Foliage and fighting: Forest resources and the onset, duration, and location of civil war¤

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Abstract

Forests can provide refuge, funds, and food for combatants in civil war. Insurgents may also use forested regions to hide from government troops and the government may choose to ignore them if they remain in remote forested regions. Case studies of Burma, Cambodia, and other countries show that forest resources have served to fuel armed conflict. Several scholars and NGOs have portrayed this as a world-wide problem, but there are hardly any relevant statistical studies. This article first develops theoretically the different mechanisms relating forest resources to conflict. It then looks at the empirical relationship for the onset and duration of conflict at the country level and finds very little support for a general and direct relationship. At this level, it would appear that many have generalized too hastily from the case studies. The analysis then moves to the disaggregated level and looks at the duration of conflict when forest resources are available in the conflict zone. Again, no general relationship is found. We find that a shorter distance to the coast tends to make the conflicts in forested conflict zones longer. On the other hand many of the significant results we find are driven by one or two cases. While several generalizations from case studies seem overly ambitious, a more careful modeling of the mechanisms revealed by the cases finds some support in the statistical study.

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¤Our replication data and do files can be downloaded from www.prio.no/cscw/datasets. The replication dataset also includes the following appendices, which are referred to in the text: (1) Descriptive statistics and analyses with control variables, (2) Main forest table, (3) The amount of forest in the conflict zones, (4) Measuring forest resources, (5) Kaplan-Meier estimates.

Introduction

In the past decade increasing attention has been given to the idea that forest resources may be an important contributing cause to armed conflict. Prominent examples are found in recent reports from the Food and Agriculture Organization of the United Nations (FAO, 2005), the US Agency for International Development (USAID, 2005), and the Centre for International Forestry Research (CIFOR 2003). According to these reports, timber is a valuable commodity that can be exploited to finance participation in an armed conflict and forests can also provide safe havens where insurgents may be out of reach from government troops. A number of case studies have pointed to the use of forest resources in conflicts in Liberia, Cambodia, and elsewhere. On this basis, a general argument has been put forward that forest resources affect the risk of conflict.

To date there are very few comparative or statistical studies of this issue, and the few that have touched on it do not find any support for a positive relationship between forest and conflict. However, none of these studies make forest conflict their main object of study. This article aims to fill that gap. We question whether a generalization from a few case studies is warranted. Since the case study literature is unclear whether forest resources primarily affect the onset or duration of conflict, we test for both. We look at different mechanisms and situations that might link forest and conflict.

We find no general relationship between forest resources and the onset of conflict. Nor do we find any general relationship between forest resources and the duration of conflict as long as we keep the analysis at the national level and for the longest period that we study, 1970–99. On the contrary we find that more forest cover leads to fewer and shorter conflicts. In the disaggregated study we find some results more in line with our expectations when we look at conflicts close to the coast and conflicts without other sources of finance such as diamonds and oil. However, these results are not very robust. We conclude that in general forest resources do not increase the risk of conflict onset or longer conflicts.

Previous studies

A series of recent studies have examined how rebels and predatory and corrupt politicians make use of resource rents to try to capture power or hold on to it. We identify three groups of scholars who have investigated the relationship between natural resources and civil armed conflict. The first group is most prominently represented by Collier & Hoeffler (1998, 2004), who claim to find a strong and robust positive relationship between natural resource dependence and the onset of civil war. Following the work by Sachs & Warner (2001) on the resource course, they use the ratio of primary commodities exports to GDP as their measure of natural resource dependence.

A second group of scholars have criticized the primary commodities-to-GDP measure for providing a poor measure of resource dependence and several studies have failed to find support for Collier & Hoeffler's finding. Ross (2004b: 340–342) suggests that the primary commodities variable in the Collier-Hoeffler model is overly broad. It includes commodities that appear to be strongly linked to conflict (such as oil) and others that are not (e.g. agricultural products). If only a subset of commodities have a potential for generating conflict, the broad correlation between the primary commodity variable and conflict may be weak or unstable. In a reanalysis of Collier & Hoeffler's data, Fearon (2005) shows that the relationship is very sensitive to model specification and data structure and argues that oil is the key commodity related to civil war. De Soysa (2002), also critical of the Collier & Hoeffler measure, employs alternative data from the World Bank (1997) on available natural resources per capita. However, these data are available for fewer countries and do not include all metals or important lootable resources like diamonds.

Rather than lumping all, or a number of resources into one category, a third group of scholars have turned to analyzing the relationship between specific natural resources and conflict, such as oil (Fearon & Laitin, 2003; Lujala, 2008; Ross, 2006) or diamonds (Humphreys, 2005; Ross, 2006, Lujala, Gleditsch & Gilmore, 2005). Some of these datasets are in disaggregated form (Gilmore, Gleditsch, Lujala & Rød, 2005; Lujala, Rød & Thieme, 2007) and permit the researcher to focus specifically on location. Using GIS technology, such studies can match disaggregated data for where the fighting takes place with data for the location of specific natural resources. This article belongs to that tradition.

Forest resources and conflict

In a theoretical argument about rough terrain, Collier & Hoeffler (2004) equated forests and mountains. In their statistical analysis, they used a FAO measure of the proportion of a country that is forested, but found it not to be significantly related to conflict. Similarly, Collier, Hoeffler & Söderbom (2004: 266) found forest cover to be insignificant in accounting for the duration of civil war 1960–2000. In neither case did they pursue the analysis further. Fearon & Laitin (2003: 81) discussed the general importance of rough terrain to insurgency. But in their empirical analysis they settled for using just the mountain variable, while acknowledging that this does not pick up other types of rough terrain that can be useful to guerrillas, 'such as swamps and jungles'. Ross (2004b: 346) is essentially correct when he notes that the relationship between forest resources and conflict has not been tested statistically.

Forest cover has also been included in a few disaggregated studies. Buhaug & Rød (2006) tested onset of conflict using grid cells as the units of observation without finding any support for the forest and conflict argument. Buhaug & Lujala (2005) analyzed the duration of conflict using conflicts as the units of observation; they found a negative relationship between forest resources and conflict duration. Again, forest conflict was not a main focus of these studies.

However, there is no lack of case studies suggesting a relationship between forest resources and conflict. Burma is a frequently cited example (Global Witness, 2002, 2003; Ross, 2004a: 48). Its valuable arsenal of teak has proved as much of a curse as a blessing. The ruling elite use the revenues from the forest resources to tighten its grip on the reins of power. At the same time, revenue from illegal timber sales and from trade control along the borders has enabled insurgents to finance a rebellion of long standing. Timber resources have also been used in exchange for political, financial or military support from Burma's neighbors and political allies. The government's mismanagement and corruption has crippled most of the formal economy, and the country has become ever more dependent on timber revenues. This also puts a strain on the environment in certain areas, which in turn may stimulate grievance-based conflict.

