INDUSTRIAL HEARTLANDS OF NATURE: THE POLITICAL ECONOMY OF BIOLOGICAL PROSPECTING IN MADAGASCAR

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ABSTRACT OF THE DISSERTATION

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This dissertation centers on the 50 year history and politics of biological prospecting in Madagascar. I examine three case studies of drug discovery and development and analyze the politics of access to biogenetic resources used in bioprospecting. The three cases featured in the dissertation include the commodity chains centered on the medicinal plants, rosy periwinkle (*Catharanthus roseus*) and *Prunus africana*, and the contemporary bioprospecting project launched under the auspices of the International Cooperative Biodiversity Groups (ICBG). It involved 14 months of intensive ethnographic field surveys and participant observation carried out in 2005 and 2006. These were implemented in multiple sites in northern town of Antsiranana, the central region of Bealanana, and the southern regions of Anosy and Androy. It also included interviews with scientists in laboratories, state institutions, and NGOs in the capital of Antananarivo. I document how bioprospecting has changed over time in terms of technology, laws of access to resources, and the actors involved. I found that there has been a move towards a more mechanized and rationalized process by the industry, both spatially and economically. This move can be explained by the many attempts to control the “natural” and social barriers that impede production, and to overcome the place-based conditions of production. Rather than the full industrialization of the process, however, my analysis highlights countervailing instances where "nature" still holds sway. Results show that scientists and bioprospecting firms overcome these “natural” obstacles primarily by gaining and maintaining control over rural labor, negotiating access to endangered forests, and alienating thousands of plant specimens from their places of origin. This is explicitly seen in contemporary bioprospectors’ shift from collection based on place-based traditional knowledge towards rational collection, the de-skilling of the Malagasy labor force including bench scientists, and creating global storehouses of botanical knowledge, all of which are efforts used to speed up the production process and place it more firmly under industrialized control. These developments, in turn, cause some Malagasy scientists, researchers and administrators to question their participation in bioprospecting projects and reveal that current natural resource policies of extraction, commercialization and benefit-sharing face many challenges.

Preface

This project first began in 2003 as a graduate student at Rutgers University in New Jersey. It is a combination of my scholarly academic interests in political ecology and economy and professional experiences in international development and natural product commercialization in Madagascar, Africa, and in the U.S. This work was informed by seven months (September-November 1999 and May-July 2000) I spent working on my Master's thesis, "Vegetative propagation strategies for agroforestry trees," trees in the eastern rain forests of Madagascar. For my Master's work I conducted a mixed-methods approach using quantitative propagation experiments and qualitative interviews with farmers about multipurpose fruit and high-value homegarden agroforestry systems, called *tanimboly* in Malagasy. The purpose of this work was to develop sustainable agricultural alternatives to swidden cultivation in Madagascar. While conducting my Master's research, I came to the conclusion that the benefits derived from sustainable development schemes implemented by NGOs were shared unevenly by participants across the rural landscape in Madagascar. It was out of this work that I decided to investigate the effects of a large scale bioprospecting projects in Madagascar to see how bioprospecting policy was implemented and benefits shared among the participants of the practice. In particular, who was profiting most from the commercialization of Malagasy biodiversity, and why?

This dissertation would not be possible without the outstanding support of Richard Schroeder. His dedication to mentoring and advising went above and beyond. I am indebted to his tireless encouragement and skillful editing. I would like to thank my tremendously supportive dissertation committee members, David Hughes, Kevin St.

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My family was supportive throughout the dissertation process, providing invaluable financial and moral support. I am particularly grateful to my parents and family, Gloria and Nelson Neimark, Jessica and David Feldan, and Jason Neimark, for their patience and support thought this long journey of discovery. Finally, my academic colleagues, and close friends who were always there for me, Sharon Baskind, Chelsea Booth, Adam Diamond, Cynthia Gorman, Andrew Gerkey, Glenn, Torie, and Eli Lines, Dillon Mahoney, Emily McDonald, Rhonda Prenski, Debarati Sen, John Wing, and Bradley Wilson. Last but not least, a *gros bisous* to my loving wife Céline and baby boy Raphael,

without their love and support my life wouldn’t be so enjoyable or complete. This dissertation is dedicated to my mother and in loving memory of my father.

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Chapter 1

The biological prospecting *filière*: Political economy of access and extraction in Madagascar

Problem and rationale

In the late 1980s, the famed biologist Norman Myers published a series of articles that drastically modified the global conservation map. Calling attention to locations with unusually high concentrations of species endemism and areas facing exceptional threats of species extinction, Myers argued that these "hotspots" should be accorded the highest priority for protection (1990; 1988). Myers' original article identified 10 hotspots for protection, and two years later, he expanded his list to 18. By the year 2000 it had grown to 25 (Myers, 2000; Mittermeier, et al., 1999), and by 2004, 34 hotspots had been proposed for special attention (Mittermeier et al., 2004). Throughout this period of hotspot proliferation, there was one site in particular, the island of Madagascar, which was continually recognized as one of the "hottest" of all other hotspots (Myers, et al., 2000).

It is easy to see conservationists' attraction to Madagascar. Split off from the supercontinent Gondwana roughly 160 million years ago, Madagascar is the fourth largest island and the world's largest oceanic island (Mittermeier et al., 1999). Due to its convergent evolutionary history and unique bio-geography, it is endowed with some of the most mysterious and unique flora and fauna, playing host to an estimated 13,000 flowering plant species of unmatched endemism including 25 percent of the genera and eight entire families (Rasoanaivo, 2002; De la Bâthie, 1933). Madagascar also boasts of unparallel fauna, with amphibians and primates at 99 percent and 100 percent endemic rates, respectively (Goodman and Benstead, 2005).

It is not only conservationists who have taken note of the value of Madagascar's unique flora and fauna, however. Every year, thousands of plants, amphibians, insects, marine animals and microorganisms are identified, collected and transported off the island for use in drug discovery and development. Plant parts and insects are extracted out of the high, humid forests of the east; succulents are gathered in the western dry-spiny forests; and soft coral sponges are fetched on the northern reefs. The unique flora and fauna have distinctive biological traits and exceptional chemical properties, highly attractive for those who wish to discover new drugs. It is in this context that the pharmaceutical industry, like Norman Myers, places a special value on Madagascar's nature.

The systematic search, screening, collecting and commercial development of valuable genetic and biological resources is sometimes called "bio-prospecting" (Laird, 2002; Reid et al., 1993; Eisner, 1989). As the term suggests, bioprospectors, similar to those who search underground for gold or semi-precious stones, are also on an exploration mission - to locate, test, isolate, and extract the distinctive chemical scaffolding concealed under layers of cellular tissue and transformed by years of evolutionary history.

The classic image of bioprospectors was embodied by descriptions of the daring Western ethnobotanist surrounded by "indigenous" forest dwellers, preparing a concoction of a "traditional" medicinal remedy - a la Dr. Schultes and the Amazonian natives.[1] However, contemporary bioprospecting in Madagascar is a very different enterprise; the circulation of valued biogenetic material is orchestrated by a number of foreign and Malagasy scientists, research institutions, businessmen, environmental organizations and individuals, many of whom are associated with highly-structured projects and commercial operations. Contemporary bioprospecting is a process that begins with the collection of tons of leaves and bark from the most remote villages brought to large scale pharmaceutical labs in the U.S. and Europe and run through super high throughput bioassays capable of a million screens per day. What was once the provenance of the "barefoot doctor" looking for the cure to all of humanity's ills under the canopy of the rainforest, has now turned into an elaborate industrial process that uses some of the most advanced technology to turn nature into drugs. Bioprospectors are continually seeking new ways to mechanize the process of drug discovery and exclude nature from the process altogether. However, as this dissertation demonstrates, there are countervailing forces driving bioprospectors to return to "nature" to access biogenetic resources find ways to overcome the obstacles to capital accumulation by "industrializing" nature, knowledge and labor at the sites of production.

Although there are a number of accounts of the worldwide practice of bioprospecting, surprisingly little attention has been directed towards Madagascar, one of the premier

[1] The famed Harvard ethnobotanist, Dr. Richard Evans Schultes, was once known as the "father of modern ethnobotany" (*NYT*, 2001). He was director of Harvard's Botanical Museum and was recognized as establishing ethnobotany as a universally recognized academic discipline.

sites of bioprospecting in the world.[2] This dissertation remedies the absence of studies conducted on the practice of bioprospecting in Madagascar. It is informed by 14 months of on-site ethnographic research on the practice of drug discovery and development from plants and other natural products. By taking into account explicit historical trajectories, subjectivities and the embeddedness of those who are included in, and excluded from, the practice, I shift the current debate surrounding bioprospecting from a dichotomy of development/piracy to specific sites where bioprospecting takes place through a detailed account of the bioprospecting labor processes.

In the dissertation, I demonstrate the increasing efforts by bioprospectors to "industrialize" the overall process of drug discovery and use chemical substitutes instead in attempts to disengage from nature altogether (Parry, 2004; 2000; see Chapter 2). These technological changes in the industry have been laid out in detail within the literature by Bronwyn Parry and others (2004; 2000; see also Dorsey 2003; Hayden 2003). In her work, Parry documents how historical and contemporary bioprospecting collections have yielded disproportionate amounts of power to botanical institutions and repositories (2004; 2000). For Parry, access to emerging technology has allowed the owner of these collections to accrue immense commercial value for corporate actors involved in bioprospecting. I seek to move beyond Parry’s analysis to focus concerns the structural and scientific relations of the collection process itself, and how changes in the industry over time have affected particular sites of production in Madagascar. I will show how even with all the technology at the disposal of the industry described by Parry,

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[2] Most of this work has been focused on legal aspects of bioprospecting (see Quansah, 2003; in the French literature see Philippe Karpe, 2002).

bioprospectors are still continuingly looking to return to nature to collection valuable resources for drug discovery. The dissertation highlights three case studies in which researchers must return to “nature” in Madagascar. Results show that scientists and bioprospecting firms overcome many of the “natural” obstacles primarily by gaining and maintaining control over rural labor, negotiating access to endangered forests, and alienating thousands of plant specimens form their places of origin. This is explicitly seen in the shift from traditional knowledge towards rational collection, the de-skilling of the Malagasy labor force, and efforts used to speed up the production process and place it more firmly under industrialized control.

On the bioprospecting trail

In November 2005, I was fortunate to observe a bioprospecting expedition. I was the lone *vazáha* (foreigner, in Malagasy), in a group of Malagasy scientists, researchers, guides and porters.[3] Equipped with our headlights, plant clippers, sisal-sacs and *antsy-be* (elongated machetes), we were traveling thorough the heart of Madagascar’s “vanilla triangle” on our way to the remote region of Daraina, a relatively unknown forest nestled within the isolated Loky and Manambato River valley in Madagascar’s northernmost province of Antsiranana.

During our expedition, I was listening attentively to the lead botanist of the group, Jean, as he explained the purpose of a Geographic Positioning System (GPS) device to a group

[3] The term *vazáha* in Malagasy means foreigner. The term traditionally was used to signify white Europeans during the colonial period is sometimes used by ethnic groups on the coasts referring to people of the highland Merina group.

of porters he hired from a nearby village.[4] Jean remarked: “The device was given to me by a U.S. botanical repository. It is used to locate my exact position when I collect a plant, and when the plant is analyzed in a laboratory in the U.S. and found to have interesting medicinal qualities, I then can return to the spot and collect more.”[5] After hearing Jean’s description, I was interested in finding out what exactly the porters knew about bioprospecting, so I chimed in to ask what they thought of people from the U.S. being so interested in plants growing in their backyard. One porter responded in the Antankarana dialect: “…what does a *vazáha* want with plants? Sapphire, gold, yes, but plants?” [6] The fact that this was the first time the porters had seen a GPS device was not very surprising since this remote area hosts relatively few outsiders, but I was interested to learn that the porters had not heard of the team’s reason for prospecting for plants. Surely, they would at least be informed of the purpose of the trip. Were these hired laborers not *part* of the bioprospecting mission?

The research team (including myself) was perceived by one of the porters who spoke French as “*vazáha qui suivent le chemin des anciens prospecteurs*” or “whites who follow the path of previous prospectors.”[7] Those hunting for minerals and other riches have a long and storied history in Madagascar, and especially in Antsiranana which is home to a wealth of precious gems and historically was the site of the biggest gold deposit in the country (Campbell, 1988). The porter, who might have been hired to carry bags for mineral prospectors in the past, was now part of a new type of prospecting

[4] All names of research participants are pseudonyms. Malagasy village names have also been changed.
[5] ANON 4 (June 20, 2005).
[6] ANON 15 (June 20, 2005).
[7] ANON 7 (June 20, 2005).

mission, one in which the correct biology and chemical tinkering might produce a new drug with value vastly more significant than gold or sapphires. Also, as with previous missions, the porter was attempting to personally benefit as much as he could; however, in this case, his take only amounts to a one day wage of 5000 Malagasy Ariary (approx. U.S. $2.50). In the opinion of one leading conservation practitioner, whose organization is part of the bioprospecting mission, "…They [the porters] are happy to cash in their bioprospecting chips. It's like someone who gets paid to shovel in a gold rush."[8] This statement adds to the multiple complexities of benefits and burdens that exist within bioprospecting, and is reminiscent of Martinez-Alier's notion of inequality in the Third World, that "[t]he poor sell cheap" (2002:22).

Industrial heartlands of nature: The intersections of bioprospecting and hotspot conservation in Madagascar

"Such forests are, as it were, the industrial heartlands of nature, where a rich supply of energy mobilizes the earth's minerals and chemicals to make more kinds of products."

-The other group of seven (*Economist*, 1988)

A focused alternative to earlier piecemeal conservation strategies that were highly localized and exclusionary in context, the "hotspot" conservation strategy targets unique areas that contain exceptional biological species. It also builds on a larger conservation shift that took place in the latter half of the 20th century away from draconian methods of "fences and fines" (Anderson and Grove, 1987) and toward more market-based approaches (Peet and Watts, 2004; 1996; McAfee, 1999; Neumann and Schroeder, 1995). This wave of environmental policy was facilitated in the Third World by multilateral and bilateral donor institutions and their macroeconomic approach to rural development and

[8] ANON 42 (Jan. 17, 2006).

debt reduction, including decentralization, community-based management, buffer-zones and "sustainable" income generation schemes such as bioprospecting (Schroeder, 1996; Escobar, 1995; Redclift, 1987).

In Madagascar, bioprospecting has been carefully packaged as an engine for economic development and fueled by the "hotspot" conservation strategy. Its proponents maintain that monetary benefits derived from the discovery of natural products will help prompt rural Malagasy to embrace biodiversity conservation (Kingston, 2006; Miller et al., 2005). However, it is under this rubric of conservation and development, that we are now witnessing the congruence of bioprospecting with the enclosure of large areas of territory. This matching of interests between the global conservation community and multinational pharmaceutical companies is, in effect, transforming "nature under capitalism," and uses the "protection" of parks and protected areas in Madagascar as an accumulation strategy (Katz, 1998:48; see also Heynen et al., 2007; Smith, 1984). This development is clearly highlighted in Madagascar where the same sites that house some of the most critical biodiversity targeted for extraction by bioprospectors have been secured under the most aggressive conservation. Furthermore, bioprospecting tends to be conducted in rural areas where residents are reliant on natural resources that grow in areas now targeted for bioprospecting and conservation. This raises significant questions of *distributive justice* surrounding the purported benefits and unforeseen burdens of participation (see Chapter 5).

It is within this *milieu* that particular policies and interventions constructed to improve livelihood strategies within vulnerable populations are rather adversely affected by the intervention itself (Brechin et al., 2003; Zerner et al., 2000; Schroeder, 1999; Rochelaeu et al. 1997; Peluso, 1992). Hughes (2006) observes that inequalities that stem from the uneven development of environmental policy are often found within “frontier” conservation zones. These frontiers, namely forests and agrarian land, are purposely represented by conservationists as “wild,” “untouched,” and "extremely threatened," so as to make policy interventions less political and to reduce the potential for resistance by rural residents (Hughes, 2005; see also: Neumann, 1998; Adams and McShane, 1996). Contrary to being “wild” uninhabited areas, however, in reality these pockets of “hotspots” in which bioprospectors operate are populated by different interest groups: settler farmers, shifting cultivators, and absentee urban landholders. Questions of the legitimacy of such interventions and broader moral economic questions have been raised in rural areas where conservation and bioprospecting most directly overlap and affect the livelihoods of vulnerable populations (see Chapter 5).

Access and control of natural commodities

For some time, scholars and policy planners have been developing theories focused primarily on "property" as a way to understand formal rights, legal claims or customary rights to natural resources (Ribot, 1998; Schlager and Ostrom, 1992; MacPherson, 1978). These rights are based primarily on Locke's notions of property and are generally characterized as liberal and individualistic. According to Locke, property (mainly of land) is derived by mixing labor with nature and is justified through one’s advances or improvements (1947 [1689]). This premise, which laid the foundation for the classical economic theory of property, serves as the basis for contemporary patent and intellectual property law and has a significant effect on how natural resource, access and benefit-sharing policy in bioprospecting is conceived and implemented (Laird et al., 2002; Ried et al., 1993).

Recent scholarship in agrarian studies and political ecology has opened new ways of analyzing, defining and theorizing access to, and extraction of, natural resources (Peluso and Watts, 2001; Zerner, 2000). For example, Sara Berry's history of the politics of land access and control within sub-Saharan agrarian settings typifies the burgeoning and insightful literature that has shaped much of the work on access and control of natural resources (1997; 1993; see also Ribot, 1998). Berry highlights the fact that peasant-based social networks often play a large part in helping to define who gains and maintains access to productive agricultural land. Furthermore, many scholars of access have observed similar social relations within common property regimes (Shipton and Goheen, 1992; Ostrom, 1990; Bromley, 1989; McCay and Acheson, 1987) and alternative economies (St. Martin, 2001). This groundbreaking work has opened up opportunities to rethink the distribution of benefits captured from natural resource extraction (Rocheleau et al., 1995), and particularly distributive rights following commercialization (Zerner, 2000; Schroeder, 2000; Ribot, 1998).

This dissertation centers on questions of access to, and control of, natural resources. Most noteworthy, I explore the political economy of those actors included within, and excluded from, commodity chains of valuable “natural commodities.”[9] The study of bioprospecting provides a unique opportunity to build on theories of access, particularly highlighting themes of social relations, culture and power in mediating access to “productive resources" (Berry, 1993). Peluso notes that access to resources is made available to local elites though kickbacks, bribery and selective social networks made possible through “coercive conservation” (1995). Similar patterns are observed in bioprospecting networks in Madagascar, where access is granted to firms and scientific elites as a result of extraction-oriented conservation projects (Peluso, 1992).

Jesse Ribot’s work on the Senegalese charcoal commodity chain was instrumental in addressing how access relations must be observed under both legal and "...extra-legal mechanisms, structures and relations governing resource use..." (1998:311). Ribot observed that access is also often negotiated by extra-legal means, including coercion and theft, and argues that detailed studies of access must move beyond formal definitions of property to include informal mechanisms of access as well (Ribot, 1998: 310).

Ribot highlights the importance of maintenance and control as important components of delineating access. For Ribot, maintenance is about "expending resources or power to keep access open for one's self or others,” whereas control is exerting power over “others' access” (1998:311). Gaining, controlling and maintaining access are the constituent strands that make up Ribot's access mapping paradigm. Each of these aspects is relevant to my study of bioprospecting in Madagascar especially since many of the claims of

[9] In my work, natural commodities include valuable biogenetic resources used in drug discovery and development (see chapters 2 and 6).

misappropriation of resources in the practice are tied into formal definitions of property similar to what Ribot is writing against. For example, foreign and Malagasy scientists and pharmaceutical firms use a number of legal (permits, licenses, fees, taxes) and extra-legal (subsidies to development projects, marketing, lobbying) means to gain and control the flow of some of the most desirable biogenetic resources on earth for use in drug discovery and development. Furthermore, the maintenance of access to these resources is ensured through the development of a full-scale bioprospecting "industry." This industry, including organizations, institutions and individuals, are trained and equipped with some of the most advanced technological tools and facilitated with the legal rights sanctioned by the Malagasy government. These access dynamics are highlighted in all three case studies of the dissertation, and most specifically in the case study of *prunus africana* (see Chapter 4).

Theorizing the natural barriers to production and agrarian change relating to bioprospecting

Historically, social scientists have been concerned with questions of production and capitalist expansion within rural peasant societies (Guthman, 2004; Goodman and Watts 1997; Mann, 1990; de Janvry, 1981; Mann and Dickenson, 1978). These scholars, who are mainly concerned with agrarian change, have taken a critical look at the persistence of "non-capitalist" rural production systems, namely the family farm and peasant small holdings, within advanced capitalist agriculture (Mann and Dickinson, 1978).

Questioning the differences in development of certain spheres of capitalist penetration in rural societies, Susan Mann and James Dickinson developed a theory that expanded on both Marxist and non-Marxist understandings of industrial capitalism and agrarian change. First appearing in 1978, the Mann-Dickinson thesis has become a foundational piece to explain capitalist development in rural societies (Mann and Dickinson, 1978; see also Mann, 1990). Primarily, the Mann-Dickinson thesis draws attention to the incongruence between labor time (working time) and production time, or the "lag" time during which workers must wait for the processes of “nature” to run their course (e.g., photosynthesis in plant growth, animal gestation in livestock, and maturation of fruit). Unlike capitalist industry, Mann and Dickenson maintain that it is because of these "natural barriers" in that capitalists cannot completely or successfully be in command of all the factors of production in agriculture (1978: 472). Principally, capitalists attempt to overcome these natural barriers by taking advantage of smaller production units (i.e., the family farm or the rural peasant) to absorb the costs associated with this lag time. As noted by the authors:

Thus, even in advanced capitalist societies, we are confronted with a significant anomaly: the persistence and co-existence of rural petty commodity production alongside a dominant capitalist mode of production. Capitalist development appears to stop, as it were, at the farm gate (1978: 467).

Since the original manifestation there have been many expansions to the theory (Goodman and Watts, 1997; Goodman and Redclift, 1991; Kloppenburg, 1988; Goodman, et al., 1987). Most notable has been the development of a host of empirical studies of how capitalism has been able to overcome the "natural" barriers in capitalist agriculture mainly through the appropriation of new and emerging technology in plant breeding and biotechnology.

Goodman and Redclift (1991) and Goodman, et al., (1987) build on Mann and Dickinson by introducing the concepts of "appropriationism" and "substitutionism" to express ways that agricultural capitalists begin to overcome the natural barriers in agriculture or at least reduce the effects of these temporal disruptions in the realization of capitalist profits from agriculture. The authors use appropriationism to express the on farm innovations made to reduce the effects of natural cycles thereby facilitating capital accumulation. Examples of the removal of natural barriers include the use of inputs produced off the farm, including application of pesticides that kill off unwanted pests and inorganic fertilizers that help achieve higher yields in shorter periods of time and increasing the accumulation of capital upstream of the farm itself. Substitutionism, on the other hand, refers to the complete replacement of “natural” products altogether (Goodman et al., 1987; see also Goodman and Redclift, 1991). An example of substitutionism includes the adoption of synthetic fibers, or, in the case of bioprospecting the chemical synthesis of bioactive chemical compounds otherwise found in nature.

My work examines the natural barriers to bioprospecting in Madagascar. I show that both the appropriationism and substitutionism have been attempted, but with only partial success. Bioprospectors are still heavily reliant on nature for drug discovery, and thus must find ways to overcome the natural and social barriers to collect the biogenetic resources necessary. It demonstrates how Malagasy scientists and researchers and pharmaceutical companies over time, are able to access vital resources needed for drug discovery by gaining, negotiating and maintaining control over rural labor, critical land, resources, and knowledge of forest biodiversity in Madagascar. It is particularly the nature and labor connection that this dissertation will address. This analysis allows for a fuller theoretical and empirical understanding of complex extractive systems such as bioprospecting that share commonalities with agrarian systems theory. This dissertation will highlight these attempts at both the appropriationism and substitutionism of nature to limit the effects of natural barriers to capital accumulation through the flow of resources out of Madagascar.

Commodity chain analysis

Commodity chains were first defined by Hopkins and Wallerstein to describe "network[s] of labor and production processes whose end result is a finished commodity" (1986:159). This approach mainly developed out of world systems theory, which used a commodity chain analysis as a theory to explain vertically integrated structures of production and consumption and a tool to measure how surplus value is extracted at different “nodal” points (Gereffi and Kornzeniewicz, 1994). Since then, commodity chains have been applied to “webs of power relations” (Ribot, 1998; Bernstein, 1996) and they have also been used to map the disenfranchisement of actors along the chain (Thrupp, 1995).

Commodity chains as a tool for analysis were strengthened by Hopkins and Wallerstein (1994) who traced relationships between sites of production (periphery) sites of consumption (metropolis). Raikes et al., (2000) note that early theorists of commodity chain analysis were concerned mostly with the configuration, regulation and governance, and organization of production and consumption patterns, but they were largely descriptive, leaving out many key social and political economic questions in their analysis.

Scholarly work into commodity chain analysis, however, has opened the door both theoretically and empirically for exploring power relations that coalesce around different commodities (Gibbon and Ponte, 2005; Ribot, 1998; Goodman and Watts, 1997; Bernstein, 1996; Thrupp, 1990; Friedland et al., 1981). Rather than using the market as an abstract object of empirical understanding, these scholars used it as a way to investigate questions of power and access. Bioprospecting follows similar trajectories observed in other producer-driven commodity chain studies in which the material relations (i.e., available labor, location it grows, ease of extraction) surrounding the resource ultimately affects its value (Dupuis, 2002: Goodman and Watts, 1997). For example, Ribot and Peluso illustrate that “bundles of powers” ultimately affect the value of a resource and subsequently shape any given actor's ability to benefit from that resource (2003). They list a number of categories (i.e., technology, capital, markets, labor, knowledge, authority, identity, and social relations) that must be factored into a political economic analysis of natural resource extraction (Ribot and Peluso, 2003). In the case of bioprospecting, these bundles “crystallize” within different social and economic "nodes" in the chain and must be “adequately unpacked” and better understood so as to trace how benefits are distributed (Ribot and Peluso, 2003:159).

Furthermore, Bernstein notes that the original approach to constructing a commodity chain was found in the earlier French industrial economic literature, in which the term *filières vivrieres* (food commodity chains) was used. This approach investigated interconnectedness at different nodes or stages through stages of transformation (1996:120).[10] My study follows this global *filière* approach with an empirical and political economic focus on "markets" themselves (Ribot, 1998). As noted by Raikes et al (2000), it was the *filière* approach that incorporated historical nuances and regulation issues with commodity systems' more structural components. The *filière* framework used in this analysis of bioprospecting focuses on a material study of natural resources rooted in historical and social relations, incorporating the whole geographic landscape of production, exchange and distribution. This analysis of bioprospecting addresses how foreign and Malagasy scientists and companies access vital biogenetic resources for subsequent drug discovery and development. It is the relative power among, and within, the nodes that determines their ability to access the resources.

Surveying the country[11]

Situated in the Indian Ocean, Madagascar rests roughly 400 km off the east coast of southern Africa, separated by the Mozambique Channel. It has an area of 587,045 km^2 (roughly the size of France) and it runs approximately 1600 km north-south. At its widest point, it measures nearly 580 km. It is crossed by the Tropic of Capricorn near the southern town of *Tuléar* (Toliara).

Madagascar's physical topography is described as "wedge-like," with a string of volcanic mountains running the length of the island (Metz, 1995). The country's largest peak,

[10] The *filière* approach was heavily influenced by the French Agricultural School, and was first used in the French colonial and post-colonial states for agricultural commodities (Raikes, et al., 2000).
[11] The bulk of the background geographical information included in this section is taken from Jerkins, 1987 and Metz, 1995.

Maromokotro, reaches over 2,800m in the Tsaratanana massif of the north (Allen and Covell, 2005; see also Goodman and Bernstein, 2003). The highland plateau which begins in this northern massif runs along the backbone of the country, forming a climate and hydrologic division between the eastern and western regions. The east coast is characterized by heavy rainfall which can exceed 3000mm/year, and by frequent cyclones. In contrast, the west coast receives less than 400 mm/year.

Many parts of Madagascar are laden with *ferralitic* soil containing very high amounts of aluminum and iron (Rasambainarivo and Ranivoarivelo, 2003; Roederer, 1971 Jenkins, 1987; Paulain, 1984).[12] These toxic elements bind to the critical nutrients of nitrogen and phosphorous, making agriculture in the country a challenge. Over the years, the people of Madagascar have devised a number of integrated farming systems to overcome the constraints of nutrient deficiency in the soil. Such systems include shifting cultivation, paddy rice cultivation, animal husbandry, and multi-crop homegardens. Rice is the primary Malagasy staple food. Rice accounts for approximately 44 percent of land under cultivation and nearly 50 percent of caloric intake in Madagascar (FAO, 1998). However, some recent estimates suggest that most farmers cannot produce enough rice to feed their families (Moser and Barrett, 2003). Seventy percent of Malagasy grow rice, yet an estimated 67 percent are net-rice buyers and 80 percent have been reported to have bought rice at one time during the year (Minten and Barrett, 2008; Barrett and Dorosh, 1996).

[12] Roederer, 1971.

Rice is chiefly grown in shifting cultivation or upland swidden agricultural systems. Shifting cultivation is a practice widespread in the high-humid and montane forests of the eastern forest corridor, and it has been an intricate part of the Malagasy agricultural landscape for many centuries (Kull, 2004; Jarosz, 1996). This system, known as *tavy* in Madagascar, utilizes the burning of forest vegetation to release nutrients for the production of upland rice and is thus a vital part of Malagasy household food security. This system is followed by a two-year cycle of maize and beans, sweet potato and cassava, with the length of crops depending on soil capabilities and climate. When this agricultural cycle has run its course after three to five years, fields are left fallow (*savok*a), allowing the return to secondary growth (Styger et al., 1999). The regeneration of natural vegetation is a traditional practice for restoring fertility to the system.

The practice of *tavy* is deeply rooted in both the culture and history of the highland Malagasy farmer. It is a custom that is handed down from the ancestors, and the *tavy* field is a sacred site where the farmer can directly communicate with the ancestors (Althabe, 1969). It has been associated with political resistance by peasants during the colonial era, and serves as an organizational framework for village life, defining gender roles and individual responsibilities (Kull, 2003; Jarosz, 1993). Historically, shifting cultivation in Madagascar has been deemed by many within the conservation and development community as a destructive and primitive practice, linking the clearing of forested land under *tavy* directly to the extinction of rare flora and fauna (Styger et al., 1999; Sussman et al., 1994). Historically, this environmental devastation was directly attributed to rising population and poor peasant management. However, current scholarship has provided a much broader interpretation of this environmental change including a more nuanced analysis of factors of poverty distribution, commercial resource extraction, internal migration patterns and division of labor (Kull, 2003; Jarosz, 1993).

Madagascar's political geography

Madagascar's current population is estimated at roughly 16.5 million inhabitants, amounting to roughly 28.8 inhabitants per km^2 (Christenson, 2002).[13] The ethnic population of Madagascar can be loosely divided into 18 ethnic groups (Jenkins, 1987). The groups all speak a certain dialect of the same Indio-Malayan language (Allen and Covell, 2005; Verin, 1981). Nonetheless, one can find Arabic, Swahili and Bantu language influences within the coastal regions (Larson, 2000; Verin, 1981).

There is a long-standing debate among historians, anthropologists and linguists regarding Madagascar's first inhabitants (Verin, 1981; Kent, 1970). The theory advanced by many is that Madagascar was first encountered by Polynesian settlers some time between the fifth and eighth centuries that were active in the trade networks of the Indian Ocean. Many of these early travelers are thought to have made successive stops in coastal Africa and Arabia (Allen and Covell, 2005; Verin, 1981). Information from archaeological remains of these early settlements marks a vibrant coastal trade of manufactured goods and agricultural produce (Campbell, 2005; Allen and Covell, 2005). A number of important trading posts were later joined by the Arab-East African "Swahili" networks of Mombassa, Zanzibar, Lamu and Comoros (see also Campbell, 2005; Alpers, 2000).

[13] Population data is found in: Christenson, 2002.

These island trading networks were still very active when the Portuguese slave traders landed in Madagascar in the early 16th century. This European "contact" was seen to have determinate effects on the Swahili slave-trading networks as the Portuguese, and later the Dutch, arrivals shattered whatever connection the island had with its east African partners (Allen and Covell, 2005). By the mid-to late 17th century, France and England had stepped in to revitalize much of the Indian Ocean's commercial activity, and began reestablishing the trading networks abandoned by the Swahili, most notably the slave trade (Alpers, 2000).

Both the French and British made attempts at settlements in Madagascar, the British in 1645-1646 at St. Augustine Bay, and the French in Ft. Dauphin from 1642-1674 (Allen and Covell, 2005: xv). Concurrently, both large and small kingdoms were established in the interior of Madagascar, including the Sakalava, whose control over the Western coast allowed for frequent trade of slaves out of the port of Mahajanga (Allen and Covell, 2005). Similarly, around the 18th century the Betsimisaraka confederation formed on the eastern coast (Cole, 2001). But none was to rival the most important kingdom of the central highlands of Madagascar, the Imerna, who ruled under a centralized system of government commanded by King Andrianampoinimerina (Brown, 1978; Kent, 1970). Andrianampoinimerina set up a host of royal pronouncements that helped to establish civil and penal codes, land distribution and rules governing commerce (Allen and Covell, 2005). These codes, in fact, began to lay the grounds for attempts at unifying the different tribal areas across the island (Brown, 1978).

The 19th century saw the establishment of diplomatic negotiations between the British who by this time occupied Mauritius and South Africa, and the French who maintained *Réunion* Island and a post at Sainte-Marie Island off the Malagasy east coast (Allen and Covell, 2005). What followed was a political back and forth, starting with Queen Ravavalona I's harsh policy against foreign occupation which expelled many of the English missionaries, most notably the London Missionary Society (LMS). This reign was followed by Radama II and Queen Ravavalona II, each of whom held a more open policy to European society and religion, strengthening ties and placating both the French and English interests in the island. In 1895, after a treaty exchange with the British, the French invaded and began full-scale occupation which lasted until independence was declared in 1960 (Allen and Covell, 2005).

After full independence in 1960, Madagascar maintained close economic and political relations with France. This led to a period of successive strikes and social crises for the new and fragile state under Philibert Tsiranana known as the First Republic (1960-1972). In 1975, the socialist Didier Ratsiraka gained power promoting a nationalistic and isolationist policy (Marcus, 2004). This marked the Second Republic of Madagascar (1975–92) which was characterized by a distinct brand of social and economic policy that maintained loosely based ties with both the West and the Soviet Union. A number of strikes and economic crises in the early 1990s forced the coming of a Third Republic to Madagascar, marked by the rather short tenure of Albert Zafy as president (1993-1996). However, after the impeachment of Zafy, Ratsiraka was reinstated as president in 1997.

Late in his tenure as president, Ratsiraka, following the advice of the World Bank and IMF, instituted neo-liberal reforms and open market policies which brought the country into a slow growing and uneven economic trajectory (Marcus and Ratsimbaharison, 2005; Marcus, 2004). In 2001, Ratsiraka lost a turbulent reelection bid to President Marc Ravolomanana. After a successful second election in 2006, Ravolomanana was forced to resign in 2009 handing over power to Andry Rajoelina.

Current economic indicators

Madagascar ranks 146 of 177 countries on the Human Development Index.[14] Seventy-four percent of its population lives in rural areas, and 78 percent of the rural population lives in abject poverty. Agriculture accounts for the largest share of GDP (35 percent); economic growth has accelerated over the past four years (5.2 percent in 2004) as the government shifted from socialist to private sector-led growth policies. After a turbulent change, Madagascar has followed its African neighbors on the paths of privatization and neoliberalism paved by the World Bank and IMF (Marcus, 2004). This strategy has put the country on an uneven growth trajectory, and in 2002 a political crisis triggered a 12 percent drop in GDP, placing 71 percent of the Malagasy population below the poverty line.[15]

It was in 2002 that newly elected President Ravolomanana first attempted to revive the national economy with an economic policy that addressed poverty and sought to eliminate corruption. This brought international recognition and the return of much

[14] IMF, 2005.
[15] IMF, 2006.

needed donor support. Since Ravolomanana took office, exports of some consumer goods, such as clothing apparel, have boomed (Mertz, 1995). However, most of this newly spurred economic wealth was felt mainly within the highland areas of Antananarivo and Ansiribe (both sites are political strongholds of Ravolomanana), and the port areas of Tamatavie. Furthermore, outstanding issues such as land tenure and corruption are still major challenges facing the country (IMF, 2006).

Madagascar's "environmental" landscape: The National Environmental Action Plan (NEAP) and the Durban Vision

Madagascar's national interest in the protection of its environment began in 1984 when it drafted a publication titled *National Strategy for Conservation and Development* (Marcus and Kull, 1999; Gezon, 1997). Noted as one of the first of its kind in Africa, this document reflected larger currents of biodiversity conservation seen worldwide. Faced with financial and economic crises and burgeoning debt, the government of Madagascar was in a precarious position to pursue the demands of international donors who supported the document. The fast-track approval and implementation of the document into policy was a way for the government of Madagascar to obtain a reprieve from harsh austerity measures imposed by structural adjustment (Hewitt, 1992; see also Kull, 1998).

Building on its new national strategy, the Malagasy government hosted an environmental conference in 1985, in order to launch the strategy and garner technical assistance from the international donor community for its implementation. The international community responded with zeal, helping the government of Madagascar in 1989 put into practice an ambitious 15 year investment program known as the Madagascar National Environmental

Action Plan (NEAP). The ratification of NEAP began under the governance of the Malagasy Third Republic and President Albert Zaffy in 1992; it was then reinstated by President Ratsiraka (Gezon, 1997). The plan consisted of three five-year phases of environmental policy and programs. These NEAPs were financially supported by multilateral and bilateral donors, with the goals of ensuring that the country would be able to take advantage of its unique and valuable resources to further economic development and achieve "a better quality of life."[16]

Overall, the NEAPs held a broad range of conservation and development objectives. For example, the first phase of the NEAP was aimed at policy reform and creating an institutional framework for implementation of forthcoming conservation strategies (World Bank, 2004; Falloux, et al., 1990). The second phase, which began in 1997, attempted to widen the target areas of intervention (World Bank, 2004a). It was developed to counteract what many saw as population pressure and mismanagement of forest resources through integrated conservation and development interventions beyond the "buffer zones" of protected areas into regional watersheds and forest corridor zones (Freudenberg and Freudenberg, 2002). The final phase started in 2003 with the aim of "mainstreaming" conservation of critical biodiversity areas through "sustainable financing and policy reform." (World Bank, 2004a)

What began in the mid-1990s as a national strategy for environmental problems and rural development challenges has since been transformed into full-scale conservation and

[16] World Bank, 2004.

development industry (Sodikoff, 2007; Gezon, 2006; Harper, 2002). For example, those cooperating in phase one of NEAP included donor institutions,[17] international environmental Non-Governmental Organizations (NGOs),[18] research institutions, and land-grant universities (Bertrand and Sourdat, 1998; Kull, 1996).[19] By the third phase, however, it had expanded into an environmental complex which included hundreds of NGOs, state institutions and private organizations.

The financial support Madagascar received from foreign donors for its NEAP programs is immense. The country is among the largest recipients of donor aid for environmental programs in Africa. United States Agency for International Development (USAID) support alone tripled to an approximate total of 123.4 million over the three NEAPs (1991-2008) (Horning, 2008; World Bank, 2004). In May 2004, the World Bank announced the approval of one of its largest financial packages for their environmental program, providing Madagascar with an additional U.S. $40 million .[20] This concession was noted by the World Bank as one of the largest ever awarded in its 60 year history (World Bank 2004).

Following suit, in 2003, President of Madagascar Marc Ravolomanana declared to the 5th World Parks Congress in Durban, South Africa, that his government would triple the amount of protected area on the island nation to the IUCN-recognized standard of ten percent of terrestrial land (Durban, 2005). It was this declaration, later known as the

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[17] World Bank, United Nations Development Program, *Coopération Suisse, Coopération Française*, the Food and Agriculture Organization of the UN (FAO) and the European Union (EU) (see Kull, 1996).
[18] Environmental NGOs include World Wildlife Fund for Nature (WWF), Conservation International (CI).
[19] Research universities include Duke, Cornell, and Stony Brook.
[20] This was awarded through an International Development Association Grant (IDA) (World Bank, 2004).

"Durban Vision," which helped produce new spatial boundaries for "conservation and development" schemes to be enacted, including, eco-tourism and biological prospecting. The Durban Vision was integrated into an overarching framework known as the Madagascar Action Plan (MAP), or *Madagascar Naturellement* (Madagascar Naturally), developed by the government in response to the Millennium Development Goals of the UN Sustainable Development Conference of 2002. This inclusion into policy marked the correspondence of national social and political goals in concert with the global conservation community's interests. These interests are based on years of academic and scientific research backed by substantial foreign aid and lobbying (Marcus and Kull, 1999; Gezon, 1997).

The environmental-industrial complex of conservation organizations and research institutions has helped (both materially and discursively), first to create the space for conservation and development schemes to operate in Madagascar and then to secure unfettered access on behalf to the organizations and institutions conducting bioprospecting. In effect, Madagascar has become the premier destination for bioprospectors to operate in.

Two of the primary organizations involved in contemporary bioprospecting, the Missouri Botanical Gardens (MBG) and Conservation International (CI), hold prominent positions on the Durban Vision advisory board. This advisory board provides technical data, administrative support and advice for locating and demarcating new sites for conservation.[21] These newly demarcated sites hold some of the richest resources of intact biodiversity still remaining in the country, and they have become choice destinations for plant sample collection.

