

Developments in Primatology: Progress and Prospects
Series Editor: Louise Barrett

Laura K. Marsh
Colin A. Chapman *Editors*

Primates in Fragments

Complexity and Resilience

 Springer

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Laura K. Marsh • Colin A. Chapman
Editors

Primates in Fragments

Complexity and Resilience

 Springer

Editors

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To JMF, because you keep
on believing in me.

Laura K. Marsh

To all of those individuals who
have dedicated their time and energy to
conservation.

Colin A. Chapman

Foreword

Modern attention to habitat fragmentation and its implications for conservation and science really grew from the theory of island biogeography after it emerged in the late 1960s when many of today's senior scientists were schoolchildren. I vividly recall seeing a copy of MacArthur and Wilson's 1867 book when it arrived for the first time in the Amazon where I was doing my dissertation field work. It ignited a burst of research and by early in the subsequent decade, application of island biogeography to actual island faunas quickly raised implications for the island analogs of forest fragments.

Initially the question that was sweeping in scale, namely, what was better for conservation a single (S) large (L) reserve or (O) several (S) small (S) ones of equal total area (the famous SLOSS debate). While studies on animals with extensive home ranges certainly implied that large areas were important, the debate raged as only one can in the absence of direct data. It led my Brazilian colleagues and me to initiate the forest fragments project in the late 1970s in collaboration with Brazil's National Institute for Amazon Research (Instituto Nacional de Pesquisas da Amazonia; INPA) north of Manaus. An ongoing project in its 34th year, it has shed lots of insights on the important and complex consequences of fragmentation.

In retrospect it is interesting how little appreciated fragmentation was as a major factor in the way humans affect nature, even though fragmentation is close to ubiquitous as the handmaiden to habitat destruction. Surely scientists and naturalists observed some of the effects without necessarily attributing them to fragmentation, but I think it is fair to say that virtually nobody detected the seriousness of its impact is on biodiversity.

Primates, along with birds and woody plants, were and are an obvious group to study to illuminate the consequences of fragmentation. Thinking back on the Manaus project, at a coarse level some of the results were predictable from what is known of diet and home ranges. From that perspective howler monkeys and saki monkeys should (and did) do very well even in 10 ha fragments, while spider monkeys with their 600 ha home ranges found even 100 ha fragments untenable. But those were the simple results; whereas, the biology of the actual animals themselves was affected in more complex ways.

Now, of course, much more is known, both in particular and in general, about habitat fragmentation and primate biology, and this volume makes a significant contribution by assembling professionals from throughout the tropics. Indeed it is notable that this is the second such volume. The first appeared in 2003 also edited by Laura Marsh. Together they are testament to the complexity and richness of the subject of primates and habitat fragmentation and most intriguingly, to how this science has grown and changed over the last three to four decades.

The studies in this volume span the continents where primates are found, and it is clear that the topic is rich and complex. Beyond fragment size, factors of importance include the degree of isolation from other primate populations, the cause of the fragmentation, the type of the intervening habitat (the “matrix”) within which the fragments occur (and their spatial configuration), and of course, the other human stresses (like hunting) which are often involved. Disease is an important factor both in terms of wildlife diseases spilling over into human populations, as well as in human diseases and parasites affecting the isolated primate populations. The summary chapter makes the richness and the complexity of the topic of this volume quite clear.

It is encouraging to see the growing understanding of the art and science of restoration of connectivity between fragments in landscapes. While such efforts may seem like just individual efforts here and there (such as in golden lion tamarin habitat in the Atlantic Forests of Brazil), they should be seen as just the first halting—although very important—steps of a much more extensive ecosystem restoration to come. Indeed, it is my fervent hope that this volume will be succeeded by a third one, in which ecosystem restoration research and action are central.

An era characterized by a wave of restoration across the face of the planet is essential for the future of primates and biodiversity and, for that matter, the management of the planet as the living planet that it is. That will be no simple task—no matter of simply standing back and just letting nature recover. Grand and important as restoration at scale is, it will in the end consist of a tremendous amount of detail based on the kind of growing understanding of the complexities of “fragmentation ecology and biology” of the sort these volumes so superbly examine and illustrate. A thriving science of primates and habitat fragmentation is essential to restoration and sustainable development in the tropical forest regions of the world.

