THESIS

EVOLUTION OF COMMUNITY STRUCTURE IN THE SYSTEM OF GLOBAL ENVIRONMENTAL GOVERNANCE

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ABSTRACT

EVOLUTION OF COMMUNITY STRUCTURE IN THE SYSTEM OF GLOBAL ENVIRONMENTAL GOVERNANCE

Self-organization can arise in systems where actors interact in non-trivial ways and adapt their rule-sets in response to their environment. In the global system of environmental governance (GSEG), countries that interact frequently develop cultures of practice and aggregate into larger structures or communities. Network analysis provides a powerful set of tools to describe the evolution and composition of observed communities. Methods developed for bipartite networks are used to consider the behavior of countries and agreements simultaneously in the years between 1950 and 2000. Specifically, the BRIM algorithm, a bipartite adaptation of Newman's eigenvector method of community discovery, is implemented to identify the borders of densely connected international environmental communities. Our analysis of community structure provides a more precise quantification of the evolution of the international environmental system of governance noted by regime theorists.

To my wife, Teresa, who inspires me every day.

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CHAPTER 1: INTRODUCTION

The global system of environmental governance (GSEG) is a complex adaptive system, where patterns of cooperation and structure emerge in localized groups. The GSEG is not pyramidal with a distinct core and periphery, nor is it chaotic or randomly organized (Najam et al., 2004). Researchers note different national blocs and groups in the international system (Depledge, 2006; Najam et al., 2004; Paterson et al., 2003; Roberts and Parks, 2007; Victor and Coben, 2005), as well as different lineages of treaties and political regimes (Sanwal, 2004; Mitchell, 2002). There is a large body of research on treaties (Mitchell, 2003; Denemark and Hoffman, 2008; Hoffman et al., 2007), but insufficient work on synthesizing known relationships between agreements and states, mapping bipartite structures, or determining borders of national blocs or treaty regimes. Network analysis provides a powerful set of tools to apprehend these complex relationships. In this paper, I examine the development and persistence of communities of countries and treaties in the GSEG. Results provide important insights into global political dynamics as well as generate new directions for future research.

Political realist and rationalist approaches to international relations suggest that environmental cooperation without a strong central authority is untenable. The optimal strategy in one-shot public goods games (absent a coercive central authority) is always defection and free-riding the environmental risk mitigation efforts of others. Yet, over

700 multilateral environmental agreements and 1000 bilateral environmental agreements have been enacted since the late 19th century (Mitchell, 2003). Regime theory attempts to explain the organization of the international system. Krasner (1982) describes regimes as international institutions or agreements that function as frameworks for cooperation. These frameworks ease uncertainty, minimize temptations to free-ride, and set in motion self-reinforcing processes where "treaty-making begets treaty-making" (Denemark and Hoffman, 2008).

In the GSEG, treaty lineages are path dependent, with initial bargains typically followed by periodic amendments, conferences, and protocols. Depledge (2006) recognizes that regimes support future cooperation, but notes that regimes can ossify and frustrate bargaining efforts in the GSEG. Ossification results from the formation of smaller coalitions meant to reduce the complexity of environmental negotiations involving 160 or more countries. The North / South divide is a common indicator of ossification in the global community (Roberts and Parks, 2007). Rather than bridging mechanisms, regimes may reinforce historically persistent North / South, East / West or G7/G70 divisions.

Apart from historical or geographical forces, Najam et al. (2004) suggest that grouping, clustering, and coalition behavior of nation-states may result from *negotiation fatigue*. States expend large amounts of resources to participate in environmental agreements. States hire legal experts, train delegates, and send diplomats and foreign ministers to negotiate strategic bargains. Regimes function to minimize negotiation uncertainty and transaction costs. From this perspective, feedback loops between

institutions and treaties, inheritance of practices from one regime or lineage to the next, and other underlying pathways (such as personal relationships between foreign ministers or shared environmental risks) generate observable aggregations of state-actors and agreements. Regime theory has the ability to explain institutional cooperation and the clustering behaviors of nation-states but no single institution or state can explain the dynamics of the GSEG. Complexity science offers an approach to science that considers the nonlinear, emergent behavior characteristic of the GSEG.

In complex systems global properties supervene from the interactions of component parts, with no single component having properties or behaviors that define the system as a whole (Sawyer, 2005). International relations are composed of multiple levels, including individual human beings, non-governmental organizations, nation-states, and, at the lowest resolution (or highest level), international alliances, regimes and blocs of nation-states. The interactions of these different components at each level constitute the landscape of international politics. No single foreign minister, soil quality agreement, or NGO has properties of the whole system, and it is the behavior of the system as a whole that is most consequential to effective management of the global environment.

Cîndea (2006) maintains that no single factor causes events such as war or sustained peace in the international system. Cîndea employs the concept of an *attractor* from the study dynamical systems to explain system outcomes of war and peace. Attractors are the effects of rules that govern actors in complex systems and can be used to simplify descriptions of system behavior. In mathematical dynamical systems, a

gradual change to a parameter can produce sudden and dramatic changes in attractors. New attractors may emerge or configurations that were attractive become repulsive.

Attractors and the emergence of organization are very common themes in complexity science. From Axelrod's (1995) *Tribute Model* "it is possible to use simple local rules to generate higher levels of organization from elementary actors." Axelrod's Tribute Model was created to lend "abstract plausibility" to a *Landscape Theory of Aggregation* (Axelrod and Bennett, 1993), suggesting that attractors exist to which actors in an international system aggregate. This concept is extended by Macy et al. (2003) where actors make binary choices based on the influence of other actors, leading to the emergence of polarization. Macy et al.'s model is very sensitive to initial conditions, and parameters defining the initial density of the configuration space determine observed basins of attraction. While different assumptions underwrite these models, they provide plausible intuitions for the existence of attractors in the GSEG.

In the empirical GSEG, many distinct state-actors navigate configurations of agreements to sign. Given the processes of negotiating agreements, the multitude of feedback loops that exist within the system, and the tendency for actors to adapt their behavior to a changing landscape, I expect aggregate communities to form in the GSEG as well. To minimize negotiation costs and fatigue, states gravitate toward attractors in configuration spaces of cooperation, representing local minima of frustration. Actor behavior in the system is dependent on the status and position of other system actors. As actors form clusters and develop cultures of practice, they become increasingly likely to sign treaties with countries they signed treaties with in the past. Like living

organisms that transition from single-cellular to multi-cellular life forms, or how independent small agrarian villages coalesce into united empires (Turchin, 2009), individual nation-states form densely cooperative groups by signing and enacting environmental agreements that constitute the GSEG. The large aggregations of densely connected countries and agreements that define the GSEG can be derived and observed with network scientific tools.

In this thesis, I will provide precise and comprehensive description of the development of the network. Additionally I will empirically confirm the idea, set forth by regime theorists, that regimes are intervening variables within the international arena. Further I will test the idea that throughout the history of the system the structure of the network is complex and modular rather than regular or random. In the next chapter I will review relevant literature to public goods and international governance, complex systems, and network science. In chapter three I will discuss the source and cleaning of the data as well as the network methods employed. In chapter four the results of the analysis are presented and analyzed. In chapter five I discuss the findings relative to the problems.

CHAPTER 2: BACKGROUND

In the 20th century multilateral treaty-making became the predominant method of creating international policy in the global system of environmental governance (GSEG). Aside from crisis-driven interruptions, there has been a steady exponential growth in the use of multilateral treaties. Using Mitchell's (2003) definition and resulting database, there have been over 700 multilateral environmental agreements and 1000 bilateral environmental agreements since the late 19th century. Denemark and Hoffman (2008) suggest that the rise of treaty-making as the predominant method of forging international policy was the result of a self-reinforcing process, that is "treaty-making begets treaty-making". State institutions form internal processes to deal with the effects and the preparations of treaties, delegates are trained and experienced with treaty-making, and when the need arises to form mutual policy between two or more states the diplomats turn to familiar processes.

Political realism suggests that environmental cooperation without a strong central authority is untenable. Yet cooperation does exist in what is frequently considered an anarchic arena. Regime theory explains the origin of organization in the international system as the development of institutions, norms and practices through which trust and cooperation can operate (Krasner 1982). It is often suggested that regimes are needed in order to support international cooperation. Depledge (2006)

argues regimes certainly support cooperation, but they can also lead to ossification, a withdrawal or complacence within the GSEG. I focus on one aspect of Depledge's ossification: the strengthening of relationship among participants. Learning or the strengthening of relationships is bounded rather than global and the structure of the GSEG has stabilized. Depledge suggests a number of reasons for the ossification such as the formation of smaller coalitions to reduce the complex situation of negotiating between 160 or more countries. The North / South divide is a common case study of ossification in the global community (Roberts and Parks, 2007). Many of these politically marginalized countries are located where many of the suspected environmental catastrophes occur and they bear their burden in lives rather than money. Southern countries are often excluded from the creation of international policy so when they have the opportunity to exercise their limited power they sometimes use it for revenge on Northern countries. Treaty participation within regimes, rather than bridging regimes, is easier but can reify and reinforce the North / South, East / West or Soviet bloc divisions. These structures have become rigid and shape the behavior of environmental participation.

Krasner (1982) suggests regimes are more than just epiphenomenal. Through their interactions states become embedded in larger social systems of norms, rules, and institutions and the behaviors; the regimes themselves become 'intervening variables'. Patterns of behavior create regimes and the regimes shape the patterns of behavior. This underlies what Grewal (2006) sees as a paradox of globalization. Ward describes the global stage in terms of *network power*. "The notion of network power consists in the joining of two ideas: first, that coordinating standards are more valuable when greater

numbers of people use them, and second, that is dynamic … can lead to the progressive elimination of the alternatives over which free choice can effectively be exercised" (Grewal 2006:4). This process plays out in global environmental governance whereby the emergence of one standard or coalition can preclude the entrance of another. Cooperation with one group of states may lead to the exclusion of others. The GSEG is a constant shuffle of freely cooperating states and the slow accretion of norms and rules that restrict behavior.

Apart from basic causal variables such as history or geography many of the tightly bounded cooperative groups of nation-states emerged organically from state actors exercising free action and navigating a complex political system. Najam et al. (2004) suggest the grouping and clustering may be due to 'negotiation fatigue.' States expend large amounts of resources to participate in environmental agreements so many of the structures that have emerged are the result of states attempting to reduce the negotiation costs. From this perspective feedback loops between institutions and treaties, inheritance of practices from one regime or lineage to the next, and other underlying pathways (such as social connections between foreign ministers or shared environmental cultures) have lead to the appearance of 'attractors' to which state-actors and agreements have aggregated.

From People to Regimes

While many states sign treaties because they see it as good governance, other nations sign merely to maintain a presence in the system and signal their cooperation. Victor and Coben (2005) suggest many instruments were created as a superficial political

act. The authors see price instruments as more effective, yet those that have been implemented are too general to be effective. Quantity-based instruments are more common, but less effective. They believe general price instruments and copious quantity instruments (two approaches to regulating emissions) are due to a 'herd mentality' in the environmental community. Many countries sign treaties simply to remain within the system and rush to sign any treaty they are able to (Roberts et al. 2004; Victor and Coben 2005). These processes mean the existing structure of relationships, cultures and practices should be expected to be a significant predictor of future behavior.

International governance is foremost a multi-level process. It consists not only of large international institutions but also the psychological makeup of state delegates, the intervention of non-governmental organizations, or the movement of aid. The psychological and philosophical makeup of foreign ministers affect decisions they make and that the recommendations of foreign ministers are often taken very seriously by the states they represent (Crichlow 2005). Long-term delegates to environmental conferences develop personal relationships (Depledge 2006) and a network of delegates and institutional employees exists between organizations established by agreements (Selin 2003). These ties may develop at the institutional or even personal level, but they can have a dramatic effect when it comes time to negotiate a new treaty. The contact between delegates can lead the creation of a common culture and practice of negotiation at the micro-scale leading to the aggregation of larger structures at a meso-scale.

Internal non-governmental organizations and other international organizations have a strong influence on a state's willingness to participate in agreements. Recchia

(2005) argues that "environmental organizations are an effective integrative mechanism that can articulate and aggregate environmental interests toward decision makers, elites, and the general public." Roberts et. al. (2004) found the most significant predictor of ratification in their studies is the number of NGOs in the country. Other research has found that transnational social movement organizations, many of which are NGOs, increase relative to the flow of aid to a country (Smith and Wiest 2005). It is possible that increased aid in the form of official development assistance (ODA) flows would increase NGO presence and therefore participation in environmental agreements. And since many treaties ask richer countries to provide ODA to developing countries in addition to reducing their own emissions, a feedback loop between the proliferation of environmental agreements and a state's willingness to participate in environmental agreements is created and sustained.

The citizens of a state can form endemic organizations as well, which are often influenced by transnational forces such as cultural attitudes towards the environment or the movement of information. Environmental pressure groups internal to countries are the product of what Steinberg (2003) calls "bilateral activists," individuals who have a connection to the foreign ideas and funding catalytic to foundation and funding of environmental organizations. These organizations in turn try to increase funding to their programs and encourage the state to increase participation in international agreements through citizen mobilization and lobbying efforts. The environmental organizations and their connections to the international community facilitate a feedback loop between the number of environmental pressure groups and environmental agreements and each works to sustain the other.

The transfer of ideas in a democratic state is important to the formation of groups that influence state activities (Steinberg 2003; Smith and Wiest 2005; Roberts et al. 2004; Paterson et al. 2003). Paterson et al. (2003) argue that governance of the environment relies on the priority environmental values receive relative to other values. Right now consensus in many countries has not been reached and it presents a significant hurdle to negotiation. But nation states are open systems to global culture. A change in one country has the ability to affect other states. David Frank argues that the global culture has altered its perception of nature and the government's role in preserving it over the past century (Frank et al. 2000; Frank 1997). Frank suggests the perception of nature in the 20th century which moved away from the idea of nature as provider or feral to nature as a life-sustaining ecology and thus prompted increased public interest in its protection (Frank, 1997).

Globally the concept that the state should be a steward of the natural environment was soon integrated into the 'blueprint' of state government (Frank et al. 2000). Meyer et al. (1997) suggest the structure of international environmental governance is the result of associational arenas (such as the U. N.) and the "expansion of rationalized and authoritative scientific interpretation, which structures perceptions of common environmental problems". Another feedback loop between the government structures and global culture surrounding the role of government and environment developed driving global discourse and internal changes. Participation in international agreements became a part of being a national steward of nature and the process reinforced itself. But while cultural interpretations may help explain increased

participation, it does not satisfactorily answer the Balkanization or modularity of the GSEG.

Increased symmetry of environmental values and norms can form the basis of trusting relationships. Tennberg (2007) suggests many dimensions of trust: an expectation that obligations will be fulfilled, that knowledge is reliable and available, and that one can be safe putting their success in the hands of others. Interviews among environmental project managers involved in long term cooperation assessed their trust levels very positively. Trust in others involved in conferences is key; 'disrupters' can sometimes appear at conferences dedicated to ruining or controlling the conference to their own benefits (Depledge, 2006). Sometimes Southern countries seek vengeance on Northern countries for perceived past wrongs in other environmental treaties and make unreasonable demands and stifle cooperation when they have the opportunity (Roberts and Parks, 2007). DeCremer (1999) peformed psychological experiments on public goods found reducing the level of fear that other participants will exploit them improved cooperation. Ensuring that those who cause fear of exploitation are excluded from negotiations may improve cooperation on agreements, but it also fuels division in the GSEG. Trust builds on cooperation and cooperation feeds on trust. It is therefore expected that communities of reciprocity and trust, once established, will self-sustain.

The many levels and systems of trade, culture, institutions and individuals conspire to structure the international environmental system. Structure emerges spontaneously within this system without any strong top-down governors. There are many real mechanisms in the negotiation of treaties that facilitate the creation of these aggregates. The first is geography. Clearly states have an easier time negotiating with

those who are near to them; in addition many geographically close state actors share similar environmental concerns (such as water resources, deforestation and desertification, and biodiversity). The other is the act of negotiation. Many similar treaties could be debated simultaneously among many actors in order to reduce the cost of negotiation. In addition to allowing the creation of aggregates this also leads to the creation of treaty lineages. If a large treaty is created and signed, then it is expected that the group of countries invited to the original signing would be invited back in the event of amendments or additional protocols. The GSEG is massively complex with many elements interacting across many levels. Regimes emerge as political forces because cooperation itself, while simple when reduced to one-shot games, becomes complex when embedded in repeated interaction embedded in a large international system.

Complexity of Cooperation

Hardin (1965) presents a metaphor for the commons as a field that anyone can use to graze their goats. Due to political strife, famine, and other causes of death the population remains in check and the commons remains stable. After a sustained period of peace, industrial, and economic development the population booms and soon the commons is flooded with goat herders. The commons is quickly reduced to sand. Hardin suggests the tragedy of the commons is very similar to a game a tic-tac-toe, one could try to look for a perfect winning strategy, but it logically does not exist. The only winning option is to abandon the game entirely; there is no technical solution. Hardin

suggests problems such as these require extending moral progress to reign in freedoms in the interest of sustaining society.

A simple two-player game underlying the tragedy of the commons is the Prisoner's Dilemma. The name of the game is derived from the most common fictional scenario used to describe it. Two suspects are arrested by police, but the police do not have enough information to convict either of them. The officers independently try to convince the captives to provide information enough for a conviction. There are four outcomes to the game detailed in Table 2.1. If both suspects remain silent they will both be convicted on a lesser charge and receive only 6 months. If they both confess, they will both serve 5 years. If only one suspect confesses while the other remains silent, the confessor is let go while the silent suspect is sentenced to 10 years in prison, this is called the "sucker's payoff". *Cooperation* in this game is defined as cooperation between the suspects (that is, they both remain silent), while *defection* is a confession. In a single play of this game, the optimal solution for a *single player* is to confess, however the optimal solution for the *system* of both players is to always stay silent.

Table 2.1. Outcomes for Prisoner's Dilemma Game

	Suspect 2 Stays Silent	Suspect 2 Confesses
Suspect 1 Stays Silent	Both serve 6 months	Suspect 2 goes free Suspect 1 serves 10 years
Suspect 1 Confesses	Suspect 1 goes free Suspect 2 serves 10 years	Both serve 5 years

This simple game gave birth to an entire branch of mathematics and decision science known as game theory. Computer simulations are a frequent tool used to explore the dimensions of choice in these games. Axelrod (1984) invited people to submit strategies for tournament of iterated Prisoner's Dilemma, the game is played

repeatedly with the same computer players. He found the most successful (and very simple) strategy was Tit-for-Tat (TFT) wherein a player starts by cooperating and does what the other player did in the last turn. TFT's success is due to its ability to sustain cooperative streaks and not descend into continuous punishment. Axelrod's 'competition' demonstrated that although there were a number of reasonable strategies for iterated prisoner's dilemma, there was a clear optimal strategy. It also showed that not only is cooperation possible, but that even small populations of cooperators can swing the entire system into cooperation.

The public goods game, unlike Prisoner's Dilemma, is played by many players with a single pool of resources. Public goods are characterized on two dimensions, they are non-excludable, meaning no individual can be prevented from consuming the good, and they are non-rivalrous, meaning that one individual's consumption does not affect any other individual's consumption (Olson, 1971; Grunberg et al., 1999; Ferroni et al., 2002). Because of the non-exclusivity dimension it is possible for players to free-ride. The action with the highest expected payoff, the rational choice, in one-shot plays of the game is to always free-ride.

While often rational, humans are not computer programs. The actors in real systems often have frequent interactions and a number of variables can affect contribution such as communication between parties, repeated iterations of the game, or non-economic motives such as respect, status, or trust (DeCremer 1999; DeCremer 2006; DeCremer 2003). The structure of networks has also been found to intervene on the outcome of cooperation. Cooperation will spread faster and have better success in scale-

free[1] networks than in a regular lattice (Santos et al. 2008). Regular lattices look like a chicken wire fence where the structure is consistent throughout, but scale-free networks have a few players that have a great many connections while most players have only a few. The scale-free topology encourages more universal cooperation and larger payoffs overall, but they also create a more uneven distribution of wealth and power.

Within the scope of global politics, central authorities do not exist which can completely govern global resources. Instead the complexity and structure of such systems and their tendency to self-organize is a powerful tool for cooperation and managing the commons. Ostrom (Ostrom and Gardner 1993; Ostrom 1999; Ostrom 2000; Ostrom 2009) suggests that social-ecological systems are complex systems consisting of micro-organisms, ecologies, local farmers or fisheries, local governments, state and federal governments, non-profit organizations, etc. that all interact with each other. Depending on the different rule-sets and norms, successful socio-ecological systems can self-organize into sustainable, self-governing systems. The different rules of the system include boundary rules which define what an agent of the system is, or rules for conflict-resolution, or payoff rules that adjust how costs and benefits are managed. A number of these rules exist through norms or explicitly in the GSEG and they alter how state actors behave. The rules change the behavior of the actors and the actors can change the rules. Through this constant feedback, actors are connected to one another and form a complex adaptable whole. It could emerge as a self-sustaining entity or collapse creating room for new systems to coalesce. A proper rule-set can create a system where cooperation is a stable attractor, if only locally.

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[1] The degree of each node is distributed according to a power law.