Surveying the dissertation

While this study offers an entry point for understanding contemporary bioprospecting in Madagascar, it also provides a window into changes that have taken place in the industry over time, beginning with the initial systematic prospecting in the 1950s and ending with the market-based conservation *ethos* of current bioprospecting initiatives. I examine the biophysical realities and social, political and economic factors that have helped shape, and have in turn been shaped by, the commodity chain of the bioprospecting industry. I also highlight how particular actors have maintained access to vital natural resources and the benefits that derive from them.

In chapter two of this dissertation I address the history of the practice of bioprospecting in more detail. Specifically, I describe technological and regulatory changes in the practice of bioprospecting and structural shifts in the industry over time. I highlight how powerful industrial actors, in the face of considerable obstacles, have been able to navigate the difficult terrain to access the valuable biogenetic resources for use in drug discovery and development. This chapter provides a substantive foundation for the three ensuing case studies by providing a historical account of attempts to rationalize the production systems of drug discovery.

[21] Representatives from Conservation International, the Missouri Botanical Gardens and many of the National Malagasy scientific centers (CNRE, CNARP) sit on the advisory committee for the "Durban Vision."

These three case studies represent vital biogenetic resources that have been identified, transformed and extracted from Madagascar for processing in large scale laboratories in the U.S. and Europe. Chapters three and four feature commodity chains centered on the medicinal plants, rosy periwinkle (*Catharanthus roseus*) and *Prunus africana*, while chapter five analyzes and the contemporary bioprospecting project launched under the auspices of the International Cooperative Biodiversity Groups (ICBG).[22] Taken together, all three empirical chapters display a *dual* historical trajectory of changes in the bioprospecting industry. This first highlight changes in bioprospecting collection approaches over a 50 year period, while the second expresses the development of these extraction regimes under different forms of environmental regulation.

Chapter three involves the discovery and contemporary extraction of the prized anti-cancer alkaloids found in the plant rosy periwinkle. Periwinkle establishes a historical and comparative foundation for the other two case studies. It describes a mode of production that has undergone a complete cycle of commercial integration including prospecting, extraction, cultivation, and development of subsequent drug patents. Its initial extraction and commercialization took place almost thirty years before the Convention of Biological Diversity (CBD); thus, it provides a point of departure to observe bioprospecting prior to the implementation of international distributive justice mechanisms. This historical analysis is followed up with a detailed analysis of contemporary extraction. This window into contemporary production provides insights

[22] These will be generally referred to as periwinkle, *prunus* and ICBG for the remainder of the dissertation.

into the political economy of valuable biogenetic resources extracted for use in drug development.

For the periwinkle case study, I carried out oral histories with Malagasy and U.S. research scientists on the initial extraction of the periwinkle from Madagascar between 1950 and the 1970s when cultivated plantations of periwinkle were set up in Western Texas. This historical data was supplemented by a contemporary study of periwinkle extraction in the Tolagnaro District (Ft. Dauphin) of Madagascar. This latter study included ten sites in the Androy and Anosy regions. It involved market surveys and semi-structured interviews and oral histories with businessmen, traders and market sellers of periwinkle. I conducted interviews with 39 peasant harvesters, 22 industrial collectors and four self-identified middlemen. I performed five interviews with high level employees of the plant exporting companies and pharmaceutical firms. I also carried out interviews with government officials in local administrative offices and with elected officials (mayors and commune heads) in the market regions and the district capital, Ft. Dauphin.

Chapter four concerns the commercialization of the bark from the medicinal tree *Prunus africana*. *Prunus* is a resource that has been clearly identified as possessing important medicinal properties, but unlike the periwinkle case above, it is neither chemically synthesized nor easily cultivated on plantations. It thus still relies on the extraction of the biological material at its "point of origin." As such, its extraction continues to put pressure on "wild" stocks of the species. This pressure has become so intense that the species is now listed on Appendix II of CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) and, since 2002, an injunction has been instituted against open access harvesting in Madagascar. The purpose of the CITES designation was to restructure the commodity chain and rein in rogue collectors. However, its effect has been to concentrate control of *prunus* in the hands of only a few remaining companies and collectors, who are now able to access *prunus* in the face of widespread regulation.

Between the periods of October 2005 and April 2006, I made two successive trips, the first three weeks long and the second two weeks long, into rural areas in northwestern Madagascar to document the recent history of collection and commercialization of *prunus*. The two areas selected for data collection included the Sofia Region in Madagascar's northwestern Province of Mahajanga and the region of Anjozorbe, a site roughly 90 km north of Antananarivo. These sites were chosen because of their historical and current significance to the *prunus* commodity chain, respectively. The former was the first site of *prunus* extraction and the latter a site of contemporary extraction. At both sites, attempts were made to speak to harvesters, collectors, and transporters of the bark. In total, I conducted in-depth interviews with 30 harvesters, five collectors and two *chefs d'équipe* (heads of collection) in five representative villages. Follow-up interviews were also done with project managers and administrators in charge of *prunus* conservation in Antananarivo. I was able to interview 25 project managers, university and independent scientists and researchers, and administrators of the National Prunus Committee (NPC) and staff located at different agencies involved in *prunus* regulation, including the *Silo*

National Graines Forestières (SNGF), the *Direction Générale des Eaux et Forêts* (DGEF), the national pharmacological research center (CNARP) and the University of Antananarivo.

Chapter five engages contemporary bioprospecting under the U.S. federally-funded bioprospecting project, International Cooperative Biodiversity Groups (ICBG). The ICBG is a consortium of U.S. and Malagasy research institutions, environmental NGOs and industrial partners such as Conservation International, the Missouri Botanical Gardens, Virginia Tech University, and Dow AgroSciences and Eisai Pharmaceuticals. The study illustrates product development in a protean state exemplified by its exploratory nature. Unlike the first two studies, this case centers on a commodity chain in the making, one characterized by sampling procedures and preliminary negotiations around access agreements to specific territories, rather than clearly identified plant compounds. My focus in this instance has been on how international environmental regulation found in the CBD has affected the way researchers practice bioprospecting, most noteworthy being the use of "ethical" collecting practices. In particular for this study, I will be describing a range of practices, including the collection and extraction of biogenetic resources and the preparation of the samples for export within the national pharmacological laboratories.

Research for the case of contemporary bioprospecting under the ICBG project was centered in two main locations. The first phase included an institutional ethnography, participant observation, and semi-structured interviews with administrators and researchers at the national zoo and botanical gardens (*Parc Botanique et Zoologique de Tsimbazaza* -PBZT) and at three national research centers - National Center of Environmental Research (CNRE), the National Center of Applied Pharmaceutical Research (CNARP), and the National Center of Oceanographic Research (CNRO), all located in Antananarivo.

The second portion of this case study was conducted at remote sites of plant collection and identification. Semi-structured interviews were conducted in two separate rural areas in Madagascar's northernmost Antsiranana Province. These interviews focused on local knowledge of, and involvement in, bioprospecting projects, and livelihood strategies involving natural resources, especially forest use management and familiarity with new protected area management schemes corresponding with the ICBG project. The first set of 81 interviews took place in the villages in the communes of Ramena and Mahavanona, located 10 to 15 km southeast of the provincial capital of Antsiranana. The second set of rural interviews was completed within the district of Daraina, in the village of Mahavanapano. For this set, 17 interviews were carried out with rural Malagasy guides, porters and cooks who had been on, or had knowledge of, bioprospecting expeditions. I also interviewed members of environmental associations and elected administrative officials who live and work in the village. In total, I performed 92 semi-structured research interviews with rural Malagasy living adjacent to areas of plant collection within the region of Antsiranana.

Finally, I accessed additional background data through contemporary archival and document searches at selected national research institutes, including the Malagasy forest service research institute (FOFIFA), the Malagasy national archives, and the National Association for the Management of Protected Areas (ANGAP). I also compiled relevant ecological data on plant species. Most of the ecological data was found in secondary sources (i.e., scientific publications) and through interviews conducted with collectors in botanical repositories or commercial traders.

Map 1.1 Madagascar and location of specific case studies

Chapter 2

The historical trajectory of the bioprospecting industry

Introduction

The late 20th century was a watershed moment for bioprospecting. Advances in drug-related therapy and access to user friendly drug screening technologies, such as computerized databases and robotics, increased the demand for a unique array of biogenetic resources (Soejarto, et al., 2005; ten Kate and Laird, 1999; Reid, et al., 1993). For awhile, this demand mostly came from large-scale public laboratories, but as the practice became commercially attractive, private sector involvement increased and individual pharmaceutical and agro-industrial firms expanded their natural product divisions (Reid, et al., 1993).

The majority of the most biologically desirable flora and fauna discovered to date were found in tropical and subtropical ecosystems of the Third World, quite a distance from the major drug development centers in U.S., Europe, and Japan. This raised a number of issues concerning the proprietary use of natural resources and knowledge systems associated with their commercialization (Macilwain, 1998; ten Kate and Laird, 1999; Reid, et al., 1993). Related ethical issues prompted concerned researchers and policymakers to propose new regulations for monitoring the flow of biogenetic resources (Swanson, 1995; Glowka et. al., 1994), culminating in the signing of the Convention on Biological Diversity (CBD) at the Earth Summit in Rio in 1992 (ten Kate and Laird, 1999; Glowka et. al., 1994; Reid et al., 1993).

The architects of the CBD promoted it as setting off a “new age” of natural product commercialization, which included *transparent* and *ethical* collection practices including the return of benefits and technology transfer to countries which supplied the resources (Reid et al., 1993). Nevertheless, the practice of bioprospecting remained a contentious and politicized practice. As critics forecast warnings of "piracy" of biological material and knowledge (Shiva, 1997; see also Hayden, 2003; ETC, 2000), many in the industry complained that the CBD added yet another layer of bureaucracy to the already difficult process of drug discovery (Koehn and Carter, 2005; ten Kate and Laird, 1993).

The purpose of this chapter is to build on, and contextualize, the historical and current scientific trajectories of the bioprospecting industry. This detailed analysis will provide an important backdrop to the political, social and regulatory dynamics of bioprospecting in Madagascar and abroad. First, I describe the importance bioprospectors place on nature in drug discovery.[1] Second, I illustrate the natural, social and political barriers bioprospectors face when trying to access this nature. And finally, I highlight the efforts that bioprospectors make to overcome these barriers mainly through the mechanization of the production process and a reordering of labor, knowledge, and space in Madagascar overall. Paradoxically, this process of industrialization has over time thrown into question many of the efforts taken to bring transparency through ethical collection practices and benefit-sharing. For example, Bronwyn Parry and others (2004; 2000; see also Dorsey 2003; Hayden 2003) have demonstrated many of these technological changes in the bioprospecting industry. Building on Parry’s analysis, my focus concerns the structural

[1]In this context, nature includes the biogenetic resources collected from marine organisms, microbes and plants.

and scientific relations of the collection process itself, and how changes in the industry over time have affected particular sites of production in Madagascar. I will show how even with all the technology at the disposal of the industry described by Parry, bioprospectors are still continuingly looking to return to nature to collection valuable resources for drug discovery. This chapter will serve as a point of departure for the three case study chapters in the dissertation which will document the effects bioprospecting in Madagascar.

Background to bioprospecting

Humans have been using biogenetic resources for medicinal products for thousands of years (Sneader, 2005; Cragg and Newman, 2001; ten Kate and Laird, 1999). For example, the Chinese *Materia Medica* (125 BC) was a landmark medicinal text providing many medicinal plant prescriptions and over 1000 drugs utilized during many of the ancient ruling dynasties (Cragg and Newman, 2005, Sneader, 2005). In India, *Atharvarvada*, a text thought to be the last of the Vedas or the Brahamanic constitutions of Hinduism and which dates back to 1000 BC, is filled with countless references to the use and preparation of medicinal plants for healing and spiritual purposes (Sneader, 2005). From the 5th to 12th century, Arab civilizations became the center of medicinal plant use and knowledge. Physicians of this period, including the Abu Bakr al-Razi, the Abu Al-Qasim Al-Zahrawi, and the Persian philosopher, Avicenna, published some of the most influential medical practices using herbal remedies known at that time.[2]

[2] Of particular importance was Avicenna's *Canon Medicinae* published in 1025 (Sneader, 2005).

The rapid advancement of organic chemistry in the 19th century, led chemists in Europe to some of the earliest remedies rooted in mineral salts and natural-based metals (Drews, 2000). These discoveries, spurred by growth in the scientific fields of organic and advanced analytic chemistry, paved the way for the discoveries of ergotamine (1818), quinine (1819) atropine (1831) turbocurarine (1835) and cocaine (1860) (Drews, 2000; Tyler, 1996).

European exploration in the new world also proved very important for furthering medicinal plant use. Some sources claim that the discovery of the medicinal remedy for intermittent sickness originated with Jesuit priests who observed Indians in Quito, Peru using cinchona bark (*Cinchona officinalis* L.) in a decoction to reduce shivering and cold spells. This medicinal remedy subsequently led scientists to isolate quinine to treat malaria (Sneader, 2005). Another important discovery brought over from the new world to Europe was a treatment for amoebic dysentery derived from ipecacuanha root (*Cephaelis ipecacuanha*). This compound is still used to this day as an emetic for respiratory infections (Sneader, 2005).

Heightened interest in drug discovery from natural products in the U.S. came in the 1940s with the demand for much needed antibiotics to treat wounded solders during WWII. Government contracts with Pfizer, Inc., for the mass production of penicillin spurred rapid advancement in the science of drug discovery. In 1955, the US Cancer Chemotherapy National Service Center (CCNSC) was formed to coordinate chemotherapy programs, including the procurement of drugs, screening, pre-clinical studies and clinical evaluation of new agents. By 1958, the CCNSC had progressed into full-scale drug research and development (Cragg and Boyd, 1996).[3] And almost two decades later, in 1976, the CCNSC was placed under the direction of the National Cancer Institute's Developmental Therapeutics Program (DTP), which currently houses the bulk of U.S. funded preclinical drug discovery and development (NCI, 2008).

Following this drive for drugs from nature was another initiative spearheaded by the Natural Products Branch (NPB) of NCI's Division of Cancer Treatment and Diagnosis, which began a massive program of collecting biological resources worldwide (Cragg and Newman, 2005).[4] The first NCI plant screening program (1955-1982) included 14,000 crude natural products (plant, marine, microorganisms) sourced from 60 different countries (Alyward, 1995). During this period, the NCI received roughly 3,500 to 4,000 dried plant samples a year, and was screening approximately 114,000 extracts accounting for close to 35,000 plant species (Cragg et al, 1994; Suffiness and Douros, 1982).

In 1986, spurred by the discoveries of the anticancer paclitaxel (Taxol) from the bark of the Pacific yew (*Taxus brevifolia*), the NCI natural products program began a second

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[3] Established in 1937, the NCI's role was to coordinate the US government's research efforts against cancer. This responsibility now rests with the Developmental Therapeutics Program (DTP), a major component of the Division of Cancer Treatment and Diagnosis (DCTD).

[4] There are generally three agreed upon methods to discover new drugs: the empirical approach, rational design and the improvement method (Aylward, 1995; Austel and Kutter, 1980; see also: ten Kate and Laird, 1999). The empirical approach is described as the screening of randomly selected chemical compounds and structures. In effect, researchers test for a compound's chemical efficiency against a selected disease target, (HIV/AIDS, cancer, etc.), and then evaluate its potential in different concentrations (Aylward, 1995). This is in contrast to the method of "rational" design, which employs different types of pre-existing knowledge surrounding the biomedical processes of the "target" disease to find a "designed" product that may ultimately hold the most efficacies. The third method uses known compounds and structures, which are either improved upon or regulated to create a useful drug. In contrast there is drug discovery that does not use any natural products at all, but rather chemically derived synthetics or semi-synthetics instead.

phase of natural products research (Alyward, 1995). In Phase II (1986-1997), NCI signed its first five year multi-renewable contracts with three different major botanical institutions - the Missouri Botanical Garden (MBG), the New York Botanical Gardens (NYBG) and the University of Illinois (Aylward, 1995). These contracts, which averaged U.S. $2.7 million, obligated the institutions to collect plant samples, voucher specimens and gather any associated botanical, ecological and ethnobotanical information that potentially lead towards new drug discoveries. The collection sites included tropical and subtropical locations in 13 South and Central American, six African, and seven Asian countries (Aylward, 1995; Cragg et al., 1994). Additionally, NCI signed individual collaborative ventures with selective institutions and researchers in other countries (Cragg et al., 1994). Scouring the globe, collaborations netted up to 60,000 plants, microbes, marine organisms, and the NCI eventually tested 500,000 extracts for anti-tumor activity (NCI, 2008).

Modern bioprospecting under the INBio and ICBG

The advances mentioned above in drug discovery science and genomics observed in the 1990s coupled with the advent of new high-throughput screening, automation and new information technology, paved the way researchers to run thousands of extracts of biological resources at rates commercially attractive to large-scale private laboratories and pharmaceutical firms (Jim Miller, pers. communication; 2003). As private sector involvement increased, so did the concern for fair compensation for those who supplied the resources and intellectual property which led to the discovery. This coincided with scientists' growing anxiety for the environment, including mass species extinction

(Miller, 2007; Dorsey, 2003). These concerns mainly stemmed from a long history of colonial extraction of natural resources, and commercial exploitation of vulnerable populations in areas of collection in the Third World.

As a result, new bioprospecting schemes where founded on the logic that discoveries would be monetarily rewarded in a pre-determined compensation deal, or Access and Benefit-Sharing agreement (ABS) (Barrett and Lybertt, 2000; Eisner, 1993). For many involved in the projects, these schemes amounted to “win-win” scenarios which provided the motivation to finance conservation efforts in tropical ecosystems, where both biodiversity and traditional knowledge of medicinal usage were deemed to be the highest (Eisner, 1993; Balick, 1990). Two examples of bioprospecting programs designed on this "sustainable development" model include the INBio agreement and ICBG.

The INBio bioprospecting project was based on an agreement signed in September 1991 which brought the U.S. pharmaceutical giant, Merck and Co., and the National Biodiversity Institute of Costa Rica together on a joint research sharing platform. According to the terms of the agreement, Merck paid $1.135 million for a two-year research and sampling project and royalties on products subsequently commercialized from plant, insect and other biological samples (Reid et al., 1993). In return, INBio was to contribute 10 percent of the budget and 50 percent of any royalties to biodiversity conservation efforts in Costa Rica (Reid et al., 1993). This bioprospecting agreement, which ran from 1992 to 1997, was lauded by many, and heralded as delivering on many of the core tenets of the CBD (Reid et al., 1993; 2). Moreover, it signified a major transformation in the way public-private collaborations between the "developed" and "developing" countries operated, paving the way for subsequent bioprospecting initiatives (Aylward, 1996).

The ICBG was funded by the National Institutes of Health, the National Science Foundation and the United States Agency for International Development (USAID).[5] Since its founding, the ICBG has expanded into one of the most ambitious bioprospecting projects ever attempted by the US government involving eight collaborative research groups which conduct research in 12 countries (Rosenthal and Katz, 2004; see Chapter 6). By 1999, the ICBG had reported the collection of 11,000 samples from approximately 5,800 species of plants, 550 insects and over 500 fungi. It had conducted up to 200,000 different types of therapeutic screens (Rosenthal and Katz, 2004), and had located 260 active compounds, 60 of them reported as “novel” (Rosenthal et al., 1999).

The INBio and ICBG projects were structurally designed to directly address many of the issues in the Earth Summit and the subsequent signing of the CBD. These issues included the safeguarding of intellectual property for those engaged in research, the conservation of biodiversity, the promotion of economic and social development in the Third World and most importantly, the equitable distribution of benefits from the exchange of biodiversity and appropriation of ethnobotanical knowledge (Schweitzer et al., 1991; see also Brown, 2003; Rosenthal, 1997). These projects became the building blocks of a new collaborative exchange involving drug development, biological conservation and economic growth defined by the “sustainable” development schemes promoted by the

[5] USAID has been replaced by the Foreign Agriculture Service of the USDA.

1992 Earth Summit (Schweitzer et al., 1991). To the U.S. scientific community at the time, these bioprospecting projects allotted the opportunity for global recognition, financing and natural-resource sourcing on a scale previously unforeseen. Bioprospecting, which was the shining star of the Earth Summit, had now come of age.

Why is "nature" so important for drug discovery?

Given their prior success, the champions of natural products drug discovery argue that "nature" (i.e., natural products in the form of plants, marine organisms and micro-organisms) remains the preeminent source for bioactivity and drug discovery (Cragg et al., 2005; Newman et al., 2003; Grifo and Rosenthal, 1997; Farnsworth, et al, 1985; 1976). For example, a survey revealed that over $8 billion of U.S. prescription drugs in 1980 were plant-based, and that out of the top 150 brand names prescribed during a period of nine months in 1983, 57 percent of those drugs contained an active principle from a biological source (Grifo et al., 1987).

Following a more recent review, Newman et al. (2003) concluded that from 1981 to 2002, over 60 percent of all new drugs introduced worldwide were based on a compound found in a natural product. Furthermore, others have argued that natural products provide remarkable diversity unmatched by anything we can create synthetically (Cragg et al., 2005; Newman et al., 2003). For example, Newman et al. found that out of the 67 percent of synthetically derived New Chemical Entities (NCE) entered into the FDA clinical trials, roughly 16 percent contained molecules patterned from a natural product (2003).

There are different opinions on which type of “nature” is actually best for drug discovery (Coley et al., 2003; Balick et al., 1996; Eisner, 1994; Kinghorn and Balandrin, 1993). Although drug discovery programs have recently stepped up their collections to include marine and microbial organisms, some from the most extreme environments on earth, plants have historically been the most important source of natural products and will remain so for some time (Cragg and Newman, 2005; Grifo and Rosenthal, 1997; Balick et al., 1996; Kinghorn and Balandrin, 1993). Unlike fauna, which have the ability to flee when under some form of threat, plants are immobile and must rely on other mechanisms for defense (Coley and Barone, 1996). In theory, this has led many plants to develop chemically active defense shields (Coley et al., 2003). These defense mechanisms contain an array of chemicals known as secondary metabolites (secondary because they show no actual metabolic utility) including alkaloids, cyanogenic glycosides, flavonoids, phenolics, saponins and tannins, etc. (Eisner, 1991). If identified and isolated correctly, the unique chemical properties found in these compounds may be harnessed for use in new medicines. As a renowned chemical ecologist, Thomas Eisner, explains:

> [Secondary metabolites are]…those myriads of compounds, often aberrant in structure, that are produced by specialized metabolic pathways unique to individual species or species groups. Secondary metabolites are secondary in name only. They are the chemical marks of distinction of the individual species, and in the biotic world they are as diverse as life itself. To the organisms that produce them, secondary metabolites are adaptive keys to survival. And to humans, they are aids to progress on a diversity of technological and chemical fronts, including most importantly medicine. Secondary metabolites are the gems of the treasury of nature, a treasury upon which we have come to depend and which is threatened with depletion (Eisner, 1991:197).

Many scientists contend that only a relatively small number of plants have actually been investigated for their medicinal value (Fabricant, and Farnsworth, 2001). Out of the approximately 250,000 to 300,000 known vascular plants, only six percent have been screened for any therapeutic bioactivity and only 15 percent have been tested for possible phyotochemical value (Fabricant, and Farnsworth, 2001; see also Grifo and Rosenthal, 1997). However, many questions remain as to which plants to actually test. Recent attempts by researchers to address this question have resulted in a number of targeted collection strategies intended to limit the number of trials and improve the chances of finding bioactivity (Miller, 2005; Blaick and Cox, l996).

The collection of nature

The odds of finding a potential "blockbuster"[6] are steep. It has been estimated that for every 10,000 compounds screened, roughly 250 will make it to the next round known as pre-clinical testing, only five will see the next step of clinical trials, and only one lucky compound will become an approved-FDA drug (McChesney, 1996). The cost to bring a drug to market is said to range anywhere from US $100 to 500 million (PhRMA, 1998),[7] and may take an average of ten to fifteen years (McChesney, 1996; see also ten Kate and Laird, 1999). Pharmaceutical companies are willing to take on these costs since estimated global sales for a new blockbuster drug may reach into the hundreds of millions of dollars. This is reflected in the overall revenue figures for the pharmaceutical industry which in 2004 topped US $500 billion globally (Laird et al., 2007:3).

Given the massive numbers of natural products, researchers must focus their collection of natural products in order to be able to obtain the largest number of samples with the

[6] Blockbuster is a name given to a drug that has significantly exceeded the costs of research and discovery (R&D).
[7] Laird et al., 2005 note that the pharmaceutical research and manufacturers of America (PhRMA) member companies, a leading US industry lobbing group, spend as much as US $49.3 billion/year on R&D (2005).

highest probability of bioactivity. Table 2.1 provides a description of the different collection methods in use by researchers.

Table 2.1 Relative advantages of different botanical collection methods used in bioprospecting projects[8]

Type of collection	*Theory*	*Example*	*Comment*	*Cited*
Eco-rational	Focuses on ecosystem or climatic characteristics of a particular biome that might have been shown in the past to hold specific desired characteristics.	International Cooperative Biodiversity Groups (ICBG) - Panama	Tropical plants are thought to have more secondary metabolites than temperate plants; marine and microorganisms have shown bioactivity as well	Coley et al. 2003: Reid et al. 1993; Beattie et al., 2001.
Ethnobotanical	Employs past and present cultural or traditional knowledge of medicinal and functional use.	New York Botanical Garden Bioprospecting program in Belize; ICBG – Peru	Implied moral obligation with particular person or group that provided the information	Cox and Balick, 1994; Lewis et al. 1999; Balick 1990.
Random	Makes use of an *arbitrary* selection of plants found in a designated geographic range; collection of fertile species.	National Cancer Institute's contract collections; ICBG -Madagascar Phase I and II	In many cases where this method is used, only plants in fruit and flower are collected for true identification	Miller et al., 2005; Spjut, 1985.
Taxonomically guided	Focus attention on botanical families or genera with known bioactive interest.	Comprehensive Cancer Center (CINCAN); South-American Office for Anti-cancer Drug Development (SOAD), Lutheran University of Brazil, Canoas, RS, Brazil	Tends to be especially useful for the substitution of rare or endangered plants known to be bioactive (i.e., cultivation of Taxus *sp*.)	Mans et al., 2000; Miller and Gereau, 2000; Balick and Cox 1996.
Zoopharmacogno -sy / Ethno-zoopharmacogno - sy	Employs previous knowledge of the studies of wild and domestic mammal usage for sickness or healing purposes	Institute for Chemical Biology and Drug Discovery (ICB&DD) at Stony Brook	Based on studies of foraging patterns of primates	Berry et al., 1995; Rodriguez et al., 1995; Wrangham, 1994.

[8] Adapted from Miller, 2005 (see also Balick, 1990).

Eco-rational collection

It is widely held that as compared to temperate plants, tropical flora posses a much wider range of potential chemical bioactivity (Voeks, 2004, Coley and Barone, 1996). This theory is based mainly on the fact that both the number of overall species and species richness (number of types of different species in one area) are much higher in the tropics as compared to temperate regions (Raven, 1988; Myers, 1988). Secondly, due to the presence of larger numbers of herbivores to defend against in tropical ecosystems, plants in the tropics hold higher concentrations of secondary metabolites which they use to defend themselves (Coley and Barone, 1996; Hay 1986; Coley and Aide, 1991; Levin and York, 1978; Levin and Funderburg, 1976; Levin, 1971).

This focus on tropical plants is reflected in the geographic focus of the majority of U.S.-funded bioprospecting projects. Of the fourteen countries signing formal collection agreements with the NCI natural products screening program between the years 1992 to 2002, the majority were located in the tropics or sub-tropical climates (Craig, et al., 1993). Furthermore, all of the projects launched in the first three rounds of funding secured by the ICBG were located in the tropics or sub-tropics (Rosenthal and Katz, 2004).[9]

This collection method is based on following particular ecosystem or biome characteristics, including tropical, temperate or marine ecosystems. By far, tropical

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[9] Of the eight new projects added since, only one project focused on the plant, fungal and microbial biodiversity of the Central Asian countries of Uzbekistan and Kyrgyzstan, led by Dr. Ilya Raskin of Rutgers University.

environments have been the first choice for researchers looking for bioactivity in natural products. However, other environments have recently gained interest. For example, many new interesting structures have been found within marine ecosystems (i.e., seaweeds, sponges, soft corals and marine invertebrates) (Mann, 2002). Most noteworthy has been the detection of anti-cancer agent bryostatin 1, isolated from the marine plant bryozoan (*Bugula neritina*) (Mann, 2002). Another interesting development in eco-rational collection has been the targeting by researchers of natural products that inhabit extreme environments known generally as extremophiles. These organisms can live in high and low pressure, oxidation, extreme pH levels and heat and cold and have gained considerable interest for all types of natural product discovery. There is increasing interest in exploring extreme habitats for useful enzymes from microbes, including acidophiles (from acidic sulfurous hot springs), alkalophiles (from alkaline lakes), halophiles (from salt lakes), thermophiles (from deep sea vents), and psychrophiles (from extremely cold waters) (Laird et al., 2007).

Ethnobotanical collection

One way to overcome the high costs of research and development associated with natural products is to use “ethnobotanical” leads. Ethnobotany is generally described as a scientific study of medicinal and functional use by different ethnic and cultural groups (Balick and Cox, 1996). This “traditional” or “indigenous” knowledge is usually passed down orally among family lineages, clan networks and ethnic groups.

Using a number of different social science methods (i.e., interviews, observations and archival searches), and advanced empirical investigation (chemical analysis and elucidation of bioactivity), ethnobotanists “translocate” age-old belief and knowledge systems into usable information for those who employ natural products for drug discovery (Balick and Cox, 1996).

Ethnobotanist Michael Balick recognizes that the ethnobotanical approach has two components. First is the “cultural pre-screen,” a “trial and error process that occurs over thousands of years.” The second involves the adaptation of this information into the “body of scientific knowledge” (1990:27). This "ethnobotanical filter” provides researchers a useful guide to target specific plants that hold potential bioactivity. Furthermore, ethnobotanical knowledge also provides vital information for proper preparation of extracts, harvesting times and ecological growing conditions (Balick, 1990).

Random collection

The process of random collection involves the collection of *all* flowering and/or fruiting plants in a pre-determined area (Miller et al., 2005; Spjut 1985; Balick, 1990). As Balick suggests, the locating and collection of only fertile species as compared to sterile species can reduce time and resources (1990). This type of collection is advantageous for botanical collectors seeking as many species as possible in a particular environment. The random approach provides the researcher with a systematic method of collecting true voucher specimens,[10] and allows species to be correctly identified later on. The collection of bulk specimens is helpful for botanical repositories interested in surveying an area for

[10] True voucher specimens include all plant parts that help to identify the plant “type” or what distinguishes a species from related subspecies (Huber, 1998).

its botanical inventory (Miller et al., 2005; Balick, 1990; this method is described in more detail in Chapter 6).

A random approach is the preferred method of collection for programs that want to collect the most plant samples in the shortest period of time (Balick, 1990). This method is helpful especially in countries which are very rich in diversity and relatively understudied. Bulk collection allows for mass production of extracts to be made which can then be identified for recollection purposes. The systematic identification of the species avoids the costly research expenses in replication or misidentification sometimes found in the “ethnobotanical filter” approach (Kingston, 2006).

Taxonomically guided collection

Rather than focusing on ecological niches to find plants with bioactivity, some researchers argue that the best method for discovering drugs may be to draw on information that we already know. *Taxonomically guided* searches, for example, target plants that are closely related to known sources of bioactivity as a means of raising the likelihood of successful drug discovery (Mans et al., 2000; Miller and Gereau, 2000; Balick and Cox, 1996). This approach allows for the precise targeting of select species, with less research cost needed for having to transport bulk species.

Zoopharmacognosy / Ethno- zoopharmacognosy

Much like ethnobotanical collection, zoopharmacognosy or ethno- zoopharmacognosy employs cultural knowledge of wild or domesticated animal uses of natural products to guide their collection for drug discovery (Huffman, 2001; Berry et al., 1995; Rodriguez, et al., 1995; Wrangham, et al., 1994). Following empirical evidence of foraging patterns gathered by biologists and ecologists, zoopharmacognosy selects plants that animals (especially primates) use in combating or preventing sickness and examines how animals use plants to combat sickness, or to prevent sickness. Ethno-zoopharmacognosy differs by incorporating human "cultural knowledge" of animals' use of plants for illnesses as a pre-screen for collecting the plants for the practical methods of drug discovery (Huffman, 2001).

In sum, these different collection methods have developed over time to try to reduce the financial barriers by reducing the time and resources needed to locate bioactivity in nature. However, the ability to access the natural resources needed is dependent on a series of "other" highly variable factors, including seasonality, regulatory issues concerning collection and transport of materials, and property rights and tenure issues (Kingston, 2006). These natural and social factors also pose significant barriers to drug discovery with which bioprospectors must also contend.

The "natural" barriers to drug discovery

Sites most prized for finding bioactive natural products are located in countries of the Third World, quite a distance from where the research and development take place (Macilwain, 1998). Therefore, bioprospectors face considerable transport obstacles while trying to source the biogenetic resources. First, to conduct adequate natural product research and then develop a drug, a large amount of raw material is sometimes needed.

For example, for the discovery of Eli Lilly's "wonder drug," Oncovin (vincristine), from the medicinal plant rosy periwinkle, up to one ton of the raw leaf material is needed to extract just a single ounce of the active alkaloid for the usable drug (Irving Johnson, pers. communication, 2007). Sourcing tons of the raw material from Madagascar or India (two sites chosen by Lilly for collection) was over time a financial liability for Lilly. This eventually led the company to experiment with the production of periwinkle on plantations in the U.S. (see Chapter 3). [11]

Tropical forests are also difficult to transverse. The locations, usually far from population centers, can take weeks to find, and in the rainy season roads are routinely impassable. Unpredictable climate conditions are also problematic: violent storms, cyclones and heat are only a few of the climatic obstacles that bioprospectors encounter. Furthermore, once material is located, it may also be very difficult to obtain. Flowering samples, often located high in trees, and buried roots may pose significant obstacles to obtaining enough source material to conduct even the most basic screens.

Even after promising resources are located and collected, the challenges continue for bioprospectors. Plant material must be dried quickly since it is vulnerable to fungal contamination and rot. Furthermore, once in the laboratory, many topical plant extracts are found to contain high amounts of phonemic compounds, with some plants said to

[11] Another example of supply issues of a natural product includes the collection of the pacific yew (*Taxus brevifolia*) for the anti-cancer drug paclitaxol. Due to the scarcity of the woody shrub and overexploitation in the wild, a cultivation method of a closely related cousin (*Taxus baccata*) was soon devised and the enough bioactive compounds in the bark were made available to researchers for isolation of the synthetic compounds. The use of the "cousin" plant is an example of taxonomically-guided bioprospecting.

have up to 90 percent of their weight in tannins, unusable to bioprospectors. The structural complexity of natural products can slow down the ability to trace bioactivity, making further fractionation and identification of the compound difficult (Kingston, 2006). And finally, in natural products research there exist many problems of replication, where after countless hours of research and resources spent, the "novel" molecular structure found to be bioactive is actually a duplicate discovery. Other specific examples of natural barriers are considered in the case study chapters below (see Chapters 3, 4, and 5).

The "social" barriers to drug discovery

Alongside these natural barriers, there are a significant number of social and regulatory obstacles that bioprospectors must overcome when trying to access natural products. For example, the CBD is one of the premier documents in environmental governance developed to date. The key innovation of the CBD was to establish a framework for the development of national strategies to negotiate access to biogenetic resources in return for adequate benefit-sharing. These benefits included technology transfer to host institutions and monetary returns from subsequent commercialization of drugs to governments and local inhabitants (ten Kate and Laird, 1999; Glowka et al., 1996; cf. Dorsey, 2003). Although the CBD is by far the most comprehensive agreement to date, its vague language left signatory parties with considerable confusion as to how to move forward and address the concerns of intellectual property rights and the distribution of benefits from commercialization (Svarstad, 2005).

For example, one of the most widely cited protocols of the CBD is Article 15(1), which describes the individual nation-state's rights over its natural resources. Bioprospectors maintain that rather than facilitating a country's resources for access, some states have imposed a draconian interpretation of the Article, making it harder for foreign researchers and even host-country scientists to access source materials.[12] Second, in many source countries, national access and benefit-sharing agreements are not uniformly consistent with the Article, leaving bioprospecting programs to basically "write their own rules" to access the resources, sharing of benefits, and prior informed consent (see Chapter 5).[13] As an industry representative from Dow AgroSciences noted:

> A big obstacle has actually been the biodiversity treaty [CBD], which is not standardized in developing countries. Local people have different ideas of what companies are going and not going to do, and it's just too expensive for companies to do one-on-one negotiation with everyone involved.[14]

Many scientists note that inconsistent bioprospecting rules and regulations have slowed down the process, and that the misinterpretation of the CBD by many national governments coupled with unrealistic expectations of benefits have left a difficult environment in which to operate effective bioprospecting programs (Koehn and Carter, 2005; ten Kate and Laird, 2000). And even though one of the pinnacle promises of the CBD is to provide unencumbered access to a country's biodiversity, for many in the industry it has slowed down the process of drug discovery from natural sources considerably (Koehn and Carter, 2005).

[12] This was expressed in a number of interviews.
[13] ANON 2 (March 11, 2006).
[14] ANON 40 (April 10, 2007).

A second regulatory obstacle that bioprospectors face chiefly concerns the protection and enforcement of intellectual property. Internationally, the World Trade Organization's (WTO) Agreement on Trade Related Aspects of Intellectual Property Rights, or TRIPS was the main force behind much of the debate of intellectual property rights (IPRs). TRIPS put more emphasis on private property rights, especially concerning intellectual property, providing an easy way for companies and individuals to patent discoveries made from nature based on scientific or traditional knowledge.[15]

IPRs are goods that are derived from the mind or intellect, and are a feature of property that is reflected in copyrights, patents, trademarks, industrial design, trade secrets and domain names (Walden, 1995). In effect, they provide the "holder" the right to maintain exclusive control over the material (Walden, 1995). The economic rationale for IPRs holds that shielding of monopoly rights provides "motivation and remuneration for the creativity of inventions and [can be used to] ward off any competitors" (Walden, 1995:182). One of the most contentious issues facing IPRs has to do with claims of "novelty" involving biogenetic resources and traditional knowledge.[16] Critics claim that the patenting of biological life under biotechnology and bioprospecting breached ethical boundaries setting a damaging precedent for corporate control of life forms (Shiva,

[15] To date, the Uruguay Round was most notable for the transformation of the General Agreement on Tariffs and Trade (GATT) to the WTO. The agreement included trade tariffs, barriers and subsidies pertaining to textiles and clothing, agriculture and tropical produce. Its subsequent agreement, TRIPS, began the discussion pertaining to IPRs and commercialization and paved the way for governments to approach the basic issues of copyright, patents, trademarks, industrial-trade secrets, and geographic origin (GRAIN, 2004).

[16] This precedent began with the 1980 Supreme Court ruling that upheld a lower Federal US court's decision that life forms were patentable after the plaintiff, Amanda Charkrabarty, attempted to patent a bacterium he developed which was capable of breaking down the structural components of petroleum while working for General Electric. The case *Diamond vs. Charkrabarty* was a landmark decision for the patenting of life forms (Shiva, 1997).

1996). Second, many concerned scholars and activists remarked that "traditional" knowledge was never formally accounted under the agreement, and rather than offer protection, TRIPS made it easier to privatize knowledge under the framework of capitalism and patent rights (GRAIN, 2004; McAfee, 1997; Shiva, 1996).

The TRIPS agreement was not the only international framework that addressed intellectual property. One can point to a number of agreements that attempted to recognize traditional access rights and "cultural" knowledge in more formal terms. Other examples include the 1988 International Conference of *Belém*, Brazil, and the second Code of Ethics of the International Society of Ethnobotany codified in 1991 in Kunming, China (Soejarto et al., 2005). These agreements were the first formal recognition that traditional knowledge was not only "intellectual," but also "innovative," and thus, was protected under any formal patent rights (Soejarto et al., 2005:16; see also: Posey and Dutfield, 1996). Subsequently both of these agreements were codified under the CBD in 1992, which again established a number of regulatory hurdles that bioprospectors had to overcome in order to access and utilize traditional medicinal knowledge, including obtaining informed consent from all the parties involved in the exchange and sharing benefits with those who supplied the knowledge.

In the end, the difficulties in identifying and ensuring that all parties would be informed and would share in the benefits that derived from commercialization ultimately caused confusion and misunderstandings in the industry about the correct way to move forward with the collection of natural products and the ethical return of benefits (ten Kate and

Laird, 2000). These problems ultimately led many in the pharmaceutical industry to explore other options to discover drugs. One such option included computer generated and synthetic-based compounds. These new efforts were seen as “rational” and “scientific,” and promised to bring new drug discoveries without all the political entanglements that came along with “nature” (Parry, 2000).

The industry’s attempts to “roll back” nature

Just as the empirical approaches using natural products were becoming abundant in the late 1980s and 1990s, other approaches utilizing chemical or synthetic alternatives were gaining steam (*Economist*, 1999; Macilwain, 1998). In fact, the advent of new combinatory-chemistry, or “combichem,” approaches fostered a “chemical revolution,” which quickly gained mass-appeal in the pharmaceutical industry (*Economist*, 2004). Combichem, a process that uses robotically created combinations of synthesized molecules to derive a large number of “virtual libraries” of new chemical structures, enables derived molecules to be “tailored” to fit the desired molecular target in disease related therapy. This breakthrough in technology promised to shorten the time and lessen the financial burden in bringing home the “blockbuster” drug (*Economist*, 2004). For many in the life-science industry, combichem’s promise of quick and inexpensive drug discovery was very appealing and resulted in a shift away from natural products which many in the industry saw as “clumsy” (Koehn and Carter, 2005; see also: Harvey, 2000; see also: ten Kate and Laird, 1999; Laird et al., 2005).