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Preface

Ten years ago when I put together the first *Primates in Fragments* book, I had great hope for the business of damaged habitats. Even as I was initially gathering the chapters for this second volume—calling in the experts and seeking new authors—I was sure the story we would tell would be one of promise: that somehow our combined efforts over the last decade had made a difference to the lives of primates around the world. Don't get me wrong, in many ways I believe we did have an impact: one of awareness, if nothing else, that Fragmentation Science is its own discipline and that primates that experience these landscapes have a different skill set than those that live in continuous habitat.

The first volume, subtitled “Ecology and Conservation,” was meant to show promise and movement in the field. This volume, “Complexity and Resilience,” is meant to show our maturity in the field. We know there are issues that primates and the people who live with them face. We know there are challenges to conservation and the study of these animals. We also know both primates and people are managing in many cases in very bleak circumstances. Every decade brings a new host of stories about primates in fragments that we are eager to tell, as many species' very existence depends upon us paying attention to them, even in the worst of habitats.

Compared to the first *Primates in Fragments*, where we had 51 authors from 10 countries and 4 sections with 21 chapters, we have 104 authors from 23 countries and 7 sections with 34 chapters in this volume. In the first volume, there was only one chapter on genetics, seven on population dynamics, seven on behavioral ecology, and five on conservation and management. In this volume we branch out. We had far more genetics chapters than we could include, but settled on six that discuss not only advances in genetic work on primates in disturbed habitats, but also diseases and parasites. New to this volume are the Long-Term and Regional Studies and Endemic, Endangered, and Nocturnal sections. The latter is of particular relevance since it is likely in the next decade, we will see more and more chapters on endangered primates in fragmented landscapes. Several things have become clear in the last 10 years: more people are studying primates in damaged habitats, more people acknowledge fragmentation as distinct science, and more people have a concern for them.

No collected work is ever perfect, and we certainly have some holes. For one, we do not have any chapters on apes this time, and in the section on long-term studies some obvious sites are missing. But unlike the introductory nature of the first volume, we go deeper in this volume into topics like climate change, disease, and survivability. This time, it starts and ends with conservation because without a collective focus on habitat loss in general and how best to mitigate it, our forest-dwelling primate species are doomed.

I am grateful that the first *Primates in Fragments* has had over 500 citations for all of the chapters combined, has been used by universities and classes as a text book, and has been a go-to reference for students all over the world. And I am even more grateful that the first volume will be available electronically with this one, so that even more people can get a good, inexpensive resource that can be made available in even the remotest campuses.

When I was 18, I was standing in a rainforest before I ever knew what one was. In high school in southern California, our biology texts had a final chapter in them called “Environment.” It in part had two paragraphs and one photo on each of the major biomes—including rainforest—and a paragraph about conservation. We never got to that chapter. I always wanted to read the texts that started with environment as a cohesive unit, or that started with conservation. Now we have two excellent volumes where students can be informed about the current tropical landscape. It is my hope to everyone reading about forest fragments for the first time that you understand what you are getting into before you are standing in one.

I have to thank all of the contributing authors and especially my co-editor Colin A. Chapman without whom we would not have this finished book. He very consistently and enthusiastically nudged me to keep going on it and helped mightily with the editing of individual chapters.

We are also two of the first in the new generation of authors and editors of primate books to put our money where we say our conscience lies: both Colin and I will donate all of our personal proceeds from the sale of this book to the International Primatological Society’s Conservation Fund. We challenge other authors in our field to do the same.

Santa Fe, NM, USA

Laura K. Marsh

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Section I

Introduction

Chapter 1

Because Conservation Counts: Primates and Fragmentation

Laura K. Marsh

Introduction

Books about wild primates are plagued with opening paragraphs about rates of deforestation. There are new estimates of forest loss popping up all of the time, making the “real” determination of forest coverage difficult to effectively interpret. However, it is increasingly clear that these rates mean a variety of things pending the definitions used. When primatologists speak of fragmentation, we typically mean forest within the tropical dry to humid biome and the resultant fragmentation–matrix combinations that dominate tropical landscapes. Seemingly simple enough, but Lund (2008) found more than 800 different definitions for forests and wooded areas in use around the world, with some countries adopting several definitions for the same patch of land. Thus, instead of beginning with the various predictions of loss, a closer look at what remains is worthwhile.