Self-Organization

When small components interact and respond to other components, without any central director, to form a structure larger than themselves, that structure is said to have self organized. Self organization is an important phenomena in chemistry, physics, and biology as well as sociology and political science. In human dynamics lines and pathways emerge in crowds, neighborhoods emerge in cities, political parties emerge from interaction and sharing of opinions, and international regimes emerge from the historical interactions of state actors. In the same way line in a crowd persists because it represents a path of least resistance, regimes may persist because the represent the path of least resistance to international governance.

The importance and power of self organization can be demonstrated through agent-based models (ABM) (Shalizi 2006). ABMs are computer simulations where synthetic agents, each with their own properties, navigate a landscape and interact with each other. These models display many of the same non-linear or discontinuous properties of real world social systems. Schelling's (1978) segregation model is a very simple example of nonlinearity and rule based interaction resulting in large structures. Schelling's model considers a checkerboard neighborhood where black and red pieces live. If a black piece's neighborhood does not consist of a certain proportion of other black pieces, it will move to a random empty location somewhere else on the board. It will continue to move until it has found a place that satisfies its preferences. Only a slight preference for similarity can lead to almost complete segregation. And while predicting the outcome of any single actor on the board is subject to immense error,

predictions about the outcome of the whole can be reliably accurate (e.g. an individual preference for at least 30% similarity leads to an overall segregation of about 75%).

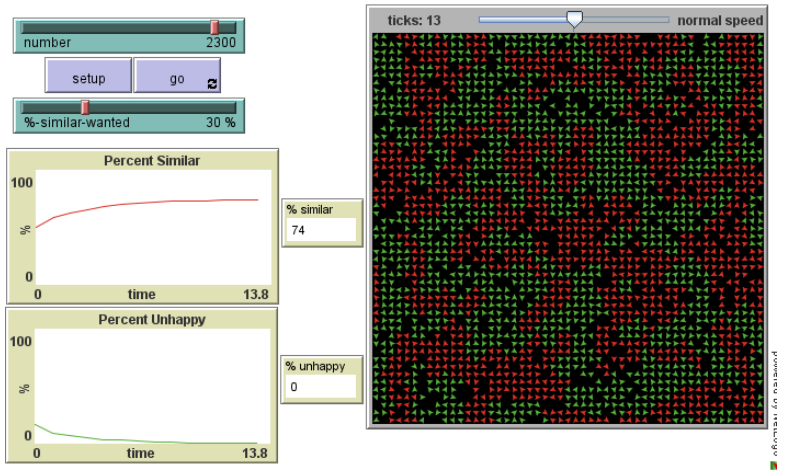

Figure 1.1. A NetLogo example of the Schelling Segregation Model run until all agents are "happy" (Wilensky 1997).

Axelrod's (1995) simulation of independent political units, the Tribute model, demonstrates that a set of agents with random starting positions can aggregate into larger structures that act as a whole. Over 1,000 iterations ("years") actors make demands of other actors and decide whether to fight the aggressor or pay up. Over time commitments and alliances form and strengthen to the point that one set of actors is completely committed to each other and not at all committed to the others. This results in (typically) two large, cohesive units that fight one another instead of the 10 actors that existed initially. No central director commands the agents to aggregate into structures; instead the behavior is the result of rule-based interactions.

The perspective of complexity, of which self-organization is a key concept, is ideal for analyzing the international environmental arena, and a wealth of empirical

evidence already exists to support many of its theoretical assertions. With this in mind many researchers have begun to view the history of politics through the lens of complexity. Hoffman (2006) applied ideas of complexity to help explain the shift from a 'North-only' participation model in the ozone depletion regime to one of universal participation. International agreements related to ozone depletion occurred in several steps and after each agreement was made an evaluation of the results altered the rule-sets of many of the actors. The altered rule sets resulted in a change in global outcomes of the system. Although he did not apply them in his study, Hoffman advocates the use of ABMs to demonstrate "the abstract plausibility, though not the empirical validity, of the explanation for regime transformation" he developed. Cîndea (2006) explains that the international system is incredibly complex and no single factor can be considered the cause of events such as war or sustained peace. Cîndea employs the concept of an 'attractor' from the study dynamical systems to help explain the dynamics of war and peace. An attractor, as Cîndea describes, is like the center of a tornado, it is not the cause of the movement of air but the air is moving towards it. Attractors are the effects of the rules that govern actors in complex systems and can be used to simplify descriptions of a system.

Agent based models suggest the existence of attractors in the GSEG and the Tribute model was created to lend 'abstract plausibility' to the Landscape Theory of Aggregation (Axelrod and Bennett 1993) which suggests that attractors exist to which actors in the international system gravitate. His explanation for the aggregation of actors is that attractors exist in the configuration space based on the initial conditions. There are many important similarities between the assumptions of the Tribute Model

and the GSEG. Over time many states develop binding agreements with one another that may preclude similar agreements with other states precipitating the emergence of larger political units. Given the processes of negotiating agreements, the multitude of feedback loops that exist within the system, and the tendency for actors to adapt their behavior to a changing landscape I expect aggregates to form in the GSEG as well.

Network Analysis

Every actor in the GSEG can be considered a part of a large global network. Each makes free choices in relation to other actors in the network. These choices accrete and converge on standards which then confine choices. This perspective "allows us to maintain our common-sense view of people as reasonable, choosing agents while simultaneously allowing that those doing the choosing may be subject to a form of external compulsion" (Gewal 2006). This perspective expands Krasner's (1982) description of regimes and exposes their complexity.

Network analysis concerns the study of networks composed of *nodes* and *edges*, where nodes are entities connected to one another through edges. I use network analysis to describe the evolution of the environmental regime network over time. Network analysis bridges a wide range of substantive arenas (Bhadra et al., 2008) and network analysis is not new to the study of political networks or international relations (Hafner-Burton et al., 2009). Faber (1987) used information from the Conflict and Peace Databank to construct an international diplomatic network and applied confirmatory factor analysis on a correlation network to identify communities. Grossman and Dominguez (2009) used a projection of a bipartite network to study patterns of funding

between political candidates and interest groups. Waugh et al. (2009) use modularity maximized community discovery to study party loyalty and polarization in the US congress, finding a non-monotonic relationship between network modularity and changes in majority party. Hoffman et al. (2007) used network analysis to study multi-lateral treaties between countries, deploying a country-by-country unipartite projection at four time points with a cutoff of 4 common treaties to dichotomize the network. Ward (2006) also projects the two-mode network of countries and treaties into a one mode network, but instead treats it as a weighted network. The research found significant correlations between centrality and sustainability.

New methods are frequently developed to tackle larger and more complex problems related to the study of networks.[2] In this work I focus on two methodologies which have not yet been applied to the study international agreements to detail the modular structure that binds the GSEG. The first set of methodologies focus on statistical analysis of bipartite networks. A *bipartite* network is one in which two colors can be used to color every node in the network in such a way that no two nodes of the same color share an edge. Many social networks are composed of two different elements. Whether women and the clubs they attend, students and classes, or nation-

[2] In addition to network analytic tools, agent based models are often used to explain the dynamics and formation of structure in networks, with some researchers modeling bipartite networks in particular. For example, Saavedra, Reed-Tsochas, and Uzzi's (2009) model cooperation by specifying two mechanisms, *specialization* and *interaction*, that lead to the emergence of community structure in bipartite networks. Specialization specifies how many other actors a node interacts with, and interaction specifies which nodes an actor interacts with. These agent rules adequately recreate observed community structures in bipartite networks.

states and the international agreements they sign, there exist two distinct and interdependent sets: *actors and events*. Many researchers reduce bipartite networks to a single mode weighted network by assigning arbitrary cut-offs. This betrays the underlying structure and reduces the structural role of one half of the vertices in the network to a weight rather than a unique entity. Methods developed specifically for bipartite networks have few of these problems and can study both sets of vertices in detail.

The second set of methodologies focus on identifying dense subgroups of networks and tracking their evolution over time. A network can often be divided into *communities* or subsets of the nodes within the network that are more likely to share edges with each other than they are to nodes outside the communities. While a wide array of community detection algorithms have been developed for one-mode networks (Fortunato, 2009), methods for two-mode networks have been slow in coming (Sawardecker et al., 2009). I use an implementation of the BRIM algorithm (Barber, 2007) to define community structure of our bipartite network without reduction.[3] The BRIM algorithm is based Newman's (2006a) method of finding communities using the eigenvectors of a modularity matrix. The modularity matrix is based on a null model of network connectedness that assumes the likelihood of any two nodes connecting is relative to the degree of both nodes. In effect, modularity is a measure of the deviation from the null model of a given grouping of nodes in a network.

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[3] Other methods have been developed for finding communities in networks (Sawadecker et al. 2009) and BRIM was found comparable to the method based on simulated annealing developed by Guimera, Sales-Pardo, and Amaral (2007). Both methods demonstrate better accuracy than clique-based methods.

An entire class of community discovery algorithms has been designed on the basis of maximizing modularity. The BRIM algorithm and others (Fortunato, 2009) build off previous work by Newman (2006b) on measures of assortativity and modularity in networks. These methods provide researchers with a quick and reliable way of studying community structure in complex networks. Recently there has been interest in the study of how community structure changes over time (Palla et al., 2007; Mucha et al., 2009; Rosvall and Bergstrom, 2009). Palla et al. (2007) developed a method of linking found communities across time points as well as new measures describing communities and their behavior over time. These methods are elaborated in the data and methods section.

CHAPTER 3: DATA AND METHODS

The data come from the online database Environmental Treaties and Resource Indicators (ENTRI) developed by the Center for International Earth Science Information Network at Columbia University (http://sedac.ciesin.columbia.edu/entri/). The data were cleaned to remove agreements which never had a signatory in the sample period and to remove signatories which are not considered state actors or countries (such as the Cayman Islands and the Food and Agriculture Organization of the UN). The list of all agreements and state actors can be found in Appendix A. The treaties are considered international environmental agreements (or IEAs) since they include treaties, amendments, protocols and other agreements (Mitchell, 2003). I use the terms IEA and agreement interchangeably through the rest of the thesis. The data cover IEAs signed from 1868 through the first few months of 2000. Our analysis covers the 51 years from 1950 through 2000, a period where the bulk of IEAs are signed. Countries in the dataset are also identified by their UN region and ENTRI has created key words to describe the nature or purpose of an agreement or treaty.

To examine the network consider a bipartite graph with two different node sets (Faust, 1997; Borgatti and Everett, 1997; Latapy et al., 2008). In the network, the first node set is the set of state actors engaged in signing IEAs, and the second node set is the IEAs that countries sign. Countries connect to IEAs by signing them. Countries are only

connected to other countries through the IEAs they co-sign. A rectangular matrix A_{ijt} of IEAs and countries is generated for each year (t) where the entry a_{ij} = 1 if country i signed agreement j by a year t or earlier and 0 otherwise.

By using a bipartite network one can study both classes of nodes simultaneously and avoid the structural data loss that occurs through unipartite projection. Additionally, results of community discovery in a weighted unipartite projection are often uncorrelated with observed communities in original bipartite networks (Sawadecker et al., 2009). Many researchers simplify the weighted network by creating a binary network using a cut-point, k, to remove the weighting. Any edge with a weight of k or greater is considered a link while anything less than k is dropped from analysis. Analysis of the bipartite network includes all edges in the analysis. With a bipartite network the role of the countries and IEAs can be analyzed in tandem. In addition to examining key countries in the system, one can also identify the most central IEAs and their modular role in the network.

I calculate the *betweenness centrality* for each node in then network. Betweenness is a measure of a node's tendency to be in between two random nodes in a network. When a theoretical message (or behavior) travels between any two points in the network and takes the shortest route possible, it is more likely to travel through high betweenness nodes than low betweenness nodes. The betweenness of node v is defined by:

$$C_B(v) = \sum_{s \neq v \neq t \in V} \frac{\sigma_{st}(v)}{\sigma_{st}}$$

where σ_{st} is the *number* of *shortest paths* between two random nodes *s* and *t* and $\sigma_{st}(v)$ is the number of shortest paths between *s* and *t* that also go through the subject node *v*. Betweenness for node *v* is this fraction summed for all pairs of nodes in the network where *s* is not equal to *t*.

Figure 3.1 illustrates a simple network diagrammed on the left of the figure. The *degree centrality* of a node is the number of edges incident on (connected to) a node. The *degree distribution* is on the right of the diagram. The degree distribution can be a simple way of understanding the structure of a network. Scale-free networks are characterized by many nodes with few connections and few nodes with many connections (the distribution is typically characterized by a power law). The network in Figure 3.1 is also useful to show the difference between betweenness centrality and degree centrality. In the diagram both nodes C and E have the same degree centrality, 4, but node E has a higher betweenness centrality. This is because any paths between nodes F and G to any other node in the network will travel through E, thus E is *between* many nodes in the network. While for node C it is possible to access nodes A, B, and D along a shortest path without having to traverse C at all.

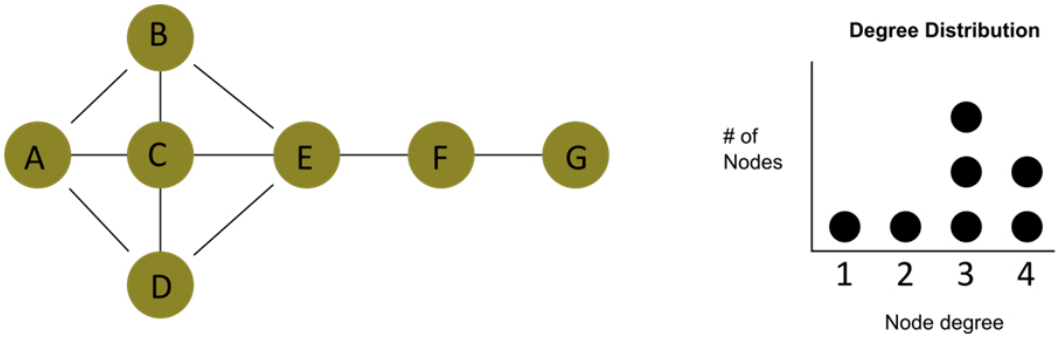

Figure 3.1. Simple Network Example

As part of this research we would like to confirm the GSEG is a complex system, and one property of complex systems is their balance on the edge of chaos. A complex system is neither a random network nor a model of perfect order such as a crystal. Prokopenko et al. (2007) suggest measuring the level of assortative noise in a system to estimate its entropy. A network with little assortative noise has greater predictive efficiency. In this article I use a measure based on assortativity called modularity (Newman, 2006a). To estimate modularity, I use the bipartite recursively induced modules (BRIM) algorithm (Barber, 2007). The BRIM algorithm is built from Newman's (2006b) method that exploits the eigenvectors of the modularity matrix to constantly partition a network. Since the modularity matrix of a bipartite network is rectangular rather than square, the BRIM algorithm uses a generalization of singular value decomposition to recursively generate the modules.

To evaluate the partitioning of the network I compare it against a null model of network connectedness. Consider our IEA network with p agreements and q countries that form a p x q incidence matrix at time t, A_t, and let k_i be the degree of the agreements and d_j be the degree of the countries. The null probability, P_{ij}, that agreement i connects to country j is equal to $P_{ij} = \frac{k_i d_j}{m}$, where m is the number of edges in the network, and thus the modularity matrix is defined as:

$$B_{ij} = A_{ij} - P_{ij}$$

I assign agreements and countries to communities using two binary index matrices where each column of the matrix represents a community: $\boldsymbol{R}_{p\,x\,c} = [\, r_1 \mid r_2 \mid \cdots \mid r_c \,]$ for agreements and $\boldsymbol{T}_{q\,x\,c} = [\, t_1 \mid t_2 \mid \cdots \mid t_c \,]$ for countries and c is the number of

communities. Each row of the matrices sum to 1 and represent an individual agreement or country so that each node is assigned to one community. Using the modularity matrix and the index matrices modularity is calculated by:

$$Q = \frac{1}{m} Tr\ \boldsymbol{R}^T \boldsymbol{B}\boldsymbol{T}$$

The community vectors $\boldsymbol{T}$ are initialized by assigning each country randomly to a community and re-write the equation for modularity so that $Q = \frac{1}{m} Tr\ \boldsymbol{R}^T \widetilde{\boldsymbol{T}}$ where $\widetilde{\boldsymbol{T}} = \boldsymbol{B}\boldsymbol{T}$. Since the rows of the matrix $\boldsymbol{R}$ consist of a single 1 with the rest as 0, to maximize Q the element of each row of $\boldsymbol{R}$ is chosen so that the corresponding value of $\widetilde{\boldsymbol{T}}$ is the maximum. While the assignment of countries is initially random, agreements are chosen so that the selection maximizes Q. Then the equation is rewritten again ($Q = \frac{1}{m} Tr \widetilde{\boldsymbol{R}}\boldsymbol{T}$ where $\widetilde{\boldsymbol{R}} = \boldsymbol{R}^T \boldsymbol{B}$) and countries are assigned to communities such that Q is maximized. The process takes advantage of the bipartite nature of the network to induce the modules. Hence the name of the algorithm: bipartite recursively induced modules (BRIM).

To find the number of communities in the network the algorithm is run 500 times, assuming 2 through 30 initial communities. After 14,500 runs of the algorithm, the set of $\boldsymbol{R}$ and $\boldsymbol{T}$ index matrices that produce the highest measure of modularity, Q, is the partitioning of the network that is kept. This process is performed on the accumulated network generated at each time point from 1950 to 2000. Although the algorithm can be initialized with 2 or more communities, there is no check to ensure communities are not left empty.

To identify communities across time points, Palla et al. (2007) advanced a method of linking a community discovered at an initial time point (t_0) to a different community in the next time point (t_1). The method relies on generating an un-weighted union graph containing all links and nodes across time points. The communities are connected to the union graph by comparing the node overlap.

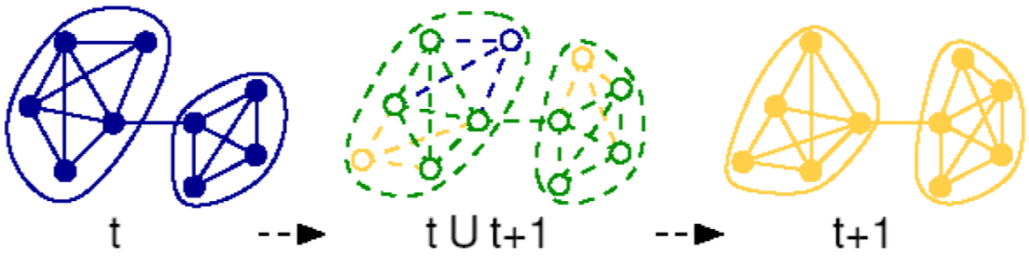

Figure 3.2. Matching of communities from *t* to *t+1* using a union graph (reprinted from Palla et al., 2007, © 2007 by the Nature Publishing Group).

Six possible behaviors of communities can be captured: birth, death, growth, contraction, merging, and splitting. For instance, if a majority of vertices in community c_1 at time t_0 are also found in u_1 in the union graph, but in time t_1 two communities c_4 and c_5 in the network also have most of their vertices in u_1, then c_1 connects to both c_4 and c_5 in time t_1 and c_1 is considered split. The community c_1 is then matched to either c_4 or c_5 (whichever has the highest node overlap) and the remaining community is considered to have been born. The merging of communities is tracked in a very similar fashion. Figure 3.2 shows an example of community matching using a union graph. Time point *t* is in blue and time *t+1* is in yellow.

Once the communities are identified over time they can be analyzed for their lifespan, their size, and their *stationarity* (Palla et al., 2007). The correlation of a community *A* between birth and some time point *t* is described as $C_A(t)$,

$$C_A(t) \equiv \frac{|A(t_0) \cap A(t_0 + t)|}{|A(t_0) \cup A(t_0 + t)|}$$

where $|A(t_0) \cap A(t_0 + t)|$ is the intersection of the nodes in community *A* at time t_0 and time $t_0 + t$ and $|A(t_0) \cup A(t_0 + t)|$ is the union of the nodes in both time points. The average correlation between each time is described by ζ,

$$\zeta \equiv \frac{\sum_{t=t_0}^{t_{\max}-1} C(t, t+1)}{t_{\max} - t_0 - 1}$$

where t_{max} time point of the death of the community and t_0 is the birth. The average correlation is referred to as the *stationarity* and is a measure of retention in the community ranging from 0 to 1. A community with a stationarity of 1 has the exact same members between each time step, while a stationarity of 0 has none of the same members between any two time steps. The left community in Figure 3.2 has a stationarity of 0.66 (four communities that persist in both time points, divided by 6 in the union graph) and the right has a stationarity of 0.80 (four in both, divided by five in the union).

Figure 3.3 provides examples of the 6 scenarios in the evolution of communities. Nodes and edges never decay in the GSEG network, so death is an impossible scenario. Communities only decay when they merge into a more dominant community. Contraction only occurs when nodes move to a different community.