This is not unique for Burma. Both Ross (2004b) and the FAO (2005) and the USAID (2005) reports emphasize that the same predicament is found in several countries, including the Democratic Republic of Congo, Liberia, and Cambodia. In Cambodia the Khmer Rouge was able to exploit timber and gemstones to hold on to power in the north for several years after being chased out of the capital by the Vietnamese invasion (Global

Witness, 2004). However, in order for timber to be a viable source of finance in civil war, control over large forested areas is needed. This makes it harder for rebels to take advantage of forest resources in countries that are small or easily accessible. Also, forest logging is easily detected. Thus, in order for timber to be a viable source of finance in civil war, these operations require secure control over large areas. In our dataset, the three countries mentioned above are among the 20 most forested countries in the world, in other words countries where it is comparatively easier for rebels to exploit the forest resources.

The FAO (2005) and USAID (2005) reports go well beyond the individual cases and characterize forest conflict as a world-wide phenomenon, as do publications from the Centre for International Forestry research (e.g. CIFOR, 2003). Several scholars have also used insights from the case studies and aggregated them up to a more general level. Le Billon (2001: 570) claims, when arguing that resources closer to the capital is easier to control by the government, that ‘gem mines and forests in remote or border areas tend to be overrun by rebel groups and integrated into their armed conflict economy (e.g. Cambodia, Sierra Leone)’.

Even more broadly, Klare (2001: 190) states that: ‘Gold, diamonds, valuable minerals, and old-growth-timber are in high demand around the world, and so their possession can be a source of considerable revenues. Internal warfare over such resources has, in fact, proved to be one of the most prominent and disturbing features of the current political epoch’. Similarly, de Jong, Donovan & Abe (2007: 1–2) argue that ‘forests and extreme conflict show a strong relationship. Three-quarters of Asian forests, two thirds of African forests and one third of Latin American forests have been affected by violent conflict. […] [C]ountries affected by violent conflict are home to more than 40% of the world’s tropical forest. Indeed, the last remaining tropical forests are located in areas that over the past two decades have been subject to violent conflict’. All of this implies a general relationship between forest resources and conflict, at least in the past two decades or in the ‘current political epoch’, an argument not without some theoretical plausibility. Ross (2004b: 346) maintains an open mind: ‘Because this issue has not been explored statistically, we cannot know if these are isolated cases or part of a larger pattern.’ This article takes up the challenge from Ross: Is the relationship between forest resources and conflict a general one, or is this a problem limited to a few specific cases?

Theoretical framework

Two main mechanisms have been invoked to explain the link between forest resources and conflict. The first is the economic opportunity that forest resources can provide, and the second is the rough terrain argument, arguing that forests provide ideal safe havens for rebel groups. In the following we look more closely at both these mechanisms.[1]

Economic opportunities

According to the 'greed' interpretation of civil war, rebellion is a violent way of generating profits, reflecting the opportunity of looting abundant valuable and tradable resources through major and minor banditry.

Several authors highlight the importance of natural resources, including forest resources, in war economies. Selling natural resources is often the only economic option in poor countries, where most armed conflicts take place. This is particularly true after the end of the Cold War, when financing from the two superpowers or their agents dried up. Oil, diamonds and other gemstones, scarce minerals, drugs, and timber are among the most frequently mentioned conflict commodities.

[1] A third hypothesis, building on a neomalthusian scarcity argument, relates deforestation to civil war. Rustad (2006), Hauge & Ellingsen (1998), and Theisen (2008) have examined this relationship without finding much support for it.

Several characteristics of timber make it a poor candidate for a lootable resource – notably great bulk, difficulties in transportation and concealment, and a relatively low value-to-weight ratio, particularly compared to diamonds. All of this may discourage its use as a conflict commodity where more attractive alternatives exist. On the other hand, the extraction of timber does not require advanced technology or specific know-how, and this adds to its attractiveness. The location of the forest resource is crucial in this regard. Forest resources located in remote areas are more susceptible to looting or extortion, and the government's ability to tax, exploit, or trade them may be minimal. In the language of Le Billon (2001), timber is a *diffuse* and *distant* resource. Diffuse resources are widely spread out and may be harvested by less capital-intensive industries with a large workforce. Distant resources are difficult for the government to control, particularly when located in remote territories along porous borders or within the territory of social groups that are potentially marginalized or in opposition to the regime. Because belligerents will need to respond and adapt to the characteristics of the available resources, Le Billon (2001: 573) concludes that different resources may be associated with different types of conflict and argues that warlordism is particularly likely in areas with diffuse and distant resources.

Forest as safe havens – the rough terrain argument

Prominent writers in the opportunity school of civil war argue that 'rough terrain' increases the possibility that insurgents can use a remote area as a safe haven from government forces (Collier & Hoeffler, 1998, 2004; Fearon & Laitin, 2003). This argument has been applied to mountains, but also to forests. In the tropical jungle mature trees can reach a height of 60 meters or more, forming as many as three or four overarching canopies. Gigantic lianas, some at least a foot thick, festoon from great heights to the bottom, making orientation very difficult (Collins, 1998: 115-116). Thus, a forest can provide cover, particularly against detection and aerial attack. In this article we use closed forest as an indicator of this type of forest. A forested area is classified as closed forest when it has more than 40% canopy coverage, while for regular forest the threshold is set at 10% (FAO 2005).

Due to a lack of local knowledge, it is difficult for government forces to track down rebel groups. Among the rebel groups that have sustained their campaigns by using forests as safe havens, are the Revolutionary Armed Forces of Colombia and the Abu Sayyaf guerrilla in the Philippines.

In the Vietnam War, the US tried to counter the insurgents' use of forest cover (the Ho Chi Minh trail) by massive defoliation, but the environmental consequences were severe and this tactic was widely discredited (Westing, 1976).

Units of analysis

Until recently all cross-national statistical analysis of intrastate conflict were conducted at the national level, using nations or nation-years as units of analysis. Studies that aim to focus on aspects of the regimes involved in civil wars will benefit from a nation-based unit of analysis as this level allow an efficient use of existing data on the characteristics of the states. As pointed out by Buhaug & Lujala (2005), Buhaug & Rød (2006), and others, this approach does have weaknesses: It ignores characteristics of nonstate actors, it ignores transnational ties, and it ignores internal variations in countries with conflict. In this article, we first conduct an analysis at the national level of conflict onset and duration and then a duration analysis at the level of the conflict zone, allowing us to take into account the internal variations of forest cover in countries with conflict.

Nation-level analysis

We test four hypotheses at the national level. Since the case study literature does not distinguish clearly between mechanisms that may stimulate conflict onset from mechanisms that may stimulate conflict duration, we test for both. Hypotheses 1a and 2a are derived from the greed argument, while 1b and 2b are related to rough terrain.

Onset

H_{1a}: If a country has valuable forest resources, a conflict onset is more likely.