Closed Forests

Closed forest is not synonymous with continuous forest (c.f., Marsh et al., this volume, Chap. 34). The United Nations Environment Programme/Food and Agriculture Organization (UNEP/FAO) defined closed canopy forest (all forests, not just tropical) as forest that has at least 40 % of its canopy interlocking (UNEP 2001). According to their report as of 1995, 21 % of land in the world contained closed forests with 81 % found in 15 countries, 12 of those tropical, with Russia, Canada, and Brazil containing 49 % of all closed forests. In 2006, the UNEP used this definition for forests: 10 % of canopy interlocking with a 0.5 ha minimum land cover, and

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a minimum tree height of 5 m (FAO 2006)—a definition that clearly includes fragments. However, for any country reporting per the Kyoto Protocol (starting in 2005), there is a sliding scale for values: 0.01–1.0 ha for minimum area, 2–5 m for minimum tree height, and 10–30 % for minimum crown cover. Whereas the FAO maintains true “closed forest” as 40 % crown cover, forest with 10–40 % is considered either open or closed, depending on the connectivity. In general, the UNEP/FAO does not take into account agroecosystems or mono-cropped forests, which can be important to primates living within or in proximity to these systems (Marsh 2003a).

The percentage of forests that are actively being protected varies greatly by country, and even report. Only 9 % of all global closed forests have been accorded some sort of protection (FAO 2001). Venezuela is the highest with 62 % of its forests under federal protection. Other countries with comparatively higher amounts of protected forests are: Bolivia (29 %), Colombia (25 %), Indonesia (20 %), Brazil (17 %), and India (12 %). At the lower end of the scale is the Democratic Republic of Congo with 9 % and the USA at 7 %. Although not tropical, the USA is far worse at protecting forest resources than many countries in the tropics (FAO 2001). Almost more important than simple percentages of forest protected is the human pressures on the environment. For instance, India has 12 % of its forests under protection, but has 2,697 people per hectare nationwide versus the DR Congo with only 9 % of its closed forests protected and only 160 people/ha (FAO 2001). These numbers have of course increased in the last decade, but are staggering regardless.

In general, the world’s closed forests have survived because: (1) particular areas are economically not worth exploiting as they lack sufficient quality or quantity of commercially valuable species, (2) particular areas are located in remote or inaccessible areas, (3) particular areas have been protected as national parks and sanctuaries, (4) the forest is valued over below-ground resources, and/or (5) there is a local community willing to protect the area for heritage rights, religious reasons, ecotourism, or by law. All of these vary depending on the cultures and governments in power. All habitats are negotiable in terms of use for profit or development, and their fate rests on politics. Furthermore, studies are now showing that even these fundamental reasons for forests to remain standing are increasingly under threat (Evans et al. 2012).

The rapid destruction of tropical forests imperils global biodiversity more than any other contemporary phenomenon. Laurance et al. (2012) reviewed 60 protected areas throughout the tropics to determine their functionality in terms of “ecosystem health” and their ability to maintain the biodiversity they were set up to preserve. They concluded that about half were meeting the needs of the species within their boundaries, but that the other half were “experiencing an erosion of biodiversity that is often alarmingly widespread taxonomically and functionally.” The primary culprits are familiar to those working in fragmented forest regions: habitat disruption, hunting, and forest product exploitation. These were the strongest predictors of declining reserve health. Changes inside reserves strongly mirrored effects taking place in the surrounding matrix, so much so, the authors suggested that the fates of the protected forests were intimately tied to the surrounding habitat. The best way to prevent further loss of species within protected areas is to develop effective buffer zones, something that has been proposed repeatedly since the 1980s (c.f., Marsh

2003b). Understanding what forest remains, whether closed, open, fragmented, continuous, or protected, helps us determine how to improve conservation such that cumulative effects do not continue to undermine our efforts.

Cumulative Effects

Those who work in tropical fragmented ecosystems can easily cite the ever-expanding litany of disturbances that impact not only the remaining primate habitat but also humans within the matrix. Effects like logging, non-timber forest product harvesting, fires, hunting (for subsistence), bushmeat (for market sales), roads, oil exploration and extraction, land tenure disputes, poverty, war, hydroelectric dams, pet and trophy trade (e.g., freshwater fish, butterflies, and orchids, especially), poaching for medicinal use (plant and animal), “pest” extermination (e.g., crop raiders), firewood gathering, charcoal, tourism, small- and large-scale mining, agriculture, and ranching all amplify each other. Rarely does one impact occur without a ripple of multiple disturbances.

