consolidation of power in Chechnya by the Kadyrov family in 2004-2005, was largely limited to Chechnya, has in recent years spread to neighboring regions, particularly Dagestan, Ingushetia and Kabardino-Balkaria (Malashenko and Trenin, 2002; Kramer, 2004, 2005; Sagramoso, 2007; Souleimanov, 2007; Vendina et al., 2007; **?**; Kuchins et al., 2011). As shown in Figures 1-4, our data largely support these narratives. In 2000-2002, fighting was mostly confined to the Chechen Republic, with occasional rebel incursions into neighboring republics and majority-Russian areas, like Stavropol Kray. Following a spike in violence in 2004-2005 (after the assassination of Akhmat Kadyrov), violent attacks became less frequent, but covered a broader swath of territory. Attacks in Ingushetia and Dagestan became more common, while Chechnya became more calm.

An equally important issue was whether some individual events may be mis-coded due to references to historical events, odd phrasings or other problems that could be more easily detected and avoided by a human coder with subject matter expertise. While, due to the many sources error described above, we should be wary of treating any human codings as a "gold standard," a basic comparison of the two types of measures can serve as a useful "sanity check." With this reasoning, we performed the following procedure multiple times: a set of 50 event summaries were randomly selected from the corpus, and hand-coded by one of the co-authors according to their location, date, and event type. The human event coding rules used were the same as the machine rules outlined in section 1.2. The human codings were then compared against the automated codings, and the level of agreement was calculated as the proportion of event summaries where the two sets of codings were identical. If the level of agreement fell below .9 (more than five disagreements out of 50), the set of events was then manually inspected to determine the source of disagreement.

If the source of disagreement was determined to be systematic, we modified the coding procedure to flag such potential problems for manual inspection with a dummy variable called "`INSPECT`." For

[4]Due the complexities of Russian grammar, we did not use stemming as part of natural language processing. This enabled us to distinguish between various grammatical permutations of location and actor names in the construction of the dictionary.

instance, in the case of miscodings of paramilitary units' home bases as locations of events – as in "Novgorodskiy OMON" – we set `INSPECT=1` if a location name was followed or preceded by a term representing a political actor in an event summary.[5] To address historical references directly, we set `INSPECT=1` if more than one date, month or year was mentioned in a summary, or if more than one location was mentioned in a summary. This procedure also helped us distinguish between cases where event summaries included references to multiple simultaneous events (e.g. "air strikes were carried out on March 13 in villages A, B and C"), as opposed to event summaries that made references to a single current event and one or more historical events (e.g. "an air strike was carried out on May 15 in village A. This operation marks the first series of air strikes in the area since March 13.") The goal here was to minimize the risk of double-counts and false positives, while avoiding false negatives that would result from mistaking multiple events for historical references.

We then performed a manual inspection of all cases where `INSPECT=1` (originally, 24% of the events), and corrected the codings by hand where deemed necessary. We then selected another 50 event summaries at random, and repeated the entire procedure (a total of 7 times) until the level of agreement exceeded .9 for three consecutive sets of 50. Only after we became convinced that the accuracy of individual event codings approached those of a human subject matter expert (>.9), did we aggregate the events to the level of village-month as described in detail below.

4 Road Network Data and Dynamic Spatial Weights Matrix

To model the spread of insurgent violence as a network process, and to formally account for road obstructions and other denial actions in the connective structure of the conflict zone, we measured the accessibility between populated places with a time-variant origin-destination (OD) matrix $\mathbf{D}_t$, in which entries d_{ijt} are geodesic (i.e.: shortest length in kilometers, if more than one route can be taken) path distances between places i and j along the local network of roads.[6] The resulting spatial weights matrix was also dynamic (time-variant): if a denial action was reported at municipality i at time t ($\texttt{BLOCK}_{it} = 1$), we modified the matrix to reflect that location's temporary inaccessibility due to road obstructions – effectively treating the municipality as a geographic isolate with no road connections heading in or out. To account for the difficulty experienced by insurgents, as they attempt to break through the government cordon and expand operations to other towns, the resulting matrix cells d_{ijt} were then assigned the maximum road distance in the region.

OD matrices have been the subject of a vast literature in urban planning and transportation engineering,[7] but have not – to our knowledge – been widely used in political geography, despite the many advantages of network relative to Euclidean distance. Although the calculation of road network distances is far more computationally intensive than their planar counterparts, OD matrices can be estimated with Python scripts, Java programs or ArcGIS extensions (Steenberghen et al., 2009). For these data, we used a geoprocessing script which relies on ArcMap's Network Analyst engine.[8] The result is a dense $7,584 \times 7,584$ matrix, with 57,517,056 shortest-path road distances

[5] This procedure was performed through string operations on the original text, rather than the "bag of words" representation of the text following the removal of stop words and the discarding of word order.

[6] Geospatial data on the road network in the Caucasus, as well as other spatial data of interest (population density, elevation, land cover), were taken from the U.S. Geological Survey's Global GIS Database (Hearn et al., 2005)

[7] See Cherkassky et al. (1996); Zhan and Noon (1998)

[8] In OD matrix estimation, villages located beyond 5 km of a major road were initially treated as isolates. In these cases, we calculated the Euclidean distance to the nearest municipality accessible by road, and used the sum of this statistic and the nearest-on-road-village's distance data as the off-road municipality's road distance data.

between villages.