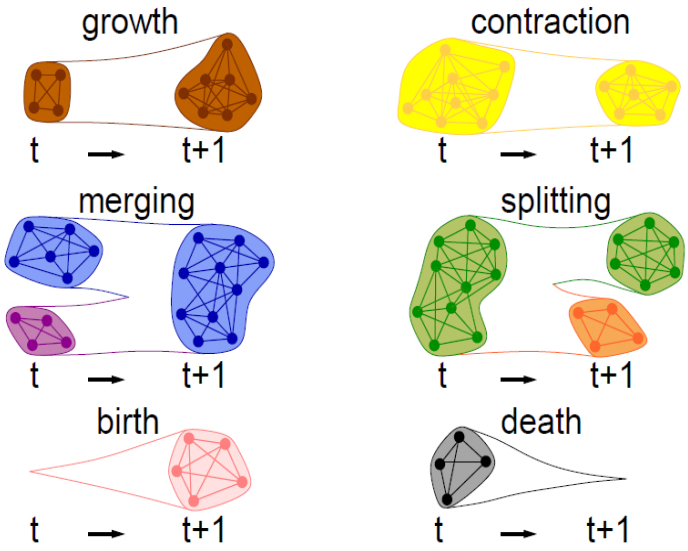

Figure 3.3. Possible scenarios in the evolution of communities (reprinted from Palla et al., 2007, © 2007 by the Nature Publishing Group).

Examples of how the BRIM algorithm identifies communities can be found in Figure 3.4. The top row of nodes can be thought of as agreements while the second row could be considered states. In the first box (a-c) shows what occurs with different configurations of edges. In *a)* the graph has a strong coupling between the two communities, in *b)* the communities are more separated resulting in a higher value of modularity (0.42). In the last graph in the box, *c)*, two communities are completely disconnected resulting in a modularity of 0.50. The second column of graphs shows what happens in the addition of new nodes. A single agreement is signed by the two middle states (after graph *d)*). Graph *e)* shows the results from the algorithm when only two communities are searched for. In graph *f)* the number of assumed communities is three. In this example the algorithm finds a higher modularity if three communities are assumed rather than two. The three community solution is considered a better

representation of the community structure. Finally in graph *g)* modularity increases when a new agreement is added to which only the blue community signs. In the GSEG many of the increases to modularity are due to communities signing new agreements where signatories are all within a single community.

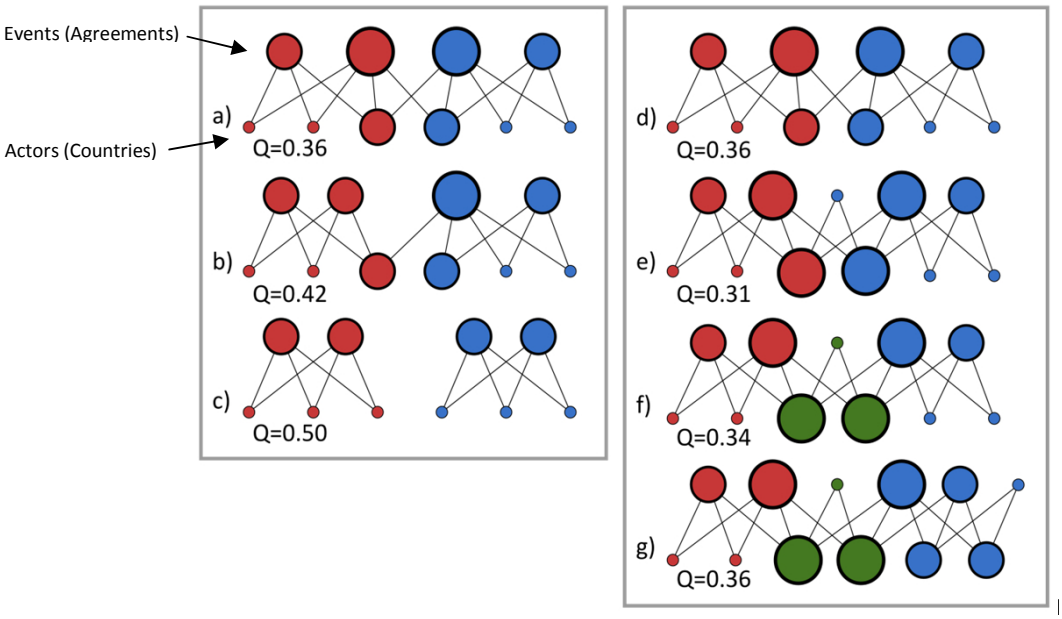

Figure 3.4. Changes in community structure resulting from changes in the network

CHAPTER 4: RESULTS

I divide the analysis of the GSEG into three parts. First I analyze the network for basic statistics such as the number of actors over time , the mean degree, and centrality. Second I look at overall community evolution noting the lifespan, size, and stationarity of observed communities. Third I walk through the evolution of network as visualized through network diagrams.

Network Statistics

Figure 4.1 shows the number of IEAs and countries by year. In 1950, there were few IEAs relative to the number of countries (23 IEAs and 80 countries). Around 1970 the number of new IEAs signed relative to the number of new active countries increased. By 1982 there are more IEAs signed than countries signing them. By 2000, the network was composed of 192 countries and 336 different IEAs signed.

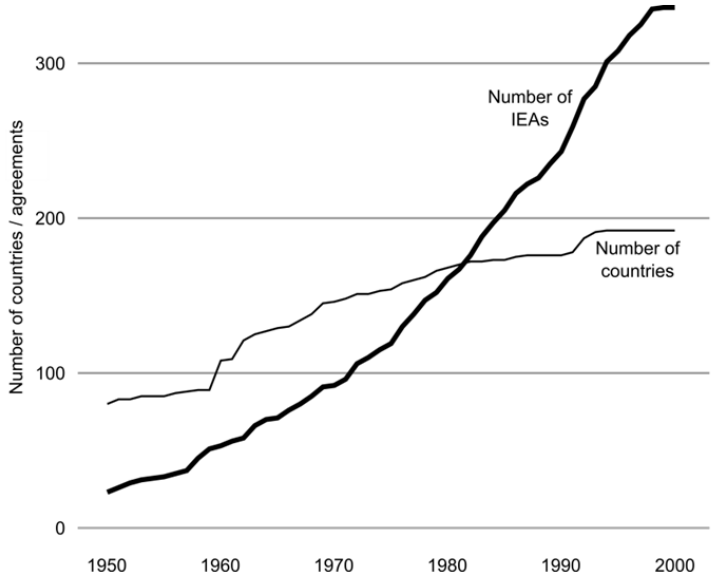

Figure 4.1: Size of Network over Time

IEAs and countries displayed very different behaviors in the network. The degree distribution among countries was roughly log-normal throughout the sample period. It was most likely that countries signed at least a few agreements throughout the sample period, while a statistically few number of countries signed only a few agreements and few countries signed a great deal of agreements. Most of the high-signing states are in Europe and sign many global agreements as well as many Euro-centric agreements.

Each state continued to sign more and more agreements each year in the sample period. The mean number of IEAs signed by countries increased linearly each year by 0.65 (±0.04) from 6.8 to 40.3. The number of countries that had signed each IEA (the degree of the agreements) had a very long tail, approximating a power law. Most agreements had only a few signatories, while a small number of agreements were signed by nearly the entire system. I fit a power law distribution to the IEA degree distribution

(Clauset et al., 2009) at each time point to examine the trend in the exponent. The *xmin* was determined using the power law fit program in the *igraph* package in R. The α-exponent was 2.33 (±0.50) throughout the sample period. While the mean number of signatures per state increased throughout the sample period the mean degree of IEAs varied between 20 and 24. The trend in the mean size of agreements is shown in Figure 4.2.

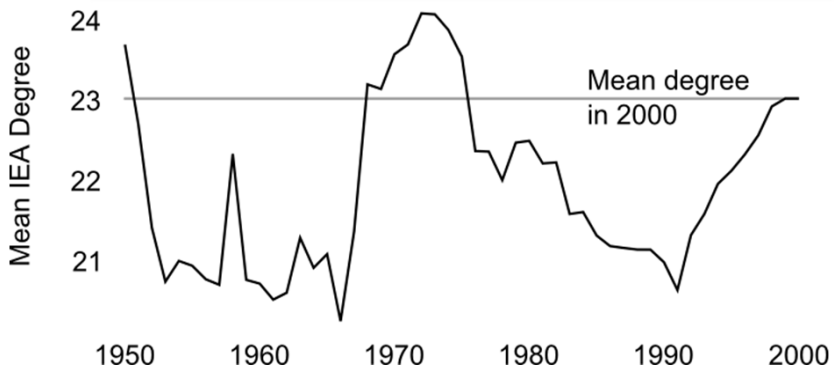

Figure 4.2: Mean IEA Degree over Time

In the final accumulated signature network in 2000, countries were on average far more central in terms of betweenness[4] compared to agreements (p<0.001). The top 10 agreements and countries, ranked by betweenness centrality are shown in Table 4.1. The top agreements were more central than the top countries. Agreements tie the system together more than the states themselves. The most central agreements by keyword were those related to sea jurisdiction, legal and intuitional questions, and the atmosphere. The topics of these agreements tend to transcend regional boundaries as all

[4] Betweenness is defined in Chapter 3: Methods and Data.

the skies, oceans, and legal/financial organizations are connected or strongly coupled. Participation in these topics is necessarily trans-boundary or global.

Community Structure

The BRIM algorithm found between 4 and 8 communities at each time point, far below the maximum searched of 30. Values for modularity can range from 0 to 1. If Q=0 then there is one community and all nodes belong to it; if Q=1 then there are as many communities as there are nodes and each node belongs to its own community. Neither scenario indicates a complex community structure. Meaningful values for Q lie between these two extremes. The modularity of the IEA network over time is displayed in Figure 4.3.

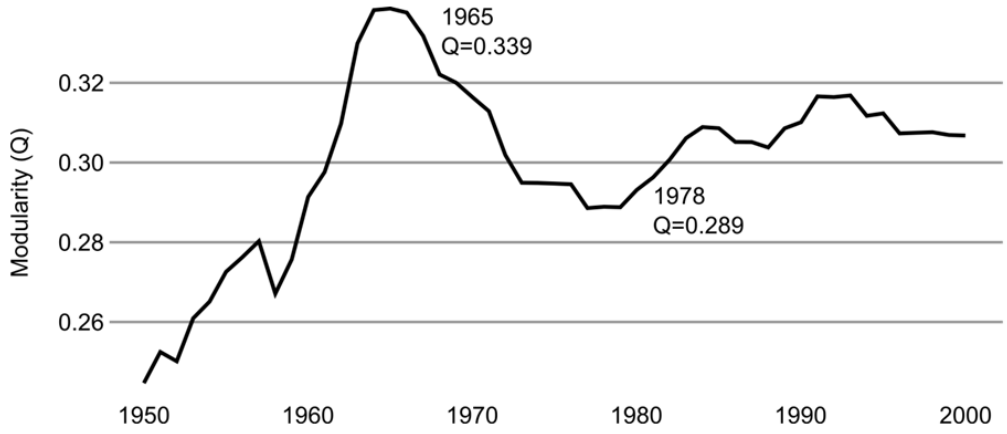

Figure 4.3: Modularity of Network over Time

Modularity varied between a minimum of Q =0.24 in 1950 to maximum of Q=0.34 in 1965 indicating an increase of intra-community environmental activity. Although the degree to which it is divided into communities varies over the sample period, the network is clearly complex and displays and emergent structure (Newman

2006b; Hoffman 2006). Modularity declined from its peak in 1965 to Q=0.29 in 1978, following multiple global agreements that bridged observed communities. The modularity from 1985 through 2000 has remained somewhat stable around 0.31 although the number of agreements signed increased. This result indicates in the past 15 years there has been little disturbance to the community structure of the system. New agreements recreate the structure as the system develops standards and norms that reinforce the boundaries or modules that had developed over the previous century (Grewal 2006; Krasner 1982). By about 1985 the system has ossified (Depledge 2006) and community structure had reached a stable state.

The community matching algorithm found 25 unique communities tracked over the sample period that either existed at the beginning or emerged at some point during the sample period. The mean lifespan of observed communities is 10.3 years. There were 10 communities lasting 2 years or less which occasionally split from larger communities, possibly a result of the random starting conditions of the algorithm. Two communities lasted the entire period of 51 years from 1950 through 2000. There were seven communities with a lifespan of 10 years or more; I focus on these communities because of their reliability.

Figure 4.4 shows the size of the communities and the movement of network actors between the communities. Only communities with a lifespan greater than 3 years are displayed. The diagram starts at the bottom in 1950 and proceeds up to the most recent configuration in 2000. Communities are labeled by the order of their birth or emergence (C01 is first, C02 second and so on). The lifespan and growth of

communities, as well as the movement of actors in the network between communities are evident. Each community is represented as a vertical line. The width of the line indicates the number of countries in the community at that time. Splits and merges are indicated by a connecting line.

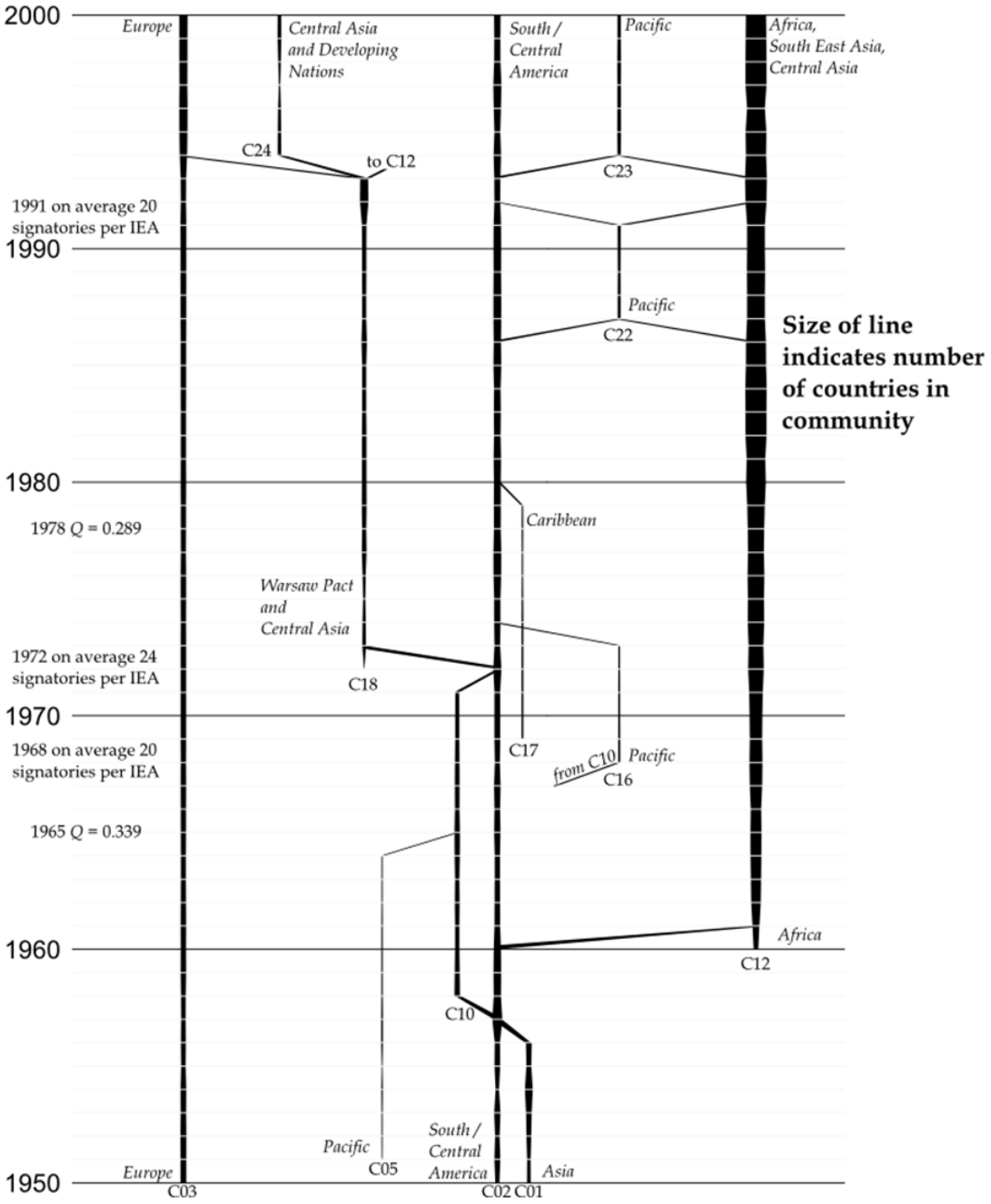

Figure 4.4: Tree Diagram of Community Evolution

Communities are born when new sets of countries or agreements enter the system. A set of countries could enter the system on a treaty they all share, such as many African nations in 1960 (C12) with the signing of the Constitution of the United Nations Educational, Scientific, and Cultural Organization, or a community is born by splitting from a larger existing community. A split typically occurs when a new agreement or lineage of agreements start among a subset of countries within an existing community. This can create a denser region of the community such that modularity is higher if this new dense region is mathematically rendered a new community. Pacific nations can be seen splitting and merging from C02 and C12 three times because of many regulatory agreements on the use of the sea, such as whaling and transportation restrictions. This behavior can be best understood by referring to Figure 3.4.d-g. The Pacific regime has a number of agreements of which only its members have signed, this typically means that the algorithm will find a higher modularity for the system whenever the Pacific regime is defined as its own community. But many of the members, such as the United States and Japan, sign many agreements outside of the community. As these members sign more agreements outside the community modularity is not optimized by defining the Pacific regime as a community, but as new agreements are signed within the Pacific regime, or new actors (such as some South Pacific island nations) join the GSEG within the Pacific regime modularity is again optimized by defining a Pacific community.

Between 1950 and about 1970 the formation of new communities was as much driven by the addition of new agreements as it was the addition of new countries. Between 1980 and 1991 the number of countries in the system saturated and any changes

to the structure of the system were caused by the entrance of new agreements. Since signed IEAs are never considered to have left the system, communities only die when they are absorbed. Community absorption occurs when countries in a delineated community sign enough common agreements with countries from other communities – a process of inter-community cooperation.

Over the time period examined, about 5 communities are observed at each time point, with a floor count of 4 communities.[5] At a general level, five communities appear to stabilize following the saturation of new state actors. These large aggregations define the present period of the GSEG, and are observable in Figure 4.4 at the top of the graph: *Europe; Central Asia and developing nations; South and Central America; Pacific nations; and African, Southeast Asian and Central Asian nations*.

Interestingly, countries that comprise these communities are not always geographically proximate or regional neighbors. This suggests modules / regimes exist as a phenomenon independent of geography and geo-politics and act as an intervening variable in the creation and signing of IEAs (Krasner 1982). The geographical distribution of communities over time is shown in Figure 4.5. The maps depict the network at 4 time points, representing the first year of analysis (1950), the point of the highest measured modularity (1965), the local minimum measured modularity (1978), and the last year of analysis (2000). Countries in white have not been recorded as having signed an agreement by that time. Countries with matched color are part of the same community.

[5] A high number of communities observed in a given year may be a function of uncertainty in the algorithm due to transitions in structure, rather than any observable trend.

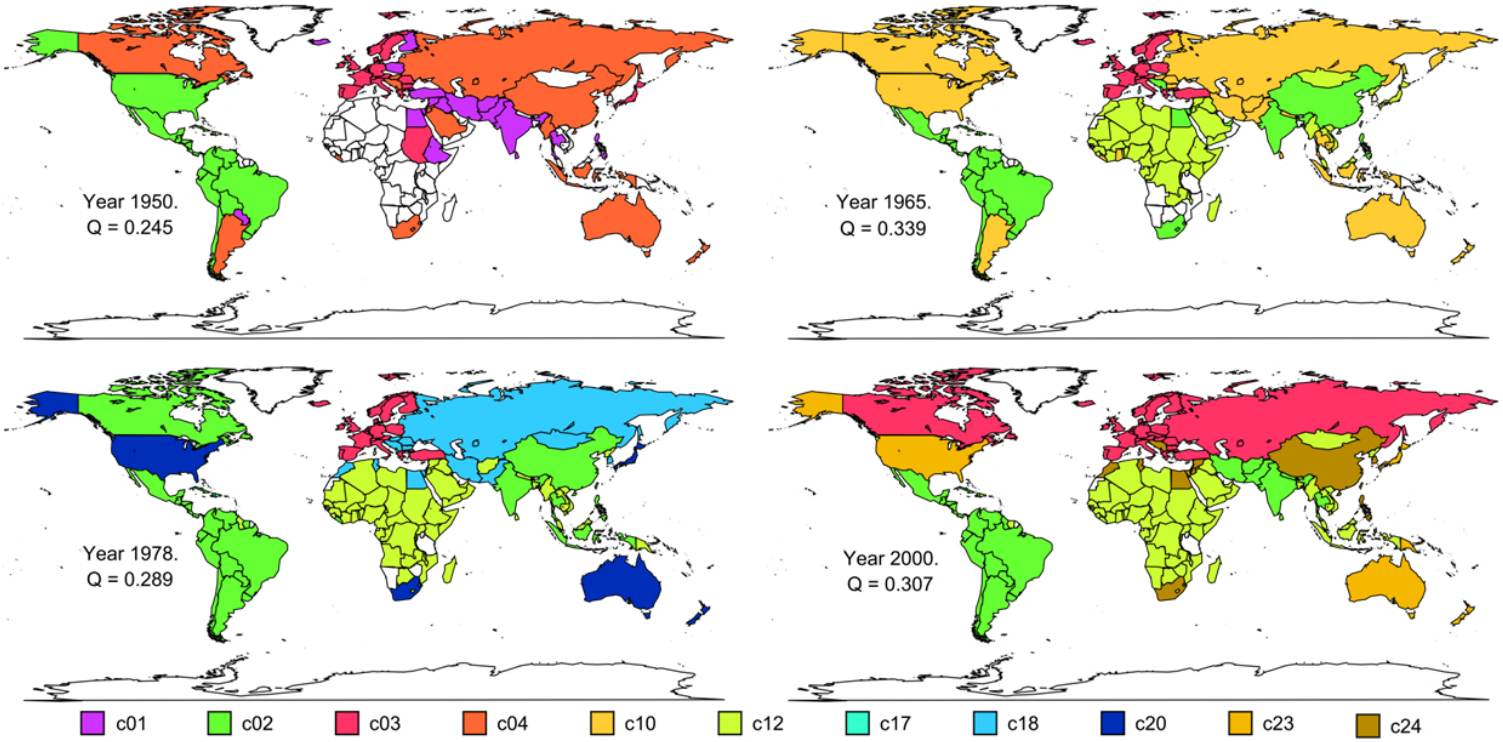

Figure 4.5: Maps of Community Membership at Four Time Points

The exact assignment of all the nodes in the network to each community can be found in Appendix B. Each community is uniquely colored. From Appendix B it is possible to see the path each state actor or agreement takes through the system over time. Agreements are listed first, followed by countries. The full names of each of the nodes can be found in Appendix A.