H_{1b}: If a country has large areas of closed forest, a conflict onset is more likely.

Duration

H_{2a}: If a country has valuable forest resources, a conflict is likely to last longer.

H_{2b}: If a country has large areas of closed forest, a conflict is likely to last longer.

Data

Both the onset and the duration data are from the UCDP/PRIO conflict dataset and cover the period 1970–99.[2] The UCDP/PRIO Armed Conflict Dataset[3] defines a conflict as a contested incompatibility between two organized parties, where at least one of the parties is a government of a state, and the number of battle deaths reaches 25 in a given year (Gleditsch et al., 2002). An intensity variable indicates if a conflict reaches the level of war (1,000 battle deaths or more). We have rerun the onset analysis on this subset of the armed conflicts without any significant differences. The threshold of 25 casualties is reasonable for two reasons. Firstly, since few conflicts escalate all the way to war, there is a lower a priori probability of finding a significant relationship at that level. Secondly,

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[2] The dataset includes a total of 4,621 observations and 121 onsets. Due to missing data on some of the control variables, the number of observations analyzed is usually lower. However, robustness tests without these control variables indicate that this does not seem to affect the results.

[3] www.prio.no/CSCW/Datasets/Armed-Conflict/.

as resource conflicts tend to occur in a small part of the country only, they are likely to be less severe than interstate wars or full-scale national civil wars fought over governmental power.

'Onset' of armed conflict is defined as the outbreak of a new armed conflict. For recurrent conflicts a new onset is recorded only if five years have passed since the conflict was previously active.[4] We also include a variable for peace years and use cubic splines to control for time dependency (Beck, Katz & Tucker, 1998). Although we use lower battle death threshold, the onsets are still few (2.6% of all observations), so we use rare events regression (relogit) as suggested in King & Zeng (2001).

To test the duration hypotheses we use a new dataset (Gates & Strand, 2006), based on the UCDP/PRIO Armed Conflict Dataset, but with more precise start and end dates.[5] This dataset measures conflict in days instead of years or months.[6] We use Cox regression in the duration analysis.[7]

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[4] We also analyzed the data with a new onset coded after two and eight years. There were no important discrepancies in the results.

[5]In the national duration analysis we have 195 subjects (i.e. conflicts) and 163 failures (i.e. conflicts that end in the analysis period 1970–99). In the disaggregated duration analysis the dataset set includes 275 subjects and 246 failures (1946–2004).

[6] The duration dataset has a two-year threshold for ending a conflict. That is, if a conflict in the UCDP/PRIO conflict dataset is inactive for a period less than two years, the conflict is coded as ongoing. The argument for doing this is that even if the conflict did not reach 25 battle deaths in a single year between two years with active conflict, there was probably some armed violence going on and would be a mistake to code the conflict as ending and restarting less than two years later.

[7] This is a semi-parametric model, where the parametric form of the hazard function is not specified. In situations where the form of the baseline function is not of substantive interest, the Cox model is preferred (Box-Steffensmeier & Jones, 2004: 48).

To test the effect of forest resources we use a logged transformed variable of the absolute value of forest cover for all areas with more than 10% crown cover, which is the FAO definition of forest (see Appendix 4[8]).[9] The variable is measured for the 1990s,[10] and is fixed for all years within each country.[11] To test the forest resource-rent hypotheses, we use a variable of the value of total forest product exports as a percentage of the total value of exports. The forest export data are based on data from FAO's forestry database FAOSTAT.[12] These data include all types of forest products. The figures for total exports are from Gleditsch (2002). This variable does not pick up the timber smuggled by rebels. But it is still of interest since in several countries, such as Burma and Cambodia, the regime exploits timber to finance its participation in conflict.

To test the rough terrain hypotheses, we use a logged variable of closed forest cover (exceeding more than 40% crown cover) as a share of total land area. In the duration analysis we use the country-level forest data, i.e. all conflicts in the same country are coded with the same level of forest cover.

As control variables we include regime type and regime type squared based on the Polity index (Jaggers & Gurr 1995), ethnic fractionalization and ethnic fractionalization squared, population size, and population density. We also include percentage of mountain

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[8] All the appendices are found in our replication data file, at www.prio.no/cscw/datasets.
[9] We have also run the analysis using forest cover variables that were not log-transformed. The results do not differ significantly. We therefore only report the results for the log-transformed variables.
[10] These data are based on satellite images taken in 1992–93 and 1995–96.
[11] To our knowledge, there is no consistent dataset on global coverage that gives a historical record of forest cover changes. But since we are looking at the total amount of forest, using a fixed value will do.
[12] http://faostat.fao.org/, downloaded November, 2004.

terrain in the country. In the analyses testing forest export we include forest per capita (log transformed) as a control variable[13]. Finally, we control for GDP per capita as an indicator for the level of development level. These are standard variables in studies of civil war (Hegre, Ellingsen, Gates & Gleditsch, 2001, Fearon & Laitin 2003). Tables A.1 and A.2 in the Appendix report descriptive statistics for the variables we include in the onset and duration analyses. In Table A.4 the analyses in Models 1 and 4 with control variables are included.

Results

The forest variable in Model 1 is significant, but only at a 0.1 level of significance. Contrary to our hypothesis the variable shows a negative relationship with conflict onset, indicating that the risk of conflict is *lower* in forested countries. The closed forest variable in Model 2 is not significant, but it also indicates a negative relationship. We find no such suggestion in the case study literature and have no good explanation for it. Perhaps forest cover makes the terrain inhospitable for the rebels just as it becomes less accessible for the government. We also tested whether there were any significant differences if the forest was located in a tropical or sub-tropical zone (not reported in the table), but the results did not change.

Table 1
Forest and conflict: Onset and duration analyses at the national level, 1970–99

[13] Ethnic fractionalization, population density, and forest per capita are not included in the disaggregated analysis reported in Table 2. However, including them did not change the results substantially.

	Onset analysis Coefficient (standard error)				Duration analysis Hazard ratio (standard error)		
Explanatory variables	Model 1	Model 2	Model 3a	Model 3b	Model 4	Model 5	Model 6
Open forest cover	–0.124 (0.068)*				1.005 (0.059)		
Closed forest cover		–0.038 (0.039)				1.080 (0.050)*	
Forest exports			0.021 (0.011)*	0.018 (0.015)			0.999 (0.123)
N (no. of onsets)	3,636 (104)	3,626 (103)	3,519(102)	3,490 (97)			
Subjects (failures)					170 (134)	167(131)	164 (127)

*p < 0.10; **p < 0.05; ***p < 0.01. The control variables are not reported. Ethnic fractionalization, forest per capita, GDP per capita, and total population were significant in the onset analysis. In the duration analysis only conflict intensity and population density in Model 4) were significant. 'Subjects' indicates how many conflicts were included in the analysis, and 'failures' indicates how many of these ended within the period of analysis.