Valued network data are often dichotomized for ease of interpretation (by distinguishing between neighbors and non-neighbors) and computational efficiency (the valued matrix is over 3GB in size). However, dichotomization also risks the loss of potentially important information (Thomas and Blitzstein, 2009). Because the epidemiological model assumes continuous measures of network distance, we avoided the use of dichotomizing cutpoints and preserved the continuous distance data. A visual representation of the road network structure is provided in Figure 5.

5 Coding Rules for Aggregated Data

5.1 Geographic locations and dates

Case ID (municipality-month) (`TSID`) Unique identifier for municipality-month observation. Use for sorting data, creation of time lags.

Case ID (month-municipality) (`TSID2`) Unique identifier for month-municipality observation. Use for sorting data, creation of spatial lags.

Time ID (month) (`TID`) Unique identifier for each month.

Date (`YRMO`) Date of observation, in format YYYYMM.

Place ID (`CID`) Unique identifier for city, town, village or populated place.

Place Name (`NAME`) Name of city, town, village or populated place, from GeoNames (2009).

Region ID (`OBLAST_ID`) Unique identifier for region (*oblast*).

Region Name (`OBLAST_NAME`) Name of region (*oblast*).

District ID (`RID`) Unique identifier for district (*rayon*).

District Name (`RAYON_NAME`) Name of district (*rayon*).

Latitude (`LAT`) Use UTM 38N or UTM 39N for projected coordinate system, WGS84 for geographic coordinate system.

Longitude (`LONG`) Use UTM 38N or UTM 39N for projected coordinate system, WGS84 for geographic coordinate system.

5.2 Conflict dynamics

Dependent Variable

Insurgent attack (count) (`REBEL`) number of episodes of insurgent violence, as defined above, observed in municipality i during month t.

Insurgent attack (binary) (`REBEL_b`) $\begin{cases} 1 & \text{if at least one episode of insurgent violence was observed in village } i \text{ during month } t \\ 0 & \text{otherwise} \end{cases}$

Insurgent attack (count, time lagged) (`L_REBEL`) number of episodes of insurgent violence, as defined above, observed in municipality i during month $t-1$.

Insurgent attack (binary, time lagged) (`L_REBEL_b`) $\begin{cases} 1 & \text{if at least one episode of insurgent violence was observed in village } i \text{ during month } t-1 \\ 0 & \text{otherwise} \end{cases}$

Punishment Actions

Kinetic operations (count) (`SPETZ`) number of government-initiated kinetic operations, as defined above, observed in municipality i during month t.

Kinetic operations (binary) (`SPETZ_b`) $\begin{cases} 1 & \text{if at least one kinetic operation was observed in village } i \text{ during month } t \\ 0 & \text{otherwise} \end{cases}$

Kinetic operations (count, time lagged) (`L_SPETZ`) number of government-initiated kinetic operations, as defined above, observed in municipality i during month $t-1$.

Kinetic operations (binary, time lagged) (`L_SPETZ_b`) $\begin{cases} 1 & \text{if at least one kinetic operation was observed in village } i \text{ during month } t-1 \\ 0 & \text{otherwise} \end{cases}$

Denial Actions

Cordon operations (count) (`BLOCK`) number of government-initiated cordon operations, as defined above, observed in municipality i during month t.

Cordon operations (binary) (`BLOCK_b`) $\begin{cases} 1 & \text{if at least one cordon operation was observed in village } i \text{ during month } t \\ 0 & \text{otherwise} \end{cases}$

Cordon operations (count, time lagged) (`L_BLOCK`) number of government-initiated cordon operations, as defined above, observed in municipality i during month $t-1$.

Cordon operations (binary, time lagged) (`L_BLOCK_b`) $\begin{cases} 1 & \text{if at least one cordon operation was observed in village } i \text{ during month } t-1 \\ 0 & \text{otherwise} \end{cases}$

Distance to nearest recent insurgent attack (log) (`ln_NEAR`) natural logarithm of $\min(w_i \text{Insurgent Violence}_{j \neq i, t-1})$, where w_i is a vector of road distances between village i and all other villages j. Where a denial action (`L_BLOCK_b`) was reported, we modified the matrix $\mathbf{W}$ to reflect that location's temporary inaccessibility due to road obstructions – effectively treating the municipality as a geographic isolate with no road connections heading in or out.

5.3 Control variables

Population density (`POP`) Population per square kilometer.

Elevation (`ELEVATION`) In meters. Sea level = 0.

Slope (SLOPE) Slope of terrain at municipality's location, in degrees. Zero represents flat terrain; 90 represents a vertical slope.

Unemployment (UNEMPLOY) Members of a region's working-age population (15-72 yrs.) without employment at $t-1$ (thousands)

Distance to military base (log) (ln_DMIL) natural logarithm of d_{ik}, the road distance (in kilometers) between village i and military facility k

Regional capital (CAPITAL) $\begin{cases} 1 & \text{if municipality } i \text{ is a republican or oblast capital} \\ 0 & \text{otherwise} \end{cases}$

5.4 Interactions (pre-coded for transitional model)

Insurgent Attack × Kinetic Op (I_SPETZ) $\begin{cases} \texttt{L\_SPETZ\_b} & \text{if at least one episode of insurgent violence was observed in village } i \text{ during month } t-1 \\ 0 & \text{otherwise} \end{cases}$

Insurgent Attack × Population Density (I_POP) $\begin{cases} \texttt{POP} & \text{if at least one episode of insurgent violence was observed in village } i \text{ during month } t-1 \\ 0 & \text{otherwise} \end{cases}$

Insurgent Attack × Elevation (I_ELEVATION) $\begin{cases} \texttt{ELEVATION} & \text{if at least one episode of insurgent violence was observed in village } i \text{ during month } t-1 \\ 0 & \text{otherwise} \end{cases}$

