Armed Conflict over International Rivers: The Onset and Militarization of River Claims

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As global demand for water increases but usable freshwater resources decrease, many have suggested that water scarcity is and will be an important source of armed conflict -- but little systematic research has investigated this topic. We examine the management of all shared rivers in the Americas, Western Europe, and the Middle East, seeking to understand both the outbreak of explicit disagreements over the use of rivers ("river claims") and the militarization of these claims. We argue that increasing water scarcity and water demands make states more likely to begin river claims and to begin militarized conflict over these claims, but that treaties can help to prevent both the emergence and militarization of river claims. Empirical analysis with rare events logit models indicates that greater levels of water scarcity and greater demands on water increase the risk of both claim onset and militarization, while river treaties have mixed effects on claim onset but significantly reduce militarization. We conclude by discussing implications for future research in this area.

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Water is an essential resource for human survival, as well as for agriculture and industry. Access to water has become a part of many states' national security concerns, with one body of scholarship (the "Neomalthusians") describing competition over water as a likely source of violent conflict. Other scholars (institutionalists or "Cornucopians") are more optimistic about the impact of water, emphasizing the cooperative aspects of shared waters and arguing that disagreements over shared waters are handled better through cooperation than through military threats. While these general schools of thought disagree about how disagreements over water will be handled, though, both recognize that disagreements over water are likely to occur.

In this paper we will address both perspectives in studying the management of international rivers. We begin by investigating the conditions under which states are most likely to begin explicit disagreements over rivers ("river claims"), a topic that to our knowledge has never been investigated through systematic large-N analysis. Where river claims do emerge, we investigate the conditions under which these claims are likely to become militarized. While earlier studies have examined the possible linkage between shared rivers and conflict, this is one of the first studies to examine the militarization of river claims specifically, rather than including all conflicts between riparians (including many conflicts that did not involve river or water issues directly).

We begin by reviewing the existing literature on international rivers, water scarcity, and conflict. We then provide a theoretical framework for the study of river claim origins as well as militarization, focusing on water stress and river institutionalization. Our analyses of the resulting hypotheses break new ground by studying river claim onset systematically, as well as by examining individual rivers shared by neighboring states rather than aggregating all shared rivers together. These analyses indicate that greater levels of water scarcity and greater demands on water increase the risk of both claim onset and militarization, while river treaties have mixed effects on claim onset but significantly reduce militarization. Democracies are better able to avoid river claims, while claim militarization is much more likely over cross-border rivers and

over claims that are more salient to the riparian states; navigation claims seem to be particularly prone to lead to militarized conflict. Finally, we conclude by discussing the implications of this paper for future research in this area.

Shared Rivers and Interstate Conflict

Since the end of the Cold War there has been a growing interest in the concept of environmental security, seen as a part of a broader concept of human security (e.g., Gleditsch 2001; Gleick 1993; Renner 2002, Rogers 1997; Yoffe et al. 2004). The effects of scarcity or abundance of special natural resources have gained a prominent place in this line of research. Water is one of the most essential resources and has received considerable attention (e.g., Beaumont 1997; Gleick 1993; Kalpakian 2004; Klare 2001; Lonergan 2001).

One group of researchers investigating water and international relations, the Neomalthusians, focuses on water as a source of violent conflict. This approach originally developed from Thomas Malthus' writings about the relationship between population pressure and societal capacity for sustaining means of livelihood in *An Essay on the Principle of Population* (1798). Although not adopting such a strict view of the situation as Malthus[1], the Neomalthusians focus on population growth in combination with other factors such as economic and industrial development. Together, such factors are expected to produce scarcity through either increased demand on a limited resource or degradation of the resource. Scarcity will in turn lead to securitization of the resource, disagreements over the use of the resource will occur, and violent conflicts are likely to result from these disagreements.

Neomalthusian arguments receive support from several sources. Only 3% of the world's water is freshwater, and most of that amount is not directly available for use -- whether because it is locked up in icecaps or deep aquifers or because it is polluted. According to the most recent *Human Development Report* (UNDP 2006), more than one billion people lack access to clean water. Another report (UNEP 1999: 4) forecasts that if present patterns of increasing

[1] Malthus argued that the geometric progression of population growth and the linear growth in food production would at some point inevitably produce a food crisis. Among the consequences of this crisis were famine, pestilence, and war.

consumption persist, two out of every three persons will live under water-stressed conditions by the year 2025. These figures vary across countries or regions, though, as accessible freshwater is distributed very unevenly. North America has an annual run-off of 17,000 m^3 per capita per year, while Africa has 6,000 and Egypt just 50. Less than 1% of the world's usable freshwater is located in the Middle East or North Africa, yet this region contains 5% of total world population. Many of the countries with low water availability today also have a high rate of population growth, so the problem seems likely to increase further in the future (Beaumont 1997: 358). In Africa, for instance, by 2025 an additional eleven countries will have joined the fourteen that are considered to be experiencing water stress today (UNEP 1999: 6).

To Neomalthusians, disagreements are likely to come about because of this scarcity, and these disagreements may very well become militarized. Among the Neomalthusian theorists, Homer–Dixon and his associates have conducted the best-known body of work linking resource scarcity and environmental degradation to conflict (e.g., Homer-Dixon 1994, 1999). Although claiming that conflict is generally more likely over non-renewable than renewable resources, they argue that among the renewables water has the greatest potential for stimulating armed conflict. Based on a number of case studies, they conclude that environmental scarcities contribute to violent conflict in many parts of the developing world, and will do so increasingly in the future as the scarcities grow (Homer-Dixon 1994: 18 ff); other scholars (e.g., Gleick 1993; Rogers 2002) make similarly pessimistic forecasts about water scarcity as a crucial national security issue and source of future conflict. Several large-N studies (Toset et al. 2000; Furlong, Gleditsch & Hegre 2006; Gleditsch et al. 2006) have found that sharing at least one river basin increases the probability of militarized conflict between states, although these studies have not focused exclusively on conflict over rivers, so their results offer at best indirect support for a linkage between water scarcity and conflict (because they suggest that conflict may be conditioned by shared rivers or water scarcity, but they can not say how much of the observed conflict is directly over the water or river itself).

While these studies offer some support for the Neomalthusian view, other evidence supports a more optimistic view. More optimistic researchers, often informed by liberal

institutionalist theory, suggest that cooperation over shared waters is a more likely outcome than conflict (e.g., Keohane & Ostrom 1994). The large number of water agreements -- more than 3,600 water-related agreements were signed between the years 805-1984 alone -- offers substantial support for this argument (Wolf 2002: 189). Wolf (1998, 2002) argues that the nature of shared water resources makes armed conflict counterproductive; shared interests along waterways seem to overwhelm water's conflict inducing characteristics and stimulate cooperation instead, and water management institutions tend to be very resilient once in place. Kalpakian (2004) agrees, noting that case studies from the Nile, Tigris-Euphrates, and Indus river systems suggest that water disputes do not cause serious conflicts, and suggesting that the "mainstream core assumption" that water disputes cause conflict is flawed and must be strictly scrutinized. Indeed, when investigating international interactions over rivers between 1948–99, Yoffe, Wolf, and Giordano (2003) were able to identify only seven incidents of water conflict, and no shots were fired in three of these seven.

Among large-N studies, Brochmann and Gleditsch (2006) find that sharing a river is related to several general measures of positive interstate interaction (trade, alliances, and joint membership in international organizations) as well as low-level conflict. Hensel. Mitchell, and Sowers (2006) examine the management of river basins and find that river-related treaties and institutions increase peaceful efforts to resolve river claims. Tir and Ackerman (2004) examine the origins of international river treaties and find that while economic development, regime type and joint IGO membership increase the chances for a treaty, the upstream/downstream scenario can severely cripple these chances.

