Ecology, Politics and Hydroelectric Power in the Alexander Skutch Biological Corridor, Costa Rica

Simon John Luffman

Supervisor: Felipe Montoya-Greenheck

July 31st, 2014

A Major Paper submitted to the Faculty of Environmental Studies in partial fulfillment of the requirements for the degree of Master in Environmental Studies,

York University,

Ontario, Canada

Student Signature

Supervisor Signature

Abstract: Hydroelectric dam projects are ideal foci for examining ecology, conservation, privatisation, globalisation and water rights. Proposed construction of hydroelectric power projects in the Alexander Skutch Biological Corridor (ASBC), Perez Zeledon, Costa Rica, and in neighbouring areas, may have grave consequences for the local and watershed level ecology. Decisions to undertake these projects, or oppose them, must be understood contextually in regards to local issues, national economic agreements and supranational interests. While micro-level studies have a place in practicality, the ASBC will benefit from examination from a much wider lens that goes beyond the political economic forces that generate such projects; to examine greater philosophical connections between humans, technology and nature. If viewed from a holistic ecological viewpoint, the ecosystem called the ASBC is a form of cyborg supra-organism, a gestalt of human, non-human and technological elements working in simultaneity, if perhaps not in concert. The result is a schizophrenic state in which biological elements antagonistically interact thanks to technological evolution spurred by external stimuli of ideology. The "environmentalist" industry of the corridor cannot be conceptually separated from its dependence on electricity derived from the same sources as the one ostensibly poised to destroy it. These biological and technological elements are inextricably intertwined for the foreseeable future, making all local and foreign interactions with the Corridor dependent on understanding and consideration of this hybrid state.

Acknowledgements

This work has been made possible by many people; I would like to thank my family for their support, without which I would have never been able to embark on this academic adventure. My fiancée Kathleen, who has put up with my many hours sequestered in the study.

York University, with its diverse faculties and staff, provided the ideal location for the sort of introspective, creative projects that culminated in this work

Special mention is deserved for Professor Felipe Montoya-Greenheck, who provided both the initial remark that got the ball rolling, as well as the opportunity to undertake the work.

The Social Science and Humanities Research Council and Ontario Graduate Scholarship provided essential financial support that facilitated this work.

Foreword

This paper represents the culmination of my graduate degree in Environmental Studies, as well as my Plan of Study. I find myself in an odd position with this paper, as the topic may seem on the surface to have little to do with the main theme of my initial plan. I had intended upon entering the program to undertake research into the aquarium industry, a space in which I have been both a hobbyist and employee for the last fifteen years. I had planned to draw upon my undergraduate education in social science and anthropology in examining the cultural elements that generate trade in exotic wildlife, specifically fish, and how those cultural elements impact ecology in their collection locations. As I began to lay the groundwork for a practical application of this idea, several major issues became apparent. First, I was concerned that while the idea was interesting in theory, its practical application would be at best extremely generalized, and at worst discriminatory. I did not want to create a final paper that cataloged the exotic animal trade by ethnicity. More pertinent to this work, I discovered as I began my preliminary research that I could not separate the exotic animal trade from the larger natural resource-use sectors that they were invariably embedded. The marine ornamental fish trade and its accompanying destructive practices was only a minute fraction of far larger food fisheries. The ecological impacts of freshwater river fisheries in the Amazon paled in comparison to local food fisheries and hydroelectric projects. Collection of reptiles and amphibians in tropical forests was miniscule when compared to damage wrought by forestry, climate change and disease. As I mulled this, I was afforded the opportunity to apply the themes of my plan; ecology, culture and resource use, to another theatre, one that explored the same ideas with far more practicality and depth.

My interest in the Alexander Skutch Biological Corridor began with the observation by my supervisor that many Costa Ricans turn their backs to the rivers; a situation I felt was rather strange given the focus on conservation that seems to pervade much of the discourse in and about the nation.

While in Costa Rica, specifically the provinces of Buenos Aires and Perez Zeledon, I found it extremely curious that there seemed to be a total absence of freshwater fauna in the myriad of educational posters and informational materials we found. Identification cards existed for mammals, birds, reptiles and amphibians, invertebrates and plants, but I could not find a single example, despite my best efforts, of Costa Rican freshwater fish. Why this total absence? While the lack of large bodies of standing freshwater in the mountainous areas might lead one to assume this oversight was the work of regionalism, marine fish, both the Atlantic and Pacific species, were displayed proudly alongside the local species. Where were the rich and colourful cichlids, notorious amongst the ichthyological and aquarium communities for their fastidious parental care and bellicose disposition? *Parachromis dovii,* colloquially the Wolf Cichlid or Guapote to locals, is one of the most iconic freshwater predators thanks to its prodigious size, ferocity and fearsome dentition. What about the plethora of migratory species that move from the coastal waters into the interior, one of the largest biological migrations in the Americas? Likewise, nowhere to be found are the unique inhabitants of the mountain rapids, replete with suckers, grappling hook claws and other biological paraphernalia specially adapted for their niche habitat.

It was with some shock (and a small measure of nascent academic greed) that I discovered that many of the rivers of southern Costa Rica, especially those in the foothills of the Talamanca Mountains, were largely unsurveyed. Given the area's status as a biological corridor, it seems odd that knowledge of the rivers' inhabitants would be so lacking, at least amongst foreign academics and conservationists. Perhaps the drably coloured species likely to be present at such altitudes were overshadowed by the impressively attired avian fauna of the corridor, birding being the most prominent ecological attraction in the area, and likely the reasons for the corridor's existence. In any case, the pressing need for an icthyological survey of the area went well beyond my curiosity thanks to the looming construction of a series of hydroelectric dams not only in the ASBC, but along every major river in the immediate area.

The situation provided me with an ideal melting pot for research work, combining as it does aquatic and terrestrial biology, human social and economic interactions, globalization and philosophical ideas about nature and environment.

Table of Contents

1.0 Introduction

South of York University's Las Nubes Biological Reserve, in the midst of the Alexander Skutch Biological Corridor, is the proposed site of a hydroelectric power project, one that will fundamentally change the nature of the area's major river, the Penas Blancas. The project will include the installation of a small diversionary dam which will divert most of the water from the river itself, leaving a significant portion dewatered until it is returned far downstream. The ecological implications of this type of project are well documented elsewhere in the world; causing considerable damage to the ecology of the river, severing migration routes, degrading water quality and impacting the surrounding terrestrial environment. In the Alexander Skutch Biological Corridor (ASBC), the potential damage is exacerbated by the lack of information regarding the area's rivers, the apparent lack of interest in freshwater ecology that seems to pervade Costa Rica as well as the privatised nature of the project itself. This paper will examine the potential impacts of hydroelectric projects and how they might apply to the environment and faunal assemblage of the ASBC's river habitat. At the same time, the situation of the project in Costa Rica's energy plan and its relation to international financial and ideological regimes will be provided in order to understand the pressures faced by those opposed to these constructions. The local dimension needs to be placed in a macro-level political-economic context, one with a particular spatial and temporal locus rooted firmly in current trajectories of corporatized globalization. Last, the ways in which humans beings relate to and conceptualize natural resources must be considered in order to understand the genesis of hydropower projects themselves.

Personally, this has placed me in a rather unique position; a foreign aspiring academic ostensibly opposed to dam construction in the area, but simultaneously an advocate of renewable energy sources. As far as potential energy sources go, hydroelectric dams are generally cleaner than oil and gas, as well as being cheaper and more durable than solar or wind collectors. Dams have their fair share of negative

attributes, especially the large reservoir style ones that have become both famous (the Hoover dam) and infamous (the Three Gorges dam). Small dams, like those proposed for the ASBC, have a relatively small impact, comparatively. How then am I to critique, even constructively, the ASBC hydroelectric projects without falling into the clichéd trap of a neo-colonial environmentalist with a NIMBY agenda based on foreign ecological romanticism? I am, after all, typing this paper on a computer that Hydro Ontario's website informs me is being currently run on 20% hydro-generated electricity. Rather than a critique of hydropower outright, I hope to present an unveiling of the complexities that are present in this situation, ones that go far beyond a positive/negative binary that often characterises environmental/energy conflicts. While the negative impacts of a hydro-electric dam, to be laid out in the following sections, are obvious, the more pertinent question becomes whether they are preferable to those impacts created by other energy sources. If we accept, as Costa Rica seems to have, that hydroelectric dams are the lesser of two evils when contrasted to other options, then we must ask what limits there must be to hydropower development? One small diversion dam may have relatively little impact on the area, but what about when a dam is placed on every river? What is the cumulative impact of multiple dams upon upstream and downstream habitats? How can we avoid the fish stock collapses and disasters created by North American hydroelectricity?

As I have pondered these questions, I have been less and less able to separate the various facets that are often compartmentalized in academic study. One cannot study the ecology of the ASBC without inclusion of the alien biotic elements, human beings, and their technological web. The ecology of the area itself is literally permeated by "unnatural" elements; alien species like domesticated dogs, cats and plants like coffee and banana. It is divided by wires and roads, patched with farms and homesteads, ditches and culverts. The air is invaded by fumes from combustion engines, waves of electromagnetic radiation from wireless technology, radio signals, noise and artificial light pollution. There is no "pristine" environment to study, only a hybrid system of surviving native species, alien invasives,

technological and infrastructural networks and managed landscapes. Beyond the physical, the ASBC is a confluence of agendas, technological and environmental discourses, and development ideologies. The simplified debate that dams are "bad" fails to consider need for power for development, or that the problem lies with location, design and control of these projects, especially at the hands of privatised companies invested in the area solely for profit. It is in this spirit I undertook my research, to provide a counterpoint to the reports provided by the hydroelectric company regarding the viability of dam projects in the area. When presented or understood as objective science, a simple environmental impact report can be a powerful of hegemonic development.

1.1 Costa Rica and Environmentalism

Costa Rica stands out among the Central American nations, and perhaps the rest of the world, for its lack of a state military and express focus on conservation and environment in its policies (Davis, 2009: 104). For example, in the early 1990s, Costa Rica amended part of its constitution to include the rights to a healthy and ecologically balanced environment for its citizens (Lindo, 2006: 301**)**. This was followed several years later with a second amendment that obligated the state to facilitate and protect the above environmental rights. This is an impressive and quite progressive piece of legislation, one that I believe leads directly to the current hydroelectric trajectory that is transforming the southern Talamanca provinces. A specific state focus on a balanced environment seems to mandate a push for renewable energy sources, of which wind, solar, geothermal and hydroelectric are the available options. Costa Rica's recent court battles over private access to the nation's offshore Atlantic oil reserves suggests that this policy is not simply lip service, but one that will be backed by the government even under the threat of major economic sanctions or legal complications. Recognition of the country's waters ways as public spaces and resources, under Article 1 of the Water Law (Lindo, 2006: 301) for example, includes a preferential hierarchy for projects that places public over private installations. Costa

Rica does not lack for environmental legislation, however in many cases it is the enforcement that is deficient. As with any organization mediating such powerful and lucrative issues, Costa Rican institutes have both been accused of corruption, specifically approving Environmental Impact Statement reports that should have been rejected (Lindo, 2006: 308**).**

Like all nations, Costa Rica's policies are works of compromise between innumerable agendas, treaties, factions and economic factors. The state's ratification of the Central American Free Trade Agreement (CAFTA) for example, often seems the antithesis of its stated environmental objectives. Other government institutions expressly support conservation efforts, including the National Fund for Forestry Financing (FONOFIFO), which issues grants for conservation purposes (Daugherty, 2002: 8). The particulars of this strange and often antagonistic scenario will be detailed in a following chapter.

1.2 Diversionary Hydropower

The word dam often conjures a vision of a titanic wall of concrete, holding back an artificial lake. Although these forms of dams exist, and have been proposed for Costa Rica (the infamous El Diquis is one), the dams slated for the ASBC are of a different construction and operational principle; run-of-the-river or more accurately, diversionary dams. Canadians, especially those in Southern Ontario, should be familiar with this form of hydropower, as we have one of the largest diversionary hydroelectric projects in the world on our doorstep; Niagara Falls. Water is taken from a diversion in the river upstream of Horseshow Falls, running in a penstock under the city of Niagara Falls, to emerge at the generator stations several kilometers away. The flow is regulated depending on season and time of day, with the waterfall itself, the one of the largest in the world, actually being "turned down" at night. The ASBC dams are simply scaled down versions of this technology.

Smaller hydropower projects use the same operational principles, diverting water from a small dam set in a watercourse and sending it down a channel or pipe to the generator station, where it is

returned to the river (Gower, et al, 2012: 3**)**. Sharply graded terrain is ideal for these projects, as gravity provides the necessary motive force and pressure. In some diversionary dams, like the ones slated for the ASBC, water from the river is held in reservoirs, to be released at peak hours for additional power production. Some dams will store water behind the dam itself, however in the case of the ASBC a reservoir, fed by diversions on the Rio Penas Blancas and Blanquitas, will hold some 45,000 square meters of water (Hidroelectrica Buenos Aires, 2013: 12-13). Situated on the Rio Penas Blancas and Blanquitas are two concrete diversion sites which channel water into the regulation reservoir. The dam structures themselves are low, approximately two meters, and almost thirty meters wide (Hidroelectrica Buenos Aires, 2013: 12). Water will run through two buried pipes or concrete sleeves for about one quarter and one half a kilometer, respectively, before terminating in the reservoir. Downstream, the return point is the powerhouse, a structure some fifteen by twenty meters. The project, including the buried penstock pipes, is designed in such a way as to minimize visibility.

It should be noted that river diversion projects are often considered as more ecologically friendly than large reservoir dams (Gower, et al, 2012: 3). This environmentally-friendly perception, which some will undoubtedly contend is a form of "green-washing", has led to the popularization of these projects worldwide, especially for private companies likely concerned with political visibility. Reports released by the dam builders, Hidroelectrica Buenos Aires, specifically highlight the benefits of hydropower in reducing greenhouse gases and dependency on non-renewable energy sources like oil (Hidroelectrica Buenos Aires, 2013: 14). Ironically unregulated development of these projects may create a far greater impact than any single large dam, as is the case in the Costa Rica.

1.3 Hydropower in CR

Hydropower is an extensive industry in Costa Rica, providing a considerable amount of the nation's power. Development in the Southern Pacific regions is relatively new compared to those of the

Northern Atlantic coast, where numerous dam projects were instituted in the 1990s (Anderson, Pringle and Freeman, 2008: 408)**.** Interestingly, a solution that would not involve a reduction in hydropower generation would be the concentration of dams into single rivers, rather than dispersing them across an entire watershed (Anderson, Pringle and Freeman, 2008: 408**).** We see this pattern on rivers in Canada and the United States, which often play host to multiple dams. South of the Alexander Skutch Biological Corridor lies the Rio Grande de Terraba, site of one of Costa Rica's most contentious hydropower projects, the Boruca dam. Conceived in the 1970s, this mega-project is the prototypical dam most people expect, a massive concrete structure 250m high, that would create an artificial lake, submersing 260 square kilometers (McLarney, et al, 2010: 34**).** Inundated by this artificial lake would have been the lands of several indigenous ethic groups, making it vastly controversial. Its construction would render the question of fish migration in Las Nubes a moot point, as the dam would have blocked all migration upstream of the project, meaning the entire southern slope of the Talamanca range and the La Amistad World Heritage Site (McLarney, et al, 2010: 34). The project was understandably unpalatable politically and never materialized. Like the much maligned Plan Puebla Panama that we will examine later, Boruca has been rebranded as El Diquis and is currently once again under consideration. This version is two thirds of the height, floods one quarter of the area and displaces slightly over a thousand people (McLarney, et al, 2010: 34**),** which is either an acceptable compromise or a social and ecological atrocity, depending on which side of policy one stands. Regardless of its reduced scale, El Diquis will still prevent upstream migration into more than half of the Rio Grande de Terraba watershed, unfortunately where the ASBC is located.

Costa Rica has, thanks to its sharply graded topography and moist climate, large numbers of rivers easily exploited by small hydroelectric projects like those found south of Las Nubes. These small streams and rivers are ideal sites for "run of the river" hydroelectric dams, which are more accurately called diversionary dams. Despite the hierarchy that prefers public hydroelectric projects (Lindo, 2006:

301**)**, the opportunities for private business in this case are undeniable and lucrative. This is especially true when the Instituto Costaricense de Electricidad (ICE), the governmental body that provides, regulates and monitors all electricity in the nation, is the sole and guaranteed customer. This total monopoly allows the ICE to tightly regulate electrical prices, but at the same time absolves the private dam operator from dealing with uncertain markets and courting clients. Costa Rica has historically limited private hydropower projects to producing a maximum of 15% of the national electrical supply (Lindo, 2006: 303), however this was increased in 1995 to 30%. Costa Rica has largely been able to avoid the overwhelming pressure of privatisation that has swept much of Central and South America, still limiting private hydropower companies to a maximum of 65% foreign investment and their generative capacity to 20 megawatts. By comparison, the ASBC project will produce 8.91 megawatts (EIS, Penas Blancas II, 2013).

In keeping with the ethos of the nation, private dam operators must apply for a state contract, a major requisite of which is conducting an Environmental Impact Statement (EIS) through the National Environmental Technical Secretariat (SETNA) (Lindo, 2006: 302). This EIS must describe the ecological damage the project may cause and the damage mitigation strategies that will be implemented. The role and scope of the EIS reports are an important aspect of the dam projects slated for the ASBC. The standards required however, vary based on the way the river is classified; for example, rivers designated for bathing and drinking have stricter requirements than those designated for hydropower (Lindo, 2006: 303). While the EIS reports, whether one believes in their usefulness or not, provide a baseline of environmental impacts, they often do not consider the ramifications of long-term damming, cumulative impacts on the watershed from multiple dams, and the possibility of disastrous singular events. The major problem with these three issues lies in the fact they occur well after the construction is complete and operation has begun. These types of impacts are often unpredictable, at least by engineers concerned with the immediate situation. More importantly, with the damage already done, these

situations are only repairable at great cost, or not at all. The release of a deluge of sediment from the Penas Blancas dam (a northern river of the same name as the one in the ASBC), caused extensive damage to the Penas Blancas and San Carlos rivers, killing thousands of fish and other wildlife (Lindo, 2006: 307). At this point, the damage was done, and mitigation solutions for the dam's negative effects are rather pointless. If anything, catastrophic single events like this render rivers unsuitable for anything except hydropower. A sobering thought; that these sorts of unpredictable accidents essentially absolve dam operators of their future environmental concerns. We see this pattern repeated in North America, where unforeseen environmental disasters prove irreversible and render further environmental protection measures a moot point.