For those in the industry, synthetically-driven drug discovery and natural products maintain both advantages and disadvantages. Koehn and Carter (2005) summarize a number of advantages of the synthetics as follows: first, synthetics provide the ability to speed up the industry's systematic testing of compounds and meet their demand for more "screen friendly" bioassays than they can derive from natural products. Second, with new innovations in computerized data-basing, thousands of chemically-derived synthetics could be stored indefinitely for use "on-demand" without the risk of degradation or loss of quality. A third factor is the advantage of an exponentially increased number and variety of molecular targets to test for drug discovery, following the scientific rationale that "[t]he wider range of candidate compounds, the better the chances of finding a good fit with the target."[17] Fourth, the industry overall focuses less and less on the treatment and therapy of infectious diseases which, as Koehn and Carter remark, are one of the main "strengths" of natural products (2005). Overall, Koehn and Carter observe that in the commercially-driven world of drug discovery,[18] methods of synthetically-derived chemical libraries, which utilize rapid "hit-identification" and "hit-to-lead development," hold significant advantages over the much slower "bio-assay-guided isolation" of natural products (2005:207).

The many arguments in favor of synthetic drug development notwithstanding, the pharmaceutical industry's output under combinatory chemistry has not lived up to expectations. David Newman and Gordon Cragg (2003) of the National Cancer Institute

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[17] *Economist*, 2004; see also: ten Kate and Laird, 1999.
[18] Commercial inputs from the pharmaceutical industry for drug discovery are massive. For example, the industry reported a relative tripling of research and development costs from 10 billion to 30 billion from a period of 1984 to 2003 (Koehn and Carter, 2005), and the highest-ever investment in 2004 for research and development of $49.3 billion for PhRMA member companies alone (Laird and Wynberg, 2005).

(NCI) concludes that even with the marked increase of combinatory chemistry techniques, the percentage of synthetics as new chemical entities (NCE) has not shown any substantial increase and has failed to create a single FDA-approved drug through the end of 2002. Laird and Wynberg note that the industry has shown little success in finding any candidate drugs awaiting clinical trials and that the "pipelines are empty" (2005). Furthermore, they mention that combinatory chemistry provides "a useful development tool for optimization of leads," but it rarely provide the highly prized "molecular diversity" needed for novel drug discovery (2005:10). And because combichem has yet to bring anything substantial to market, the return to search for bioactivity from natural products is inevitable, if not already under way (Laird and Wynberg, 2005).

Advocates of bioprospecting hold that there are many advantages to using natural products that inevitably bring people "back to nature." For example, it has been noted that natural products might be more "drug-like" than anything chemically-derived (Koehn and Carter, 2005; Kingston, 2006; Harvey, 2000). To start, in comparison to combinatory compounds and synthetic drugs, natural products' overall structural assortments of "molecular descriptors" have been found to be more advantageous for drug discovery (Ortholand et al., 2004; Lee and Schneider, 2001; Harvey, 2000). Kingston notes that natural products' structure holds more potential for bioactivity; first they are generally comprised of more "chiral" (unique) centers and second, they are overall are higher in "sterical complexity" (structurally diverse) than synthetic drugs or combinational libraries. All of these factors are found more favorable to finding bioactivity and subsequent drug discovery (2006:2).

Natural products also differ from their synthetic counterparts. They are characteristically "oxygen-rich" and contain more "hydrogen-bonds," which form bonds quicker than what is found in synthetics, and thus make it easier to affect their targeted disease (Ortholand et al., 2004:272; Lee and Schneider, 2001). In addition, natural products hold a lower ratio of anatomic ring atoms to heavy atoms, and it is thought that these "privileged structures" modulate the bio-chemical and protein-protean reactions needed for the wide variety of therapeutic uses (Koehn and Carter, 2005; Evens et al., 1988). When compared to synthetics, natural products are better suited for human consumption because they are typically smaller and therefore more easily metabolized and absorbed by humans (Harvey, 2000). And in the end, many hold that the temporary move away from natural products was just another adjustment in a unpredictable industry (Cragg et al., 2005; see also: Laird and Wynberg, 2007; Koehn and Carter, 2005). Overall there are many factors that drive researchers' decisions to use either nature or chemical approaches to drug discovery. In my subsequent case studies, decisions are based on the need: 1) to access material because it cannot be produced synthetically; 2) to take advantage of the labor pool available in Madagascar to collect raw material; and 3) to access the critical "hotspot" sites in Madagascar thought to house unique and bioactive material found nowhere else.

Ethics of bioprospecting

As I expressed earlier in this chapter, bioprospecting has shown the potential to deliver novel life saving drugs and other natural products that can benefit humanity. There remain, however, a significant number of ethical challenges in contemporary bioprospecting concerning natural resource policies of extraction, commercialization, and benefit-sharing.

Contemporary bioprospecting projects seek to leverage the benefits derived from drug discovery to conserve natural resources, improve scientific capacity, and aid rural livelihoods in the countries where the resources and traditional knowledge are sourced. Results of this dissertation show that there is a shift towards mechanization and rationalization within contemporary bioprospecting which in effect is excluding some rural Malagasy from participation while reshaping the way others are participating. The practice, in this new form, raises ethical questions about how Malagasy are participating are now incorporated into the practice and if benefits are being delivered evenly overall.

Up to this point, ethical questions surrounding bioprospecting have mainly developed around approaches to ameliorate environmental inequality should be addressed in terms of fairer distribution of benefits (i.e., compensation provided to individuals of groups in return for their participation).[19] Recently, however, scholars of environmental equality more generally have begun to view questions of environmental "in-justice" under a more procedural or democratic framework. According to Lake, procedural justice includes "…full democratic participation not only in decisions affecting distribution outcomes but also, and more importantly, in the gamut of prior decisions affecting the production of costs and benefits" (1996:165). Following Lake, I hold that if we truly seek to strike a

[19] I define external cost as a burden (monetary, social, health of other cost) that may be internalized by the actor who has not participant in the transaction.

balance in bioprospecting, then a more complete definition of environmental justice must be incorporated into policy and practice, one, I argue, that includes *both* distributive and procedural mechanisms.

These ethical issues found in this dissertation are informed by scholars engaging in these key concerns of environmental equity and distributive and procedural justice (Schroeder et al., 2008; Bryner, 2002; McDonald, 2002; see also Lake, 1996; Pulido, 1996). For example, at the rural level where resources are collected, Malagasy hold very little knowledge about the projects and what any type of benefits, if any; they may receive from the discovery of a drug. This ignorance may develop because of purposeful attempts by bioprospectors to hold back vital information about their goals of drug discovery so that first, rural actors will not restrict access to collection sites if they feel they are not being fairly compensated, and secondly, continue to participate as manual laborers.[20] This ignorance also questions just how Malagasy are participating in the decision-making process of drug discovery and related conservation activities. Although there have been some reserved optimism from rural Malagasy about the protection of local resources affiliated with related conservation activities of bioprospecting projects, there still seems to be quite a bit of confusion as to just what “protection” means in this context (see Chapter 5). And in some cases, residents question their ability to restrict access to any foreigners (scientists or businessmen) coming to collect mineral or bioprospecting resources. Many of these access dynamics, which are taking shape within areas of

[20] This development that has been observed in contemporary bioprospecting sites in Mexico and Peru where bioprospectors were denied access to collecting sites by locally organized resistance groups (see Greene, 2004; Berlin and Berlin, 2004; Hayden, 2003).

bioprospecting collection, need to be addressed if procedural and distributive justice questions are to be addressed in the practice.

In the end, I hold that bioprospectors must find creative ways to inform rural inhabitants about the project's goals and possible benefits of their activities, and devise ways that rural inhabitants can participate in the decision making process of bioprospecting and associated conservation activities. Furthermore, conservation projects must occur in the context of a more democratic process, with input from inhabitants who are potentially most affected by the projects themselves (see Chapter 5 and 6). Compensation for participation in bioprospecting must also include any potential burdens of livelihood that may take place within sites of production (i.e., restricted access to due to newly designated protected areas stemming from a bioprospecting project) (see Chapter 6 for a further discussion on this). This participation must include a full share of decision-making by rural actors which are accountable by both the Malagasy state (the legal owner of the forested sites of collection) and the larger bioprospecting actors along the natural products commodity chain. For example, state agencies and institutions, which provide bioprospectors access to these sites, must be willing to hold back collection permits unless a more democratic and distributive process is adopted. This must include a process in which rural Malagasy are informed and participate in the process of decision making and are fairly compensated for their participation.

In the drug discovery phase, uneven partnerships between collaborating laboratories have shifted much of the decision making power in favor of foreign scientists and laboratories.

These uneven power relations have resulted in skilled scientists conducting menial tasks such as exporting of ready-made extracts to high-tech labs in the U.S. to conduct drug discovery. To address this situation, in return for the source material, host-country laboratories should be provided with current drug discovery equipment and materials so they can conduct parallel drug discovery research using their scientific knowledge and skills. Second, compensation for participating Malagasy scientists needs to be levied on the ability to discover new molecules, and not new drugs (which at this point, host-country labs are not in a position to do) (see Chapter 5). Third, actors (including laborers and scientists) along the natural products pharmaceutical chain need to be paid a fair, not only for their labor, but also for their skills and ability to conduct comparable research within their host-country. Furthermore, compensation for bioprospecting can potentially be delivered in the form of health care, either technical capacity (training of doctors, nurses or medical technicians) or much needed pharmaceutical products to Madagascar. This last suggestion has been discussed by some bioprospectors; however, up to this point it has continued to be dismissed by many of the commercial and research partners as not economically or politically feasible.[21]

Conclusion

Historically, the use of natural products (biogenetic resources) in drug discovery has a proven record of success (Cragg and Newman, 2001). Recently, however, there has been a transformation in the drug discovery industry, which is attempting to shift away from natural products towards synthetic and computer generated molecules that can be tailored to fit particular diseases. This progression away from natural products is theoretically a

[21] Gordon Cragg, pers. communication, 2005.

way to overcome many of the biophysical, social and regulatory obstacles that are inherent within the production processes of bioprospecting. Significantly, from an industry perspective, they are also a way to “speed up the process” in so far as computer derived molecules can be created much faster than anything derived from nature.

These efforts to disengage from nature in bioprospecting are specifically taken up by geographer, Bronwyn Parry (2000). Parry examines both “the fate” of collected biogenetic materials in botanical repositories long after they have been collected, and the power of the actors who now control access. She remarks that we must look past traditional notions of collecting as apolitical and “benign.” Rather, for Parry, collecting may be seen as "…a process that enables individuals or groups to alienate (both territorially and epistemologically) particular bodies of material for their exclusive use." She notes that we must also go beyond the standard apolitical definitions of collections to see it as a complex process that allows value to accrue for the recipients of the material (2000:375). She remarks that due to the appropriation of high-input technologies in the fields of horticulture, genomics and biotechnology, plant material collected may be regenerated at a quicker rate and stored for longer periods of time (Parry, 2000). Furthermore, she notes that these new advances in rational drug discovery processes such as pharmacological screening, combinational chemistry and robotics have "fundamentally alter[ed] the nature of the biological materials so that they become infinitely more amenable to collection, concentration and control" (2000:382).

A key conclusion that can be drawn from this chapter is that even amongst all the new technological advances Parry describes, there remain countervailing currents facing bioprospectors to return to “nature” to collect the biogenetic resources needed for drug discovery and development. Alongside Parry, I argue that bioprospecting is hardly a benign activity of exploratory searches and collection; rather it is a commercially-led scientific practice which produces highly politicized ecological and social spaces. The remaining chapters of the dissertation will move beyond Parry’s analysis to trace the return to nature within the politicized spaces of production in Madagascar.

The ultimate purpose of this chapter was to highlight the practice of drug discovery and its general historical and contemporary landscapes. This chapter provides the essential background to the three case studies that follow. The three case studies contextualize the practice in more detail, describing some of the earliest drug discoveries and commercialization in Madagascar while also tracing bioprospecting modes of production under increasing levels of environmental regulation and benefit-sharing.

Specifically, the following case studies draw attention to the uneven development of bioprospecting in Madagascar. First, I describe the increasing use of new technology by bioprospectors in their attempts to roll back “nature,” and the overall industrialization of land, labor and knowledge within rural sites of collection and laboratories in Madagascar. Second, I illustrate the social and political networks that bioprospectors maintain to access critical sites of extraction and to tap into vital labor pools needed for collection. Third, I demonstrate the use of securing access through “new” conservation interventions, the tension that exists within rural sites of collection, and the effect on rural livelihoods. And finally, I illustrate different moral "claims" surrounding bioprospecting, including distributive justice (i.e., biopiracy and benefit-sharing), and the political and moral economic landscapes in Madagascar.

Chapter 3

At the "Pharm" gate: The case study of the rosy periwinkle (*Catharanthus roseus*)

Introduction

My research assistant and I were already in the thick of market interviews when the sacrifice happened. It was 5:00 AM, and we were set up on the National Road 10, trailing peasants hauling large bundles of rosy periwinkle roots to a nearby processing station in the deep south of Madagascar. Alongside the road, I noticed a group of periwinkle collectors standing around a patch of bloodstained earth. I moved closer to find out a bit more when, abruptly and unexpectedly, I was handed a small plate of charred meat and asked to sit before the speeches began.

I soon learned that the meat was part of a sacrificial ram ceremony that had taken place just minutes before our arrival. However, the sacrifice was not unprovoked. Roughly a week prior, there was an accident in the town. A truck full of freshly collected periwinkle roots returning from the market cracked its axle and veered into a roadside home. The truck took down two walls of the house and was destroyed. Fortunately, no one was home, and miraculously no one in the truck was seriously hurt. The sacrifice was an offering by the periwinkle firm that owned the facility to the local ancestors for looking out for the safety of their employees,[1] and like many other measures taken by the firm, was meant to solidify their social position with a rural base of periwinkle producers (Ribot, 1998; Berry, 1996). As the manager of the facility explained:

[1] There is a rich literature devoted to Malagasy customs concerning ancestral worship; cf. Middleton, 1999; Mack, 1986.

> It [the sacrifice] was something that had to be done. Those in the accident believed that they needed to be cleansed, and wanted to give thanks that they survived. So the first thing I did yesterday was to gather them to show them my concern and my sympathy. Sometimes you have to forget about your objective and respect and to be involved with their customs. You know, that accident happened on Tuesday and no one wanted to collect plants until this was done. That was a kind of indirect obstacle to our work.[2]

This manager is dependent on thousands of laborers who help him source tons of periwinkle throughout the expansive areas of southern Madagascar. Similar to many bioprospectors in the past, his ability to gain, control and maintain the benefits that derive from the periwinkle trade rests on successfully accessing the "cheap" rural labor needed to extract it.

The following chapter contrasts contemporary extraction in Madagascar with some of the original research, discoveries and cultivation of the rosy periwinkle done 50 years ago. The first part of the study follows the social, political and economic history surrounding the periwinkle plant. Specifically, this analysis traces this history from the collection of original source material in the late 1950s to production in large-scale plantations worldwide today. It provides insights into how biogenetic resources were accessed and extracted for commercialization prior to the "ethical" guidelines of transparency, benefit-sharing and promotion of conservation found in current bioprospecting initiatives.

In part two of the chapter, I discuss contemporary perspectives of operators of pharmaceutical firms, collectors, out-growers and peasant producers who participate in a large and disparate commodity chain spanning the area from the southern littoral of Madagascar to large-scale pharmaceutical firms in the US and Europe. Held up against the other two case studies in this

[2] ANON 61 (Feb. 2, 2006).

dissertation, the chapter offers a detailed study of a natural product that has undergone a complete cycle of commercial integration including prospecting, extraction, cultivation, attempts at chemical synthesis, and full drug development. However, despite all of the commercial development, there has been a partial return to “natural” sources in Madagascar to access the periwinkle. The following section highlights the main reasons for this return to Madagascar, including the need for pharmaceutical firms to obtain periwinkle in bulk supply and tap sources of cheap labor to collect it.

Part I: Shifting propagation of periwinkle

In 1958, Gordon H. Svoboda, a phytobiologist at the U.S. pharmaceutical company Eli Lilly, tested extracts of the flower, rosy periwinkle (*Catharanthus roseus*), as part of a detailed investigation of its previous "folkloric usage" to regulate sugar in the blood. Lilly was looking for novel ways to administer insulin orally. Instead, chemical screening of the plant found a number of useful bioactive *indole*-alkaloids found in infinitesimal quantities in the leaves and roots, which subsequently led to the development of two very powerful anti-cancer drugs (Svoboda, 1983). The drugs were used in the treatment of acute leukemia, Hodgkin’s disease and non-Hodgkin’s lymphomas, and helped save thousands of lives, including those of many children (van der Heijden et al., 2004: 608; Svoboda, 1983). These discoveries distinguished the once indigenous Malagasy plant as a global pharmacological treasure. It certainty brought riches to Eli Lilly, which earned hundreds of millions of dollars from the sale of their two patented compounds (Stone, 1992).

However, due to political unrest as Madagascar was making its transition to a socialist regime, supply and quality of periwinkle sourced in Madagascar were beginning to slip, and Lilly was not able to guarantee the vital stock of thousands of kilograms of the plant's leaves and roots needed for drug development (Svoboda, 1983; see also Sheldon et al., 1997). As a result, Lilly shifted its focus away from "wild" collection towards production of periwinkle on plantations in McAllen, Texas (Sheldon et al., 1997). However, Lilly's efforts at diversifying its supply did not stop there. The company also began to buy prepared extract from suppliers in Budapest, Hungary, and made numerous attempts at *in vivo* cultivation (i.e., micropropagation and microsourcing) and chemical synthesis (Sheldon et al., 1997; see also Brown, 2003).

Lilly's efforts to limit disruptions in its production process, and avoid having to travel across the world to source the material, can be characterized as attempts at mastering the constraints of nature through mechanization. Scholarship in agrarian change and peasant studies has remarked on such developments with the industrialization of agriculture (Goodman and Watts, 1997; Page, 1997), new forms of the division of labor (Goodman and Redclift, 1991) and the persistence of petty producers within the commodity system (Mann and Dickenson, 1978; see also: Mann, 1990). Furthermore, such efforts at overcoming the barriers of production through mechanization have been shown to develop unevenly within rural production systems (Kloppenburg, 2004; Fine, 1994). As I demonstrate below, periwinkle production only partially resolves these constraints or "natural" barriers.

The botanical trail of periwinkle

The periwinkle plant is a mid-sized perennial which can grow up to 32 in (80 cm) in height with glossy, dark green and oval shaped leaves. Its flowers are pinkish to red with five lobes (Stern, 1975). It is one of nine species found under the independent genus Catharanthus, eight of which are indigenous to Madagascar and one to India (van der Heijden et al., 2004; Stern, 1975). Today, the rosy periwinkle can be found growing in Africa, Mediterranean Europe, Asia, the Americas, and in some Pacific Islands (van der Heijden, et al., 2004).

The first written botanical description of the rosy periwinkle was by Governor-General Etienne de Flacourt of the southern French enclave of Ft Dauphin, Madagascar, who included it within his natural history compilation entitled, *L' histoire de la grande ile de Madagascar*:

> Tongue, grass-like Saponaria which flower like jasmine, one is white, the other is colored purple, the root is very bitter, which they use against the evil of heart, and is good against poison, its approach, Vincetoxicon or Asclepias, and is not in high [dosage]. …the white flower has more virtue (Flacourt, [1661] 1995).[3]

It was not until much later in the late 18th century that Carl Linnaeus registered a systematic description of the plant. It was Linnaeus who first recorded the periwinkle within his *Species Plantarum* under the names Vinca *minor* and Vinca *major*. This description was shortly followed in more detail in the fifth edition of *Genera Plantarum*. In 1759, Linnaeus placed *Vinca rosa* in the botanical encyclopedia *Systema Naturae*, under the synonym Lochnera. This was the name that periwinkle maintained until 1835, when botanist G. Don placed it in his "General System of Gardening and Botany" under the Genus vernacular "*Catharanthus*." The rosy periwinkle

[3] *Tongue* was an older Anosy name for the plant used in the region. Although it goes by many names, it is now commonly known as *tonga*.

(*Catharanthus roseus*) is commonly known as the “Malagasy” periwinkle, reflecting its country of origin (van der Heijden et al., 2004; Stearn 1975).[4]

The trail of cultivated periwinkle follows a well established transfer of plants and animals to European botanical gardens of the early 18th century. It was the botanist, Phillip Miller, who first cited Madagascar as the origin of the plant: “The seeds of the plant were brought from Madagascar to Paris and sown in the King’s Garden at Trianon, where they succeeded in the Chelsea Garden” (Miller, 1757; cited in Stearn, 1975:12). The plant was then said to be naturalized at the Royal Gardens in Paris and seeds were shared with the Chelsea Physic Garden in London and the Leiden Botanical Garden in the Netherlands (Stearn, 1975: 36; see also: van der Heijden et al., 2004). The plant was spread to the new world by merchant sailors who carried its seeds to combat fatigue, hunger and minor tooth ailments (van der Heijden et al., 2004). By the 19th century, periwinkle was sold commercially as an ornamental (Brown, 2003; see also van der Heijden et al., 2004).

<u>The “twin” discoveries of prized vinca-alkaloids</u>

Many reports confirm that the discoveries of the prized vinca alkaloids were made independently by two different natural products laboratories somewhat simultaneously in the late 1950s (Johnson, pers. communication, 2007; see also Svoboda and Blake, 1975). The two laboratories were the Collip Medical Research Laboratory located at the University of Western Ontario and

[4] Madagascar was not always the accepted source of the periwinkle. In fact, some botanists have questioned if Madagascar was just the site of its first description (Brown, 2003).

led by Robert Noble, Charles Beer and John Cutts, and a laboratory run by the pharmaceutical company Eli Lilly Inc. based in Indianapolis, Indiana.

Medical historian, Jaclyn Duffin (2000), provides an insightful and detailed account of the Noble team's discovery in Canada. Duffin notes that Noble and his colleagues originally received samples of a "bush tea" used for the treatment of diabetes from a surgeon and recent graduate of McGill University, Dr. C.D. Johnston, who practiced medicine in Black River, Jamaica (2000). Robert Noble also remarked that "[Dr. Johnston was] quite convinced that his diabetic patients had received some benefits from drinking extracts of the periwinkle leaves" (Noble, 1990:1344; 1958; see also Duffin 2000).

Noble sent a handful of the original supply of periwinkle leaves he used to his brother, Clark Noble, also a medical doctor, who later forwarded them to the Collip Laboratory (Noble, 1990). Looking to corroborate *any* reports of the effects of the periwinkle on diabetes, they sent two members of his team to confirm the methods used in preparation of the tea (Duffin, 2000).[5] The trip to Black River ended inconclusively; however, it did secure a supply of continuing stock material for the laboratory. As Noble remarks:

> He [C.D. Johnston] would send boy scouts into the jungle to gather the leaves, which we received by mail in little packages. We also received many parcels of leaves and flowers labeled periwinkle from well-wishers, and even a box of delicious periwinkle snails from the East Coast (1990:1346).

[5] These two members included pediatrician, John C. Rathbun, and endocrinologist, Hugh A. McAlpine (Noble, 1990).

According to Noble, the supply of periwinkle coming from Jamaica was not enough. The team therefore began to cultivate the plant in greenhouses in Ontario, Canada with the help of a commercial firm (Jaclyn Duffin, pers. communication, 2007). Ultimately, however, the laboratory found no significant evidence of an effect of oral dose of the leaf extract on sugar and glucagon levels in the blood. Yet a host of other unexpected findings led the team to explore using the plant for other purposes, including anti-cancer treatments (Duffin, 2000; Noble et al., 1958).

The Lilly team

Lilly had always shown a profound interest in insulin-related therapy, having produced the first animal "porcine" and "bovine" insulins used in the treatment of diabetes.[6] The lead phytobiologist for the Lilly team, Gordon Svoboda, was well aware of the folkloric claims that periwinkle could be used to treat diabetes (Laird et al., 1993). The earliest reports of its medicinal use are said to be found in a 1910 article of the *Australian Journal of Medicine*, which was frequently cited by Lilly in the late 1950s (see Johnson et al., 1959).[7]

In comparison to Noble's group, the Lilly operation was a giant. For example, Lilly, one of the largest pharmaceutical companies working on all areas of biomedical and agricultural research, maintained a much larger staff and more overall resources than Noble's group (I. Johnson pers. communication, 2007). Furthermore, Lilly had close collaborations with large-scale US federal research institutions, including the National Cancer Institute's (NCI) Developmental

[6] Letter from Irving I. Johnson, 2007.
[7] Irving I. Johnson, pers. communication, 2007.

Therapeutics Board and the Cancer Chemotherapy National Service Center (CCNSC). Over time, these extra investments paid off handsomely. During their trials, the Lilly team discovered four bioactive alkaloids including lencocristine (vincristine), vinblastine, leurosinea, and leurosidine,[8] and they subsequently brought two very powerful anti-cancer drugs to market - Oncovin and Velban (Duffin, 2000). Oncovin, for example, provided a breakthrough in childhood lymphocytic leukemia therapy, boasting a 50 percent remission rate when administered alone and a 90 percent remission rate in combination therapy (Svoboda, 1983). After a brief period of providing the drugs at cost, Lilly switched over to the commercial production of Oncovin which over time brought in hundreds of millions of dollars for the company (Stone, 1992: see also Brown, 2003).

Claims of "biopiracy"

The story of the periwinkle does not end there, however. Rather it is only the beginning of claims and counter-claims by activists and concerned scholars who charged Lilly with biological piracy (biopiracy), or theft of the periwinkle and its "traditional" medicinal knowledge used to make the drugs (Stone, 1992; cf. Laird, 2002). At first glance, the story of the Malagasy periwinkle reads like a textbook case of "biopiracy": following leads from indigenous medicinal knowledge, a large multinational pharmaceutical company extracts a "wonder" plant deep in a remote forest of a Third World country. And while the company banks millions on the sale of the drug, the source country (Madagascar) receives virtually nothing in the way of monetary compensation. This tale

[8] Noble's group was credited as the discoverer of vincaleucoblastine (vinblastine), Noble's vinblastine against Hodgkin's disease also boasted a rate of 80 percent remission (Kididela 1993).[8]

is told repeatedly in the media by scientists and activists worldwide, and is echoed in the highest offices in Madagascar to this day.[9]

The thrust of "biopiracy" claims entered the discourse via a commentary in the journal, *Science* (Stone, 1992:1624). Included in the article was a picture of a periwinkle flower with the following caption: "No more easy picking. The rosy periwinkle of Madagascar, the source of two anti-cancer drugs." One volume later, also in *Science*, the former Vice-President of research for Eli Lilly and Co., Irving S. Johnson, countered:

I can say that the reality [of the periwinkle discovery] was very different [from Stone's previous commentary]. First, two different groups were investigating the plant because of folklore suggesting the use of a tea of the leaves for diabetes. These reports were from the Philippine Islands and Jamaica. The plant, however, grows wild or is cultivated in most temperate and semitropical parts of the world. At the time it could be harvested because of its rampant growth in India and Madagascar, and it was grown commercially in Texas. It was not a rare and endangered plant investigated by an ethnobotanist. More than 60 complex indole and dihydroindole alkaloids were isolated, and eventually two were marketed for the treatment of cancer [Velban (vinblastine), Lilly and Oncovin (vincristine), Lilly]. The latter was originally isolated in a yield of 1 ounce per ton of dried leaves, and for some time was marketed for the cost of manufacture. In this case I do not believe there is a compelling reason to suggest that Madagascar's role in the discovery of the pharmacological action of a few of the alkaloids from this plant represents 'easy picking' or any logical requirement for compensation. It was certainly not easy and required millions of dollars in investment (1992:860).

But the realties that developed from the periwinkle paint a somewhat different picture. As anthropologist, Michael Brown, suggests, "Lilly's allegedly exploitative use of the rosy periwinkle has become the ethnobotanical equivalent of an urban legend" (2003:136; see also Laird et al., 2000). First, the periwinkle is a pantropical weed found growing across the tropics

[9] Throughout my research interviews with Malagasy government officials in 2005-06, the "rosy periwinkle" was frequently characterized as a misappropriated resource mainly because Madagascar never received any benefits from its commercialization.

and subtropics, and by the time of the discoveries in the late 1950s, periwinkle could be located from a number of different source countries (Laird et al., 2000). Secondly, the traditional medicinal leads that the scientists were following, the use of periwinkle as a hypoglycemic for the treatment of diabetes in Jamaica and the Philippines, were fairly well-known at the time (Laird et al., 2000). And lastly, the alkaloids that were subsequently developed into drugs were used for the treatment of different cancers; the researchers were originally searching for a diabetes cure and, in Lilly's case in particular, a way to administer oral insulin.

Those involved in the research contend that the case study of periwinkle highlights the immense difficulties of assigning intellectual property rights based on the "point of origin" of the biogenetic material and associated knowledge (Brown, 2003:136; see also Svarstad, 2004; Laird et al., 2000). Moreover, it provides a starting point to contextualize changes in the practice of bioprospecting over a 50-year period in which the bioprospecting community witnessed the enactment of international regulations pertaining to the ethics of collecting practices and benefit-sharing protocols (see also Chapter 5).

Table 3.1 Some commercial forms of C. *roseus* alkaloids and specific parts used[10]

Alkaloids	*Commercial name*	*Plant part used*	*Diseases treated*
Vincaleukoblastine-Vinblastine	Velbe, Vincaleublastine	Leaves	Several forms of Hodgkin's leukemia Neuroblastomia, breast cancer and chorio-carcinomas
Vincaleurocristine Leurocristine Vincristine	Oncovin, Laurocristine	Leaves	Leukemia acute Hodgkin's disease, Wilm's tumors in children, breast cancer, rhabomyosarcomas
Ajmalicine, Yohimbine	Hydiserpan, Lamuran	Roots	Hypotension artery and vascular medicine
Reserpine	Reserpine	Roots	Hypotension, arteriole hypertensive and neurodepresseur
Serpenline	Serpenline	Roots	Hypotension
Leuresine	Leuresine	Leaves	Some forms of cancer, anti-tumor
Anhydrovinblastine	Anhydrovinblastine	Leaves	Cervical and lung cancers[11]
Vinorelbine Vinorelbine Tartrate	Navelbine	Leaves and roots	Lung, breast or ovarian cancers

Constraints of the source material

For Lilly and others, the work conducted on the periwinkle culminated in remarkable discoveries which led to lifesaving drugs for children (Table 3.1). The production of these new drugs over time was not without its difficulties, however. The amount of active ingredient needed to produce the drug found from periwinkle is extremely low, yet supply problems were a major bottleneck for the company (Svoboda, 1983). As explained by Irving Johnson:

> …you must realize that over sixty alkaloids were present in the plant, but the amounts were infinitesimal in quantity. The active alkaloids were all large *dimeric-indole-dihydroindole* compounds which have never been [chemically] synthesized.[12]

Very infinitesimal indeed! It took up to one ton of dry leaves to isolate one ounce of vincristine, and up to fifteen tons to make one *ounce* of vinblastine [13] Furthermore, the *antineoplastic* (or anti-tumor) alkaloids found in two tons of processed leaves provide roughly one gram, the

[10] Table adapted from Andriamanalintsoa, 1995; see also FAO, 2003.
[11] van der Heijden et al., 2004 .
[12] Irving Johnson, pers. communication, 2007.
[13] Irving Johnson, pers. communication, 2007.

equivalent of just six weeks' treatment (Rasoanaivo, 1990).[14] The fact bioactive components only occur naturally in infinitesimal quantities in each plant is one of the most glaring examples of the "natural barriers" that firms faced (Mann and Dickenson, 1978).

Over these early years, Lilly made many creative efforts at sourcing periwinkle. These efforts included reproduction from tissue culture and acquiring ready-made extract. Brown notes that the company purchased purified vincristine in Budapest, Hungary, for U.S. $1.3 million per kilogram (2003). Furthermore, there were also very ambitious attempts at full chemical synthesis of the bioactive substances in the periwinkle. However, due to the complexity and size of the *indole*-alkaloids most of these attempts failed. [15]

In the end, Lilly relied on harvested periwinkle for its supply. And to obtain the amount needed, Lilly set up contracts with commercial plantations where some of the best quality periwinkle could be found (Svoboda, 1983). This is well documented in an interview conducted in 1992 with Svoboda:

My original crude drug came from India, followed by the Philippines, Australia next and finally Madagascar, plantations being established therein by the French. The crude drug happened to be of the highest quality which we had received to date. The natives eventually became restless, threw the French out, and took over the plantations. Drug quality became questionable, supply deliveries unreliable. This could not be tolerated: lives were at stake. So Texas became our

[14] In the 1950s, Gordon Svoboda's work on vincristine demonstrated that it took over 12 tons of the dried material to produce one ounce of the needed vincristine sulfate (Svoboda and Blake, 1975).
[15] There are roughly 130 known alkaloids found from the rosy or Malagasy periwinkle. They are part of the terpernoid-indole alkaloid group, which are part and parcel of large and complex compounds found in very low quantities in the plants roots and leaves (van der Heijden et al., 2004; Rasoanaivo, 1990; Svoboda, 1983). The extraction of the biologically active components is found costly and highly laborious; subsequently, there have been numerous unsuccessful attempts to reproduce the active components synthetically. However, many derivatives have been found in semi-synthetic and synthetic mixes (van der Heijden et al., 2004; Irving I. Johnson, pers. communication, 2007).

source of supply and still is. The cost factors of labor and farmland were overcome by the use of proper planting and fertilizer methods, along with harvesting mechanization. I hasten to add that in each case Lilly paid for all supplies received, thereby contributing to the economy of the country of origin (Svoboda, Eli Lilly, pers. comm., as quoted in Laird, et al., 1993:118).

Lilly's shift away from obtaining periwinkle from "nature" was mainly due to political instability in source countries which began to cost them financially (Svoboda, 1983). Fearing disruption in their supply, Lilly started "experimental" plantings of periwinkle in western Texas, where they alone could control many of the external factors of production (Svoboda, 1983). To cut the production costs they were now facing in the U.S., Lilly began to mechanize many of the production systems through horticultural innovations, including a mechanical "forage" harvester, introduction of new varietals and improved irrigation regimes (Svoboda, 1983). These changes, over time, supplied Lilly with a sufficient harvest to begin production of the drug.

Lilly's sole reliance on its Texas plantations, however, did not last long. By the late 1970s, the demand for periwinkle became so great that Lilly's domestic production needed to be supplemented with an alternate stock (Sheldon et al., 1997), and so Lilly again looked to the large-scale plantations in Madagascar. Production in Texas with imported stock of periwinkle continued until the mid-1980s. In 1986, Lilly's patent finally expired. The loss of sole proprietary rights to the drug resulted in increased competition for periwinkle-based drugs and eventually led to the end of Lilly's U.S. based periwinkle operation in the early 1990s (Sheldon et al., 1997:15).

There seem to be two main reasons for the return to Madagascar to source periwinkle rather than to other sites. The first is that the periwinkle found in its southern littoral is said to be of vastly better quality than anywhere else in the world (Sheldon et al., 1986). Second, the bioactive chemicals in the periwinkle were found in such small quantities that tons of the leaves and roots were needed and periwinkle was still in ample supply in Madagascar. Third, Lilly was able to access the labor needed to extract the raw material at a fraction of the cost of labor in the U.S. The cheap labor, thus, became a way to overcome the "natural barrier" of the significantly low bioactive chemicals found in the plant. This dynamic is similar to what drives contemporary firms who also look to Madagascar for extraction of periwinkle rather than to large-scale contracted plantations.

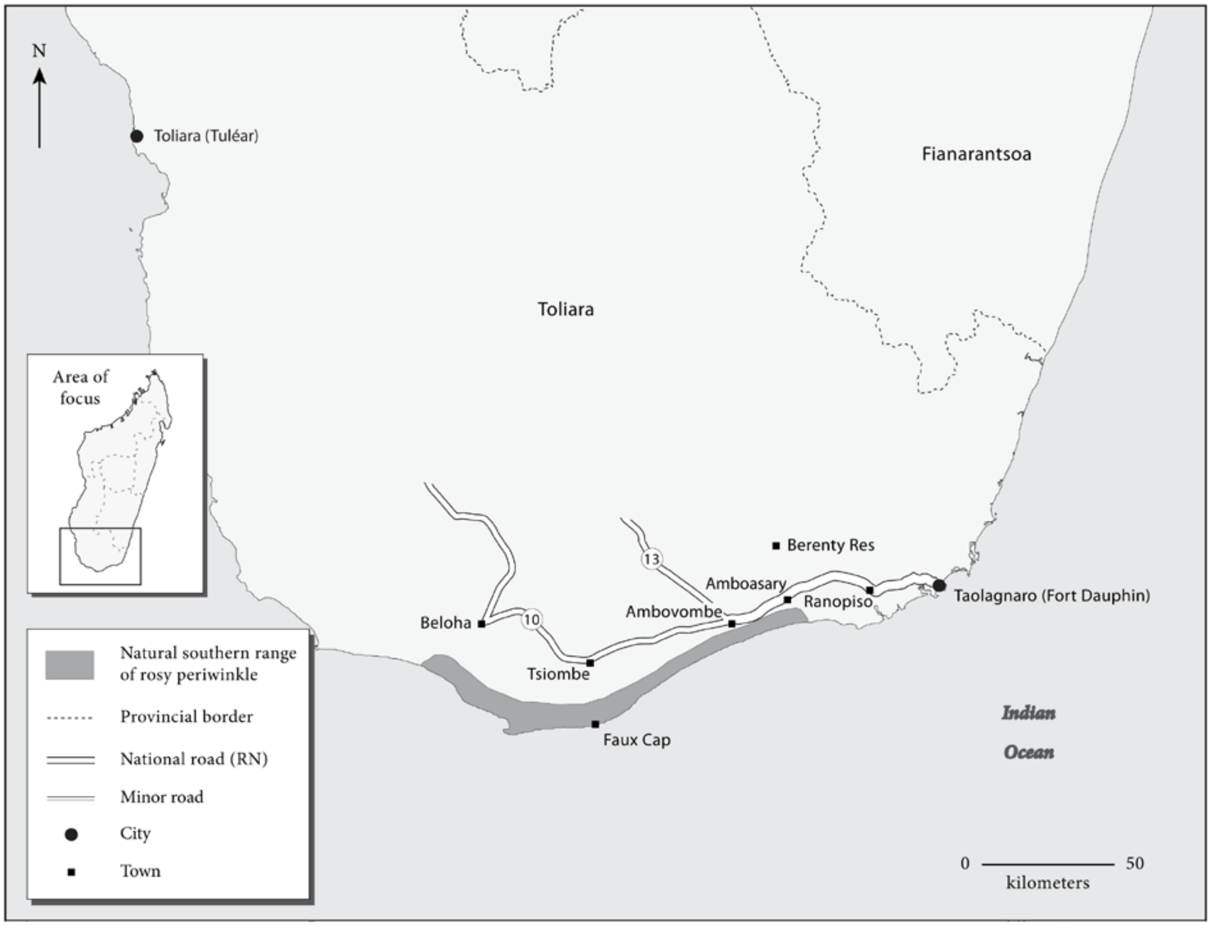
Part II: Periwinkle *redux* - the periwinkle commodity chain in Madagascar

Periwinkle is a pervasive self-seeder and especially "weedy" (Jolly, 1980). In Madagascar, periwinkle can be found growing in previously cleared fallow land and on the boundaries of denuded hillsides (Andriamanalintsoa, 1995). The majority of the periwinkle is found in humid altitudes of 20 to 350m, relatively warm temperatures of 10 to 27C and rainfall amounts of 300 to 400mm/per year (Andriamanalintsoa, 1995). It is thought that its natural geographic distribution began within the southern littoral ranging from Ft. Dauphin, Ambovombe, and Amboasary to its western range from south Beloha to Tsiombe. It is identified by a number of different vernacular terms, including *tonga* (Ft. Dauphin), *trongatsy* and further west as *befela*.[16]

[16]ANON 61 Feb. 2 2006.

Roughly 90 percent of the annual periwinkle production comes from this area in the south (see Map 3.1).[17]

Map 3.1 Southern range of periwinkle production



Historical production in Madagascar

The collection of periwinkle plants in Madagascar by chemists and botanists interested in exploring the plant's fascinating chemistry for medicinal use began in 1967 (Andriamanalintsoa,

[17] ANON 61 Feb. 2 2006. The area is flush with succulents and aloes which inhabit the unique spiny and dry forests characteristic of the southwest of Madagascar (Goodman and Benstead, 2003). The lack of available water for irrigation, however, places major constraints on agricultural production for many inhabitants of the area. Nonetheless, these soils provide a prime ecological niche for some of the world's highest quality rosy periwinkle to flourish.

1995). Most of this collection was centered in the littoral areas of the south, but by 1970, an intermediary of the German pharmaceutical firm, Hoechst, began small-scale production of 60 ha in the Alaotra region in northeast Madagascar. The plot, which was finally abandoned due to poor harvests, was later surpassed by large-scale "wild" collection in the south (Andriamanalintsoa, 1995). A second periwinkle plantation was established on a colonial concession of 2000 ha by two commercial firms, Emile Sthele-Cie and Tropic-Import. This plot, located 42 km northwest of the southern city of Ft. Dauphin in the region of Ranopiso, was to become the first "industrial" plantation of periwinkle in Madagascar (Andriamanalintsoa, 1995).