In Models 3a and 3b we test the relationship between forest exports and conflict onset.[14] In Model 3a the variable is positive as expected and significant at a 0.1 level, indicating that the greater the value of forest exports, the more likely is an onset of conflict. When running the analysis without Burma in Model 3b the variable is positive but not significant. This indicates that the relationship between forest export and conflict is not a general pattern, but rather driven by certain cases. Burma has the largest reservoir of teak in the world, and its military regime has been accused of selling illegal timber.

[14] Swaziland reports extremely large numbers for its forest exports; this outlier is removed from the analysis.

In the duration analysis at the nation level (Model 5) closed forest is significant. But the hazard ratio exceeds one, indicating that the risk of the conflict ending is higher. We find a similar relationship in Model 4 although not significant. This provides no support for the hypotheses suggesting that forest resources prolong conflicts by providing cover for insurgents.[15] On the contrary, conflicts with forest cover or even closed forest cover tend to have *shorter* conflicts. However, the closed forest variable is significant, but only at a 0.1 level of significance. The forest exports variable is unrelated to duration (Model 6). Interactions with tropical and sub-tropical zones (not reported in Table 1) are not significant either.

In reporting their own insignificant finding for forest cover and civil war duration, Collier, Hoeffler & Söderbom (2004: 266) comment: 'Evidently, mountains and forests offer safe havens for rebels in necessity. Perhaps, however, the results suggest that in the circumstances where it has proved feasible to escalate the conflict to a substantial scale – so that it is included in our sample – it can be sustained militarily even without favorable geography.' Had this conjecture been correct, we should have expected forest cover to have a significant relationship either to onset or duration in our analysis, which includes conflicts with a much lower threshold of violence. Instead, we conclude that there is no support for the hypothesized positive relationship between forest and conflict, whether we look at onset or duration and whether we look at forest cover or forest exports. Yet,

[15] In a survival analysis, Stata reports the hazard ratio, which is the change in the hazard rate from the baseline. A hazard ratio greater than 1 indicates that an increase in the covariate will increase the likelihood of the conflict ending, whereas a hazard ratio less than 1 indicates a lower likelihood of a conflict ending.

this might be an outcome of the problems we have identified with analysis at the nation level of a mostly local phenomenon like armed conflict. We now move to a disaggregated approach.

Disaggregated analysis at the level of the conflict zone

To establish a more precise link between forest resources and conflict, we need more accurate data on location. The UCDP/PRIO dataset represents each armed conflict-year event with geographical coordinates (latitude and longitude) as well as a radius as a first approximation of the conflict's extension (Buhaug & Gates, 2002). Here, we move beyond these circular conflict zones and use GIS-generated polygons. Based on narrative information with place names for the location of the various battles we have generated a new and more precise dataset on conflict affected areas.[16] The conflict zones generated for this article have not been published previously but are released with the replication data. For Africa, the new polygon zones are similar, but not identical, to the conflict zones used by Buhaug & Rød (2006). To be able to further explore the relationship between forest resources and conflict we run a duration analysis using the conflict zone as the unit of analysis.

If rebels use the forest as a refuge, they may want to keep the fighting away from their base. Their tactic might be to emerge from the forest to engage the government and then once again duck for cover in the forest, as in the Chiapas conflict in Mexico. If this is the case, looking at forest cover in the conflict zone might be misleading. However, the

[16] The main sources are various volumes of *Keesing's* as well as the conflict data archive in the Department of Peace and Conflict Research, Uppsala University.

conflict zones we are using include rebel headquarters, where such information is available. Fig.1 shows the extent of forest and conflict in Congo and the DRC; it also indicates where known rebel headquarters are located and where the battle events took place. We see that large parts of the forest in the DRC coincide with the conflict zone, including the headquarters. If the government knows that the rebels are hiding in the area, they are likely to attack the headquarters even if they are situated far away, and the area surrounding the headquarters will become a part of the conflict zone. Fig. 1 shows that a number of battle events do occur in proximity to the headquarters. In the Vietnam War, when the Vietcong attacked targets outside of the forest, the South Vietnam government and the US responded by defoliation and bombing the forest.

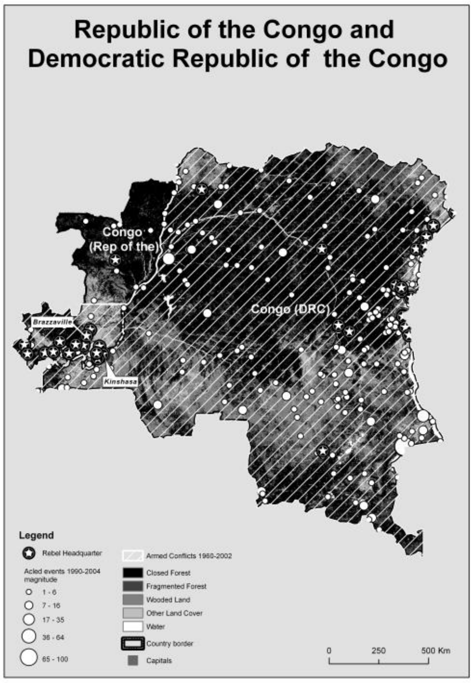

Fig 1. Conflict and rebel headquarters in Congo and the Democratic Republic of Congo
The map displays data from the ACLED dataset, www.prio.no/CSCW/Datasets/Armed-Conflict/Armed-Conflict-Location-and-Event-Data/.

Hypotheses

Based on our theoretical framework, we have designed four sets of hypotheses to shed light on the relationship between conflict duration and forest resources in the conflict zone. First, we test the same hypotheses that we tested at the nation level, based on the opportunity and rough terrain arguments. Further, we test three additional sets of hypotheses, to see whether other factors interact with the forest variables in their impact on conflict.

Forest alone

In an ideal test of our theoretical argument we would have formulated separate hypotheses for the economic opportunity argument and for the rough terrain argument. But since we are unable to measure forest exports or any other variable indicating the value of the forest in the specific conflict zone, we can only test a single general hypothesis relating forest resources and conflict at the disaggregated level. If our hypothesis is supported, we are as yet unable to say whether the operating mechanism is economic opportunity or rough terrain.

H3: If a conflict zone has large areas of forest, the risk of a longer conflict is higher.

Geographical location of the conflict zones

Areas with abundant forest resources tend to be remote and inaccessible and are often regarded as peripheral and of low political importance for the government. Fig. 2 shows a map of the forested areas in Burma with the territorial conflicts superimposed. The conflicts occur largely in forested areas, along the international boundary, and far away from the contemporary capital.