1.4 EIS Blancas and Blanquitas

The Environmental Impact Statements released by HDBA include descriptions of the project, as well as the impacts to the area. These are conceptualized as the Project Area (AP in Spanish), and the Area of Direct Influence (AID in Spanish). The AID is the most interesting from our point of view, encompassing as it does the communities of Santa Elena and Quizarra (Hidroelectrica Buenos Aires, 2013: 15)**.** In the case of the EIS papers released for the Rio Penas Blancas and Rio Penas Blanquitas, I found it curious and somewhat troubling that only a smaller portion of the report, some 6 pages out of the 150 pages total, were devoted to the flora and fauna of the area (Hidroelectrica Buenos Aires, 2013: 60-66)**.** As the AID includes Quizarra and Santa Elena, it also includes the considerable biodiversity of the Alexander Skutch Tropical Bird Sanctuary. There is a great deal of detail in the EIS concerning the geology and geological history of the area, which while pertinent to the construction of the dam itself, is not likely to be impacted by the project other than minor dynamiting of large boulders in the construction phase.

The descriptions of land vertebrates found in the area are woefully small when considered against the data collected by other workers in the area. While I realize that this is possibly the result of cursory observations sighting the most common species, I would hope that a comprehensive scientific assessment would consider rare, and possibly endangered, species that have also been recorded in the area. Despite the limited number of species on the list, the report notes that not all were even recorded by the survey, utilizing previous studies and neighbour consultation to create a probable species list (Hidroelectrica Buenos Aires, 2013: 61). Interestingly, of the ten species listed on the EIS (Hidroelectrica Buenos Aires, 2013: 62), all but one (a species of small vine snake) are considered pests. These include several species of agouti and possum, as well as raccoons, armadillo, arboreal porcupine, rabbits and squirrels, along with the dangerous Fer-de-Lance viper. The Fer-de-Lance, Costa Rica's most dangerous snake, feeds on small mammals. The others, all mammals, are agricultural pests and adapt readily to human habitation, especially rural and agrarian areas.

This would explain their dominance of the survey, as pest animals are often regarded as such thanks to a propensity for survival in anthropocentric environments, despite our best efforts to dissuade them. They may simply be the remains of the ASBC's mammalian fauna after decades of human habitation, the now abandoned Squirrel Monkey Sanctuary being a testament to the difficulties faced by many species in the ASBC. A cursory wildlife survey of Toronto would yield a number of similar species; rabbits, opossum, raccoons and squirrels being familiar urban denizens. The more conspiratorially minded might assume however, that the nature of the animals presented lends a particular character to the dam projects; that, with the exception of the unassuming vine snake, the animals presented are at best common and at worst are actively undesirable, improving the approval prospects of the dam project. The composition of wildlife certainly alters perceptions of whether it not it should be conserved. I have only to think of my own family cottage in Muskoka, where the wildlife bears a sharp similarity; containing as it does rabbits, raccoons, opossum, squirrels, groundhogs, muskrats and porcupines. It

simply doesn't seem as "pristine" or natural as the nearby national parks, likely because the wildlife in the park doesn't actively invade my space. The porcupine seems somehow less majestic and wild when it awakens me in the middle of the night, gnawing on the cottage siding. While I would tend to agree with the more logical explanation; that the species present are pests simply because pests are the most likely to survive in rural areas with agricultural infrastructure, there is one troubling aspect; the survey contains no amphibians.

While in the ASBC, I was able to document a number of amphibian species with only casual efforts. A number of frogs, toads and caecilians were all found within the ASBC, and while I cannot definitively say they exist on the lands slated for the dam as I haven't surveyed them, I find it difficult to believe that they would be absent given presence both north and south of the project, included in the AID. Perhaps the EIS surveyors fell into a familiar trap of recording the larger charismatic species as many of us would, certainly everything listed is, again excepting the vine snake, at least a pound in weight. At the same time, amphibians are the group of vertebrates likely to be most affected by the dewatering presence of the dams, requiring as they do water for spawning habitat for tadpoles and for shelter. They are also excellent environmental indicator species and often prove charismatic as conservation symbols. The report notes that no endangered or threatened species were found, *within the AP.* While the rest of the report concerns the surrounding communities, the requisite section for identifying endangered species has been restricted to only the sites of the project's structures. This is particularly telling, as, unless read very carefully, it gives the impression that the area entire is devoid of threatened species, rather than simply the degraded pasture that will house most of the project. No mention is made of endangered species with the AID itself.

1.5 Study Area

Before we go any further with our delving into the local and global dimensions of the proposed hydro-electric dams, we must become familiar with the Alexander Skutch Biological Corridor and the surrounding counties. The Las Nubes Biological Reserve is an area of high altitude cloud forest located in southern Costa Rica, on the Pacific slope of the Talamanca mountain range (Daugherty, 2002: 1). Las Nubes borders the southern edge of Chirripo National Park, which itself forms the western edge of the La Amistad World Heritage Site, a massive international park that extends into Panama (Rapson, et al, 2012: 5). Las Nubes itself sits at an elevation between 1100m and 1500m above sea level.

The main river that flows through Las Nubes, and the ASBC as well, is the Rio Penas Blancas, a relatively shallow, high flow watercourse that contains cool, clear water. It is joined by the Rio Penas Blanquitas halfway through the ASBC, from the eastern side. The river joins the larger Rio General some 200 meters below sea level south of the ASBC (Hidroelectrica Buenos Aires, 2013: 44)**.** The general form of both rivers is that of highly sloped, fast moving mountain streams with steep basins (Hidroelectrica Buenos Aires, 2013: 44-45)**.**

At the southern end of the of ASBC we find Los Cusingos Neotropical Bird Sanctuary, once the homestead of renowned American ornithologist Alexander Skutch, in whose honour the biological corridor is named. This is the lowest point in the corridor, some 600m to 700m asl. Los Cusingos is now managed by the Tropical Science Center, a partner with York University in the ASBC **(**Daugherty, 2002: 6, Rapson, et al, 2012: 5) and receives funding from FONOFIFO for land protection in the corridor. Las Nubes and Los Cusingos form the ecological poles of the corridor if you will, having a much greater species richness than the surrounding patchwork of agriculture (Rapson, et al, 2012: 12).

This area, including the watershed of the Penas Blanca, is officially recognized as belonging to the Mesoamerican Biological Corridor (Daugherty, 2002:2), a massive pan-Central American project stretches from Mexico to Panama. The MBC, while ostensibly a conservation project, has a number of linkages to globalized financial and corporate institutions, which we will examine in a later section. One uniquely southern Mesoamerican element is the relatively narrow geography of the area, the Atlantic and Pacific oceans a mere few hours' drive apart. The ASBC itself is less than an hour's drive from the Pacific coast. This gives the area an ecologically significant aspect, being one of the most threatened ecosystem types in Central America **(**Daugherty, 2002: 2)**.**

Although the area is a "biological corridor", it is not, as we might imagine, free of human influence or habitation. The ASBC is a patchwork of private forest fragments, small agricultural operations growing coffee and sugarcane, cattle and horse pastures and cleared lands (Hidroelectrica Buenos Aires, 2013: 14-15). As a biological corridor, the general ethos of the corridor is ostensibly one of sustainable development and ecologically friendly business. This is not omnipresent however, as large expanses of cleared area, and proposed dam projects, show an alternate vision of land use. In the last ten years, forest cover in the corridor has decreased by 19% (Rapson, et al, 2012: 11).

One of the major initiatives is the transition from sun grown to shade grown coffee plantations, a holistic approach that decreases the need for chemical pesticides, enriches soil naturally and creates usable space for wildlife (Daugherty, 2002: 3, 6). Another is the restoration, or reforestation, of degraded lands once cleared for cattle pasture. Both will increase species richness as well as providing migration avenues from the major ecological reserves.

The Las Nubes Biological Reserve is currently owned by York University, a donation by Canadian Woody Fisher (Daughtery, 2002), who also established the Fisher Fund for Neotropical Conservation. York University is also currently involved in constructing an " eco-campus" and research station in the

western edge of Las Nubes, plans for which have been in development for the last ten years or so (Daugherty, 2002: 6), as well as a community library. Other community initiatives include the annual ecological and craft festival aimed at promoting local biodiversity and awareness.

The ASBC is only a short distance from the Pacific coast, and it is this proximity that has bestowed it with such a unique group of aquatic species. The higher altitude rivers of the ASBC are refuges for many fish from the larger predators found in the Rio Grande de Terraba water basin, the largest watershed in Costa Rica (McLarney, et al, 2010: 62). The Grande de Terraba empties into the Pacific Ocean through extensive mangrove forests that provide a veritable nursery paradise for many marine and estuarine species. The nutrient rich water feeds a host of minute larvae and young fish, which migrate out into the ocean, as well as returning to rivers where they were spawned.

These factors have all combined to lend the ASBC a fairly unique character, one that makes it alternately an excellent location for hydropower projects thanks to geography, and a terrible location thanks to an ideological focus on environmentalism. The struggle here is a representation of larger conflicts in Costa Rica, and in many other places in the world. Hydropower represents some of the most reliable renewable energy technology, yet is not without significant potential for negative environmental impacts.

2.0 Ecological Effects of Hydro-electric Dams

2.1 Introduction

For proponents of renewable energy sources, hydro-electric dams provide one of the most cost effective options in terms of construction, maintenance and longevity. Assuming consistent patterns of rainfall and other hydrological factors that provide the necessary water, these operations should essentially run for an indefinite period at a relatively consistent level. For the ASBC dams, the predictably rapid nature of their host rivers, located on steeply inclined terrain, provides an endless supply of potential power and profit. The tangible benefits of these projects are immediate and easily quantifiable, posing a challenge for those interested in revealing the far more nebulous negative environmental impacts. The potential negative effects of these projects are difficult to weigh against benefits couched in economic and development terms. Attempts have been made to value ecosystem services on a monetary scale, such as the recent Rouge River development controversies in Ontario. While the effort to compete at the economic table is commendable, valuations in these cases are often rather speculative, and most importantly, ambiguous about the beneficiaries of both the savings and debits. To my mind, the problem with embarking on these quantitative valuation projects comes when moving beyond the more readily calculable facets of an ecosystem such as carbon sequestration or fish production. How does one calculate the ecosystem value of a particular frog species or flower (Berkamp, et al, 2000: 8)? What about the value of natural heritage; should it be managed solely on the basis on quantifiable tourism in the area? The reduction of conservation controversies to "simple" value comparisons could set a dangerous precedent for projects in areas where ecosystem services are undervalued. More importantly, it may give lucrative projects the green light. Take for example the case of Lake Victoria in Africa, where the local and comparatively worthless (economically) local fish species have been almost entirely replaced by *Lates niloticus,* the Nile Perch, a species that supports a multi-

million dollar international industry. If judged purely on their economic worth, the native Victorian cichlid fish have only subsistence level local fisheries and aesthetic value in the ornamental aquarium industry, falling woefully short in comparison with the income generated by the invasive Nile Perch. On that basis, I will not be presenting the ecological effects of dams as an economic valuation, but rather highlighting the general effects of dams that have been well documented in a variety of cases all over the world. Reviewing these, we can make some probable predictions as to the consequences of building dams in the ASBC and other neighbouring areas. As with many of the cases to be examined, some impacts have not been concretely defined until decades later. Perhaps this paper will serve as prognostication of sorts, examinable by future students working in the ASBC and the nearby La Amistad World Heritage Site.

The effects of hydro-dams on local ecosystems vary considerably with the particular design and the effort that has been put into mitigation solutions; however they are never “beneficial”, very rarely neutral and almost always negative in some fashion. Dams create a permanent alteration to the very base of a river ecosystem, altering water flow, parameters such as temperature and oxygen levels, as well as creating a physical, and often insurmountable, barrier to migration of fish and other aquatic species. If one looks beyond the immediate value of rivers and considers a more holistic view of ecosystem linkages, these local alterations may have a significant and detrimental effect on the larger biome. Rivers provide import and export corridors for nutrients, sediment and living organisms (Gower, et al, 2012: ii); their blockage with hydro-electric dam projects may prove as damaging as a blockage of an artery that may affect a human body. The most interesting and troubling aspect of this is the unpredictable consequences that alteration to one habitat may have on a seemingly unrelated other. As ecosystem planners, we humans are often caught unawares of these linkages (Moulton, 2009: 2). In British Columbia, effects of forest logging had enormous impacts on the populations of salmon running through their forests. Cumulative alterations, such as removal of shade-providing trees and driftwood

shelter from the rivers proved as detrimental to salmon populations as a dam built on the river itself (Safina, 1997: 223). After the fact, these connections may seem obvious; however the damage done at that point may be irreparable.

For those on the side of precautionary conservation, the uncertainty present with these probable effects poses the greatest handicap in active development and planning discussions. Without concrete “proof”, these probabilities can seem at best like worries of an environmental hypochondriac and worst like desperate attempts at derailing economically beneficial development projects. How then do these currently unproven linkages between infrastructure and ecology enter the practical discourse of infrastructure development in the ASBC? The most prudent approach would be one based in the cases of similar dams elsewhere in the region and the world. While no one case is an exact parallel to the ASBC and its dams, they all lead to one inescapable conclusion; that all dams, regardless of form or location, create some form of negative ecological impact. These impacts must be mitigated by proactive design and placement considerations, and supported by retroactive monitoring and if necessary, modification to structure and operating regimes.

2.2 Fieldwork within the ASBC

Alongside my work examining the more generalized impacts of hydroelectric projects, the ideological regimes that support and the abstract forces that shape our interactions with nature, I felt a small measure of practical application was due for the sake of legitimacy. My small contribution will hopefully serve as a counterpoint to the EIS reports provided by Buenos Aires Hydroelectric. My methodology was extremely simply, largely for two reasons. First, I am not formally trained in biology or scientific survey methods, any attempt to mask my conclusions as such would be dishonest. My experience comes from two decades of amateur "herping" and involvement in the commercial importation and trade of aquatic organisms, reptiles and amphibians. I would venture that in this

respect, I have more practical experience with the positive and negative consequences of manipulating water chemistry on aquatic organisms than many field workers, given it is a daily part of commercial aquarium maintenance. The second reason is due to the seemingly cursory nature of the EIS report itself, the species list provided (Hidroelectrica Buenos Aires, 2013: 61) listed a fraction of the known inhabitants of the ASBC, distilled from existing studies, local knowledge and extrapolation. From my own time in the corridor, it is apparent that many people there do not have a good working knowledge of their own ecology, evidenced by claims to the venomous nature of boa constrictors and misidentified species. I chose to counter this assessment with a cursory study of my own; specifically to see which "other" vertebrate species might be encountered on the roads and trails of the corridor, specifically reptiles and amphibians. I deliberately laid no traps, did not venture off the trails or put much effort into finding these species, ideally to demonstrate the ease in which they could be spotted. These sightings came from areas surrounding the project; Los Cusingos in the south and Las Nubes in the north, as well as the communities of Santa Elena and Quizarra in the east and west.

2.2.1 Species Sighted

Anurans (Frogs and Toads); the dominant group of amphibians in the area and given their sensitivity to pollutants and complicated reproductive phases, one of the best environmental indicators.

- *Bufo marinus*, Cane Toad
    - The most common species
- *Bufo hematiticus*, Litter Toad
- *Colostethus talamancae*, Talamanca Rocket Frog
- *Eleutherodactylus underwoodi*, Underwood's Rain Frog

    - Adults and juvenile, found at both the northern and southern boundaries of the corridor. The Rio Penas Blancas is likely the major conduit for these frogs within the area.
- *Similisca phaeota*, Masked Treefrog
    - Both adults and tadpoles
- *Atelopus varius.* Harlequin Frog
    - Juvenile. This brightly coloured and endangered species was not seen by me personally, but was encountered just south of Las Nubes the day before our excursion. This is of particular note as this species lives on the margins of shallow, rapid streams. The presence of a juvenile indicates a breeding population, possibly one of few remaining within Costa Rica.

Other Amphibians; two species recorded

- *Gymnopis multiplicata,* Purple Caecilian
- *Oedipina uniformis*, Common Worm Salamander

Lizards; likely the group least affected by the presence of the dam, except aquatic species like the Common Basilisk (*Basliscus basiliscus)*, not seen by me within the corridor, but was seen repeatedly in adjacent areas of similar terrain.

- *Iguana iguana,* Green Iguana
- *Norops aquatics,* Water Anole
- *Norops capito,* Pug-nosed Anole
- *Sphenomorphus cherriei,* Striped Litter Skink

Snakes; many species in Costa Rica prey on amphibians, alterations to local habitat that negatively impact amphibian populations adversely affect their predators.

- *Boa constrictor imperator,* Central American Boa
    - Seen on both excursions to Los Cusingos
    - Convention for International Trade in Endangered Species (CITES) listed at II
- *Bothrops asper*, Fer-de-Lance Viper
    - One of the most common species, and the most persecuted by local people thanks to its well deserved reputation as Costa Rica's most dangerous snake.
- *Chironius grandisquamatus,* Ebony Keelback
    - This large and aggressive species was sighted on both Las Nubes excursions. It is a predator of amphibians, specifically *Eleutherodactylus* frogs (Savage, 2002: 650).

With less than 24 hours of actual field time, no scientific collection methods or surveys, I was able to double the vertebrate count of species found within the AID. Those workers involved in avian conservation would undoubtedly share my critique of the EIS, as only a fraction of the three hundred or so recorded species from the ASBC are listed in the EIS. It should be abundantly clear by this point that the EIS reports are heavily slanted towards economic and political agendas rather than an objective, scientific assessment. This should come as no surprise however, as pure objectivity is an illusionary farce, one we will discuss in the last chapter. The EIS, and reports like them, are a tool of legitimating particular ideologies of natural resource relations. These are the kind of relations that approve environmental impacts of energy production as a necessity for development and modernity.