Insurgent Attack × Slope (I_SLOPE) $\begin{cases} \texttt{SLOPE} & \text{if at least one episode of insurgent violence was observed in village } i \text{ during month } t-1 \\ 0 & \text{otherwise} \end{cases}$

Insurgent Attack × Dist. to Nearest Attack (I_ln_NEAR) $\begin{cases} \texttt{ln\_NEAR} & \text{if at least one episode of insurgent violence was observed in village } i \text{ during month } t-1 \\ 0 & \text{otherwise} \end{cases}$

Insurgent Attack × Dist. to Nearest Base (I_ln_DMIL) $\begin{cases} \texttt{ln\_DMIL} & \text{if at least one episode of insurgent violence was observed in village } i \text{ during month } t-1 \\ 0 & \text{otherwise} \end{cases}$

Insurgent Attack × Regional Capital (I_CAPITAL) $\begin{cases} \texttt{CAPITAL} & \text{if at least one episode of insurgent violence was observed in village } i \text{ during month } t-1 \\ 0 & \text{otherwise} \end{cases}$

Insurgent Attack × Unemployment `I_L_UNEMPLOY`) $\begin{cases} \texttt{L\_UNEMPLOY} & \text{if at least one episode of insurgent violence was observed in village } i \text{ during month } t-1 \\ 0 & \text{otherwise} \end{cases}$

6 Summary Statistics

Table 4: **Summary statistics for aggregated data (village-month level) and list of sources**

Variable Description	Variable Name	Min	Median	Mean	Max	Source
Insurgent Attack (count)	REBEL	0	0	0.0041	46	GeoNames (2009); Memorial (2009)
Insurgent Attack (count, time lagged)	L_REBEL	0	0	0.0042	46	GeoNames (2009); Memorial (2009)
Insurgent Attack (binary)	REBEL_b	0	0	0.0023	1	GeoNames (2009); Memorial (2009)
Insurgent Attack (binary, time lagged)	L_REBEL_b	0	0	0.0024	1	GeoNames (2009); Memorial (2009)
Kinetic Operations (count)	SPETZ	0	0	0.0019	31	GeoNames (2009); Memorial (2009)
Kinetic Operations (count, time lagged)	L_SPETZ	0	0	0.0020	31	GeoNames (2009); Memorial (2009)
Kinetic Operations (binary)	SPETZ_b	0	0	0.0011	1	GeoNames (2009); Memorial (2009)
Kinetic Operations (binary, time lagged)	L_SPETZ_b	0	0	0.0011	1	GeoNames (2009); Memorial (2009)
Blocking (count)	BLOCK	0	0	0.0004	5	GeoNames (2009); Memorial (2009)
Blocking (count, time lagged)	L_BLOCK	0	0	0.0004	5	GeoNames (2009); Memorial (2009)
Blocking (binary)	BLOCK_b	0	0	0.0004	1	GeoNames (2009); Memorial (2009)
Blocking (binary, time lagged)	L_BLOCK_b	0	0	0.0004	1	GeoNames (2009); Memorial (2009)
Population Density	POP	0	13	166.3	25181	GeoNames (2009); Hearn et al. (2005)
Elevation	ELEVATION	-31	239	523.1	2818	GeoNames (2009); Hearn et al. (2005)
Slope	SLOPE	0	1.1604	3.6733	40.0156	GeoNames (2009); Hearn et al. (2005)
Unemployment	UNEMPLOY	1.9	24.9	52.18	376.5	GeoNames (2009); Goskomstat (2009)
Unemployment (time lagged)	L_UNEMPLOY	1.9	24.6	52.08	376.5	GeoNames (2009); Goskomstat (2009)
Road Distance to Nearest Attack (log)	ln_NEAR	0	5.024	4.97	7.139	GeoNames (2009); Goskomstat (2009)
Distance to Nearest Military Base (log)	ln_DMIL	0.0065	4.0343	3.8717	5.3435	GeoNames (2009); Janko (2009); Hearn et al. (2005)
Regional Capital	CAPITAL	0	0	0.0012	1	GeoNames (2009)
Insurgent Attack × Kinetic Op	I_SPETZ	0	0	0.0004	1	GeoNames (2009); Memorial (2009)
Insurgent Attack × Population Density	I_POP	0	0	3.39	11576	GeoNames (2009); Memorial (2009)
Insurgent Attack × Elevation	I_ELEVATION	-27	0	0.8217	2146	GeoNames (2009); Hearn et al. (2005)
Insurgent Attack × Slope	I_SLOPE	0	0	0.0053	24.18	GeoNames (2009); Hearn et al. (2005)
Insurgent Attack × Dist. to Nearest Attack	I_ln_NEAR	0	0	0.0010	7.139	GeoNames (2009); Hearn et al. (2005)
Insurgent Attack × Dist. to Nearest Base	I_ln_DMIL	0	0	0.0075	5.17	GeoNames (2009); Janko (2009); Hearn et al. (2005)
Insurgent Attack × Regional Capital	I_CAPITAL	0	0	0.0002	1	GeoNames (2009); Memorial (2009)
Insurgent Attack × Unemployment	I_L_UNEMPLOY	0	0	0.4038	376.5	GeoNames (2009); Memorial (2009); Goskomstat (2009)