Although obviously disagreeing about the nature of international interaction over water, both Neomalthusians and institutionalists agree that water is considered an essential resource worth preserving and that disagreements over shared waters may occur between states. They disagree quite strongly, though, over the question of how such disagreements are handled. To date, no research has examined the conditions under which river disagreements are most likely to emerge, and very little work has considered the conditions under which they are most likely to be managed by military threats or actions. This will be done below.

Hypotheses

Although our theoretical approach currently uses a general conceptual model rather than a game theoretic model, this general approach might productively be formalized in future work. The model begins with two states that share an international river. One state -- the upstream state -- has access to the water resources of the river before they reach the downstream state, and may choose to take advantage of these resources for any of a variety of purposes; human consumption, industry, irrigation, and damming for hydroelectric power generation are some of the most prominent. If it chooses to do so, there may be some effect on the amount or quality of the river's water that reaches the downstream state. If the downstream state believes that the upstream state's actions have such an effect (or will have this effect in the future), it may respond by making explicit demands that the upstream state stop or modify its actions in such a way as to protect the downstream state's interests. Finally, if such demands are made, the two sides may choose from any number of actions to address the demands: the upstream state may decide to comply with the demands, the two states may attempt to settle the issue peacefully (whether through bilateral negotiations, talks with non-binding third party assistance, or submission of the issue to a binding third party judgment), or either state may threaten or use military force to support its position.

For the present paper, we focus on two particular stages in this general model: the conditions under which states are most likely to become involved in explicit disagreements over international rivers (when the downstream state makes demands of the upstream state regarding its activities), as well as the conditions under which these disagreements are most likely to become militarized. While the literature reviewed above will be useful in this regard, our hypotheses will be somewhat different from the hypotheses and findings of earlier work, because our dependent variables are somewhat different. Most existing research has examined the relationship between water scarcity and the outbreak of any militarized conflict between two states (e.g., Toset et al. 2000, Furlong et al. 2006, Gleditsch et al. 2006), and many of the conflicts that are identified have little to do with water issues directly. Such studies often

describe water scarcity and similar factors as conditioning the entire relationship between two states, rather than affecting only the risk of armed conflict over water itself; we focus on disagreements directly over water, rather than on any possible indirect effect of water scarcity on non-water disagreements or conflicts. Other studies have focused on armed conflict over water issues specifically (e.g., Wolf 1998, Yoffe et al. 2003, Hensel, Mitchell, and Sowers 2006), typically finding that conflict directly over water has been a rare phenomenon.[2] While such studies presuppose the existence of some type of disagreement over water resources, though, to our knowledge no previous study has explicitly examined the outbreak of these disagreements themselves.

Water Scarcity (Supply and Demand)

In the literature on water and conflict, water scarcity is usually seen as the primary factor driving conflict. From the perspective of our general model, we begin by expecting that scarcity affects the initial decision to raise a claim. As long as water resources are abundant, and as long as the available water resources do not face great usage demands, there is little reason for a downstream state to begin an explicit river claim by making demands challenging the upstream state's usage of a river. It is only when water becomes too scarce to meet all states' usage needs that disagreement and perhaps armed conflict become likely. When one or both states are unable to meet all of their people's water needs, or fear that they may soon be unable to do so, then disagreement with other states sharing the same limited resource becomes a likely option. Up to this point, this expectation is consistent with both Neomalthusians and liberal institutionalists, as each approach recognizes that water resources might become the subject of disagreement between states.

Once river claims have begun, we also expect that high levels of scarcity also increase the risk that such claims will be militarized. When water is extremely scarce, access to the limited

[2] Gleick's (2006) "Water Conflict Chronology" identifies many more instances of apparent water conflict than other studies in this area, largely because it includes many cases where dams or rivers were used as weapons during ongoing conflicts over other issues (e.g. poisoning wells, flooding enemy lands, or bombing dams as strategic wartime targets).

supply will likely be perceived as a zero sum problem -- especially by a downstream state that sees its already scarce supply threatened by an upstream state -- and the need to ensure sufficient supplies of this vital resource seems likely to lead to consideration of the threat or use of military force. This is not to say that all river claims in the presence of water scarcity will lead to armed conflict, but we do expect that (*ceteris paribus*) the Neomalthusians are likely to be correct about the military being seen as a viable option under such conditions. Our first hypotheses are thus:

Hypothesis 1: *River claims are more likely to begin, and more likely to become militarized once begun, where water resources are less plentiful*.
Hypothesis 2: *River claims are more likely to begin, and more likely to become militarized once begun, where demands on water resources are greater.*

River Institutionalization

While we accept the general arguments of the Neomalthusians about the possibility of river claims and perhaps military force over scarce water resources (*ceteris paribus*), as noted above, the institutionalists also make an important contribution that may be able to counterbalance the conflictual side of water. Liberal institutionalists would suggest that agreements between states can ease the information flow and sharing among them, reduce uncertainty over the use of the resource, and thus resolve possible disagreements before they turn violent (e.g., Keohane 2002). This basic argument has already received some empirical support with respect to rivers, although never for the onset of river claims. Hensel, Mitchell, and Sowers (2006) argue that the presence of institutions in a basin increase the chances of positive conflict management. Brochmann (2006) finds that a signed treaty increases the chances of later water-specific cooperation in a dyad, and at least under special conditions, may reduce later water conflicts.

From the perspective of our general theoretical model, we find the institutionalist arguments convincing with respect to the militarization of river claims. River-related treaties or institutions appear likely to decrease uncertainty and provide grounds for more extensive cooperation than would be expected in the absence of any such arrangements. As a result, the

presence of institutional rules and/or procedures for managing a river -- combined with the history of past cooperation under the treaty, and the existence of the treaty's specific provisions as a reference point for the beginning of negotiations -- should offer peaceful alternatives that leave little need for the threat or use of armed conflict. To the extent that river claims exist, then, we expect relevant treaties to reduce the risk that the claims will be managed through the threat or use of force.

The case is not as straightforward, though, for the impact of treaties on the origins of river claims. By establishing rules for the use of a river at one point in time, treaties may actually set the stage for future disagreement over the use of the river -- although (as discussed above) such disagreements should be peaceful, because the treaty should reduce the risk of armed conflict. States' relations with respect to a shared river may be more likely to lead to explicit disagreements because the treaty provides a clear expectation of how disagreements will be managed; states may be more likely to raise issues that they expect can be handled through regularized peaceful means with little risk of escalation. Treaties may also increase the risk of new claims if the conditions under which the initial treaty was signed change over time. This can come about in several ways: failed or insufficient implementation of an agreement may lead to new claims, new issues may appear that were not anticipated in the original agreement, one state may become much more powerful and thus feel entitled to the use of more water than was initially allocated, water resources may become more scarce (whether due to natural causes such as drought or human causes such as diversion for irrigation or damming for hydroelectric power generation), or water demands may increase (due to development, increased irrigation, population growth, or similar causes).

This leads us to propose the following hypotheses. The first is general in nature, applying these arguments to the presence of river treaties and the origin or militarization of any type of river claim. The second focuses on specific types of river claims, in the expectation that a treaty over water allocation principles is likely to affect the outbreak or militarization of claims over water quantity, a treaty over water quality is likely to affect claims over water quality, and a treaty over navigational issues is likely to affect claims over navigation -- but that each type of

treaty is likely to have little systematic effect on other types of river claims.