Community Evolution 1950-2000

Detailed statistics on 15 communities are presented in Table 4.1, including figures on community lifespan, the mean number of countries and agreements constituting a community, and stationarity estimates.

Table 4.1: Descriptive Statistics of Longest-Lived Communities

Community	Life Span	Mean # Countries (S.D.)	Mean # IEAs (S.D.)	Stationarity
c01	7 (1950-1957)	3.3 (8.6)	0.6 (1.6)	0.58
c02	51 (1950-NA)	29.9 (5.3)	28.5 (19.0)	0.76
c03	51 (1950-NA)	26.2 (4.4)	71.8 (48.4)	0.91
c05	14 (1951-1965)	1.6 (2.7)	1.4 (2.3)	0.80
c08	3 (1955-1958)	0.5 (2.2)	0.1 (0.4)	0.32
c09	3 (1957-1961)	0.2 (0.7)	0.1 (0.2)	0.60
c10	14 (1958-1972)	5.9 (9.7)	3.0 (5.2)	0.74
c12	41 (1960-NA)	60.9 (35.3)	22.5 (20.0)	0.85
c13	3 (1962-1965)	0.1 (0.2)	0.1 (0.2)	0.67
c16	6 (1968-1974)	0.9 (2.6)	1.1 (3.2)	0.74
c17	12 (1968-1980)	1.6 (3.0)	0.5 (0.9)	0.80
c18	22 (1972-1994)	8.6 (11.1)	8.3 (11.3)	0.72
c22	5 (1987-1992)	1.3 (3.9)	2.0 (6.2)	0.75
c23	7 (1994-NA)	2.2 (5.5)	4.2 (10.7)	0.76
c24	7 (1994-NA)	1.9 (4.9)	3.1 (8.2)	0.62

Communities with a very low stationarity, but a long lifespan would be interesting. They would represent something like a whirlpool in the GSEG, indicating some property of the global system tends to make states and agreements come together only to move on to new more stable positions. In general communities with a higher stationarity also had a higher lifespan. Communities C18 and C12 have somewhat low stationarity for their lifespan, indicating that these countries and agreements circulated attractors based on the rules inherent to the system rather than merely following political or geographical boundaries (Axelrod and Bennett 1993; Axelrod 1995; Cîndea 2006).

Network diagrams are presented in Figures 4.6-4.11 showing the evolution of the network every decade between 1950 through 2000. The position of nodes are determined using a force-layout method (Force Atlas layout in Gephi[6]). In force-layouts the nodes are repulsed from one another if they are too close, but attracted to each other if they share an edge between them. The nodes start with a random position then from the "physical" forces of attraction and repulsion settle on a layout. These layouts tend to approximate known community structure (Noack 2009).

The nodes are sized relative to their betweenness centrality. The colors represent the different communities. Colors differ between communities, but the color of a community is not consistent throughout the evolution of the network (i.e. C02 may be blue in 1950 but yellow in 1960). The nodes are labeled using a shortened name that can be referenced in Appendix A. Nodes with names such as Agree47, Const5, Conve62, etc. are agreements, while United_Sta, Luxembourg, Iran_Isla are states. In the bottom left

[6] Community developed graph visualization software found at http://gephi.org.

of each diagram there is a smaller diagram showing the different communities in the network at that time. The community nodes are sized by the size of the community and links between communities are sized by the number of shared links between the communities.

If the GSEG behaves like the agent based models discussed in Chapter 2 (Schelling 1978; Axelrod 1995; Macy et al. 2003) then the initial arrangement of agreements is critical to the future structure of the system. At first countries act and cooperate freely and as they do so they sign new regulations and develop norms and practices. These norms and practices can preclude the signing of future international policy thus restricting the freedom of future behavior of state actors (Grewal 2008). As new agreements enter the system they tend to reproduce those earlier defined boundaries.

The graph in 1950, Figure 4.6, represents the network at the beginning of the sample period. The first agreement in the dataset (and the only agreement from the 19th century) was Revis1, *Revised Convention on the Navigation of the Rhine,* which can be seen as a small node on the far right of the network as part of C03. The network begins tied together by five major agreements. Agree46 and Agree47, the *Agreement of the International Bank for Reconstruction and Development* and *Agreement of the International Monetary Fund* are key agreements throughout the life of the network, but only indirectly represent environmental concerns. Three of the other top agreements tying the beginning of the system also concern international institutions and laws, Const3 establishes UNESCO, Const5 establishes the WHO, and Chart2 is the charter of the UN.

These agreements establish protocols and norms the vast majority of state participants use.

In addition to the major central agreements, many agreements establish community structure by maintaining well-defined boundaries to participation. The agreement Chart1 for instance establishes the Organization of American States and sits at the center of C02 for its entire lifespan, establishing protocol and norms for predominately South and Central America. Community C03, predominately European nations, also has a number of agreements internal to the community. These two communities and their internal agreements are responsible for the majority of the modularity in the system (which is currently at its lowest value in the sample period, Q=0.245).

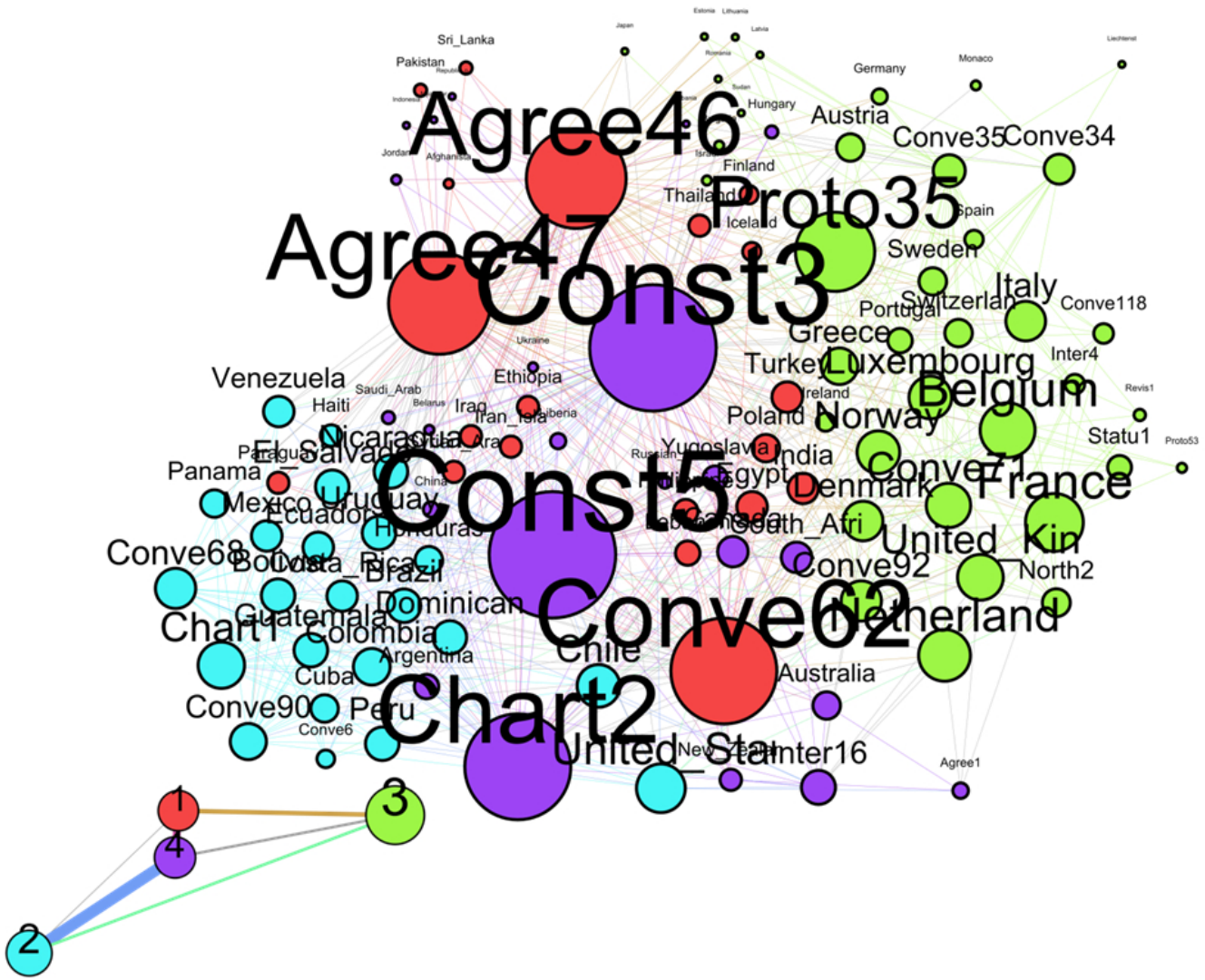

Figure 4.6. Diagram of Network in 1950

In 1960, Figure 4.7, the community C12 (green) emerges as many African countries sign UNESCO (Const3) and the *International Bank for Reconstruction and Development* (Agree46). Community C12 continues through the rest of the sample period and hosts many Southern or economically marginal states. Central Asian, East Asian, and South American, and South Pacific nations also join Africa at different time points. Two tiny communities appear in this time point, C11 and C9. Community C11 consists of one agreement and one country, the Dominican Republic and Inter18 (*International Convention for the Safety of Life at Sea*). In future time points other countries in the Caribbean sign Inter18 and Dominican Republic is absorbed into C17 with other Caribbean countries, which is later absorbed into C02 with other American nations (as shown in Figure 4.4).

The Pacific Community (or one form of it) appears in this time point as C05 (pink/purple). It consists of Japan, Australia, United States, New Zealand and at this time Canada. This community emerges again as communities C16, C22, and C23 at different time points but is occasionally very different from past forms and is assigned a new community number. These nations follow two sets of rules. Since all of these countries are advanced and English-speaking they tend to participate in UN centric and many Euro-centric global agreements. Their position on the globe requires them to follow another set of rules governing the Pacific Ocean, such as whaling and shipping regulation. New countries, new signatures, and new agreements tug these countries in and out of the community.

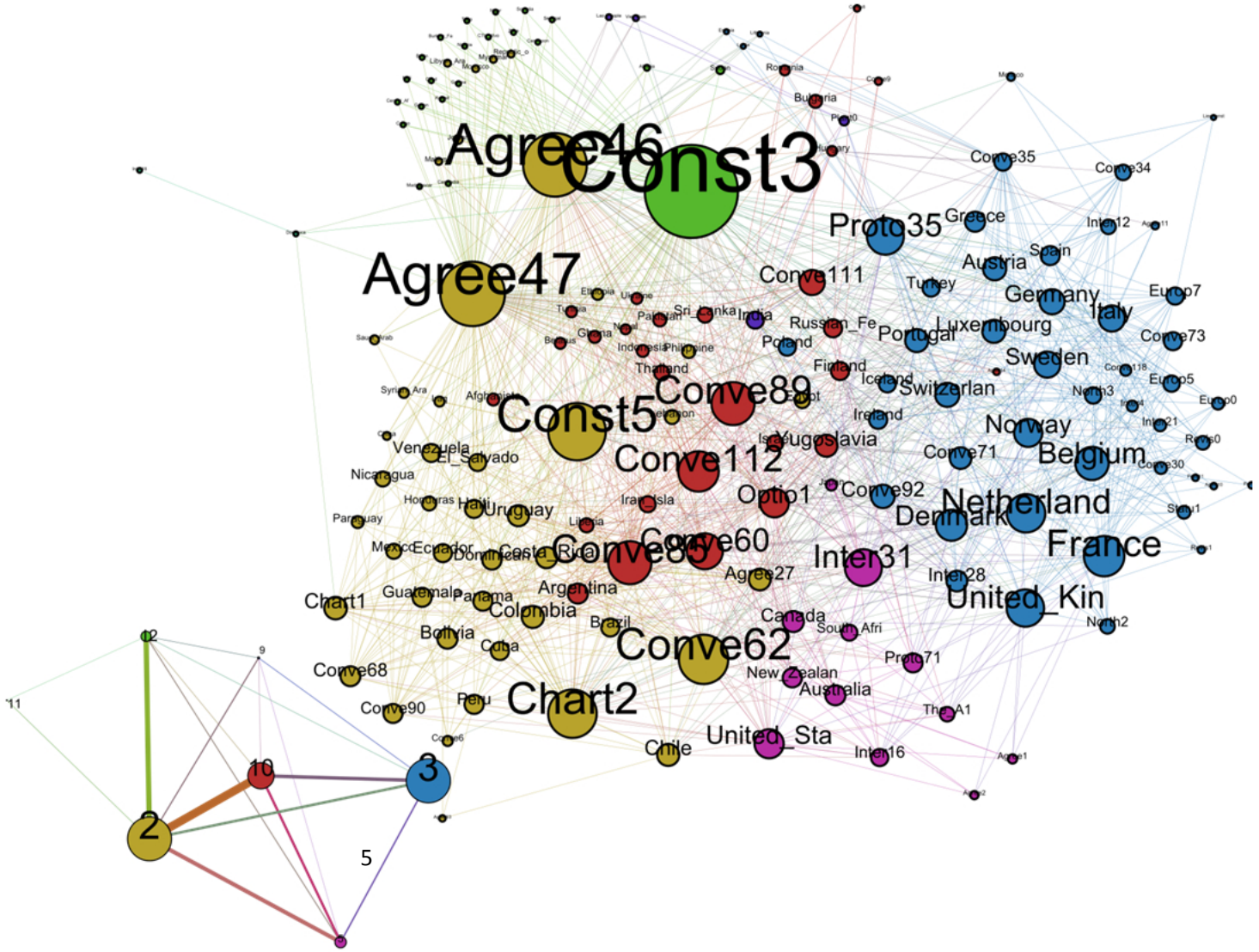

Figure 4.7. Diagram of Network in 1960

By 1970 community C12 had grown significantly. Modularity peaked in 1965 at Q=0.339 spurred by centripetal behavior on the part of the existing communities including C12 and C02. Agree22, *Agreement establishing the African Development Bank*, and Afric0, *African Convention on the Conservation of Nature and Natural Resources* were both signed by African countries providing a center of the community and increasing the overall modularity of the network. The large global agreements discussed before as well as a two new agreements regulating the nuclear armament and testing are members of C12 because they are more likely to be signed by countries in C12 than any other country. These agreements have very high betweenness centrality because they sit on many paths between the many countries in C12 and the rest of the GSEG. Because European countries in C03 sign these C12 agreements as well as the multitude of European agreements the agreements in C12 and the countries in C03 have high betweenness. This structure is prototyped in Figure 3.4.b. where a country acts as a bridge between the communities by signing an agreement in a foreign module.

Community C05 reappears as community C16 again in 1970. Inter31, *International Plant Protection Convention,* was signed in the 1960's which every member of C16 signed, in addition to a new amendment to the South Pacific Commission which further reinforced the community structure. Repeated cooperation continues to reinforce norms and practices making it more likely for new agreements to follow the same patterns. Community C17 and consists of Caribbean island nations and lives for 12 years from 1968 and 1980. Caribbean countries are anchored by Agree24, the establishment of the Caribbean Development Bank.

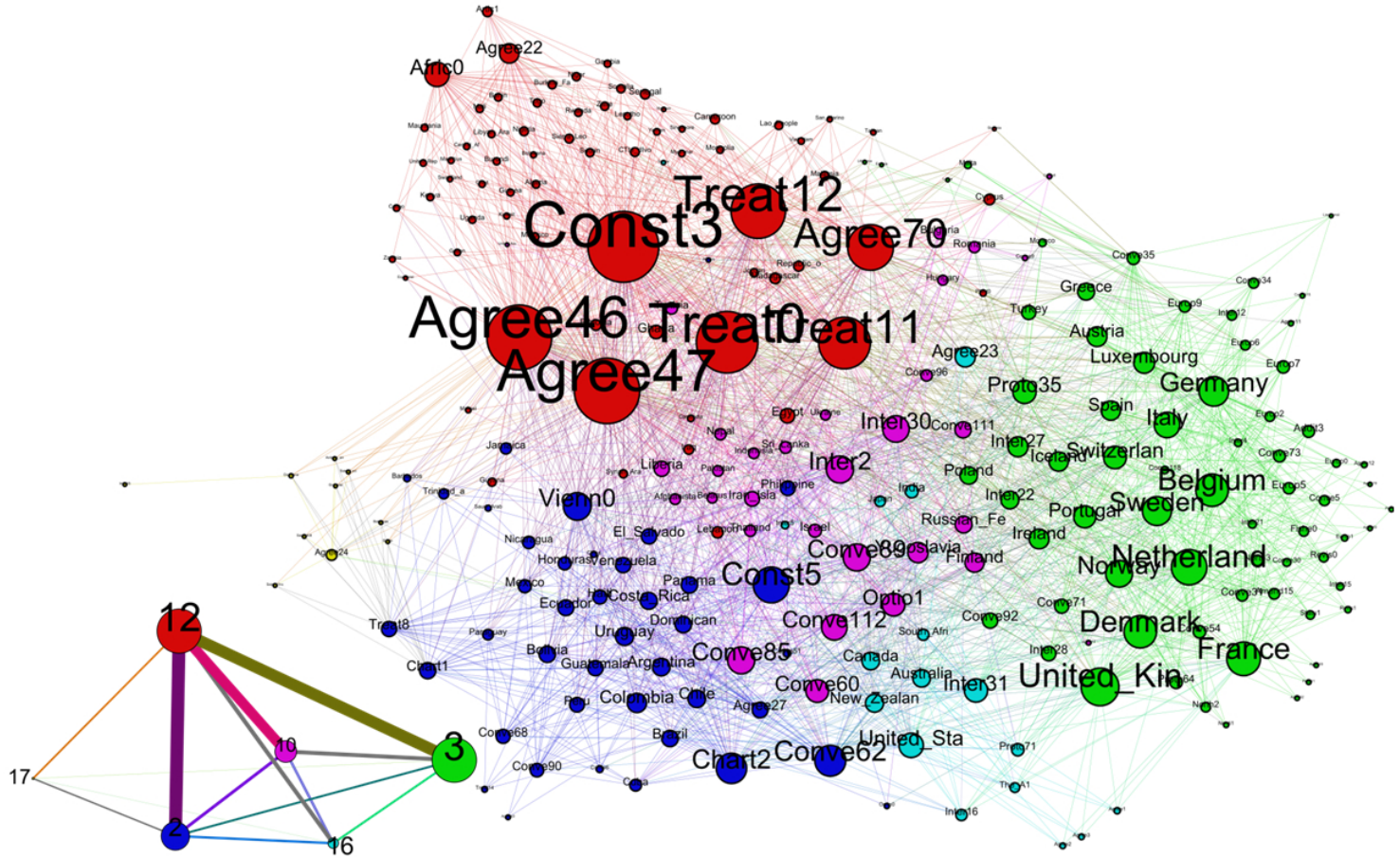

Figure 4.8. Diagram of Network in 1970

Figure 4.9 shows the GSEG in 1980. By this point in the development of the GSEG almost all state actors that will participate, have joined the network. The structure has begun to ossify (Depledge 2006) and the community structure has begun to settle on a stable configuration (Axelrod 1995; Macy et al. 2003). Many of the rules norms and practices have been settled and new agreements continue to reinforce existing structure.

There are only four communities represented at this time point. Community C12 has grown and C17, most Caribbean nations, has merged into it. Community C03 has continued to reinforce itself adding new agreements internally while still signing many agreements within C12. Community C02, with the Amazon and Central American rainforests, has continued to focus on biological diversity and the development of agricultural resources. While many marginal states jump at any chance for participation in the global arena (Roberts and Parks 2007) C18 contains many countries which seem to participate only out of sheer necessity. Iran, Belarus, Israel, and Egypt are all members of C18, and many of these countries were also part of C10 in previous diagrams. The signing behavior of all these countries is similar so they tend to cluster together, but they are spread over a vast and varied geographical area (as seen in Figure 4.5) and maintain many conflicting political positions. Many of the agreements they sign regard the safe containment of toxic or nuclear waste, or the use of land mines and other weapons. This community never develops a distinct core of agreements as the other three in this time period have done, which leaves the boundaries of this community very unstable.