By 1972, with production of periwinkle on the rise, the company, Emile Sthele-Cie, began the large-scale exportation of periwinkle to markets in the U.S. and Europe. To ensure its supply, the firm solicited help from a German NGO and local forestry offices to promote the establishment of plantations in the Androy region, including the areas of Sampona, Tsiombe, Faux-Cap and Ambovombe (Andriamanalintsoa, 1995). This technical and material support came in the way of the distribution of seeds, training in cultivation, and the testing of horticultural varieties. This period gave rise to a massive land transformation from the dry spiny forests that inhabit the area to cultivated periwinkle fields (Andriamanalintsoa, 1995; see also Newman, 1994; Rasoanaivo, 1990). Many of these plots, however, were later abandoned due to the political crisis of 1973 which caused a brief disruption in supply due to political instability.[18]

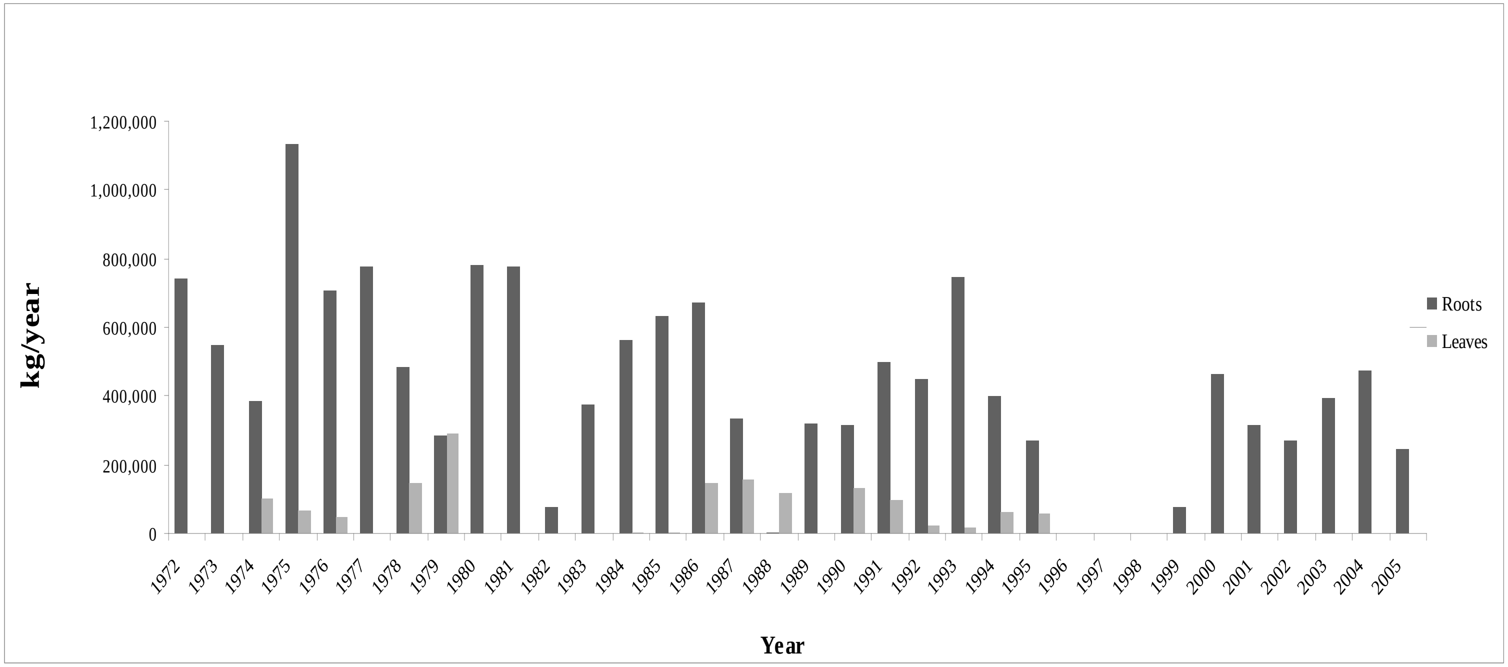
[18] ANON 63 (Jan. 31, 2006). This is the same development that caused Eli Lilly to leave and set up plantations in Texas (see part I of this chapter). It is difficult to say what economic impact this might have had on the area of Southern Madagascar; however, Gordon Svoboda reported a significant loss of jobs and revenues due to Lilly's pullout (1983).

In 1974, the industry was revived by the German pharmaceutical firm Boehringer Mannheim and its subsidiary agribusiness firm, SEAR (*Société d'Exploitation Agricole de Ranopiso*), in Ft. Dauphin (Andriamanalintsoa, 1995). At this time, Madagascar found itself in the center of a "boom" cycle of periwinkle production (Rasoanaivo, 1990; see also: Sheldon et al., 1997), with seven different firms engaged in exports, including Pronatex, Sevproma, Sopraex, Soamadina, Ets Razanatseheno H., Vokatra Voafantina and Atsimo-Export (Andriamanalintsoa, 1995).

Periwinkle exports reflect a highly irregular pattern as exports more than doubled in a single year totaling 1,200 tons in 1975 (see Figure 3.1) (Sheldon et al., 1997; Rasoanaivo, 1990; Rakotomanana, 1982). However, by 1978, with worldwide demand waning, many of the major companies bowed out of periwinkle production (Andriamanalintsoa, 1995). This downward trend continued until the mid-1980's when a short surge in production fostered another highly irregular six year period in the periwinkle market (Rasoanaivo, 1990). During the period of 1988 to 2004, worldwide demand for the periwinkle roots remained relatively stable, with an average of 800 tons of periwinkle exported annually. While demand has been shown to fluctuate over the years the overall export of leaves has been more sporadic than roots. One reason for the consistent demand for roots is due to their higher alkaloid content (up to 0.13 percent) as compared to that in the leaves (Davis, 1990).[19]

[19] ANON 67 (July 31, 2006).

Figure 3.1 Periwinkle exports from Madagascar (1972-2004)[20]



[20] Data on exports from 1996 to 1999 are currently unavailable. These data are mainly taken from the Ministry of Water and Forests (now General Direction of Water and Forests under the Ministry of the Environment). Some export data taken at the point of disembarkment (Port sites) are not reported to the correct government ministries, resulting in inconsistencies between different sources.

The rosy periwinkle commodity chain in the Androy and Anosy regions

Table 3.2 contains a typology of the key actors in the periwinkle commodity chain based on their roles, their tenure rights, and their means of compensation.

Table 3.2 Typology of actors involved in the periwinkle commodity chain

Actor	*Description of activity*	*Tenure rights (state, firm, individual held land)*	*Compensation (contract, wage or payment on sale)*	*Estimated numbers directly involved*
Peasant producers	Collect "wild" periwinkle	State and individual	Payment	7,000
Out-growers	Cultivate periwinkle	Firm and individual	Contract and wage	50
Laborers	Work on periwinkle plantations	Firm	Wage	50
Private collectors	Transport material	Firm	Wage	<100
Staff collectors	Buy/sell transport, post-harvest production	Individual	Payment	25
Market brokers	Buy/sell periwinkle	Individual	Payment	20
Exporters	Buy, package and export material	Firm	Payment	2-3
Importers	Buy and transform material into finished drug	NA	Payment	~4-5

Peasant producers

There are a number of actors who are involved in producing plant material for the market, including peasant producers, laborers and out-growers. Of these, the peasant producers comprise the largest category of actors within the periwinkle chain. Some estimates suggest that up to seven thousand rural farmers are directly involved in periwinkle production and another fifteen thousand are indirectly supported from cultivation through extended kin networks.[21]

Many peasant producers allot up to two full work days (eight to ten hours) per week to collect periwinkle. Periwinkle is typically harvested in the rainy season, usually just before flowering to allow for seeds to drop and fully germinate before the plant is taken out of the ground. With adequate moisture, you can harvest after six to eight weeks.[22] Three to four harvests are commonplace and with proper irrigation even more harvest are possible.[23] However, the exact timing of the harvest is dependent on labor availability, the need for cash income and the simultaneous ability to access a harvestable stock of periwinkle. This allows for the dispersion of the seeds simultaneously with harvesting (the seeds are said to drop during the process of de-rooting the plant). Also, it is said that after the rains the soil is soft and makes uprooting the plant much easier.

While leaves are normally harvested continuously by multiple thinning, periwinkle branches are also sometimes coppiced in the field and transported to the harvesting site for de-leafing (Andriamanalintsoa, 1995). Leaf material is either dried in a multi-step process in the field or within a central village courtyard. Depending on the season, leaves are ready for transport within three to seven days (Andriamanalintsoa, 1995). This timeframe is essential for highest quality, since a second drying will diminish the chemical content of the product. To ensure quality,

[21] ANON 60 (April 26, 2006).
[22] Some harvesters mention they wait up to six months to harvest.
[23] ANON 61 (Feb. 2, 2006).

whole families (men, women and children) join up to conduct post-harvest activities such as drying and sorting roots and leaves.[24] The recruiting of family to finish this task is said to be encouraged by the firms, and is reflected by the total number of extended family members estimated to be involved in the trade.[25]

Important actors commonly overlooked in the production of periwinkle are older women producers. These women carry significantly lower amounts of periwinkle to market, sometimes only up to 5 to 10 kg per trip; however, they account for a disproportionate percentage of the overall total of material collected. Furthermore, the income derived from periwinkle sales is extremely important for women's subsistence, which is advantageous for the firm since it fosters women's continual participation despite the little income derived. Furthermore, since periwinkle can be found harvested in the wild, older women can harvest without any significant land holdings. As one older female harvester put it, "Even without enough rain we always find some periwinkle to harvest…even if the price is bad…we still need to collect because our children need to eat."[26] Another stated: "I might die if there is not more periwinkle to harvest; I don't know what I would do otherwise."[27]

Periwinkle roots are usually carried by hand in large bundles tied together by sisal twine. The amount any one harvester can bring varies widely. Male producers reported carrying up to 60 kg loads and up to 200 kg of roots per week, whereas women and children bring in 20 to 25 kg. Many peasant producers mentioned they only walk up to an hour to a market where periwinkle is

[24] This was observed in field visits in February and April, 2006.
[25] ANON 60 (April 26, 2006).
[26] ANON 70 (April 27, 2006).
[27] ANON 78 (April 26, 2006).

exchanged, yet others have noted a dramatic increase in the distance they now need to transport. The increasing distance is becoming an important factor in determining if they will continue to participate in the harvest.

However, transport distance is only one of the many factors affecting the level of involvement in periwinkle collection. For example, they must also consider if the quantity of the harvest will be large enough to make it worth the trip, and if market conditions will be favorable at the time of sale. Since many peasant producers are also farmers of other crops, they must decide if they will haul their periwinkle or other crops to the market first, a decision which varies according to the relative prices of other food crops (i.e., particularly corn and small brown beans called *vagnemba*; see Table 3.3).

Some peasant producers do maintain flexibility as far as what they will bring to market. For example, if periwinkle roots are dried and stored properly they can hold up to a month or so before losing quality. So if market prices for alternative commodities are high, then harvested periwinkle is stored for a later sale date and the non-harvested periwinkle can be left growing in the field.[28] These market decisions concerning periwinkle were reflected in a comment made by one peasant: “Now [during the rainy season] *tonga* (periwinkle) prices are about the same as with other products such as cassava, but during the dry season, when there is not much food to sell, the *tonga* trade saves our lives.”[29]

[28] However, some mentioned that after they grow periwinkle on their land, then it is very difficult to grow anything else on the piece of land because of the chemical residue left. This could not be confirmed.
[29] ANON 71 (April 27, 2006).

The firms who buy from the peasant producers in this region work hard to attract their business. In fact, the firms use a number of economic incentives to attract peasant producers, including the use of new bank notes which are favored by the peasants because they are to be "crisp" and "clean," and the weighing of shipments with older scales that are familiar to the peasants, and considered to be "more trustworthy."[30] And lastly, female periwinkle buyers ("collectors") are strategically placed in various areas of the market to entice women producers to sell to them.[31] These methods are obviously working, since firms in this area generate some of the highest annual production totals in the country.[32]

Table 3.3 Producer prices in May 2006 at a market in Ankaramena

Crop	*Malagasy name*	*Price for 1kg (FMG)*
Fresh cassava	Manioc maiaima	2,000
Rice	Vary tse-tse	5,250
Orange	Vaongy	5,000
Mango	Mangy	1,000
Periwinkle[33]	Tonga	1,000

However, these market dynamics are not evenly distributed across the two regions of Anosy and Androy. In the region of Androy, closer to Ft. Dauphin, an increasing number of producers are now abandoning periwinkle to work on food crops. This is mainly due to the better prices that farmers can obtain at the market for food crops (Table 3.3), and to the fact that production is so labor-intensive. However, the further west and south you proceed into Anosy, the trade of periwinkle is vibrant, with more farmers increasing by the day. [34]

[30] ANON 70 (April 27, 2006).
[31] These are all observations I encountered while conducting market surveys during my field research in February 2006.
[32] ANON 61 (Feb. 2, 2006).
[33] The market price of approximately 1,000 FMG kg (U.S. $0.10) is set by the firm operating in that market.
[34] ANON 72 (April 27, 2006).

Reasons for the geographical differences of the importance of periwinkle for rural farmers can be reduced to a few factors. First, the further out you get from the larger urban areas the access to markets where peasants can sell food becomes increasingly limited and the periwinkle sale becomes their only source of income. Second, the areas in the west and south have historically been zones prone to periodic drought and famine, and peasants store food for future consumption rather than for sale. Finally, transportation is a serious obstacle facing the peasants; the more west and south you proceed, the soils become sandier and harder to transverse and more difficult for transporting food crops. To ease the long transport of periwinkle, firms have set up a decentralized network of drop-off kiosks in different villages so that peasants are encouraged to continue producing periwinkle over food crops. These factors all help ensure that periwinkle remains a viable revenue source vitally important to those living in the more western and southern regions.

Out-growers and laborers

Beyond the peasant producers are two other sets of actors who contribute to the production of periwinkle roots and leaves; they include contract out-growers and laborers. Out-growers are independent employees of collection firms or individual businessmen. They are provided with basic materials (seed, shovels, buckets, etc.) for producing periwinkle and a guaranteed market. This provides the impetus for out-growers to cultivate larger areas of periwinkle. Plot sizes are anywhere from 1 to 5 ha and are usually maintained by the cultivators themselves or by hired laborers. These plots are carefully maintained and monitored by collection companies, and are said to be an important supplemental source to annual harvests.[35]

Laborers, on the other hand, are specific farmhands who work directly for the companies. They are provided with a daily wage to grow and harvest periwinkle on cultivated plots. Most plots are situated close to the firms' headquarters in Ft. Dauphin so that operators can have quick access to the material, while supplying the firm with a supplemental stock and "security" net if not enough periwinkle is netted from peasant producers in a given year. Comparatively, their overall contribution of tonnage exported is small; however, these cultivated plots allow for controlled experimentation on growing techniques, pest and irrigation management and the introduction of new varietals, all of which are of vital importance for the companies to maintain a quality stock of periwinkle for export. In return, the out-growers and laborers receive specific training in horticultural and post-harvesting techniques so as to ensure that their production and quality is consistent.[36]

The collectors

The collectors represent a group of individuals who essentially act as middlemen and women between the firms and the producers. These collectors work either independently (private collectors) or as direct hires (staff collectors), and are charged with negotiating the bargaining price, weighing the material and checking the quality at the "point of sale." Private collectors

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[35] ANON 76 (April 26, 2006). From a single hectare, one can harvest up to 600 to 800 kg of roots; or 800 kg of leaves (roughly three harvests) from the same plants.
[36] ANON 61 (Feb. 2, 2006).

work on a part-time basis using their own capital and transportation (e.g., ox-cart, car, bicycle) to buy up periwinkle at select sites along the roadside or village depots as they await harvester "drop-offs." In comparison, the staff collectors have access to the companies' resources, such as trucks and financial capital to conduct the same job.

Both private and staff collectors work out of "drop-off " kiosks which consist of a drying shed, a weighing scale and advertising materials (advertising includes colorfully painted signs with the logo of the firm). These kiosks, which are built by the firms, fulfill two very important functions. First, their distribution along main roads and in regional level market towns facilitates access to periwinkle gathered by peasant producers in more remote areas which would not be cost effective for the firm to pick up, and thus become powerful brokers for the firm in very remote areas. Second, the kiosks provide space for collectors to store periwinkle for sale at a later time.

Another group of collectors responsible for gathering harvested periwinkle are market brokers. Market brokers are hired employees of the firms who set up scales at market centers at strategically recognizable locations (sometimes at the entrance of the market). Unlike staff collectors, market brokers get a percentage of what they sell. Each has a weighing scale provided to them by the firm, and is brought directly to the market via a firm truck. Some brokers mentioned that about 50 peasant producers will approach them each week to sell them their periwinkle. Sometimes incentives are provided directly out of the brokers' pockets to maintain good relations with particularly productive peasant producers. This act of providing "bonuses" was explained to me by a market broker:

I collect a lot because I maintain good social relations. The ploy to get people to like us, and work with us, is to provide 'tobacco money.' This is how they respond to me in a good way.[37]

Another market broker echoed:

The problem is that the companies have always kept the price of the plants at 750 FMG (US $0.075). And we, the collectors, have decided to increase it to 1000 FMG (US $ 0.10). The increase was decided by the collectors to encourage the people to come to them, and keep coming back.[38]

Larger brokers will receive about 5 tons of periwinkle roots each market day. The material, which has to be stored and guarded properly until someone from the firm comes to collect it, is usually held in massive storage houses. Like the smaller kiosks, these large structures are built by the firms, but are manned by workers that process (dry, sort and select) roots and leaves that are to be packaged for export.

Since the periwinkle is exported as a non-processed product, it is subject to both national and international phytosanitary regulations. The first stage is at the collector's level at the "point of sale," and the drying sheds provide the second stage of quality control. Most selections at this stage are based on moisture content and size. Poor looking roots are selected out and discarded. These centers are equidistant along the road between Ft. Dauphin and Tuléar where peasant producers can bring roots directly. These workers are given directions by the firms themselves on how to select roots (see Figure 3.2).

The relationship between the firm and a market broker was explained in more detail by a firm representative:

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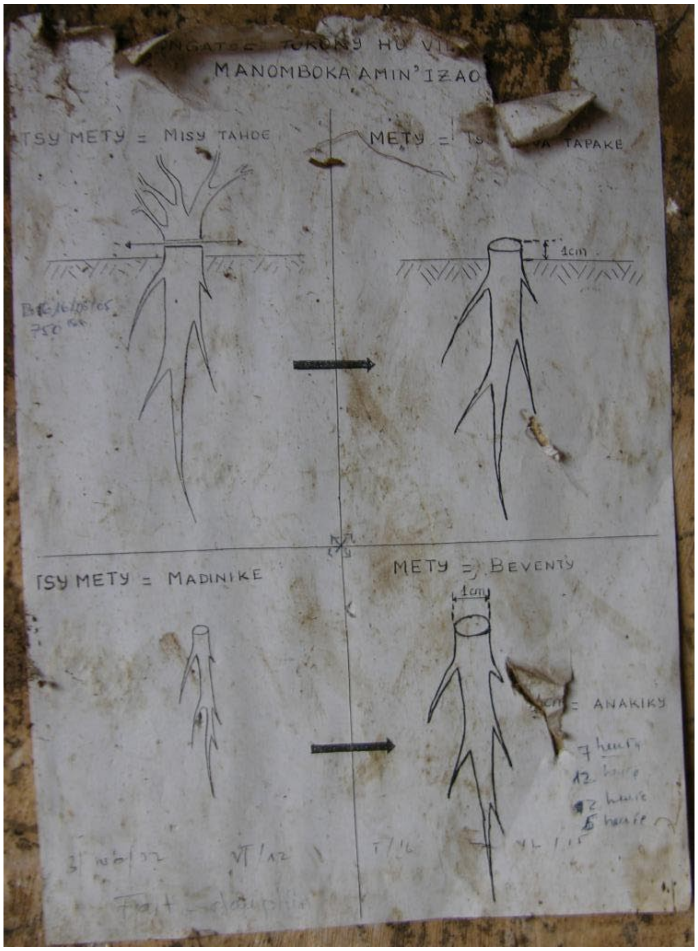
[37] ANON 75 (Feb. 3, 2006).
[38] ANON 74 (Feb. 3, 2006).

> A fractioned drying process is not good; we need it dry in one shot. We can't have a drying process that is 'stop and go.' In these cases the quality is not very good. This is the reason why we bought the scale for him [the broker], so that he can make sure that nothing gets lost in the transfer, and that he can make sure that the amount going into the truck is what he is getting money for. If he puts it on the truck it is no longer his responsibility. The firm will give him some tin roofing materials to be used for the storage house and will bring clay to make a level drying place. He worked for another firm before as a small collector, but he is now working for us. He has profited a lot. Furthermore, the firm will even buy him a car, on credit; it is common for the firm to pay for cars and other items on credit.[39]

These makeshift processing sites become decentralized centers where periwinkle can be dropped, producers paid, and roots and leaves can be processed before they are packaged for export. As the number of independent collectors who participate in the commodity chain increases, so do these "drop-off" points, especially in remote areas where independent collectors house large stocks of roots and leaves that await transport to the processing centers. In sum, this decentralized network of producers and collectors provides the company with the flexibility to reach even the most remote sites of periwinkle production without having to transport the periwinkle on long distances and on difficult roads.

[39] ANON 61 (Feb 2, 2006).

Figure 3.2 Directions on quality control selection posted on a wall of a storage house



Exporters

The dynamics of the periwinkle production are dependent on a number of factors that all must be contextualized within the larger political economy of the global drug discovery market. First, as I observed in the beginning of the chapter, the market for periwinkle is a specialized commodity chain where there are only selective buyers of the raw material. For example, the buyers of the product are life science and pharmaceutical firms which now need a sustainable supply for drug development or discovery. The firms are relied upon to produce copious amounts of roots and leaf material for larger companies at the drug production end of the commodity chain. Many of the firms working in Madagascar are actually horticultural and agro-business subsidiaries of larger multinational pharmaceutical companies.

One method larger pharmaceutical companies employ to ensure a stable supply is to import material from a number of different locations. Countries that have historically been periwinkle suppliers include India, the Philippines, Australia, Israel and Madagascar.[40] For example, one of the largest firms operating in Madagascar must compete with the global prices for periwinkle, as noted in an interview with the head of operations for the firm:

Even though labor costs are much higher in India, we have much higher operation costs here [in Madagascar]. If a truck breaks, it can take up to two weeks to get the parts to fix it. We must therefore keep our costs down in Madagascar, and that means the price for a kg of roots must also stay low. That is why you will hear farmers complain about the price they are given for *pervanche* [periwinkle]. Then again, farmers in general always complain.[41]

This competition creates problems for those who rely on the periwinkle for direct income, especially peasant producers and collectors. Margins for bulk periwinkle roots and leaves must then be kept at a minimum, which equates to very low prices for the raw material.

There are always difficulties to ensure supply; the plant is needed on certain dates and from Madagascar you just can't ensure this. In reality, its finances that lead the decision making process. If someone makes the decision to cut the project, where does this leave all these Malagasy that I work with? I am in a particular situation when it comes to working with this group. It is really a *de facto* monopoly. The leaf in India that our parent firm buys from is really our stiffest competition. But with Madagascar we really have no insurance on supply, so that is why companies like to work in India; they have better insurance on supply.[42]

[40] Jim Simon, pers. communication, 2005.
[41] ANON 67 (July 3, 2006).
[42] ANON 67 (July 31, 2006).

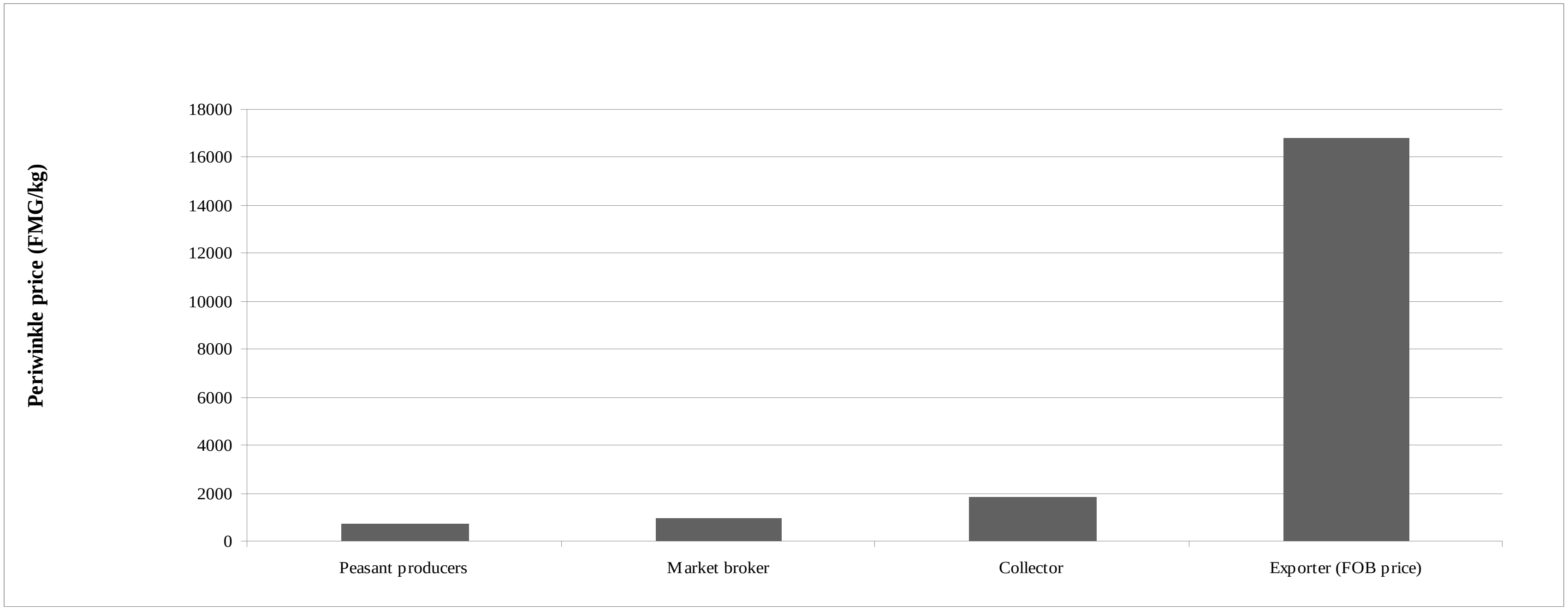
One firm that extracts periwinkle in both India and Madagascar has somewhat comparable production systems in the two countries. In total, they work with roughly 200 villages in Madagascar and 150 villages in India producing a total of 2,000 tons per year of periwinkle material for export to their laboratories in France. In contrast to the production from Madagascar, which is mostly from wild sources, India's production is mainly from cultivated plantation systems (Monnier, 2002).

Nevertheless, Madagascar does have one comparative advantage over India and other sites of periwinkle production. Reports have noted that Madagascar holds the most superior chemically active roots on the market, with the best quality to be found in the southern littoral areas of Anosy and Androy (Andriamanalintsoa, 1995). As noted to me by an exporter: "…there is some competition between Madagascar and India, yet one ton of roots from Madagascar equal the equivalent of four tons of Indian periwinkle."[43]

However, better quality does not always translate into better prices for the peasant producers, as prices for periwinkle per kg have remained low for years. These meager prices have resulted in especially low margins for peasant producers as compared to others in the chain (see Figure 3.3). As shown, margins for exporters far exceed anything that is paid to peasant producers, as compared with the increase in the export price over the past two years. In 2004, for example the average peasant producer price in FMG was 750, whereas the market broker received 1,000 and the collector, 1850. By contrast, exporters received 16,825, or roughly 22 times the average peasant price.

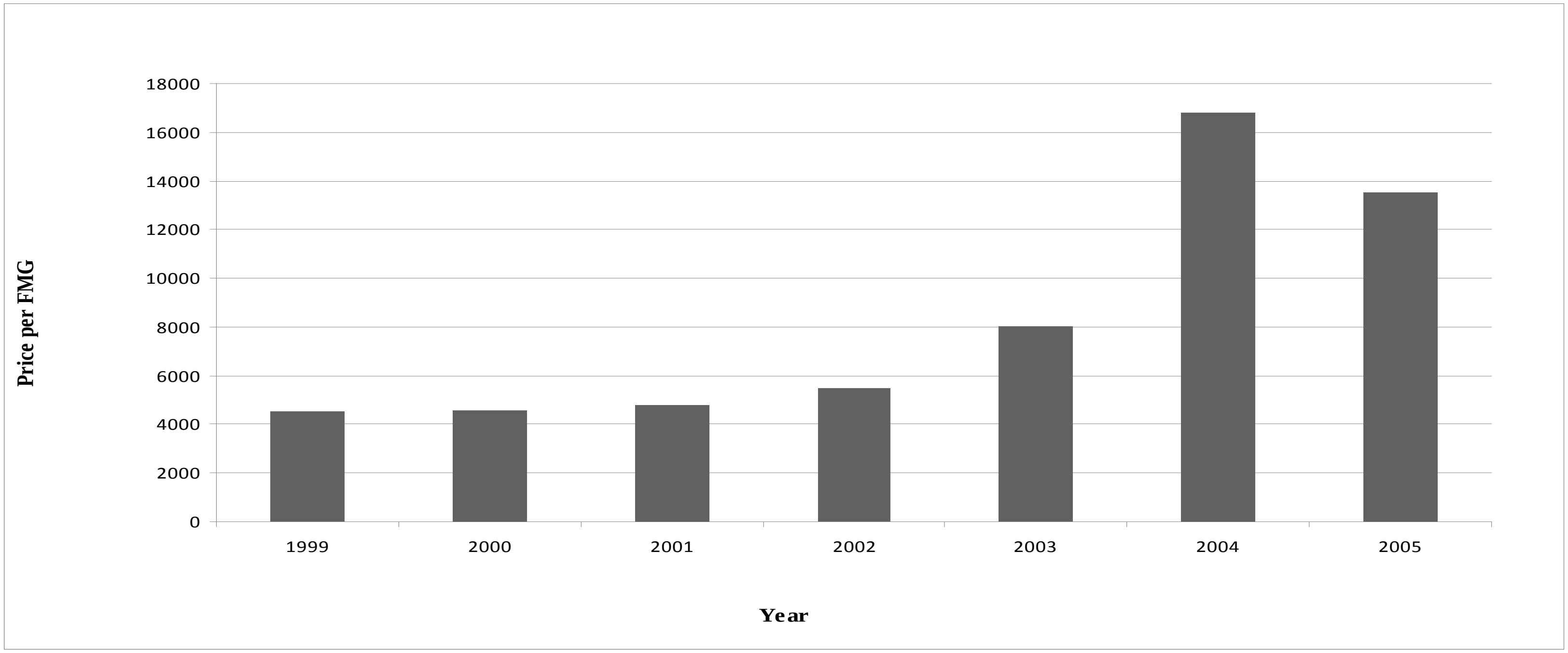
[43] ANON 66 (April 25, 2006).

Figure 3.3 Price per kilo of periwinkle roots at each level of the commodity chain, 2004[44]



[44] Data collected with each participant in two selected market surveys conducted in 2005 and 2006.

Figure 3.4 Freight on board price for kg of periwinkle roots (FOB for 1999-2005)[45]



[45] Data collected from the Ministry of the Environment.

Tax revenues and the Malagasy state

The reason the firms have been allowed to continue extracting periwinkle has been because they have continually supplied the Malagasy state offices with a vital revenue source in a generally impoverished and drought ridden area. Revenues from the periwinkle trade flow back to the Malagasy state government in two separate forms. The first is returned to Malagasy government agencies as an export tax set at 15 percent of the total FOB (Freight On Board) price, or the price paid upon export. Therefore, increases in periwinkle harvested and exported equates to more revenue that the Malagasy government collects. These prices have been steadily increasing since 1999; despite a slight drop off in price in 2005 (see Figure 3.4). The second tax is called a returns tax, or *redevance*. This is money returned to the rural communes where the periwinkle was harvested. These return taxes are charged on the amount harvested on “wild” instead of cultivated plots.[46] However, since it is difficult to differentiate between periwinkle that is harvested in the wild or grown in cultivation, firms typically pay a return on all harvested periwinkle as if it was all taken from state land. This ensures the firms’ collection permits even within the most remote locations.

On average, exporters are responsible for the extraction of 800 to 1,000 tons of periwinkle roots from Madagascar each year, primarily for export to Europe and the U.S. (DGEF, 2003). Revenues derived from periwinkle make a significant impact on the state agencies involved in monitoring the trade, most notably the local (CIREEF) and regional (DIREEF) offices of the Water and Forest Service. For example, for four months in 2005, roughly U.S. $2,000 was

[46] New permits are given out every four to five years. The terms of the convention are spelled out by the CIREEF and the firm in conjunction with *la avis de commune* or ideas of commune needs and the mayor’s approval. The district head must provide verification alongside the *Canton de Foresteire* (CEF) and the *Chef de Region*.

returned to the CIREEF and DIREEF offices in the Tuléar region. This is compared to the approximate total of U.S. $3,100 for all forest products for the region that year.[47] These payments, taxes and permit fees translate into the largest revenue share for the CIREEF in Ft. Dauphin or up to 90 percent of its total tax revenue. By contrast, timber and ornamental plants each account for two percent annually.[48] This important revenue base solidifies the exporters' access to collection permits and transport licenses which are granted at the regional offices. These permits and licenses provide the legal rights to buy and transport harvested periwinkle anywhere throughout the Tuléar Provence. It is a relationship that is built upon economic expediency and keeps the firm's political channels clear of any constraints on unfettered access to periwinkle.

For example, political networks have forest agents looking the other way when they see newly established periwinkle fields that were grown on cleared spiny forests.[49] The clearing of the spiny forests that are characteristic of the southern littoral of Madagascar have become an increasing concern for conservationists working in the area. And if the clearing continues, conservationists are likely to step up pressure on the Malagasy government to stop providing permits to collecting firms on state land. These power plays between conservationists, the Malagasy government and extraction firms have become common in many remote locations in Madagascar that are rich in resources and bring in important revenue for the state agencies (see Chapters 4 and 5).

[47] *Service de la Conservation de la Biodiversite* (SCB), 2006.
[48] ANON 68 (May 1, 2006).
[49] ANON 69 (Feb. 3, 2006). I observed some of the cleared land used for periwinkle cultivation in April 2006.

Discussion

The historical case study of the rosy periwinkle is a clear example of the problems that exist within property regimes in bioprospecting and the limits of assigning claims of ownership to biogenetic resources. For some time now, claims of “biopiracy” have been used when referring to the misappropriation of commercially useful resources and traditional knowledge. However, as the case study of the periwinkle displays, plant material can be collected, brought to other locations, and re-grown in cultivated systems. Furthermore, the material is useful only until a synthetic substitute can be found and the plant is dropped altogether from production altogether. In both instances, there have been particular difficulties in assigning property rights to resources growing across the tropics, and moreover, justifying the claims biopiracy by activists and some government officials of Madagascar particularly when the resources and knowledge used in production were collected in the Philippines and Jamaica (Laird, et al. 2000).

Second, many times property claims surrounding natural resources in bioprospecting are levied on formal ownership rights, however, as Ribot (1998) notes, that there are ways that powerful actors are able to circumvent formal rights and use economic, political and social leverage to access resources. As in the case study of the periwinkle here, and in the case studies that follow (Chapters 4 and 5), we observe a number of mechanisms used by scientists, businessman, and pharmaceutical firms to access resources for bioprospecting collection without the use of formal property rights. As scholars, we must seek to move beyond traditional notions of property rights surrounding biogenetic resources and think about bioprospecting in terms of “access mapping” or the ability of actors’ ability to gain, control, and maintain access within critical sites where the resources can be found (Ribot and Peluso, 2003).[50] This approach will provide scholars with a better understanding of who benefits from the natural products pharmaceutical chain and eventually lead to a fairer distribution of those benefits.

The contemporary periwinkle commodity chain raises a number of geographical issues worth noting. First, the larger market pressures coupled with the need for access to massive amounts of the roots and leaves of periwinkle force companies to maintain and manage a network of semi-contracted peasant producers. Rural producers and collectors are not easily induced to maintain a constant supply of periwinkle, however. The benefits of participation in the trade are contingent upon on a number of external market forces such as prices of other crops at the time of harvest and overall need for cash. Producers will sometimes hold their periwinkle growing on their fields or storage, rather than bringing it directly to market, in exchange for profit. In these cases, producers will sometimes bring other crops to market instead, disrupting the overall production of raw material needed.Therefore, the firms must cast a wide enough net to entice and lure sporadic peasant producers while not marginalizing the more productive ones. Also, they must maintain strong links with collectors at varying levels of contractual relationships to maintain a large enough harvest and reach the most distant peasant producers. Second, the export of periwinkle is directly affected by international competition from India and other sources of periwinkle. These external market pressures force the firms to keep costs down; this ultimately results in low prices being paid to peasant producers for the material, making it even more

[50] Up to this point to a large extent the scholarly literature dealing with access is focused mainly on resource extraction in agrarian settings (Berry, 1993; Blaikie, 1985). However, due to the similar tenure-dynamics of bioprospecting collection and legal approval (i.e., collecting permits) a useful theoretical parallel may be made to mining and prospecting studies.

difficult to sustain a steady supply. Third, since periwinkle is found growing on farmer-owned land, but also on “wild” state-owned land, the burden of paying the taxes mentioned above rests with the firms who purchase the “already harvested” product. Firms must then keep up good relations with state officials who pose a potential regulatory obstacle to unfettered access and extraction.

This analysis builds on the important work of scholars who seek to compare a diverse array of commodity production systems (Guthman, 2004; Goodman and Watts, 1997; Fine, 1994; Friedland et al., 1981). Some theorists of agrarian change try to reconcile processes in capitalist industries with those of agriculture and see developments within agricultural landscapes that are similar to the uneven trajectory observed in industrial settings, especially in terms of organizational structure and division of labor (Guthman, 2004; 1998). Although there is much to be gained from this line of analysis, studies of the political economy of agriculture must also account for the distinct differences in the timing of the production process, where working time (i.e., investment of human labor) is not congruent with production time (Mann and Dickenson, 1978). Furthermore, nature is unpredictable, and climate variations and erratic weather conditions make the overall circulation of capital difficult to control. Variable weather can impede the harvest and may disrupt post-harvest activities such as drying or transporting. Such differences are observed to impede a fully capitalistic mode of development in agricultural settings.

The natural barriers to accumulation by agriculture are not insurmountable, however. As capitalist enterprises percolate into the rural landscape, they are constantly seeking ways to decrease the extent of variation that natural cycles impose on the production. Goodman et al. (1987) have contributed two important concepts, “appropriationism” and “substitutionism,” to explain patterns observed as capitalists contend with these barriers in agriculture. Appropriationism is the attempt to reduce the importance of nature through the implementation of new “man-made” innovations so as to reduce the impacts of the natural cycles on the production process. This phenomenon is highlighted by the use of new varieties and inorganic inputs such as fertilizer and pesticide that Eli Lilly used to produce periwinkle on cultivated plots in the U.S. These innovations were adopted in order to speed up production and increase yields, thereby facilitating capital accumulation by the firm downstream on the production cycle. Substitutionism, on the other hand, refers to attempts at replacing nature altogether with of industrial substitutes, as was observed with Lilly’s early attempts at substituting the natural bioactive compounds with factors that are chemically synthesized. More generally, this step away from nature and towards industrialization is reflective of a host of techniques that contemporary bioprospectors use to accelerate production and mechanize the process of drug discovery from nature (Parry, 2000; see Chapters 2, 4 and 5).

Nevertheless, there are times, as shown explicitly in this case study, when the natural product is vital to the discovery or development of the drug and a return to “nature” is imminent. To overcome the associated risks of contending with natural cycles and variation, capital enterprise will transfer many of the extra costs of production to smaller units of production. Mann and

Dickenson (1978) suggest capitalists will purposely halt their production at the "farm gate," encouraging the participation of small-scale producers within a fully-capitalized production system. This dynamic is evident in the periwinkle case study. Rather than developing large industrial-size plantations, firms have instead enlisted thousands of rural Malagasy to take on many of the costs and risks of production. The firms have done so by shifting many of the tasks of harvesting in difficult climatic conditions, transporting the material long distances, and conducting quality control screens to the supply side of the commodity chain.

Conclusion

This chapter began with the discovery of bioactive alkaloids from the medicinal plant rosy periwinkle. In this case, tons of the plants' leaves and roots were needed to derive the sufficient quantities bioactive alkaloids, and after several attempts were made to find alternative chemical sources of supply, in the end, Lilly was forced to rely on the raw material grown on mechanized and controlled cultivated systems in the U.S. and on harvested periwinkle from Madagascar and India. This study highlights one of the most glaring examples of natural barriers in bioprospecting that the bioactive components only occur naturally in infinitesimal quantities in each plant. This is a case in point of how constraints on the source material for drug discovery and development forces bioprospectors to seek out the resources in either a substitute form, or in farmed systems (Eisner, 1989; Sheldon et al., 1997).