Hypothesis 3: *River claims are more likely to begin, but less likely to become militarized once begun, where states have signed treaties over river management.*

Hypothesis 3a: *River claims over each type of river issue (water quality, water quantity, or navigation) are more likely to begin, but less likely to become militarized once begun, where states have signed treaties over the specific type of river issue in question.*

River Characteristics

While our main expectations in this paper concern water scarcity and river institutions, we also consider the impact of several other factors that appear likely to affect river claims. Earlier research (Toset et al. 2000: 989) has suggested that the shape of rivers can have an important impact on their management, focusing especially on rivers that cross international borders as especially conflict prone.[3] An upstream state may increase or change its use of the river, potentially altering its course or its discharge, and this will in turn affect the quality and or quantity of the water reaching the downstream riparian(s).

An example of the potential for problems with such rivers involves the building of the Upper Keban Dam on the Tigris-Euphrates river system by Turkey in the 1960s and 1970s. This dam, Turkey's first large water development program on the river system, was finished and started filling in 1974. That same year a drought hit the region and reduced water flow through the river system to the downstream countries, especially Syria and Iraq; a serious dispute over these waters may have ended peacefully only because of heavy Arab League and Soviet pressure (Kalpakian 2004: 102). Turkey is also a good example of a powerful upstream state, controlling

[3] Other possible river shapes include a river that forms an international border but never crosses from one state's territory into the other's; a U-shaped river that flows from one state into the second state before crossing back into the first; or a river that flows through one state's territory and then either forms the border or enters a river along the border but never crosses into the other state. It is also possible to have a mixture of types, such as a river that flows through one state, forms the border, then crosses into the other state. For our present purposes any river that flows through the territory of both states is considered a cross-border river, although future research might benefit from a more detailed conceptualization of possible river river shapes/types.

much of the river system before it reaches Syria or Iraq. Relative capabilities in a basin are thus crucial for the nature of the interaction. Many scholars expect that conflict is most likely where the downstream riparians is more powerful than its upstream counterpart (e.g., Homer-Dixon 1999). A powerful upstream state is free to do more or less as it desires without being afraid of the reaction from the downstream states. It should be able to ignore claims or demands from the downstream state because of its military advantage; even if the upstream state's actions threaten the supply of water, the downstream state should be reluctant to make explicit demands or back up these demands militarily. A relatively more powerful downstream country, on the other hand, will have the necessary means to put force behind a claim raised against the upstream state.

But the downstream state also possesses some advantages in the relationship over the river, regardless of the power configuration. Issues such as navigation favor downstream states as they can block ships from the upstream state from reaching downstream harbors or the ocean. We thus present three hypotheses, focusing on the combination of river shape and the relative capabilities of the riparian states:

Hypothesis 4: *River claims are more likely to begin, and more likely to become militarized once begun, over rivers that pass through the territory of the upstream state before crossing into the downstream state*.

Hypothesis 4a: *Claims over water quantity or water quality are more likely to be militarized over rivers that pass through the territory of a weaker upstream state before crossing into the territory of a more powerful downstream state*.

Hypothesis 4b: *Claims over navigation are more likely to be militarized over rivers that pass through the territory of a more powerful upstream state before crossing into the territory of a weaker downstream state*.

Characteristics of the Riparians

The burgeoning body of democratic peace theory would suggest that pairs of political democracies should have less conflict than other pairs of states, *ceteris paribus* (Gleditsch & Hegre 1997). Beyond the general (and widely supported) expectation that democracies engage

in relatively little armed conflict with each other, though, other research suggests that democracy may have more specific effects with respect to the environment and resources such as water. Payne (1995) argues that as democracies are better in conserving their resources they will therefore be less prone for scarcity conflicts. Neumayer (2002) emphasizes that democracies have a higher international environmental commitment. They may not have better environmental outcomes, as they generally pollute and waste more. But they do also tend to participate more internationally through signing more environmental agreements and participating in international environmental organizations. This discussion suggests that democracies may be better able than other states to avoid taking actions that threaten each others' water resources, or at least more interested in environmental concerns and thus better able to address any problems that might arise before the reach the level of explicit demands or possible military threats.

These studies suggest that river claims will be less likely to emerge between democracies, because of their higher environmental commitment (Neumayer) and their better conservation of resources (Payne). This is not to argue that democracies can avoid river claims altogether, and indeed they may be able to raise claims against each other with little fear of the escalation that might characterize claims against authoritarian states, but river claims should be less likely to emerge between democracies (*ceteris paribus*). Once begun, furthermore, any river claims between democracies should be managed peacefully, in keeping with a large and growing body of literature on the peaceful management of conflicts between democracies.

Hypothesis 5: *River claims are less likely to begin, and less likely to be militarized once begun, when the states sharing the river are both democracies*.

River Claim Salience

Once a river claim has begun, our general theoretical model would suggest that the content of the claim will have an important influence on how the claim is managed. Specifically, claims that are considered highly salient -- or highly important to the claimant states -- should be more likely to lead to armed conflict than claims that are less important to the states. A variety of

research (e.g., Hensel 2001; Hensel, Mitchell, and Sowers 2006; Hensel et al. 2006) suggests that the salience of a given contentious issue increases the risk that the issue will be handled through militarized conflict, with similar results for territorial, maritime, and river issues in the modern era.

With respect to river claims, salience refers to the value of the river to each contending party. Factors such as the population served by the river, the navigational or irrigational value of the river, and the presence of hydroelectric projects on the river will increase the value of the water supply to one or both sides. The more value the two sides place on the river that is covered by a river claim, we suggest, the more likely one or both states should be to use the most dangerous means at their disposal -- the threat or use of military force -- to assert or defend their respective positions with regard to the river. This leads to the following expectation:

Hypothesis 6: *River claims are more likely to be militarized when the claim is more salient (that is, when the subject of the claim is more valuable to the claimants).*

Research Design

These hypotheses are tested using a data set with one observation per year for each major international river shared by two states in the Americas, Western Europe, or the Middle East from 1900-2001. The list of rivers has been compiled by the Issue Correlates of War (ICOW) project, which defines a major international river as a river of at least 100 miles length that forms or crosses an international border.[4] This project is ultimately intended to cover all regions of the world, but the necessary data collection has only been completed for these three regions so far; work is currently underway to complete this data set for the remainder of the world.

An argument could be made for studying international river basins rather than individual rivers. We believe that studying individual rivers offers important advantages over past research,

[4] These rivers have been identified, and their length measured, using a number of sources: the *National Geographic Atlas of the World*, 8th edition; *Times Atlas of the World*, 10th comprehensive edition; *Hammond Concise World Atlas*; Macmillan's *Planet Earth Atlas*; *Merriam-Webster's Geographical Dictionary*; and the *Columbia Gazetteer of the World*.

which has typically aggregated all rivers shared by two states into a single observation per dyad-year, or at best a single observation per dyad-year for each shared basin. Yet such research has often attempted to draw inferences about the effect of the length or shape of rivers, and aggregating all rivers shared by two states (or all rivers in a single basin shared by two states) makes it impossible to determine whether (for example) it is rivers that form borders that are responsible for conflict -- an important element in Gleditsch, et al.'s (2006) investigation of "fuzzy boundaries." Because our river claims data and claim militarization data are tied to specific rivers, we feel that studying the management of each river separately is the most appropriate approach.

Operationalization of Variables

Dependent Variables

Our first dependent variable is the outbreak of a river claim between two states that share an international river. This variable is taken from the Issue Correlates of War (ICOW) project's data set on river claims, as described by Hensel, Mitchell, and Sowers (2006). Briefly, a river claim involves explicit contention between official government representatives of two or more nation-states regarding the use or abuse of international river waters. For the purposes of our analyses of claim onset, we code a dummy variable that indicates whether or not a new river claim began over a particular river between two riparian states on that river during a particular year of observation.