Table 5: **Correlation Matrix**

	REBEL	REBEL_b	SPETZ	SPETZ_b	BLOCK	BLOCK_b	POP	ELEVATION	SLOPE	L_UNEMPLOY	ln_NEAR	ln_DMIL	CAPITAL	I_SPETZ	I_POP	I_ELEVATION	I_SLOPE	I_ln_NEAR	I_ln_DMIL	I_CAPITAL	I_L_UNEMPLOY
REBEL	1.0	0.6	0.6	0.3	0.4	0.3	0.1	-0.0	-0.0	0.1	-0.0	-0.0	0.2	0.3	0.3	0.1	0.0	0.3	0.2	0.4	0.2
REBEL_b	0.6	1.0	0.3	0.2	0.1	0.1	0.1	-0.0	-0.0	0.1	-0.1	-0.0	0.1	0.2	0.2	0.1	0.1	0.1	0.2	0.2	0.2
SPETZ	0.6	0.3	1.0	0.7	0.3	0.3	0.1	-0.0	-0.0	0.0	-0.0	-0.0	0.2	0.3	0.3	0.1	0.0	0.2	0.1	0.3	0.1
SPETZ_b	0.3	0.2	0.7	1.0	0.2	0.2	0.1	-0.0	-0.0	0.0	-0.1	-0.0	0.1	0.2	0.2	0.1	0.1	0.2	0.1	0.2	0.1
BLOCK	0.4	0.1	0.3	0.2	1.0	0.9	0.1	-0.0	-0.0	0.0	-0.0	-0.0	0.1	0.1	0.2	0.0	0.0	0.1	0.1	0.1	0.1
BLOCK_b	0.3	0.1	0.3	0.2	0.9	1.0	0.1	-0.0	-0.0	0.0	-0.0	-0.0	0.1	0.2	0.2	0.1	0.0	0.1	0.1	0.2	0.1
POP	0.1	0.1	0.1	0.1	0.1	0.1	1.0	-0.1	-0.1	-0.0	-0.1	-0.2	0.2	0.1	0.2	0.0	0.0	0.1	0.1	0.1	0.0
ELEVATION	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	1.0	0.8	0.2	-0.1	-0.0	-0.0	-0.0	-0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0
SLOPE	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	0.8	1.0	0.2	-0.1	-0.1	-0.0	-0.0	-0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0
L_UNEMPLOY	0.1	0.1	0.0	0.0	0.0	0.0	-0.0	0.2	0.2	1.0	-0.5	-0.1	-0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.0	0.1
ln_NEAR	-0.0	-0.1	-0.0	-0.1	-0.0	-0.0	-0.1	-0.1	-0.1	-0.5	1.0	0.1	-0.0	-0.1	-0.1	-0.1	-0.1	0.0	-0.2	-0.0	-0.2
ln_DMIL	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.2	-0.0	-0.1	-0.2	0.1	1.0	-0.1	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0
CAPITAL	0.2	0.1	0.2	0.1	0.1	0.1	0.2	-0.0	-0.0	-0.0	-0.0	-0.1	1.0	0.2	0.2	0.1	0.0	0.1	0.0	0.4	0.1
I_SPETZ	0.3	0.2	0.3	0.2	0.1	0.2	0.1	-0.0	-0.0	0.0	-0.1	-0.0	0.2	1.0	0.5	0.2	0.1	0.3	0.3	0.4	0.3
I_POP	0.3	0.2	0.3	0.2	0.2	0.2	0.2	-0.0	-0.0	0.0	-0.1	-0.0	0.2	0.5	1.0	0.3	0.1	0.3	0.4	0.6	0.3
I_ELEVATION	0.1	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.1	-0.1	-0.0	0.1	0.2	0.3	1.0	0.8	0.1	0.7	0.1	0.5
I_SLOPE	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	-0.1	-0.0	0.0	0.1	0.1	0.8	1.0	0.1	0.6	0.1	0.5
I_ln_NEAR	0.3	0.1	0.2	0.2	0.1	0.1	0.1	-0.0	-0.0	0.0	0.0	-0.0	0.1	0.3	0.3	0.1	0.1	1.0	0.2	0.3	0.2
I_ln_DMIL	0.2	0.2	0.1	0.1	0.1	0.1	0.1	-0.0	-0.0	0.1	-0.2	-0.0	0.0	0.3	0.4	0.7	0.6	0.2	1.0	0.1	0.7
I_CAPITAL	0.4	0.2	0.3	0.2	0.1	0.2	0.1	-0.0	-0.0	0.0	-0.0	-0.0	0.4	0.4	0.6	0.1	0.1	0.3	0.1	1.0	0.2
I_L_UNEMPLOY	0.2	0.2	0.1	0.1	0.1	0.1	0.0	-0.0	-0.0	0.1	-0.2	-0.0	0.1	0.3	0.3	0.5	0.5	0.2	0.7	0.2	1.0

Figure 1: **Spatio-temporal distribution of dependent variable** (insurgent attacks), July 2000 - Dec 2002