An example of both cumulative deforestation effects and the success or failure of protected areas within a complex agroecological matrix is a new study that quantifies across South America’s biodiversity hot spots’ indirect impacts on deforestation from coca cultivation for the global cocaine market. Davalos et al. (2011) studied coca cultivation regions in the southern Colombian Andes, Choco, and Amazon between 2002 and 2007. The authors conducted landscape-level analyses of forest conversion and revealed that forest with proximity to newly developed coca plots, and thus a greater proportion of an area planted with coca, increased the probability of forest loss. The principal reason was the rural population’s additional use of forest products in the remaining non-protected forest: “Neither eradication nor coca cultivation predicted deforestation rates across municipalities. Instead, the presence of new coca cultivation was an indicator of municipalities, where the increasing population led to higher deforestation rates.” Conversely, the authors showed that designating protected areas successfully reduced forest conversion of those plots in coca-growing regions. They concluded, like in all regions throughout the tropics where poverty demands are higher than forest protection, that the manner in which a rural population is developed makes all of the difference. They maintained that conservation in Colombia’s vast forest frontier, which overlaps with its coca frontier, requires a mix of protected areas and strategic rural development on the front-end to succeed (Davalos et al. 2011). In terms of primate conservation, some of our efforts are best used toward understanding the cumulative drivers to deforestation and working at a management level with the people on a landscape scale, rather than only on understanding the remaining forest.

While illegal drug growers in Colombia are respecting protected areas, indigenous people living within critically endangered primate habitat in Madagascar, a country where 90 % of its forest has been lost, are not. In another case of “hidden” effects, bushmeat hunting is on the rise in Madagascar—even in regions where the lemurs were respected under tribal consumption taboos or “fadys” (Jenkins et al. 2011).

Jenkins et al. (2011) suggest that hunting of protected species in eastern Madagascar is “increasing due to rapid social change as appetites for meat increases and traditional taboos protecting the species, especially lemurs, become less powerful.” The authors observed that young men in particular have more available cash and leisure time due to the transition from subsistence farming to panning for gold. As a result, they spend more time than ever before in bars eating fried meat snacks with their drinks. Lemur hunting appears to have increased to supply this new market even among those who cite their knowledge of fadys on *Indri*, for instance. According to the authors, “The power of the taboo is declining under pressures of globalization and human mobility.” Cumulative insults like these can amass over time into what is now being described as creeping environmental changes.

Creeping Environmental Changes

There are a growing number of researchers working in the field of creeping environmental changes, in particular with regard to global diplomacy (<http://www.disasterdiplomacy.org/cep.html>), which in turn impacts environmental conservation. Glantz (1994, 1999) and Kelman (2006) defined creeping environmental changes as incremental changes in conditions which accumulate to create a major catastrophe or crisis, that are apparent only after a threshold has been crossed. Such as changes that significantly impact all spatial scales, frequently crossing borders, making them useful cases for disaster diplomacy. These are human interactions with the natural environment that have a slow onset, advance incrementally, and eventually pass a threshold that quickly leads to changes in the environment, and then ultimately, to society. The ones most familiar to primatologists are tropical deforestation, biodiversity loss, and climate change, but others include acid rain, stratospheric ozone depletion, desertification, mangrove destruction, soil erosion, water pollution, overfishing, coral bleaching, and more localized impacts, such as groundwater contamination by leaky landfills (FAO 2012). All of these began as something simple to manage and were correctable in the small scale, but can expand to be encompassing and cumulative if left unattended.

Socioeconomic drivers are some of the most insidious underlying reasons for habitat degradation (FAO 2012). Critical socioeconomic factors outlined by the United Nations Intergovernmental Forum on Forests include (1) poverty, (2) lack of secure land tenure patterns, (3) inadequate recognition within national laws, and jurisdiction of the rights and needs of forest-dependent indigenous and local communities, (4) inadequate cross-sectoral policies, (5) undervaluation of forest products and ecosystem services, (6) lack of participation, (7) lack of good governance, (8) absence of a supportive economic climate that facilitates sustainable forest management, (9) illegal trade, (10) lack of capacity, (11) lack of an enabling environment at both national and international levels, and (12) national policies that distort markets and encourage the conversion of forest land to other uses (IFF 2000). Understanding the baselines that have layered creeping and compounding environmental issues may help us to better plan for the future of primates living in fragments.

Early intervention on any one of the environmental issues would avoid expensive local and global environmental and social costs in the long run. In regions where deforestation has taken costly tolls on a government, say from excessive flooding of downhill towns (e.g., Catemaco, Mexico hill deforestation for tobacco, pers. obs.), it might be possible to convince policymakers and stakeholders to work toward front-end interventions with the goal of not saving habitat, but of saving the local economy from having to backtrack to correct outcomes if these changes are left unmanaged. Action is not likely to be taken unless scientists can make a clear connection between a particular change and an important consequence of this change (FAO 2012). The challenge then for primatologists working in disturbed habitats is to collaborate with country professionals and officials to mitigate and identify potential future changes and underlying socioeconomic issues before they impact primates and the people living with them.