We also distinguish between different types of river claims in another set of analyses, to determine whether different factors have systematically different effects on different types of river claims. Three types of claims are distinguished: claims over water quantity, where the main concern is over the amount of water reaching the challenger state (often due to concerns about dam or irrigation projects diverting too much water); claims over water quality, where the main concern is over the quality of water reaching the challenger state (often due to pollution); and claims over navigation, where the concern is over the challenger's right to navigate the river. It should be noted that some river claims include multiple elements, as with concerns about both

water quantity and navigation should a dam project be completed; each type of claim is analyzed separately, so claims with multiple types are analyzed for each type of demand that is present.

The final dependent variable is the militarization of river claims. This variable is originally based on the Correlates of War (COW) project's Militarized Interstate Dispute (MID) data set, which identifies every case where one nation-state threatens, displays, or uses military force against another (Ghosn, Palmer, and Bremer 2004). Unlike most research on rivers and conflict, though, we are only interested in militarized disputes that explicitly attempt to resolve river claims (as described above). We thus use the ICOW project's coding of militarized disputes over each specific river claim, as described by Hensel, Mitchell, and Sowers (2006).

Water Scarcity (Supply and Demand)

Water scarcity is central to most theorizing about the relationship between water and conflict, but there seems to be little agreement about how best to measure this important concept. One possible approach is to use state-level data such as that used by Hensel, Mitchell, and Sowers (2006), which drew from a variety of state-level surveys or studies to try to measure the average level of water supply and water demand for each nation-state. State-level data remain open to challenge, though, because many states cover wide ranges of territory that exhibit great variation in water supply and demand. While a relatively small state such as Israel or Belize likely shows little variation across its territory, such states as the United States, Canada, China, or Russia show great variation in water supply or water demands within the state.[5]

Instead, we employ basin-level data on both water supply and water demands, drawing from the Transboundary Freshwater Dispute Database (TFDD) spatial data set at Oregon State University. This source includes two useful basin-level measures of water supply: water

[5] We used the state-level measures from Hensel, Mitchell, and Sowers (2006) to test the robustness of our results, and the results were largely similar. River claims are significantly less likely to begin when there are more abundant water resources in a dyad (measured as the lowest state-level total of renewable water resources in the dyad), although this variable has no systematic impact on claim militarization. Claims are significantly more likely both to begin and to become militarized when there are greater demands on water (measured as the higher state-level total of water usage as a percentage of renewable water resources in the dyad).

discharge (the volume of water that flows through rivers in the basin) and water runoff (the amount of water -- whether from rain, snow melt, or other sources -- that flows over the land surface) in each basin.[6] It also includes a number of possible basin-level measures of water demands, of which we employ two. We use the average population density in the river basin (logged) in the analyses reported in this study's tables, to capture the impact of human settlement on water demands. In followup analyses that are not reported, we replace this measure with the percentage of the basin covered by (dry or irrigated) cropland, to capture the agricultural demand for water; the population density and cropland variables can not be used in the same model because they are highly correlated (r = .73), but their effects are similar.

River Institutionalization

The amount of institutionalization over a given river is measured by the presence of river treaties over the basin, as compiled by the TFDD project at Oregon State. While that project has collected information on hundreds of treaties related to rivers, though, we are specifically interested only in those treaties that directly address the three possible types of ICOW river claims. We thus focus on a subset of TFDD treaties, includes all treaties that focus on any of three topics: treaties addressing the allocation of water quantities between two or more riparian states, treaties with specific water quality provisions, and treaties concerning navigation of international rivers. Treaties with other provisions (e.g. setting the price of hydroelectric power that is produced by a dam on a shared river or agreeing to share technology) are not included.

Most of our analyses employ a dummy variable indicating whether any of these three topics has been addressed for a given river. In several tables, though, we focus on the different types of treaties separately. Most notably, in our analyses of the probability that river claims will

[6] Where one or both sides of a given international river are governed as colonies or other dependencies of a foreign power, the water scarcity variables that are used reflect the value for the colony rather than the colonizer, because that is the area affected by the river in question. For example, the water supply and demand figures for France have very little impact on the demand for rivers shared by French Guiana and Brazil, although French Guiana's water supply and water demands likely have a significant impact. All other variables in our analyses (such as democracy and relative capabilities) reflect the colonial ruler, though, as this is the actor that is involved in any conflict or negotiations over the use of the river.

become militarized, we focus specifically on river treaties that are relevant to the type(s) of river claim being prosecuted. For a river claim over navigational issues, then, a treaty is only relevant if it directly addresses navigational issues for the dyad in question. For river claims that involve multiple types of river issues, the presence of a treaty covering any of the issue types is considered sufficient to code the river as being covered by a relevant treaty.[7]

River Characteristics

We measure the characteristics of individual rivers based on the shape of the river and the relative capabilities of the riparian states being observed. Rivers can follow a variety of shapes, as illustrated by Gleditsch et al. (2006: 365). For the purposes of this paper, we are interested in a simple distinction: whether or not a given river crosses the border between two riparian states at some point during its course. A river may cross directly from one state's territory into the other's, it may pass through one state's territory and then form the border for a stretch before crossing into the other state's territory, or it may pass through one state and into the other before returning to the first. Each of these cases is considered equivalent for our current purposes, although these different situations are also recorded so that future work might explore the differences between them in greater detail. The important thing to note about these situations is that they all give the upstream state a chance to divert, pollute, or otherwise affect the quantity or quality of water reaching the downstream state.

Several of our hypotheses distinguished between such cross-border rivers where the upstream state is stronger and where the downstream state is stronger. We determine relative capabilities using the COW project's Composite Index of National Capabilities (CINC) score, a measure that indicates a state's share of the total capabilities in the international system across an evenly weighted index of six capability indicators: military personnel, military expenditures, iron and steel production, energy consumption, and both total and urban population. Using this

[7] It should be noted that this measure is not tautological -- the presence of a relevant river treaty is no guarantee that no river claim will begin, or that any claim will not be pursued through militarized means. As noted above, a river treaty may reflect the interests, water supply/demand levels, or relative capabilities of the time period in which it was signed, all of which may be dramatically outdated when compared with the time being studied.

measure, we distinguish between cross-border rivers where the upstream state is stronger and those where the downstream state is stronger; the referent category against which both of these situations are compared includes all other river shapes (e.g., those where the river forms the border between two states but never crosses from one state's territory into the other's, or those where the river passes through one state's territory and then ends in a river at the border without crossing into the other state).

Characteristics of the Riparians

We measure the characteristics of the riparian states using conventionally accepted approaches. Joint democracy is measured using the Polity IV data, as a dummy variable indicating whether both riparian states are considered democratic (as measured by a value of six or greater on the Polity index of institutionalized democracy). For our analyses of river claim militarization, we draw from a common measure of rough parity as a dummy variable, which is often found to increase the risk of armed conflict between two states when compared to situations where one side is dramatically stronger than the other. Two states are considered roughly equal if the stronger has no more than three times the CINC score of the weaker in the year of observation.

River Claim Salience

River claim salience is coded by the ICOW Project and is based on six factors: (1) river location in the state's homeland territory rather than in colonial or dependent territory, (2) navigational value of the river, (3) level of population served by the river, (4) the presence of a fishing or other resource extraction industry on the river, (5) hydroelectric power generation along the river, and (6) irrigational value of the river. Each factor contributes one score per state to the overall salience index, producing a dyadic measure that ranges in principle from zero (lowest salience) to twelve (highest salience). For more details see Hensel, Mitchell, and Sowers (2006) and Hensel, et al. (2006).