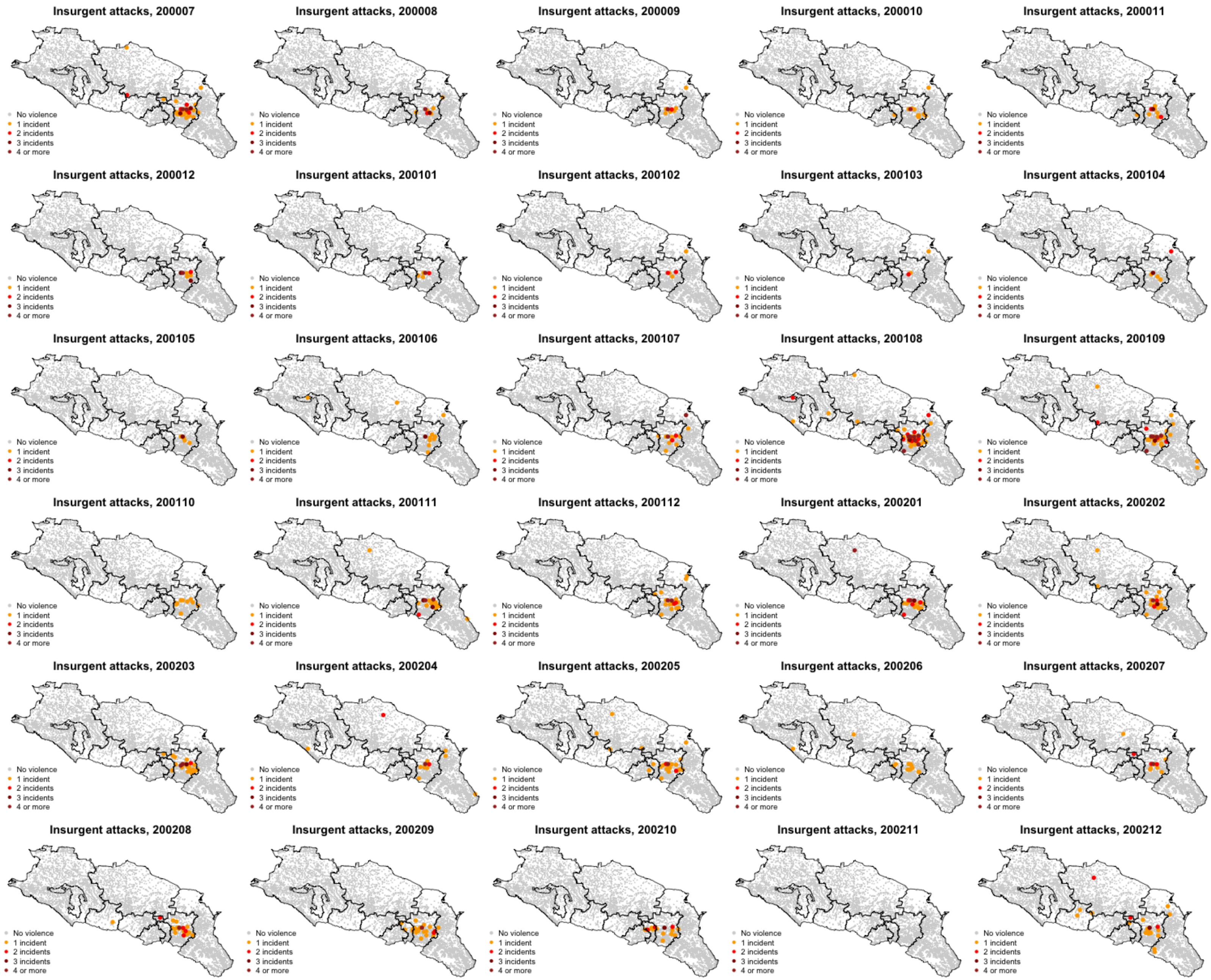


Figure 2: **Spatio-temporal distribution of dependent variable** (insurgent attacks), Jan 2003 - Jun 2005