The periwinkle is a "pan-tropical weed," found growing in wild areas across the tropics and subtropics (Laird, 2000). The ability to propagate periwinkle on plantations clearly makes it different from the other case studies found in the dissertation where the plants are only found *in situ* or in the “wild.” The ability of pharmaceutical companies to partially overcome the "natural" barriers of geographically constrained production requirements (Mann and Dickenson, 1978) complicates the tasks of assigning culpability for misappropriation of biogenetic material and associated knowledge and determining how to equitably share benefits from related drug development. Does Madagascar have any claim to benefits given the conditions of the discoveries? What is Madagascar’s leverage if a plant can be taken out of its territorial boundaries and cultivated elsewhere (cf. Schroeder, 2000)?

In the second part of this chapter, I demonstrate that pharmaceutical firms are reliant on peasants for the base of its operations and must tap into this rural labor force to extract surplus. This case study of the rosy periwinkle describes a process of access and control of natural resources through the appropriation of labor, particularly rural labor in the Malagasy southern littoral regions of Anosy and Androy. Results show that firms maintain extensive social networks throughout large areas of southern Madagascar. Many of these peasants are lured in, and kept participating, through the use of economic incentives. The firms are also sensitive to the cultural dynamics taking place in the production areas to keep peasants from leaving. Ultimately, this dynamic allows for firms to guarantee a reasonably steady supply of periwinkle even at the low prices, and with producers casually dropping in and out of the trade.

The labor relationships observed above provide select economic advantages and levels of flexibility for the firms. The ability of the firms to control the production process depends on the labor of thousands of peasant producers participating in the commodity chain, in particular older women, who are key actors in continuing access and producing tons of periwinkle even at the lowest of margins. Furthermore, the firms' ability to keep different types of collectors on staff allows the firms to reach many remote producers in an extensive geographical range where periwinkle grows best. The firms are thus able to pass on many of the burdens of transporting the bulk of the highest quality periwinkle to these actors and of thereby ease many of the spatial constraints (i.e., bad roads to transverse) that impede collection.

These dynamics are similar to those described in the next chapter, where firms must overcome multiple natural and social barriers to access the valuable bark of the tree *Prunus africana*. However, unlike periwinkle, *prunus*' status as an endangered species adds regulatory barriers to the list of difficulties with which export firms must contend in order to access and control the trade of a valuable medicinal source

Chapter 4

Commercialization within conservation parameters: The commodity chain of *Prunus africana* in Madagascar

It was the firms themselves that have asked for regulation [CITES], to stop competition, but now they have also blocked themselves.

-A longtime *prunus* exporter

Introduction

In 2005, a CITES (Convention on International Trade in Endangered Species of Wild Flora and Fauna) meeting was held in Madagascar's Forest Service headquarters in the capital of Antananarivo at which the medicinal tree, *Prunus africana*, was widely discussed.[1] The meeting was held to determine who was to receive harvesting quotas for *prunus* bark extraction for the upcoming year. On our way home from that meeting, my research assistant asked a very insightful question: "*Out of the large numbers of* [Malagasy] *state officials, conservation and development agents present at the meeting, why were only two commercial firms there*?" The small number of firms present at the meeting was reflective of the strong political and economic undercurrents surrounding the contemporary commodity chain of *prunus* bark. At one point in its extraction history, there were numerous firms and individual traders collecting and exporting bark to Europe and the U.S., yet at the time of my research only two remained.

Prunus africana (Hook f.) Kalkman (referred to as *prunus* henceforth) is found growing across Africa, where it is sometimes referred to as *Pygeum africanum*, African cherry or red stinkwood (Cunningham and Mbenkum, 1993). For over three decades, medicinal

[1]The central Forest Service location in Madagascar is known as *Direction Générale des Eaux et Forêts* or DGEF.

properties found in the bark have been used commercially in the treatment of benign prostatic hyperplasia (BPH) and prostate gland hypertrophy (Wei et al., 2005; Bombardelli and Marazzoni, 1997; Marandola et al., 1997). *Prunus* represents a genetic resource that has been clearly identified as possessing important medicinal properties, but can neither be chemically synthesized nor easily reproduced *ex situ*. It thus still relies on the extraction of the biological material at its "point of origin." As such, its continued extraction continues to put pressure on "wild" stocks of the species. At the height of commercialization, the industrial sale of raw, semi-crude, and firm bark extracts represented the largest trade by volume for any African medicinal plant (Cunningham et al., 1997). However, the heavy commercial exploitation of the species has led to a decline in populations of mature trees in many African countries, prompting a growing international concern that culminated in 1995 with the listing of *prunus* under Appendix II of CITES.[2] It was the mandated downsizing of the *prunus* industry following this period of heavy exploitation that prompted my research assistant's comment about the relative absence of commercial firms at the 2005 CITES meeting.

In Madagascar, concerted action was taken to regulate the overexploitation of the species and to conserve remaining stands. For example, a special scientific committee was formed to study the feasibility of quotas, nursery cultivation and trainings on sustainable harvesting (Cunningham, 2006; DGEF, 2000). *Prunus* seeds were collected and nurseries were established across the country by Malagasy national research institutes, conservation NGOs and exporting firms. Despite years of conservation efforts, however,

[2] Listing on CITES Appendix II stipulates the declaration of all exports of the species, and exporting countries are required to set quotas at levels that do not have adverse effects on the populations of the species (Cunningham et al., 1997). Madagascar has been a signatory of CITES since 1975.

bark exports continued to increase, reaching to their highest level in 2000 (SNGF, 2006). These developments, in turn, spurred an injunction by the Malagasy government against all *prunus* bark collection by 2002.[3]

For some in Madagascar, the trade of the bark of the afromontane species, *Prunus africana*, represents a vital livelihood activity and lucrative commercial enterprise; for others, it is the quintessential example of unfettered forest exploitation and species mismanagement. The commercial exploitation of the species illustrates how conservation and resource extraction are connected and politicized. Unlike the dynamics surrounding periwinkle observed in the previous chapter, where plants can be picked up and grown in managed systems almost anywhere, *prunus* is considered an endangered species and can only be found growing in a few sites in Africa. Madagascar, which is considered a *prunus* "hotspot," is also now targeted for biodiversity conservation by large-scale environmental NGOs and the Malagasy government (see Chapter 1). Access to *prunus* is thus heavily regulated and controlled at a number of different political levels. Extraction firms, however, have found ways to negotiate around regulations to gain access to specific sites of critical biodiversity where *prunus* is still found, raising a number of questions about who will maintain future access to the species, and under what provisions this access will be provided. Firms have primarily gained and controlled and maintained access to *prunus* in two ways: first they have teamed up with Malagasy state institutions and conservation organizations to carry out "sustainable" harvesting and other associated conservation

[3] As observed in the Inter-ministerial order 13.855/2001 of November 2001 and found in the Forestry Law 97/781 and 98/782. Two firms were allowed to collect due to existing permits that continued into 2003 (SNGF, 2006).

activities; and second, they have reorganized the labor force, taking advantage of flexible workers, and reaching more remote areas where *prunus* can be found.

In this chapter, I provide a history of *prunus* extraction in Madagascar. I highlight the impact of the CITES listing, a subsequent injunction against open access harvesting, and the resultant restructuring of the commodity chain. An explicit focus on the labor relations and politics of environmental regulation surrounding the industrial extraction of the medicinal tree bark provides a fuller understanding of the primary actors who are able to gain access to critical sites where *prunus* is found and thereby control the market.

Prunus africana, biology, history and background

Prunus africana, a member of the Rosaceae family, is part of a large subfamily best known for its important commercial horticultural value (e.g., peach, plum, cherry, almonds and apricots, cf. Stewart, 2003a). Mature trees are approximately 30 to 40m in height and may be found growing in montane to high humid forests between the altitudes of 1000m and 2500m (Stewart, 2003; Sunderland and Tako, 1999; Cunningham and Mbenkum, 1993). The species has a wide range spanning 22 different countries, from Ethiopia in the north to South Africa in the south, west to Equatorial Guinea and east to the Comoros and Madagascar (Hall et al., 2000). Cameroon and Madagascar are reported to maintain the largest populations of the species due to the fact that they contain the largest concentration of intact montane forests. *Prunus* thrives in environments with annual rainfall of 500 to 3000 mm and distinctly moderate temperatures of 11 to 19 degrees C (Hall et al., 2000:10; see also Stewart, 2003).

Prunus is used medicinally as well as for construction, tools and artisanal crafts throughout central and eastern Africa (Stewart, 2003; Sunderland and Tako, 1999; Cunningham and Mbenkum, 1993). Most noteworthy are its traditional medicinal uses in Cameroon, where traditional healers use it to treat up to 30 different medical ailments, including fever, indigestion, muscle aches and malaria (Stewart, 2003; Sunderland and Tako, 1999).

The medicinal properties of *prunus* purportedly first came to the attention of western scientists and doctors when Zulu men in the Vryheid district of KwaZulu/Natal in South Africa demonstrated its use in treating urinary problems to Europeans living in the area (Cunningham and Cunningham, 2000). Jacques Debat, a French chemist, subsequently developed a preparation of crystalline and non-crystalline extracts of *prunus* for benign prostatic hyperplasia (BPH) and other urinary complications (Cunningham, 2006), a finding that he then patented in 1966 (Debat, 1974; see also Cunningham and Cunningham, 2000). Shortly thereafter, Debat began exporting the bark commercially as a treatment for BPH and glandular disorders (Hall, 2000).

In 1972, *Laboratories Debat* opened the Plantecam facility in Mutengene, Cameroon to facilitate the large-scale export of *prunus* bark from that country. The French company *Groups Fournier* bought Plantecam from *Debat* in the early 1990s (Cunningham and Cunningham, 2000), and the factory became a major source of supply. Roughly 2,000 tons of bark were harvested from Cameroon in 1992 alone, the bulk of which was sold to

European markets (Cunningham and Mbenkum, 1993). By 1997, *prunus* had an estimated annual value of close to U.S. $220 million worldwide (Cunningham et al., 1997). At that time, the two countries of Cameroon and Madagascar were responsible for supplying up to 60 percent of the demand, or roughly 3,200 to 4,900 tons of the bark annually (Cunningham and Cunningham, 2000; Cunningham and Schippmann, 1997; Schippmann, 1997).

Originally shipped only in raw bark form, *prunus* later became available as macerated bark powder or as extract. The lipophilic extracts are made from a chemical reaction of dry powdered bark by a method of chloroform extraction (Simmons et al., 1998). Up to 5 kg of extract can be made from 1,000 cubic tons of raw bark (Cunningham and Schippmann, 1997). Analysis of *prunus* bark extract demonstrates that its bioactivity can be attributed not to one single compound, but rather to a synergistic effect of phytochemicals, including pentacyclic triterpenoids (ursolic and oleanic acids), beta-sitosterol, lipid soluble substances, fatty acids (C12 to C24) and two ferulic esters (n-tetracosanol and n-docosanol) (Bombardelli and Marazzoni, 1997; Marandola et al., 1997; Martinelli et al., 1986; Longo and Tira, 1981). This association of biochemicals is said to exhibit a "cocktail" effect which prohibits easy chemical synthesis and necessitates extraction of the raw material from "wild" sources.[4]

Furthermore, unlike some industrialized natural products such as the rosy periwinkle (see chapter 3) and select species of *Taxus* sp., which can be easily cultivated on plantations, *prunus* domestication has been less successful (Sheldon et al., 1997). Although reports

[4] Sarah Laird, pers. communication, 2004; see also BIODEV, 2000.

have expressed some optimism for vegetative propagation of *prunus* by the use of cuttings and air layering in Cameroon (Tchoundjeu et al., 1999) and Kenya (Simmons et al., 1998), this success has not been replicated in Madagascar. Some Malagasy scientists note that the tree requires a strict shading regime especially at a young age (1-4 years), and that planting schemes such as those tried in Madagascar have generated poor results after out-planting (Dr. Rabodo Adriantsiferana, pers. communication, 2005). This has constrained commercial bark collection to wild sources in Madagascar and has added to the considerable decline of the tree in some regions of the country (Dawson and Rabevohitra, 1996; Walter and Rakotonirina, 1995).

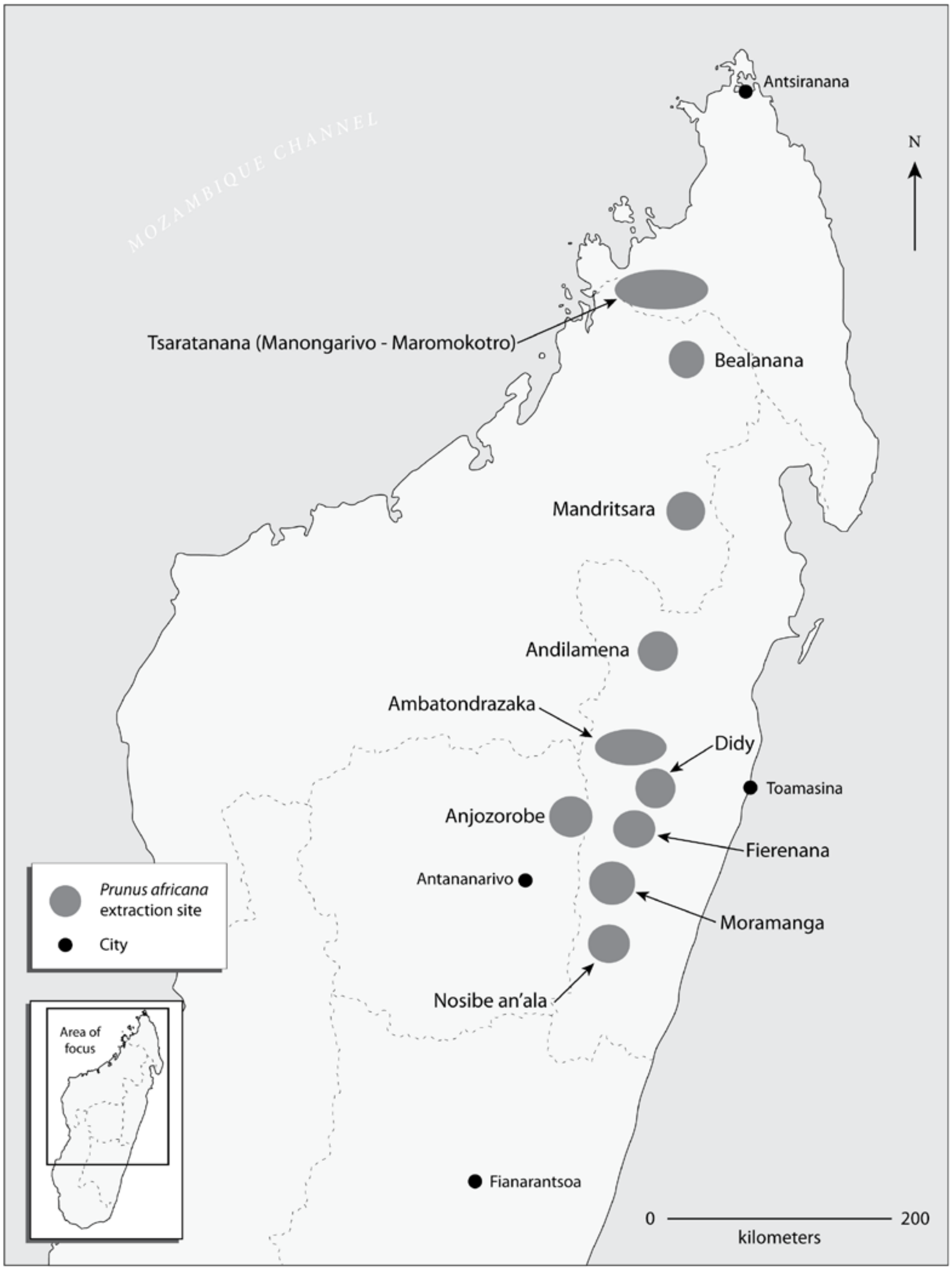
<u>The condition of prunus in Madagascar</u>

Prunus is known across the island of Madagascar by a number of different names: *paisoala* (Betsileo), *tsipesopeso* (Moramanga), *sofintsohihy* (Brickaville, Vohimena), *menalaingo* (Vatomandry) and *tsintsefintsohihy* (Ambatondrazaka). However, Malagasy are most familiar with its vernacular names *kotofihy* or *sary* (Randriambololona, 1994:31; see also Quansah, 1999; Walter and Rakotonirina, 1995). *Prunus* can be found primarily growing across three different regions of Madagascar. It is found in the north, from the Tsaratanana mountains to the central Tampoketsan and Ankazobe-Ankaratra range (SNGF, 2006); in the western province of Mahajanga, especially in the region of Sofia; and extensively in the eastern regions of Moramanga and Ambatondrazaka (Dawson and Rabevohitra, 1996) (see Map 4.1).[5] The tree's altitudinal range is estimated somewhere between 1000 and 2800m, showing varying regional phonological characteristics.

[5] ANON 85 (Nov. 15, 2005). Although reports do exist of *prunus* growing in the southern regions near Fianarantsoa, this data was not corroborated by any official surveys.

Fruiting occurs between April and November in the north and between September and October in the central and eastern regions (Dawson and Rabevohitra, 1996).

Map 4.1 Geographical distribution of *Prunus africana* extraction in Madagascar[6]



[6] This map was adapted from BIODEV, 2000; see also Walter and Rakotonirina, 1995.

The industrial exploitation of *prunus* in Madagascar began in the early 1970s in the region of Sofia, mainly around the northwestern town of Bealanana (FAO, 2003). Bark was collected by French and Malagasy companies and transported to the western port of Mahajanga for export to Europe.[7] These early operations were fairly centralized with just a few companies controlling the transport and collection of the bark (SNGF, 2006).[8] This region continued to be the main site for *prunus* until 1984, when stocks of the tree diminished and sites on the eastern forest corridor began to open for exploitation. In 1988, the forests bordering on the Integral Natural Reserve (RNI) of Zahamena and the classified forests of Ambohilero and Didy became the main sites for *prunus* extraction (BIODEV, 2000; Walter and Rakotonirina, 1995). This region continued to be harvested until 1994, when exploitation widened to engulf regions surrounding the towns of Moramanga and Ambotonazaka (Walter and Rakotonirina, 1995).[9] Unlike earlier phases, collection of bark in the east was highly decentralized, with many small firms and individuals operating from scattered forest sites as far north as Antsiranana, down to Moramanga and Ambotonazaka, and even as far south as Fianarantsoa, including the areas of Anjozorobe, Andilamena and Nosibe-an'ala (see Map 4.1 and Walter and Rakotonirina, 1995). In 1999, *prunus* collection returned to the Sofia region. This was to remain the last site of official collection until the government injunction in 2002. At the time of my research in October of 2005, only a limited number of official collections were still sanctioned via a state quota system (BIODEV, 2005).

[7]ANON 82 (Jan. 23, 2006). Mahajanga has since stopped functioning as an international port.
[8] ANON 57 (Oct. 6, 2005).
[9] The guidelines for regulation of additional forest products, including *prunus*, are found in the Inter-ministerial decree No. 2915/87 of June 30, 1987.

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<u>The dynamics of *prunus* commercialization in Madagascar</u>

There have been three periods of *prunus* exportation in Madagascar since its inception in 1972. Each of these periods reflects the commercial trajectory of *prunus* bark, increasing awareness of the consequences of overexploitation, and the subsequent tightening of regulations controlling commercial extraction. The periodization also illustrates how political changes in Madagascar over time have restructured the relationship among the Malagasy government and *prunus* collectors, and the overall commodity chain.

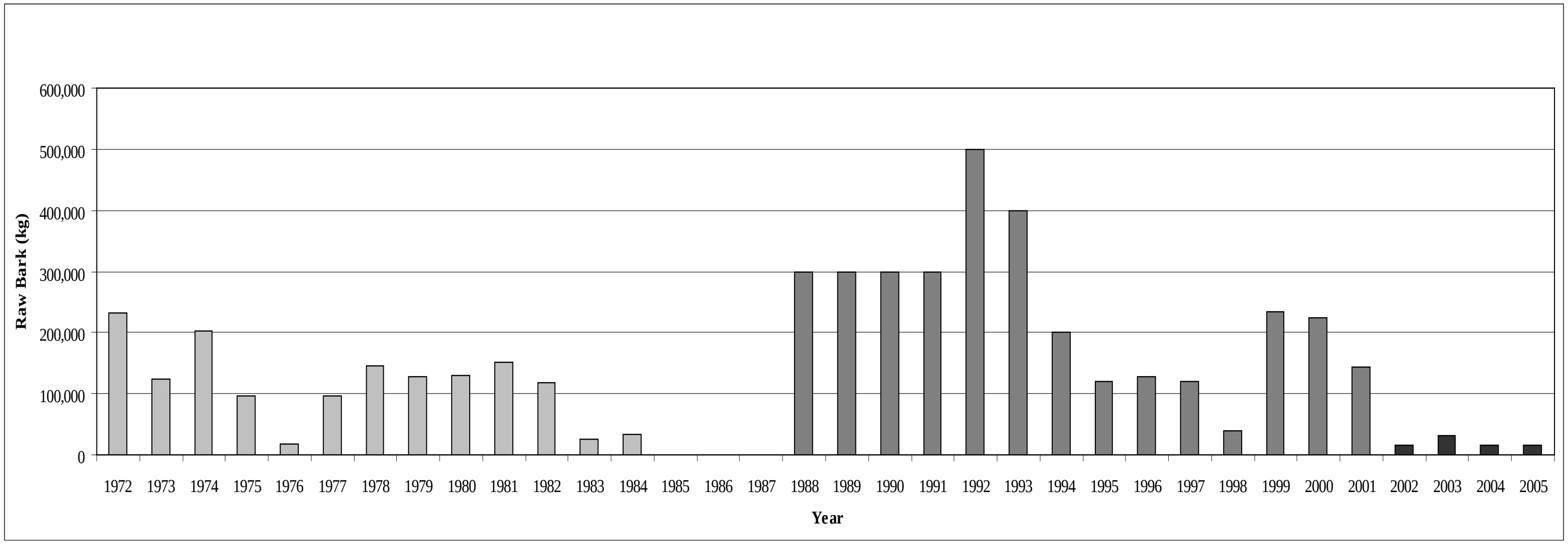
The first period, which ran roughly between 1972 and 1984, was characterized by open access and unfettered *prunus* commercialization. Madagascar at this time was economically and politically tied to France under the First Republic (1950-1972) of Philibert Tsiranana and the beginning of the Second Republic (1975–92) of Didier Ratsiraka (Barrett, 1994; see also Marcus, 2004). Much like other foreign companies operating in Madagascar at this time, commercial *prunus* operators such as Pronatex and Auximad were able to maintain a strong foothold in the country and to continue exporting even through successive waves of economic strikes and political unrest.[10] This dynamic began to change under the Second Republic of Ratsiraka, who's economic and social policies known as "scientific socialism" caused some European companies with fears of nationalization to flee the country (Marcus and Ratsimbaharison, 2005). However, many operators working in the rural regions of the north and west, well out of sight to the state, opted to stay in the country and continue to extract.

[10] ANON 63 (Jan. 31, 2006). This period was a particularly turbulent time in Madagascar due to the transition of the first government to state socialism.

In this early period of *prunus* extraction, the state maintained very little control either over the quantity of bark collected or the specific locations demarcated for extraction. One of the larger French operators apparently set its own voluntary limits on the amount of bark that was to be harvested in a specific area, presumably to make the harvest more sustainable.[11] Nonetheless, even these harvesting rules were rarely enforced, and individual harvesters were essentially left to regulate themselves due to the remote nature of the harvesting locations.[12] This lax control resulted in heavy extraction throughout the Sofia region as close to 1.3 million kg of raw bark were exported out of Madagascar during this period (Schippmann, 2001). Although bark exports fluctuated, a rough Malagasy government estimate places the number a bit over 115 tons of *prunus* were exported out of Madagascar annually (see Figure 4.1).[13] *Prunus* was thus firmly established as an important revenue generator for the Malagasy state, as Madagascar became one of the largest exporters of in the world, second only to Cameroon (Schippmann, 2001).[14]

[11] ANON 58 (Oct. 13, 2005). For example, only up to 50 percent of the bark on each standing tree could be harvested on trees that were old enough to withstand harvesting (Walter and Rokotonirina, 1995; Cunningham and Mbenkum, 1993).
[12] ANON 57 (Oct. 6, 2005).
[13] These government estimates are difficult to verify since very little documentation exists on the exportation of prunus during that period. This puts the number somewhere at about 1.6 million kg.
[14] ANON 82 (Jan. 23, 2006).

Figure 4.1 Total *prunus* bark exported from 1972 to 2005[15]



Period of prunus extraction reflected in figure

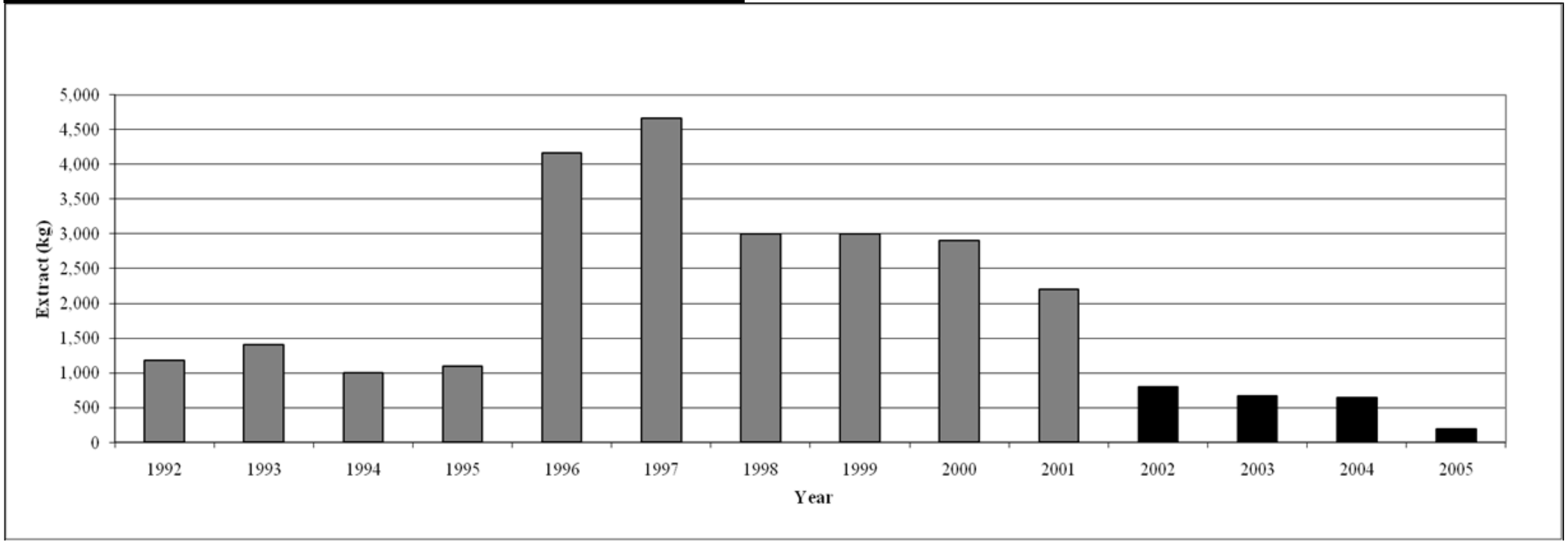
First period - 1972 to 1984

Second period - 1986 to 2001

Third period - 2002 to current

[15]Export data was complied from the following sources: Rasoanaivo, 1996 (1972-1987); (1985-1995) ; Walter and Rakotonirina, 1995; *Service technique* (1996-1988) ; *Service de la conservation de la biodiversite* - DGEF (1999-2005). The data set from 1986 and 1987 is currently unavailable.

Figure 4.2 Total p*runus* extract exports from 1982 to 2005[16]



Period of prunus extraction reflected in figure

Second period - 1986 to 2001

Third period - 2002 to current

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[16] Rasoanaivo, 1996 (1992-1995); *Service technique* (1996-1988) ; *Service de la conservation de la biodiversite*- DGEF (1999-2005).

Following a brief suspension of *prunus* harvesting by the state in 1985, a second period of commercial extraction began in 1986. This time Madagascar was in an economic downturn. Facing bankruptcy, President Ratsiraka was under intense pressure to address the country's international debt (Marcus, 2004; Hewitt, 1992). Seeking to capitalize on the worldwide demand in the herbal market and especially on a growing interest in medicinal plants at the time, the Malagasy government began a joint venture with the Italian company, Indena SpA, to create a factory to process medicinal plants in Fianarantsoa, a city in the south-central region of Madagascar (Dr. Rabodo Adriantsiferana, pers. communication).[17] The point of the facility was to potentially capture profits usually lost through the export of lesser-value raw material and return benefits to the State. The facility was thus run primarily by a state company, SODIP (*Société pour le Dévelopment Industrial des Plantes Madagascar*), and its exporting arm, SOPRAEX (Société *Promotion pour les Produits Agricoles d'Exportation*), with a private Italian pharmaceutical firm, Indena, providing technical support.[18]

The SODIP facility focused on the production and exportation of plant extracts for research on the production of phytomedicines (Andriantsiferana, 1992). The initial plan was to expand the industrial production of vanilla and manufacture essential oils. Once established, however, SODIP focused on the extraction and export of the country's two most important medicinal plants, *Catharanthus roseus* (rosy periwinkle) (see Chapter 3) and *prunus*. Paradoxically, neither of the two medicinal plants actually grew in the area,

[17] ANON 84 (Dec. 1, 2005). This location was chosen as being an important site to spur industry and economic development outside the capital of Antananarivo.
[18] ANON 80 (Dec. 1, 2006).

so the new establishment had to absorb heavy transport costs. However, even with external costs accounted for, the facility ultimately solidified the Malagasy medicinal plant market and provided the State with prospects for long-term revenue from *prunus* commercialization.[19]

As part of the wave of privatization by the Ratsiraka regime, in December of 1999, SODIP was sold outright to Indena SpA, and the Italian firm proceeded to transform the site into one of the largest and most profitable medicinal plant operations in East Africa.[20] Due to the new technological capacity of the facility, bark could be brought to the facility moist or dry, and crushed or whole. These new processes of *prunus* production not only changed the way *prunus* could be collected, but because bark was now being transported mainly in extract form more of it could be exported per year (Kloppenburg, 2004; Mann and Dickinson, 1978).[21]

At this time, increasing concern for conservation of the species by international environmental NGOs placed heavy pressure on the State to monitor the species and related commercialization activities. Madagascar had become a signatory to two international environmental agreements, the CBD and CITES, and by the mid-1990s both were beginning to be enforced worldwide. The CBD proposed to conserve biological and genetic resources by facilitating access and providing a greater share in the benefits from

[19] ANON 80 (Dec. 1, 2006).
[20] The facility is still exporting bark extracts from Madagascar to Tours, France, and the company's home-base of Milan, Italy. In Madagascar, Indena SpA which markets the drugs Pigenil and Prunuselect, reported sales of more than U.S. $150 million in 1999, with U.S. $60 million of those sales in the U.S. (Cunningham, 1996:23).
[21] ANON 87 (Feb 19, 2005).

their use, while CITES targeted rare and endangered natural resources through strict monitoring of commercialization.

By 1995, *prunus* was officially listed on CITES' Appendix II, and it did not take long for *prunus* operators to begin to feel the pinch of regulation. As far as national adoption of regulations, Madagascar still did not at this time preclude felling of the tree and stripping of the bark; however, there were measures put into place to promote regeneration. For example, two trees per hectare were required to be left standing, and cutting close to watershed was not allowed. Two-year permits for collection were granted on condition that sustainable harvesting regulations would be followed and that firms would contribute to the regeneration of the species in the wild.[22] Although it was mandatory for collectors to obtain permits, no limits were set for the number of trees or the amount of bark that could be harvested (Walter and Rakotonirina, 1995).

The larger *prunus* companies, including Pronatex and Indena, responded to the CITES designation with "self-imposed" harvesting rules. These firms also set up *prunus* conservation projects through negotiations with bilateral development organizations and foreign institutions.[23] These projects, under the guidance of the USAID-funded Landscape Development Interventions' environmental programs, contributed to a number of inventories of *prunus* stock and established nurseries at two different sites in northern

[22] Explanations of permits are found in the Inter-ministerial decree No. 2915/87 of June 30, 1987.
[23] ANON 80 (Dec. 1, 2006).

Madagascar (Cunningham, 2006; Dailey and Fernandes, nd).[24] They also conducted out-planting exercises in forested areas surrounding Moramonga and Ambatondrazaka. Also during this time, firms were obligated to collect *prunus* seeds during the harvest, return them to the scientific committee, and pay extra taxes and fees to regional and district forestry offices for materials and training support for sustainable collection methods.[25] *Prunus* companies responded by partnering up with conservationists, scientists and government officials to find ways to continue harvesting without interruption and secure unfettered access to collection sites.

During this period, the global demand for *prunus* was on the rise. Thus, even with large-scale regulation in effect, more bark was exported than at any other time in Malagasy history. This is reflected in the increased exports of both bark powder and extracts, with roughly 600 tons of raw bark (Schippmann, 2001) and 14,000 tons of bark extract (estimated dried bark equivalence of 2.82 million kg) exported to France, Italy and Switzerland annually between the years of 1995 to 1998. Extracts peaked at their highest levels in 1997 with 3,091 tons (Schippmann, 2001). The continued heavy exportation of *prunus* reflects its importance to the Malagasy economy at a time when it was designated as one the country's leading exports commercial products (Schippmann, 2001). Malagasy government statistics show overall that the exportation of raw bark and bark extracts remained at moderately high levels until 2001. This is roughly a 42 percent increase in

[24] ANON 80 (Dec. 1, 2006). This work was financed by the Landscape Development Interventions (LDI)/USAID project in cooperation with the Universities of Cornell (US) and Bangor (UK) and the international mining company, Phelps Dodge.
[25] ANON 82 (Jan. 23, 2006)

raw bark exports from the first to the second period (1972 to 1984) (see Figures 4.1 and 4.2).

The third period, which commenced in 2002 and continues today, is characterized by a contentious relationship between a few remaining firms that collect and export *prunus* and the Malagasy government. This uneasy relationship follows the adoption of neoliberal economic and political policy directives favoring pro-market approaches by the President Marc Ravolomanana (2002-2009), and the Millennium Development Goals (MDG) outlined in the 2002 Sustainable Development Conference in South Africa. By following the approach of the MDG, state revenues from NGOs and multilateral and bilateral donors who are interested in conservation have risen dramatically. This has placed considerable pressure on the state to conform to the objectives of these donors, and to specifically fulfill its commitments under CITES.[26] The decision-making power related to the use and control of valuable natural resources has thus shifted dramatically in favor of environmental NGOs, which view *prunus* as a leading example of inept state enforcement and poor natural resource management by rural Malagasy (see also Chapter 5). This tension between operators and NGOs has culminated in the injunction on all collections of *prunus* bark mentioned above, and has resulted in a dramatic decrease of both raw bark and bark extract exports since 2002. On average, raw bark has dropped from over 236,400 to 19,790 kg per year, while bark extract has declined from an average of 3,320 kg to 371 kg per year from the second to third period (see Figures 4.1 and 4.2).[27]

[26] ANON 86 (June 15, 2006).

[27] Exact data on exports must be interpreted with a bit of caution. The Malagasy government's statistics have been very difficult to verify, and have been shown to conflict with corporate data on exports. This discrepancy on exports can be observed in the government statistics (Figures 4.1and 4.2) and Indena

For some time, the Malagasy state has been cognizant of the value of its natural resources and the need to regulate commercial extraction (Polini, 2007; Kull, 2004). Early measures were put into place to control the extraction of these products and overall forest health, mostly based on French models of natural resource and forest law.[28] These were followed by a number of decrees and inter-ministerial orders designed to control forest product exports (Quansah, 2003).

More recently on the international level, two major developments have dramatically altered the landscape of *prunus* commercialization. The first involves new guidelines for the enforcement of the 1995 listing of *prunus* on CITES Annex II, which declared that *prunus* may soon become threatened with extinction unless its trade is closely monitored. The second major regulatory action was the implementation of a broad-based study to monitor *prunus* extraction. In December 2003, with funds provided by the bilateral donor, *Le Cooperation Français*, a two-year period was provided for the launching of a national action plan specifically focusing on *prunus* (*Plan d'Action National de Prunus Africana*- PNPa).

As part of the implementation of the national action plan, a law had to be written specifically for *prunus* under which a new category was created for its

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company's statistics (see Table 4.2). These differences are related to a lack of transparency of reliable export reporting and the difficulty of measuring differences in post-transformed bark from raw bark (Cunningham, 2005). The underreporting of exports has also been observed in Cameroon as a way to hide owed taxes to the state agencies and collect bark over the quota limits (Laird pers. communication, 2005). However, the overall pattern of exports has been verified by a number of sources inside Madagascar and by exports outside the country.

[28] Such early texts include the 25 January 1930 order, the deforestation (Order 60-127 of October 3, 1960) and the vegetation fires (Order 60-128 of October 3, 1960).

commercialization. This new law would ensure a certain level of compliance with quality standards, transparency and monitoring.[29] After consultation with different stakeholders (exporting firms, conservation officers, ministry officials, etc.), the new law was presented to the DGEF in February 2006 (SNGF, 2006). The goals of the action plan were to conduct inventory work, monitor and control the watershed areas where prunus is located, and carry out ecological, chemical and socioeconomic aspects of bark harvesting (BIODEV, 2000; see also Cunningham, 2006). The most significant aspect of the plan is a pilot study, with test plots selected for scientific and economic evaluation of *prunus* harvest. The three sites located in the northwest region include: Vakiantsaba-Befandriana, Ambonindoha-Mandritsara, and Andohanamberivery-Bealanana. These sites were also areas where research would be conducted on domestication and future plantations (Cunningham, 2006).

Specifically, the *prunus* plan is based on a set of procedures to monitor harvesting in order to make sure that operators are not overexploiting stocks. It is through this process of monitoring that a new convention was drawn up allowing companies in Madagascar to resume bark collection in designated "test" plots within the newly designated protected area of Makira.[30] Quotas, permits and harvesting licenses for bark exporting were granted during this period to firms cooperating within the national action plan guidelines. Thus,

[29] The present texts include the Inter-ministerial decree No. 2915/87 of 30 July 1987 and the Inter-ministerial decree No. 6686/00 of July 4, 2000. The rationale for the new text was to update the status of *prunus* within a new category of regulation reflecting its importance as a revenue generator for the state and to maintain its status as "extremely endangered" (BIODEV, 2000).

[30] Makira Natural Park will be one of Madagascar's largest protected areas, and the first established under the Durban Vision. The park will be managed by the US Conservation NGO - Wildlife Conservation Society (WCS). The site was one of the original areas that the *prunus* test plots was to be established.

the firms hand-picked for participation in the action plan were essentially provided select access designated protected areas.

Overall, the injunction has resulted in a tight consolidation of the commodity chain. While larger commercial companies are able to import bark from other sites in Africa (i.e., Democratic Republic of Congo and Cameroon) and continue extracting in Madagascar through quotas and other methods, smaller operators have been forced underground into illegal collection, or out of business altogether. Furthermore, the injunction has resulted in substantial loss of revenue both for the state and for rural harvesters, who have been left without a key source of livelihood.

The commodity chain of *Prunus africana*

The purpose of the following section is to document the changes on the commodity chain since the 2002 injunction on bark harvesting in Madagascar. As the total amount of exports decreased after 2002, there was a parallel decrease in the number of firms and individuals collecting *prunus*, and a shift in the type of actors involved in the commodity chain overall (see Table 4.1). The structure of the commodity chain of *prunus* is built on a somewhat fluid set of market relationships amongst individuals and groups that join and disengage at particular times. Bark is locally harvested by groups of rural harvesters living adjacent to forested sites. These groups are organized and assembled by a small set of local elites (*chefs d'équipe*) who buy the bark at the village level. Mature *prunus* trees are roughly 50cm in diameter with a height of around 8 or 9m. Peasant harvesters typically harvest at least two trees of that size within a one month span. An average quantity of bark per adult tree is 250 to 350 kg; however, larger trees of 50 to 60 cm in diameter have provided more than 750 kg of bark (SNGF, 2006). Once a tree is located, harvesters will fell it, and peel away the bark, and cut it into strips measuring 50 to 150 x 10 cm. Peasant harvesters noted that on average they can carry roughly 30 to 50 kg of bark (BIODEV, 2000), using a method called *filanajna* in Malagasy, which entails tying the bark in bunches and transporting it on a long post. Larger trees require multiple trips. After bark is bought at the rural sites, individual collectors, operating alone or in conjunction with collection firms, transport the bark directly to either the capital of Antananarivo or the Indena processing factory in Fianarantsoa.

At the processing facility, the bark is dried, macerated into powder, and transformed into semi-crude extract for transport. Some export companies operating in Antananarivo dry raw bark and export to it Europe out of the eastern port in Toamasina. The majority of raw bark and extracts subsequently are sent to processing companies mainly in France, Italy and Switzerland. The European firms then process the bark into capsule form, at which point it is packaged and marketed under a variety of different herbal labels (Cunningham, 2006; Schippmann, 1997).

Table 4.1 Typology of actors involved in the *prunus* commodity chain[31]

Actor	*Description of activity*	*Type of work (contract, wage or payment on sale)*	*Estimated number involved before the 2002 injunction*	*Estimated number involved after the 2002 injunction*
Peasant harvesters	Collect "wild" *prunus*	Payment on sale	>1000	>100
Chef d'équipe	Organize harvest and control the "point of sale," some quality control	Contract and wage	50	10
Firm collector	Transport material	Wage	N/A	<10
Collectors	Buy/sell, transport, post-harvest production and processing, quality control	Payment	25	10
Exporters	Buy, package and export material	Payment on sale	11	2
Importers (Europe and the U.S.)	Processing, packaging and marketing finished herbal product	Payment on sale	15	N/A

<u>Peasant harvesters</u>

The peasant harvesters are a large group that mainly locates *prunus* trees, strips their bark and transports it back to a central point of sale in a nearby village. Harvesters assemble into teams of seven to 10 men (ranging in age from 15 to 60), and set off into known areas of nearby forests to locate harvestable trees.[32] The teams are assembled by the harvesters themselves and often consist of extended family members.