Finally, our analyses of river claim militarization include a dummy variable indicating

whether the claim in question involves navigational issues. Without such a dummy variable, we expect that the model's measures of such factors as water scarcity or water demands may produce misleading results, because these factors are much more directly relevant for claims over water quantity or water quality than for claims over navigation. Including the navigational issue dummy variable allows the analyses to measure the escalatory of such issues separately, which helps to reduce the potential for confusion.[8]

Analyses

Table 1 reports descriptive statistics for the variables that will be used in our analyses. This table reveals a very important point, which is the very rare nature of river claims in the data set. Out of 26,030 observations -- each one representing a year that two states shared a specific international river -- only 70 years (0.27 percent of the data) saw the outbreak of a new river claim, and even less (0.20 percent, 0.05 percent, and 0.06 percent) saw the outbreak of a new claim over water quantity, water quality, or navigational issues. As King and Zeng (2001) note, standard statistical techniques such as logistic regression produce biased results when used for very rare dependent variables; these biases can be corrected by using their ReLogit ("Rare Events Logistic Regression") software, which is available from King's web site (http://gking.harvard.edu). We employ this technique in studying the outbreak of river claims, for both the aggregated analyses in Table 2 and the disaggregated analyses of type of claim in Table 4.

[Table 1 about here]

The first set of analyses, reported in Table 2, uses rare events logit models to investigate our hypotheses about the initial outbreak of river claims. Two different models are presented, differing only in the measurement of water scarcity as described above. Model I measures water

[8] In the long run, a better approach might be to measure the main independent variables separately for each type of river claim, perhaps through the use of interaction terms. With the small number of cases in this analysis right now, though (N = 643 observations during ongoing river claims and only 18 militarized disputes), we are reluctant to include too many interactions in the model. Furthermore, because around 15% of the river claims in our data set include two different types of issues -- either water quantity and quality, or water quantity and navigation -- we do not feel comfortable forcing a decision about which type of claim to code with respect to the interaction terms in such an approach.

scarcity using basin-level discharge data, while Model II uses basin-level runoff data. Hypotheses 1 and 2 suggest that river claims are more likely to begin when water is less plentiful, and when demands for water are greater; both hypotheses are supported by each model in Table 2. Regarding water scarcity/abundance, claims are significantly less likely to begin ($p < .001$) when water resources are more abundant, whether measured by basin discharge or basin runoff. Regarding water demands, the population density of the river's basin significantly increases the likelihood of claim onset ($p < .001$) in both models.[9]

[Table 2 about here]

Hypothesis 3 suggests that river claims are more likely to begin over rivers that are already covered by a treaty between the riparians, although these claims may be less likely to become militarized. The presence of any type of river treaty has a positive impact on river claim onset in both models, but the impact is only statistically significant in Model II ($p < .15$ for Model I, $p < .04$ for Model II), offering mixed support for the hypothesis.[10] Hypothesis 4 suggests that claims are more likely to begin when the river passes through the upstream state before entering into the downstream state. The results are generally consistent with Hypothesis 4, as cross-border rivers increase the probability of claim onset; this effect is statistically significant in Model I ($p < .02$) and comes close in Model II ($p < .11$). Finally, Hypothesis 5 suggested that jointly democratic dyads should be less likely to experience river claims than other combinations of regime types, and this expectation is supported ($p < .01$).

[Table 3 about here]

Table 3 supplements the statistical analyses from Table 2 by presenting the marginal effects of each variable on the probability of claim onset. The first thing that becomes apparent from this table is how rare an event claim onset is. The baseline probability, where all variables

[9] As an alternative, we replaced population density with the percentage of the basin that was covered by cropland, also obtained from the TFDD web site. The results were in the same direction as for the population density variable in all of the tables reported in this paper, suggesting further support for a connection between greater water demands and claim onset or militarization, although in many cases the results had somewhat less statistical significance.

[10] Further investigation suggests that different types of treaties have different effects. Water allocation treaties have a significant positive effect, consistent with the hypothesis, while water quality treaties and navigation treaties both have negative but statistically insignificant effects.

are held at their means (or modes for dummy variables), is only .0018 and .0019 in Models 1 and 2 respectively, indicating very small probabilities of claim onset. This table also reveals that water availability has a substantial impact on the probability of a claim beginning. Moving from mean value of discharge to a case with the minimum discharge increases the probability of a claim onset from .0018 to .0180, or ten times the original probability. On the other hand, an increase in discharge to the maximum level reduces the probability of a claim by about two thirds, from .0018 to .0005; similar results are found with the basin runoff measure. The effect of water demand is also considerable, with a move from the mean to the maximum population density increasing the probability of a claim onset by approximately half in the two models. The modal category of river shape is the cross-border river, which was covered by the hypothesis; moving from this to any other river type reduces the probability of claim onset by at least half in each model. Finally, a joint democratic dyad has about half the probability of claim onset as a dyad with at least one autocratic state.

There is reason to believe that different types of river claims -- those involving issues of water quantity, water quality, and navigation -- may emerge under different circumstances. Table 4 investigates this with separate models for each type of claim, using the basin discharge model presented in Table 2; the results are quite similar if the basin runoff model is used instead. It should be noted that a given claim may involve multiple components -- eleven of the seventy claims in our data set involve two different types of issues, combining either water quantity and water quality concerns or water quantity and navigation concerns, although none involve all three types.

[Table 4 about here]

Access to water, measured through basin discharge, significantly increases the probability of claims over either water quantity or water quality, consistent with Hypothesis 1, although there is no systematic impact on claims over navigational issues. Population density in the basin also significantly increases the risk of claims over both water quantity and navigation ($p < .001$) , consistent with Hypothesis 2, although there is no systematic effect on claims over water quality ($p < .22$).

Hypothesis 3a suggests that river claims of each type are more likely to begin over rivers that are covered by a treaty over the issue in question. This hypothesis is strongly supported ($p < .01$) for water quantity claims, but it encounters much greater difficulties for the other two types. Water quality treaties perfectly prevent the onset of water quality claims, meaning there are no claims beginning over water quality when there is a treaty concerned with water quality present over the river; navigation treaties almost perfectly prevent the onset of navigation claims, with only one claim over navigation in the presence of a navigation treaty. While this makes it impossible to include these variables in the statistical models, this clearly indicates that these treaties have their intended effect of avoiding disagreement over rivers (contrary to our expectations)

Hypothesis 4 suggests that the probability of each type of river claim onset should be greatest for cross-border rivers. This hypothesis receives mixed support, with claims over water quantity being slightly (but not significantly) more likely over cross-border rivers. For the other two types of claims, though, cross-border rivers account for every single river claim onset. This is very much in line with our expectations, although it makes the variable impossible to include in statistical analysis. Finally, mixed results emerge for Hypothesis 5. Pairs of democracies are significantly less likely to begin claims over water quantity ($p < .001$), and somewhat (but not significantly) less likely for navigational claims ($p < .15$), although there is absolutely no effect for water quality claims ($p < .86$)

Our final set of analyses examines the conditions under which river claims become militarized. Because we have already examined the conditions under which river claims are likely to begin, we would like to take advantage of this information in studying the conditions under which claims become militarized. The best way to do this is with Heckman selection models, which are also known as censored probit models or probit models with sample selection. Such models allow the study of a dependent variable of interest (such as river claim militarization) that is only observed as the result of a non-random selection process (such as the onset of river claims). The model estimates the impact of each covariate on each stage of the model (the selection process and the outcome process), as well as estimating the correlation

between the two processes' disturbance terms. This will allow us to determine whether our key independent variables have a systematic impact of claim militarization after we consider the impact of many of these same variables on the outbreak of claims; it is quite plausible that many factors such as water stress or river institutionalization are most relevant in the initial onset of disagreements over rivers, with little separate impact on the likelihood that a claim (once it has begun) will become militarized.