2.3 Cumulative Impacts

One of the most troubling aspects of the permitting process for diversionary dam construction, not only in Costa Rica, but virtually everywhere dams are built, is the localized focus of environmental

impact assessments. Virtually all discuss only the immediate surroundings, and the impacts in this may seem minor (Anderson, Pringle and Freeman, 2008: 409). "Only" a kilometer of river dewatered. "Only" half of river rendered inaccessible to migratory fish species. However, when taken as a collective whole, the potential impacts to the watershed could be far more prominent. In the case of the ASBC dam projects, the local impacts must be examined alongside the eight other projects that are being built in tandem. The impacts of the ASBC dams will occur on every river traveling down the southern slope of the Talamanca mountain range. The cumulative impacts for both the upstream forests, which include the La Amistad world heritage site, and the downstream communities, may be considerable. This "basin scale" (Anderson, Pringle and Freeman, 2008: 408**)** approach is arguably the most important unanswered question in terms of probable impacts. This uncertainty is further compounded in Costa Rica, where despite prodigious amounts of research into biodiversity, data regarding freshwater ecosystems is lacking. Impacts on water quality are difficult to measure, as in many areas there are no historic records to compare. This is compounded by the fact that while Costa Rica restricts the amount of electricity generated by private hydropower operations, it does not restrict the number of dams per watershed (Lindo, 2006: 307**).** While the limitation to the size of hydro projects should be appreciated by environmentalists, the solution for profit-hungry hydro companies is simply to build more dams, a situation which may be more dangerous for the environment in the long run. This is of immediate concern for those interested in the ASBC, as well as the ecology of the larger area. Unable to construct a single larger dam on the nearby Rio Grande de Terraba, the alternative is to build nearly a dozen smaller dams on every river on the Southern Pacific slope of the Talamanca Mountains. As the Environmental Impacts Statements only apply to the immediate area around each dam project, the cumulative impacts are virtually unknown and difficult to predict (Anderson, Pringle and Rojas, 2006: 689-690)**.**

This local dimension is simply a reflection of a much greater debate in scientific circles regarding the nature of ecosystems and the practical application of conservation projects. The debate is essentially

between a top-down or bottom-up formation of the concept of an ecosystem; some regard such systems as conglomerations of biotic and abiotic factors that create a working gestalt structure (Moulton, 2012: 424). The structure is a reflection of the small parts. Others feel ecosystems have a self-regulating nature, that they are entities in their own right with particular rhythms. Ecosystem ecology has often been studied as a separate field form the ecology of communities with ecosystems (Moulton, 2012: 423). The ecosystem, as a concept, has been a contentious subject within the field of ecology, as its practical management and boundaries are difficult to define. Ecosystems, after all, have no genetic structure with which to categorize, no exact borders to separate them from neighbouring systems (Moulton, 2012: 423). We can certainly see this in the case of the montane coastal ecosystem in which the ASBC sits. While defined by certain types of fauna, the nutrient import and export functions of its rivers question the geographical borders often ascribed to it. The health of the aquatic species in the rivers relies as much on coastal mangrove forests as they do on the rainforest through which they pass (Greathouse, Pringle and Holmquist, 2006: 696). The field is somewhat divided between these two views, with practical ecosystems managers unsurprisingly leaning towards the bottom-up approach. It is difficult to conceive how one could attempt manipulations of something as gross and ill-defined as a whole ecosystem. Minute alterations to fauna and abiotic factors seem far more realistic. Still, there are others that prefer a more holistic outlook which parallels its contemporary in the medical field, leaning towards health as a full body function rather than specific systems. There is also a segment of this group who are essentially waiting for a body of knowledge supporting ecological holism to emerge, without which speculation is pointless (Moulton, 2012: 423-424). Interestingly**,** much of the work suggesting a holistic approach comes from the field of thermodynamics, examining biological energy processing systems. While I believe that the situation in the ASBC could be described using both sides of the coin, the holistic view is more in line with the collaborative nature of the ASBC, including as it does human "components" and "interfacing" with economic and socio-economic models (Moulton, 2012: 425**).**

Ecological health cannot be separated from the human element, owing as it does so much to human endeavors. The migratory fauna and their blockage by the proposed dam are a perfect example of the need to consider a holistic view, a macro-esque lens if you will, when evaluating projects of this sort. This sort of ecological change is driven entirely by a spatial proximity to human projects.

It should be noted that I choose, when referring to a holistic view of ecosystems, to adopt the noun "entity" rather than organism as some do. Organism signifies a bounded and identifiable creature with definitive features. Entity is much more nebulous, suggesting regulatory functions and existence, but in a much more insubstantial form.

2.4 Site Selection

In a report released by the World Bank (Ledec and Quintero, 2003), one of the architects of the controversial Mesoamercian Biological Corridor, the issues with site selection, design and impacts are addressed. Rather succinctly titled *Good and Bad Dams: Environmental Criteria for Site Selection of Hydroelectric Projects* (Ledec and Quintero, 2003), this report addresses these issues from a top down, proactive perspective that should be encouraging to those opposing such projects from a grassroots standpoint. With recognition of site selection as a primary factor in distinguishing “good” and “bad” dams, residents of the ASBC communities must wonder what particular set of qualities belong to their area that should bestow upon it so many dam projects. It should be noted that this report deals specifically with large dams, and therefore may seem unsuited to deal with the small, diversion type dams proposed for the rivers in the ASBC and surrounding areas. When contrasted to other literature, it will become abundantly clear that most of the negative impacts of small dams, recorded by other authors in their work, closely parallel those of larger dams. In the case of the dam chain proposed for Perez Zeledon and Buenos Aires counties, the implementation of a dam on every river in the area could quite likely have significant cumulative impacts on the area as a whole. In this regard, the greater

ecological impacts of large dams might also be applied to the Perez Zeledon and Buenos Aires projects. Based on the criteria provided for dams in general, upper tributary dams, of which the Perez Zeledon projects would be included, are generally seen as less damaging than main river dams (Ledec and Quintero, 2003: vii, 15), such as the controversial and highly publicized Boruca and El Diquis dams proposed for the Rio Grande de Terraba. Cumulative impacts may be another matter entirely, especially given the number of low-profile, small dams present or proposed in Mesoamerica, especially in Costa Rica, where 80% of electricity is generated by hydroelectric means (Anderson, Pringle and Rojas, 2006: 680, 686).

I hope that this point begins to dissolve the binary often present in these debates, one which frequently characterizes the World Bank as a villainous opportunist and dams as inherently "bad". Site selection is pivotal for creating "good" and "bad" dam projects, ideally minimizing potential environmental impacts by targeting areas with high levels of ecological resilience.

2.5 Impact Description Framework

To conceptualize these impacts, we must have a system of categorization. Impacts of dams can be generally segmented into several sections (Berkamp, et al, 2000: 14, McLarney and Mafla, 2007: 10-11**)**, with each iteration becoming more difficult to tangibly quantify and to accurately predict in damage and scope. While the exact definitions vary between authors, all described impacts can be generally divided into three stages; those of abiotic alterations, those affecting aquatic biota and those affecting terrestrial biota, the system I will using in the following sections.

The first stage impacts concern the immediate alterations to the abiotic environment; water and the variables of the rivers themselves (McLarney et al, 2010: 76). These include temperature, water flow and speed, ph levels, oxygen levels and other chemical properties created by the physical structure of the dam combined with its regular operations. These are the most visible and easily measureable

impacts, as well as the most predictable. Mitigation solutions often come from changes in design and operation that are undertaken relatively easily. Some, like those concerning the erosion of river banks of the Madawaska River near Ottawa, have been dubiously solved by simply building more dams. Concerning the ASBC dams, these impacts are the simplest to predict, some having already been preordained by the proposed operation of the dam itself; the reduction in water is already specified for example. Diversion-style dams in North America are well studied in their impacts on hydrology, providing a list of almost certain changes. These are also the most visible and easily studied by workers in the area.

The second stage impacts comprise those affecting the biota of the river itself, including species extirpations, population reduction, loss of valuable ecosystem functions such as detritus removal and algae consumption (McLarney et al, 2010: 15-16). These impacts can be predicted with some certainty based on case studies in other regions. Unlike the immediacy of stage one impacts, these changes may take months, years or even decades to manifest. Mitigation of these issues is far more difficult than those of the first stage. Various engineering and mechanical solutions have attempted, with various degrees of success, to overcome these problems. In North America, vast sums are spent by hydropower companies to mitigate the damages caused by their operations. In the Columbia River, some 30 million dollars are spent annually simply moving fish across the physical obstacle of the dams themselves (Safina, 1997: 229). For the aquatic biota of the ASBC, only the most cursory studies have been conducted recently, requiring some extrapolation as to the likely species composition of the rivers to be done in order to predict these impacts.

The third stage impacts are the most nebulous. These concern the effects of river alteration on the surrounding terrestrial environment. Due to extreme complexity of feedback mechanisms and biotic relationships, predicting these impacts becomes tenuous at best. Effects may take decades to manifest.

Examples include the loss of fish populations in the Amazon affecting forest health by removing a vital source of nitrogen found in annual mass deaths during the dry season. This effect has been well documented in North America, on the West Coast where forests were once fertilized by phosphorus, carbon, calcium and nitrogen delivered from the ocean by vast numbers of spawning salmon (Safina, 1997: 223). Without this yearly dispersion, the rivers have become nutrient poor, a state that extends its effects into the surrounding water table, impacting local terrestrial vegetation. These issues are almost certainly the most difficult to mitigate, not only because of complexity, but because by the time they become manifest, the damage may already have been done. In the ASBC, an examination of terrestrial fauna in the area, especially those species reliant on the river, should provide clues to the potential impacts on damming in the area. Amphibians are particularly relevant in the regard, with many species requiring river habitats and seasonal flooding for reproduction.

All of the alterations are sequential, affecting first abiotic conditions, before impacting aquatic life and then terminating with effects on the local terrestrial fauna and flora. For example; changes to oxygen levels, caused when large quantities of stagnant water are released from the dam's reservoir, may dramatically decrease the oxygen content of the water; an abiotic change that immediately impacts the biotic, as many montane river species are not adapted to these conditions leading to fish mortality. Terrestrial fauna may then find itself without a staple food source thanks to inhospitable river conditions.

An interesting element of dam construction in this region is the reservoirs themselves. The southern slope of the Talamanca mountain range is naturally without large standing bodies of water. What will be the impact of the ecosystem of a string of artificially created small lakes? We must be especially concerned about the stagnant nature of these reservoirs, which could serve as incubation grounds for tropical diseases such as malaria, dengue fever and schistosomiasis (Greathouse, Pringle

and Holmquist, 2006: 707). While it is not without precedent that tropical aquatic species, like Machara (*Brycon guatemalensis*), might exploit this new habitat (McLarney and Mafla, 2007: 12), these represent a much more significant possibility of hosting invasive species. Invasives like the African tilapia for example, are much better adapted for the relatively stagnant and much warmer water found in the reservoir than are any fish native to the area.

2.6.0 Alterations

2.6.1 Fragmentation

The most visible and well documented impact of dams of any sort is fragmentation of river habitats due to the physical barrier posed by the dam itself (Ledec and Quinterro, 2003: 6, Anderson, Pringle and Freeman, 2008). These barriers are often insurmountable to fish and other aquatic species, impacting populations on two levels (Rolls, et al, 2013: 625-626). The first is the segregation of populations on a genetic level, which may lead to long term issues thanks to a small and isolated gene pool (Anderson, Pringle and Rojas, 2006: 685). The second, and much more immediate, is the physical impediment to migration (Moulton and Wantzen, 2006: 660). Dams quite simply prevent fish and other aquatic species from completing their natural migratory journey, meaning a lack of recruitment into populations upstream of the dam, or loss of ability to reach spawning sites. Elsewhere in Costa Rica, migratory river shrimp of the genus *Macrobrachium* and *Atya* were absent upstream of an 8 meter high dam, despite being common downstream (Anderson, Pringle and Freeman, 2008: 414)**.** Many dams in North America have a variety of technical systems in place to mitigate this issue. These may range from simple “fish ladders” built into the structure of the dam itself, to complex mechanized lift systems designed to move fish from pools over the dam itself, to sorting systems that isolated returning young which are shipped by vehicle to locations downstream. It should be obvious that the expense of many of these mitigation solutions is considerable, making it unlikely that they would be implemented by private

companies without significant government pressure. In the United States, the economic importance of certain species (trout, salmon) makes these mitigations viable, whereas the relatively invisible *Scycidium* gobies of the ASBC rivers would likely lack similar economic justification.

While the physical structure of small, run-of-river dams like those proposed for the ASBC is not as monolithic as that of a typical large reservoir dam, the barrier they produce may be even more difficult to circumvent given the diversionary nature of their operation. Diversion dams operate by way of a small dam which removes water from the river and sends it into a storage reservoir to be used at peak electrical need hours (Anderson, Pringle and Rojas, 2006: 685, Gower, et al, 2012: 3). The major issue, as is the case in the ASBC, is that the length of river between the diversion site and the powerhouse return point is depleted of water, by as much as 90% (Anderson, Pringle and Rojas, 2006: 687). This dewatered expanse, approximately a kilometer long is referred to as the "diversion reach" (Gower, et al, 2012: 3). The effects of these types of dams in Costa Rica are relatively unknown, but comparisons can be made to operative hydro projects elsewhere in the world.

This lack of migration routes is of pressing importance to the species present in the Southern Pacific coast region of Costa Rica. Given the proximity to the ocean, many of the species present are diadromous in nature, requiring the ocean as a vital element of their reproductive cycle (Anderson, Pringle and Rojas, 2006: 685**)**. In the ASBC and surrounding areas, the high elevation, and steep grade of the streams makes it likely that most of encountered species are diadromous, including Mountain Mullet (*Agonostomous monticola), Scycidium* genus gobies and species of prawn (*Macrobranchium sp)* (Anderson, Pringle and Rojas, 2006: 685, McLarney et al, 2010: 50). Unfortunately this region remains the least studied in terms of aquatic biota, making definitive conclusions difficult. It is telling however, that the cursory sampling provided in the EIS report provided by the ASBC dam builder (Hidroelectrica Buenos Aires, 2013: 64-65) recorded three species of fish at the dam sites, two of which were

diadromous; *Scycidium* gobies and mountain mullet. Studies conducted by a York University student in the same area return the same results (Pardo, 2014). To their credit, the EIS notes that the dam poses a considerable risk of severing the connectivity required by migratory species (Hidroelectrica Buenos Aires, 2013: 66)**.** If these species are not found upstream of the project in later samples, steps must be taken to remedy the physical impediment.

One of the more troubling possibilities of dewatering is the loss of altitudinal connectivity that the Rio Penas Blancas provides. Forest cover in the corridor has decreased 19% or so over the last decade (Rapson, et al, 2012: 11). Given the relatively narrow nature of the corridor itself, this means that connections traveling upwards towards La Amistad, and downwards towards the coast, are severed. The Rio Penas Blancas represents its own corridor in this regard, connecting the high and low altitude areas of the corridor. Dewatering over a considerable portion may reduce the effectiveness of the river as an avenue of migration, not only of fish but for birds and other animals as well. The now deserted squirrel monkey sanctuary we witnessed near Los Cusingos should serve as a major highlight of the ecological decline of certain areas within the Corridor.

2.6.2 Dewatering

The reduced flow, or dewatering, created by diversion dams is one of the most significant factors in the blockage of upstream migration. With water levels being commonly reduced by 90%, and up to 95% in some cases, once active water courses quickly become dried beds devoid of life. These dewatered expanses commonly stretch for a kilometer, and may reach more than five (Anderson, Pringle and Freeman, 2008: 413). The relative health of both abiotic and biotic elements of rivers is maintained by water flow, a system of complex, complimentary factors that has come to its present form over thousands of years. These factors include seasonal water flows, downstream movement of sediment and debris, as well as the mutual relationship between the river and riparian vegetation

(Gower, et al, 2012: 8). The river is more than a resource provider and static habitat; it is a conveyor of nutrients, sediment and biological matter. Reduction of an active water course to 10% of its natural flow rate over the course of a kilometer creates a dead zone, a vast stretch without power to move abiotic elements downstream and perilous for aquatic organisms to cross. One has only to visualize a forest corridor reduced in size by 90-95% to imagine the effect this would have on the inhabitants and ecosystem connectivity. In the dewatered expanse, the conditions would resemble a prolonged drought (Anderson, Pringle and Freeman, 2008: 414).

Drought conditions in the dewatered area pose a number of problems for aquatic species (Anderson, Pringle and Freeman, 2008: 414-415**)**. Available habitat is reduced to 10% percent, meaning crowding occurs and resources become far scarcer. Predation becomes far more of a threat as volume and shelter are reduced dramatically. A previously traversable section of the river becomes a gauntlet filled with jostling, starving competitors and eager predators. Larger species, dependent on sufficient depth for shelter, are likely to be the worst affected. *Brycon* (a trout-like characid), mullet and gobies were all absent in proximity to dams in the Sarapiqui River basin (Anderson, Pringle and Freeman, 2008: 414)**.**

These acceptable amounts of dewatering are the result of ecological flow calculations, one of the most controversial aspects of dam planning, often reducing natural fluctuations to simplistic percentages **(**Arthington, et al, 2006: 1311). One of the flaws of many "ecological flow" determinations lies in the fact that river flows are not static, and the minimum flow for viability (a concept I would strongly contest regardless), is variable during different times and for different reasons. Simplistic, static percentile allocations can range from 5 to 50 percent of a river's flow being designated as necessary, with the rest seen as surplus to be commandeered for human projects. In the case of the ASBC dams, only 10 percent of the river water is designated as the ecological flow (Hidroelectrica Buenos Aires,

2013: 18). This amount is a general guideline accepted by most in the industry (Anderson, Pringle and Rojas, 2006: 690). This is a sharp contrast to the 20-30 percent flow recommended by some authors for arid regions, and the 50 percent recommended for equatorial regions like Costa Rica (Arthington, et al, 2006: 1312). Regardless of the percentage used, this is an anthropocentric approach (Suen and Eheart, 2006: 1).