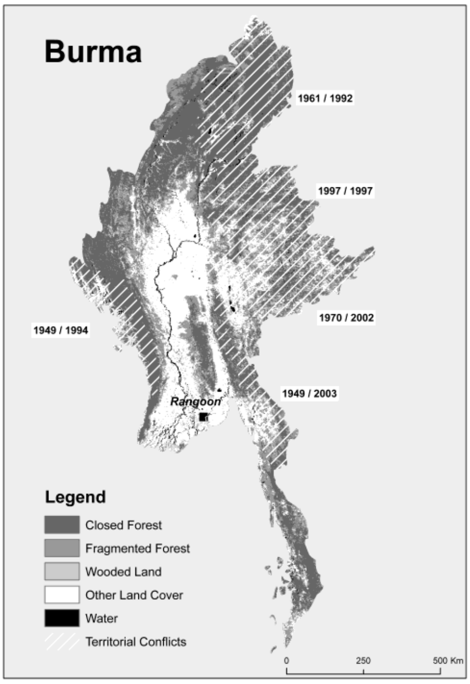

Fig. 2. Territorial armed conflicts in Burma superimposed on a map of forest cover
The years refer to the first and last entry of the conflict in the database. The forest cover data come from FAO, and the data for the armed conflict come from the UCDP/PRIO dataset. Both datasets are identical to those used in the statistical analysis.

Buhaug & Rød (2006) find, for the period 1970–2001, that distance from the capital and proximity to an international border increase the risk of onset of an internal armed conflict in Africa. In Cambodia the geographical location of forest at the periphery of the country along the border with Thailand was a key factor in permitting the Khmer Rouge to generate revenue for continued fighting after 1989. Tropical timber became one of the most important financial sources for the rebels. We therefore formulate the next pair of hypothesis based on the geographical position of the conflict zone. If the conflict is situated close to the capital, it is easier for the government to control the activity of the rebel groups. Since timber is large and bulky, it is difficult to conceal during transportation, hence the closer it is to the political center the harder it is to hide the traffic. Further away, the rebels can exploit the resources more easily, with less chance of getting exposed and caught by the government. From this follows Hypothesis 4.

H_4: A forested conflict zone close to the capital will on average experience shorter conflicts than a forested conflict zone further away.

Following the same logic, if the conflict zone is situated close to an international border, i.e. far from the political center, the rebels can more easily exploit the forest resources and it is more likely to affect the conflict. According to Le Billon (2001), remote forests tend to promote warlords. Also, the closer the conflict zone is to the border, the easier it is to smuggle the timber out of the country. Thus, Hypothesis 5:

H_5: A forested conflict zone close to an international border will on average experience longer conflicts than a forested conflict zone further away.

One of the best ways to transport timber is by waterways. Therefore, the distance to the coastline should also matter:

H_6: A forested conflict zone close to the coast will on average experience longer conflicts than a forested conflict zone further away.

Forest as a second choice

Oil and diamonds seem to have a robust effect on civil war, although there is disagreement about the mechanisms at work (Lujala, Gleditsch & Gilmore, 2005; Fearon & Laitin, 2003; Ross, 2006). These are particularly attractive natural resources, from the point of view of lootability, both by rebels and governments. Other natural resources may perhaps take second place if oil and diamonds are available. This logic suggests that the rebels may have preferences that create a 'resource hierarchy' based on the degree of lootability and value of the resource. In such a hierarchy both diamonds and oil would be more attractive than timber. Hypothesis 7 expresses this idea:

H_7: A forest conflict zone without diamonds and oil will on average have longer conflicts.

Governmental versus territorial conflict

Buhaug (2006) finds a clear difference in the factors that affect the onset of governmental and territorial conflicts. The former are conflicts over government power in the country as a whole, where rebel groups seek to overrun the current state apparatus. The latter are conflicts for secession or autonomy for a part of the country, sometimes (as in Aceh, Indonesia) a very small fraction of the national territory. In these conflicts rebels fight for a specific territory, which they consider their home base, such as the Tamil Tigers in the northern areas of Sri Lanka. Buhaug shows, for example, that geographical variables are more important for territorial conflicts, while governance variables are more important for government conflicts. Along these lines, we would expect that different factors might also effect the duration of the two types of conflict, although this has not been tested previously. Since territorial conflicts are usually limited to a specific area, often in the periphery, we expect forest resources to have a larger impact on territorial than on government conflicts:

H_8: The duration of territorial conflicts is more likely to be affected by forest resources than the duration of government conflicts.

Explanatory variables

Forest variables

We have used the dataset developed by the EROS Data Center (EDC) for the Food and Agricultural Organization of the United Nations (FAO) using FAO's four broad land cover categories: closed forest, open/fragmented forest, other wooded land and other land (see Table 1 and Appendix 4). We have reclassified the data to include the two first categories: closed forest and open/fragmented forest as well as the other wooded land category. Based on this, we have calculated three variables expressing the share of the conflict zone covered by closed forest. Wooded land means land either with a 5–10% canopy cover of trees exceeding 5 meters height, or with a shrub or bush cover of more than 10% and height less than 5 meters. In the analyses the forest including woodlands variable includes all three categories, the open forest variable includes both open forest and closed forest, while the closed forest variable includes only closed forest. All three variables measure the percentage of the conflict zone covered by forest, and are centered. All the models in this article have been tested with all three types of forest (closed forest, open forest, and woodland). If there are no substantial differences between these three categories only open forest is reported. Descriptive overviews of the forest data are given in the appendices.

Geographical position

From each of the conflict zone's center points, we calculated the distance between the capital and the conflict zone. The distances were measured from the capital to the center of the conflict zone and from the capital to the closest edge of the conflict zone using an ArcView extension named 'Distances and Bearings between Matched Features, v. 2'.[17] This extension calculates the distance between features with identical attribute values along geodesic curves. We also calculated the distances from the conflict zones' center points to the nearest international border. To calculate these distances all the coastline borders had to be removed from the dataset to ensure that the distance was measured to closest international border. For island countries which lack contiguous neighbor states, such as Sri Lanka, the distance was measured to the edge of the country. In the analysis testing distance to the capital and to international border we also included a dummy variable indicating whether the country had a coastline or not. Because timber is often transported by waterways, we have included, for conflict polygons in coastal states, a distance measure to the nearest coast, as well an interaction with the forest variable.[18] Table 3 presents the results from this analysis.

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[17] Downloaded from www.jennessent.com/arcview/distance_by_id.htm. The script only works for ArcView 3.x.
[18] Conflicts in land-locked states are assigned the value 10,000 km.

Other conflict resources

To test whether there is a hierarchy of natural resources, we look at diamonds, oil,[19] and pipelines.[20] Instead of testing the effect of each of the resources by themselves we created two dummy variables, one for the conflict zone and one for the country in general, indicating whether or not other conflict resources were present. Since we are interested in the cases where no other conflict resources are present in the conflict zone, the dummy variable gets the value 1 when there are no other resources and 0 when they are present. To be able to test the effect of forest resources when other conflict resources are not present, we include an interaction term between the forest variable and the dummy variable for other conflict resources. In the analysis reported in Table 4, we included both alluvial (secondary) and kimberlite (primary) diamonds. However, we have also run tests with alluvial diamonds only, since these are more lootable and more accessible for rebels than kimberlite diamonds (Lujala, Gleditsch & Gilmore, 2005). This did not affect the results, so we do not report the additional tests here.