[31] Adapted from Walter and Rakotonirina, 1995; see also SNGF, 2005.
[32] ANON 56 (Oct. 13, 2005). These estimates are based on assessments from both interviews and documents of previously published material of the *prunus* commodity chain (SNGF, 2006; BIODEV, 2000).

Peasant harvesters can be generally grouped into three categories, including contract, seasonal, and opportunistic harvesters.[33] Contract harvesters work directly for the collection firms and usually live in areas where *prunus* has historically been collected. Since contract harvesters are employees of the firms, they will usually keep an eye out for illegal harvesting by competitors and will conduct inventories in unexplored areas. Seasonal harvesters only harvest during "down" times in the agricultural calendar when they are otherwise unoccupied. Sometimes these harvesters are known to migrate to areas for a harvesting season or two. The third type is an opportunistic harvester. This group consists of farmers or rural inhabitants, who rely on other significant activities for their primary source of income, yet but use the harvest as a second source of cash income.

Since the injunction and increasing inconsistency of harvests, more and more collecting firms are relying on opportunistic collectors for the bulk of their collection. Although relying on an inconsistent and unskilled labor force poses some risks for the firms, it nevertheless allows the firms to reach deeper within remote areas where most of the *prunus* is now located without the overhead of transporting contracted harvesters to the sites. The harvest for the peasant thus becomes a short-term income generating activity without any concern for conservation. As an older seasonal harvester put it:

> We didn't know anything about this tree; we just know it by what he [collection firm representative] described to us. We did not ask about the techniques of harvesting bark or the collector's legality. They came in and showed us everything about harvesting *kotofihy* [*prunus*]. The only thing we were thinking about was money. The price was very interesting, so everybody wanted in.[34]

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[33] Dr. Hughes Rajason, pers. communication, 2005

[34] ANON 51 (Jan. 20, 2006). Harvesters are said to make a significant amount of supplemental income from the trade of *prunus* (SNGF, 2005). Many reportedly earn a rough average of about 350,000 FMG (approximately U.S. $41), annually from a *prunus* season, and some as high as 750,000 FMG (U.S. $88).

Similar sentiments were expressed by a younger seasonal harvester:

Formerly, there was no use of *kotofihy* because nobody knew about this tree. We did not keep it, but we sold all that we got. Nobody thought to conserve trees so as to be able to take them later. We were in a hurry and we cut all the trees we saw because the money we got was unexpected.[35]

While most harvests took place close to the villages, some (conducted in 2002 and 2003) involved treks up to three hours to find mature trees, usually in small isolated forest patches.[36] Dawson and Rabevohitra (1996) remark that a lack of harvestable trees in a particular area usually indicates a pattern of overexploitation.

Historically, bark is harvested in the rainy season from December to April (Stewart, 2003); however, since the injunction, harvesting has been reported to take place all year long.[37] The collection company's desire for more bark is matched by the harvesters' quest for more cash:

"…[S]ometimes the car was not full, and the collector told us: 'Try to take more.' And we returned to the forest once again because we want also to make money...There is nobody to limit where or when the harvesters go. It's a veritable free-for-all."[38]

Similar statements concerning overexploitation were echoed by another harvester in the same area:

The extraction made me sad because some harvesters take off roots to get more bark. I told him, 'Don't do it like this because it kills the tree.' Before weighing the bark, the collector cut it in little strips and put it in a sack. We didn't think about conserving some trees for the next collection. We took all. The collection stopped when there were no more trees. The exploitation made me very sad, but I did it because I needed the money. We didn't know anything about this tree. The collector just said that the bark is for a drug fabrication abroad.[39]

[35] ANON 52 (Jan. 20, 2006).
[36] ANON 81 (Oct. 16, 2005).
[37] ANON 81 (Oct. 16, 2005).
[38] ANON 55 (Oct. 13, 2005).
[39] ANON 50 (Jan. 20, 2006).

Some more experienced harvesters noted that in the past the collection companies would try to offer guidelines for appropriate harvesting methods, e.g., they would strip bark at 50cm panels 1m from the base of the tree. However, as expressed by the harvester above, very few mentioned ever having received any type of training in "sustainable" collection methods.

Prior to the 2002 halt on collection, many collection companies were spending up to five years in particular areas before stocks were diminished. Once their collection permits expired, the companies would just move to another area of the country. However, since the injunction, there has been a definite shift in the numbers of villagers who will take on the activity as compared to before. Some mentioned giving up bark harvesting altogether because it has become too difficult a task.[40] Others, who maintained more regulated seasonal harvests, noted that they occasionally rummage through forests to collect on an ad hoc basis, gathering *prunus* and selling it underground illegally to anonymous collectors.[41]

Our real job is agriculture, but *kotofihy* helps us earn money for buying food in the rainy season because, often, our agricultural products are not sufficient to feed us during one year. Since there was no real season for taking *kotofihy*, we do it when we are short of food. It's not like the collectors help the village by building houses or streets, or by supplying even building materials; when they got what they needed, they just went away.

Even after the injunction, harvesters were by far the largest group in terms of overall numbers involved in the commodity chain, with some estimates at the height of collection involving hundreds of harvesters in one season (see Table 4.1). Although the harvesters

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[40] ANON 58 (Oct. 13, 2005).

[41] Personal observations were made in 2005 of stocked storehouses of illegally harvested *prunus* that was sold to a collector.

usually receive the lowest price for the bark as compared to any of those located downstream in the chain, the *prunus* trade is still considered an important economic activity that can provide a significant boost to the local economy and individual livelihood. In most of the rural sites where income opportunities are meager and participation is widespread.

Chef d'équipe

Negotiating who will be given the opportunity to participate in the harvest is the job of the *chef d'équipe*, or head of the harvesters. There are two types of *chefs d'équipe*. The first is a permanent employee of the collection company, and the second is a contracted hire who works on a temporary basis. Both do essentially the same tasks, in so far as they maintain the interests of the company by conducting inventories and guarding stocks of harvested bark from theft or unauthorized sale.[42]

The *chef d'équipe* essentially acts as a middleman between the operators (who are primarily headquartered in the capital Antananarivo) and the peasant harvesters. They usually have family relations in the village and maintain contacts with local leaders in surrounding areas for access to nearby villages and organizing the hiring of harvesters on short notice. Furthermore, the *chef d'équipe* is in an important position to uphold the structure of the commodity chain. These close relations with harvesters allow him access to the village sites to mediate prices and broker inclusion into the chain. This is extremely vital for those who live on the forest margins where most of the *prunus* is now collected.

[42] The failure of peasants to observe contract obligations is seen as a big problem in medicinal plant operations; villagers will sell harvested stock to the first collector who comes along. This places considerable importance on the *chef de équipe* to keep harvesters from selling to another company.

The *chef d'équipe*, in effect, will facilitate access for companies wishing to tap into these critical sites.

Buying points are usually selected because of their proximity to forested areas, the availability of laborers, and access to a national road. However, these sites are also attractive to individual "rogues" or unlicensed collectors, who will attempt to buy the bark illegally right after harvest. As one company representative expressed to me about how these rogue collectors find *prunus* sites, "*When you ask enough villagers, sometimes you will get someone to tell you where the prunus is; also, they* [rogue collectors] *follow your tracks, and see where you have been collecting.*"[43] Furthermore, as stocks of *prunus* have been decreasing, rogue harvesters have been more active and competition between collectors has become a big issue. For example, bidding wars over price and non-payment for harvested bark have become more common occurrences; it is essentially the *chef d'équipe* who maintains order at the "point of sale" in the village.[44] The *chef d'équipe* has become vital at mediating disputes between *prunus* collectors. As expressed by a *chef d'équipe*:

Outside collectors came here also for *Kotofihy's* bark collection. The first collector didn't like it, and he asked the second one if his paper was legal. The second collector didn't have any authorization. The first collector told the second one: 'If you don't have a permit, you cannot do the collection, so get out.' And the second collector stopped his collection, and he left the village.[45]

The *chef d'équipe* also conducts quality control at the point of sale. Bark usually comes from the harvesters in irregular sizes and with varying levels of moisture. The *chef*

[43] ANON 83 (Jan. 23, 2006)
[44] ANON 56 (Oct. 13, 2005).
[45] ANON 53 (Jan 20, 2006).

d'équipe must determine if the bark is dry enough to avoid rot or fungal growth. When the bark is weighed, both fully dry (*seche*) and moist bark (*humide*) are purchased at different prices (see Table 4.2).[46] The quality of the bark is always a concern for *prunus* firms. As such, supplies must be monitored closely by the *chef d'équipe*:

> We are in the field before we buy because we want to see if bark is wet or dry. We prefer it in 15cm strips and we must see if it is wet. That is why we don't accept bark when it is chopped or already in bags. This is why it is not transported in gunny sacks but out in the open, or tied on a stick. …it must dry in the village, because the bark loses half its weight when dried and it costs much less to transport if dried correctly in the village rather than in Antananarivo.[47]

If the bark harvest is successful and enough quality bark is found, the *chef d'équipe* can profit handsomely. At the height of collection in the year 1999, one *chef d'équipe* earned a salary of 250,000 FMG per month (US $40). While this was only a fraction of the value of the more than 200 tons of moist bark and 100 tons of dry bark the company harvested in the village,[48] it was roughly two and half times more than most harvesters made. The overall number of *chefs d'équipe* has remained constant even after the injunction. However, many reported diversifying beyond *prunus* collection to other forest products or agricultural products, and fewer remain on contract from the companies.[49]

Collectors

There are generally two types of collectors involved in the *prunus* trade. The first is a company collector, who is hired directly by a collection firm and retains an annual salary. These collectors live in a central town, and travel to different villages organizing the

[46] Weighing scales are given to the *chef d'équipe* by the collection companies.
[47] ANON 83 (Jan. 23, 2006).
[48] ANON 56 (Oct. 13, 2005).
[49] Personal observations made in 2005 in Bealanana and surrounding villages. Forest product extraction included ornamental plants, fiber (raffia) and some small-scale timber production. In many of these areas, coffee and rice are the main agricultural crops.

harvest with the *chef d'équipe* and gaining consent from the different heads of the village.[50] Ultimately, they are charged with many aspects of the collection including transport and post-harvest processing (i.e., drying and storage) of the bark. The second type is a contracted collector who works independently from the collection company. These independent collectors are local businessmen who trade goods and agricultural products in a number of different villages. These collectors are highly mobile and through their extensive contacts in the villages, either through extended family or well-established trading networks, are able to organize a harvest quickly and handle all of the logistics of the collection and post-harvest, even from the most remote villages.[51]

Within the past few years, and especially since 2002, there has been a substantial decrease in the number of collecting companies. For example, at the time of this research in 2005-06, only two collection firms were actively operating in the area of Sofia, whereas before the injunction, up to a dozen collectors could be seen operating at one time.[52] There has also been a shift towards the use of contracted collectors rather than company collectors. The use of contracted collectors allows companies to reach out to more remote sites where prunus can now be found. It also transfers much of the cost of transport and post-harvesting of the bark to these smaller collectors, which were previously paid by the firms themselves.

[50] Consent is usually given by a local customary authority called an *Anpanjaka* (chief) or elected president of the village.

[51] These collectors maintain the space and capital to hire the laborers for this intensive post-harvest production. These resources become very important for post-harvest because it allows the bark to be held for longer periods of time without losing quality. For example, after harvest, *prunus* bark must be dried; this is done with either direct sunlight or mechanical dryers to completely remove all the moisture. This requires a large drying field where the bark will lose up to 50 percent of its weight in moisture (Walter and Rakotonirina, 1995).

[52] ANON 82 (Jan. 23, 2006). These latter permits have been regulated by specific quotas and are part of the National *Prunus* Action Plan, described in detail below.

<u>Exporters</u>

The Indena facility in Madagascar is one of the largest of its kind in East Africa. It maintains the standardized equipment and technical and human capacity to process 800 tons of bark annually.[53] The facility exports its products in either extract or macerated bark powder form to firms across Europe, including *Inverni Della Beffa* and Indena SpA based in Milan, and Indena S.A.S. based in Tours, France. At one point in the late 1990s, *Inverni Della Beffa* held 85 percent of the world market of medicinal plants and 50 percent of the world market of *prunus* (Walter and Rakotonirina, 1995).

Prior to the construction of the factory in 1988, *prunus* in Madagascar was dried and exported only as rough bark. However, the facility provided an opportunity to recoup some revenue with the export of a semi-processed product (first as macerated bark powder and then as bark extract) rather than as an unprocessed bark.[54] In 1999, SODIP was sold outright to Indena. The technological improvements made by Indena allowed for far more bark to be processed and transformed into extract. In 2000, Indena reported its best harvest with 435 tons of Malagasy bark.[55]

[53] ANON 84 (Dec. 1, 2005). Due to current regulations only roughly 400 tons of extract is produced annually, an average of about 35 tons/month.

[54] ANON 84 (Dec. 1, 2005). The different stages of post-harvest processing are conducted according to the feasibility of the facility. The first stage consists of placing the newly arrived bark into industrial dryers; the dried bark is then crushed and placed in organic solvents. The solvents are recovered for reuse by evaporation and distilling or a process of separation called rectification. The extract is then placed in metal or standardized plastic drums, and shipped via air cargo to the importing companies in Europe.

[55] Some have noted that because bark was mainly shipped as extract, it is too difficult to tell how much bark was actually transformed and that the export quantity may in reality reflect much higher numbers of total bark extracted and exported (Cunningham, 2005).

Nonetheless, with the severe changes in *prunus* regulation since the injunction, bark from inside Madagascar has become harder to come by. This development was explained by site manager of the Indena facility in 2005: "The harvest of 2000 is now extremely difficult to replicate ever since the halt on collection in 2002. This has made it virtually impossible to obtain adequate collection permits." Permits for exporting *prunus* are granted by a number of different government bodies. First, as with any exporting product, a permit must be issued by the Ministry of the Environment and DGEF. Since *prunus* is listed on Appendix II of CITES, a license must be obtained via the scientific authority that administers the trade of endangered flora and fauna.[56] Furthermore, *prunus* extract was produced using imported raw materials, as in the case when raw bark and chemical solvents are imported to the Indena facility, and a re-exportation certificate must also be obtained (SNGF, 2006).[57] In addition, if bound for European Union countries, a license of importation must be acquired by the exporter from the country of destination (SNGF, 2006).

To overcome these many regulatory obstacles to obtaining Malagasy bark, Indena has begun to import bark from other sites in Africa. In 1999, with the closing of bark processing operations in Cameroon, Indena made the innovative move of importing bark from Cameroon and the Democratic Republic of Congo (formally Zaire). This became important for two reasons: first, it secured a supplement to their dwindling Malagasy stock, and second, with the impending injunction from 2002, it provided the company with a way to continue operation while others dropped out due to regulation. As a result,

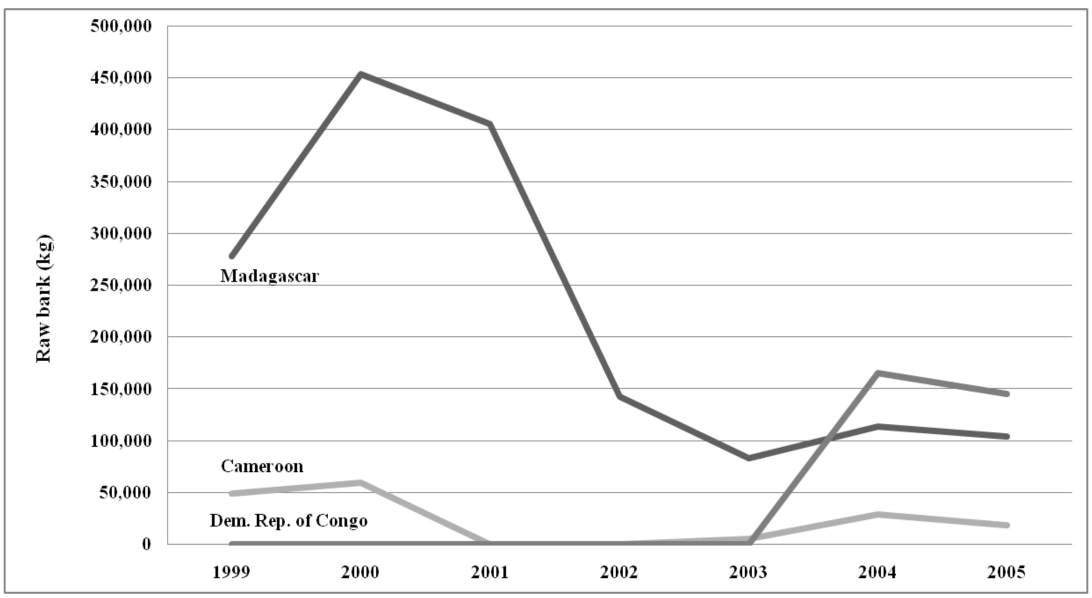
[56] ANON 87 (Feb 19, 2005).
[57] ANON 83 (Jan. 23, 2006).

imports from Cameroon and Congo have significantly increased since 2003. Indena's exports of bark derived from imported stock increased to their highest levels for the years 2004 and 2005, respectively (see Table 4.2 and Figure 4.3).[58]

Table 4.2 Exported raw bark since 1999 by Indena[59]

Year	*Raw bark from Madagascar (kg)*	*Raw bark from Cameroon (kg)*	*Raw bark from the Democratic Republic of Congo (kg)*
1999	277,998	48,841	-
2000	453,603	59,693	-
2001	405,902	-	-
2002	142,736	-	-
2003	83,449	5, 343	-
2004	114,306	29, 159	164, 998
2005	104, 300	18, 241	145,325

Figure 4.3 Exported raw bark since 1999 by Indena



[58] ANON 87 (Feb 19 2005). This importation is happening amid reports that bark from Malagasy stock continues to reach the factory, even with the injunction in place.
[59] General Director of Indena, response to survey, 2006. In the years 1996 and 1997, a total of up to 600 tons were imported from Cameroon and Congo (Zaire) (SNGF, 2006). This table, however, does not include bark extract or bark powder, which will then be imported for further processing at the factory as well (Cunningham, 2006).

Furthermore, even with the bark secured for most exporting firms, there remain long delays in obtaining export permits and expensive taxes on the transformed product. The export duty on rough *prunus* bark and extract currently stands at two and four percent, respectively. However, Indena remains within a tax-free exporting zone (called *zone franche*), and thus is able to circumvent many of the difficult exporting standards on imported materials and exported semi-processed products,[60] allowing for a cheaper and quicker export than any other company.

"We [Indena] need at least a month to get our CITES certificate. Then it will take another month for the importing country to have its own certificate. That's two months; then there are minor things that would delay, so in the end, it would take three months for exportation…yet, we are in a special category [*zone franche*] for many of these issues…."[61]

The increasing time it now takes for firms to export their bark due to increasing regulation results in considerable tension among *prunus* firms, environmental NGOs and their political allies within the Ministry of the Environment and DGEF. As expressed by a large operator:

If I lived in the forest and was hungry, I would need to sell bark to eat. If the large conservation NGOs brought their money directly to my village that would be good; however, they don't do this. We [*prunus* firms] provide money directly to the village in taxes that we pay to the DGEF, and to the state through export taxes. Basically, when you don't give money to the Ministry in the manner that Conservation International and other conservation organizations do, you do not have a voice in policy decisions. But unlike the large NGOs, we provide the villagers with jobs, they do not![62]

The rough estimates of profits gained by the different actors in the prunus commodity chain display a common pattern observed within the forest product commodity chains

[60] Under a newly proposed decree on export taxes for additional forest products includes a recommendation to increase the export taxes for *prunus* to four, six and eight percent respectively, for processed, semi-transformed and rough products (SNGF, 2006).
[61] General Director of Indena, response to survey, 2006.
[62] ANON 83 (Jan. 23, 2006).

more generally (Neumann and Hirsch, 2002; Cunningham and Cunningham, 2000; Ribot, 1998). Actors involved in the trade of *prunus* must maintain continuous social and political relations, and overcome many of the difficult regulatory barriers to accessing the few remaining sources of *prunus* in Madagascar. Nonetheless, the payout is well worth their time and effort. Walter and Rakotonirina (1995) note that in eastern Madagascar, harvesters receive less than two percent of the value that is obtained at export; however this figure still represents over 30 percent of village level annual income (1995:15). I found that peasant harvesters were paid less than one percent of the export price (see Table 4.4), yet were receiving on average 0.2 and 0.4 of the collection firms' and Indena's overall profit, respectively (see Tables 4.3 and 4.4).

Table 4.3 Estimated prices of prunus bark at different levels of the commodity chain (prices in Malagasy Ar/kg)[63]

Actor	*Price paid on bark*[64]	*Mark up on bark*	*Net profit on margins*[65]
Harvesters[66]	250	-	200
Chefs d'équipe	350	100	76.6[67]
Independent collectors	400	150[68]	126.6[69]
Collection firms	1040	690	377[70]
Indena	4000	2960	2210[71]

Table 4.4 Estimated average annual net profits by actors in the *prunus* commodity chain in 2005[72]

Actors	*Estimated average annual net profit* (U.S.$)[73]
Peasant harvesters[74]	54
Chefs d'équipe	1,656
Independent collectors	2,737
Collection firms	81,535[75]
Indena	477,838

63 This table reflects revised prices as noted in SNGF, 2005. Currently, a newly proposed decree places a fixed amount close to 600 to 700 Ar per kg (independent collectors' price) for cut or non-cut bark, respectively. This price also takes into account any excess labor, distance traveled and transport. See SNGF, 2005 for a full description of the proposed revised prices.
64 This column reflects only dry bark which is sold in a higher price range than bark that contains more moisture.
65 Margins are determined by calculating price paid for bark minus individual expenses. However, the collection firms/Indena price paid/mark up depends if they buy it directly from the *chefs d'équipe or* collection firms.
66 Harvesters' labor time is roughly based on a 7 hour work day (a harvesting trip usually takes 8 hours minus one hour for to prepare and eat lunch).
67 The price is based on the mark up on bark minus 20 Ar per kg for cutting of the bark, and 8.4 Ar per kg for placing it in the bags, costing a total of 28.4 Ar per kg of *prunus* bark.
68 Independent collections buy directly from harvesters, so the mark up on bark is calculated on price paid directly to harvesters without the extra cost of the *chefs d'équipe*.
69 This price is based on the independent collectors' mark up minus taxes, royalties and transport to storage house. The independent collector does not buy from a *chef d'équipe*, so this extra cost is not factored into this calculation. A "return" tax of 100 Ar is paid by collection firms and/or independent collectors. The independent collectors do not buy from a *chef d'équipe*, so the "middle-man" transaction is not factored into the calculation.
70 This price is based on the firm's buying price minus forest royalties or a licensing fee of 28 Ar per kg and total transportation costs of 235 Ar per kg (cost of money from point of sale to the storehouse was calculated at 75 Ar per kg and from the storage site to Indena's processing factory at 160 Ar/kg). The
71 ANON 87 (Feb. 19, 2005).This margin is based on deduction of expenses from the price paid to collection firms (Indena's mark up) minus costs of transformation and a 4 percent royalty charge on exports paid at the point of disembarkment. These latter costs were estimated at 750 Ar/kg.
72 The rate of Malagasy Ariary (Ar) for 2005 was estimated at 1,850 Ar for one U.S. dollar.
73 All calculations for this table were based on a reported 40 metric tons per annual harvest or 40,000 kg after conversion.
74 Peasant harvester price was estimated at 500 kg.
75 Although firms receive bark form both independent collectors and *chefs d'équipe*. This calculation uses the independent profit margin due to the fact that the majority of their bark in recent years comes directly from these sources.

The large profit derived from the trade of *prunus* provides the rationale for the continual extraction of the tree by both the collection firms and Indena (Table 4.4). As the demand for bark in outside markets continues to shape external economic dynamics of the commodity chain, the internal access dynamics - especially the political and economic relations that firms maintain with both Malagasy state agencies and institutions and the conservation organizations - will ultimately shape how firms' access will be determined in the future.

<u>The international market for *prunus*</u>

Overall, between 1995 and 2000, roughly 2,980 tons of *prunus* bark were traded annually worldwide (Cunningham, 2006). In that same period, 2,380 tons of bark powder and 460 metric tons of bark extract were also exchanged (Cunningham, 2006). Stewart (2005) notes that the overall sales of dried bark decreased from a peak of 3,225 tons in 1997 to approximately 1350 to 1525 tons per year in 2000.

Current commercial sales of *prunus* are reportedly steady or increasing in some countries (Cunningham, 2006; Laird et al., 2004). For example, Cunningham listed over 40 different commercial products, both herbal preparations and nutraceuticals, made with *prunus* (2006). Furthermore, between 1985 and 2000, there have been 15 new patents taken out on *prunus* in the U.S. alone, showing a continued increase in investment in *prunus* products and a potential spike in extraction (Cunningham, 2006).

The pattern that is likely to continue in the near future includes diminishing exports in previously reliable sources, and new demand in Asia, most notably China and India

(Cunningham, 2006).[76] Furthermore, demand may also increase due to the further discovery of new therapeutic uses for extracts of *prunus* (Cunningham, 2006:24). However, given the injunction in Madagascar and overall scarcity of the resource in many other African countries, many questions remain as to where the bark to furnish the possible increasing demand may be found.

Discussion

If political economy, in its most minimalist definition, is essentially a detailed analysis of resource scarcity, then *prunus* can be seen as a classic case study. The *prunus* case highlights the effects of environmental regulation on the commodity chain of a valuable and endangered natural resource. More specifically, it illustrates the ability of powerful actors to overcome the regulatory barriers such as injunctions, quotas and licenses on collection, to benefit from resource extraction. First, firms are able to obtain quotas through the participation in various “conservation activities,” including collection of viable *prunus* seeds, funding of nursery establishment and payments of extra taxes and fees to regional forestry offices for inventories and trainings on new “sustainable” collection methods. Sanctioned by the Malagasy state, this "green conditionality" is viewed by extractors as a necessary “trade-off” to continue collections (Schroeder, 1999; Ribot, 1999). This attempt to finesse competing imperatives highlights the tension experienced by revenue-strapped state agencies which must constantly negotiate the uneasy territory between their need for tax revenue and their obligations under CITES.

[76] Cunningham notes that civil conflict in the Dem. Rep. of Congo and diminishing stocks of *prunus* held by companies in Cameroon might cause an increased demand for *prunus* (2006). China and India since 1999 have imported a combined total of over 27,000 kg of *prunus* bark.

Second, as tighter regulatory controls led to a full injunction against *prunus* harvests in 2002, firms shifted towards a more flexible labor force to access more remote areas. This study is relevant to recent work conducted in political ecology on access and control of natural resource commercialization (Ribot, 1998; see also Berry, 1989; Blaikie, 1989; Haugerud, 1989; Okoth-Ogendo, 1989). For example, Jesse Ribot, highlights that actors engaged in the extraction of natural resources use both legal (property rights, customary rights) and extra-legal (social networks, coercion, bribery, favoritism) mechanisms to improve access for themselves and others (Ribot, 1998). Ribot's work represents a departure from previous notions of "access" conceived through the lens of formal property rights by critically re-examining which actors have the ability to access resources and participate in market transactions. For my study, commercial profits from the *prunus* market are garnered by firms through the control of political and social networks at different levels of the chain. These benefits are thus derived mainly through gaining access to harvesting permits within critical sites where *prunus* grows, mobilizing the flexible labor pools to extract it, and tapping into international markets to distribute finished products.

In all three case studies in the dissertation, a parallel can be made with other studies that detail the capture of forest products (i.e., wood for charcoal and timber, see Ribot, 1998 and Peluso, 1994, respectively) and the social and political relations that are used by powerful actors to extract forest commodities without the need of formal property rights of the forests. As these study shows, firms are able to negotiate their way with harvest brokers, middlemen, forest authorities, local and regional politicians, NGOs and government officials to gain, control, and maintain access to valuable forest commodities and the profits that derive from them (Ribot and Peluso, 2003).[77]

This work also contributes to other scholars' work on "access" dynamics surrounding labor relations at the sites of production (Peluso, 1993; Okoth-Ogendo, 1989; Haugerud, 1989). Unlike the case study of the periwinkle where a species can be transplanted into cultivated systems virtually anywhere in the tropics or sub-tropics, that of contemporary bioprospecting where important species are collected over a large range in multiple sites, *prunus* is a grounded resource found growing only within selective forested sites in Africa. Furthermore, if it is true as noted above that it was the collection firms themselves that initially asked for the implementation of CITES to stop competitors, especially the smaller operators, from controlling and undercutting their business, the uneven enforcement of CITES regulation has become the defining feature of the *prunus* commodity chain. First, there has been a significant shift in laborers involved in the practice of collecting. The most significant shift observed has been from "permanent" contracted collectors, *chefs d'équipe* and seasonal harvesters towards a more flexible labor force, such as regional traders and opportunity harvesters. At the same time the skill base among harvesters is declining as collectors have had to rely on peasants hired for the short-term in the remote areas where prunus is located rather than trained harvesters who need to be brought out to the sites.

These shifts in the commodity chain are somewhat similar to what Cunningham and Cunningham observed in their study of *prunus* extraction in Cameroon (2000). They

[77] For a more extensive discussion on "access mapping" see Ribot and Peluso, 2003.

found that monopolistic control of *prunus* bark was being lifted, and licenses were being granted to a number of Cameroonian collectors and businessmen. This resulted in a higher rate of *prunus* tree felling than when only a few firms operated. Although Madagascar shows a trend of centralization with only a few firms still in operation, it has become difficult to limit extraction and regulate volume of the many underground and illegal harvesters who are shut out of official collections. This latter development highlights the challenge conservationists face in securing the long-term survival of the tree, as short-term returns are sought by those not trained in "sustainable" methods of harvesting. This finding contributes to the scholarship of access by emphasizing the negative effects of superimposing *de jure* regulations upon existing patterns of resource control (Ribot, 1998; see also: Peluso, 1996; Okoth-Ogendo, 1989; Haugerud, 1989). In the case of *prunus*, the layering of new regulations within rural areas has caused unintended and undesirable consequences as far as long-term conservation stewardship of the resource is concerned.

In Madagascar, access to sites where *prunus* is found is maintained by government agencies, which have historically been the "gatekeepers" of the *prunus* harvest. However, the Malagasy government is also one of the main beneficiaries of the trade of the bark, and thus is either hesitant or unable to enforce strict regulation. Moreover, there is increasing pressure by a host of environmental NGOs and by multilateral and bilateral foreign donors to carry out their commitments to environmental conservation. In this chapter, I highlighted the increasing tension that exists between commercial extraction firms and conservationists, as the Malagasy state is driven by its need for increased revenue while also motivated by the production of benefits that are garnered in its alliance with international conservation NGOs. This tension is only going to increase as localized "hotspots" or critical areas of biodiversity which house some of the last remaining stands of *prunus* are targeted for protection under new conservation interventions. The demand to open up these localized *prunus* hotspots for extraction is going to place countervailing pressure on the state by firms and conservationists who represent opposing interests. Thus far at least, firms have been able to finesse their way to continue access to areas of remaining *prunus*.

Conclusion

This chapter described the social, political and economic social relations surrounding the important medicinal tree, *Prunus africana*. Historically, the bark of the tree has been exported out of Madagascar for an herbal remedy to treat prostate inflammation or benign prostatic hyperplasia (BPH). For the past 30 years (especially in the past decade), the exportation of *prunus* bark out of Madagascar has been under much scrutiny by conservationists, and diminishing tree stocks have caused tighter regulatory controls, culminating in its listing as an endangered species in 1995 on Appendix II of CITES.

Similar to the previous case study of the rosy periwinkle, the bioactive compounds found in *prunus* are not easily synthesized chemically; however, unlike the ubiquitous periwinkle which can be easily propagated almost anywhere, large-scale cultivation of *prunus* in Madagascar has proven to be quite difficult, if not impossible. *Prunus* is a tree that is only found growing in particular mid-altitude forest sites in southern and eastern

Africa, and thus its extraction is limited to collection from remote locations deep within Madagascar.

The purpose of *prunus*' CITES listing was to restructure the *prunus* commodity chain, and rein in rogue collectors of the bark. But the subsequent injunction against open access harvesting has allowed larger operators to continue harvesting in Madagascar. Furthermore, this consolidation of the commodity chain forced smaller operators, basically much of the competition, into illegal underground harvesting under unsustainable conditions, while others bowed out of business altogether. Overall, this development has left a wide open field for those who had the ability to "brave the storm" of regulation and maintain selective access to the species. Large exporters have taken advantage of improvements in bark processing to extract more bark over time. These industrial innovations now allow bark to be processed more efficiently into extract or powder for export at a much higher rate. Furthermore, these industrial improvements have also fostered increased bark imports into the factory from other countries in Africa, such as Cameroon and the Democratic Republic of Congo. This "industrialization" process is a theme reflected in all three of the case studies in the dissertation, and especially in the next chapter, which highlights the political, economic, social and environmental effects of contemporary bioprospectors' attempts to "master nature" through technology.

In terms of benefits, this study provides interesting contrasts to the other two case studies in the dissertation. Similar to the periwinkle, *prunus* discoveries were made long before any benefit-sharing protocols were developed under CBD. Thus, no attempts were made to return benefits to those who originally supplied traditional medicinal knowledge of the bark in South Africa (Cunningham and Cunningham, 2000). In a post-CBD environment, the return of these types of benefits is now typically placed within a framework of access and benefit-sharing agreements. As this case study demonstrates, the return of benefits under bioprospecting initiatives that require strict regulation (i.e., CITES listed) and hold a strong conservation component (i.e., ICBG see Chapter 5) may be better suited under a framework of distributive and environmental justice (Bryner, 2001; see also: Schroeder et al., 2008; McDonald, 2002). In these cases, claims of benefit returns should be based not only on a commercialized product, but also claims of compensation for "burdens" placed on rural inhabitants and producers of newly devised conservation schemes and protected areas including restriction on access to livelihood resources (Emerton, 2001). This distributive justice paradigm may ensure a more suitable financing scheme that in turn ensures the continual survival of the tree, while recognizing the adverse effects of conservation on rural livelihoods (Schroeder et al., 2008; Zerner, 2000; Neumann, 1998).

In sum, in this case study I have demonstrated that large-scale regulation of *prunus* for conservation purposes has placed control of the resource in the hands of a few firms which are now able to access the critical sites to continue extraction. This presents an important point of departure for my discussion of contemporary bioprospecting projects in the next chapter. For example, the tension alluded to in this chapter surrounding different uses and valorization of natural resources continues in the next chapter as we observe contemporary bioprospectors seeking to extract biogenetic resources in some of the most critical areas of biodiversity in Madagascar. Similar to the *prunus* industry's ability to finesse their conservation counterparts and continue harvesting the bark, bioprospectors also are able to access sites through the promises of benefit-sharing and under the banner of biodiversity conservation. However, contemporary bioprospectors' attempts to overcome many of the natural and social barriers to access massive amounts of biogenetic resources are accomplished through the industrialization of the practice within sites of production, throwing into question many of the efforts to operate in full compliance with the benefit-sharing and conservation protocols of the CBD. And thus, raises a host of new questions surrounding the "ethics" of contemporary bioprospecting overall.

Chapter 5

Ethical bioprospecting in a Malagasy hotspot

Part I: Bioprospecting collection in Madagascar

It was in late April 2005 that I met up with a team of Malagasy bioprospectors in Sambava, a town located in the heart of Madagascar's vanilla triangle.[1] Just back from a plant collecting mission, the team was holed up in its hotel room among hundreds of white cotton sacs filled with bioprospecting samples. The sacs were laid across the floor, as odors emanating from the newly collected plant material filled the room with an almost toxic smell. I was on the balcony with Philippe, asking questions about details of the trip, when he remarked, "...the purpose of our trip was to conduct collection. There were no exceptions; we took everything we could with a fruit and flower."[2] Rather stunned, I responded, "What do you mean you took everything!" This inquiry erupted in an unexpected outpour of enthusiastic responses in unison from the others in the team, "We do 'random' collection! We do 'random' collection!" Philippe then noted:

> What they [the team] mean is that we go to an area, and if the plant has a fruit and/or flower, then we collect it. It is 'random,' meaning we do not follow any leads from 'traditional knowledge.'[3]

This mantra of "random collection" was echoed in responses by scientists, administrators and government officials involved in the ICBG, helping to define the project as distinct from other bioprospecting missions that used a "shaman," or ethnobotanical knowledge, to guide their collections. For the scientists, the International Conservation Biodiversity Groups (ICBG) in Madagascar represented a new kind of bioprospecting, one that shifted

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[1] Madagascar's leading export is high quality vanilla sold in the form of processed beans which are grown on the northeast coast of the island.
[2] ANON 102 (March 5 2005).
[3] ANON 102 (March 5 2005).

attention from local traditional knowledge (see Table 2.1 found in Chapter 2) to the "sweep up" of thousands of biological extracts at an industrial pace and efficiency.

The methods of collection that the team uses must be positioned against the backdrop of opportunities, knowledge, participation and constraints in which scientific experimentation is rooted (Latour, 1999). For bioprospectors, the goal is to gain access to, and procure sample extracts of, as many unique and understudied species as possible. Currently, the ICBG exports roughly 5000 to 6000 plant and marine extracts out of Madagascar annually.[4] While most of the public Malagasy laboratories are at screening capacity, the more advanced U.S. laboratories, which hold the capability of running thousands of high-speed bio-assays, constantly yearn for more raw material.[5] However, the ability of the team to deliver on the desired number of samples can only be met through the use of a method where samples are collected in bulk. As noted by a leading scientist in the ICBG:

> We'll do the best that we can, collecting whatever we can. For us, the more extracts the better; it all depends upon the number we can get our hands on.[6]

To access enough extracts, scientists in the ICBG are continuously seeking to overcome the natural and social barriers in bioprospecting (see Chapter 2). This process of capitalist accumulation in drug discovery is put forth by excluding "nature" and "culture" in the form of local knowledge from the process primarily through efforts to "industrialize" the

[4] David Kingston pers. communication, 2007. Each plant collected provides roughly five samples or extracts (bark, wood, leaf, flower/fruit, and root) which translate into somewhere around 1,000 plant species collected per year. This estimation is based on projections from the Missouri Botanical Garden project's documentation of the NCI collection (MBG, 1996).
[5] Don Hahn, personal communication, 2007. During the ICBG 2005 annual meeting, one of the private institutions offered monetary incentives to individual collectors who could bring in more samples. The offer was met with political resistance at the upper levels of the ICBG structure.
[6] ANON 1 (Feb 11, 2006).

practice within large-scale screening laboratories in the U.S. and Europe (Parry, 2004; 2000; see also ten Kate and Laird, 2000). The capitalistic imperative to extract surplus within the pharmaceutical commodity chain is expressed through a modern “ordering” of knowledge, space, labor and institutions, and fixing space in which capital can operate in Madagascar (Mitchell, 1990; see also Agrawal, 2005; Luke, 1999; Foucault, 1991). As this chapter will demonstrate, this has been accomplished through the processes of switching over to rational collection strategies that employ a host of new geo-referencing technologies, global networks herbarium archives, and high-technology rapid screening methods.

The purpose of the following is to detail the social, political and environmental relations of a modern bioprospecting project that emerged *after* the signing of the CBD and the implementation of benefit-sharing protocols worldwide. This case provides a contrast to the two previous cases in the dissertation that represent drug discovery initiatives prior to the CBD. In this study I highlight how different actors, including rural inhabitants, regional politicians, local NGOs, individual research scientists, national institutions and government administrators are differentially incorporated into the commodity relations surrounding contemporary bioprospecting. In part one of this chapter, I describe the move to rationalize the collection process by shifting away from place-based traditional knowledge. The adoption of random collection methods is intended to speed up the production process and industrialize it overall. In part two of this chapter, I discuss the effects of this shift on the ethical landscape of bioprospecting, in particular, that of distributive justice and the prevailing moral economy in rural sites of production and research laboratories. I provide an ethnographically-informed account of the technological changes, and provide a methodological framework for tracing who captures the benefits, and who is most affected by the burdens, of contemporary bioprospecting in Madagascar and abroad.

The birth of the modern bioprospecting institution

The ICBG is composed of private and public international organizations, research institutions and companies involved in a large-scale collaborative effort to discover novel pharmaceutical and industrial products (Rosenthal and Katz, 2004; Brown, 2003; see also Reid et al., 1993; ten Kate and Laird, 2000). Specifically, the ICBG-Madagascar is a bioprospecting project which originated from the Biodiversity Utilization in Suriname Project (1993-1997), led by Dr. David Kingston at the Virginia Polytechnic Institute and State University (VPISU). The project in Suriname was one of five initial projects contracted by the ICBG in 1993. It used a mixed approach drawing on both “traditional” knowledge sources and random collection (see Chapter 2). After the first funding cycle, the team led by Kingston submitted a proposal in conjunction with some of the larger organizations involved in Suriname who also had operations in Madagascar for the second round of ICBG.[7] Subsequently, the team was granted a second five-year round of funding, and expanded to Madagascar.

[7] This team also included representatives from the Missouri Botanical Gardens (MBG) and Conservation International (CI).