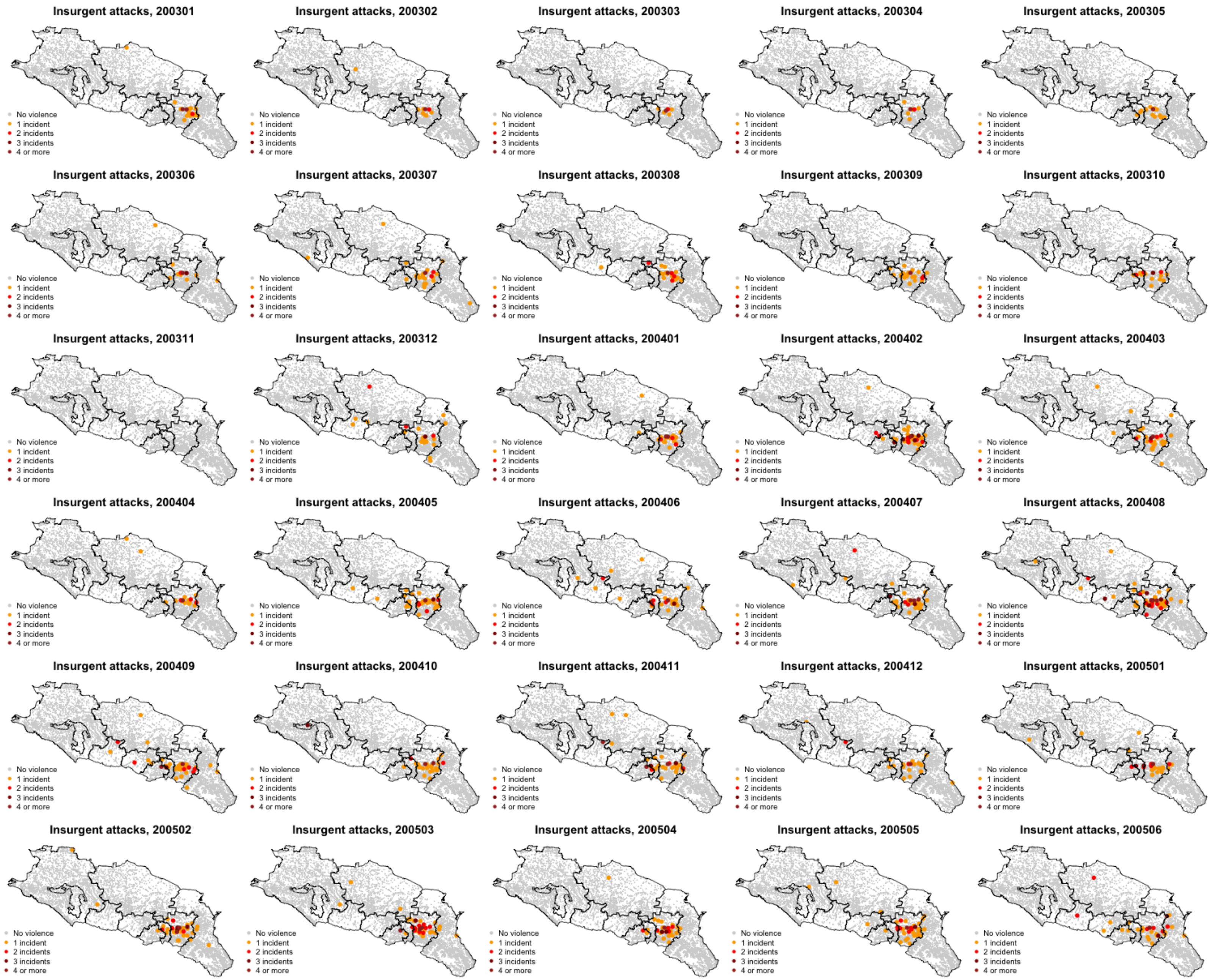


Figure 3: **Spatio-temporal distribution of dependent variable** (insurgent attacks), July 2005 - Dec 2007

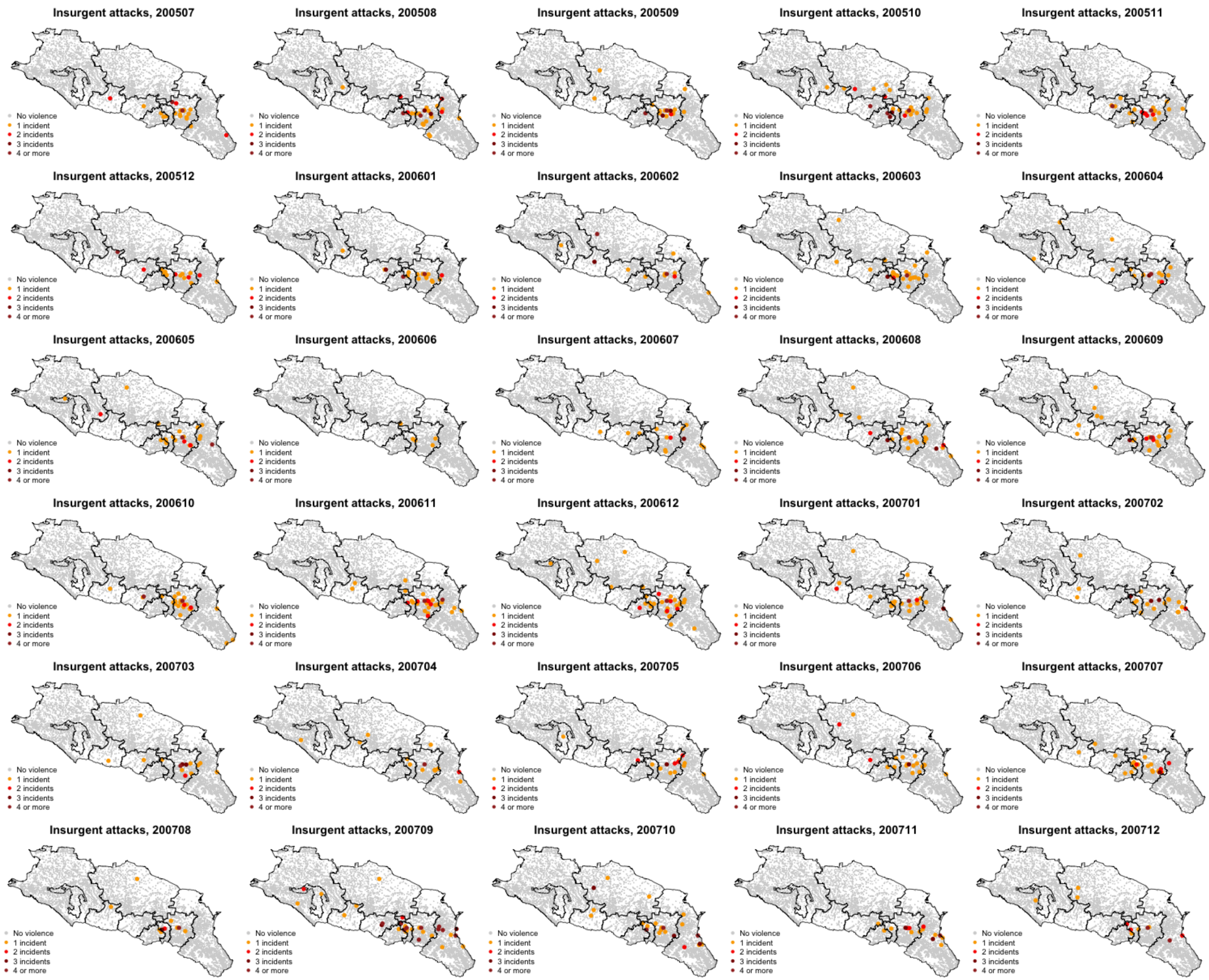


Figure 4: **Spatio-temporal distribution of dependent variable** (insurgent attacks), Jan 2008 - Dec 2008