Russia had been a member of C10, but joined Europe by 1980 by cooperating with Nordic countries such as Finland (also a former member of C10). Saavedra et al. (2008) had created a model which managed to create modularity in two-mode networks

such as the GSEG based on rules of specialization and interaction. Specialization defined how many partner (or in this case, agreements) a node will connect to. Interaction determines *which* partners (agreements) the node will interact with. Russia's split from C10 (which includes many Russian political allies) could be interpreted as a change in the interaction rules for Russia guiding participation within the network. Russia maintained an important seaport out of St. Petersburg, for instance, and it became necessary to develop strong relationships with countries such as Finland, Sweden, and other nations along the water ways. It was clear there were many environmental concerns in Northwestern Russia and the surround waterways. European agencies set up institutions to help with funding, establish norms and rules, which eventually lead to tenuous but trusting relationships between the neighboring countries (Tennberg 2007). From this point on, Russia maintains strong environmental relationships with the rest of Europe. Successful cooperation between Russia and Europe reduces uncertainty that Russia (or Europe) cooperate rather than defect or free-ride in future efforts to curb destruction of the environment.

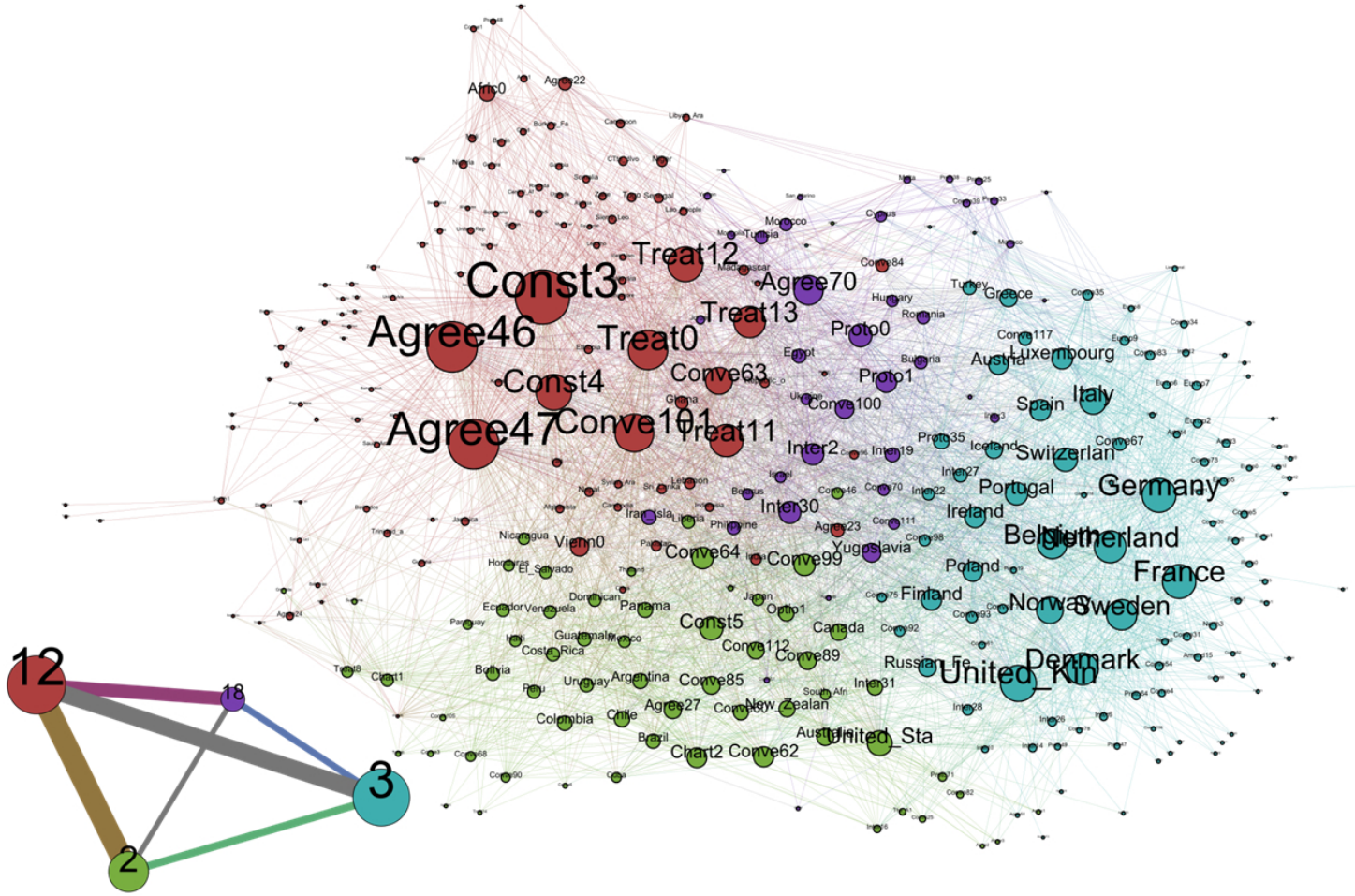

Figure 4.9. Diagram of Network in 1980

Figures 4.10 and 4.11 show the GSEG in 1990 and 2000. The three familiar communities from 1960 are still present (C02, C03 and C12), and the Pacific community has emerged again. The betweenness of the C03 countries has grown since they have signed many new C03-internal agreements in the 1980's. By this point in the evolution of the GSEG, the structure has become nearly static. New state actors are very rare at this point, but the network continues to grow as more agreements continue to be signed. Many classic divisions are present in these diagrams. The North / South divide is clear in the connections between communities C12 and C03 (Roberts and Parks 2007), which East / West divides are seen between C03 and C18 (which contains Bulgaria, Yugoslavia, Romania, etc.).

Community C02 continues to be genuinely concerned with the maintenance of biological diversity, the establishment of national parks, and the maintenance of water ways and agricultural land. Institutional structures set up in the 1950's and 1960's continue to assist in conflict resolution, funding, and enforcement of agreed regulations. Many global and location agreements are part of C02 showing how environmental concern starts at a local level within the community and branches out to affect the policy on an global scale (Steinberg 2003).

The largest and most central agreements within the system are all related to the United Nations. This indicates the central role which the United Nations plays in coordinating environmental regulations and norms (Meyer et al. 1997). But while these agreements serve to offer some centralization, most of the agreements in the system exist within communities, rather than between them.

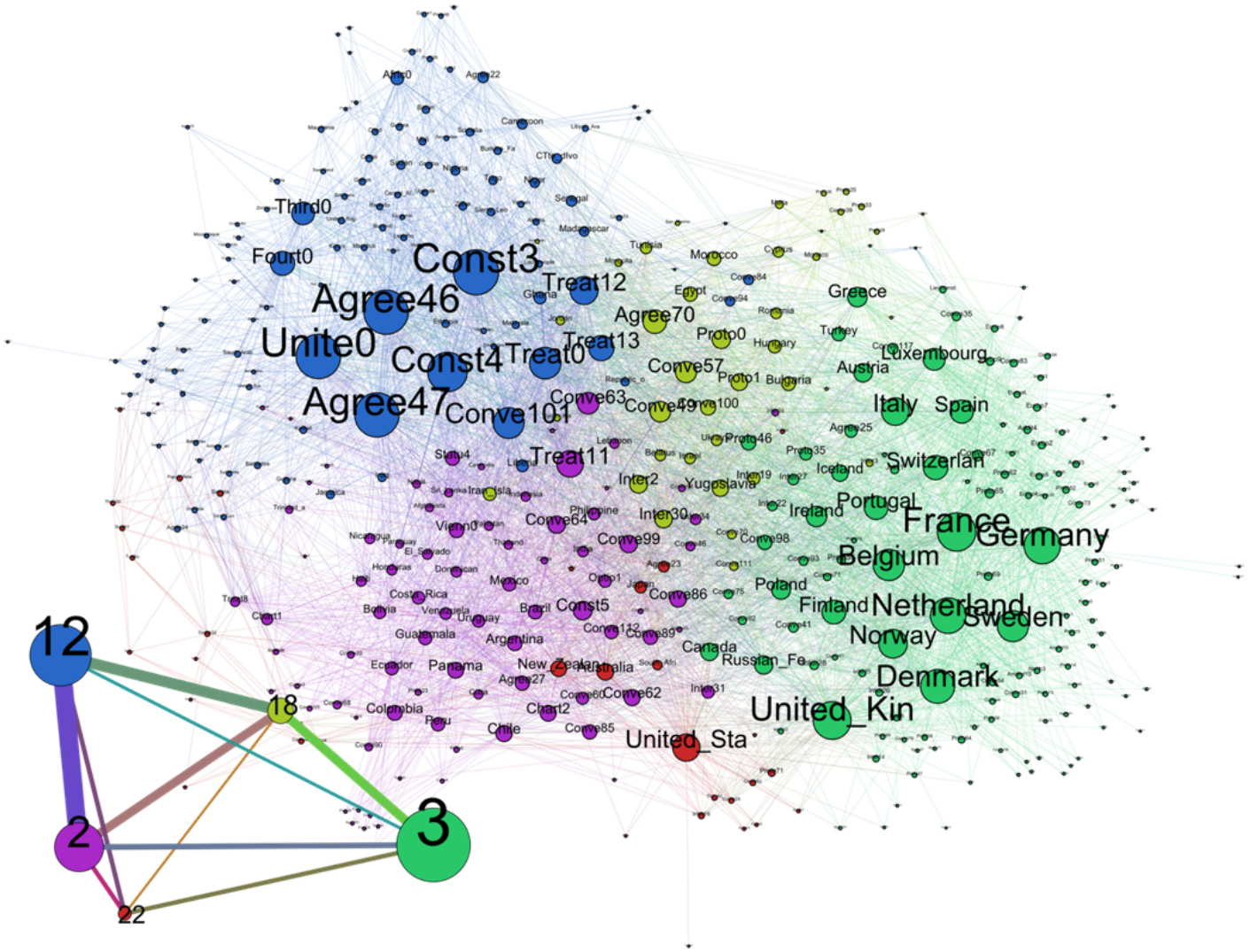

Figure 4.10. Diagram of Network in 1990

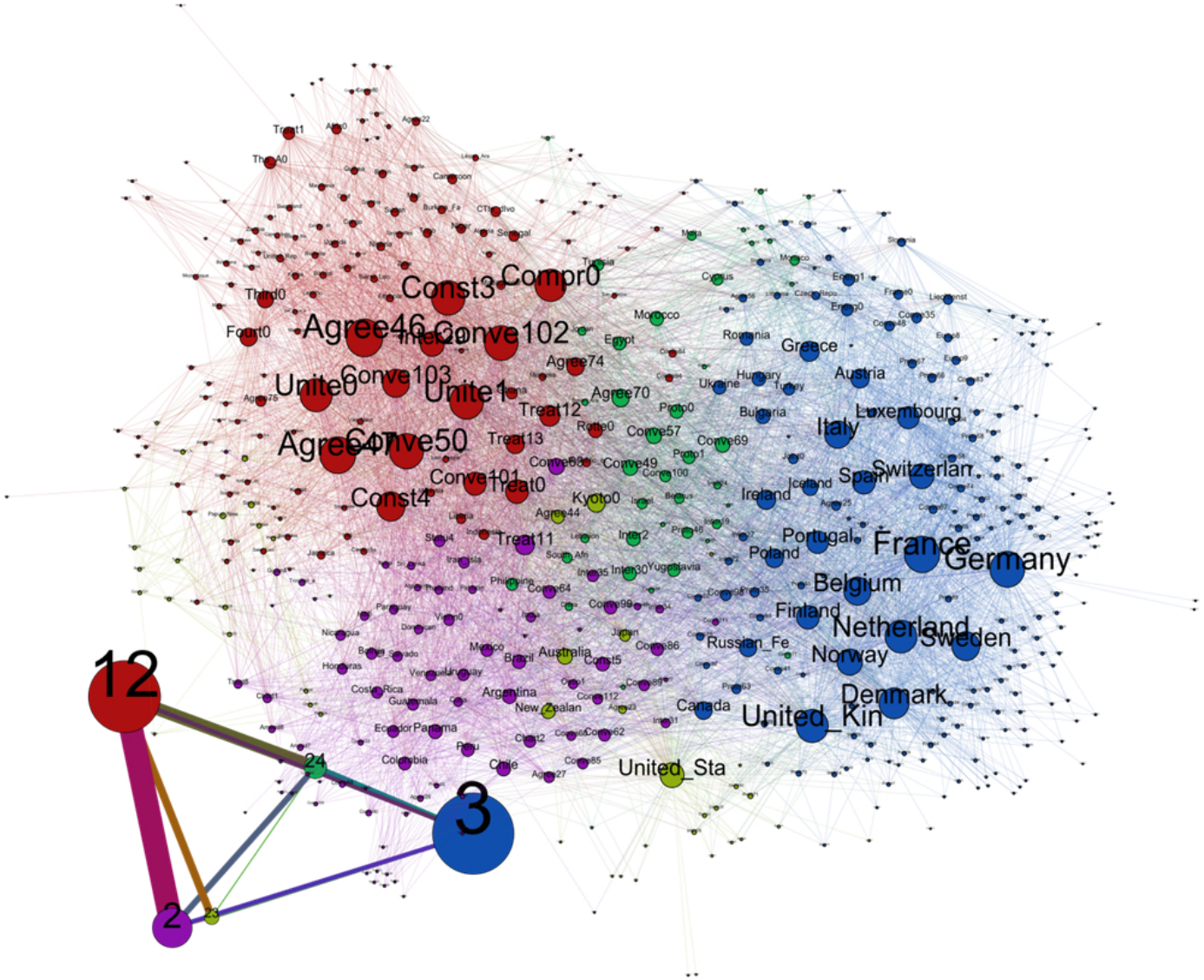

Figure 4.11. Diagram of Network in 2000

CHAPTER 5: DISCUSSION AND CONCLUSION

During last half of the 20th century the global system of environmental governance experienced a burst of growth. This research applied a bipartite network analysis to quantify and map the evolution the system. We discovered a complex arrangement of countries and environmental agreements consistent with descriptions provided by regime theory. Regimes are frameworks of explicit norms, rules, and procedures through which international cooperation is possible (Depledge, 2006; Krasner, 1982). These frameworks ease uncertainty, and build trust and norms of reciprocity that minimize defection (Denemark and Hoffman, 2008). Depledge (2006) argued regimes can breed ossification, with new international legislation functioning to reinforce past divisions and boundaries.

The complexity of the environmental system is what leads to ossification. Coordinating the behavior of 160+ participants is costly and fraught with challenges (Depledge, 2006). Reducing the number of participants may ease negotiation costs, but also imposes boundary rules on association. The regime structures effectively removed much of the uncertainty associated with resource games such as the Prisoner's Dilemma in the multi-party negotiations, increased trust and reduced free-riding. Agreements and institutions founded within boundaries of the communities facilitate future within-boundary cooperation. Our analysis shows evidence of community ossification. Following a chaotic configuration between 1950 and 1980 the structure of the GSEG was

stable from 1980 through 2000. While new agreements and actors were continually added to the network, the modularity stabilized and many communities remained static. The movement of states in and out of C03 was very rare.

Complexity is a considerable driving force of the structure of the GSEG. Mathematical dynamical systems suggest how complex systems can behave and evolve over time. Dynamical systems often exhibit attractors, locations in space to which actors move or orbit (Cîndea, 2006). Gradual changes in the parameters of a system can lead to bifurcations or dramatic changes in the location or existence of attractors. In the GSEG, IEAs function to anchor communities, facilitating future negotiations and bargaining relationships among nations.

The GSEG, like both Axelrod's and Macy et al.'s agent-based models of cooperation and organization, is very sensitive to initial conditions. The first few agreements to be signed with a group of countries tend to define the boundaries of observed communities. This is the case for the small set of biological diversity agreements in C03 in 1950, or the Organization of American States for C02, or the UNESCO agreement for C12. Geography forms the initial conditions for many agreements. Community C18 takes shape based on agreements regulating the use of the Danube and Black Sea. But later agreements intrinsic to C18 have no basis in geography (such as the International Convention for Safe Containers), but these agreements have boundaries largely defined by past geographic agreements.

Krasner (1982) suggests regimes are weakened if rules and norms become less coherent or cultures of practice become inconsistent. Complexity interprets the

condition of regime weakening by suggesting the actors' rules for interaction have changed, involving the movement of the location of attractors in the system. Saavedra et al.'s (2008) model for cooperation in bipartite networks attempts a mechanistic explanation of the emergence of community structure, specifying the two mechanisms of *specialization and interaction* that lead to the emergence of community structure in bipartite networks. Shifts in rules guiding *specialization* (or the number of agreements a country interacts with) and *interaction* (or the type agreements a country interacts with) for both node sets alter community structure. Countries shift which agreements they sign as well as how many they are able to sign. One clear shift in the interaction was the change in behavior that led to Russia moving from C10 to the European community C03. It became evident that many of Northwestern Russia's environmental problems required some level of coordination with nearby Europe. Rules for specialization, especially changed throughout, evidenced by Figure 4.2. The number of countries invited to sign agreements increased in the early 1970's to accommodate a growing global arena following the de-colonization. But the size reduced to a 1950's level by 1990 meaning during the intervening period agreements were more localized to regions or specific needs, thus increasing modularity and reinforcing the community structure.

IEAs initially involving a small group of countries routinely open up to the larger community of nations. Hoffman (2006) applies this notion of incremental expansion to the ozone depletion regime. He explains how legislation was initially geared as *North-only*. Following the Montreal Protocol it was realized that ozone-harming industries could develop in the Global South. The United States called for universal participation, thus changing the participation rules for the ozone depletion

regime. Regime theory, Hoffman argues, generally overlooks these dynamics. Conversely, participation rules can be narrowly defined, such as in the whaling regime. A few nations (such as Japan, United States and New Zealand) account for the vast majority of whaling, thus the successful whaling legislation demands their inclusion.

In our study, other examples of participation shifts were discovered. Community C18, which consisted of Eastern Europe, Western Asia and a scattering of other nations, broke apart as the rule for Eastern European participation in European environmental regimes changed following the collapse of the Soviet Union. The early Pacific community (C05) merged with C10, a community focused largely on the regulation of water in 1965 as countries found it necessary to sign the same agreements. The rules for Caribbean island nations (C17) initially defined their environmental problems as Caribbean-only, but these rules shifted and C17 merged with South / Central America (C02).

A long-since signed agreement that defines a community could be signed later by a number of countries in a different community, slowly shifting the landscape position of that agreement and the prior signatories. Many of the very short-lived communities (1- 2 years, not shown) emerge for this reason. An agreement or set of agreements is initially signed by a small group, spawning a new community, but in the next year, many other countries from the larger community of nations sign the agreement as well, merging the agreement back into the larger community.

Differing from case or small n studies of agreement behavior or research that aggregates global level behavior, our approach of bipartite network analysis and

modularity provides insights at the meso-scale. Regimes are usefully defined as meso-scale structures, consisting of more than one state actor and typically covering only a part of the international system. The analytic approach of our paper also differs from other studies on agreement networks (Hoffman et al., 2007) by maintaining the bipartite structure of the network throughout the analysis. This approach allows a simultaneous examination of both the countries and the agreements they sign. We can define the geographic or political boundaries of communities and also consider which agreements define them. As expected, the role of agreements is considerably different than that of countries. Agreements are more likely to either further ossify communities or unite them on a global scale. There are no countries which have taken to signing agreements in a wide variety of communities that, in effect, unite the system. Our analysis also extends modularity analysis (Palla et al., 2007) with longitudinal assessment of changes in community boundaries. We tracked modularity over time and were able to measure changes in polarization.

Improvements could be made to algorithms used in this research. Randomness in the BRIM algorithm could be harnessed to identify community overlap. Also, communities were established first, and the connections from each time point were identified second. The integration of the two algorithms could improve performance and accuracy (such as seeding the community sets using the communities from a previous time point rather than randomly). This research is at a meso-scale and the effects of network position on state behavior are not explicitly explored (such as the role of centrality and the risk of ratifying agreements).

In this work we examined the evolution of community structure in the global system of environmental governance from 1950-2000. The methodology used opens up a number of existing networks for similar analysis, as in economic or security agreements signed between nations. By maintaining the duality of countries and agreements the roles of both classes can be studied in tandem. The formation, stability, and dynamics of the discovered community structure are consistent with regime theory and complexity science models. Network science concepts and techniques will be increasingly important to developing and empirically testing theory and mechanisms underpinning cooperation within international relations.