Table 5.1 US federally funded bioprospecting projects in Madagascar and Suriname

List of project	*Years*	*Geographic location*	*Type of collection*
International Conservation Biodiversity Groups-Suriname	1993-1997	Suriname	Ethnobotanical/ Random
International Conservation Biodiversity Groups-Madagascar - Phase I	1997-2003	Madagascar - Zahamena National Park, in the eastern forests of the Toamasina Province	Random
International Conservation Biodiversity Groups-Madagascar - Phase II	2003-2008	Terrestrial and marine locations in the Province of Antsiranana (previously known as Diego-Suarez) in northern Madagascar.	Random

This stage of the project which was designated Phase I (1997-2003) in Madagascar was designed around collections within the Zahamena National Park, in the eastern forests of the Toamasina (Tamatave). In contrast to Suriname, however, the Malagasy project *only* used the random collection approach. In 2002, a third round of funding was awarded to Kingston's team, this time to work solely in Madagascar, again only using random collecting (see Table 5.1).

One of the ICBG project's leading scientists directly addressed the reason behind the change from ethnobotany to random collection, remarking that the use of ethnobotanical knowledge in Suriname was inefficient and the "shaman" particularly difficult to work with:

[In Suriname] ethnobotanical knowledge did not deliver. For example, when you bring village healers together, eighty percent of the time the plant they are showing you is not in flower. And we found ourselves with a number of unidentifiable plants which were many times replicates with other village healers. Secondly, delivering benefits became a very complex process legally. Even with Conservation International rushing the issue, it took over a year to identify the right party to deliver the benefits. So as you see, IPRs [Intellectual Property Rights] became extremely complex, especially when tribal

Amerindian villagers started to claim that they were owed benefits, because they were living in the collection sites before the 'Bush-Negros,' whom we were working with.[8]

He then added: "…the use of a healer in Suriname was not very productive, so we decided to keep it 'very clean,' and not use ethnobotany."[9] The scientist's reference to keeping the process "very clean" referred to bioprospectors' desire to control all the variables, risks and difficulties that arise during collection and avoid the messy and inefficient obstacles that can arise when working with a shaman.

Many of the problems associated with ethnobotany, especially IPRs and the return of benefits, are not unique to Suriname, however. One of the former directors of the ICBG in Madagascar noted that right from the beginning of the ICBG, some Malagasy institutions raised concerns with ethnobotanically-guided bioprospecting. These concerns were mainly warranted by the complex nature of the ownership of traditional knowledge in Madagascar. As noted by a former Malagasy director of the ICBG:

If a traditional healer in Madagascar gave us good information that led to a drug discovery, in the end it would be very difficult to protect their intellectual property. This is mainly because here in Madagascar it is thought that the healer is not an individual property owner of the traditional knowledge. Rather, it is believed that they inherited this knowledge from their ancestors, and it is the property of his lineage or 'community.' In this context, it would be difficult to share the benefits of this research with the informer, and it would be very difficult to organize the return of these benefits overall.[10]

Taken at face value, the scientists' remarks provide a description of the many challenges bioprospectors face when engaging in ethnobotany in Madagascar and the delivery of benefits. A more critical read, however, suggests that the ability to frame traditional

[8] ANON 1 (Feb. 11, 2006).
[9] ANON 1 (Feb. 11, 2006).
[10] ANON 17 (Feb. 14 2005).

knowledge as “inherited” and “communal” serves the bioprospectors well in terms of not having to identify individuals to whom to return benefits.

In fact, instead of being passive subjects willing to share their knowledge with outsiders, many ethnobotanists and other social scientists have noted that traditional healers are seen by their communities as keepers of sacred knowledge charged with the responsibility of preserving and protecting it from outsiders (Brown, 2004; Hayden, 2003). This safeguarding of their knowledge may also be interpreted as resistance against hegemonic forces that are continually extracting natural resources from their forests. Acts of resistance, such as “foot dragging,” “slowdowns” and “work stoppages,” have been observed by James Scott and others as subversive “weapons” sometimes used by less powerful actors against dominant powers (Scott, 1985; see also Kull, 2004; Peluso, 1992). As noted by Steven Beyer,

> …shamans play a role in resisting, ameliorating, and influencing the course of colonial contacts and history; they become the source and symbol of an indigenous culture capable of defending itself against colonial power and the nation state…(2008).

In previous studies of shamans, scholars have shown that healers purposefully hold back information about plant use, misdirect bioprospectors, demand money, and obscure access to their forests (Brown, 2005). [11] For bioprospectors, the shamans or traditional healers and their demands become “social” obstacles to accessing the vital resources needed to discover drugs. Held up in this light, the shaman, is the last line of “access control” of traditional knowledge causing potential delays in the drug discovery process.

[11] I use the term shaman and traditional healer (as used in Madagascar) interchangeably in this chapter to refer to someone who self-identifies with the profession of diagnosing and prescribing medicinal plants and other biological resources to cure ailments.

In Madagascar, the practice of traditional healers and diagnosing medicinal plants for illness was deemed illegal during colonial times.[12] And even to this day, traditional healers will not come out and forthrightly discuss which plants are used for medicine. They typically still work in informal groups and refuse to identify themselves to scientists and especially to foreign bioprospectors.[13] As noted by a leading Malagasy scientist in Madagascar, "They [traditional healers] give *us* [Malagasy] some information about plant uses, but they wouldn't talk to foreigners. They'll never tell you what they would tell us."[14] Echoing this response was a leading Malagasy ethnobotanist who noted, "Traditional healers [in Madagascar] sometimes lie to ethnobotanists to hide what they know."[15] This begs the question if these traditional healers not fully cooperate with bioprospectors as a form of resistance, or because they genuinely do not think they as healers have a right to share the knowledge because they view it as communal property?

Malagasy pharmacology might not be compatible with capitalist modes of extraction found in bioprospecting because Malagasy healers value a lineage or community above the individual. Exclusive individual rights form the basis of Western notions of property and are protected by patent rights established through the practice of bioprospecting. The different economic worldviews that the shamans hold conflict with the ICBG's understanding of nature's exchange value and different view of property relations concerning their resources overall. In response to any social resistance to collection on

[12] ANON 103 (Nov. 1, 2006).
[13] ANON 103 (Nov. 1, 2006); ANON 8 (Dec. 5, 2006); ANON 10 (Oct. 15, 2005).
[14] ANON 103 (Nov 1 2006).
[15] ANON 37 (March 3, 2006).

the local level, bioprospectors have increasingly turned increasingly towards rational and "scientific" approaches to resource and knowledge capture such as random collection. This shift away from traditional knowledge allows bioprospectors to maintain relatively unfettered access to collect plant material in bulk at the local level.

Random collection

Plants desired in bioprospecting can turn out to be just as elusive as scientific quests for prized fauna, since they are hidden under layers of dense forest canopies and often quite quite difficult to access. Many scientists have noted that randomly collecting plant species has been shown to be one of the best ways to collect the most samples in the shortest amount of time (Miller et al., 2005; Balick, 1990; Spjut 1985).[16] In this respect, the method is a perfect fit for the ICBG, which aims to access massive amounts of bioprospecting samples and herbarium specimens.

Randomly collected species are determined by locating samples in a broadly defined area (Balick, 1990). Once a plant is obtained, however, it is almost impossible even for the best trained botanist to identify. Collecting the flower helps to resolve this problem by completing a "true" voucher specimen, this usually includes a fruit, the flower, multiple branches, and leaves to facilitate systematic identification. The voucher is imperative to fully identify the range of species available in Madagascar, where up to 14,000 flowering

[16] Michael Balick (1990) notes that successful collection of plant species is dependent on both seasonality and the number of fertile samples that can be found in an area (see Chapter 2).

plant species are thought to exist (Lowry, pers. communication, 2006; Miller et al, 2005; Balick, 1990).[17]

Through the use of random collection, bioprospectors are now able to circumvent the place-based knowledge of the shaman and take advantage of new capabilities to run high-throughput and super-high throughput assays at a fraction of the time. The role of technology mediating productive practices has been observed by scholars looking at the effects of new and emerging science and capitalism in agriculture (Kloppenburg, 2004; see also Goodman and Redclift, 1991). Jack Kloppenburg remarks that there is a shift in the way scientists engage with nature, especially since the emergence of biotechnology and genomics. Kloppenburg shows that advances in agricultural biotechnology which alter how seeds function demonstrate the many efforts put forth by agro-industry to overcome the "natural" barriers (i.e., time waiting for seeds to germinate) and labor constraints (i.e., hand pollination) inherent in many forms of agriculture (2004:2).

Unlike agricultural biotechnology, however, bioprospectors have not yet made significant inroads in overcoming the natural barriers, and are dependant on the biogenetic resources found in Madagascar. Nonetheless, through the adoption of random collection and other new technologies, they are able to mechanize the labor process and overcome the social constraints inherent in ethnobotanical approaches. These technological departures have changed the position Malagasy occupy in the bioprospecting division of labor.

[17] Earlier estimates of species numbers in Madagascar are approximately 7-8,000 (see White, 1983; Humbert 1959). Yet now most scientists agree upon much higher estimates, closer to 12-14,000 (Pete Lowery, pers. communication; see also Schatz et al., 1996).

The bioprospecting labor force

The trained eyes of bioprospectors go to work, peering over the dense forest canopy; within the shades of greens and browns, they see flickering yellows, oranges and hues of rose. Once a flower is located, the team converges on the tree in a mad rush. Like a factory supervisor, the lead botanist directs each of the hired workers in his specific task - fruits and flowers are clipped, leaves are picked and stuffed, and wood and root samples are cut. After a sample is taken from each plant part (roots, leaves, bark, wood, fruit and flower), it is placed in a cotton cloth sac for the porters to haul back to base-camp. These laborers, hired to work as porters, guides, guards and cooks, are indispensable to the success of the ICBG's main goal: to access plant samples in bulk.

Although the more technical jobs are rotated among the scientists in the group, the hard manual bioprospecting work requiring brute strength is reserved for the hired laborers. For example, tasks such as digging out the roots and cutting bark are done by those with strength since considerable effort is required to dig out rocks and soil debris to get at the roots. These day laborers are invaluable assets because they are paid for their local knowledge, the ability to locate flowering plants and trees at a rapid pace, and especially their willingness to assume the hard physical labor tasks at low pay.

I found most bioprospecting workers quite happy to accept a daily wage for their hard work. Yet, beyond this daily wage, their involvement in the project was minimal. In a survey conducted in the three village collection sites in 2006, only half of the rural residents (including the day laborers) interviewed held any knowledge of the collection team's activities, and most were unfamiliar with the organizations that work on the project (i.e., *Service d'Appui à la Gestion de l'Environnement* - SAGE and the Missouri Botanical Garden - MBG). Of those who had heard of the researchers, less than half knew that they were collecting plants to make a drug or medicine (see Table 5.2); moreover, very few had any other detailed knowledge of the bioprospecting project.

Table 5.2 Knowledge of bioprospecting team and activities in three collection sites

Village	*Had heard of the Missouri Botanical Gardens*	*Had heard of the NGO SAGE*	*Had some knowledge of researchers collecting plants*	*Mentioned they were collecting plants for a "drug" or "medicine"*
Sabatinava	2	5	10	8
Ambatofaroa	6	5	29	16
Varindirina	6	8	7	6
Total	14 (n=81)	18 (n=81)	46 (n=81)	30 (n=81)

The lack of knowledge that rural Malagasy held about the ICBG was not surprising. First, the organizational structure of the project was extremely complex and difficult to understand. Second, although the ICBG had been active in Madagascar since 1997, it was relatively new to the Antsiranana region (since 2003) in comparison to the long history of NGOs, missionaries and community associations even in the most remote areas of northern Madagascar. Finally, the ICBG spent relatively little time in each site, only up to one to two weeks per location, and mostly out of view of rural inhabitants. This *collective ignorance* held by rural inhabitants begs the question of what role these villagers play in the decision making process governing bioprospecting, and whether they maintain any control over their natural resources at all, especially since access and benefit sharing mechanisms are based on the idea of Malagasy participation into bioprospecting activities.

Furthering this point, is the adoption of new technology which is re-ordering the bioprospecting labor force and the role the Malagasy play in it. For example, once a bioprospecting sample is taken, it is tagged with a collection code. This code, which includes the initials of the collector, the sample number and the plant part collected, is stored in a log book, alongside associated ecological data and other key information including time, date, GPS coordinates and the collectors on the trip. This data is then used for locating the species if subsequent testing identifies bioactivity. The adoption of technological innovations came after attempts to re-collect the same species in different locations or misidentification of species had resulted in lost time, confusion, and unsuccessful re-collections. This led bioprospecting teams to use a more precise process of geographic markers, including portable GPS trackers and geo-referencing techniques, allowing plants to be re-collected from the same environment and maybe from the same tree.[18]

Accurate collection also helps to avoid duplicate samples, which is a costly mistake for bioprospectors. And, most importantly, it provides bioprospectors greater flexibility. Since the data allows collectors to identify the precise locations where the plants were originally found, local guides are not needed for re-collection. This development follows many efforts to overcome the spatial barriers of collection through the use of new collection technologies. With this technology, bioprospectors are able to place “locally” collected knowledge found in remote areas of Madagascar and fix the information and nature into “global” networks of exchange (Parry, 2004).

[18] David Kingston, pers. communication, 2006.

Botanists and the banks of botanical material and knowledge

The main thrust of random collection is to pick up plant samples, both for bioprospecting and matching herbarium samples, in bulk. For example, to date, there are close to 8,000 to 10,000 specimens in one Malagasy herbarium, the majority of which have been collected and identified under the ICBG project.[19] Others outside Madagascar are even larger, some holding 60 times that amount.

The mass production of thousands of bioprospecting samples and associated herbarium specimens clearly illustrates the dual mandate of the ICBG that alongside discovery of new drugs, species are to be collected and categorized within "global centers" of botanical repositories and herbariums (Parry, 2000; see also Foucault, 1969). For example, alongside each sample taken, five corresponding herbarium specimens are also collected. As part of the ICBG agreement, voucher specimens are disseminated to five botanical herbariums - located in Madagascar (PPZT, FOFIFA, CNARP), in Paris- *Muséum National d'Histoire Naturelle* and the U.S. - Missouri Botanical Gardens Herbarium, St. Louis. This is an agreement written with the Malagasy government (see Table 5.3).[20]

[19] Some of these herbariums in Madagascar are remnants of the French colonial collections conducted by OSTROM (*Office de la Recherche Scientifique et Technique Outre-Mer*).
[20] Jim Miller pers. communication, 2006.

Table 5.3 Relative size of six separate herbarium collections

Name and location of botanical repository	*Numbers of Malagasy Species held in major herbarium collections*[21]	*Official partner in ICBG Project*
Muséum d'Histoire Naturelle Paris, France	600,000 to 675,000 herbarium specimens, 13-14,000 individual species	No - but does receive ICBG voucher specimens
Parc Botanique Zoologique et Tsimbazaza (PBZT), Antananarivo	120,000 specimens and 8,000 unique *taxa* represented	No - but does receive ICBG voucher specimens
Missouri Botanical Gardens (MBG), St. Louis, Missouri, USA	109,167 in database 11,522 unique *taxa* represented[22]	Yes
Centre National d'Application de Recherches Pharmaceutiques (CNARP), Ivandry, Antananarivo	10,403 herbarium specimens; 3,011 species belonging to 2,011 genera and 247 families[23]	Yes
Centre National de la Recherche Appliquée au Développement Rural Département de Recherches Forestières et Piscicoles (FOFIFA) - TEF, Antananarivo	4,000 woody specimens represented	No
Royal Kew Botanical Gardens, UK	NA - database not available[24]	No - and does not receive any vouchers from the ICBG

The ICBG has facilitated the creation one of the largest computerized databases including thousands of Malagasy and other global botanical *taxa* (Parry, 2000). MBG has built a base of operations in Madagascar equal to that of the leading botanical organizations in the world, including the Royal London Gardens and the Natural History Museum in Paris. As one botanist revealed, this database has not only established MBG's status as the leading botanical organization in Madagascar, with expertise and advisory roles on

[21] Some of these may represent replications of specimens found in "shared" herbarium collections, but do refer to access by the selected institutions.
[22] Jim Solomon, pers. communication, 2007 - Curator of the herbarium at the Missouri Botanical Gardens, St. Louis, MO.
[23] Much of CNARP's herbarium specimens are left over from the French ORSTOM collection.
[24] Stewart Cable, pers. communication, 2007 - Project manager of the Kew Millennium Seed Bank Project, U.K.

environmental and conservation policy, but it has also given them "quasi-diplomatic status."[25] As one of the leading scientists in the ICBG put it:

The ICBG has been a huge win for MBG. Within a period of about eighteen years of operation in Madagascar, they have amassed herbarium numbers comparable to the largest collection in Madagascar - the PBZT [*Parc Botanique Zoologique et Tsimbazaza*]. The majority of it [specimens] was collected under periods of bioprospecting programs.[26]

The uneven power relations that develop within these large botanical repositories is not unique to the ICBG, however. Bronwyn Parry argues that two fundamental changes in the collection and production processes of bioprospecting exacerbated and politicized its uneven development on a global scale:

…[T]he amount of power and value that derives from being in possession of a collection of materials may well be increasing (1) as processes of technological innovation that fundamentally alter the nature of biological materials so that they become infinitely more amenable to collection, concentration and control; and (2) as processes of global economic and regulatory change improve collectors' ability to reticulate and regulate the flow of collected materials more strategically and thus to further advantage (2000:382).

However, there is increasing concern that these "banks" of material and knowledge have become sites which present large-scale laboratories with the opportunity to conduct bioprospecting directly out of these collections (Parry, 2000). As Parry observes, the use of *ex situ* libraries of biogenetic material, "…operates on the premise that these materials can be utilized and reutilized by any number of interested parties" (2000:390). Schroeder notes that it is this increasing trend toward what Parry calls "re-mining" that has made accountability "up and down the production chain next to impossible" (2000:55). This inevitably raises questions concerning bioprospecting firms' relationship with people in the sites where resources are collected.

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[25] ANON 9 (May 12, 2006).
[26] ANON 9 (May 12, 2006). The PBZT is located in Antananarivo, Madagascar.

Experts as technicians

A few weeks after my return from my trip to Sambava in 2006, I was interviewing Robert, a head chemist at the leading Malagasy research institution involved in the ICBG, the *Centre National d'Application des Recherches Pharmaceutiques* (CNARP), about his experience with the ICBG project. Sitting in his laboratory surrounded by outdated glassware, centrifuges, flow-hoods, and chromatography machines, I asked where the plants collected on my bioprospecting trip to Antsiranana might be. Robert led me over to a new refrigerator in the corner of his laboratory, lifted the cover, and pulled out six four-inch glass tubes filled with a dark brown and deep-green grainy liquid. "Here," he said, "these may be them. These are the extracts made from those plants which are now ready to ship to laboratories in the U.S."

I inquired about how hard it is to get the material to the U.S. Robert indicated a cardboard box in the corner of his laboratory which held the distinctive yellow tape and red lettering of the international shipping company, DHL, and stated flatly, "It's actually quite easy." Robert went on to explain that since extracts are not subject to the same rules of phytosanitation as other biological material, such as live plants, the ICBG is able to ship thousands of extracts at a fraction of the cost in terms of time and money.[27]

In drug discovery, the chemist holds a special role. For example, as a chemist, the quintessential objective is to identify molecular compounds that hold promising novel bioactivity. This task entails a multi-stage process of elucidation, fractionation,

[27] ANON 40 (April 10, 2007).

purification and identification that requires expert knowledge and training in organic and inorganic chemistry, as well as the ability to tap into libraries of known compounds (Weiss and Eisner, 1998). Chemists are usually the first to identify any novel bioactivity and frequently take a lead in publishing the results.[28] Robert was known by his peers to be a first-rate chemist. As part of the ICBG "perk," he had just returned from a six-week trip to David Kingston's Laboratory at Virginia Polytechnic University (VISPU) to attend ICBG meetings and follow-up on some interesting leads found from Malagasy plants. Robert noted that his trip was very productive:

> [T]he work I conducted in that six-week time saved me up to one year of research time back in Madagascar. It is very frustrating to return because I have to wait for everything to be set up and ready for work. I have to wait for chemicals, organic solvents to be shipped in…At VISPU the organic solvents flow like water from the tap.[29]

Back in Madagascar, Robert now lacks the essential equipment to fully identify chemical compounds and to access ready-made organic solvents, and his role as a lead chemist therefore diminishes to that of a research technician. For example, chemists must have the structural availability to systematically transfer materials to biologists to screen. To conduct these assays, they correctly identify the bioactive "leads" with vital identification equipment and materials and information technology, most of which are not found in Madagascar. These materials include large amounts of organic solvents to make extracts, and high-tech equipment required to separate molecular compounds, including high

[28] This is especially true in Madagascar, where chemists involved in drug discovery hold very prestigious positions in many of the public and private scientific institutions including: CNRE, IMRA and the Secretary General of the Ministry of Scientific Research and Higher Education.
[29] ANON 12 (Sept. 8, 2006).

power liquid chromatography (HPLC), gas chromatography (HPGC), and mass spectrometry (MS), which separate by liquid, gas, and weight respectively.[30]

However, the most essential piece of equipment needed to identify molecules in drug discovery is the nuclear magnetic resonance spectroscopy, commonly known as NMR. Without it chemists are stymied, and left dependent on scientific collaborations with laboratories equipped with an NMR to conduct elucidation and identification of the material. The lack of such capability has effectively reduced the highly trained chemists at CNARP to the status of technicians. As expressed by a leading Malagasy chemist in the ICBG:

…for the time being, our laboratory is not able to identify molecules, so we need to send the extract to VIPSU and they do the identification. It has always been like that. So for now, this [the ICBG] is the only way to get funding and also to reinforce our capacity to do research.[31]

The Malagasy chemist's role is simply to facilitate access and extraction by their counterparts in the U.S. and it is the latter who conduct the "science" of drug discovery *in lieu* of direct participation. This de-skilling of Malagasy scientists has generated considerable frustration and mistrust among the institutions involved in the ICBG. This discontent was vocalized by a source close to the top of the ICBG hierarchy:

We [Malagasy institutions] are a passport for plant material…The ICBG is not a bad program, they provide some materials. But it holds back when it comes to very vital research interests that we need. So it is just not the best for us [Malagasy].[32]

A similar reaction was echoed by an independent Malagasy scientist at the *Institute de Pasteur Research* in Antananarivo: "What will Madagascar as a country gain from this

[30] A HPLC has been bought for CNARP with ICBG funds, but at the point of the end of this research in September 2006, nine years into the project, it had not yet arrived.
[31] ANON 16 (Jan. 19, 2006).
[32] ANON 10 (Oct. 15, 2005).

[ICBG]? We will continue to be a plant provider."[33] This feeling of disenfranchisement was echoed later by another research scientist:

> When it comes down to it, I dream of discovering new drugs because this is what I was trained in. I am just happy to contribute to scientific knowledge because 50 years down the line you never know...But when I think of the ICBG project, I feel cheated as a Malagasy, as a scientist.[34]

Part II: Distributive justice, ethical bioprospecting and benefit-sharing

One of the goals written into the programmatic structure of the ICBG is to support economic development and conservation interventions in rural areas (Rosenthal and Katz, 2004). These conservation and development programs offer economic incentives to the Malagasy government and regional *communes* to conduct rural-level micro-development projects or microprojects. The ultimate purpose of the microproject is to provide tangible "compensation" to "local communities" for the collection of the biological material.[35]

The term "upfront compensation" was used by many of the informants and participants to describe payments given to the rural inhabitants for their participation in conservation activities in areas located near sites of collection.[36] The funds for the project are to be provided before or during collection, and are upfront or prior to any other monetary returns such as royalties or milestone payments that may be received after any discoveries are made. The logic behind the compensation scheme is rather straightforward: drug discovery is a complex process that takes a great deal of time (estimates to bring a drug to market are upwards of 10 to15 years). This upfront payment

[33] ANON 3 (March 11, 2006).
[34] ANON 3 (Jan. 11, 2006).
[35] The term "local communities" is used commonly as an area of intervention by the ICBG microprojects.
[36] ANON 9 (Dec. 14, 2006). The term "upfront compensation" was designed by the architects of the ICBG - Suriname project and imported into Phase I of the ICBG in Zahamena.

accordingly provides an example of benefits that may be gained from protecting their biodiversity. Moreover, the project holds that by providing rural Malagasy some economic alternatives through income generating activities, they will begin to reduce charcoal production, pasture burning and other "unsustainable" livelihood practices, and begin buying onto long-term conservation stewardship.

However, the technological shifts that have taken place in the ICBG over time raise questions regarding who is able to capture the majority of the benefits and just what the burdens of participation are. I posed these important distributive justice questions to rural residents living in collection areas and Malagasy research scientists at the national pharmacological laboratory at CNARP. The purpose of this analysis was to provide a better understanding of Malagasy perceptions of project benefits and burdens and rural residents sense of distributive justice within the ICBG.

Benefits and burdens of participation in the ICBG

Once the bioprospecting team obtains collecting permits from the Malagasy government, there is no other legal obligation for them to respond to demands of any local authorities or inhabitants before entering a forested area.[37] However, it is the ICBG policy to arrange "courtesy" visits with rural Malagasy before collection. This short meeting (*kabary* in Malagasy) between the project and the president of the *fokontany* greatly benefits the

[37] All forested land not under cultivation or under any type of co-management scheme (GELOSE or GCF) is designated as property of the state property (Raik, 2007; Kull 2002). See also Schoonmaker-Freudenberger, 1995; Keck et al., 1994.

researchers.[38] The kabary is an opportunity to explain the researchers' objectives and needs,[39] and begin the process of selecting workers, including fifteen to twenty men and women who are chosen by the village head to work as guides, cooks and porters. The meeting provides the researchers unlimited access to intact forests near the village during collection and guarantees their safety throughout their stay.

The payment is negotiated at this point at the ICBG rate at 5,000 Ar per day. Due to the somewhat easy access to many of the vegetative areas in Antsiranana, porters usually work for two days (one day drop off and one day return). Cooks and guides stay for the duration of the trip and maybe for multiple trips, depending on the next location. The porters each load 25 to 30 kilos of materials and food, and carry it to and from the requested site. The site is usually found by the hired guide in the area, with water availability and central location as criteria. It seems that sites are chosen where the guide can maintain access and personal communication with the village, and in return, the village can keep an eye on the researchers.

Most workers hired have some relationship with the village head, and their hiring was seen by many in the village as a favor passed down through the village administration. In the end, the process of hiring "local" is vital for the team's success. Although legally the

[38] ANON 18 (Dec. 7, 2005). A kabary is a cultural form of communication, whereby Malagasy indirectly explain an historical event relevant to a current situation. As defined by Harman (2002) as "…the discussion of telling of ancestral proverbs, metaphors, and riddles, frequently in a dialogue using call and response."

[39]ANON 18 (Dec. 7, 2005). Formal communication with rural Malagasy remain a formidable obstacle for the bioprospecting team since many of the researchers are from the Merina ethnic group and do not speak any of the Antsiranana dialects used in the area.

researchers may enter the forest, their collecting activities have the potential to be disrupted if they do not hire locally. As Lanto, a porter hired by the team, indicates:

> Yes, they are allowed to go into the forest, and we can't do anything to stop them. All we need is money and we won't do anything. We don't know much about what they do, but if they [researchers] give us something for our pockets [money], we won't bother them.[40]

However, not everyone was in concert with how benefits were exchanged, as observed by Henri, a rural resident:

> If they [ICBG] tell us that they get new drugs from the plants, and not hide it, maybe there will be a benefit for people in the village. Still, we didn't know why they had gone into the forest, and it was only after they came back that we found out. In the end, we didn't know if they had their collecting permits or not.[41]

This confusion of just what the project was about leads to the question: how are rural Malagasy to learn about the benefits of bioprospecting if even those who are involved in the project are still left without any significant knowledge of the project's mission? And beyond a few days of employment, how else are Malagasy participating in the ICBG?

<u>Whose water trough is this?</u>

In 2004 and 2005, ICBG information meetings were held within the two rural communes of Ramena and Mahavanona and a larger meeting was held in Antsiranana.[42] The purpose of these meetings was to explain the application procedure to apply for rural level conservation and development projects (microprojects henceforth) funded by the ICBG and how the vetting process for selection was going to proceed. Applications were to be

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[40] ANON 21 (March 5, 2006).
[41] ANON 32 (March 5, 2006).
[42] ANON 23 (May 31, 2007). There were several secondary or follow-up meetings and information sessions that were held in the region by SAGE with mayors, presidents of representative *fokotany* and some rural residents. The meeting participants ranged from a few people (three to five) to 30, and were generally held at the commune office or president's house. The second meeting in Antsiranana was focused mainly on conservation programs around *Nosy Longo*, *Orangea* and *Montagne des Français*.

written by the commune head and sent to a screening committee composed of the Malagasy representatives of the three leading organizations of the ICBG (CNARP, MBG and CI). By the end of the application process, fifteen small and medium range projects were selected in the three different communes, those of Nosy Be (marine site), Ramena and Mahavanona (terrestrial sites) (see Map 5.1 and Table 5.4).[43]

[43] ANON 19 (June 27, 2006)

Map 5.1 Locations of ICBG's plant collection and microprojects in Antsiranana

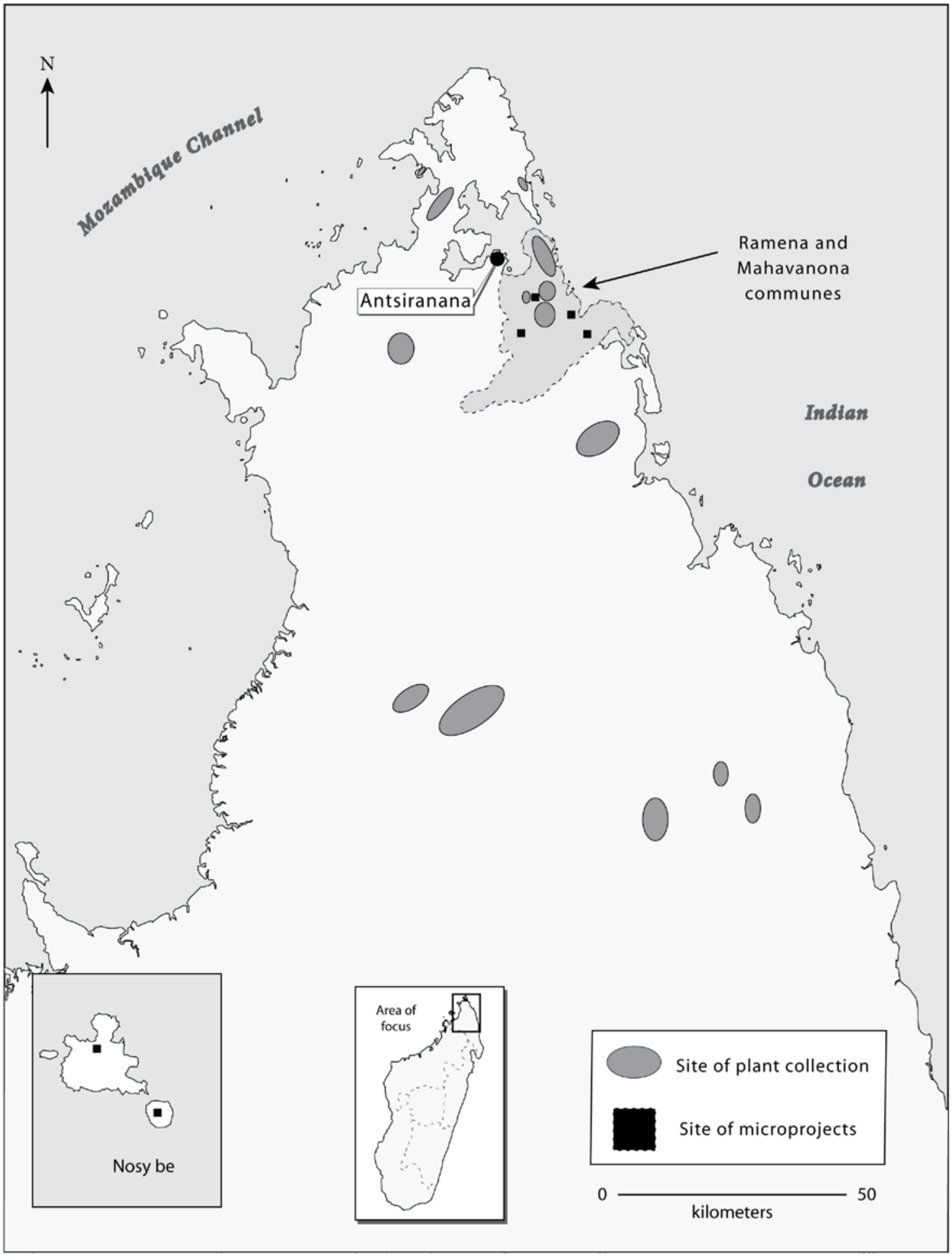

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Table 5.4 List of microprojects in the Antsiranana region[44]

Commune	*Village*	*Type of project*	*Type of collection (marine or plant)*
Nosy Be	Nosy Lafy	Community building Animal breeding Horticulture	Marine
Nosy Be	Anrodrimna	Animal breeding Horticulture Reforestation/afforestation	Marine
Ramena	Varindirina	Water well/irrigation dam[45] Animal breeding Horticulture projects Reforestation/afforestation	Plant
Mahavanona	Sabatinava Ankadino Ambatofaroa Mandjaranivavo	Feeding troughs Animal breeding Horticulture projects Reforestation/afforestation	Plant

For many scientists involved in the project, the benefits returned to the villages, either in the form of labor payments or the microprojects themselves were viewed favorably. For example, the virtues of the microprojects are mentioned repeatedly by ICBG representative as "…a method of giving something back to the source country and especially the 'local community'."[46] The permanent representative of the MBG, for example, commented on the completion of a Phase I microproject:

There was the construction of a bridge and granary. I was there during the inauguration [of the bridge]. They were happy to see their work accomplished. The real advantage of the bridge allowed the villagers to get to the hospital easier.[47]

But how do the rural inhabitants view the microprojects? For some, such as the president of Varindirina, they seemed like an equivalent exchange for their resources:

[44] Reported by SAGE**,** Feb. 2005.
[45] While the project claimed a 100 percent completion, a site visit to the village in Feb. 2005, I found only partial delivery of the microprojects. The only reports of completed projects were of the dam, the planned irrigation well ran into complications and was never completed.
[46] ANON 17 (Feb.14, 2005).
[47] ANON 19 (June 27, 2006).

I think it is equal. They came here only once. They spent one week and gave us [Varindirina] 14,000,000 Ar (roughly U.S. $6,900). So, I think it is equal. Maybe they got more compared to what they took but whatever we get is already fine for us.[48]

More generally, within the three villages surveyed, residents' accounts of the microprojects were mixed and participation in the microproject and implementation was largely limited to a few individuals in each. And even though all three villages had microprojects that were actively or previously constructed, most residents had little or no knowledge that they were even occurring, much less that they were linked to the ICBG (see Table 5.5).

Table 5.5 Knowledge of ICBG-led microprojects in three sites (n=81)

Village	*Any knowledge of microprojects*
Sabatinava*	2
Ambatofaroa	8
Varindirina*	6
Totals	16

* indicates villages with microprojects

As shown earlier with knowledge of the ICBG, there seems to be collective ignorance held by rural inhabitants about the microprojects overall. This questions whether the choices for the microprojects have any rural level input at all. For those who did know anything about the project, the survey seemed to show that knowledge of the project was only diffused to those who lived close to the project sites, who were direct relatives of the president, or who worked with him in some capacity (e.g., vice-president of *fokontany*, school teacher).[49] An example of villagers' description of benefits was noted by the president's brother:

[48] ANON 25 (March 6, 2006). Ariary (Ar) was calculated at the Jan. 1, 2006 rate of exchange at roughly 2,029 for one U.S. dollar.
[49] ANON 34 (March 5, 2006).

The president reported to us during a meeting that we had…the project about the dam is related to the fact that MBG came here [the benefit we got from them]; however the microproject about keeping chickens or ducks is to make people stop making charcoal which destroys the forest.[50]

In many interviews, villagers said they felt the microprojects did not represent what they wanted. For example, since a very few actually owned *zebus* (the local breed of cattle), a watering trough was not suitable. When I asked the president of the *fokontany* of one of the villages why many of his residents felt disappointed in what the ICBG delivered, he said:

It was a bit difficult, because there was no participation of people in the village. If we want to carry out a successful microproject, people should participate. The money is already there, but people don't want to participate. In Sabatinava, for example, the water place has already been dug, but people don't want to work on it. And I don't know why. The local NGO, SAGE, is in charge of the project and works with the *commune*. What I think happened is that what *commune* gave us is not what people really want. They want to raise chickens or do something that people can get a direct benefit. People don't want a well or a watering hole.[51]

When I asked further why a watering trough was selected, he expressed the project's urgency "…in getting a project done, rather than what people really wanted."[52] In another interview a village president said:

They [SAGE] said they asked them [the residents], but people didn't really understand the process. So SAGE planned the project, but I think it was only done on table [SAGE didn't go to the village to ask people's opinion]. SAGE just did it. The *commune* didn't protest because they knew it was something urgent to get done.[53]

It is easy to see why the *commune* and other elected officials see the benefits of the project, since they have been the main beneficiary all along. For example, in 2002-03, each commune received roughly U.S. $7,000 for the microprojects. When these payments

[50] ANON 35 (March 4, 2006).
[51] ANON 26 (March 5, 2006).
[52] ANON 26 (March 5, 2006).
[53] ANON 26 (March 5, 2006).

are compared to the 2002 annual budgets for the communes of Ramena and Mahavanona, which reported roughly U.S. $ 4,200 and $10,600 respectively, they represent a sizable supplement to the annual operating budgets for village projects and programs.

Questions of "who benefits" from a project might better be rephrased as: who has the *ability* to participate and what does participation mean in terms of trade-offs and costs to the individual or group? In fact, beyond the daily wage to porters, guides and cooks, many felt that overall neither they personally nor the village benefited from the project, and many were eager to highlight how *some* benefited more than *others*. For example, when I asked Bako, a woman farmer in Varindirina, if she had received any direct benefit from the project she said:

> Only the president received benefit from these researchers because he went with them. He has also taken some people from the village with him, but they are the only ones who get money. They gave him money and gifts. Moreover, he didn't report to his people what they did there. Even people in the village don't know what they are doing there.[54]

Since the president was cited by many respondents as a major, and sometimes the only, recipient of benefits, the respondents also questioned the role of the "community" commonly featured in bioprospecting projects. In reality, the rural residents I spoke with represented groups of differentiated individuals whose benefits from bioprospecting varied from a one-time cash payout to nothing at all, and whose participation consisted of a couple of days work for a few workers at most.

One local observer summed up the situation by claiming that the bioprospectors were just following a long line of other *vazáha* who came to their forests and extracted "their" resources. This was reflected in the following reaction by Bako:

[54] ANON 27 (March 6, 2006).

> They take everything they want, for example [precious] stones…but they analyze everything they get. What is written in their permit is like a title that they are going to collect plants, but in fact they collect something else after…[t]hey can go everywhere with their permit …these foreigners [researchers] come here because there are lots of things in the forest…there are gold and sapphire…*there are treasures there*.[55]

In Malagasy, the use of the term *misy valeur be ao* "there are treasures there" in this context is particularly significant, because it reflects knowledge of the researchers' mission to extract resources that may be both "unique" and "quite valuable." It also indicates that rural residents are quite aware that their forests are among the richest biodiversity *hotspots* in Madagascar and the world and it is important to control access so that they can begin to benefit from anything extracted.[56] As Mamy, a rural resident in the village reflects:

> The microproject is not compensation given by the researchers for collecting plants; *it is to get the people out of the forest*. We haven't seen the compensation yet [from the researchers]…and it will probably never come. The important people will keep it. That's why I said that it is better that *we* take over the management of the forest.[57]

Similar to other peasant economies, rural Malagasy depend on the forest for a number of livelihood resources. Unlike the southern and eastern regions of Madagascar where forests are used for *tavy* or upland shifting cultivation agriculture (see Chapter 1), forests in the north are providing multiple economic and social benefits including timber for construction, fodder for livestock, fuelwood, charcoal, medicinal plants, and fibers.[58] Furthermore, for many rural Malagasy, forests are particularly important social meeting spaces and many places hold sacred cultural significance (Kull, 2005; Gezon, 2005).

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[55] ANON 27 (March 6, 2006).
[56] ANON 9 (May 12, 2006).
[57] ANON 24 (March 4, 2006).
[58] ANON 86 (June 15, 2006). I conducted a detailed survey of forest resource use by rural Malagasy in the Beforona area for my Master's research in 1999 and 2000 (see Neimark, 2001).

Despite these facts, the many ways Malagasy use the forest are not factored into the design of the microprojects. Rather the microprojects are meant to be “alternative” activities (see Table 5.4) to get Malagasy “out of the forest” altogether. And in the end, keeping rural Malagasy out of their forest for conservation objectives may simply add to the considerable burdens borne by a vulnerable group.

Paradoxically, many rural Malagasy in this area look towards new conservation programs to unlock forest access. However, few actually understood the process of protected area management. Some expressed excitement about the new “protection” of their forests, yet their explanations seemed to express a different interpretation of what protected status actually meant to conservationists. In fact, when I asked local residents to describe “protected areas,” many suggested that their purpose was to set into place “…some sort of control mechanism to exclude ‘outsiders’ looking to extract their resources.”[59] This position of course is in stark contrast to the conservationists’ understanding of protected status, which historically identifies the rural inhabitants themselves as culprits in environmental degradation through daily livelihood practices (Gezon, 2006; Kull, 2004; Peters, 1999) and restricts their access to forest resources (Neumann, 1998).[60]

<u>Bioprospecting and protected areas</u>

Bioprospecting and protected areas are linked in a number of ways. First, the science used to justify the newly designed protected space under the Durban Vision is based on

[59] ANON 24 (March 4, 2006).
[60] ANON 80 (April 14, 2006).