2.6.3 Fluctuation

While the barrier presented by the diversion reach or dam itself may seem like the most formidable alteration to the river's ecology, there are a number of downstream impacts that may be just as significant, and even more so in some cases. Daily fluctuations during peak hours can strand unexpecting fish or bombard them with sudden oxygen and temperature changes. A variance of more than 35cm was recorded in as little as 15 minutes in Puerto Viejo (Anderson, Pringle and Rojas, 2006: 687). Often the unnatural regime imposed by diversion hydropower proves a negative environment, as river ecosystems often require seasonal fluctuations in flow and temperature to maintain the local environment and to stimulate the breeding cycle of many of its inhabitants (Gower, et al, 2012: 11-12). While the effect is more pronounced in areas that rely on seasonal flooding, such as the South American grasslands (Calheiros, Seidi and Ferreira, 2000: 685), periodic increases in river flow provide vital renewal and nutrient dispersal, as well as providing biological cues for aquatic species that stimulate migration and breeding (Greathouse, Pringle and Holmquist, 2006: 705). Artificial regulation of these natural rhythms may prove detrimental not only for the diversion reach itself, but also for organisms farther downstream whose biological functions are tied to expected seasonal variations ((Rolls, et al, 2013: 626). A further consideration is the reduction of water velocity due to changes in natural pressure created by a reservoir. For example, goby larvae have only a finite amount of time to reach coastal waters before they become exhausted and perish (Lyons, 2005: 242, Greathouse, Pringle and Holmquist,

2006: 705-706)**.** These fluctuations can prove disastrous for organisms in the dewatered expanse as the massively reduced water volume insures a far greater impact (Anderson, Pringle and Freeman, 2008: 414)**.** River fluctuations can become more natural and environmentally friendly if the effort is put into them. A massive hydro-engineering project in India, for example, times a massive discharge of water to coincide with religious bathing ceremonies for some 88 million people as well as the endemic population of river dolphins (O'Keeffe, 2012: 187).

2.6.4 Sedimentation

Sedimentation is another vital element of rivers, and one that directly affects the operative efficiency of any hydropower project utilizing a storage reservoir. Rivers naturally transmit fine particulate matter, typically clay, gravel, silt and sand, along their length. The sediments settle in low gradient areas, forming sandbars and beaches, as well as providing a bulwark against coastal erosion. In some areas, the interruption of the natural sedimentation process has resulted in measurable reductions of coasts, as once deposited sand and silt instead languishes in the reservoirs of dams (Gower, et al, 2012: 10-11). This is far from a purely ecological risk, and apart from the obvious drawback of coastal erosion, sedimentation is counterproductive to the operation of dam projects themselves. Many older reservoirs have seen their capacity reduced by considerable amounts due to buildup of fine sediment at the bottom of reservoirs, with some not longer even holding water (Greathouse, Pringle and Holmquist, 2006: 697). While the dams in Puerto Rico maybe decades old and nearing the end of their projected lifespan, similar issues have appeared after only three to five years in Costa Rican dam reservoirs (Anderson, Pringle and Freeman, 2008: 414, Anderson, Pringle and Rojas, 2006: 686). The polar opposite of sediment storage occurs when dam projects unexpectedly release large quantities of sediment into their rivers, smothering fish and other aquatic life. This was documented elsewhere in Costa Rica on the northern Penas Blancas River (Lindo, 2006: 307). Alongside

finer sediments, larger macro-debris, specifically wood from fallen tree branches, naturally moves downstream and is impeded by the physical barrier of the dam itself, as well as the shallow and meandering diversion reach. This debris provides a crucial habitat for fish, especially juveniles, and a plethora of aquatic invertebrates like insects and crustaceans (Gower, et al 2012: 14). The importance of woody debris in rivers is starkly displayed in the Pacific coastal rivers of North American, where its removal proved disastrous for migrating salmon populations (Safina, 1997: 223). In this case, the debris provided vital shade and shelter for migrating adult fish, without which many became exhausted by the unrelenting river current, as well as shelter from predators such as eagles and herons (Safina, 1997: 223). In the case of the northwestern American rivers, this situation has been compounded by an intensive forestry program that often clear cuts areas right to the banks of the rivers themselves. Fortunately regulations in Costa Rica mandate a minimum distance from rivers that must be left intact.

2.6.5 Water Parameter Alterations

The dewatered upstream expanse, while the most physically obvious impact of a diversion dam project, may not be the most problematic for aquatic biota. One might assume that fish will exist in a relatively untouched state downstream of the diversion reach, that the blockage will only isolate the upper reaches, a necessary sacrifice in the quest for anthropocentric power generation and societal advancement. This is unfortunately however, not the case, as the downstream effects may be just as dramatic, if perhaps not as visible (Rolls, et al, 2013: 628). A montane river, tropical or not, typically contains a fairly consistent set of water parameters; especially in regards to temperature and oxygen content. The rapid movement over terrain of a significant gradient, as well as the often shallow depth, means that water of most mountain streams is highly oxygenated (Wright, 2010: 59, Anderson, Pringle and Freeman, 2008: 415).

As mentioned in the preceding section, the nature of diversionary hydropower inevitably involves the discharge of water from the reservoir during times of peak need. This water is often radically different from the expected, natural parameters of the stream in both temperature and oxygenation. This is at best stressful and downright lethal at worst. Fish that live in these river systems are dependent on this high oxygen content, without which they become listless and weak, without the energy to evade predators or engage in other typical activities like feeding or breeding (Calheiros, Seidi and Ferreira, 2000: 685, 692, Berkamp, et al, 2000: 30-31). At worst, they may simply be unable to survive. I am reminded of a visit to trout farms during my field experience in Costa Rica, where the respiratory distress of trout kept in shallow, earthen ponds was readily apparent for anyone with experience with fish. For species like many of those found in the surveys of the ASBC rivers, a massive discharge of deoxygenated water may be an immediate death sentence.

When coupled to a diversion dam, the natural stability of a river changes quite dramatically. The reservoir contains a large amount of stagnant water, an alien state in an area with no natural large lakes or ponds. While the forest river is in constant motion through largely shaded covers, constantly turning over rocks and other debris, water in a reservoir simply sits. Immobile and bathed in sun, the water in a storage reservoir becomes both depleted of the oxygen restored by the motion of the forest river and heats to a higher temperature (Berkamp, et al, 2000: 30). To compound these problems, the bottom of a reservoir, which is essentially a small lake, becomes deprived of oxygen thanks to lack of water motion and decaying organic debris. Sedimentation plays an important role in this, as instead of being distributed downstream, it builds in the reservoirs (Berkamp, et al, 2000: 31). This mélange of decaying organics and anoxic water is then periodically released back into the river system with predictably detrimental results. Temperature in the river changes dramatically, disturbing or reversing natural temperature gradients. Oxygen levels plummet, as well as the ph level, meaning the water becomes much more acidic. Instantaneous alterations of ph are something fish do not tolerate well at all, as it is

very rare in nature. I have seen fish placed in radically different ph ranges literally roll over and die, and one can imagine what such a calamitous effect this could have on downstream aquatic life caught in such a deluge. To make things worse, deoxygenated, low ph water creates ideal conditions for potentially toxic cyanobacterial algae blooms. Typically the relatively rapid pace of the river may prevent such outbreaks, however local agricultural activities provide nutrients that exacerbate cyanobacteria growth, making it a possibility.

To be thorough, and for future comparison, Wright (2010: 59) provides water quality and parameters of the Rio Penas Blancas watershed, including surrounding tributaries and Rio Penas Blanquitas.

- Dissolved oxygen content between 4 and 6 parts per million. Below 2 is considered unsuitable for life.
- Turbidity index of between 0 and 5 (JTU), indicating clear water.
- Phosphate of between 1 and 4 ppm
- Nitrate between 0 and 5 ppm
- ph of between 6.5 and 8.3, with an average of 7.88, above neutral.
- Temperature between 14 and 27 degrees C

These parameters indicate the Rio Penas Blancas to be clear, clean and of relatively high oxygen content, as one would typically expect from a mountain, rainforest stream. In a particularly unscientific assessment, I have filled drinking water bottles at Fischer Falls in Las Nubes, without any ill effect. Lower in the water course this would be unadvisable due to potential contamination from agriculture and human grey-water. Both phosphate and nitrate, naturally occurring fertilizers, can increase through anthropogenic causes like farm water run-off or pollution, and increase the growth of algae. Increasing agriculture in the area coupled with decreased water flow and absence of natural algae grazers could

profoundly affect the nature of the Rio Penas Blancas in future. The EIS notes that maintenance of water quality is a priority, however it fails to mention long term mitigation measures, focusing instead on the construction phase (Hidroelectrica Buenos Aires, 2013: 66).

2.7 Diadromy and Species of the Pacific Slope Watershed.

Less studied than the species of the opposing Atlantic slope, the aquatic fauna of the Pacific slope of the Talamanca present some problems for those interested in predicting the negative environmental impacts of the proposed hydro-electric dams. Rather than write off predictions based on lack of data, I believe it would be beneficial to examine areas with similar species composition and geography. Puerto Rico is one such example, sharing as it does a sharply graded geography that makes hydropower development there as attractive and lucrative as it does in Costa Rica. Puerto Rico also shares considerable similarity in the composition of its migratory fauna, especially in regards to diadromous species adapted to small, rapid river systems. As dam development is decades ahead of projects in southern Costa Rica, the detrimental impacts of dam construction across entire watersheds is well documented.

Proximity to the ocean lends itself to an aquatic fauna that is heavily diadromous, requiring both fresh and saltwater for a complete lifecycle (Greathouse, Pringle and Holmquist, 2006: 696). There are two major types of diadromy; anadromy and catadromy (McLarney and Mafla, 2007: 3). Anadromous organisms primarily live in marine environments but migrate to inland waters for reproduction. North Americans are well acquainted with some of the most famous examples of this process; trout and salmon. Catadromous organisms live in freshwater, but move to saltwater for reproduction. The American eel is a familiar example, journeying deep into the Atlantic to breed. Many of the species in the ASBC release their larvae into the rapid streams, which are then carried to the coast where they grow rapidly in the nutrient rich mangrove forests. Both types of migration are impeded by dam

construction, well documented in the temperate zones like North America, but far less so in the tropical regions (Greathouse, Pringle and Holmquist, 2006: 696)**.** Puerto Rico, thanks to its inclusion as a US state, developed hydroelectricity infrastructure much earlier than its Mesoamerican and Caribbean contemporaries and is now experiencing the impacts of such projects on its ecology (Greathouse, Pringle and Holmquist, 2006: 695). Ironically, the limitations of Puerto Rico as a case study for most tropical river ecology (short drainage, migratory fauna, low diversity, etc) are precisely the reason why it makes an excellent model for the future of the ASBC.

Of the seven diadromous fish species found in Puerto Rico, one, the mountain mullet (*Agonostomous monticola)*, is also present in the Rio Penas Blancas and one other, a species of algivorous goby (*Sicydium plumeri)* is very closely related to *Sicydium salvini*, found in the ASBC rivers (Hidroelectrica Buenos Aires, 2013: 64). Puerto Rico also is home to a number of decapod crustaceans, inlcuding palaemonid and atyid shrimp (Greathouse, Pringle and Holmquist, 2000: 701-702), which are present in high altitude watercourses in Costa Rica due to an absence of piscine predators. Sicydium gobies and atyid shrimp are both well adapted to scale waterfalls and other obstacles that would prove impassible to any other species. Sicydium gobies use pelvic fins modified into a suction disk, while atyid shrimp have massive front limbs with large claws, both can move over vertical, almost sheer surfaces with only minute water cover (McLarney and Mafla, 2007: 8-9). This unique set of specializations mean that these creatures are among the only larger river denizens found at higher altitudes like Las Nubes and La Amistad. When this is combined with the specialized ecological functions that both perform; *Sicydium* gobies eating algae and atyid shrimp breaking down organic detritus and particulate matter, the consequences are potentially dire if they are excluded from the upper reaches of the rivers (Freeman, et al, 2003: 262, McLarney and Mafla, 2007: 10-11). Migratory shrimp and prawns are integral bio-turbators and shredders of organic compounds like algae and leaf litter (Freeman, et al, 2003: 259-260). Experimental studies involving the exclusion of these organisms, as well as algivorous gobies,

strongly suggest that their presence is an indispensible part of river system function and multiple studies in various areas blocked by dams exhibited increase growth of algae. In addition to the exclusion of herbivorous species, the dams will also prevent the migration of predatory species from the upper reaches of the Rio Penas Blancas, with the mountain mullet being the largest piscine predator present (McLarney and Mafla, 2007: 6). The mountain mullet is omnivorous, feeding on small invertebrates and fish. The species is a particularly strong swimmer, able to traverse rapids and occurs at altitudes beyond most of its trophic competitors. The elimination of this fish from the upper water courses poses two problems, the first being its consumption of small insects. Without the mountain mullet regulating populations, insect species may become overabundant, including biting and non-biting midges. The second is the trophic subsidy (Freeman, et al, 2003) effect, providing a import of protein to larger fauna, without which species dependent on fish for sustenance may not survive, including kingfishers, herons and otters. I was unable to record any shrimp or prawns personally during field visits; however I did find a species of freshwater crab, likely a Pseudothelphusid species at an elevation of approximately 1200 meters. Assuming a correct identification of the family, these crabs are not a migratory breeder, however it may be a female member of the newly discovered species *Allacanthos yawi*, endemic to the Grande de Terraba watershed.

Greathouse, Pringle and Holmquist (2006) outline the impacts dam have on upstream populations of diadromous fauna in Puerto Rico. While their study involves barrier dams fifteen meters in height or more, I would contend that the dams proposed for the ASBC will prove no less of an impediment, and possibly more, thanks to the size and nature of the dewater diversion reach. Whereas fish ladders and other structures can mitigate the obstacle of a barrier dam for many species, especially rather acrobatic or mobile ones like mullet and gobies, an expanse of water reduced to a minute fraction will provide a gauntlet of temperature and predation these species are unable to easily navigate (Anderson, Pringle and Freeman, 2008: 414). The dewatered expanse somewhat resembles the spillway

of large barrier dams, which provides an avenue to cross for some species, however in most large dams it is measured in meters, not kilometers. Large fish species were not able to cross the barrier, even with a significant spillway (Greathouse, Pringle and Holmquist, 2006: 702). Gobies and shrimp were, unsurprisingly, totally absent from upstream of dams without spillways, as even their formidable climbing abilities do not extend to scaling waterless, fifty foot concrete walls. Studies conducted on high-gradient rivers, much like those of the ASBC, show measureable differences between those rivers with dams, and those without. The number of diadromous shrimp and gobies in unobstructed rivers was more than three hundred times that of a dammed river (Greathouse, Pringle and Holmquist, 2006: 703**).** While still present above dams lacking a regular spillway discharge, numbers of individuals were so low as to be undetectable by standard sampling methods. Age may be a factor in some cases, as atyid shrimps may live over a decade, possibly several, suggesting that specimens were present before the dam was constructed (Greathouse, Pringle and Holmquist, 2006: 704).

While loss of the biodiversity associated with a limited numbers of species is troubling in and of itself, these types of fauna provide vital ecosystem functions that become evident when they are removed. In rivers where both *Sicydium* gobies and shrimps were blocked by downstream dams, algae biomass was nine times higher than in unblocked streams (Greathouse, Pringle and Holmquist, 2006: 707)**.** This growth of algae can smother desirable aquatic plant species, reduce available habitat and water quality for aquatic species like amphibians as well as creating an unsightly nuisance for people in the ASBC who use the river for recreation and tourism. The missing species, especially crustaceans, are also an important part of the food chain for many terrestrial species, including wading birds, turtles and aquatic mammals like the Neotropical River Otter (*Lontra longicaudis)*, a species rumored to call Las Nubes home.

2.8.0 Terrestrial Impacts; Vegetation

The impacts of diversionary hydropower on the surrounding terrestrial ecosystem are not well studied in Costa Rica; however comparisons can be drawn to documented issues in North America. From these, we can hope to predict the impacts dewatering may have on the ecology of the Alexander Skutch Biological Corridor. Like any construction project, the dams will require a certain amount of deforestation, mostly in the areas immediately adjacent to the river diversions and powerhouse. As these structures are not particularly large, the deforested portions of the project would not likely pose much of a threat to the area's ecology, especially compared to the nearby private lands cleared as horse and cattle paddocks (Hidroelectrica Buenos Aires, 2013: 31-33). The large reservoir is slated to be constructed on degraded land once used as cattle pasture, requiring little habitat disruption. Development of infrastructure will include roads, power transmission lines and water service, most of which is already in place. The avenue for the main pipeline that conveys the water from the reservoir to the powerhouse will have to be cleared during construction. Roads and transmission lines may create barriers to migration, especially in areas as already fragmented as the ASBC. For example, many arboreal species will not be able to cross roadways or areas kept free of trees for power transmission lines. Additional power lines also pose increased risks of electrocution for birds and arboreal mammals (Gower, et al, 2012: 26)**.** Roads are well documented as vectors of biodiversity loss (Gower, et al, 2012: 23), allowing easier access for hunters and poachers, however given the limited size of the forest patches and number of current roads, the damage is likely already done.

This scale deforestation is not typically a cause for alarm, but this may change depending on the ecological sensitivity of the area (Gower, 2012: 24-25). The geographically limited nature of the habitat in the ASBC makes it a potentially sensitive area, especially when one considers certain species are altitude dependent, leaving them with narrow margins of habitable areas. In the case of species limited

to a specific geographical area thanks to size or limited mobility, like many amphibians, changes to small areas may have profound effects. Riparian vegetation, those species that grow at the margin of the river, is of particular interest in the ASBC. Although a minor amount may be lost in the areas adjacent to the powerhouse and diversion sites, the greater loss is likely to be over the diversion reach. Riparian vegetation is often heavily affected by damming, as natural shorelines and water chemistry change, leading to changes in species composition (Smith, 2006: 2-3)**.** These riparian zones provide vital space for many species, including amphibians, reptiles, mammals and birds that require the river as habitat. In areas with degraded vegetation or deforested pasture, these riparian zones may be the only corridor for species to move up- and downstream (McLarney and Mafla, 2007: 13). The dewatered expanse between the diversions and the return loses much of the moisture in both the soil and air, as velocity decreases the rapid nature of the river becomes turgid. Plants (and animals) requiring high degrees of humidity that once thrived may find the diversion reach to be considerably drier and hotter than before (Gower, et al, 2012: 17).