Territorial conflicts

In Table 5 we exclude all conflicts where the incompatibility between the parties is over government, and only include the conflicts coded as territorial[21].

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[19] The georeferenced data for oil and diamonds were taken from the datasets Petrodata (Lujala, Rød & Thieme, 2007) and Diadata (Gilmore, Lujala, Gleditsch & Rød, 2005).

[20] Pipelines in general include gas, oil, and other pipelines. These data have not been published previously, but are released with our replication data.

[21] We have also run the analysis with governmental conflicts only, but the results are not significant. We present only the analysis for territorial conflicts in this article since we have a theoretical argument for why we should expect these to be longer in forested areas.

Control variables

To avoid the forest cover variable absorbing the effect of the size of the conflict zone, we use a control variable that measures the absolute size of the conflict zone in km^2 and log-transformed. In addition, we have added four control variables, which are measured at the country level: a log-transformed variable of total population and population density (World Bank), a lagged and log transformed GDP per capita variable, and finally the lagged Polity score and its square term. We use Cox regression and the same duration dataset as for the nation-level duration analyses, but look at the longer time period, 1946–2003.[22] Table A.3 in Appendix 1# contains descriptive variables for the disaggregated duration analysis.

Results

In Table 2 we look at the three sets of hypotheses over the period 1946–2003. Model 7 tests whether the geographical position of the conflict zone makes forest resources more or less important in affecting the duration of conflict. The model indicates that geographical distance does affect the duration of conflict, as both distance to the capital and distance to international border are significant. The further away the conflict zone is from the capital the lower the probability that the conflict will end, and the further away the conflict is from the border the higher the probability of the conflict ending. In general, the geographical distance does not seem to affect the relationship between open forest

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[22] We have also run the analysis with the same time span as in the national level analysis, but the results do not change substantially.

and conflict. We also tested the interaction between forest resources and the distance variables, but the interaction terms are not significant, and are not reported here. We also tested the forest variables including only the control variables, but neither of them provided significant support for Hypothesis 3.

Table 2
Disaggregated survival analysis of forest cover in the conflict zone, distance measures, and other conflict resources, 1946–2003

Explanatory variables	Model 7 Hazard ratio (st.e.)	Model 8 Hazard ratio (st.e.)	Model 9 Hazard ratio (st.e.)	Model 10 Hazard ratio (st.e.)
Open forest [a]	0.999 (0.003)	0.985 (0.061)**	0.998 (0.002)	0.996 (0.003)
Distance to capital	0.907 (0.052)*	0.899 (0.053)*		
Distance to border	1.290 (0.083)***	1.314 (0.088)***		
Distance to ocean		1.062 (0.037)*		
Distance to ocean * Open forest		1.003 (0.001)**		
Other conflict resources [b]			1.009 (0.183)	1.069 (0.194)
Other conflict resources * Open forest				1.008 (0.006)
LL	–801.31118	–798.20115	–812.33538	–811.11363
Subjects (failures)	222 (188)	222 (188)	222 (188)	222 (188)

*p < 0.10; **p < 0.05; ***p < 0.01. The control variables are not reported. In all models size of conflict area and democracy were significant; in Model 8 democracy squared was also significant.
a We have also tested woodland and closed forest but the results do not change, and we therefore only report open forest here.
b We also tested other conflict resources in the country, but the results are the same, and are therefore not reported here

In Model 8 we find that distance to the coast matters. Both the interaction term and the interaction factors by themselves are significant. Consistent with Hypothesis 6, when the distance to the ocean becomes shorter and the forest coverage increases the conflicts are less likely to end. Also, if the distance to the ocean increases and the forest coverage decreases the conflicts tend to be shorter. This is shown in Fig. 3. When looking at the data behind Model 8, we see that the Burma, Papua New Guinea, Senegal, and Bangladesh have a short distance to the ocean, more than average forest in the conflict zone, and all these conflicts have lasted more than eight years. If we take these four conflicts out of the analysis, the significance disappears. But the results are driven by a combination of the four, not by a single conflict.

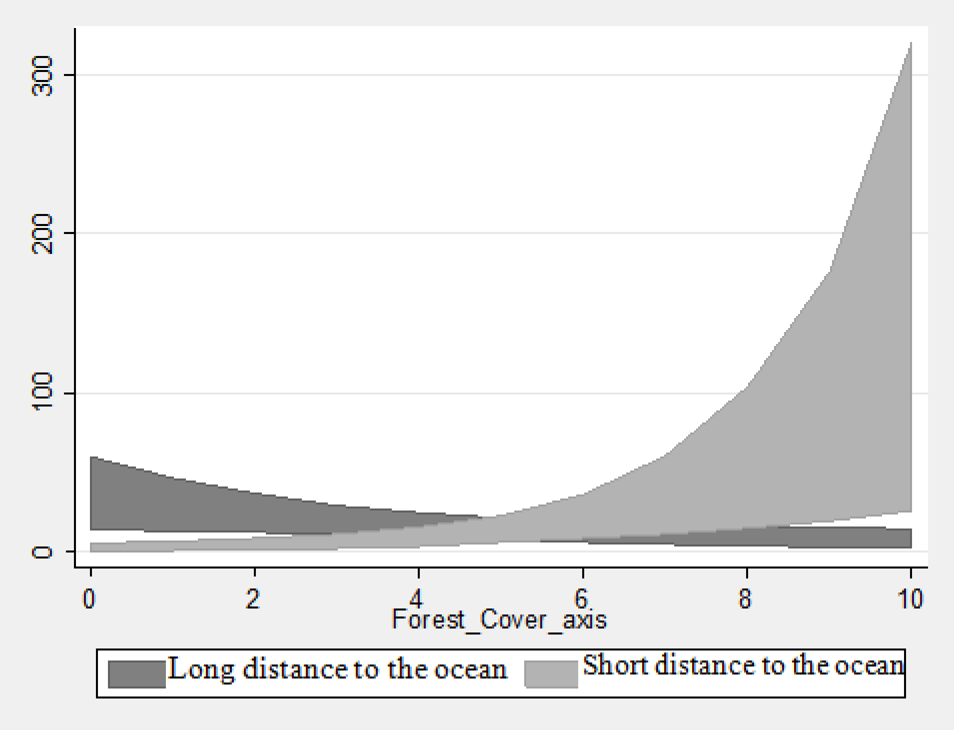


Fig. 3.
Forest cover, conflict and distance to ocean from the conflict zone. Date from Model 8

In Models 9 and 10 we look at the third set of hypotheses; whether forest resources are a second choice for rebels. The idea is that if forest resources are the only valuable resources in the region they become more important than what is the case in regions that also have oil and diamonds. We test this by including an interaction term between forest resources and the lack of other resources that are assumed to stimulate conflict. In Model 9 we test whether the lack of other conflict resources[23] in the conflict zone affects the importance of forest resources, while in Model 10 we assess the impact of forest when it is the only valuable conflict resource in the conflict zone. However, none of the results in these two models are significant, indicating that forest resources do not become more attractive in the absence of other conflict resources such as oil and diamonds. In Table 3 we test the hypotheses that forest resources matter more in territorial conflicts. In Models 11 we test the distance variables. In contrast to Table 2, the distance to the capital is not significant. This is easily explained by the fact that this analysis only includes territorial conflicts, which generally occur far from the center. On the other hand the distances to an international border and to the coast are significant; the closer the conflict is to the international border or the coast the longer its duration. However, the forest variables are still not significant.