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APPENDIX I: LIST OF ACTORS

Code	Full Name	Type
ASEAN0	ASEAN Agreement on the Conservation of Nature and Natural Resources	Agreement
Addit3	Additional Protocol to the Convention on Third Party Liability in the Field of Nuclear Energy	Agreement
Addit4	Additional Protocol to the European Convention for the Protection of Animals during International Transport	Agreement
Addit5	Additional Protokoll No 4 to the Revised Convention on Navigation on the Rhine	Agreement
Afric0	African Convention on the Conservation of Nature and Natural Resources	Agreement
Agre0	(Agreement on the Protection of Confidentiality of Data related to Deep Sea-bed Areas for which application of Authorisation has been made)	Agreement
Agree1	Agreement Establishing the South Pacific Commission	Agreement
Agree2	Agreement Extending the Territorial Scope of the South Pacific Commission	Agreement
Agree3	Agreement amending the Agreement Establishing the South Pacific Commission	Agreement
Agree4	Agreement between the Central African States concerning the Creation of a Special Fund for the Conservation of Wild Wild Fauna	Agreement
Agree7	Agreement concerning Cooperation in taking Measures against Pollution of the Sea by Oil	Agreement
Agree9	Agreement concerning Interim Arrangements relating to Polymetallic Nodules of the Deep Sea Bed	Agreement
Agree10	Agreement concerning Measures for the Protection of the Stocks of Deep Sea Prawns (Pandalus Borealis) Lobsters (Homarus Vulgaris) (Nephrops Norvegicus) and Crabs (Cancer Pagurus)	Agreement
Agree11	Agreement concerning the Adoption of Uniform Conditions of Approval and Reciprocal Recognition of Approval for Motor Vehicle Equipment and Parts	Agreement
Agree12	Agreement concerning the International Commission for the Protection of the Rhine against Pollution	Agreement
Agree13	Agreement concerning the Protection of Water of the Mediterranean Shores	Agreement
Agree14	Agreement concerning the Regulations of Lake Inari by means of the Kaitakoski Hydro - electric Power Station and Dam	Agreement
Agree16	Agreement concerning the Voluntary Contributions to be given for the Execution of the Project to preserve Borobudur	Agreement
Agree17	Agreement concerning the Voluntary Contributions to be given for the Execution of the Project to save the Temples of Philae	Agreement
Agree19	Agreement concerning the voluntary contributions to be given for the execution of the project to save the Abu Simbel Temples	Agreement
Agree20	Agreement constituting the National Commission for the Development of the Riverbed Rio Pilcomayo	Agreement
Agree22	Agreement establishing the African Development Bank	Agreement
Agree23	Agreement establishing the Asian Development Bank	Agreement
Agree24	Agreement establishing the Caribbean Development Bank	Agreement
Agree25	Agreement establishing the European Bank for reconstruction and development	Agreement

Agree26	Agreement establishing the Fund for the Development of the Indigenous Peoples of Latin America and the Caribbean	Agreement
Agree27	Agreement establishing the Inter-American Development Bank	Agreement
Agree28	Agreement establishing the South Pacific Regional Environment Programme	Agreement
Agree30	Agreement for Cooperation and Consultation between the Central African States for the Conservation of Wild Fauna	Agreement
Agree31	Agreement for Cooperation in Dealing with Pollution of the North Sea by Oil and other Harmful Substances	Agreement
Agree35	Agreement for the Establishment of Southern African Centre for Ivory Marketing (SACIM)	Agreement
Agree42	Agreement for the Establishment of the Near East Plant Protection Organization	Agreement
Agree43	Agreement for the Establishment of the Network of Aquaculture Centres in Asia and the Pacific	Agreement
Agree44	Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks	Agreement
Agree45	Agreement governing the Activities of States on the Moon and other Celestial Bodies	Agreement
Agree46	Agreement of the International Bank for Reconstruction and Development	Agreement
Agree47	Agreement of the International Monetary Fund	Agreement
Agree49	Agreement on Co-operative Enforcement Operations directed at Illegal Trade in Wild Fauna and Flora	Agreement
Agree51	Agreement on Conservation of Polar Bears	Agreement
Agree52	Agreement on Reciprocal Access to Fishing in the Skagerrak and the Kattegat	Agreement
Agree53	Agreement on Regional Co-operation in Combating Pollution of the South-East Pacific by Hydrocarbons or other Harmful Substances in cases of Emergency	Agreement
Agree55	Agreement on the Action Plan for the Environmentally Sound Management of the Common Zambezi River System	Agreement
Agree56	Agreement on the Conservation of African-Eurasian Migratory Waterbirds	Agreement
Agree57	Agreement on the Conservation of Bats in Europe	Agreement
Agree58	Agreement on the Conservation of Cetaceans of the Black Sea	Agreement
Agree59	Agreement on the Conservation of Seals in the Wadden Sea	Agreement
Agree60	Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas	Agreement
Agree61	Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin	Agreement
Agree62	Agreement on the European Economic Area	Agreement
Agree63	Agreement on the Exploitation and Conservation of the Maritime Resources of the South Pacific	Agreement
Agree64	Agreement on the Joint Regulations on Fauna and Flora	Agreement
Agree65	Agreement on the Organisation for Indian Ocean Marine Affairs (IOMAC)	Agreement
Agree66	Agreement on the Preparation of a Tripartite Environmental Management Programme for Lake Victoria	Agreement
Agree67	Agreement on the Preservation of the Confidentiality of Data concerning Deep Seabed Areas	Agreement
Agree69	Agreement on the Protection of the Salmon in the Baltic Sea	Agreement
Agree70	Agreement on the Rescue of Astronauts Astronauts and the Return of Objects launched into Outer Space	Agreement
Agree71	Agreement on the Resolution of Practical Problems with Respect to Deep Seabed Mining Areas	Agreement

Agree72	Agreement on transboundary cooperation with a view to preventing or limiting harmfull effects for human beings property or the environment in the event of accidents	Agreement
Agree73	Agreement regarding Monitoring of the Stratosphere	Agreement
Agree74	Agreement relating to the Implementation of Part XI of the United Nations Convention on the Law of the Sea of 10 December 1982	Agreement
Agree75	Agreement to Establish the South Centre	Agreement
Amend4	Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer	Agreement
Amend7	Amendment to the Treaty for the Prohibition of Nuclear Weapons in Latin America	Agreement
Amend8	Amendment to the Treaty for the Prohibition of Nuclear Weapons in Latin America	Agreement
Amend1	Amendment of the Plant Protection Agreement for the Asia and Pacific Region	Agreement
Amend13	Amendments to the Annexes to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter	Agreement
Amend15	Amendments to the Convention for the Regulation of the Meshes of Fishing Nets and the Size Limits of Fish	Agreement
Artic1	Articles of Association for the establishment of an Economic Community of West Africa	Agreement
Artic2	Articles of Association of the South Asia Co-operative Environment Programme	Agreement
Benel0	Benelux Convention on Nature Conservation and Landscape Protection	Agreement
Chart1	Charter of the Organization of American States	Agreement
Chart2	Charter of the United Nations	Agreement
Compr0	Comprehensive Nuclear Test - Ban Treaty	Agreement
Const3	Constitution of the United Nations Educational Scientific and Cultural Organization	Agreement
Const4	Constitution of the United Nations Industrial Development Organization	Agreement
Const5	Constitution of the World Health Organization	Agreement
Conve1	Convention Creating the Niger Basin Authority	Agreement
Conve3	Convention Establishing the Latin American Economic System (SELA)	Agreement
Conve4	Convention Relating to Civil Liability in the Field of Maritime Carriage of Nuclear Material	Agreement
Conve5	Convention Supplementary to the Paris Convention of 29th July 1960 on Third Party Liability in the Field of Nuclear Energy as amended in 1964 and 1982	Agreement
Conve6	Convention and Statute on the Regime of Navigable Waterways of International Concern	Agreement
Conve8	Convention concerning Fishing in the Black Sea	Agreement
Conve9	Convention concerning Fishing in the Waters of the Danube	Agreement
Conve11	Convention concerning Navigation on Lake Constance	Agreement
Conve15	Convention concerning the Protection of Alps	Agreement
Conve22	Convention establishing a marine scientific organization for the North Pacific Region (PICES)	Agreement
Conve23	Convention for Co-operation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region	Agreement
Conve24	Convention for the Conservation of Anadromous Stocks	Agreement
Conve25	Convention for the Conservation of Antarctic Seals	Agreement
Conve27	Convention for the Conservation of Southern Bluefin Tuna	Agreement
Conve28	Convention for the Conservation of the Biodiversity and the Protection of Wilderness Areas in Central America	Agreement

Conve30	Convention for the Establishment of the European and Mediterranean Plant Protection Organisation	Agreement
Conve31	Convention for the International Council for the Exploration of the Sea	Agreement
Conve32	Convention for the Prohibition of Fishing with Long Driftnets in the South Pacific	Agreement
Conve33	Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region	Agreement
Conve34	Convention for the Protection of Birds Useful to Agriculture	Agreement
Conve35	Convention for the Protection of Human Rights and Fundamental Freedoms	Agreement
Conve36	Convention for the Protection of the Marine Environment and Coastal Area of the South-East Pacific	Agreement
Conve37	Convention for the Protection of the Marine Environment of the North-East Atlantic	Agreement
Conve38	Convention for the Protection of the Marine and Coastal Environment of the Eastern African Region	Agreement
Conve39	Convention for the Protection of the Mediterranean Sea against Pollution	Agreement
Conve40	Convention for the Protection of the Natural Resources and Environment of the South Pacific Region (SPREP Convention)	Agreement
Conve41	Convention for the Protection of the Ozone Layer	Agreement
Conve42	Convention for the Protection of the Rhine against Chemical Pollution	Agreement
Conve43	Convention for the Protection of the Rhine from Pollution by Chlorides modified by Exchanges of letters	Agreement
Conve46	Convention of the Carriage of Goods by Sea	Agreement
Conve47	Convention of the World Meteorological Organization	Agreement
Conve48	Convention on Access to Information Public Participation in Decision-Making and Access to Justice in Environmental Matters	Agreement
Conve49	Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency	Agreement
Conve50	Convention on Biological Diversity	Agreement
Conve51	Convention on Civil Liability for Nuclear Damage	Agreement
Conve52	Convention on Civil Liability for Oil Pollution Damage resulting from Exploration for and Exploitation of Seabed Mineral Resources	Agreement
Conve53	Convention on Conditions for Registration of Ships	Agreement
Conve54	Convention on Conduct of Fishing Operations in the North Atlantic	Agreement
Conve55	Convention on Conservation of Nature in the South Pacific	Agreement
Conve56	Convention on Cooperation for the Protection and Sustainable Use of the Danube River	Agreement
Conve57	Convention on Early Notification of a Nuclear Accident	Agreement
Conve58	Convention on Environmental Impact Assessment in a Transboundary Context	Agreement
Conve60	Convention on Fishing and Conservation of the Living Resources of the High Seas	Agreement
Conve61	Convention on Future Multilateral Cooperation in the Northwest Atlantic Fisheries (NAFO)	Agreement
Conve62	Convention on International Civil Aviation Annex 16 - Aircraft Noise	Agreement
Conve63	Convention on International Liability for Damage caused by Space Objects	Agreement
Conve64	Convention on International Trade in Endangered Species of Wild Fauna and Flora	Agreement
Conve66	Convention on Limitation of Liability for Maritime Claims	Agreement
Conve67	Convention on Long-Range Transboundary Air Pollution	Agreement
Conve68	Convention on Nature Protection and Wild Life Preservation in the Western Hemisphere	Agreement

Conve69	Convention on Nuclear Safety	Agreement
Conve70	Convention on Registration of Objects Launched into Outer Space	Agreement
Conve71	Convention on Road Traffic	Agreement
Conve72	Convention on Supplementary Compensation for Nuclear Damage	Agreement
Conve73	Convention on Third Party Liability in the Field of Nuclear Energy	Agreement
Conve74	Convention on Transboundary Effects of Industrial Accidents	Agreement
Conve75	Convention on Wetlands of International Importance especially as Waterfowl Habitat	Agreement
Conve76	Convention on civil liability for damage resulting from activities dangerous to the environment	Agreement
Conve77	Convention on fisheries cooperation among African States bordering the Atlantic Ocean	Agreement
Conve78	Convention on multilateral cooperation in North-East Atlantic fisheries	Agreement
Conve80	Convention on the Ban of the Import of Hazardous Wastes into Africa and on the Control of their Transboundary Movements within Africa	Agreement
Conve82	Convention on the Conservation of Antarctic Marine Living Resources	Agreement
Conve83	Convention on the Conservation of European Wildlife and Natural Habitats	Agreement
Conve84	Convention on the Conservation of Migratory Species of Wild Animals	Agreement
Conve85	Convention on the Continental Shelf	Agreement
Conve86	Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal	Agreement
Conve89	Convention on the High Seas	Agreement
Conve90	Convention on the Inter-American Institute of Agricultural Sciences	Agreement
Conve91	Convention on the International Commission for the Protection of the Oder	Agreement
Conve92	Convention on the International Maritime Organization	Agreement
Conve93	Convention on the International Regulations for Preventing Collisions at Sea	Agreement
Conve94	Convention on the Law of Treaties between States and International Organizations or between International Organizations	Agreement
Conve95	Convention on the Law of the Non-Navigational Uses of International Watercourses	Agreement
Conve96	Convention on the Liability of Operators of Nuclear Ships	Agreement
Conve98	Convention on the Physical Protection of Nuclear Material	Agreement
Conve99	Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter	Agreement
Conve100	Convention on the Prohibition of Military or any other Hostile Use of Environmental Modification Techniques	Agreement
Conve101	Convention on the Prohibition of the Development Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction	Agreement
Conve102	Convention on the Prohibition of the Development Production and their Destruction	Agreement
Conve103	Convention on the Prohibition of the Use Production and Transfer of Anti-Personnel Mines and on their Destruction	Agreement
Conve104	Convention on the Protection and Use of Transboundary Watercourses and International Lakes	Agreement
Conve105	Convention on the Protection of the Archeological Historical and Artistic Heritage of the American Nations (Convention of Salvador)	Agreement
Conve106	Convention on the Protection of the Black Sea against Pollution	Agreement
Conve107	Convention on the Protection of the Environment through Criminal Law	Agreement
Conve108	Convention on the Protection of the Marine Environment of the Baltic Sea Area	Agreement

Conve109	Convention on the Protection of the Marine Environment of the Baltic Sea Area	Agreement
Conve110	Convention on the Protection of the Rhine	Agreement
Conve111	Convention on the Recognition and Enforcement of Foreign Arbitral Awards	Agreement
Conve112	Convention on the Territorial Sea and the Contiguous Zone	Agreement
Conve113	Convention on the international commission for the protection of the Elbe	Agreement
Conve115	Convention regulating the Withdrawal of Water from Lake Constance	Agreement
Conve116	Convention relative ` la collecte riception des dichets survenant en navigation rhenaneet intirieure	Agreement
Conve117	Convention relative aux transports internationaux ferroviaires (COTIF)	Agreement
Conve118	Convention relative to the Preservation of Fauna and Flora in their Natural State	Agreement
Conve121	Convention to ban the Importation into Forum Island Countries of Hazardous Wastes and Radioactive Wastes and to control the Transboundary Movement and Management of Hazardous Wastes within the South Pacific	Agreement
Coope0	Cooperation Agreement for the Protection of the coasts and waters of the North-East Atlantic against Pollution	Agreement
Easte0	Eastern Pacific Ocean Tuna Fishing Agreement	Agreement
Energ0	Energy Charter Protocol on Energy Efficiency and related Environmental Aspects	Agreement
Energ1	Energy Charter Treaty	Agreement
Europ0	European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR)	Agreement
Europ1	European Agreement on the Restriction of the Use of certain Detergents in Washing and Cleaning Products	Agreement
Europ2	European Convention for the Protection of Animals during International Transport	Agreement
Europ3	European Convention for the Protection of Pet Animals	Agreement
Europ4	European Convention for the Protection of Vertebrate Animals used for Experimental and other Scientific Purposes	Agreement
Europ5	European Convention on Establishment	Agreement
Europ6	European Convention on the Protection of the Archaeological Heritage	Agreement
Europ7	European Cultural Convention	Agreement
Europ8	European Outline Convention on Transfrontier Co-operation between Territorial Communities or Authorities	Agreement
Europ9	European Social Charter	Agreement
Fishe0	Fisheries Convention	Agreement
Fourt0	Fourth ACP-EEC Convention	Agreement
Frame0	Framework Convention for the Protection of National Minorities	Agreement
Inter0	Inter-American Convention for the Protection and Conservation of Sea Turtles	Agreement
Inter1	International Agreement for the Creation of an International Office for dealing with Contagious Diseases of Animals at Paris	Agreement
Inter2	International Convenant on Economic Cultural Rights	Agreement
Inter3	International Convention for Safe Containers (CSS)	Agreement
Inter4	International Convention for the Campaign against Contagious Diseases of Animals	Agreement
Inter5	International Convention for the Conservation of Atlantic Tunas	Agreement
Inter6	International Convention for the Prevention of Pollution from Ships (MARPOL)	Agreement
Inter10	International Convention for the Prevention of Pollution from Ships as modified by the Protocol of 1978	Agreement
Inter12	International Convention for the Protection of Birds	Agreement

Inter13	International Convention for the Protection of New Varieties of Plants (consolidated version)	Agreement
Inter14	International Convention for the Protection of New Varieties of Plants as amended on 23.10.1978	Agreement
Inter15	International Convention for the Protection of New Varieties of plants	Agreement
Inter16	International Convention for the Regulation of Whaling	Agreement
Inter17	International Convention for the Safety of Fishing Vessels	Agreement
Inter18	International Convention for the Safety of Life at Sea	Agreement
Inter19	International Convention for the Safety of Life at Sea (SOLAS)	Agreement
Inter21	International Convention on Certain Rules concerning Civil Jurisdiction in Matters of Collision	Agreement
Inter22	International Convention on Civil Liability for Oil Pollution Damage	Agreement
Inter23	International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea	Agreement
Inter24	International Convention on Oil Pollution Preparedness Response and Co-operation	Agreement
Inter25	International Convention on Salvage	Agreement
Inter26	International Convention on Standards of Training Certification and Watchkeeping for Seafarers	Agreement
Inter27	International Convention relating to Intervention on the High Seas in Cases of Oil Pollution Casualties	Agreement
Inter28	International Convention relating to the Limitation of the Liability of Owners of Sea-going Ships	Agreement
Inter29	International Convention to Combat Desertification in those Countries Experiencing Serious Drought and or Desertification	Agreement
Inter30	International Covenant on Civil and Political Rights	Agreement
Inter31	International Plant Protection Convention	Agreement
Inter34	International Tropical Timber Agreement	Agreement
Inter35	International Tropical Timber Agreement	Agreement
Joint0	Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management	Agreement
Joint1	Joint Protocol relating to the application of the Vienna Convention and the Paris Convention	Agreement
Kuwai0	Kuwait Regional Convention for Co-operation on the Protection of the Marine Environment from Pollution	Agreement
Kyoto0	Kyoto Protocol to the United Nations Framework Convention on Climate Change	Agreement
Nordi0	Nordic Environmental Protection Convention	Agreement
Nordi1	Nordic Mutual Emergency Assistance Agreement in connection with Radiation Accidents	Agreement
North0	North American Agreement on Environmental Cooperation	Agreement
North1	North American Free Trade Agreement (NAFTA)	Agreement
North2	North Atlantic Treaty	Agreement
North3	North-East Atlantic Fisheries Convention	Agreement
Optio0	Optional Protocol concerning the Compulsory Settlement of Disputes	Agreement
Optio1	Optional Protocol of Signature concerning the Compulsory Settlement of Disputes	Agreement
Plant0	Plant Protection Agreement for the Asia and Pacific Region	Agreement
Proto0	Protocol Additional to the Geneva Conventions of 12 August 1949 and relating to the Protection of Victims of International Armed Conflicts (Protocol I)	Agreement

Proto1	Protocol Additional to the Geneva Conventions relating to the Protection of Victims of Non-International Armed Conflicts (Protocol II)	Agreement
Proto2	Protocol Agreement on the Conservation of Common Natural Resources	Agreement
Proto3	Protocol Concerning Regional Co-operation in Combating Pollution by Oil and other Harmful Substances in Cases of Emergency	Agreement
Proto4	Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean	Agreement
Proto5	Protocol Concerning Specially Protected Areas and Wildlife to the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region	Agreement
Proto6	Protocol I to the Convention for the the Prohibition of Fishing with Long Driftnets in the South Pacific	Agreement
Proto7	Protocol II to the Convention for the the Prohibition of Fishing with Long Driftnets in the South Pacific	Agreement
Proto8	Protocol Relating to Modification of the International Convention for the Conservation of Atlantic Tunas	Agreement
Proto9	Protocol additionnal to the Convention for the Protection of the Rhine from Pollution by Chlorides	Agreement
Proto11	Protocol amending the Agreement concerning Measures for the Protection of the Stocks of Deep Sea Prawns (Pandalus Borealis) Norway Lobsters(Nephrops Norvegicus) and Crabs (Cancer Pagurus)	Agreement
Proto12	Protocol amending the Agreement on the Protection of the Salmon in the Baltic Sea	Agreement
Proto13	Protocol amending the Convention for the Prevention of Marine Pollution by Dumping from Ships and Aircraft	Agreement
Proto14	Protocol amending the Convention for the Prevention of Marine Pollution by Dumping from Ships and Aircraft	Agreement
Proto15	Protocol amending the Convention for the prevention of marine pollution from land-based sources	Agreement
Proto18	Protocol amending the European Agreement on the Restriction of the Use of certain Detergents in Washing and Cleaning Products	Agreement
Proto19	Protocol amending the International Convention Relating to the Limitation of the Liability of Owners of Sea-going Ships	Agreement
Proto22	Protocol concerning Co-operation in Combating Marine Pollution in cases of Emergency in the Eastern African Region	Agreement
Proto23	Protocol concerning Co-operation in Combating Oil Spills in the Wider Caribbean Region	Agreement
Proto24	Protocol concerning Co-operation in Combating Pollution Emergencies in the South Pacific Region	Agreement
Proto25	Protocol concerning Co-operation in Combating Pollution of the Mediterranean Sea by Oil and other Harmful Substances in Cases of Emergency	Agreement
Proto26	Protocol concerning Co-operation in combating Pollution in cases of Emergency	Agreement
Proto27	Protocol concerning Marine Pollution resulting from Exploration and Exploitation of the Continental Shelf	Agreement
Proto28	Protocol concerning Mediterranean Specially Protected Areas	Agreement
Proto29	Protocol concerning Protected Areas and Wild Fauna and Flora in the Eastern African Region	Agreement
Proto30	Protocol concerning Regional Co-operation in Combating Pollution by Oil and other Harmful Substances in Cases of Emergency	Agreement
Proto32	Protocol for the Conservation and Management of Protected Marine and Coastal Areas of the South-East Pacific	Agreement
Proto33	Protocol for the Prevention of Pollution of the Mediterranean Sea by Dumping from Ships and Aircraft	Agreement
Proto34	Protocol for the Prevention of Pollution of the South Pacific Region by Dumping	Agreement