2.8.1 Terrestrial Impacts, Fauna

In an area as rich in biodiversity as the ASBC, riverine habitat is host to a number of terrestrial species that require it for feeding, shelter and reproduction. Changes to food composition and available habitat for example, can have considerable impacts on amphibian populations (Smith, 2006: 4-6). Reduced habitat quality due to the dewatered diversion reach and combined with loss of water quality below, and possibly above the project, is likely to have significant impacts on the food-web of the ASBC (Gower, et al, 2012: 18). Reduced water quality and quantity is likely to have significant impacts on the composition of macro-invertebrates, specifically of insects and their larvae that reproduce within the river itself (Dunbar, et al, 2010: S32, S40, Gower, et al, 2012: 18). The blockage of diadromous arthropods like shrimp and prawns, as well as predatory fish, from the upper reaches of the river is also

a factor in alteration of macroinvertebrate species make-up **(**McLarney, et al, 2010: 67, Smith, 2006: 3-4). These insects, the larvae of which are typically benthic (bottom-dwelling), are amongst the most abundant recyclers of organic nutrients, including algae, leaf-litter and other biological matter. Their presence is a reliable tool of water quality, studies of which have already been conducted in the ASBC (Wright, 2010: 9). I am hopeful that these studies will provide a benchmark to judge the future impacts of the dams within Las Nubes and the ASBC, both below and above the dam project. Predicting the specifics of these changes in species assemblage is currently impossible given the variables involved, results from studies may be contradictory (McLarney, et al, 2010: 66-67). For example, workers on one river in Atlantic Costa Rica concluded that fish presence reduced numbers of Chironomidae (non-biting midges), while others noted that fish presence shifted macroinvertebrate assemblages towards Chironomids, shrimp presence did not. Chironomids were abundant in the ASBC, especially at lower elevations (Wright, 2010: 94). Others noted the absence of shrimp and prawns led to a proliferation of "collector-gatherer" insect species (McLarney, et al, 2010: 66)**.**

In Puerto Rico, a model for prediction thanks to similar geography and species, the exclusion of Atyid, Xiphocarid and Palaemonid shrimp at high altitudes resulted in significantly less insect biomass, the reverse of the same situation at low altitudes (McLarney, et al, 2010: 66). At the same location, other authors concluded that shrimp absence did not alter the total insect biomass, but did significantly decrease the percentage of Baetid mayflies. Baetids comprise one of the major population segments of the insect assemblage of the Rio Penas Blancas (Wright, 2010: 90). The issue here is prediction, as conclusions are so varied no major theme can be drawn. What should be taken from this is the implication that extirpation of diadromous benthic fauna, like shrimp and gobies, impacts the composition of insects found within the river, which in turn alters the biological rhythm of decomposition of organic matter. More significantly, major changes to the composition may affect the food chain. Most of these insect species have a winged adult stage, providing a major (or only)

component of the diet of birds, as well as frogs and lizards, found in the area. Alteration of population this may remove vital food sources and replace them with unsuitable species.

2.9 Biodiversity

Biodiversity often seems to fall to the wayside when dealing with institutions backed by supranational financial orders, such as the sweeping Plan Puebla Panama. The areas, such as the Talamanca range upon which Las Nubes sits on the southern slope, are incredibly rich in biodiversity. The area encompassed by the PPP, from Southern Mexico to Panama, contains some 7% of all known terrestrial species (Ramos, 2004: 18). Biodiversity however, is not without its supporters in the world of global finance; the World Bank supports a new project called the Mesoamerican Biological Corridor. Running parallel to the PPP, this initiative ostensibly aims to protect and preserve biodiversity. What could be disingenuous about that, one might ask? The contention comes from the question of access, namely who will be allowed and who will be excluded from the rich resources of the MBC **(**Stenzel, 2006: 556, Davis, 2009; 105). Indigenous peoples have voiced concerns that the MBC will parallel other large national parks elsewhere in the world and exclude them (Moulton and Wantzen, 2006: 661**)**. There is precedent in Africa, where native Masai and others are prohibited from hunting and grazing in their traditional lands, all in the name of a particular Westernized vision of conservation. This vision, as Canadian indigenous peoples have also realized, does not include human beings in its imagining of an ahistoric "natural state". The rights of indigenous peoples to practice traditional livelihoods are frequently at odds with the goals of conservation organizations, and it is no surprise that the MBC is viewed with some suspicion. Given the neoliberal trajectory of Mesoamerica's major projects and the involvement of the World Bank, there is concern that the MBC is simply a greenwashed attempt at creating an exclusive zone for biotechnology and pharmaceutical companies (Ramos, 2004: 18-19, Stenzel, 2006:556 **)**. There is some evidence for this line of thought, as the head of biotechnology firm

Grupo Pulsar, sometimes referred to as "Mexico's Monsanto", sat on the board of Conservation International, a major party in these projects (Ramos, 2004: 18**).** It should be noted that the "green economic" ethic of Conservation International is highlighted as a inspiration towards York's efforts in the ASBC **(**Daugherty, 2002: 9**),** an interesting dichotomy, as it refers to the conservation organizations policies to effectively compete with corporate interests. This would seem a beneficial situation, unless of course the "corporations" are also conservation organizations, or heavily tied or influenced by them. And of course, what particular brand of conservation is espoused by these organizations, specifically in regard to the rural and indigenous people who often are at odds with Westernized conceptions of conservation (Davis, 2009: 113, 115-116). "Biodiversity" may simply not be as important as the functionality of adjacent areas, demonstrated by scrub/savanna conflict in Africa (O'Keeffe, 2013: 185), or in our case the river itself. In North America, river biodiversity garners large amounts of conservation attention and funds largely thanks to the presence of anadromous salmonoid fish (Moulton and Wantzen, 2006: 660).

Profitability of biodiversity is a major conservation issue, especially corporatized initiatives to uncover patentable molecules. As many of these are legal enterprises, I would not go so far as to call these initiatives "bio-piracy", currently something of a trendy phrase in anti-corporate lingo, but there is a troubling aspect of market monopolization that excludes both indigenous peoples and even states themselves from control over their own biological resources (Stenzel, 2006: 588)."Bio-privateering" might be a more accurate term, sanctioned as they are by a government body. Pharmalogical exploration into tropical environments has the potential for great advances in the medicine and other chemicals, as with hydroelectric dams the issue lies not with the technology itself, but rather its control and deployment. The pressure towards private property rights that is an integral part of the free trade agreements is unfortunately the polar opposite of a socially inclusive distribution of resources. While some might view the appropriation of the waters of the Rios Penas Blancas and Blanquitas as a form of

piracy, the discourse must recognize the explicit sanction of the legal body in the process. Attempts to deal with these problems as "criminal" often fail to include the implicit hegemonic factors. I should be clear here; I am not suggesting that some corporations do not undertake illegal activities in the name of profit, but that these require alternate modes of contestation from those unethical actions undertaken within the sanction of legitimate power regimes. This is the difference between a hit man and a soldier; one is expressly sanctioned to engage in activities that would otherwise be illegal. Conflict resolution requires different methods in both cases. Concerning our issue with the MBC, the difference is between those who expressly engage in illegal trafficking of wildlife, and those who engage in the unethical trafficking of wildlife. While expressly illegal wildlife trafficking presents a highly dangerous opponent, as marine turtle advocates in Costa Rica would no doubt attest, sanctioned exploitation is far more difficult to combat given its monolithic structure and variety of institutional support. It is into this highly complex and opaque world of intersecting political and economic interests that we must venture in our attempts to understand and interact with the ASBC dam project

3.0 Globalization and Political-Economic Connections

In the previous section, we have examined the myriad ways in which dams in general, and diversionary dams in particular, impact rivers and their local ecology. The alterations and impacts are well documented, supported by considerable, tangible evidence that leads to the inescapable conclusion that dams are bad for rivers. Why then, does no one seem to care? This is the real question that requires serious discussion; one that has nothing to do with practical ecology, science or other "logical" approaches often used as the cornerstone of environmentalist opposition to such projects. We know dams are bad for rivers, but we build them anyway (Moulton and Wantzen, 2006: 660). We do so because of a complex web of personal needs, globalized financial relations as well as theoretical and philosophical relations with our environment. In this section, I will hopefully be able to provide an outline of the interactions between local potential (as found in the ASBC) and globalized regimes of finance and trade, stimulating a multi-faceted approach to the way we understand energy sector conflicts.

Costa Rica has become somewhat of a locus for hydropower, thanks to the profusion of mountainous terrain and moist climate that creates numerous rivers flowing down the sharply graded slopes (Lindo, 2006: 298). The geography of Costa Rica is ideal suited to hydropower development, however the governing ethic of a nation focused on conservation may seem at odds with the current state. Hydropower projects are increasing in number in the last two decades (Anderson, Pringle and Freeman, 2008: 409). While alternative power forms, such as wind and geothermal, are present in Costa Rica, over 80% of the nations electrical power is generate by hydropower (Lindo, 2006: 298). This prodigious generative capacity allows Costa Rica to be largely self-sufficient, requiring little fossil fuel importation for anything other than vehicular transportation (Lindo, 2009: 298). This surplus is one of the reasons Costa Rica is able to maintain its ideology of conservation and environmentalism at the

highest levels of government. The threat of environmental damage from oil extraction activities was cited as the primary reason for leaving the nation's coastal Atlantic oil fields undisturbed. It should be noted that Costa Rica refused the private exploitation of its fossil fuel reserves, leading to a lawsuit by Harken Oil (Lindo, 2006: 311-312).

This leaves those interested in conservation and environmentalism in an interesting position, one that I believe leads to far larger and more difficult questions regarding human interaction with the natural world. Supporting opposition to hydroelectric development in Costa Rica would seem to mean an increase in fossil fuel consumption. Environmentalist opposition to large hydropower projects encourages the construction of multiple small dams like those in the ASBC.

3.1 The Plan Puebla Panama and Privatisation

The Plan Puebla Panama is, depending on who you might ask, a modernizing plan aimed at improving quality of life and economic levels of Central America (OECD, 2006: 1-8), or alternately, a vast capitalist scheme aimed at transforming Central America into a haven for sweatshops and free trade hegemonic domination (O'Neill, 2004: 4). Of course, as with most things, the truth of the matter is largely dependent on one's point of view. Regardless of whether one is for or against the project, its impacts are undeniable, even in such seemingly remote places like Las Nubes. It is difficult to fathom such worldly interconnections when hiking through the tranquil forests there, however Las Nubes is cordoned above and below by immense global projects. If one ascends up, both in altitude and latitude, the La Amistad World Heritage site and Mesoamerican Biological Corridor form a linkage of ecologically valuable habitat across Central America. Descending towards the coast will soon bring one across the electrical and transportation corridors proposed to create a much more anthropocentric connectivity. Understanding the place of Las Nubes and the ASBC in modern Costa Rica will most certainly require understanding the PPP, or its current pseudonym; the Mesoamerica Project.

The Plan Puebla Panama is a supranational infrastructure and integration plan that encompasses the entire Central American region (Stenzel, 2006: 555). As one might guess from its rather succinct title, it was initially conceived to run from the Mexican state of Puebla to Panama in the south. Colombia has recently become a participant. The plan was initially introduced in 2001 by the President of Mexico, Vicente Fox (O'Neill, 2004: 4**)**, and has been joined by all the Central American leaders at this point. The integrative aspects of the project include transportation routes, industrial corridors and other infrastructure, including the electrical project SIEPAC which is slated to run south of the ASBC. It should be noted that the project was expressly created to facilitate development not simply for national development's sake, but to develop a NAFTA (North American Free Trade Agreement)-esque economic system (O'Neill, 2004: 4**).** It will work alongside and support the Central American Free Trade Agreement (CAFTA) and the Free Trade Area of the Americas (FTAA); a very specific neoliberal ethic that should be familiar to those interested in the environment and social causes, as these are often casualties of "free trade" (Stenzel, 2006: 555). These policies stress corporatisation as well as privatisation of property and essential services, often with significant cuts to social and environmental programs. The official plan contains a number of initiatives, including; human development, sustainable development, prevention of natural disasters, better telecommunications, facilitation of commerce and tourism and interconnection of transport and electrical power. While many of these goals seem admirable, over 90% of the funds allocated to the project are reserved for the last two; transport and electrical power (O'Neill, 2004: 5). For Costa Rica, this "energy highway" means greater access to exportation markets, and the current trend towards relaxing privatisation regulations makes private hydropower projects all the more attractive to investors. In Costa Rica the area through which the SIEPAC transmission lines run has already been embroiled in controversy over proposed dam mega-projects like El Diquis and Boruca. The irony of naming the Boruca dam after the people it will displace is, I hope, not lost on the reader. This "endless chain of energy" (Stenzel, 2006: 567), as it has been referred to by SIEPAC's executive

director, will power not only homes, but also industry through the PPP corridors, generated almost entirely by hydroelectric power. The proximity of the ASBC to the SIEPAC lines means dam development in the area is almost a certainty. What remains to be seen is the ability of environmental interests and local community groups to influence or check such construction projects in areas they are deemed undesirable.

Hydroelectric dams are notorious for a variety of destructive environmental impacts and the forcible displacement of indigenous and rural peoples. The infamous Three Gorges dam in China is one example. While the small, diversionary dams proposed for the area surrounding Las Nubes are not nearly so massive in size and impact, they share many of the same problems on a smaller scale. When we considered these projects we must wonder if their implementation was out of a desire to reduce environmental impacts, or perhaps out of desire to avoid the politicization and visibility of larger projects like the proposed and highly contentious El Diquis dam project. These are monolithic projects, archetypical examples of what most people would think about when they consider a hydroelectric dam. Blockading one of Costa Rica's largest river, the Rio Grande de Terraba (Anderson, Pringle and Rojas, 2006: 683), these projects would flood vast portions of the watershed upstream of the dam itself, inundating swathes of forest and several indigenous communities that reside in the area. As forcible displacement from their lands is a process the indigenous people of Costa Rica are unfortunately well acquainted with, reaction to these projects was swift and extremely negative, especially on the international stage. Despite the relatively small population of indigenous peoples, these appeals were largely able to stall the dam projects. Later the series of small diversionary dams were proposed for the slope of the Talamanca, a chain of a dozen that includes Las Nubes. One can only assume that these dams were a strategic reaction to the difficulties encountered by the larger projects. The smaller dam projects are far less visible, both physically and politically. They have much less immediately apparent impact on ecology. Most importantly, they do not infringe on land held by indigenous groups with

specific rights enshrined in legislation. The communities affected by the smaller developments have little recourse or avenue of opposition save community groups like Movimiento Rios Vivos Costa Rica (http://riosvivos.com/). Far from an isolated energy project, these dams are connected, literally and conceptually, to a far larger international network that aims to transform Central America. This is the Plan Puebla Panama, currently rebranded as the Mesoamerica Project. This project aims at a cross border development of infrastructure that will link Mexico in the north to Panama and Columbia in the south. While the project has a number of diverse initiatives including education and conservation, the vast bulk is focused on two particularly telling segments; roads and electrical production. The electrical segment is the most relevant to our study, and falls under the moniker SIEPAC, the Spanish acronym for Electrical Interconnection System for the Central American Countries.

SIEPAC includes several electrical lines, the largest of which will stretch some 1800 kilometers in length, from Mexico to Panama **(**McElhinny, 2004: 15). The project is one of the largest components of the PPP, and like most mega-projects is the focus of a great deal of contention; on one hand it promises progress and affordable electricity, while on the other threatens ecological and social damage. Some even contend SIEPAC and its associated transport networks are the vanguard of an initiative to transform Central America into a free trade hub of cheap manufacturing and labour (Stenzel, 2006: 568-569). Of all the PPP initiatives, SIEPAC is the most technologically developed and well funded (McElhinny, 2004: 16). The resulting electric grid will be controlled by two organizations; a regional regulatory body and a regional operations body that both supersede national governments. The operator of SIEPAC is a consortium made up from a variety of private investors alongside the national electrical institutions of the various nations; the ICE in the case of Costa Rica. As with the Central American Free Trade Agreement, participation in such massive, supranational projects leaves nations with strong ecological regulations, like Costa Rica, at the mercy of private interests. The largest shareholder; Spanish energy corporation ENDESA, has a total worth (in 2004) of 16 billion dollars and

controls 10% of Central Americas electrical generation. This is larger than the GDP of several Central American nations (McElhinny, 2004: 16**).** One cannot simply assume state interests will triumph over private ones with stakeholders of this magnitude. These companies, and the international institutions behind them, have very clear ideas about the role of privatisation and government control over the environmental, social support networks and the like.

Costa Rica is, like many nations, moving towards privatisation of many of its industries, hydropower being no exception. Private hydropower projects were initially limited to only 15% of the electrical grid, however in the mid 1990s, this ratio was doubled to 30% (Lindo, 2006: 303**).** The state still maintains that private hydro projects be capped at a generative capacity of twenty megawatts, and that foreign investment in these projects cannot exceed 65% (Lindo, 2006: 303). While the limitations may curb some of the excesses of privatisation, I would maintain that private operation of these projects without significant government oversight will lead to increased environmental degradation, simply because ecological maintenance is not the priority of for-profit hydroelectric generation. Balancing ecological issue may actually impede profits. A succinct example is the projects in and around the ASBC. While environmental regulations limit the size of dams, greater profits are made by simply building more, as no regulations exist governing the number of dams per watershed (Lindo, 2006: 307). There is certainly no reason, at least not a financial one, for companies not to invest in as many dams as possible. Especially when one considers that when combined, the privatised hydropower operators have a greater income than that of the ICE, some 35 billion colones versus 32, respectively (Lindo, 2006: 307).

Fortunately for Costa Ricans, state control over energy distribution prevents the increases in hydro cost that have follow privatisation in much of Central America (Lindo, 2006: 304**).** At the same time, the inefficiencies experienced by states with privatised electrical grids have largely been avoided by Costa Rica, with the ICE, with a production loss of only 9%, compared to the 20-32% of other

Mesoamerican nations (Lindo, 2006: 304). It should come as no surprise to critics of privatisation that the mantra of increased efficiency stemming from profit motive and competition has proven unfortunately naive, as between 70 and 90% of private hydro projects in Mesoamercia are controlled by only two companies (Lindo, 2006: 304).