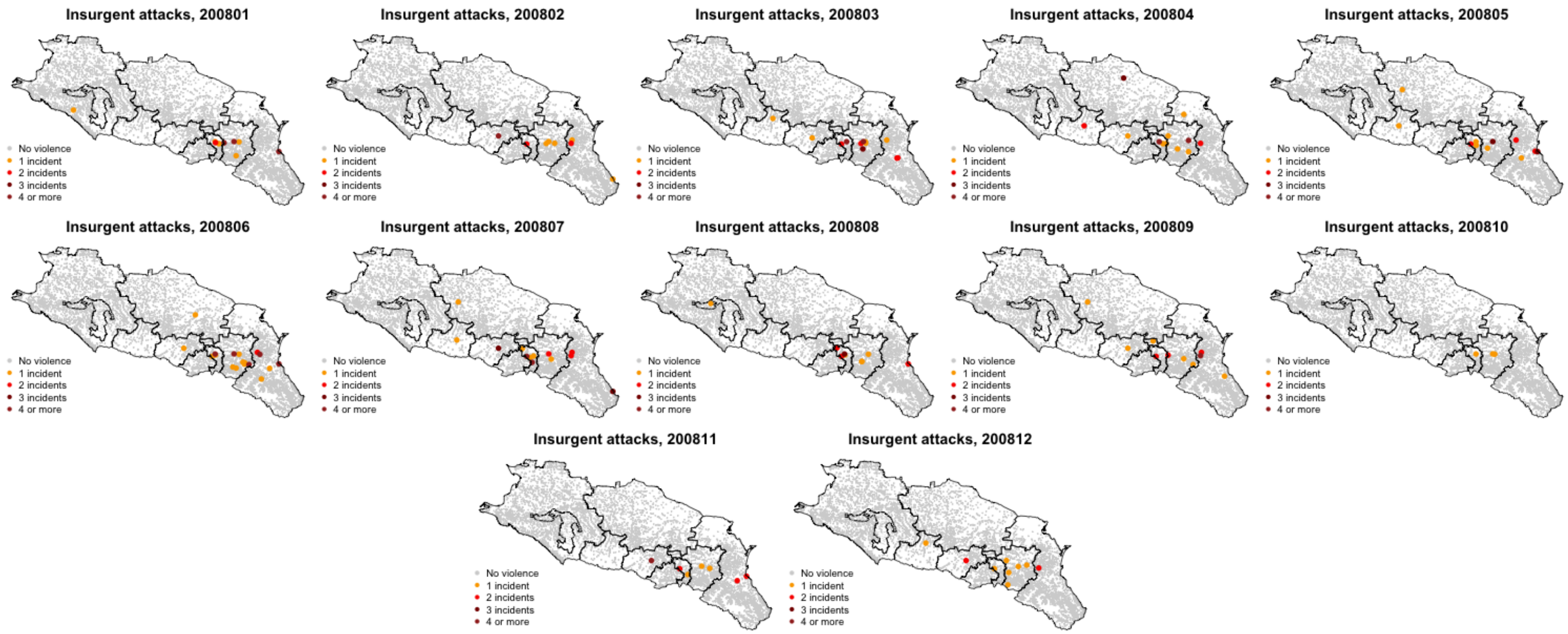
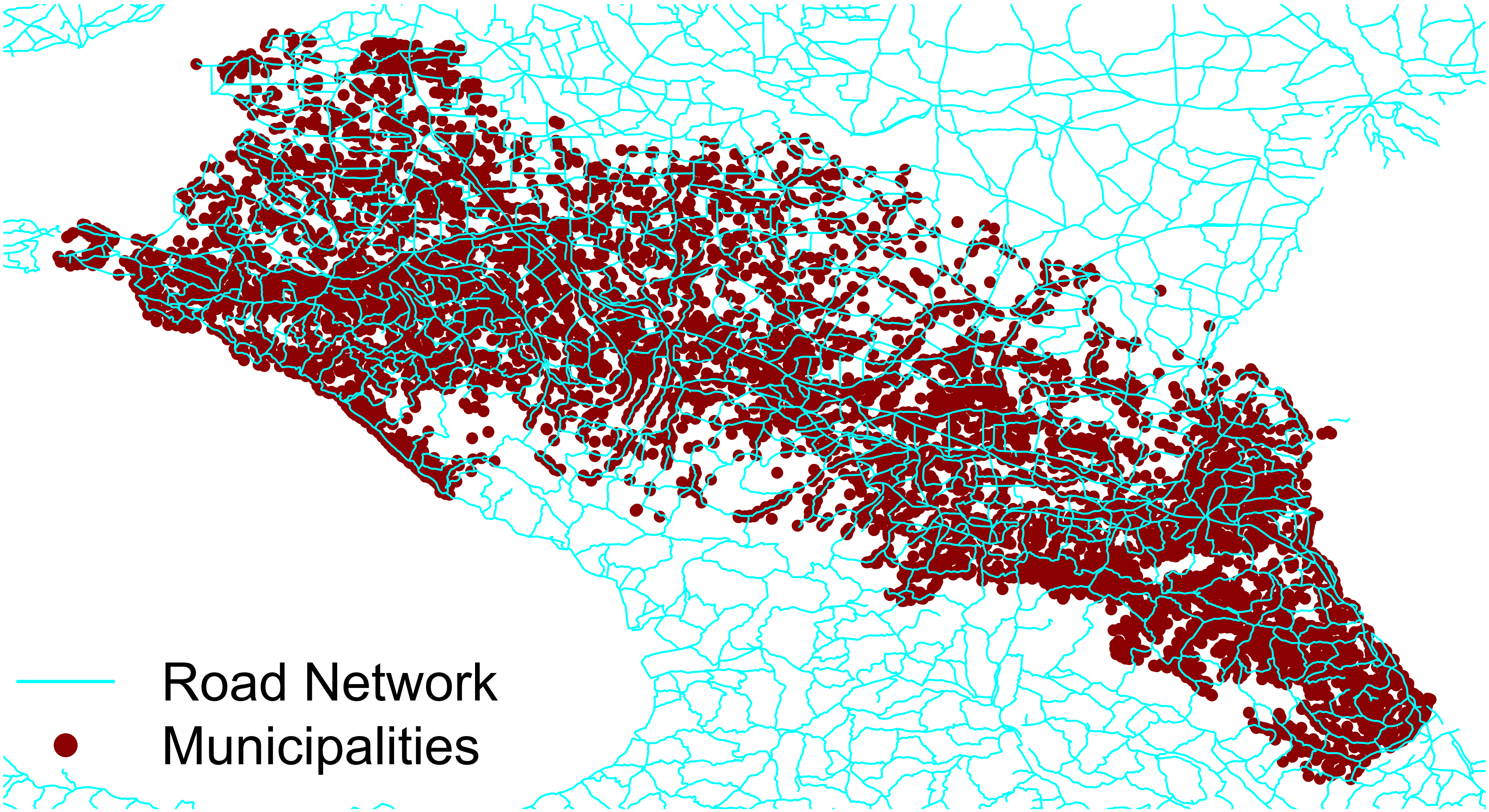