In Model 12 we test whether the resource hierarchy makes a difference in territorial conflicts. The resource variable is significant, i.e. the conflict is more likely to end if there are no other conflict resources in the region. We also ran the analysis including the interaction variables between forest cover and the natural resource variable and between forest cover and the distance variables but these were not significant.

Table 3
Disaggregated survival analysis of forest cover for territorial conflicts, 1946–2003

[23] 'Other conflict resources' is coded as a dummy variable with the value 1 if there are no other resources in the conflict zone and 0 if there are other resources in the conflict zone.

Explanatory variables	Model 11 Hazard ratio (st.e.)	Model 12 Hazard ratio (st.e.)
Open forest [a]	0.998 (0.004)	1.000 (0.004)
Distance to capital	1.080 (0.179)	
Distance to border	1.241 (0.141)**	
Distance to coast	1.184 (0.081)**	
No other conflict resources		2.088 (0.734)**
LL	–273.33431	– 270.15276
Subjects (failures)	95(78)	95(78)

* 0.1 level , ** 0.05 level of significance, *** 0.01 level of significance. The control variables are not reported. In all models democracy was significant, and in Models 11 and 12 size of conflict area was significant,
a We have also tested for woodland and closed forest, but the results do not change. Therefore, we only report the results for open forest here.

In Models 7 to 11 the distance to coast to matter in conflict zones with large amounts of forest. However, we do not find any convincing evidence that forest resources have a general effect on conflict duration, even when the data are disaggregated.

However, it is frequently argued that the greed argument is more valid in the period after the end of the Cold War when the economic support from the USA and Soviet Union dried up (de Jong, Donovan & Abe 2007: 37; Collier & Hoeffler 2004: 568–569). We therefore also ran these tests on a sample only including territorial conflicts after the end of the Cold War.[24] In most of the analyses this did not make any difference, except in Model 13a in Table 4, which includes the woodland variable. We tested the open forest and closed forest variables as well but neither of them was

[24] We include all conflicts ongoing in the post-Cold War period, including those that started during the Cold War.

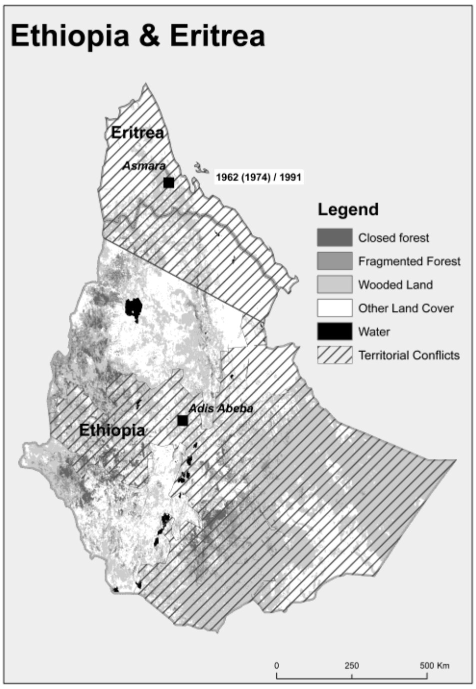
significant. Model 13a suggests that the more forest the longer the conflict in the post-Cold War period. However, this effect disappears if we exclude the Ethiopian conflict as shown in Model 13b. Ethiopia has large areas of woodlands in the conflict zone (Fig. 4), which drives these results. This reinforces the idea that the results are driven by single conflicts or countries, as we saw in Table 1 with Burma and forest export.

Table 4
Disaggregated survival analyses for territorial conflicts, 1990–2003

Explanatory variables	Model 13a Hazard ratio (st.e.)	Model 13b [a] Hazard ratio (st.e.)
Woodland [b]	0.989 (0.005)**	0.992 (0.006)
LL	–122.58067	–106.76122
Subjects (failures)	63(47)	56 (42)

*p < 0.10; **p < 0.05; ***p < 0.01. The control variables are not reported. Democracy was significant in Model 18.
a In Model 18 the Ethiopian conflicts are taken out of the analysis.
b We have also tested open forest and closed forest but the results were not significant.

Fig. 4 Territorial conflicts in Ethiopia and Eritrea starting or on-going after the end of the Cold War



In Table 5 we replicate Model 10 for the post-Cold War period.[25] However, we include also the results for the analysis with other conflict resources in the conflict zone (Model 14) as well as the results for other conflict resources in the conflict country (Model 15). If we look at both territorial and governmental conflicts after 1989, the interaction variable and the forest variable are significant. But it is stronger for the

[25] In Models 14 and 15 we test the Cold War and the years after the Cold War as separate periods. For the Cold War period we have only included ongoing conflicts after 1989. We also ran an analysis where we used a Cold War dummy variable and interacted it with all the variables to find the effect of the Cold War period. The estimates in this analysis showed the same trend as the analyses in Models 16 and 17, but due to the complexity of the model the significance disappeared and the results are very difficult to interpret.

conflicts where we only include whether there are other conflict resources in the conflict zone or not. We find the same results when testing with closed forest, but not for the woodland variable where the interaction term is not significant. This can indicate that forest that covers more than 10% of the canopy may affect conflict duration.

Table 5
Disaggregated survival analyses for all conflicts, 1990–2003

Explanatory variables	Model 14 [a] Hazard ratio (st.e.)	Model 15 [a] Hazard ratio (st.e.)
Open forest [b]	0.990 (0.004)**	0.992 (0.004)*
No other conflict resources	1.122 (0.327)	1.088 (0.367)
Interaction open forest * No other conflict resources	1.021 (0.008)**	1.014 (0.008)*
LL	–272.08133	–273.83713
Subjects (failures)	118(85)	118(85)

*p < 0.10; **p < 0.05; ***p < 0.01. The control variables are not reported. In both models size of conflict area was significant and in Model 16 democracy was significant,
[a] Model 15 reports results if there are other conflict resources in the conflict zone, while Model 15 reports results if other conflict resources are allocated in the country.
[b] We have also tested woodland and closed forest but the results do not change. Therefore, we only report open forest here.