If we consider that Costa Rica produces enough energy to meet its own needs, then why the continual development of new hydro-electric facilities? The answer lies in export, as Costa Rica provides a considerable amount of electricity to its neighbours; Nicaragua and Honduras. Both nations have far less developed energy production industries, and when coupled with Costa Rica's greater stability and wealth, means they are ideal client states for the electricity market. Hydropower in Costa Rica should not then be discussed solely in the vein of a national infrastructure issue, but rather in its context as a regional hub of a capitalist energy production. Critiques of the industry are therefore not environmental imperialism; the idealistic dictates of foreigners enamoured with exotic locales, but rather a critique of a worldwide power industry that forms a major part of our own Canadian economy.

Eventually, this vast network will ideally supply the United States with electricity (Lindo, 2006: 299). State control, in the case of Costa Rica, has allowed a far more egalitarian distribution of energy compared with the dubious "trickle down" dispersal of infrastructure improvements and living standards in other nations. 98% of Costa Rica is electrified, a fact I can attest to as I charged phones and other paraphernalia with the same ease in rural homesteads and indigenous villages as I did in hotels. Other Mesoamerican countries, despite surplus electricity production within the nation, still have large amounts of people lacking this basic infrastructure (Lindo, 2006: 305**).** This is a considerable flaw in the privatisation model when applied to developing states, where a dearth of local wealth means exportation of generated power is far more profitable than the national market. While I can't begrudge investors for desiring to make profit in their enterprises, allowing the exportation of resources while the

country itself lacks seems at best counterproductive, and at worst almost criminally exploitative. These patterns are common to neoliberal economic plans that stress privatisation, especially of agriculture.

While avoiding many of the pitfalls of a privatised energy grid, Costa Rica is still faced with the not inconsiderable challenge of balancing its national conservation ethos with that of an increasing and lucrative hydropower industry. If the state is as comprehensively electrified as figures would suggest, then why the continuous implementation of more dams? The answer lies in Costa Rica's (and every other nations') place in a vast and enormously complex web of political and financial institutions, actors and agreements. States after all require income, and with Costa Rica refusing the exploitation of its fossil fuel reserves and protecting vast swathes of its forests from logging, the obvious candidate for export is water-driven electricity.

The Plan Puebla Panama has a great deal of potential impact beyond hydroelectricity. The other major component is roadways, especially highways (Stenzel, 2006: 556), designed to improve transportation of marketable goods rather than improve quality of life. Many critics assert that the infrastructural focus on macro-economic trade will have considerable detrimental impacts on both the environment and on society itself, especially in rural and indigenous communities (Stenzel, 2006: 560). Unlike many of the empirical calculations that inform economic policy, the social and environmental costs are difficult to quantify (Stenzel, 2006: 571**).** How does one calculate the value of draining 95% of the water from the Rio Penas Blancas? Should we focus only on literal costs to business? What about aesthetic value, or value of species that will vanish? What is the cost of depriving local children of recreational swimming areas? It is this reaction to the sharply economic focus that has given rise to a number of anti-PPP organizations, notably the Network Opposed to the Plan Puebla Panama (NoPPP), whom represent a common forum of diverse groups including indigenous rights, community advocates and environmentalists.

3.2 The Central American Free Trade Agreement

The Central American Free Trade Agreement is a US-sponsored initiative aimed at restricting state control and tariff barriers to trade, with the express intent of encouraging the growth of private business. Major supporters include the Inter-American Development Bank (IDB) and the World Bank (Stenzel, 2006: 575**).** Ideally, the agreement will facilitate American investment into Central America while simultaneously creating an alternative economic zone to China for the manufacture of low cost items. Opponents of CAFTA argue it will prevent Mesoamerican nations from growing their own food, bankrupt small farmers, encourage corporate bio-privatisation and increase poverty (Stenzel, 2006: 578)**.** American companies would also be free to compete with local, often state controlled industries such as insurance, telecommunications, water and electricity.

Fortunately for Costa Rica, the relatively stable economy of the nation allowed them to resist American pressure to privatise their state energy monopoly (Lindo, 2006: 309**).** CAFTA would seem to respect the environmental laws of the state, through its own Chapter 17 legislation; "a Party shall not fail to effectively enforce its environmental laws, through a sustained or reoccurring course of action or inaction, in a manner affecting trade between the Parties, after the date of entry into force of this Agreement", as well as "the Parties recognize that it is inappropriate to encourage trade or investment by weakening or reducing the protections afforded in domestic environmental laws (Lindo, 2006: 309). Both of these statements would seem to support the right of a state to assert its own environmental agenda over the external financial ones supported by private business.

The contention and the unease that accompanied the agreement stem from the rules governing private foreign investment under Chapter 10. This section is similar to the North American Free Trade Agreement (NAFTA) Chapter 11, one that has been roundly criticised by labour and environmental groups. The primary concern is the use of Chapter 11 to enforce private interests at the expense of

governments, essentially allowing corporations to sue government for damages when national environmental laws interfere with opportunity for profit. This provision was so broadly interpreted that it allowed investors to sue for any action that would adversely affect the value of property (Lindo, 2006: 310). The profusion of court cases led the US government to attempt to curtail Chapter 11 provisions in future treaties and to limit the legal rights of foreign investors to no more than those possessed by US citizens (Lindo, 2006: 310). CAFTA contains similar provisions under its own Chapter 10, which despite wording that legitimates domestic environmental laws, leaves room for slighted investors to bring lawsuits against nations like Costa Rica for enforcing their own environmental laws.

Costa Rica was brought to court by Harken Energy over the state's refusal to allow exploitation of its Atlantic coast oil reserves (Lindo, 2006: 311-312). In 2002, Costa Rican President Abel Pacheo announced a moratorium on both oil exploration and open-pit mining in Costa Rica, based on public pressure from concerned environmentalists. Harken, who had been granted to rights to explore for oil previously, failed the required environmental impact statement and was denied the opportunity to drill. Harken then attempt to sue the Costa Rica government for 12 million dollars in reparations. This may not seem like an unreasonable amount considering the company had invested time and money into a project later scuttled by new legislation. However, when Costa Rica failed to agree to the settlement, Harken took their case to the World Bank's International Center for the Settlement of Investment Disputes, and returned with a new claim under international courts. This new claim was for 57 billion dollars, some 4750 times the original amount and almost three times Costa Rica's entire GDP. Costa Rica refused to submit to international arbitration, leading Harken to withdraw its claim several days later. If the CAFTA agreement had been in place at this time, the consequences could have been far worse for Costa Rica, as it would not have been able to avoid international arbitration by financial institutions like the World Bank.

With Costa Rica joining CAFTA in 2004, the implications for the hydroelectric sector are obvious and troubling for environmentalists. The moratorium against dam construction by the county of Perez Zeledon, where Las Nubes and the ASBC are located, was repealed less than a year after its implementation. One can only imagine the political and legal pressures that were likely deployed against the county in this case. Under Chapter 10 of CAFTA, Perez Zeledon may have been legally liable to the dam operators for its refusal to allow construction. Interestingly, CAFTA would grant the right to foreigners to sue the government for enforcing its own environmental laws, yet Costa Rica citizens themselves have no such recourse in the case of enforcement failure (Lindo, 2006: 313).

3.4 Stakeholders

The Plan Puebla Panama, while ostensibly a co-operative between nations, gains its financial backing not only from its host countries, but also from powerful financial institutions, namely the Inter-American Development Bank (IDB) and the World Bank. The benefits of these projects are not solely social, not aimed at improving infrastructure for the betterment of people, but with the express intent of considerable financial return. This should be a troubling consideration, as the financial and social benefits of infrastructure collaboration with large banks do not have a good track record on an international level. Loans and conditions from the International Monetary Fund (IMF) for example, are notoriously controversial in both their usefulness as vectors of economic improvement and their distribution of created wealth. In many cases , IMF clients are trapped into a form of debt peonage, unable to repay the prodigious interest accrued and suffering the woes of IMF enforced cuts to social services, all under the auspice of modernity. The neoliberal rationale is the strengthened economic prosperity will result in increased democratic participation and quality of life. "A rising tide, that will lift all boats", if you will (Stenzel, 2006: 587). This is the mantra of trickle-down economics, an assertion met with considerable skepticism by most critics of neoliberalism. While the theory may be sound in some

cases, in many others, especially in developing countries, it falls flat. In Mesoamerica, relaxed government standards mean that while industry will certainly be profitable, workers will make only sixty to seventy percent of what workers in Mexico are paid (Stenzel, 2006: 588).

A cursory examination of current global trade relations and finance should highlight the one inescapable fact of our modern economic structure; that some people (most in fact), need to remain poor to facilitate the lifestyle of the "developed world". This state is far from self evident however, as the current trends of the political economy of the globe tend to assume this is a given. Underdevelopment is regarded not an integral facet of the global economy, but rather an opportunity, albeit a coercive one, to improve the state of national economy. This is not duplicity in most cases. Neoliberal financial and policy organizations, despite the reservations of many of their opponents, are not cartoonish characters, plotting world destruction with all the depth and complexity of a Bond villain. While the motivations of certain individuals may be somewhat nefarious or even criminal, many members of these groups genuinely believe in a form of development relies on economic modernization, free trade and globalized networks. The multi-national Organisation for Economic Co-operation and Development (OECD), provides a review through a 2006 policy brief that should provide a succinct example.

OECD provides an "objective" base for policy amongst the world's strongest economies, a forum of discussion and strategy aimed at globalized trade and free markets. For this purpose, Mesoamerica is a considerable well of untapped potential, both in profitable resources and location in the global trade system (OECD, 2006: 1)**.** Its location, between entrenched financial powers like the US, and rising ones like Brazil means an ideal zone for a trade middleman. This position is further strengthened by the narrow geography, permitting Atlantic-Pacific transport systems like the current Panama Canal, and the proposed Nicaragua canal. The negative aspects of the region are, I would think, very similar to those

espoused by opponents of neoliberalization; poverty; disparities between rural and urban citizens, regional instability, etc. The aforementioned Plan Puebla Panama is seen as the final success in a long line of regional integration initiatives (OECD, 2006:1). The strengths of the region are recognized as tourism, agro-industry, light manufacturing and logistics. Two of these, agro-industry and light manufacturing, are viewed with scrutiny and dread by both environmentalists and humanitarian agencies. Light manufacturing is often referred to under a less flattering moniker; sweatshops. It is with some trepidation that human rights advocates view the PPP, asserting that the unique geographical position of Mesoamerica means an ideal location for low-wage, unskilled labour assembling cheap commodities for the North American markets. While the garment industry in Bangladesh generates billions of dollars, one would be hard pressed to portray it as a desirable environment for a nation's citizen to work within. Nonetheless, OECD asserts that this form of industry, if managed appropriately, will propel the Mesoamerican region towards a desirable state of modernization. Increasing the region's competitiveness is at the forefront of this process (OECD, 2006: 3-6), often in the form of lowered wages.

Alongside a number of suggested programmes for increasing integration, quality and human capital, OCED makes an extremely troubling statement; that the recommended initiatives "require modification in the governance framework of Mesoamerica as a whole and within its member countries" (OECD, 2006: 5). That is a profoundly imperialistic statement to be so nonchalantly proposed in policy brief, especially when one considers that this vast political reform is proposed solely for the benefit of a specific economic action plan. Mesoregional governance; that of supranational co-ordination and control, is idealized for the implementation of these reforms. The Plan Puebla Panama is specifically mentioned as a prime solution to the lack of regional coordination that presents such an obstacle to economic development. Regional institutions are proposed as one of the vital steps in remedying the economic woes of Mesoamerica, with the Plan Puebla Panama's SIEPAC being a prime

example; a regional electrical authority that transforms national energy institutions from autonomous entities into shareholders. With centralised government institutions bound within a supranational market driven organization, the above mentioned modification of governance occurs far more subtly than a coup or regime change.

As a student of anthropology, I cannot help examining the use of language in these debates; language is not simply value free, but shapes one's world-view and understanding. For instance, the Plan Puebla Panama is specifically described as a corrective measure (OECD, 2006: 5). Correct as a concept asserts a binary of right and wrong, of simple answers lacking in depth and variability. It is also paternalistic and authoritative. Using it in relation to the vastly complex cultural, social and political melange that makes up Mesoamerica speaks to policy approaches conceived in reductionist, quantitative terms devoid of the human element. Interestingly, the OECD notes that governance reforms do in fact require the input of local data, both quantitative and qualitative, to evaluate the success of local development projects (OECD, 2006: 6). This does work to dispel the myth that Mesoamerican policy objectives are conceived solely in top-down fashion by executives in foreign nations. There is express focus on bottom-up, sub-national integration alongside the top-down planning. For our situation in Las Nubes, this is aptly displayed by the mixed reception of the dam projects in the local counties. Citizen groups have been mobilized on both the pro and against segments, highlighting the need for careful consideration for the complexities involved. Generalizations, about the dams, economy or the opinions of local people, especially by foreigners, must be carefully tempered.

Lastly, recognition must of course be given to those with a stake against the implementation of the PPP, including indigenous peoples, community groups and others. The internet has become a collaborative headquarters of sorts for those opponents of the plan (Stenzel, 2006: 590), distributed as it is across a vast geographical area. As well as groups dedicated to the opposition of the PPP itself, there

are organizations dedicated to opposing the myriad of side projects associated with, or supportive of, the PPP. For the sake of space and clarity, only those local to the ASBC and surrounding area are being considered here. The Movimento Rio Vivos, a Costa Rican group based in the counties of Perez Zeledon and Buenos Aires, is currently protesting the construction of the dam series across the southern Talamanca pacific slope, which includes Las Nubes. Indigenous communities have a particular stake in globalization, in Costa Rica and elsewhere. Many privatisation initiatives directly conflict with indigenous traditional practices concerning access and ownership, especially in regards to commercial pharmaceuticals (Stenzel, 2006: 596-597**)** which require natural chemical compounds**.** This appropriation is not limited to pharmaceuticals though, especially in Costa Rica where conflict has occurred over large hydro-electric projects and their commandeering of land and water.

3.5 Academia

When considering globalization in relation to Las Nubes, we must also consider the role of York University itself as a proponent of globalized trade. The fair-trade coffee for example, produced within the ASBC and sold in Toronto is just as a much a product of globalization as private hydropower projects. The Las Nubes project itself requires a certain amount of introspection, as we ask ourselves why we as students come here? Virtually all of the topics and themes of the Las Nubes field course could be covered and explored in Ontario, including indigenous rights, agriculture, hydro and wind power, forestry, endangered species protection, etc. My own home town of Oakville is currently engaged in a hydropower project on a small river in cottage country for example, leading me to question why I feel the need to travel across the continent to study such issues.

The first part of the answer is rather nebulous, dealing as it does with personal and societal notions of exoticism, entrenched academic (especially anthropological) notions of "going away" for field work and my general fondness for tropical biology. There are, after all, no crocodiles in Muskoka. The

second part has to do, I believe, with the globalization of knowledge. Perhaps this is an initiative amongst academics to remove themselves from notions of the "white tower", to actively integrate areas of study into practical, real world matters, accepting social and environmental responsibilities (Daugherty, 2002: 11, Winfield, 2010: 608). This is a process that in the case of Las Nubes, has culminated in collaboration between community, academic institution, conservation and business interests to produce a (hopefully) sustainable, equitable system that relies on the power of international markets. In terms of a product for international consumption, the intangible ethic of conservation is just as exportable, if not more so, than physical products like coffee (West, 2006**).** The commercialization of conservation as an economic incentive is often a staple of foreign planning, especially from academics and NGOs. The preservation of certain species and their habitat is touted as a lucrative activity (West, 2006: 190, 193), one which will bring tourism and its associated boons. In Costa Rica, we see this in operation in places like San Gerrado de Dota, where a dozen eco-lodges line a single valley road dedicated to sighting the Resplendent Quetzal bird. The Alexander Skutch Neotropical Bird Sanctuary fills a similar niche in the ASBC. The contention comes from the practical realities of these economic assertions, especially academic visitations? How long can an area support academic "tourism" once novelty has ended? Are these areas maintained for future academic knowledge rather than integral rights to existence? In some regards, "mining" tropical areas for knowledge and academic prestige is not much different from traditional extractive industries. Both require an assumption of "nature" as a resource, that something tangible can be taken from it be it knowledge, energy or matter. While the practical realities of managing ecosystem conflicts are important, we also need an introspective examination of how we conceptualize these relations, ones that form the basis of all interactions that follow.

4.0 Ontology, Technology, Ecosystem Entities and Cyborg Ecology

We have examined the practical applications and issues of the dam project in previous chapters, what follows is an examination of the essence of the dam, the philosophy of resource use if you will, as well as what I hope will be a novel take on holistic ecosystem conceptualization, one which includes abiotic, biotic and technological elements.

As human beings, our interactions are dictated by understanding and conceptualization, by internal frameworks that are often shaped as bipolar relationships (Haraway, 1988). These relations are also often mutually exclusive and antagonistic. As one of the most polarized debates in contemporary discourse, environmental integrity is a prime example. Conflicts rapidly become battlefields between differing ideologies, fuelled by assumptions of a fundamentally different and irreconcilable aspect to each position. These ideological positions become generalized and hyperbolic, as well as failing to recognize the contradictions and parallels that could serve to highlight the common ground. For example, the green, ecological ideology presented across Costa Rica as a state ethic towards interactions with nature has the flavour of nationalism in some respects, rather than a carefully considered national ethic. In the "green" gift shops of the San Jose airport, the wings of Morpho butterflies adorn earrings and jewelry carved from deep sea corals hangs from the shelves. Both species are threatened by habitat destruction and unsustainable collection practices, making them an odd addition to an environmentally friendly business in a "green" country. In the same vein, salespersons extolled the "natural" aspect of the indigenous Boruca masks, describing the organically derived colours that I knew from visiting the Boruca artisans to be acrylic paints. It is not enough for the Boruca to be original and phenomenal craftsman, creating a world renowned niche market. Instead they must be married to both a Western ecological ideology and a near-Holmsbergian lack of recognition for their own cultural adaption and innovation.