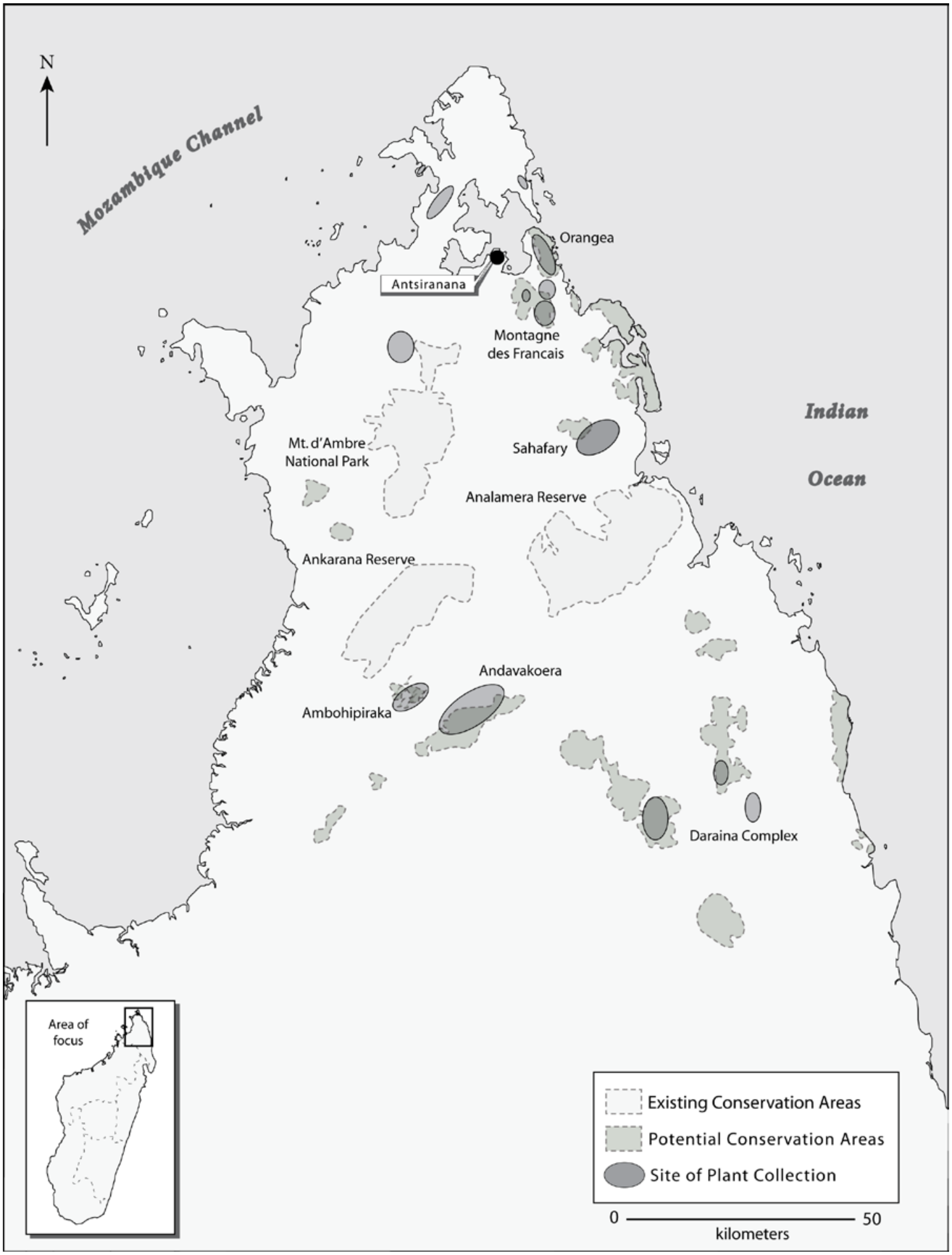
years of scientific inventories of botanical species,[61] mainly systematic and economic botany inventories by member organizations of bioprospecting programs such as the ICBG. Furthermore, floral inventories overlaid on a host of other GIS-data were originally created during botanical expeditions of the NCI and ICBG bioprospecting projects and were GIS mapped during the APAPC-MBG Priority Sites for Plants project. This GIS data was then placed next to other conservation data including CI-GEF 1995 and Birdlife International's Important Bird Areas designation set in 1999, to form a priority site list for conservation under the Durban Vision (Durban, 2005).

Second, two of the primary organizations involved in the ICBG, both MBG and CI, hold prominent positions on the Durban Vision advisory board. This advisory board provides technical data, administrative support and advice for the locating and demarcating of new sites for conservation. And last, many of the rural actors involved in the ICBG project (rural NGOs and associations, mayors, president of the *fokontany*) also act as the "point of contact" for the new SAPM co-management conservation schemes. For example, in the region of Antsiranana, nearly 72,000 ha have already been set aside for protected status under the Durban Vision. This large area of land, located in the Daraina area, is also a significantly important site for bioprospecting collection in the ICBG. The "Daraina complex," as it is known, highlights the overlap that new protected areas and bioprospecting sites share. Some areas in northern Madagascar targeted for collection by the ICBG are also slated for future protection under the Durban Vision, including Orangea and *Montagne des Français*. Other sites of collection, such as Varindirina, Sahafary and Ambohipiraka, have been noted by MBG as having particular ecological

[61] Inventories wildlife resources and geologic composition were also factors in determining priority sites.

and botanical importance warranting serious consideration for conservation (see map 5.2). It is under this conservation rubric that areas in Madagascar which house some of the most unique and biogenetic resources on earth are gazetted for current and future protected area status under national environmental policy. In addition, bioprospectors under the banner of this conservation policy can gain *selective* access to the resources in these sites with relative impunity. This ability to access these protected areas raises questions of the "ethical" component of the projects in these critical sites of extraction.

Map 5.2 Map of existing and potential conservation sites and bioprospecting collection



Moreover, the new protected areas code (*Code de Gestion des Aires Protegees*)[62] does not place legal limits on bioprospecting; nor does it specifically address spatial limits to where bioprospecting may take place. According to a leading authority of ANGAPP (the Malagasy national parks administration), national parks are off-limits to bioprospectors (Secretary General of ANGAPP, pers. communication, 2005; Quansah, 2003). However, associated scientific activities have been conducted in protected areas including national parks in the past (Quansah, 2003; see Map 5.2).

As far as benefit-sharing mechanisms in these areas are concerned, bioprospectors are generally left to write up their own protocols. In effect, these sites are essentially becoming protected extractive reserves, an outcome that has raised concerns all the way up to the highest levels of national office. As one high ranking official in the Malagasy national parks office put it:

What's wrong with bioprospecting in Madagascar is that we don't have any legal framework for this kind of activity. There is no transparency. It's a pity, because in my position I'd have liked more transparency on what's happening inside these protected areas. When I have to make reports, I don't have any clear document to present, and that's not correct. So the problem with bioprospecting right now is this lack of transparency on a general scale. And of course we can go into details and see why transparency is so important and the lack of it in reality!…I was never told there's any type of control, which is a problem since the project is taking place near or within protected areas. This is a problem for me in my position, but also as a Malagasy; it's even worse from the point of view of the citizen, since I'm not sure of what all this bioprospecting would bring for us in terms of benefits.[63]

As the government in Madagascar continues to codify more protected areas under current environmental policy, particularly the newly established protected areas that are tied to

[62] As shown under the *Code de Gestion des Aires Protegees* or COAP - Loi No. 2001/05.
[63] ANON 100 (July 20, 2006).

bioprospecting, there will continue to be calls for more transparent protocols and distributive justice policy. Furthermore, rural livelihoods that conflict with conservation interventions - especially those without any just compensation that are tied to bioprospecting activities - will put current environmental policy to the test.

Much like the privatization measures observed in recent studies looking at neoliberal policy and nature,[64] these "localized" hotspots are targeted by bioprospectors and enclosed as extractive reserves for bioprospecting (see Map 5.2). And even as bioprospectors are provided with *select* access to some of the most valuable resources, both rural Malagasy and participating scientists, many without much knowledge of the benefits of the practice, now must bear many of the burdens of bioprospecting in Madagascar.

Benefits on the cheap: Milestone payments and royalties

Of the different types of benefits that may arise from a bioprospecting project, *royalties* and *milestone payments* are the monetary benefits that have been most analyzed, but least realized (ten Kate and Laird, 2000; 1999). In a bioprospecting project, "milestone" payments are usually generated when significant discoveries are made at successive stages of the research process, whereas "royalties" only come following the full commercialization of a natural product (ten Kate and Laird, 1999; see also Miller, 2007). There have been only a few reported cases where cash payments in the form of royalties were shared by rural actors incorporated into a bioprospecting project (Laird et al., 2002; Lybbert et al., 2002; Barrett and Lybbert, 1999).

[64] In particular, see the essays on neoliberal enclosure within Heynen et al., 2007.

For those involved in the ICBG in Madagascar, if there was a royalty agreement set in place, the rural inhabitants were the last to know. In fact, very few rural Malagasy understood why they might even be entitled to any royalty rights; nor were they knowledgeable about how they would be compensated if these payments were to arise. As expressed by two rural residents in Sabatinava:

Andre: I think it is a good project because of the common benefit. If they will get new drugs from what they have found in the forest, everyone in Madagascar will all benefit from the drugs. And we expect a lot in return.[65]

BN: So, as far as you're concerned, have you received any benefits from those researchers? Money or any kind of help?

Lano: We haven't received any benefit. They just collected the plants, put them in a big bag and they were gone.

BN: So, you haven't received anything?

Lano: Nothing! However, they said that one day, they may be able to make something [drugs] from the plants and that can be our benefit. At least, that's what they said.[66]

Within the three sites investigated, I could not find any rural residents in the surrounding *Montagne des Français* area who have had the ICBG royalty payments explained to them in detail. The only person with any significant knowledge of a monetary benefit scheme was Rokoto, the president of Ambatofaroa:

Rakoto: In my opinion, I think it is an exchange because they collected plants that they would turn into medicine, and then would sell it to get money. Part of the money [they would get when the medicine is made], but I don't know how many percent will be for the villages where they collected the plants. That's how SAGE explained it to me.

BN: Did they tell you what percent?

Rakoto: They didn't tell us the percent of the money that would be for the village. They just said what they gave us is a benefit from the plants they collected, and they [SAGE] would manage the money. [67]

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[65] ANON 32 (March 5, 2006).
[66] ANON 33 (March 6, 2006).
[67] ANON 25 (March 4, 2006).

The gaps in knowledge that rural residents had of these monetary benefits are significant. The benefits that rural residents think potentially can be returned will add to their "buy-in" to the project's goals. If they see the project as a "one-time only" employment opportunity with no prospect for future returns, there is little chance of long-term biodiversity conservation. At this point, when collection from a given rural area is over, unless re-collection is ordered, many in the team will never return to the area.

Nonetheless, contrary to the misconception that the bioprospecting mission is complete, in reality as the material heads to the drug discovery laboratories, the search for a usable drug from the material collected has actually only begun. In this light, the longer-term microprojects are understood as payment to the commune for access to its forests. Would their feelings change if they understood the massive profits that might be had from the discovery of a drug? Very few rural residents seemed to understand that their plants may be valuable, yet if they understood more, would they be more willing to work with the researchers or possibly more resistant? Much remains to be seen. Yet as it stands now, if the ICBG project is keen on telling only those on a need-to-know basis, it may become more difficult to fully articulate its goals of biodiversity conservation and adequate sharing of benefits from drug discovery.

<u>Benefits in a bioprospecting lab</u>

The ICBG was a huge win for CNARP; I am not aware of any commercial products or useful spin-offs from the research, but they got a lot of equipment, not in terms of huge U.S.-pharmaceutical companies, but huge amounts for a Malagasy institution.[68]

[68] ANON 9 (May 12, 2006).

The Centre National d'Applications et des Recherches Pharmaceutiques (CNARP) is a National Research Center (NRC) in Madagascar and is the leading Malagasy institution involved in the ICBG. It acts as the liaison between the Malagasy and foreign partners and ministries.[69] CNARP overall is charged with advancing research and production of health care products, such as phytomedicines, herbal products and essential oils. The institution has been involved in collaborative agreements and contractual projects with many foreign institutions and commercial operations, including pharmaceutical companies, and over the years has received funding from multilateral and bilateral donors, including the United Nations Development Project (UNDP), the World Bank, and the United States Agency for International Development (USAID).[70]

The ICBG is currently the largest and most expansive drug discovery project operating under CNARP auspices. Of CNARP's five departments, three are directly involved in some aspect of research for the ICBG project (i.e., Botany, Chemistry and Pharmacology). And as an NRC, they have the ability to conduct some of the most vital tasks for accessing the thousands of extracts the ICBG desires. Most noteworthy is the procurement of collection permits from the Malagasy government. However, the access CNARP provides to the ICBG results in particular burdens for the laboratory. In fact, although CNARP benefited greatly from the ICBG contracts, these benefits have not come without their own set of costs for the institution and the scientists working there.

[69] Ministry of Scientific Research and Higher Education (MENRS) and the Ministry of the Environment (MINENV) are the two principal government bodies involved in bioprospecting.
[70] CNARP, 1998.

One substantial “benefit” that ICBG members have been able to pinpoint is the biological screening laboratory centered at CNARP. This laboratory has been made possible primarily through financial funds supplied by the ICBG, and partnerships made with Malagasy and other foreign institutions (not included in the ICBG).[71] The laboratory, which screens for bioactivity against malaria, uses techniques that were promoted in a conference located at the ICBG meetings in Panama in 1999. These meetings laid the groundwork for what many in the ICBG see as a practical improvement in equipment and skills for Malagasy scientists. As one of the head Malagasy biologists working in the ICBG mentioned:

> I am now at an advanced level of research. Without the ICBG, I wouldn’t be in the discovery process of new molecules on malaria. In fact, I think we are the only lab like this in this part of Africa.[72]

This department has gained some associated equipment including refrigerators to store and maintain the viability of cell cultures. Furthermore, its techniques of using inflorescence dyes can maintain long-term production using home-grown cell cultures and animal organs for screens. The inflorescence technology, in particular, allows for a more efficient way to detect malaria-infected cultures without the current use of radioactivity.[73] The inflorescence laboratory has been publicized by the leading scientists during a consortium of ICBG projects in 2004, as the highlight of “*South-South technology transfer*” (King, 2004). The small set of scientists that are able to work with this technique are now tapped into a network of knowledge production concerning new

[71] These institutions include the *Centre National de Recherche sur l'Environnement* (CNRE), *Institute de Pauster* (IdP), *Institut Malgache de Recherches Appliqués* (*IMRA*), and research partnerships in France and South Africa.
[72] ANON 15 (April 12, 2006).
[73] ANON 15 (April 12, 2006).

experimentation and technology that may help the therapeutic treatment of malaria - a disease that is within the top three in terms of fatalities in Madagascar.[74]

If anything, the ability to conduct research and screen for bioactivity to combat malaria reflects an important step for Malagasy research scientist. However, not all researchers are able to take part in this highly-publicized campaign. Out of the three biologists at CNARP, only one works on the ICBG project. The biologist is part of a cadre of experts, select individual researchers and scientists, many of whom were trained at Western universities.[75] However, as benefits appear to show fruit, access to technology is increasingly individualized, and fewer scientists are able to tap into the benefits. This dynamic of some scientists benefiting more than others in the project is causing considerable strain on the collaborative relationships that exist at CNARP.

This is not the only means by which Malagasy institutions are collaborating in uneasy territory, however. Pressure by the Malagasy ministries to produce more products that can be commercialized to supplement dwindling State funds has placed many NRC's in a weak negotiating position. CNARP is now obligated to seek out funding from foreign sources looking to access Malagasy nature for commercialization purposes. In this connection, CNARP's involvement in the ICBG might reflect what those in the bioprospecting industry like to refer to as a *win-win* scenario, albeit with benefits flowing

[74] Estimates show that Madagascar overall has seen a cyclic resurgence of malaria, especially in the mid-1980s, when the country witnessed particularly high mortality rates (see Carraz et al., 2006; Lepers et al., 1990). Statistics concerning morbidity and mortality of the worldwide epidemic are startling, with recent estimates by the WHO secretariat showing that in 2000, 803,000 children under the age of five years died of malaria in sub-Saharan Africa. Estimates of the annual number of deaths directly attributable to malaria in the world lie between 1.1 and 1.3 million, most of those in Africa (WHO, 2000).
[75] For more on the role of experts in economic development see Mitchell, 2002.

only to certain departments and select scientists in the institution. However, the "logistical" support for the host may also be understood as self-serving insofar as it clearly serves the interests of the ICBG. A more critical analysis suggests that it is not such a simple *win-win* for CNARP after all, but rather a perpetuation of select access to valued plant material. And although novel discoveries are imagined by scientists, they still face significant challenges against some of the more practical realities of drug discovery. The number of screens that it takes to find novel bioactivity is something along the lines of 1 in every 10,000 at its lowest estimate (ten Kate and Laird, 2000), and this number can go to 1 to 100,000 when one factors in clinical trials. Such calculations seem all the more daunting as the Malagasy partners of the ICBG wait for specific benefits tied to discovery and commercialization to materialize (i.e., monetary payments and royalties). This frustration was expressed to me by the lead administrator on the ICBG in Madagascar:

> To find a drug is utopist. We need new policies, a push for new molecules. We can't as Malagasy partners force them to find new drugs and for us to wait to receive the benefits! Benefits need to be calculated in terms of new molecules, not new drugs.[76]

For most of the Malagasy scientists, the inability to control the later steps in the process of drug discovery due to the lack of materials and the fact that the project is based on the export of the material means that they are left out of the process. With few major breakthroughs so far, feelings of mistrust only intensify. As a signatory in the Ministry of Scientific Research and Higher Education noted:

> Collaboration is not a problem, nor is developing the contract which enhances more capacity building. But if you can't control [the research] a little bit more…and I am not

[76] ANON 10 (Oct. 15, 2005).

talking about just separating compounds in crude extract and then sending them out of the country like we do now, then you are negotiating in a 'blind position.'[77]

This mistrust begins to infuse all aspects of the ICBG and is compounded by the lack of substantive results that sometimes are not reported back through the bureaucratic channels. The lack of reporting and sharing of bioprospecting research results in Madagascar is usually seen as a breach of transparency amongst the U.S. and Malagasy scientists involved, and has led many in the project to question the power relations between the U.S. and Malagasy collaborating institutions and organizations.[78]

Conclusion

In this chapter, I have highlighted some of the tension that exists within spaces of *extractive conservation*, or critical areas that hold some of the most unique and sought after flora and fauna, and are somewhat simultaneously subjected to the most aggressive conservation effects on earth. Ultimately, it is the political and social costs of the match that need to be illustrated and understood. Drawing on Timothy Mitchell's concept of "enframing," I argue that the designation of conservation "hotspots" is both a discursive and material formation constructed by environmental organizations, agencies and experts who have the political power and economic resources to dictate environmental policy.[79] It is this policy that provides bioprospectors *selective* access to Malagasy protected areas. Paradoxically, the discourse of "hotspots," which emphasizes the uniqueness of biodiversity, also facilitates the industrialization of this "nature" for the

[77] ANON 14 (March 2, 2006).
[78] The "un-reporting" of results was cited many times in my interviews to describe the lack of transparency found in providing feedback of scientific data and results from previous bioprospecting screens in the NCI and Phase I of the ICBG. Some scientists and administrators noted that ICBG's methods of reporting results from laboratories in the U.S. are improving, but still complained about a lack of sharing of any results and overall transparency of this aspect of the project.
[79] See Mitchell, 1990.

commercialization of new pharmaceuticals within mass bioprospecting projects. I illustrate some of the key historical and contemporary factors that have led to a perfect matching of interests of hotspot conservation and bioprospecting, and the effects in critical sites of extraction. This process provides the discursive and material structure for both foreign and Malagasy research scientists and pharmaceutical companies to overcome many of the social, spatial and regulatory obstacles in bioprospecting.

The technological innovations in biotechnology and genomics over the past century, and especially since the 1970s, have transformed the drug discovery process. New methods of screening, combinational sequencing and plant tissue culture have greatly enhanced the ability of pharmaceutical firms to utilize rich biogenetic resources, most of which are found in the Third World (Macilwain, 1998). Bronwyn Parry argues that fundamental changes in the collection and production processes of bioprospecting exacerbate uneven development and politicize it on a global scale. This transformation, realized in part through the current shift in the industry towards high-input technologies, is captured by a select few actors involved in the practice and plays itself out spatially through circuits of production/collection, exchange, and manipulation of biogenetic resources (Parry, 2004). Parry's work largely looks at plants and other biological materials that have already been collected and stored in botanical repositories and large-scale laboratories in the U.S. My own research, however, moves beyond Parry's analysis to better understand how technological innovations in bioprospecting over the years have affected those living and working in rural sites of production.

Under the ICBG, the spaces where bioprospecting collection occurs are objectified, traditional knowledge is labeled inefficient, and labor processes are rendered technical and industrialized. These industrialization efforts reveal themselves in a number of ways. First, the ICBG has conducted a wholesale change in its collection methods from ethnobotanically guided to random collecting. This change reflects a shift towards the rational and “scientific” approaches of collecting material. With the use of "random" methods by the ICBG, biogenetic resources are collected in bulk quantities without the use of traditional knowledge and thus skirt the regulations governing benefit-sharing with local healers. Scientists and researchers are able to circumvent many of the barriers of knowledge collection by basically rendering traditional knowledge obsolete. The "shaman" is replaced by an industrial process of bulk assay-ready samples collected by a pool of unskilled laborers. The changes in the practice result in a process that more or less runs mechanically, with the net effect of minimizing the role that Malagasy play altogether.

Second, to overcome the difficulties of botanical collecting in difficult physical settings there have been many advances to build archives of digitized databases of biogenetic material and associated botanical information worldwide. These “global warehouses” are stocked so that scientists and pharmaceutical companies have ready access to the botanical information and material they contain (Parry, 2000). This banking of knowledge and material outside of Madagascar shifts the balance of power and botanical sovereignty away from the country and locality in which it was collected.

Third, there have been concerted efforts to develop a mechanized workforce of modern bioprospectors. However, these workers, rather than advancing science in drug discovery, are rather left to work with outdated equipment and meager resources which have essentially de-skilled the Malagasy scientists placing them on the level of manual laborers. These scientists, who were at one time part of a national initiative to develop drugs from Malagasy nature and traditional knowledge, now perform the most basic bioprospecting tasks to ensure the supply of biogenetic extracts for export.

And, finally, rural livelihood spaces have been enclosed for extraction-oriented conservation projects such as bioprospecting. For example, sites are chosen for bioprospecting to collect biological resources where the diversity of plant and marine species is highest, unique and understudied.[80] Worldwide, the ICBG works in twelve different countries under eight separate biodiversity agreements, with eleven of those twelve countries included under the 2000 designation of Conservation International's 25 biodiversity *hotspots* (Myers et al., 2000). This is by no means a coincidence, as Joshua Rosenthal and Flora Katz of the Fogarty International Center, National Institutes of Health,[81] note: "[T]hese [hotspot] areas are in urgent need of bioinventory and protection…each ICBG addresses the general goals of drug discovery, scientific and economic development, and biodiversity conservation" (2004:458).

In comparison to the two previous case studies in this dissertation, the ICBG is a case study that displays bioprospecting post-CBD and the development of access and benefit-

[80] This crude criterion relates to other sites in the world and in Madagascar.
[81] NIH is the U.S. National coordinating Institution for the ICBG.

sharing protocols. In both of the periwinkle and *prunus* cases, benefits were mostly distributed in the form of monetary payments for the price of the material - roots, leaves or bark. These benefits allowed for actors located on the supply side of the commodity chain (e.g., peasants and collectors) to tap into *some* monetary compensation for their labor, while the larger payouts for drug discovery and production were concentrated in the hands of other downstream actors in the chain. These so-called "process" benefits, once seen as a valuable source of income for many Malagasy peasants, have been offset by the increases in transport costs and other expenses associated with raw material extraction (i.e., post-harvest work).[82] As shown by both the *prunus* and periwinkle studies, the larger industry actors, namely pharmaceutical companies, who are positioned far downstream in the commodity chain, are in a position to continue capturing the value added to the finished product in the face of rising costs.

In sites where the ICBG operates, rural Malagasy were happy to participate in the project and collect some of the process benefits it generated. Furthermore, many were also quite excited that their resources might soon be protected under new conservation interventions associated with bioprospecting. Yet, once again, many did not know of, or understand fully, either the conservation projects or the potential burdens that might soon materialize in terms of restricted access to their livelihood resources. This collective ignorance questions the level of Malagasy decision making in bioprospecting activities and overall participation in the practice in Madagascar overall.

[82] For more on "process" benefits, see Laird et al., 2000.

In the case study of the ICBG, there is not yet a commercialized product, and benefits are outlined within a pre-determined bioprospecting contract signed by all organizations and institutions involved. In this context, “upfront” benefits are distributed first on the basis of one’s involvement in the particular projects, groups or organizations, and second on the basis of one’s professional expertise. For example, some Malagasy research scientists are able to tap into scientific benefits in the form of technology (equipment and materials) and knowledge (plant databases, trainings) now available to them through their participation in the project. However, to overcome shortfalls in research funding, Malagasy research institutes are now pressured to contract with larger multi-partner bioprospecting projects that are much better equipped and can provide them with needed resources. Two of the most important services that the national research institutions provide to the ICBG are the facilitation of collection permits by the Malagasy government, and the transformation and exporting of thousands of extracts to laboratories in the U.S.

A critical view of this collaboration might characterize the Malagasy research institutions as providing their services and access to their biodiversity to foreign laboratories in lieu of conducting their own drug discovery research. This collaboration has resulted in some strong critiques on the part of some Malagasy scientists and administrators towards researchers both involved in the ICBG and closely affiliated with it. These critiques have charged ICBG collaborations the selling off Malagasy resources for no significant beneficial return. They have questioned whether Malagasy research intuitions and agencies are effectively fulfilling their role as suitable “gatekeepers” of Malagasy natural resources. They have suggested, in effect, that these institutions have taken on a more subordinate role as “facilitators” of access to the country’s unique flora and fauna rather than assume their rightful place as true partners in the bioprospecting enterprise.

In sum, my results document how bioprospecting has changed over time in terms of technology, laws of access and the actors involved. Significant shifts in bioprospecting have led to the overall industrialization of the practice via attempts to disengage with traditional knowledge and benefit-sharing with individuals. In the process, some of the more powerful foreign and Malagasy actors in the commodity chain have been able to build social networks and maintain the political relations needed to control the flow of biogenetic resources, and the scientific and monetary benefits that derive from them.

Chapter 6

Conclusion

Throughout this dissertation, I have sought to develop five main arguments.
The first focuses on the coincidence of extraction and conservation with the same zones of exceptional biodiversity in Madagascar. The second explores competing theories of accessing, and controlling natural resources. The third incorporates peasant studies theory to analyze the natural barriers to the full capitalist transformation of bioprospecting programs. The fourth pertains to new forms of environmental governance and their implications for the bioprospecting commodity chain. And the last deals with the issues and concerns of distributive justice. I will address each of these themes in turn by way of the following conclusions.

Hotspots and "extractive" conservation

In the introduction of this study, I explained why Madagascar is an ideal site to study bioprospecting. Madagascar's unique biodiversity has, over the years, sparked the interest of bioprospectors seeking to discover drugs from nature; it has also drawn considerable attention from conservationists, so much so that it has been selected as one of the "hottest hotspots" in terms of its conservation priority. This conservation imperative is reflected in the national policies of President Marc Ravalomana's "Durban Vision," and in economic development programs such as the Madagascar Action Plans (MAP) which propose to triple the amount of protected area on the island. These new economic and environmental policies reflect an overall shift away from Madagascar's long history of economic stagnation and isolationism, and towards neoliberal reforms. The reforms have effectively loosened constraints on the commercialization of natural resources for some while at the same time potentially restricting access to the same resources for others. This convergence of bioprospecting and conservation provided an ideal venue to study the tension that exists in rural spaces which are designated for protection and also targeted for extraction.

Drawing on the "chain of explanation" approach which provided a foundational theory in political ecology,[1] I was able to observe in my research how historical and contemporary bioprospecting interventions are embedded within the larger political economy in Madagascar. For example, environmental NGOs and their commercial partners have become the major power brokers in commercially-based conservation and development schemes in Madagascar. These organizations, which have become increasingly visible in recent years, control and in some ways, regulate access to some of the most critical sites of biodiversity.[2] These groups are equipped with financial, human, and technological capital and direct a cadre of Malagasy and foreign experts who implement the national environmental policy. This *environmental industry* in Madagascar has been able, through a mixture of techno-science, lobbying and brute force, to make conservation and development schemes such as bioprospecting a reality.

The uneven development trajectory of conservation and development schemes are particularly highlighted in both the *prunus* and ICBG chapters where, under the hotspot

[1] See Blaikie and Brookfield, 1987; Blaikie, 1987; Watts, 1983.
[2] See also Li, 2005; Agrawal, 2005; Mitchell, 1991.

conservation rubric, critical sites of remaining stocks of *prunus* and areas of unique and endemic plant biodiversity are now simultaneously demarcated for protection and, paradoxically, designated as sites for current and future extraction. Bioprospectors are now able, through large-scale conservation interventions and the designation of newly demarcated protected areas, to access the space, labor and resources necessary to sustain their efforts to extract wealth form nature (Katz, 1998; Neumann and Schroeder, 1995; Smith, 1984).

The study also offers key insights into some of the ethical issues of bioprospecting in rural sites where livelihood struggles and conservation interventions coexist. For example, it has been argued that conservation interventions often entail substantial opportunity costs for people in marginal areas (Laird et al., 2000; Dorsey, 1999), some unintended (Brechin et al., 2003; Brandon et al., 1998; West and Brechin, 1991). Moreover, conservation actors often have little experience with the historical and social relations of the places where their policies and interventions are enacted and may misrepresent the social, historical, cultural and political landscapes where they work (Gezon, 2006; Belsky, 2000; Neumann, 1998; Ribot, 1998; Fairhead and Leach. 1996; Dove 1993). Such ethical issues are very apparent in Madagascar, where bioprospecting is conducted in some of the most economically poor, but biodiversity rich, areas of the world. In all three case studies, I observed the effects of larger economic, environmental and social policies on rural producers and inhabitants. For example, many of those who participated in bioprospecting under the ICBG were excited to receive some of the benefits in the form of a daily wage or the implementation of rural development project, yet most were ill-informed about both the project's drug discovery mission and the goals of parallel conservation efforts; and very few had any idea at all about the prospect of any long-term benefits coming to them. The few rural inhabitants who did know of the project had a fairly optimistic view of the plan to create new protected areas of the local forests. But this was because they mistakenly believed that "protected areas" meant that they had the control to restrict access to foreign extractors or negotiate "equitable" compensation in return for extraction, all the while maintaining the ability to use livelihood resources. This control of forest resource access, for which rural inhabitants yearn, has yet to be clearly articulated in the bioprospector's conservation schemes. The generalized lack of awareness of many rural Malagasy of the bioprospecting mission's goals raises a number of questions regarding the ethics of extraction in these critical sites of production in Madagascar. Clearly no "informed consent" exists under these circumstances.

Theories of access and access mapping

The three case studies in this dissertation illustrate different approaches to the regulation of biogenetic resources. The periwinkle and *prunus* case studies represent conditions prior to the implementation of access and benefits sharing protocols under the CBD while the ICBG initiatives took place after the CBD. The term "access" in this context implies the granting of legal consent by host governments to collaborating scientists and participating citizens to begin collecting biogenetic material and associated traditional knowledge. It also implies that some sort of consent would be received in return.

In the dissertation, I move beyond the CBD's standard use of the term to describe how foreign and Malagasy scientists and companies use a number of both legal and extra-legal means to gain, control and maintain the flow of biogenetic resources for use in drug discovery and development. For example, bioprospectors used their economic and political capital to obtain permits and collection licenses to access plant material even in the most remote and sometimes restricted areas in Madagascar. Bioprospectors also employed a variety of extra-legal means to gain consent to access the plant material, including the use of economic incentives subsidizing rural development projects and providing cash payments to regional communes and villages.

To navigate the complexity of access dynamics of bioprospecting in Madagascar, I used the methodological approach developed by political ecologists, Jesse Ribot and Nancy Peluso (2003), called "access mapping." There are some advantages and disadvantages to this approach. First, access mapping puts a strong emphasis on identifying who specifically is included and excluded in capturing and controlling benefits and burdens that arise along a commodity chain. The particular focus on the social, political and economic relations provides a clearer understanding of the power dynamics that exist between institutions and individuals and shows how benefits are captured and burdens shared. The approach's primary focus on the social and economic relations of the commodity chain is also vital to demonstrate how labor is valued and appropriated. Although labor relations were a factor in all three of my case studies, they were particularly highlighted in the periwinkle study, where Malagasy labor was sought after by exporting firms at all levels of the commodity chain (harvesters, middlemen, transporters, etc.) to enable access to tons of the plant material for drug development as cheaply as possible.

Access mapping does have its shortcomings, however. The attention paid to the political, economic and social relations leaves out the important and often overlooked biophysical interactions of “natural” commodities. Unlike more traditional goods commonly analyzed in the commodity chain literature (e.g., the garment, automobile and footwear industries), natural commodities hold particular constraints in their production, which must be accounted for when tracing the political economy of their extraction. As Peluso and Watts note, it is in fact the “different properties and commodity characteristics” that shape the processes according to which labor and value are appropriated for the purposes of wealth extraction from nature (2001:26).

To effectively theorize the production regimes of contemporary bioprospecting initiatives, I carefully accounted for both the biophysical and social characteristics that help shape the "processes of transformation" and "societal relations of production" of natural commodities (Peluso and Watts, 2001). Addressing these relations head on allowed for a fuller theorization of environmental justice, moral and political economies surrounding bioprospecting extraction, and the methodological applicability of access mapping for this project overall.

Industrialization of "nature”

In the three case studies found in the dissertation, I traced the changes in the practice of bioprospecting over a 50 year period. In the studies of periwinkle and *prunus,* I analyzed the political economy of fully developed commodity chains. In contrast to these two studies, the third case study of the ICBG displayed a commodity chain in the making. The ICBG case study is not yet structured around a definite commodity per se, but rather is focused on the collection of unspecified plant material and the search for biochemical knowledge embedded within them.

There are explicit insights that can be gained from the comparison of the three case studies. Empirical data from my work points to increasing efforts by bioprospectors to "industrialize" the overall process of drug discovery from nature (Parry, 2004; 2000). This move towards a more mechanized and rationalized process, both spatially and economically, can be explained by the many attempts to control the “natural” and social barriers that impede production, and to overcome the place-based conditions of production (Mann and Dickenson, 1978: Goodman and Watts, 1997; Kloppenburg, 1988; Goodman, et al., 1987). For example, the massive financial inputs invested into random access methods and high speed screening clearly express the industry’s overall goals of limiting the dependency on nature and relying on more mechanized means of production. These goals are also observed in the industry’s efforts to synthesize the compounds responsible for bioactivity or to mass produce the natural product in cultivated systems - both attempts at ensuring a steady supply of the material without having to travel to distant locations to collect it, or without navigating harsh tropical climates and environments. Furthermore, the adoption in the drug discovery industry of computer derived molecules using combinatory chemistry or "combichem" may be characterized as the latest industry attempt at triumphing over nature (see Chapter 2; see also Parry, 2004).

Rather than the full industrialization of the process, however, my analysis has highlighted countervailing instances where "nature" still holds sway. For example, contemporary bioprospectors are observed in the hunt for the unique and endemic biodiversity in Madagascar because it is thought to hold the best chances for bioactivity. Furthermore, researchers and extraction companies continue to seek out *prunus* “in the wild,” and have returned to Madagascar where it is cheaper to cultivate and collect periwinkle in bulk, an unavoidable step given that each plant only carries an infinitesimally small amounts of active ingredient.

Results show that scientists and bioprospecting firms overcome these “natural” obstacles primarily by gaining and maintaining control over rural labor, negotiating access to endangered forests, and alienating thousands of plant specimens from their places of origin. This is explicitly seen in the ICBG’s shift from collection based on place-based traditional knowledge towards rational collection, the de-skilling of the Malagasy labor force including bench scientists, and creating global storehouses of botanical knowledge, all of which are efforts used to speed up the production process and place it more firmly under industrialized control.

In some ways, this is analogous to what many scholars have for some time been observing within agro-food production systems (Goodman and Watts, 1997), plant breeding and biotechnology (Kloppenburg, 2004; Goodman, et al., 1987), and industrial outsourcing (Watts and Goodman, 1997). A major theme running across these studies is the ability of capital to reorganize and divide labor to coincide with production needs (Goodman and Watts, 1997; Goodman, et al., 1987). Capital seeks to control peasant labor in particular so as to avoid costs associated with particular factors of production, such as the natural barriers found in agriculture (Mann and Dickenson, 1978). My hope is that the particular empirical observations made in this dissertation will inform larger theory across disciplines, especially for those looking at intersections between the changes in agrarian production systems and capitalist expansion into rural areas.

Regulation and re-shaping of the commodity chain

With the emergence of global environmental governance over the past three decades, increasing pressure has been placed on the Malagasy state to comply with international regulatory agreements and maintain a better record of stewardship over its unique resources. Two of these agreements, namely CITES and the CBD, have had varying influence on the bioprospecting industry’s collecting practices, and in particular on the structure of the pharmaceutical commodity chain. For example, in the *prunus* study, extractors have had to conform to the demands of both the national and international CITES regulators. This regulation has translated into a whole-scale re-shaping of the commodity chain. As CITES first took effect in the mid-1990s, control of the industry became consolidated into just a few firms as many collection and processing firms dropped out or went underground. Since the 2002 injunction on collecting, there has been a notable restructuring of labor from "permanent" workers towards a more flexible labor force (Goodman and Watts, 1997).

By a similar token protocols developed by the CBD have profoundly shaped the way bioprospectors collect plants and set up contracts in the countries in which they work. The ICBG, for example, represents itself as a "model project" that looks to increase participation in biodiversity conservation through systematic resource valuation and commercial income generation, while making improvements to human health through the discovery of new natural products. In pursuing these goals, bioprospectors have set up large collaborative projects that involve a consortium of public and private partner institutions and organizations. Each has a specific role to play in the project, while also complying with CBD protocols. An example is the partnership between the ICBG and Conservation International, a large-scale environmental NGO. While the ICBG goes about the business of drug discovery, the conservation organization delivers on the conservation and development objectives through small-scale microdevelopment projects (cf. West, 2006).

In contrast to the successful integration of the ICBG and its member organizations, however, attempts at incorporating Malagasy at the rural level into the ICBG's bioprospecting efforts have been mixed. Whole some short-term monetary benefits are captured by guides, porters and cooks who work for the collection teams, most of the benefits which surface in the form of the conservation and development microprojects are distributed unevenly across Madagascar and end up serving the interests of only a handful of locally elected officials and customary authorities.

In sum, if the purpose of regulation within *prunus* extraction and contemporary bioprospecting is to bring more Malagasy into the projects activities and to encourage conservation stewardship through resource valuation and income generation, paradoxically we observe the opposite effect. For example, in the periwinkle study, many of the firms that operate outside the guidelines of the CBD or CITES have relatively high levels of Malagasy participation, including the incorporation of thousands of midlevel collectors and peasant harvesters. This participation stands in stark contrast to both *prunus*, where the number of rural actors and firms involved is declining sharply, and the ICBG, where there is an overall thinning out of participation at the rural, institutional and scientific levels. Overall, the lack of participation in the *prunus* commodity chain and the ICBG project, begs the question of whether the CBD or CITES can deliver on promises to share benefits and conserve resources used by their intended target populations.

Moving beyond "biopiracy" towards more distributive and procedural justice

Critics of bioprospecting have questioned whether the benefits returned to host-country scientists and rural inhabitants are fair compensation for their natural resources and associated traditional knowledge (ETC, 2004; Shiva, 1987). They claim that given the history of "biopiracy" to which many of the countries involved in bioprospecting projects have been subjected in the past, extra effort must be made to ensure equitable benefits are being returned (Laird et al., 2002). However, up to this point, the framework for "equitable" compensation is quite problematic. For example, questions remain as to the "real" value of biogenetic resource and traditional knowledge in economic terms (Simpson, 2002; Rausser and Small, 2000; Simpson et al., 1996). Furthermore, as demonstrated in chapter 3 there are numerous geographic constraints on the return of benefits. For example, whenever resources span across national borders, neither country finds it easy to advance claims under benefit-sharing agreements (Laird et al., 2000; see also Global Exchange, 2001). In other instances, national governments have not been accountable to those living near the resources or those supplying the traditional knowledge of its use (Laird et al., 2002).

As results in this dissertation show, bioprospectors have attempted to make a connection between the extraction of biogenetic resources, benefit-sharing and long-term conservation. My research demonstrates, however, that many rural Malagasy are either ill-informed about benefits and associated conservation projects or displeased with the outcome of the projects delivered. If bioprospectors want to have the desired effect of delivering on conservation goals, project participants must spend significantly more time at the sites where collection takes place, find ways to inform rural inhabitants about possible benefits of their research activities, and devise ways that enable more inhabitants to participate in sharing some of the available "process" benefits that arise from bioprospecting (i.e., working as porters, and as guides; see Chapter 5). Furthermore, the choice of conservation projects must occur in the context of a more democratic process, with input from inhabitants who are potentially most affected by the projects themselves.

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