As it turns out, though, running our militarization analyses with Heckman models does not appear to be necessary. The most important element that distinguishes such models from standard logit or probit models is the rho parameter, which represents the correlation between the disturbance terms from the two stages of the model. In this case, the rho parameter is never statistically significant, whether we measure water supply via the basin-level discharge data (rho = 0.38, $p < .34$), basin-level runoff data (rho = 0.43, $p < .27$), or state-level renewable water resource data (rho = 0.19, $p < .62$). This suggests that there is no systematic relationship between the unobserved factors that influence the onset and militarization of river claims, which would be one of the chief justifications for using a Heckman model. We thus present a rare events logit analysis of claim militarization, in order to take advantage of the beneficial properties of this method for such rare events.

Unfortunately for our analyses (but perhaps fortunately for the world), we are unable to study the militarization of each type of river claim separately, because there are not enough militarized disputes of most type. There are only eighteen militarized disputes that represent explicit attempts to resolve the river claims studied in this paper, of which twelve involved navigational issues.[11] As a result, we are unable to test our hypotheses about the factors that affect the militarization of specific types of claims, and we can only test the hypotheses about militarization of river claims through aggregated analyses of all types of river claims. The results are presented in Table 5.

[11] The navigational disputes include one between Nicaragua and Costa Rica over the San Juan River, three between Argentina and Uruguay over the Río de la Plata, and eight between Iran and Iraq over the Shatt al-Arab. The non-navigational disputes include one between Bolivia and Chile over the Lauca River, three between Israel and Syria over the Jordan River, and two between Turkey and Syria over the Euphrates River.

[Table 5 about here]

Table 5 suggests that militarization of a claim, like the onset of a claim, is affected by the water availability and demand. Hypothesis 1 is supported in both models, with militarization being significantly less likely ($p < .001$) when water is more abundant as measured by either basin discharge or basin runoff. Hypothesis 2 receives mixed support, with no systematic effect of population density in Model I ($p < .27$) but a significant increase in militarization for rivers in more densely population basins in Model II ($p < .04$). Hypothesis 3, on the pacifying effect of river treaties, is supported for both models ($p < .03$ in Model I, $p < .04$ in Model II). River claims are much less likely to become militarized when the river in question is covered by a relevant treaty that addresses the river issue (water quantity, water quality, or navigation) covered by the claim.

All the militarized disputes over rivers are over cross-border rivers -- which is consistent with Hypothesis 4, but makes the analysis impossible to run with this variable. The militarization of ongoing river claims is somewhat less likely between democracies, as suggested by Hypothesis 5, but this result is not statistically significant in either model. Following a great deal of research on armed conflict, rough parity in relative capabilities significantly increases the probability of conflict in both models ($p < .05$).

Turning to the details of the claim itself, Hypothesis 6 suggests that militarization of a claim is more likely when the subject of the claim is considered more salient or valuable to the claimants. This hypothesis receives strong support in both models ($p < .001$). Finally, we included a variable to distinguish between claims over navigational issues and those over either water quantity or water quality. Not surprisingly, claims over navigation are different from claims over water quality and water quantity, with a significantly higher risk of militarization ($p < .01$).[12]

[12] It is worth noting that the significance of the water scarcity measures depends on including the navigational issues variable in the model. Claims over navigation do not seem to be influenced in any systematic way by the level of water scarcity in a basin, so aggregating them with other types of river claims (which are influenced by water scarcity) washes out the results. It is only when navigational claims are distinguished from the others by a dummy variable that the impact of water scarcity becomes apparent.

[Table 6 about here]

Table 6 concludes our analyses by taking a closer look at the marginal effects of each variable. As before, the baseline probability of a claim being militarized is small, only .0134 and .0096 in the two models. Again we see that the effects of water availability and demand are strong. Moving from the mean value to the minimum value of either water discharge or water runoff increase the probability of militarization of a claim to slightly more than seven times the original probability, while similar increases in population density more than double the probability. River claims that are covered by a relevant river treaty have only about one third the probability of militarization of those without such a treaty, and joint democracy reduces the probability of militarization by about one third. Finally, a river claim with the maximum value of salience increases the probability of militarization by more than ten times in each model, and contention over navigational issues increases the probability of militarization to more than eight times the original probability in Model I and more than ten times in Model II.

Discussion

Taken together, the results of our analyses provide support for several of our initial hypotheses. River claims seem to be more likely both to begin and to become militarized where water is scarce and where the demand for water is high, as suggested by Hypotheses 1 and 2. The presence of one or more treaties over a river seems to have a mixed effect on river claim onset, supporting the portion of Hypothesis 3 that suggested river treaties should reduce the risk of militarization but casting some doubt on the portion that suggested that claims should be more likely; river treaties have little systematic impact on claim onset overall. Stronger results are found for Hypothesis 3a, which focuses on specific types of treaties and specific types of river claims; water allocation treaties significantly increase the risk of river claims over water quantity, while water quality or navigational treaties almost perfectly prevent the onset of river claims over their general subject matter.

Hypotheses 4, 4a, and 4b consider the geographic configuration of the river and the relative capabilities among the riparians. Compared to rivers with other shapes, the cross-border

river seems to be the one most prone for both claims and militarization -- in fact, every militarized dispute over rivers in our data set involved a cross-border river. This is not a surprising result, but confirms that the sharing of a river that crosses the border is potentially dangerous. In combination with relative capabilities, it seems that a stronger upstream state is more critical for the risk of a claim onset. We suspect that this indicates that a substantially stronger downstream state is likely to be able to get its way without the need for explicit diplomatic controversies or military threats; substantially weaker upstream states probably undertake relatively few activities that could lead to trouble in relations with their more powerful downstream neighbors, and when they do, relatively little pressure may be needed to convince the upstream state to reverse or modify its activities. Finally, Hypothesis 5 was supported with respect to the lower probability of river claims beginning between democracies, although democracy did not have a significant impact on claim militarization.

We can conclude, then, that (as expected) water availability and demand are crucial for the outbreak and militarization of claims, and that river treaties have mixed effects. We have also found that the salience of the issue at stake in a claim plays an important role. Regardless of the overall level of water stress in a given area, more salient claims -- i.e., demands or disagreements over rivers that are more valuable to the two claimant states -- are much more likely to become militarized. These findings relate to the debate between the Neomalthusians and more optimistic scholars in several ways. Scarcity and demand have been at the core of Neomalthusian arguments about what leads to disagreements and conflicts over water. At the same time, we see that conflicts over water are rare events. More optimistic scholars, although arguing that states can reduce or remove this risk by creating institutions to manage their shared rivers, agree that claims or disagreements over water may occur if issues are salient enough. Our finding of the pacifying effect of treaties with respect to claim militarization speaks to those with more optimistic views and their claim that states cooperate rather than fight over their shared waters. The fact that relevant treaties almost perfectly prevent claims over navigation or water quality is also in line with this optimistic line of reasoning.

This paper is best considered a preliminary analysis, and much remains to be done. Data

collection is currently underway to extend the ICOW river claims data to the entire world, which should be completed by the end of the current calendar year. Once the entire world has been completed, we will be able to add the extensive history of river management in Africa and Asia, which will include such major basins as the Nile in Africa and the Amur and Mekong in Asia. We expect to identify dozens of river claims in these regions, with numerous conflictual events (including militarized disputes) and cooperative events (including dozens of treaties).