Practical operations everywhere in Costa Rica maintain the same quality of contradiction between usage and conservation (O'Keeffe, 2013: 185). Despite the ecologically friendly leanings of much of Costa Rica's policy decisions, the waste of major cities like San Jose was, until recently, dumped unfiltered into the country's rivers. In the Alexander Skutch Biological Corridor, grey water containing household chemicals and farming runoff is regularly washed into the ground and rivers. In other areas developed as sustainable communities, the proposed hydroelectric dam projects are derided as the end of local rivers, while pesticides are being wantonly sprayed adjacent to those same river systems. Conversely, the immense monocrop pineapple plantations maintained by large corporations utilize a regulated and structured system of technologies to mitigate environmental impacts. What I hope is now abundantly clear is that there are no easily defined sides in the environmental debates in Costa Rica (and elsewhere of course). We are all guilty of excess in one way or another, consuming some measure of energy or material that is unsustainable. Debates in this field require not only critical finger-pointing, but also reflexive introspection. Can we oppose hydropower in the ASBC, while the ASBC is running on hydroelectrically derived power from elsewhere in the country? It is too easy to say that *this* dam is the bad one, the one that affects us personally. Our positionality must be examined, our expectations of what the "natural" world either owes or bestows upon us is fundamental to understanding the debate over issues like hydropower.

While at a National System of Conservations Areas (SINAC) booth in Costa Rica, I noticed that listed among the various ecosystems services like carbon sequestration and water filtration, was hydro-electric power. This speaks to a very different conceptualization of the role the natural world plays in our lives. When ecosystem services are spoken of in Canada, they are typically those functions that the ecosystem performs without being forced by human beings. Once one goes down the road of including technological innovations like hydropower as an ecosystem service, virtually anything could be included within the category. Oil and pharmaceutical compounds would be two of the most lucrative and not far

off from the more typical understand of food production as an ecosystem service. The ecosystem does produce oil after all, simply in a geologic time scale unsuitable for our current consumption patterns. To borrow from a famous speech, society asks what the ecosystem can do for us, rather than what we can do for the ecosystem. This ethic is easily seen in the ecological flow calculations imposed on dammed rivers (Arthington, et al, 2013, Suen and Eheart, 2006), where a portion of the river is designated as surplus. Once we begin to view the ecosystem as a purveyor of services, it is inevitable that we also begin to ask; what more can nature give? This surplus, this reservoir of potential, is crucial for understanding the deployment of hydroelectric dams in Costa Rica, especially in regards to the ecological flow calculations that assume some 90% of the river's water is in fact a surplus of potential energy waiting to be accessed. To examine this further, I have turned to Martin Heidegger's *The Question Concerning Technology* (Heidegger, 1977), which aptly, if perhaps not succinctly, deals with this artificial imposition.

Heidegger first speaks of the essence of technology itself, a useful foray that separates technology from the essence of technology, two very different but coterminous aspects (Heidegger, 2977:1-2). Technology is a process, a practiced technique, not always a machine as it is often conceived of in the modern era. The fishing rod is not itself technology, *fishing* is the technology. The essence of fishing, as described by Heidegger, is something different. Technology is a "means to an end" (Heidegger, 1977: 2), the end in this case being the catching of fish for sustenance. The essence is the artificial imposition of a reservoir of potential upon the water course, or the population of fish themselves, that technology as practice allows the fisher to extract. Instrumentality is key in this process, the instrumentalization of "nature" into human endeavours. Flora and fauna removed from their habitats and reshaped into new forms to service our needs and hungers are one example. Rivers that now make electricity are another. What does it says for the creativity of human beings that we can look upon a watercourse and imagine the potential for lightning? This alchemy is referred to by

Heidegger as bringing forth (Heidegger, 1977: 5), a form of revealing that removes from concealment that instrumental potential of a thing. To be succinct, it is the naming of a resource, water in the case of the dam. In this regard, ecosystem services differ from technological services by their ways of revealing. Natural services reveal themselves, bring themselves forth, their instrumentality already found with their own existence. Technological services on the other hand, require human revealing, their nature concealed until brought forth by the practice of technology. Modern technology makes a demand, a challenge to nature that archaic forms do not (Heidegger, 1977: 6). A sail versus a turbine engine for example, one works in tandem with the air, movement dependent on its vagaries, while the other propels by capturing and unnaturally accelerating the same air. The saw mill as compared to the dam is another; one uses the shape of the river, while the other reshapes the river for its use. The essence here is control, in the archaic, nature controlled the technology, while in modern sense it is often technology that controls nature.

This process of challenging-forth **(**Heidegger, 1977: 7) involves the recognition (or creation) of energy surplus with natural system, followed by their revelation, and finally their transformation, storage and distribution. Central to this is enframing (Heidegger, 1977: 10-11), a sort of pre-emptive paradigmatic construction that precedes the act of technological instrumentalization of nature. Combined with modern physical science, enframing creates a form of destiny for those subjects enframed, a recognition of essence that is not simply being, but waiting. We see this clearly in the conceptualization of water in Costa Rica, where rivers are conceptualized as ecosystem services, their potential for electrical power generation an essential part of the river itself, rather than one we have forcibly imposed. When taken as a hegemonic force, this enframing makes alternative conceptualizations difficult to propose, forcing them into subaltern relationships with the dominant paradigm. In our case, this is plainly evident in the relationships between private electricity, the state and the rural inhabitants. Environmental concerns become a counterculture opinion, a dissident group

and potentially a threat to the ordering of nature promulgated by the dominant vision. This vision is all the more insidious thanks to the hegemonic nature of modern science, the power of "facts" as absolute and objective. To paraphrase Donna Haraway (1988: 581), this illusionary vision profanely creates technological aberrations with nature, "techno-monsters", of which instrumentalized nature inevitably becomes.

When looking at the nature/technology projects that we embark on; dams, monocrop plantations, forestry and other ecosystem engineering projects, one cannot help but return to Haraway's rather blunt assertion. The enframing proposed by Heidegger shares much in common with Haraway's "God-eye trick" (Haraway, 1988); the illusionary, hegemonic nature of modern science that asserts a singular truth, one that often falls into disaster when applied on a practical, technological basis. Heidegger asserts that technology is not simply applied physical science, as it is often represented. Technology involves the implicit philosophy of instrumentality. When applied practically, these projects often resemble the creations of fictitious scientists like Dr. Frankenstein or Moreau; unnatural reshaping that invariably reacts in unexpected and uncontrollable ways. Harnessed nature is much the same, that despite the predictions of modern science, unforeseen externalities are both inevitable and irreconcilable. While technology is sometimes deployed in attempts to mitigate such externalities, such as fish transport systems in American dams (Safina, 1997: 229), often these situations are treated as unforeseeable accidents that, once having occurred, are relegated to the realm of the uncontrollable. The onus for these problems is placed on the unpredictability of nature itself, a typical reaction from hegemonic power structures towards the uncooperative subjects of their manipulations.

Analysis of environmental conflicts requires an examination of vision, the situation of knowledge that Heidegger calls enframing. Enframing is not solely the province of the hegemonic however; all knowledge is situated in some context, recognizing how is the first step in a holistic examination of

environmental conflicts. One might assume that environmentalists situate their knowledge from a perspective opposed to mainstream hegemonic discourses from patriarchal authoritarian regimes. Often it seems that way, seemingly logical entreaties regarding resource use or health spurned in favour of capitalist profits or personal greed. Environmentalists may inadvertently replicate the authoritarian role we so easily bestow on private and state actors however, failing to recognize the power dynamic that comes from often wealthy, privileged foreigners asserting their own ideologies. This is especially evident when one considers the motives for relocating one's environmental efforts to another country, as the ability to exercise agendas may be considerably greater in less developed or wealthy states. A reflexive introspection into my own involvement begs the same question. Why Costa Rica; simply because the existing academic infrastructure facilitated the work? Perhaps my site selection was due to notions of exoticism and the "away" that often accompany conceptions of field work. Is it because of the potential to make a difference, to actually have academic work impact a community or ecosystem in a measureable way? The conservation ethos of the "West/North" tends to privilege charismatic species, rare ecosystems and the like, while in developing nations the focus is typically on sustainable use of resources (O'Keeffe, 2013: 185**)**, making our efforts as environmentalists more novel, if less utilitarian. A wide variety of amphibians and fish, all useless for human endeavours, are absent from scientific reports because, to a particular conceptualization of natural resources use, they simply don't matter.

In all of this my own positionality must be carefully considered. My knowledge is alternately situated in the context of a purveyor of a dominant, Western, "first world" conservation ethic as well as that of a dissident faction providing an alternative viewpoint to globalized, monopolistic enterprise. It is both top-down and bottom-up simultaneously, challenging the typical ontology that stresses a singular vantage point. This singular view, frequently invoked by environmentalists and their opponents alike, is *objectivity*, at once the most unassuming yet dangerous word in discourse. The illusion of objectivity, a single truth that exists outside of discourse, appears again and again in environmental conflicts, and is

prevalent within the ASBC hydropower debate. The various truths as known by each side in the debate are often enshrined as the only truth, failing to recognize that each is situated in a particular experiential basis, a construct of experiences and positionality that makes a mockery of reification. The assumption of an objective truth only legitimizes the choosing of sides and the failure to recognize similarities. Donna Haraway speaks to this in *Situated Knowledges* **(**1988: 575), asserting that the myth of objectivity is responsible for a widely understood invisible conspiracy of masculinity that opposes feminism in science. This is a familiar scene for those in environmental and conservation work, where oppositional agendas are often lumped together under the umbrella of a reified concept like capitalism, apparently incarnated with all the complexity of a cartoon "evil empire". Externalizing problematic elements like capitalism or imperialism allows for a disconnect between the negative outcomes and our own participation in said outcomes, however unintentional. Introspection into the situation of our own knowledge provides the opportunity to reveal these oversights, and our own participation in many problematic facets of global existence.

A cursory foray into the history of most scientific endeavours will reveal a complex and decidedly unscientific process involving political, financial and personal agendas, agendas that are starkly displayed in our study of the hydroelectric projects in the ASBC and surrounding areas. Given the immense political and financial forces being brought to bear on the Southern Pacific region of Costa Rica, I would find it extremely difficult to believe that the various scientific studies being conducted in the area are totally independent of outside influence. Objectivity in this case becomes less of an ideal to be sought, instead becoming a golden standard, a certification for reports and papers used to legitimize. We must all maintain this facade, this illusion, or be relegated to the "special interest" or fringe groups without the stamp of authenticity objectivity provides for authority regimes, be they state, academic or scientific. The problem with this recognition of objective falsehood is that it invalidates the singular solutions that accompany singular truths. The simplistic presumption of an "ecological flow" percentile,

for example (Arthington, et al, 2006: 1312**),** relies on the vision of reductionist, singular conclusions which ecologists are reluctant to make**.** Without an objective conclusion, finding a single answer becomes impossible, meaning compromises must be sought. In reality, this is how policy decisions are already made, however without explicit recognition of this, the opportunity for oppression or injustice on the part of the less powerful parties exists.

Central to this notion of objectivity is the concept of vision (Haraway, 1988: 581), one which Haraway notes can be a vehicle for partial, situated perspectives as well as the lens of objectivity. Vision in its hegemonic state is distanced from the observer, a gaze from nowhere, one that obfuscates its own presence. This is further reinforced when vision is captured through the lens of technology, as though images seen through machines are more "truthful", despite being directed by human will.

In order to shed the mantle of the objective false lens, the "god-eye trick" as Haraway (1988: 581) dubs it, we must move in the realm of partial perspective, simultaneously the most truthful and most subjective type of experience. Without becoming too Cartesian, I would stress that the only real truths are those understood individually, and when understood collectively constitute the closest we can come to an objective vantage point. The hydroelectric projects in the ASBC are, depending on one's perspective, modernizing development projects, entrepreneurial enterprises, ecological atrocities or necessary evils. They may be inevitable or frivolous, depending on how we relate to them. All of these perspectives have validity; all have elements of "truth". As we have seen in the ASBC, asserting a particular brand of truth is largely an exercise of power; be it political, economic or legal power. From those opposed to the projects, power can come from legal avenues like endangered species protection, from public opinion or organized protest. As a form of opposition to the hegemonic vision of the god-trick, subjugated viewpoints, in our case environmentalists and rural people affected by the projects, often provide a critical foil to the illusions espoused by a facade of objectivity. In many respects, my

fieldwork in the ASBC has been about doing just that, providing a counterpoint to the science contained in the EIS papers submitted for consideration of the dam's viability. The objective report published contained only a handful of species present in the area, our decidedly unscientific explorations of the surrounding areas yielded numerous other species. If one were to assume the illusionary nature of objective science as concrete, a reading of that report would leave the reader with a vision of the ASBC devoid of its biodiversity and populated with a variety of animals commonly regarded as undesirable pests. Similarly, we cannot rely on the view of the oppressed or subjugated as inherently more accurate. While those in a subordinated position may be more able to discern the critical failures of objective conclusions, the position is not itself privileged (Haraway, 1988: 584). There is also a danger of moving too far into the realm of relativism when questioning the applicability of singular vision epistemology, effectively seeing nothing where the "god-trick" sees everything (Haraway, 1988: 584). To prevent this, I prefer a holistic vision comprised of partial perspectives, one that privileges deconstruction and contestation (Haraway, 1988: 585).

My personal examination of the conflict over hydropower in the ASBC is very much in this vein, without, I hope, a binary oppositional discourse that segments the situation into easily defined categories. The major actors in this case are the local people, both for and against the dam projects, the governmental bodies associated in the project as well as the international actors like financial and academic institutions. Last and most certainly not least, is the ecosystem of the corridor itself, without its own voice in the realm of human discourse, a role which environmentalists must play. In this space, the rational, valid claims are those of the situated partial perspective as opposed to generalized, universal ones (Haraway, 1988: 589). The environment, while ostensibly an object, has its own agency of sorts, through language and culture, one that regularly confounds and surprises those who seek to manipulate or study it. Examining conflict requires the construction of a multi-sited lens, one comprised

of partial perspectives that can accept validity without falling into the gravity of the omniscient "god-eye trick".

The synthesis of partial perspectives applies equally well to ecology and the practical application of science to ecological issues. Given that generalized statements of fact are made more difficult as they are scaled up; spatially, temporally, etc, scientific studies often compartmentalize knowledge into very specific, niche fields dealing with a certain species, genus, or community within the ecosystem as a whole. Knowledge becomes segmented and isolated, and while conclusions become more definite, practical applications suffer. How can we reasonably expect to manage a species, or community of species, without simultaneous management of associated species in the environment? This partitioning is one of the major issues with the EIS reports conducted in the ASBC, each being isolated in terms of impacts from the other dozen or more reports (Anderson, Pringle and Rojas, 2006: 690). What about the cumulative impacts of these projects on an entire watershed? Within the corridor itself, the ecology of the Rio Penas Blancas is impossible to separate from the ecology of the area, being as it is the major water course and nutrient import/export vector between the mountains and coastal watershed.

My preference for a more holistic examination of ecosystem impacts has hopefully been made evident in the preceding chapters. For those of us interested in renewable energy sources utilizing natural forces like water, impact predictions must extend beyond the immediate environment to encompass the greater ecosystem. The emblematic bird of the Corridor, the Laughing Falcon, feeds primarily on snakes, many of which feed on amphibians, which themselves require both water quantity and quality for reproduction. The Laughing Falcon is well removed from the water itself, but the externalities of the dam impact its food source through a form of trophic feedback resonating through the ecosystem.

The concept of an ecosystem itself is a contested one in some circles, especially when it comes to practical management. Where does an ecosystem end? Is it reasonable for forestry managers to consider the impact that their logging might have on coastal fisheries many miles away? Just how far can we stretch precaution before it becomes absurdly speculative; considering the whole while maintaining practical applicability (Collier, 2011: 399)? These linkages between disparate subjects are quite clear after the fact, but far more nebulous in the prediction phase.

In order to assay the ecosystems we manage, various terms have come into use; resilience, stability, health, etc (Moulton, 2012: 423). The diversion between studies of communities; assemblages of species, and the greater material and energy flows of the ecosystem, have been largely separated in the field of ecology (Mouton, 2012: 423), with most work being done on the community side. This is not surprising, given the tendency towards specialization found in most sciences. Ecosystems, one the other hand, are less well defined, the term itself being found both in popular literature and scientific circles (Moulton, 2012: 423). Some have questioned the applicability of the term itself as a unit of analysis, questioning the usefulness to conservation projects and environmental policy (Moulton, 2012: 423-424). This I can certainly agree with, as the scale and complexity of ecosystems as a whole is daunting to the practical endeavour. This does not however, invalidate the ecosystem as an epistemological unit; rather it makes it a more challenging concept with which to interact. Mouton (2012: 424) notes that within ecology, there are various degrees in which ecology factors into discourse. On one end of the spectrum, there are those who work with a bottom up approach without a reliance on larger systems. The other side deals only with the larger forces at work, a top down approach. Both may fall into the illusionary trap of a "god eye trick" (Haraway, 1988); that one approach is the correct one. The question between them is largely one of control; do the macro-level forces influence the communities and species, or are they the power that generates the larger framework? This debate is strikingly similar to a structural

versus symbolic origin of society within sociology. Unsurprisingly, the practical application often requires consideration of both.

Without resorting to a chicken-and-the-egg debate (do the organisms make the ecosystem, or does the ecosystem make the organisms?), I believe that both concepts can be synthesized much as with Haraway's vision as discussed above. The ecosystem, rather than an omnipotent ordering process, is instead a vast gestalt of the partial experiences of those smaller perspectives within it. In this way, it is not simply an agglomeration of organisms, but a system that gains aspects beyond those granted by a sum of its parts. This idea, that ecosystems are actors, entities if not organisms, is perhaps more of a philosophically inclined one. At its most extreme extension, this proposes that the biosphere is itself a form of super-organism (Moulton, 2012: 424). Acceptance of this requires moving slightly beyond the bounds of mainstream science, as ecosystems as self-organizing entities are far more difficult to define then a "simple" living organism, which is concisely bounded as an analytical subject by taxonomy and more recently, DNA. This seems relatively cut and dry; however in practice most organisms, including humans, are reliant on vast numbers of other species residing on and in our own bodies for continued survival. We are all, in some respects, micro-ecosystems. Unlike organisms however, ecosystems are not structured by DNA, rather by geography, climate and other processes of the planet. Other demonstrable aspects of ecosystems as self-organizing entities are difficult to apply in practice, with the thermodynamic theory being a prime example (Moulton, 2012: 425). Other facets, whether one agrees with them as emergent properties or not, are readily measurable; including health, resilience, etc, and make for admirable, practical goals for conservation policy.