Proto35	Protocol for the Prohibition of the Use in War of Asphyxiating Bacteriological Methods of Warfare	Agreement
Proto36	Protocol for the Protection of South-East Pacific against Pollution from Land-Based Sources	Agreement
Proto37	Protocol for the Protection of the Marine Environment against Pollution from Land-Based Sources	Agreement
Proto38	Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources	Agreement
Proto39	Protocol for the Protection of the South-East Pacific against Radioactive Pollution	Agreement
Proto40	Protocol for the implementation of the Alpine Convention in the field of mountain agriculture	Agreement
Proto41	Protocol for the implementation of the Alpine Convention in the field of mountain forests	Agreement
Proto42	Protocol for the implementation of the Alpine Convention in the field of nature protection and landscape conservation	Agreement
Proto43	Protocol for the implementation of the Alpine Convention in the field of town and country planning and sustainable development	Agreement
Proto44	Protocol for the protection of the Mediterranean Sea against pollution resulting from exploration and exploitation of the continental shelf and the seabed and its subsoil	Agreement
Proto45	Protocol of 1996 to amend the Convention on Limitation of Liability for Maritime Claims	Agreement
Proto46	Protocol on Substances that Deplete the Ozone Layer	Agreement
Proto47	Protocol relating to Intervention on the High Seas in Cases of Pollution by Substances other than Oil	Agreement
Proto48	Protocol relating to the Development Fund of the Niger Basin	Agreement
Proto49	Protocol relating to the International Convention for the Safety of Life at Sea (SOLAS Prot.)	Agreement
Proto50	Protocol relating to the International Convention for the Safety of Life at Sea (SOLAS PROT 1988)	Agreement
Proto51	Protocol to Amend the Convention of 31st January 1963 Supplementary to the Paris Convention of 29th July 1960 on third Party Liability in the Field of Nuclear Energy as amended by the Additional protocol of 28th January 1964	Agreement
Proto52	Protocol to Amend the Convention on Third Party Liability in the Field of Nuclear Energy of 29th July 1960 amended by the Additional Protocol of 28th January 1964	Agreement
Proto53	Protocol to Establish a Tripartite Standing Committee on Polluted Waters	Agreement
Proto54	Protocol to amend Paragraph 2 of Article X of the International Convention for the Conservation of Atlantic Tunas	Agreement
Proto55	Protocol to amend the Convention on Wetlands of International Importance especially as Waterfowl Habitat	Agreement
Proto56	Protocol to amend the International Convention on Civil Liability for Oil Pollution Damage	Agreement
Proto58	Protocol to amend the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage	Agreement
Proto60	Protocol to amend the Vienna Convention on Civil Liability for Nuclear Damage	Agreement
Proto61	Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes	Agreement
Proto62	Protocol to the 1979 Convention on Long-range Transboundary Air Pollution on the Reduction of Sulphur Emissions or their Transboundary Fluxes by at Least 30 per Cent	Agreement
Proto63	Protocol to the Antarctic Treaty on Environmental Protection	Agreement

Proto64	Protocol to the Convention for the International Council for the Exploration of the Sea	Agreement
Proto65	Protocol to the Convention on Long-Range Transboundary Air Pollution concerning the Control of Emissions of Nitrogen Oxides or their Transboundary Fluxes	Agreement
Proto66	Protocol to the Convention on Long-Range Transboundary Air Pollution on Heavy Metals	Agreement
Proto67	Protocol to the Convention on Long-Range Transboundary Air Pollution on Persistent Organic Pollutants	Agreement
Proto68	Protocol to the Convention on Long-Range Transboundary Air Pollution on further Reduction of Sulphur Emissions	Agreement
Proto69	Protocol to the Convention on Long-range Transboundary Air Pollution on Long-Term Financing of Co-operative Programme for Monitoring and Evaluation of the Long Range Transmission of Air Pollutants in Europe (EMEP)	Agreement
Proto70	Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter	Agreement
Proto71	Protocol to the International Convention for the Regulation of Whaling	Agreement
Proto72	Protocol to the International Convention for the Safety of Fishing Vessels	Agreement
Proto73	Protocol to the International Convention on Civil Liability for Oil Pollution Damage	Agreement
Proto74	Protocol to the International Convention on the Establishment of an International Fund of Compensation for Oil Pollution Damage	Agreement
Proto75	Protocol to the Treaty on Southeast Asia Nuclear Weapon - Free Zone	Agreement
Proto76	Protocole d' adhésion de la Principauté de Monaco à la Convention sur la protection des Alpes	Agreement
Proto77	Protocole d' application de la convention alpine de 1991 dans le domaine de l' energie	Agreement
Proto78	Protocole d' application de la convention alpine de 1991 dans le domaine du tourisme	Agreement
Proto79	Protocole de l' application de la convention alpine de 1991dans le domaine de la protection des sols	Agreement
Provi0	Provisional Understanding Regarding Deep Seabed Matters	Agreement
Regio0	Regional Agreement on the transboundary movement of hazardous wastes	Agreement
Regio1	Regional Convention for the Conservation of the Red Sea and of the Gulf of Aden Environment	Agreement
Regio2	Regional Convention for the management and conservation of the natural forest ecosystems and the development of forest plantations	Agreement
Revis0	Revised Convention for the Establishment of a European Organisation for Nuclear Research	Agreement
Revis1	Revised Convention on the Navigation of the Rhine	Agreement
Rotte0	Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade	Agreement
Secon0	Second Protocol amending the Convention on the Canalization of the Mosel	Agreement
Singl0	Single European Act	Agreement
South0	South Pacific Fisheries Treaty	Agreement
South1	South Pacific Forum Fisheries Agency Convention	Agreement
Statu1	Statute of the Council of Europe	Agreement
Statu4	Statutes of the International Centre for Genetic Engineering and Biotechnology	Agreement
Suppl0	Supplementary Agreement to the 1963 Agreement on the International Commission for the Protection of the Rhine against Pollution	Agreement
Suppl1	Supplementary Protocol of 26 March 1998 to the Convention concerning the Regime of Navigation on the Danube	Agreement

Suppl2	Supplementary Protocol to the Agreement on Regional Co-operation in Combating Pollution of the South-East Pacific by Hydrocarbons or other Harmful Substances	Agreement
The_A0	The African Nuclear-Weapon-Free Zone Treaty	Agreement
The_A1	The Antarctic Treaty	Agreement
The_S0	The South Pacific Nuclear Free Zone Treaty	Agreement
Third0	Third ACP-EEC Convention	Agreement
Third1	Third Protocol amending the Convention on the canalization of the Mosel	Agreement
Treat0	Treaty Banning Nuclear Weapon Tests in the Atmosphere Outer Space and under Water	Agreement
Treat1	Treaty Establishing the African Economic Community	Agreement
Treat6	Treaty for Amazonian Co-operation	Agreement
Treat8	Treaty for the Prohibition of Nuclear Weapons in Latin America	Agreement
Treat9	Treaty of the Southern African Development Community	Agreement
Treat10	Treaty on European Union	Agreement
Treat11	Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space Moon and other Celestial Bodies	Agreement
Treat12	Treaty on the Non-Proliferation of Nuclear Weapons	Agreement
Treat13	Treaty on the Prohibition of the Emplacement of Nuclear Weapons and other Weapons of Mass Destruction on the Sea-Bed and the Ocean Floor and in the Subsoil thereof	Agreement
Treat14	Treaty on the Rio de la Plata Rio de la Plata Vertrag	Agreement
Treat15	Treaty on the Southeast Asia Nuclear Weapon - Free Zone	Agreement
Unite0	United Nations Convention on the Law of the Sea	Agreement
Unite1	United Nations Framework Convention on Climate Change	Agreement
Vienn0	Vienna Convention on the Law of Treaties	Agreement
Afghanista	Afghanistan	Country
Albania	Albania	Country
Algeria	Algeria	Country
Andorra	Andorra	Country
Angola	Angola	Country
Antigua_an	Antigua and Barbuda	Country
Argentina	Argentina	Country
Armenia	Armenia	Country
Australia	Australia	Country
Austria	Austria	Country
Azerbaijan	Azerbaijan	Country
Bahamas	Bahamas	Country
Bahrain	Bahrain	Country
Bangladesh	Bangladesh	Country
Barbados	Barbados	Country
Belarus	Belarus	Country
Belgium	Belgium	Country
Belize	Belize	Country
Benin	Benin	Country

Bhutan	Bhutan	Country
Bolivia	Bolivia	Country
Bosnia_and	Bosnia and Herzegovina	Country
Botswana	Botswana	Country
Brazil	Brazil	Country
Brunei_Dar	Brunei Darussalam	Country
Bulgaria	Bulgaria	Country
Burkina_Fa	Burkina Faso	Country
Burundi	Burundi	Country
CTte_dIvo	CTte d'Ivoire	Country
Cambodia	Cambodia	Country
Cameroon	Cameroon	Country
Canada	Canada	Country
Cape_Verde	Cape Verde	Country
Central_Af	Central African Republic	Country
Chad	Chad	Country
Chile	Chile	Country
China	China	Country
Colombia	Colombia	Country
Comoros	Comoros	Country
Congo	Congo	Country
Costa_Rica	Costa Rica	Country
Croatia	Croatia	Country
Cuba	Cuba	Country
Cyprus	Cyprus	Country
Czech_Repu	Czech Republic	Country
Democratic	Democratic People's Rep. of Korea	Country
Denmark	Denmark	Country
Djibouti	Djibouti	Country
Dominica	Dominica	Country
Dominican	Dominican Republic	Country
Ecuador	Ecuador	Country
Egypt	Egypt	Country
El_Salvado	El Salvador	Country
Equatorial	Equatorial Guinea	Country
Eritrea	Eritrea	Country
Estonia	Estonia	Country
Ethiopia	Ethiopia	Country
Fiji	Fiji	Country
Finland	Finland	Country
France	France	Country
Gabon	Gabon	Country

Gambia	Gambia	Country
Georgia	Georgia	Country
Germany	Germany	Country
Ghana	Ghana	Country
Greece	Greece	Country
Grenada	Grenada	Country
Guatemala	Guatemala	Country
Guinea	Guinea	Country
Guinea-Bis	Guinea-Bissau	Country
Guyana	Guyana	Country
Haiti	Haiti	Country
Honduras	Honduras	Country
Hungary	Hungary	Country
Iceland	Iceland	Country
India	India	Country
Indonesia	Indonesia	Country
Iran_Isla	Iran (Islamic Republic of)	Country
Iraq	Iraq	Country
Ireland	Ireland	Country
Israel	Israel	Country
Italy	Italy	Country
Jamaica	Jamaica	Country
Japan	Japan	Country
Jordan	Jordan	Country
Kazakhstan	Kazakhstan	Country
Kenya	Kenya	Country
Kiribati	Kiribati	Country
Kuwait	Kuwait	Country
Kyrgyzstan	Kyrgyzstan	Country
Lao_People	Lao People's Democratic Rep.	Country
Latvia	Latvia	Country
Lebanon	Lebanon	Country
Lesotho	Lesotho	Country
Liberia	Liberia	Country
Libyan_Ara	Libyan Arab Jamahiriya	Country
Liechtenst	Liechtenstein	Country
Lithuania	Lithuania	Country
Luxembourg	Luxembourg	Country
Macedonia	Macedonia (The former Yugoslav Republic of)	Country
Madagascar	Madagascar	Country
Malawi	Malawi	Country
Malaysia	Malaysia	Country

Maldives	Maldives	Country
Mali	Mali	Country
Malta	Malta	Country
Marshall	Marshall Islands	Country
Mauritania	Mauritania	Country
Mauritius	Mauritius	Country
Mexico	Mexico	Country
Micronesia	Micronesia (Federated States of)	Country
Moldova	Moldova (Republic of)	Country
Monaco	Monaco	Country
Mongolia	Mongolia	Country
Morocco	Morocco	Country
Mozambique	Mozambique	Country
Myanmar	Myanmar	Country
Namibia	Namibia	Country
Nauru	Nauru	Country
Nepal	Nepal	Country
Netherland	Netherlands	Country
New_Zealan	New Zealand	Country
Nicaragua	Nicaragua	Country
Niger	Niger	Country
Nigeria	Nigeria	Country
Norway	Norway	Country
Oman	Oman	Country
Pakistan	Pakistan	Country
Palau	Palau	Country
Panama	Panama	Country
Papua_New	Papua New Guinea	Country
Paraguay	Paraguay	Country
Peru	Peru	Country
Philippine	Philippines	Country
Poland	Poland	Country
Portugal	Portugal	Country
Qatar	Qatar	Country
Republic_o	Republic of Korea	Country
Romania	Romania	Country
Russian_Fe	Russian Federation	Country
Rwanda	Rwanda	Country
Sahrawi_De	Sahrawi Democratic Arab Republic	Country
Saint_Kitt	Saint Kitts and Nevis	Country
Saint_Luci	Saint Lucia	Country
Saint_Vinc	Saint Vincent and the Grenadines	Country

Samoa	Samoa	Country
San_Marino	San Marino	Country
Sao_Tome_a	Sao Tome and Principe	Country
Saudi_Arab	Saudi Arabia	Country
Senegal	Senegal	Country
Seychelles	Seychelles	Country
Sierra_Leo	Sierra Leone	Country
Singapore	Singapore	Country
Slovakia	Slovakia	Country
Slovenia	Slovenia	Country
Solomon_Is	Solomon Islands	Country
Somalia	Somalia	Country
South_Afri	South Africa	Country
Spain	Spain	Country
Sri_Lanka	Sri Lanka	Country
Sudan	Sudan	Country
Suriname	Suriname	Country
Swaziland	Swaziland	Country
Sweden	Sweden	Country
Switzerlan	Switzerland	Country
Syrian_Ara	Syrian Arab Republic	Country
Taiwan	Taiwan	Country
Tajikistan	Tajikistan	Country
Thailand	Thailand	Country
Togo	Togo	Country
Tonga	Tonga	Country
Trinidad_a	Trinidad and Tobago	Country
Tunisia	Tunisia	Country
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Uganda	Uganda	Country
Ukraine	Ukraine	Country
United_Ara	United Arab Emirates	Country
United_Kin	United Kingdom	Country
United_Rep	United Republic of Tanzania	Country
United_Sta	United States	Country
Uruguay	Uruguay	Country
Uzbekistan	Uzbekistan	Country
Vanuatu	Vanuatu	Country
Venezuela	Venezuela	Country
Viet_Nam	Viet Nam	Country

Yemen	Yemen	Country
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Zaire	Zaire	Country
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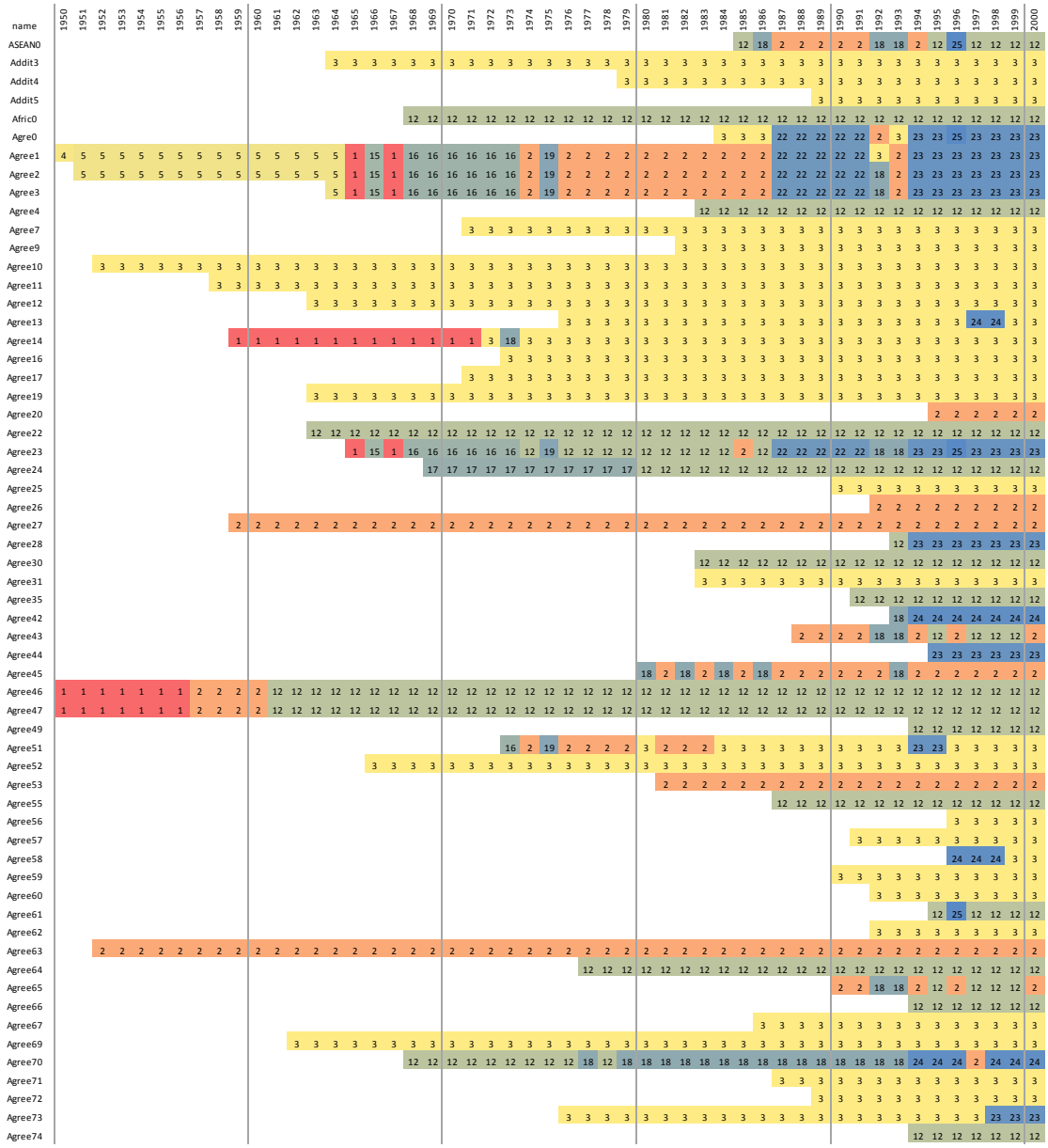
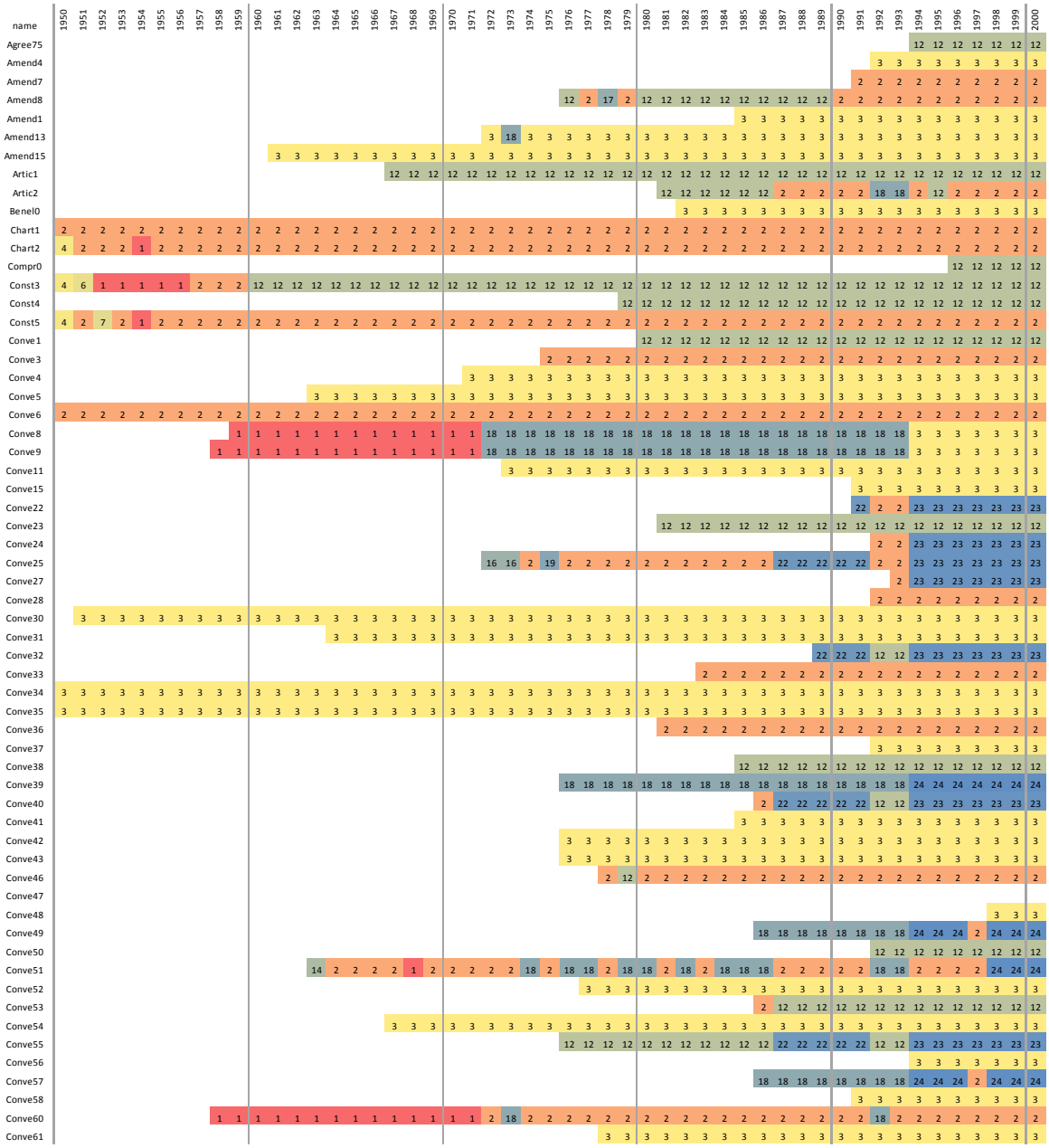
APPENDIX II: COMMUNITY ASSIGNMENTS