Our analyses of both river claim onset and militarization can be improved through the addition of better data. For example, here we have only focused on whether or not states have at least one treaty over a given river, but much more detailed analyses are possible. The specific content of treaties could have an important impact on the likelihood of river claims beginning or escalation to military action. There are many possible water allocation principles, ranging from granting the upstream state absolute sovereignty over all waters within its borders to mandating equal division of water (or of benefits derived from the water); we suspect that different allocation principles will have very different implications for relations between the riparians. Furthermore, most of our data on water stress is static in nature, with the basin-level measures being based on a GIS snapshot of basin characteristics at one point in time (as compiled by the TFDD and Basins at Risk personnel at Oregon State University), and the state-level measures being averaged from irregularly reported figures in publicly available sources. We expect that more dynamic data could greatly improve our explanatory power by capturing year-to-year fluctuations in water supply or water demands. For example, river claims may be more likely to emerge when the available water supply is decreased (e.g., by low rainfall, drought, or long-term fluctuations) or water demands are increased (by increased dam construction, irrigation, or population growth or development in the river basin area). It is unlikely that annual data can be found for each basin for the entire spatial-temporal domain of our analysis, but further analysis using whatever data can be found would be desirable.

Finally, it would be desirable to supplement this study's emphasis on the conflictual side of river management with more research on the cooperative side. A variety of work (e.g., Wolf 1998; Hensel. Mitchell, and Sowers 2006) suggests that the threat or use of military force makes

up only a small fraction of all interactions over international rivers, so this study's analyses should be supplemented with further study of how the same factors affect peaceful and cooperative interactions as well as conflict. Furthermore, some of our current analyses indicate an important role for international river treaties, but we have not investigated the conditions under which these various types of treaties are signed. Tir and Ackerman (2004) offer a promising investigation of the conditions under which states are likely to sign treaties over river basins. Their study, which produces a number of important findings about the conditions under which treaties are likely to be signed, suggests that future research on the emergence of different types of river treaties might be an important extension of the present study.

References

Beaumont, Peter (1997). "Water and Armed Conflict in the Middle East – Fantasy or Reality?" In Nils Petter Gleditsch, et al. (eds.). *Conflict and the Environment*. London: Kluwer Academic, pp. 355–374.

Brochmann, Marit (2006). "Conflict, Cooperation, and Management in International River Basins." Paper presented at the international workshop "Governance and the Global Water System," Bonn, Germany, 20-23 June.

Brochmann, Marit, and Nils Petter Gleditsch (2006). "Shared Rivers and International Cooperation." Paper presented at the Annual Meeting of the International Studies Association, San Diego, and the workshop "Polarization and Conflict," Nicosia.

Furlong, Kathryn, Nils Petter Gleditsch, and Håvard Hegre (2006). "Geographic Opportunity and Neomalthusian Willingness: Boundaries, Shared Rivers and Conflict." *International Interactions* 32, 1: 1–30.

Ghosn, Faten, Glenn Palmer, and Stuart Bremer (2004). "The MID3 Data Set, 1993–2001: Procedures, Coding Rules, and Description." *Conflict Management and Peace Science* 21, 2 (Summer): 133-154.

Gleditsch, Nils Petter (2001). "Environmental Change, Security, and Conflict." In A. Crocker Chester, Fen Osler Hamspon, and Pamela Aall (eds.): *Turbulent Peace. The Challenges of Managing International Conflict*. Washington D.C: USIP Press, pp. 53-68.

Gleditsch, Nils Petter, and Håvard Hegre (1997). "Peace and Democracy: Three Levels of Analysis." *Journal of Conflict Resolution* 41, 2 (April): 283–310.

Gleditsch, Nils Petter, Kathryn Furlong, Håvard Hegre, Bethany Lacina, and Taylor Owen (2006). "Conflicts over Shared Rivers: Resource Scarcity or Fuzzy Boundaries?" *Political Geography* 25, 4: 361–382.

Gleick, Peter H. (1993). "Water and Conflict, Fresh Water Resources and International Security." *International Security* 18, 1: 79–112.

Gleick, Peter (2006). "Water Conflict Chronology." Oakland, CA: Pacific Institute. Available at

<http://www.worldwater.org/conflictchronology.pdf> (updated October 12, 2006).
Hensel, Paul R. (2001). "Contentious Issues and World Politics: The Management of Territorial Claims in the Americas, 1816-1992." *International Studies Quarterly* 45, 1: 81-109.
Hensel, Paul R., Sara McLaughlin Mitchell, and Thomas E. Sowers II (2006). 'Conflict Management of Riparian Disputes'*, Political Geography* 25, 4: 383–411.
Hensel, Paul R., Sara McLaughlin Mitchell, Thomas E. Sowers II, and Clayton L. Thyne (2006). "Bones of Contention: Comparing Territorial, Maritime, and River Issues in the Western Hemisphere." Paper presented at the Annual Meeting of the American Political Science Association, Philadelphia.
Homer-Dixon, Thomas F. (1994). "Environmental Scarcities and Violent Conflict: Evidence from Cases." *International Security* 19, 1: 5–40.
Homer-Dixon, Thomas F. (1999). *Environment, Scarcity and Violence.* Princeton, NJ: Princeton University Press.
Kalpakian, Jack (2004). *Identity, Conflict and Cooperation in International River Systems.* Aldershot: Ashgate.
Keohane, Robert O. (2002). *Power and Governance in a Partially Globalized World*. New York: Routledge.
Keohane, Robert O., and Elinor Ostrom (1994). "Local Commons and Global Interdependence: Heterogeneity and Cooperation in Two Domains." *Journal of Theoretical Politics* 6, 4: 403–428.
King, Gary, and Langche Zeng (2001). "Explaining Rare Events in International Relations." *International Organization* 55, 3 (Summer): 693-715.
Klare, Michael T. (2001). "The New Geography of Conflict." *Foreign Affairs* 80, 3: 49–61.
Lonergan, Steve C. (2001). "Water and Conflict: Rhetoric and Reality." In Paul F. Diehl and Nils Petter Gleditsch (eds.). *Environmental Conflict*. Boulder, CO: Westview, pp. 109–124.
Malthus, Thomas (1798). *An Essay on the Principle of Population.* London: J. Johnson.
Neumayer, Eric (2002). "Do Democracies Exhibit Stronger International Environmental Commitment? A Cross-Country Analysis." *Journal of Peace Research* 39, 2: 139–164.
Payne, Rodger A. (1995). "Freedom and the Environment." *Journal of Democracy* 6, 3: 41–55.
Renner, Michael (2002). *The Anatomy of Resource Wars*. Danvers, MA: Worldwatch Institute.
Rogers, Katrina S. (1997). "Pre-empting Violent Conflict: Learning from Environmental Cooperation." In Nils Petter Gleditsch (ed.), *Conflict and the Environment*. Dordrecht: Kluwer Academic.
Rogers, Peter (2002). "The Value of Cooperation in Resolving International River Basin Disputes." In Aaron T. Wolf (ed.), *Conflict Prevention and Resolution in Water Systems*. Cheltenham: Edward Elgar, pp. 608–622. [Originally published in 1993 in *Natural Resources Forum* 17(2): 117–131.]
Siverson, Randolph, M., and Harvey Starr (1990). "Opportunity, Willingness, and the Diffusion of War." *American Political Science Review* 84, 1: 47-67.
Starr, Harvey (1978). "Opportunity and Willingness as Ordering Concepts in the Study of War." *International Interactions* 4, 4: 363-387.

Tir, Jaroslav, and John T. Ackerman (2004). "To Share or Not to Share: Politics of Cooperation between Riparian States." Paper presented at the Annual Meeting of the International Studies Association, Montreal.

Toset, Hans Petter Wollebæk, Nils Petter Gleditsch, and Håvard Hegre (2000). "Shared Rivers and Interstate Conflict." *Political Geography* 19, 6: 971–966.

UNDP (2006). *Human Development Report, 2006. Beyond Scarcity: Power, poverty and the global water crisis.* New York: United Nations Development Program.

UNEP (1999). *Global Environmental Outlook 2000*. <http://www.unep.org/GEO/geo2000/>.