My interest in this field comes from its application not as a scientific tool, but rather as a conceptual one, a tool that I believe is vital to understanding and managing the conflict over hydropower that exists in the ASBC. For those interested in predicting the ecological impacts of the

proposed construction projects, a holistic vision is necessary for a valid conclusion. Without this inclusive vision, the predictions will invariably be incomplete and when applied in practice, likely disastrous. The applicability of ecosystems as holistic entities goes well beyond that of ecology however, as the "natural" components are only parts of the conflict in totality.

If one were to consider the Alexander Skutch Biological Corridor as an ecosystem entity in the fashion described by Moulton (2012), then one would be remiss in failing to incorporate the considerable human and technological elements present. Conceptually, the ecosystem entity called the ASBC is a cyborg, a sum total of biotic, abiotic and technological elements that function more or less sympathetically to process energy and survive. The cyborg nature of the corridor is not simply physical; it is bound into an ephemeral web of ideology and technology that is often seemingly beyond the control of its human creators. For Haraway (1991: 149), a cyborg is more than a trope of science fiction, it is a lived reality for society, albeit with an ironic tone I hope is not lost on my readers here. Haraway's cyborg is post-modern; reimaging hegemonic, hierarchal relations and embodying partiality. It is the perspective, or rather perspectives plural, of the boundless, non-naturalist reaction to the traditional knowledge structures of Western domination. It is both a utopian opposition to Western thought and a product of it; "the cyborg is also the awful apocalyptic telos of the 'West's' escalating dominations of abstract individuation" (Haraway, 1991: 150-151**)**. The cyborg, while oppositional, is without the innocence of vision often ascribed to the subjugated (Haraway, 1988: 584). We see this clearly in the Costa Rica; individualism in its apogee in the form of the corporation; a financial machine with the abstract, ideological rights of a human being. It is both the reification of abstract individualism, an individual without physical body, and the personification of self-destructive consumption. However the Corridor, and the people within, are both the subjugated and the architects of their own subjugation; inextricably bound within material frameworks that privilege consumer goods and oil/electrically motivated machines. There are no simply binaries here. Dams are lamented as the death of rivers while

pesticides are indiscriminately hosed alongside unprotected rivers and children. The very nature of the river is contested, whether it exists as a useable resource or an untouchable aspect of the ecology, replete with its own inalienable rights. Ecology is privileged while alien crops are tended and wastewater flushed into the environment. The Laughing Falcon is celebrated while the Fer-de-Lance is stoned to death in the street. All of these are partial perspectives, when drawn together form the gestalt consciousness of the area, one that is, in the words of Haraway (1991: 151**),** the "illegitimate offspring of militarism and patriarchal capitalism". The hydroelectric dam is not an invasion; it is an avatar of the greater conflict present within the area (and most of the world); technological determinism and the inexorable march of progress as opposed to self-determinism, social and environmental rights.

When we think of technology, especially in its incorporation into a cyborg body, we typically envision physical mechanical or electric technologies. Modern technology transcends such ideas however, existing as much as ephemeral electromagnetic signals and wavelengths (Haraway, 1991: 153). The constant web of communications found virtually everywhere is an aspect of this, the immaterial technology which makes us cyborgs comprised not of flesh and machine, but of flesh and electromagnetic waves. This makes for a far more insidious incorporation into our lives, as the mechanisms of our symbiosis are essentially invisible. Communications are now undertaken as much by converting brainwaves into electromagnetic signals as they are into crude kinetic vibrations that comprise sound. Such a powerful and omnipresent network remains largely invisible, physically and most importantly, as Haraway notes (1991: 154), invisible politically. In our examination of the ASBC hydroelectric conflict, this is an important consideration. Assuming a conceptual framework in which we view the ASBC as a holistic cyborg-ecosystem, the invisibility or obfuscation of technological elements and interconnectivity means projects like the dam stand out amongst the other primary visual subject; the "nature". This creates something of a false impression; that the ASBC is somehow independent of these connections like those brought by the dam. In reality, it is already well enmeshed into these types

of industries. The human elements of the ASBC already draw their power from hydroelectrically power energy grids. They are already wired into the invisible network of information through cell phones and wi-fi enabled computers, television and radio signals, all purveyors of the objective advancement of technology and its dubious driver; modernity. These networks are not all distributors of negative hegemony however, allowing communication and organization of dissent groups like those opposed to the construction of hydro-projects in their hometowns. The invisible cyborg network is both hegemonic and counter-hegemonic, in some respects it is a machine of control, in others a powerful tool of resistance (Haraway, 1991: 154). Whatever aspect one subscribes to, or even both, it is the intangible nature of this hybrid existence that should provoke the most introspection, primarily in its role of unspoken prophet of modernity. Instrumental power comes from this communication (Haraway, 1991: 164)**.** For Haraway (1991: 176), the cyborg perspective is the struggle against the one communication code that translates all, the verbal offspring of the "god-eye-trick" that understands all. A cyborg politics is one that privileges noise and illegitimacy, a practice of the partial perspective, one that subverts scientific, hegemonic ontology. It does so without assuming the privileged perspective of the oppressed (Haraway, 1991: 176). It makes a mockery of the dualisms that characterize much of our discourse, suggesting a mosaic, a chimera. As well as a cyborg, the ASBC is also something of a chimera, a hybrid ecology considerably modified with invasive and artificial species. How could one manage the ecology of the Corridor without the inclusion of the most numerous mammal outside human beings; the domestic canine? Haraway brings two major conclusions, both of which I feel are pivotal to our study in the ASBC (Haraway, 1991: 181**).** One, that universal, totalizing systems of knowledge miss most of the reality of their subject and two; a demonization of development and technology fails to recognize our own complicity in its existence.

5.0 Conclusion

When I was initially approached with the opportunity to become involved with the hydroelectric dam controversy in the Alexander Skutch Biological Corridor, I was reluctant. This seemed like a project for a biologist rather than a student of the social and cultural. It became apparent quite readily that while sciences like biology and ecology were an integral part of the debate, they were wielded by far more influential social and political forces.

Dams are, as I have hopefully made clear in the preceding sections, detrimental to the ecology of the surrounding areas. They create unnatural reservoirs without the ecology and geology that maintain equilibrium in natural water bodies, leading to water quality degradation and risk of disease. Dams block migration of sediments and other essential elements downstream. Conversely, they block the upstream migration of aquatic species, many of which are vital components of riparian ecosystems, providing ecosystem services like algae control, as well as food sources for larger animals. Dams fundamentally alter the chemistry and flow patterns of their host rivers, leading to degraded habitat for species downstream of the barrier. Dams carry the risk of catastrophic events that may damage or destroy entire aquatic communities. All of these are well documented in cases all over the world. Despite this, hydroelectric power is increasing thanks to its renewable nature, the negative externalities simply the price we must pay to divorce ourselves from reliance on fossil fuels. In nations like Costa Rica, it makes up the bulk of the country's energy strategy. Even the "superfluous" energy being generated is exported to other nations, providing an important revenue stream that allows the country to maintain the ecologically-friendly policies lauded by environmentalists.

This paradox is one of the most important questions for those dealing with environmental issues, one of the most pressing concerns of our time. Environmental debates are no longer a fringe segment; they are major policy discussions that make worldwide news on a near daily basis. How do we

go about resolving the apparent disconnect between our use of energy and abuse of the environment? I could not help but feel somewhat hypocritical critiquing the dams slated for the ASBC while charging my electronics on power generated by dams on some unseen river elsewhere in the country. The arguments that more dams are unnecessary as Costa Rica has enough energy, are largely reliant on a current standard of living; a temporal position that creates an artificial norm. While Costa Rica does have "enough" energy, it would require much less without the use of cell phones, televisions, computers and other technological paraphernalia. It would also require much more if every house was equipped with air conditioners in the manner of North America. "Enough" is relative to not only a particular standard of living, but a particular standard of economy. Water in this case is a natural resource, one which helps fund a state with highly developed social systems and conservation initiatives.

There are more sinister elements to the construction in the ASBC. Privatisation is one; that the dams are constructed not for the betterment of the state, but with the explicit purpose of creating profit. Canada faces a similar situation with our oil-sands in Alberta. While these are important sectors of the provincial and national economies, they are operated by private companies intent on making immediate financial returns, rather than on the long-term ramifications of their actions. Corporations have no problem simply relocating when conditions are no longer favourable, in search of cheaper wage and manufacturing costs, a stark example of profit-focused ethics. It is in this vein that I feel comfortable lodging a critique of current hydroelectric trajectories in Costa Rica. Unlike government run projects which ostensibly operate for the benefit of the nation, private operations have little to no incentive for long term ecological maintenance, save for that imposed by the state. Compounding this is the involvement of government hydroelectric management institutions with supranational groups like SIEPAC, shifting focuses from a national level to include the wellbeing of other nations and most troublingly, corporate shareholders.

For those emerging academics like myself working in the ASBC, or areas like it, recognition of these paradoxical elements, these convoluted global forces, these hypocrisies, injustices and goals, is vital to the prevention of replicating the hegemonic domination that comes with singular vision. This issues, and those like it worldwide, are never "simply ecology", interwoven as they are with ideological, technological and social systems. Ecological issues are no longer "natural"; they are multi-species hybrids, technological cyborgs, vivisected organisms that are both constructed and autonomous, created by us and creating themselves beyond our control.

5.0 Bibliography

Anderson, Elizabeth P. Pringle, Catherine M and Rojas, Manrique.

2006 Transforming Tropical Rivers: An Environmental perspective on Hydropower Development in Costa Rica. Aquatic Conservation: Marine and Freshwater Ecosystems 16: 679-693.

Anderson, Elizabeth P., Pringle Catherine M and Freeman, Mary C.

2008 Quantifying the Extent of the River Fragmentation by Hydropower Dams in the Sarapiqui River Basin, Costa Rica. Aquatic Conservation: Marine and Freshwater Ecosystems 18: 408-417.

Anderson, Elizabeth P.

2013 Hydropower Development and the Ecosystem Services in Central America. Inter-American Development Bank; Environmental Safeguards Unit.

Arthington, Angela H., Bunn, Stuart E., Poff, LeRoy and Naiman, Robert J.

2006 The Challenge of Providing Environmental Flow Rules to Sustain River Ecosystems. Ecological Application 16 (4): 1311-1318.

Bergkamp, Ger, McCartney, Matthew, Dugan, Pat, McNeely, Jeff and Mike Acreman

2000 Dams, Ecosystem Functions and Environmental Restoration. Thematic Review II.1, World Commission on Dams, Cape Town.

Calheiros, D.F., Seidi, A.F. and Ferreira, C.J.A.

2000 Participatory Research Methods in Environmental Science: Local and Scientific Knowledge of a Limnological Phenomenon in the Pantanal Wetland of Brazil. Journal of Applied Ecology 37 (4):

684-696.

Collier, Kevin J.

2011 The Rapid Rise of Streams and Rivers in Conservation Assessment. Aquatic Conservation: Marine and Freshwater Ecosystems 21: 397-400.

Daugherty, Howard E.

2002 Biodiversity Conservation and Sustainable Community Development in the Los Cusingos - Las Nubes Biological Corridor in Southern Costa Rica. Las Nubes. Accessed from http://www.lasnubes.org/publications.

Davis, Jason

2009 The Creation and Management of Protected Areas in Monteverde, Costa Rica. Global Environment 3: 96-119.

Dunbar, Michael J, Warren, Mark, Extence, Chris Baker, Lucy, Cadman, Dan, Mould, David J, Hall, Juliette and Chadd, Richard

2010 Interaction between Macroinvertebrates, Discharge and Phyiscal Habitat in Upland Rivers. Aquatic Conservation: Marine and Freshwater Ecosystems 20: S31-S44.

Freeman, Mary C, Pringle, Catherine M., Greathouse, Effie A., and Freeman, Byron J.

2003 Ecosystem-Level Consequences of Migratory Faunal Depletion Caused by Dams. American Fisheries Symposium 35: 255-266.

Gower, T., Rosenberger, A., Peatt, A. and Hill, A.

2012 Tamed Rivers: A Guide to River Diversion Hydropower in British Columbia. British Columbia: Watershed Salmon Society.

Greathouse, Effie A., Pringle, Catherine M. and Holmquist, Jeff G.

2006 Conservation and Management of Migratory Fauna: Dams in Tropical Streams in Puerto Rico. Aquatic Conservation: Marine and Freshwater Ecosystems 16: 695-712.

Haraway. Donna

1988 Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective. Feminist Studies 14 (3): 575-599.

Haraway, Donna

1991 A Cyborg Manifesto: Science, Technology and Socialist-Feminism in the Late Twentieth Century. In Simians, Cyborgs and Women: The Reinvention of Nature. New York: Routledge.

Heidegger, Martin

1977 The Question Concerning Technology.

Hidroelectrica Buenos Aires

2013 EsIA Penas Blanquitas I & II. Accessed online from http://riosvivos.com/estudios-de-impacto-ambiental/.

Ledec, George and Quintero, Juan David.

2003 Good Dams and Bad Dams: Environmental Criteria for Site Selection of Hydroelectric Projects. Latin America and Caribbean Sustainable Development Working Paper 16. The World

Bank: Environmentally and Socially Sustainable Development Sector Management Unit.

Lindo, R. Victoria

2006 Hydroelectric Power Production in Costa Rica and the Threat of Environmental Disaster Through CAFTA. Boston College International and Comparative Law Review 29 (2): 297-321.

Lyons, John

2005 Distribution of *Sicydium Valenciennes 1837 (*Pisces: Gobiidae*)* in Mexico and Central America. Hidrobiologica 15 (2 Especial): 239-243.

McElhinny, Vince

2004 PPP Energy Integration Initiative (SIEPAC). In Plan Puebla Panama: Battle Over the Future of Mesoamerica, 2nd Edition. Network Opposed to Plan Puebla Panama. eds. Pp 15-17.

McLarney, William O. and Mafla, Maribel H

2007 Probable Effects on Aquatic Biodiversity and Ecosystem Function of Four Proposed Hydroelectric Dams in the Changuinola/Teribe Watershed, Bocas Del Toro, Panama, With Emphasis on Effects Within the La Amistad World Heritage Site. Accessed online from http://2011gift.biologicaldiversity.org/campaigns/panama_rainforest_and_rivers/pdfs/Technical_paper_supporting_La_Amistad_Petition_4_23_07.pdf

McLarney, William, Mafla, Maribel H., Arias, Ana Maria, Bouchonnet, Danielle

2010 The Threat of Biodiversity and Ecosystems Function of the Proposed Hydroelectric Dams in the La Amistad World Heritage Site, Panama and Costa Rica. UNESCO World Heritage Committee.

Moulton, Timothy P. and Wantzen, Karl Matthias

2006 Conservation of Tropical Streams – Special Questions or Conventional Paradigms? Aquatic Conservation: Marine and Freshwater Ecosystems 16: 659-663.

Moulton, Timothy P.

2009 Defying Water's End: Do We Need Different Conservation Strategies for Aquatic Systems Compared with Terrestrial? Aquatic Conservation: Marine and Freshwater Ecosystems 19: 1-3.

Moulton, Timothy P.

2012 Ecosystem Theory and Conservation. Aquatic Conservation: Marine and Freshwater Ecosystems 22: 423-426

OECD

2006 Policy Brief: OECD Territorial Reviews: the Mesoamerican Region. Organization for Economic Co-operation and Development, March; 1-8.

O'Keeffe, Jay.

2013 Rivers, Time and Conservation, Especially in Developing Countries. Aquatic Conservation: Marine and Freshwater Ecosystems 23: 184-188.

O'Neill, Brendan

2004 Plan Puebla Panama: Battle Over the Future of Mesoamerica. In Plan Puebla Panama: Battle Over the Future of Mesoamerica, 2nd Edition. Network Opposed to Plan Puebla Panama. eds. Pp 4-7

Ramos, Gian Carlo Delgado

2004 The Mesoamerican Biological Corridor: Biodiversity for Sale? In Plan Puebla Panama: Battle Over the Future of Mesoamerica, 2nd Edition. Network Opposed to Plan Puebla Panama. eds. Pp 18-20.

Rapson, Aileen, Bunch, Martin and Daugherty, Howard

2012 A Decade of Change: Assessing Forest Cover and Land Use Trends in the Alexander Skutch Biological Corridor, Costa Rica. Faculty of Environmental Studies, York University. Toronto: Canada.

Rolls, Robert J., Ellison, Tanya, Faggotter, Stephen and Roberts, David T.

2013 Consequences of Connectivity Alteration on Riverine Fish Assemblages: Potential Opportunities to Overcome Constraints in Applying Conventional Monitoring Designs. Aquatic Conservation: Marine and Freshwater Ecosystems 23: 624-640.

Savage, Jay M.

2002 The Amphibians and Reptiles of Costa Rica: A Herpetofauna between Two Continents, between Two Seas. Chicago: University of Chicago Press

Smith, Lacy

2006. Flaming Gorge Effects on Amphibians, Reptiles and Mammal Populations. Accessed online from *www.geology.ucdavis.edu/~shlemonc/html/trips/.../Smith_**mammals**.pdf.*

Stenzel, Paulette, L.

2006 Plan Puebla Panama: Economic Tool That Thwarts Sustainable Development and Facilitates Terrorism. William and Mary Environmental Law and Policy Review, 30 (3): 555-623.

Suen, Jian-Ping and Eheart, J. Wayland

2006 Reservoir Management to Balance Ecosystem and Human Needs: Incorporating the Paradigm of the Ecological Flow Regime. Water Resources Research 42: 1-9/

West, Paige

2006 Conservation is Our Government Now: The Politics of Ecology in Papua New Guinea. United States of America: Duke University Press.

Winfield, Ian J.

2010 Meeting Across the River: From Science to Impact. Aquatic Conservation: Marine and Freshwater Ecosystems 20: 607-610.

Wright, Jessica

2010 Biomonitoring with Aquatic Benthic Macroinvertebrates in Southern Costa Rica: In Support of Community Based Watershed Management. Canada: York University Faculty of Environmental Studies.