Figure 5: **Road Network**



7 Additional Regression Results

Table 6 reports regression results for four additional model, with identical specifications as in Models 1-4 in the manuscript, apart from the substitution of slope (in degrees) for elevation (in meters). Results for the slope variable are consistent with those for elevation: new insurgent violence is more likely in villages in flat, accessible terrain, but the effect is negligible for recurring violence. Results for all other variables are nearly identical to those in Models 1-4.

Table 6: **Markov transition models** (estimated with GAM logit). Dependent variable: incidence of insurgent violence in village i at time t (V_{it}.

	Model 5		**Model 6**		**Model 7**		**Model 8**	
	ϕ_C	ϕ_V	ϕ_C	ϕ_V	ϕ_C	ϕ_V	ϕ_C	ϕ_V
Intercept	-9.4101	-7.2378	-6.3059	-4.9666	-6.4671	-5.4243	-7.0321	-4.6796
	(0.9516)***	(0.9509)***	(0.3376)***	(0.3856)***	(0.3268)***	(0.389)***	(0.3739)***	(0.4812)***
<u>Punishment Actions</u>								
Kinetic Ops ($t-1$)	2.4298	0.7901	2.4132	0.7877	2.3917	0.6427	2.7761	0.5421
	(0.1427)***	(0.1641)***	(0.1435)***	(0.1636)***	(0.1444)***	(0.1706)***	(0.1627)***	(0.1976)**
<u>Denial Actions</u>								
Road Distance to	-0.1459	0.0527	-0.1307	0.0513	-0.1415	0.0341	-0.0968	0.08
Nearest Attack ($t-1$)	(0.0253)***	(0.0386)	(0.0251)***	(0.0385)	(0.0253)***	(0.041)	(0.0315)**	(0.044)
<u>Controls</u>								
Population Density	4e-04	3e-04	3e-04	3e-04	3e-04	2e-04	3e-04	2e-04
	(2e-05)***	(2e-05)***	(2e-05)***	(2e-05)***	(2e-05)***	(2e-05)***	(2e-05)***	(2e-05)***
Slope	-0.0868	0.0036	-0.0719	0.0168	-0.0696	0.0222	-0.0843	-0.0587
	(0.012)***	(0.0264)	(0.0117)***	(0.0253)	(0.0118)***	(0.0255)	(0.0132)***	(0.0392)
Road Distance to Nearest Mil. Base			-0.3746	-0.116	-0.3037	0.0359	-0.2979	0.0042
			(0.0373)***	(0.0692)	(0.0396)***	(0.076)	(0.0438)***	(0.0811)
Regional Capital					1.7649	1.6118	1.8155	1.4349
					(0.2074)***	(0.2964)***	(0.2154)***	(0.3063)***
Unemployment ($t-1$)							0.0034	-3e-04
							(5e-04)***	(7e-04)
Spatial Spline $f(Long, Lat)$	EDF: 28.77, χ^2: 1218.16***		EDF: 26.52, χ^2: 961.12***		EDF: 26.37, χ^2: 1138.65***		EDF: 26.73, χ^2: 472.09***	
N	688,315 (in-sample)		688,315 (in-sample)		688,315 (in-sample)		666,529 (in-sample)	
	77,356 (out-of-sample)		77,356 (out-of-sample)		77,356 (out-of-sample)		77,356 (out-of-sample)	
AIC	15,426.50		15,343.97		15,257.1		12,960.76	
AUC	0.932 (in-sample)		0.933 (in-sample)		0.934 (in-sample)		0.932 (in-sample)	
	0.932 (out-of-sample)		0.934 (out-of-sample)		0.934 (out-of-sample)		0.914 (out-of-sample)	

Significance levels: *$p < .05$, **$p < .01$, ***$p < .001$.

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