Global Carbon

We discuss in the final chapter climate change as a landscape-level impact to primates. But what about global carbon specifically as it relates to primate conservation? Tropical deforestation is finally getting more attention with respect to global carbon emissions; however, results are conflicting (Drake et al. 2003; Harris et al. 2012). Baccini et al. (2012) determined that deforestation contributed up to 6–17 % of carbon dioxide emissions, and that 229 billion tons of carbon are currently stored in standing rainforest. These authors found that forests in the Americas stored about 51 %, Africa 28 %, and Asia 20 % and that net emissions from deforestation from 2000 through 2010 amounted to 1.14 billion tons of carbon per year, suggesting that deforestation accounted for roughly 13 % of greenhouse gas emissions between 2008 and 2010 alone.

Remaining forest, whether closed or open, fragmented or continuous, is starting to be valued as carbon repositories, and the subsequent deforestation of these resources counts toward total carbon emissions, particularly under the post-Kyoto U.N. directed Reduced Emissions from Deforestation and Degradation (REDD or REDD+) framework (Lu and Liu 2012). Payments to landowners for not deforesting their land so that it is maintained as carbon storage “sinks”, are swiftly becoming the most lucrative tool available for tropical forest conservation purposes (FAO 2012). Creating an economic incentive for retaining standing forests regardless of size has been in discussion for decades among conservation biologists, with better tech for determining actual on-the-ground carbon values of tropical forests and ever-pressing policies to mitigate global climate change, the time may be ripe for adding on biodiversity needs, including those of primates to the REDD disbursements. However, it is still too early to know if these payouts will translate to real on-the-ground change in forest use by local communities (Griscom et al. 2009; Lund et al. 2009; Virgilio et al. 2010), particularly with respect to use of the fauna, including primates (Kapos et al. 2008).

In many cases, governments have excellent laws to combat environmental crimes “on the books,” but very little to show for them in terms of on-the-ground enforcement. Environmental crime is a top priority, not only because of the deforestation itself, but also as a means for controlling the rate of fragmentation and global climate gas emissions (Nellemann 2012). It has long been a challenge for conservation biologists and primate scientists to enforce or to seek enforcement of wildlife protection laws in any given country. However, a newly established International Consortium on Combating Wildlife Crime (ICWC), chaired by the CITES Secretariat comprising INTERPOL, the United Nations Office on Drugs and Crime (UNODC), the World Bank, and the World Customs Organization (WCO), has been created that “provides the entire enforcement chain—customs, police, and justice—a substantial new commitment to the sharing and coordination of a comprehensive international effort to help combat wildlife crime, including illegal logging” (Nellemann 2012). The success of this organization will rely heavily on constant and determined commitment from governments, society, and the private sector—which includes on-the-ground national and international researchers, students, and locals.

Compounding Conservation

The accumulation of effects on any given remaining habitat is cause for great alarm for those working with primates in fragments. If we can compound impacts, then certainly conservation can be cumulative as well. We all long for the days when the cry of “sustainable use” felt like it was enough, and that it was the right track for maintaining forests and the wildlife within them. And while there are cases where sustainable use practices do make a difference, it is this combined front that must be addressed, starting with how we perceive our world. We desperately need to know the impacts of human actions on the primates we study. Once, we believed that the behaviors of source country people were fixed, and that as cultural outsiders we should not tamper with their ways except to provide education through workshops or by other means aimed at the children or degradation perpetrators (e.g., hunters). But with smart phones in the hands of even the most rural villagers the world over—the connection to cultural ideas is merging. And while it is important for every culture to retain their core values in whatever manner that is significant to them, there is a shift toward global environmental acculturation that is as important to primate conservation as it is to global diplomacy.

We called for human behavioral changes in the last *Primates in Fragments* volume (Marsh 2003a), and now, so have many experts around the world: “Behavioural change is at the core of many environmental problems. Behavioural transformations support more effective systems of governance and help build human capacities for change. Such changes are also vital in addressing many other issues, from the depletion of water resources by overconsumption, to the mitigation of climate change by modifying mobility patterns and life-styles” (FAO 2012). The support of behavioral change is not new per se, and it has been part and parcel of environmental and health