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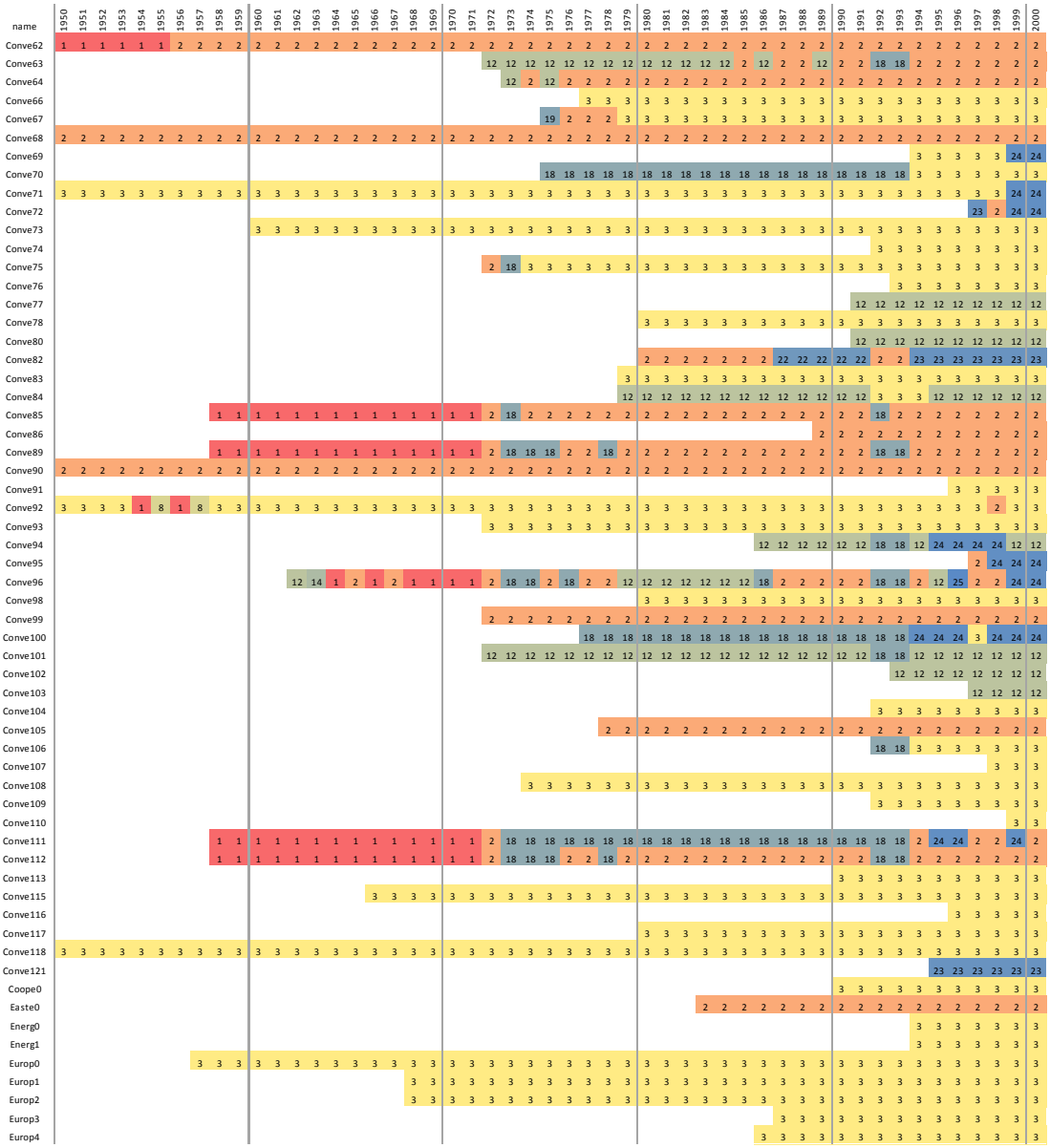
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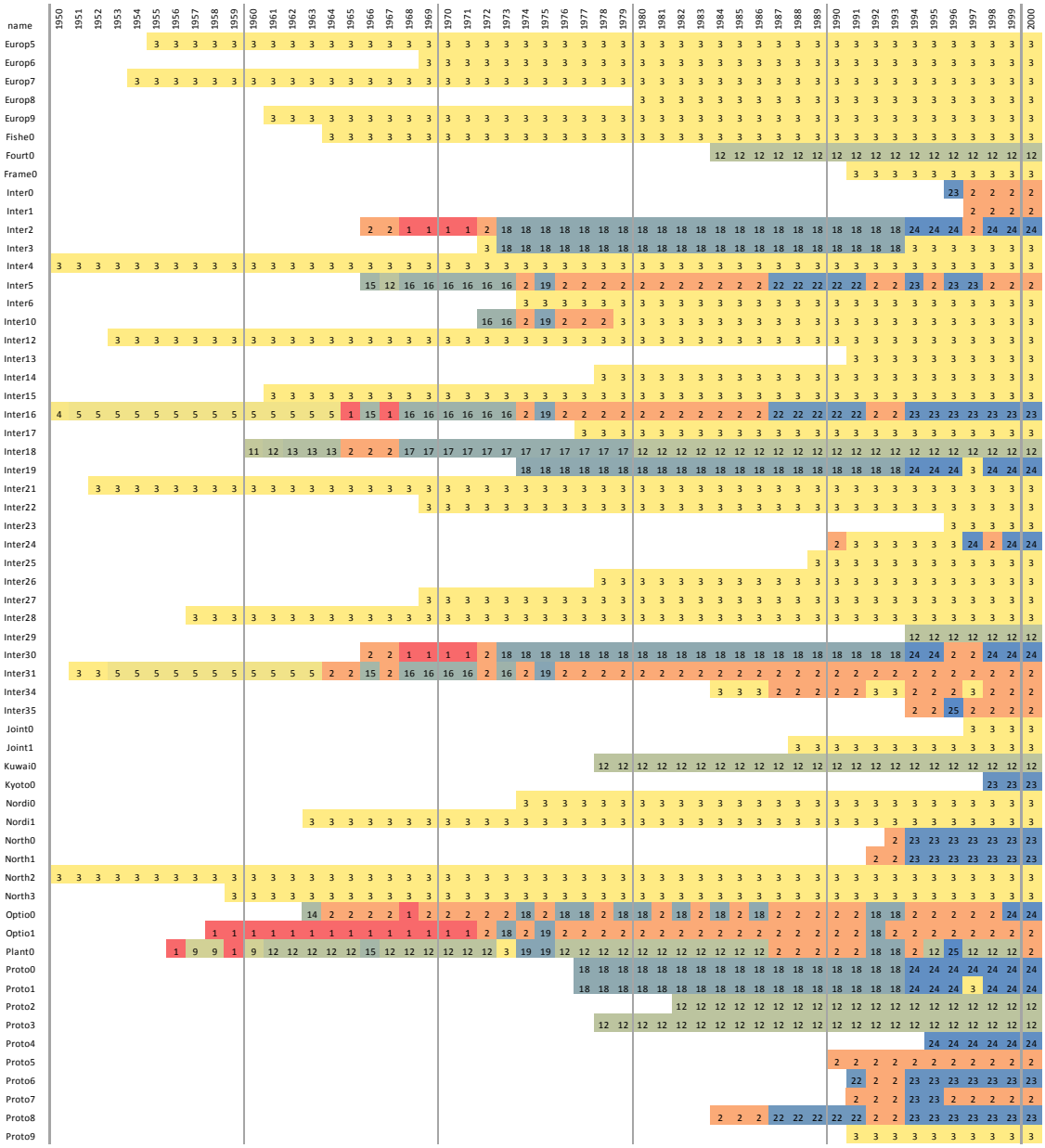
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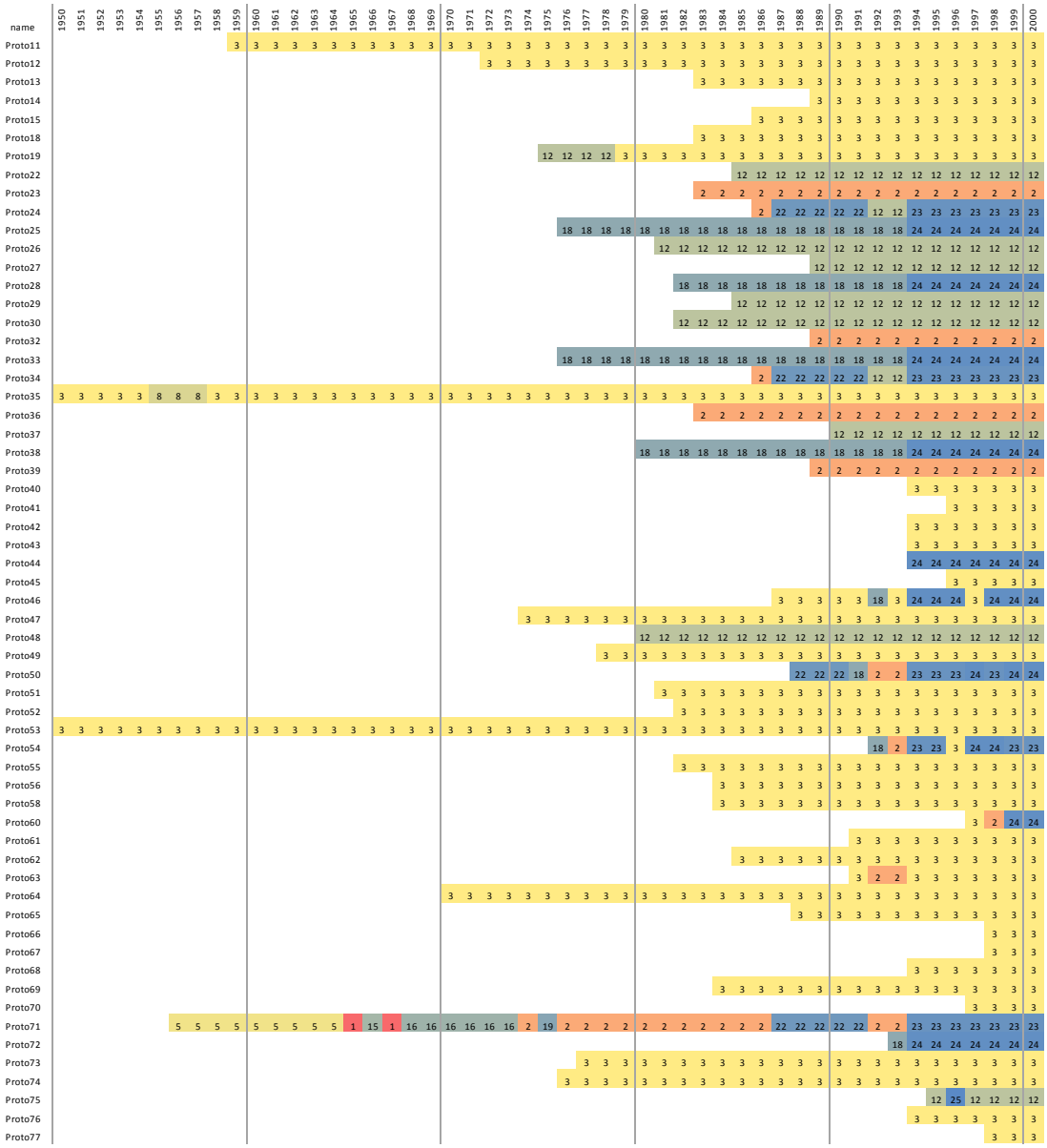
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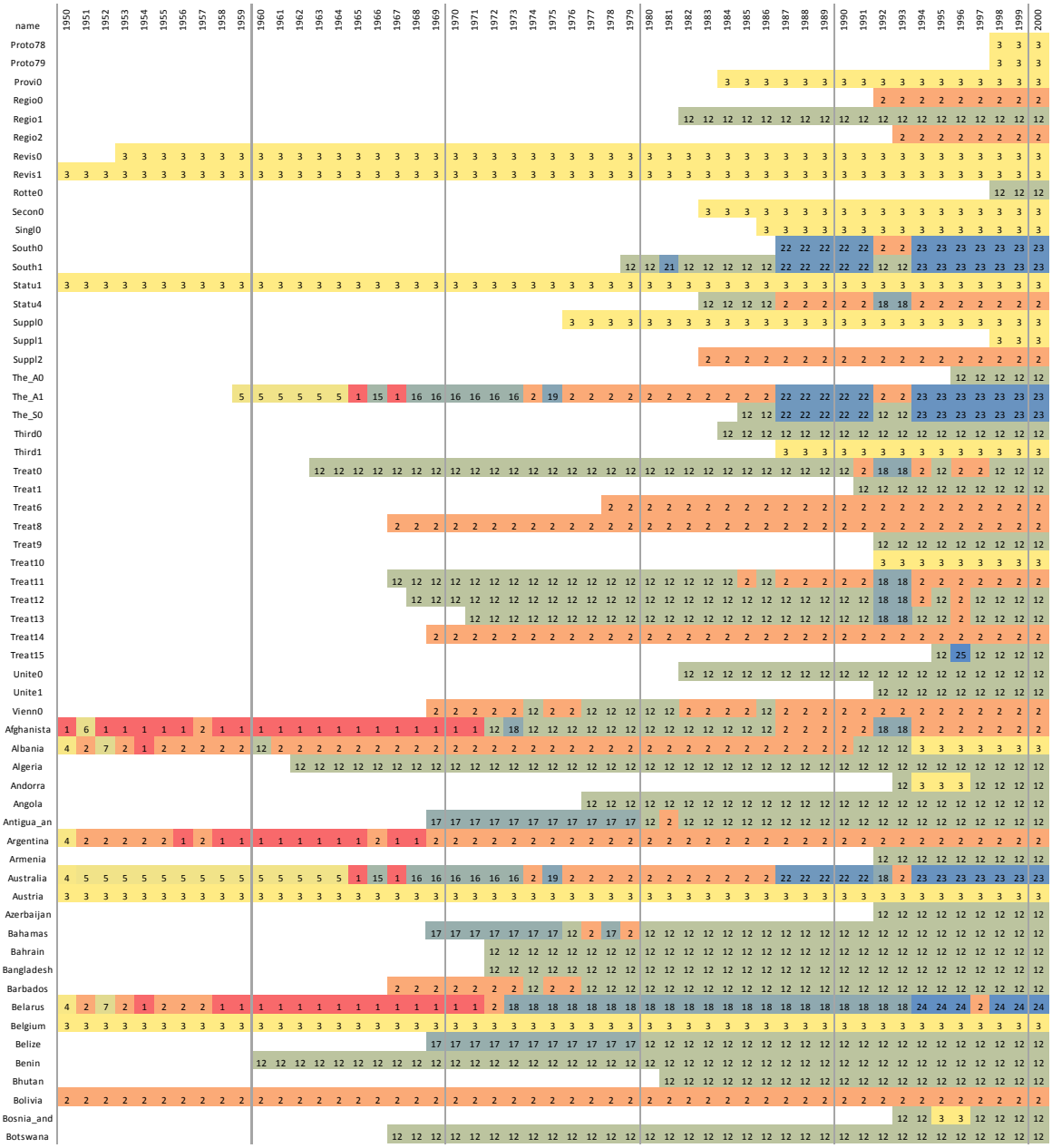
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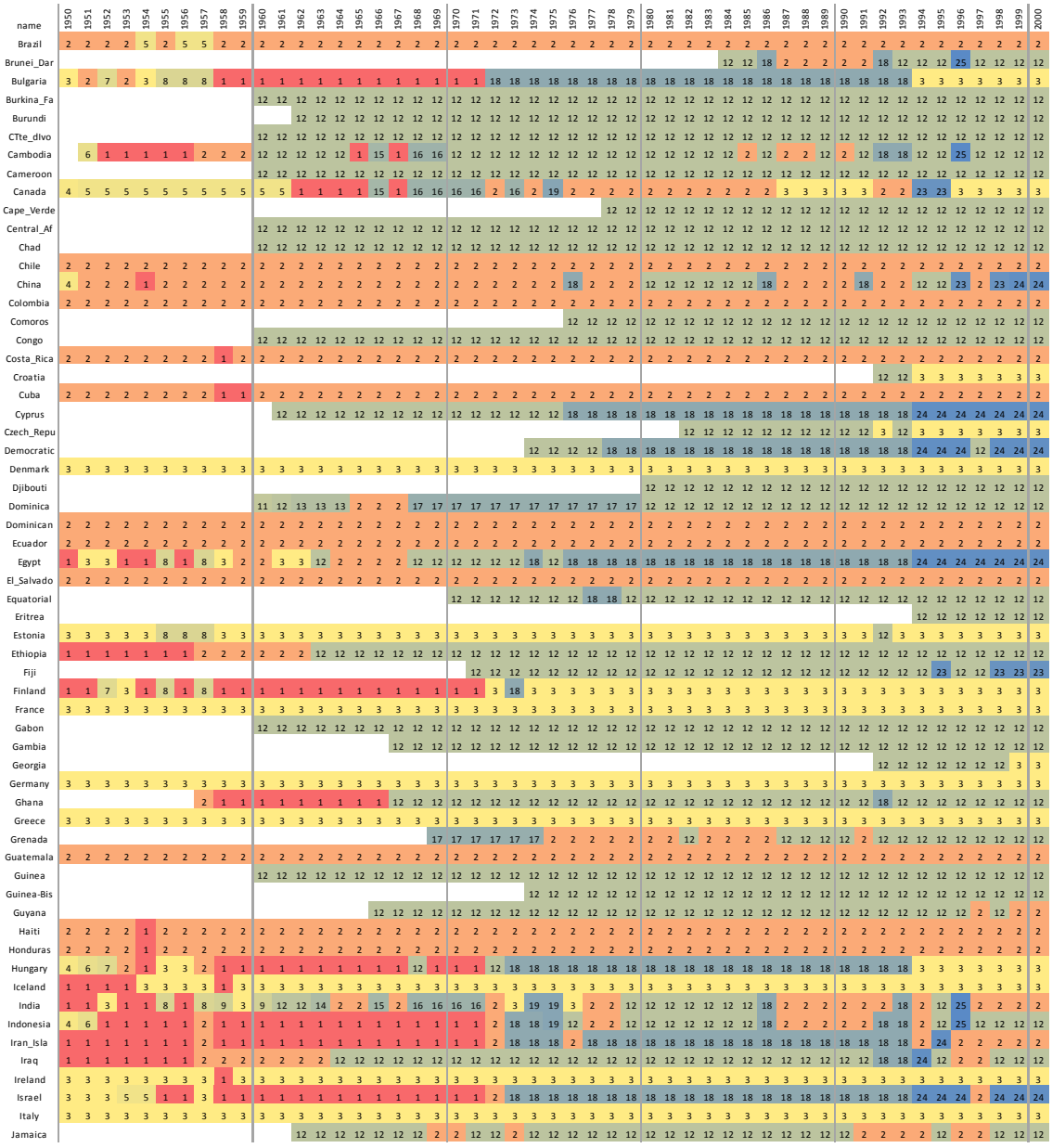
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Burkina_Fa
Burundi
CTte_dIvo
Cambodia
Cameroon
Canada
Cape_Verde
Central_Af
Chad
Chile
China
Colombia
Comoros
Congo
Costa_Rica
Croatia
Cuba
Cyprus
Czech_Repu
Democratic
Denmark
Djibouti
Dominica
Dominican
Ecuador
Egypt
El_Salvado
Equatorial
Eritrea
Estonia
Ethiopia
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Haiti
Honduras
Hungary
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