Wolf, Aaron T., ed. (2002). *Conflict Prevention and Resolution in Water Systems*. Cheltenham: Edward Elgar.

Wolf, Aaron T. (1998). ”Conflict and Cooperation Along International Waterways.” *Water Policy* 1, 2: 251-265.

Yoffe, Shira, Aaron T. Wolf, and Mark Giordano (2003). "Conflict and Cooperation over International Freshwater Resources: Indicators of Basins at Risk." *Journal of American Water Resources Association* 39, 5: 1109–1126.

Yoffe, Shira, Greg Fiske, Mark Giordano, Meredith Giordano, Kelli Larson, Kerstin Stahl, and Aaron T. Wolf (2004). "Geography of International Water Conflict and Cooperation: Data sets and Applications." *Water Resources Research* 40: 1–12.

Table 1: Descriptives for Independent Variables

A. River Claim Onset

Variable	N	Mean (S.D.)	Range
Claim onset (any)	26086	0.0027 (0.05)	0 - 1
Claim onset (water quantity)	26086	0.0020 (0.04)	0 - 1
Claim onset (water quality)	26086	0.0005 (0.02)	0 - 1
Claim onset (navigation)	26086	0.0006 (0.02)	0 - 1
Log(basin discharge)	22198	6.05 (2.26)	0.69 - 8.80
Log(basin runoff)	22301	11.95 (2.22)	3.71 - 14.57
Log(pop. density in basin)	25476	2.74 (1.63)	0 - 6.08
Any river treaty	26086	0.25 (0.43)	0 - 1
Any water allocation treaty	26086	0.19 (0.39)	0 - 1
Any water quality treaty	26086	0.05 (0.22)	0 - 1
Any navigation treaty	26086	0.05 (0.22)	0 - 1
Cross-border river	26086	0.74 (0.44)	0 - 1
Downstream stronger	25549	0.43 (0.49)	0 - 1
Upstream stronger	25549	0.31 (0.46)	0 - 1
Relative capabilities-downstream	25549	0.54 (0.34)	.0001 - .9996
Joint democracy	26086	0.33 (0.47)	0 - 1

B. River Claim Militarization

Variable	N	Mean (S.D.)	Range
MID over river claim	643	0.03 (0.17)	0 - 1
Salience of river claim	643	6.86 (1.90)	4 - 11
Log(basin discharge)	504	4.04 (2.22)	0.69 - 8.80
Log(basin runoff)	542	10.02 (2.03)	6.60 - 14.57
Log(pop. density in basin)	643	3.52 (1.16)	0 - 6.08
Relevant river treaty	643	0.42 (0.49)	0 - 1
Joint democracy	643	0.21 (0.41)	0 - 1
Rough parity	642	0.26 (0.44)	0 - 1

Table 2: Rare Events Logit Analysis of River Claim Onset

Variable	Model I: Discharge Coefficient	Model II: Runoff Coefficient
Log(basin discharge)	- 0.43 (0.07)***	---
Log(basin runoff)	---	- 0.32 (0.05)***
Log(pop. density in basin)	0.22 (0.07)***	0.34 (0.08)***
Any river treaty	0.38 (0.27)	0.56 (0.26)**
Cross-border river	1.15 (0.45)**	0.72 (0.45)
Joint democracy	- 0.74 (0.28)***	- 0.86 (0.30)***
Constant	- 5.47(0.47)***	- 4.12 (0.62)***
N:	22,101	22,204

* p < .10, ** p < .05, *** p < .01; robust standard errors in parentheses

Table 3: Marginal Impact of Key Variables on River Claim Onset

Variable / Change in Values	Model I: Discharge	Model II: Runoff
Baseline probability: (all variables at mean or mode)	.0018	.0019
Log(basin discharge):		
Mean to minimum:	+ .0162	---
Mean to maximum:	- .0013	---
Log(basin runoff):		
Mean to minimum:	---	+ .0233
Mean to maximum:	---	- .0010
Log(pop. density in basin):		
Mean to minimum:	- .0008	- .0011
Mean to maximum:	+ .0017	+ .0031
Any river treaty:		
No to yes:	+ .0008	+ .0013
Cross-border river:		
Yes to no:	- .0012	- .0010
Joint democracy:		
No to yes:	- .0009	- .0010

Note

• Marginal effects calculated using the "first difference" option in King and Zeng's (2001) Rare Events Logistic Regression package for Stata (with the relogit, setx, and relogitq commands).

Table 4: Rare Events Logit Analysis of Different Types of River Claim Onset

	Model I: Claim over Water Quantity	Model II: Claim over Water Quality	Model III: Claim over Navigation
Variable	Coefficient	Coefficient	Coefficient
Log(basin runoff)	- 0.35 (0.05)***	- 0.35 (0.11)***	- 0.05 (0.11)
Log(pop. density in basin)	0.38 (0.09)***	0.17 (0.14)	0.47 (0.17)***
Relevant river treaty	0.95 (0.28)***	N/A†	N/A†
Cross-border river	0.43 (0.44)	N/A††	N/A††
Joint democracy	- 0.60 (0.30)**	0.11 (0.59)	- 1.10 (0.75)
Constant	- 4.18 (0.67)***	- 4.25 (0.90)***	- 7.92 (1.87)***
N:	22,204	22,204	22,204

* p < .10, ** p < .05, *** p < .01; robust standard errors in parentheses

† No claims began over water quality when there was a water quality treaty between the riparians, and only one claim began over navigation when there was a navigation treaty. Because few or no claims began under these conditions, the model could not be run with these variables included.

†† Every claim over water quality or navigation involved a river that crossed an international border. As a result, the model could not be run with these variables included.

Table 5: Rare Events Logit Analysis of River Claim Militarization

	Model I: Discharge	Model II: Runoff
Variable	Coefficient	Coefficient
Log(basin discharge)	- 0.62 (0.16)***	---
Log(basin runoff)	---	- 0.62 (0.17)***
Log(pop. density in basin)	0.44 (0.39)	0.77 (0.37)**
Relevant river treaty	- 1.40 (0.63)**	- 1.21 (0.59)**
Joint democracy	- 0.72 (1.33)	- 1.04 (1.38)
Rough parity	1.03 (0.51)**	1.03 (0.52)**
Salience of river claim	0.66 (0.18)***	0.70 (0.19)***
Navigation claim	2.28 (0.78)***	2.46 (0.66)***
Constant	- 7.99 (2.54)***	- 6.13 (2.89)***
N:	503	541

* p < .10, ** p < .05, *** p < .01; robust standard errors in parentheses

Table 6: Marginal Impact of Key Variables on River Claim Militarization

Variable / Change in Values	Model I: Discharge	Model II: Runoff
Baseline probability: (all variables at mean or mode)	.0134	.0096
Log(basin discharge):		
Mean to minimum:	+ .0819	---
Mean to maximum:	- .0121	---
Log(basin runoff):		
Mean to minimum:	---	+ .0619
Mean to maximum:	---	- .0088
Log(pop. density in basin):		
Mean to minimum:	- .0075	- .0075
Mean to maximum:	+ .0144	+ .0335
Any relevant river treaty:		
No to yes:	- .0092	- .0062
Joint democracy:		
No to yes:	- .0051	- .0055
Rough parity:		
No to yes:	+ .0211	+ .0161
Salience of river claim:		
Mean to minimum:	- .0109	- .0082
Mean to maximum:	+ .1582	+ .1321
Navigation claim:		
No to yes:	+ .0969	+ .0865

Note

• Marginal effects calculated using the "first difference" option in King and Zeng's (2001) Rare Events Logistic Regression package for Stata (with the relogit, setx, and relogitq commands).