However, Fig. 5 shows that if there are no other conflict resources in the region, increasing forest cover seems to shorten conflicts. On the other hand, if there are other resources in the region, conflicts tend to be longer. Since other resource such as oil and diamonds increases the length of conflicts (Fearon 2004, Lujala, Gleditsch & Gilmore 2005), our finding may indicate that in forested areas it may be easier for rebels to hide the looting of other resources, especially diamonds.

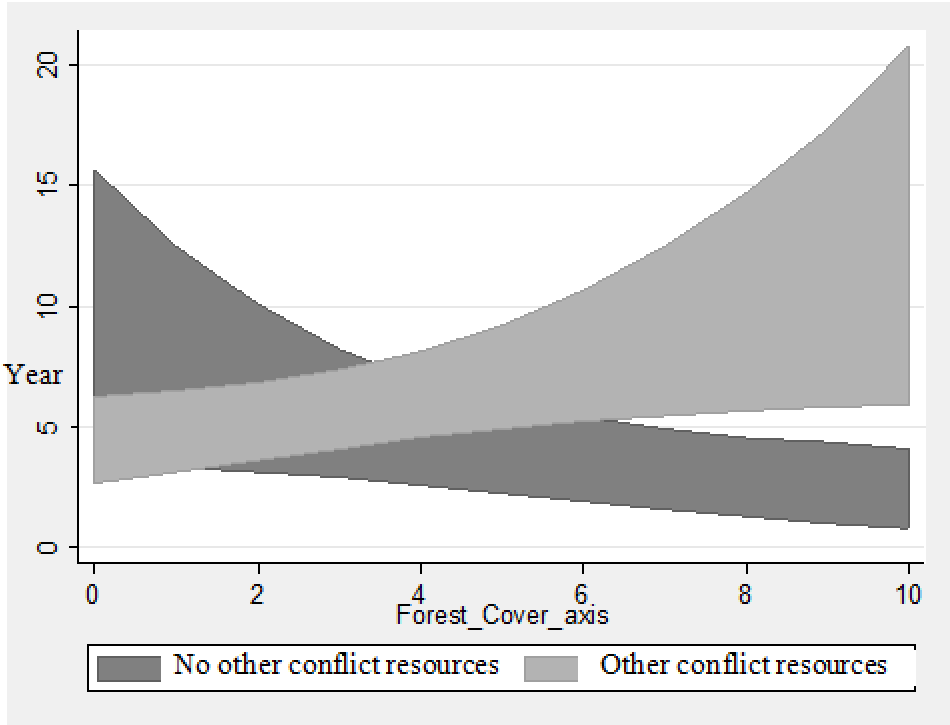


Fig. 5. Forest cover, conflict and other conflict resources present and absent in the conflict zone, 1990–2003. Data from Model 14

A closer examination of the data behind these results shows that the category with other conflict resources and large amounts of forest is made up by several conflicts in North East India, Burma, and Bangladesh. Again, Burma stands out as a country where the conflicts are clearly related to forest resources. However, the results displayed in Fig. 4 are not very robust.

Conclusions

Insights mainly derived from case studies suggest that forest resources can influence armed conflicts in two ways: as a source of financing the warfare and as a safe haven for rebels. In particular, case studies from FAO and USAID have highlighted these issues. Their reports make reference to several African, South-East Asian, and Latin American countries and portray forest resources as an important general source of conflict. Although these insights seem perfectly reasonable in the light of the general literature on the role of economic and physical opportunities in conflict, the generalizations seem premature for onset and duration of conflict when analyzed at the national level. This study has found that forest resources generally have a negligible influence both on conflict onset and conflict duration when analyzed at the country level. One of our few significant results indicates that the relationship might be opposite; the amount of forest in a country is negatively associated with the risk of conflict onset.

Research on natural resources and conflict, whether emphasizing scarcity or abundance, has been marred by a mismatch between the results of case studies and statistical studies. Quantitative scholars have usually attributed this to biased case selection in the case studies (Gleditsch, 1998). Case study scholars, on the other hand, have charged that the statistical study suffer from a naïve conceptualization of the causal mechanisms (Schwartz, Deligiannis & Homer-Dixon, 2001). This study shows that some of the general claims relating forest resources to conflict in the literature relying on case studies have indeed generalized somewhat hastily. On the other hand, using a more careful model specification based on a disaggregated design we find two justifications making our statistical analysis more compatible with specific claims made in the case study literature. Firstly, focusing on the post-Cold War period makes our statistical analysis more compatible with specific claims made in the case study literature about natural resources and armed conflict. For example, insurgencies that have the typical conflict commodities (oil and diamonds) available tend to produce longer conflicts than insurgencies without these opportunities, especially when the local extent of forest coverage increases. This indicates that during the post-Cold War period, forest cover does increase the opportunities to extract conflict commodities, but does not indicate that forest resources substitute for other resources. Secondly, by emphasizing the location of armed conflicts in relation to features which either hinders or enables the transportation of timber commodities such as nearness to capital, international border and sea, we find that distance to the ocean seems to increase the impact forest has on conflict duration. We do not find the same effect for the other distance variables. This is as expected since timber is commonly transported by sea and since it is often argued that it is harder for the government to keep remote coastlines under surveillance than roads. Thus, it is easier for belligerents in a coastal state to exploit timber economically. Even though the disaggregated design produces some more significant results, the results are not very robust, and we cannot conclude that forest resources generally are linked to conflict. Some of our results even show that by excluding one country the significance disappears.

This underlines the suspicion that the idea of forest conflicts and forest timber is driven by studies of single cases rather than a general pattern. While some of the overall measures of resource dependency (notably primary commodity exports as a share of the national product) are much too crude to capture the opportunity factors at work, excessive focus on individual resources may also prove misleading if not interpreted with caution.

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Acknowledgements

Earlier versions of this work were presented at the Norwegian National Political Science Conference in Bergen, 4–6 January 2006, the 47th Annual Convention of the International Studies Association in San Diego, CA 22–25 March 2006, the Polarization, Conflict Workshop in Nicosia, Cyprus 26–29 April 2006, and the CSCW working group meeting on environmental factors in civil war in Oslo 21–22 September 2007 and the Polarization and Conflict Workshop in Palma de Mallorca, Spain 10–11 December 2007. We are grateful to the participants of these meetings as well as Håvard Hegre, Håvard Strand, and other colleagues at CSCW and NTNU for comments and suggestions. The referees and editor of this journal also made some very valuable comments. We thank Doreen Kuse and Helena Kusch for their assistance in generating the data on the conflict polygons and the pipeline data used in the disaggregated analysis. Finally, we acknowledge the financial support of the Research Council of Norway.