The ecology of peace: preparing Colombia for new political and planetary climates

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Colombia, one of the world’s most species-rich nations, is currently undergoing a profound social transition: the end of a decades-long conflict with the Revolutionary Armed Forces of Colombia, known as FARC. The peace agreement process will likely transform the country’s physical and socioeconomic landscapes at a time when humans are altering Earth’s atmosphere and climate in unprecedented ways. We discuss ways in which these transformative events will act in combination to shape the ecological and environmental future of Colombia. We also highlight the risks of creating perverse development incentives in these critical times, along with the potential benefits – for the country and the world – if Colombia can navigate through the peace process in a way that protects its own environment and ecosystems.

After more than five consecutive decades of social, political, and armed conflict, the government of Colombia has signed a peace agreement with the largest rebel group, the Fuerzas Armadas Revolucionarias de Colombia (which recently became the political party Fuerza Alternativa Revolucionaria del Común), or FARC. The resolution of this conflict has many ecological, environmental, and socio-economic implications (Panel 1). In the aftermath of conflicts elsewhere, rural development has intensified, accelerating land transformation and other environmental changes (Le Billon 2000; Baptiste et al. 2017). In today’s Colombia, these socio-environmental transformations will occur alongside a variety of ongoing global environmental changes. This socio-environmental upheaval, which is happening in one of Earth’s most important biodiversity hotspots (Myers et al. 2000), creates challenges and opportunities for national, regional, and local governments; environmental managers; academia; and society in general. The decisions made at this crucial time will likely affect the lives of both present and future generations of Colombians, and will have ecological, climatic, and biogeochemical consequences with global implications.

We examine how current efforts to achieve peace in Colombia and ongoing changes in global climate will shape the ecological character of this biodiversity hotspot. We also highlight the risks of creating perverse development incentives in these critical times, along with the potential benefits – for the country and the world – if Colombia can navigate through the peace process in a way that protects its own environment and ecosystems.

In a nutshell:

• The resolution of armed conflicts can accelerate land transformation, especially deforestation
• Here, we analyze the possible environmental consequences of the peace agreement between the Colombian government and FARC, the former guerrilla group
• This peace agreement, in combination with climate change, will likely shape the ecological and environmental future of Colombia
• Colombian biodiversity faces risks due to more rapid land transformation and a warming climate
• To prevent or mitigate ecological and environmental degradation, the Colombian government should prioritize rural development in non-forested areas, strengthen environmental research, and engage scientists in decision-making processes

Colombia’s sociopolitical climate

Colombia’s population has quadrupled over the past century, and as of 2015 was close to 49 million people (Figure 1; WebFigure 1d). Historically, about 65% of the Colombian population has been concentrated in the Andean and Caribbean regions of the Magdalena–Cauca river basin (Etter et al. 2006).

The ongoing conflict in Colombia has lasted for more than 50 years (Álvarez 2003; Baptiste et al. 2017) and has directly affected more than 8 million victims, including 220,000 who

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were killed (Registro Único de Víctimas; http://rni.unidadvic- timas.gov.co). In November 2016, FARC, the largest group involved in the conflict, signed a peace agreement with the national government (www.altocomisionadoparalapaz.gov.co). Implementation of the agreement began in 2017. A few months afterward, the second largest group involved in the conflict – the self-proclaimed National Liberation Army, or ELN – entered into negotiations with the Colombian government.

Illegal activities by other groups, including drug-trafficking organizations and paramilitary groups, continue.

The presence and activities of FARC were concentrated in rural and forested regions of the country (Figure 1), potentially benefiting forests. As conflict drove a massive migration of people from rural to urban areas (UNHCR, 2016), forests regrew on abandoned farmlands, increasing forest cover (Sánchez-Cuervo et al., 2012). The spatial correlation between...
forested areas and FARC presence also suggests that the armed conflict may have unintentionally contributed to the conservation of large forested areas (Figure 1). However, FARC also inhabited environmentally degraded territories, including those affected by illicit crops and illegal mining. Under the new sociopolitical conditions, the forested areas previously occupied by FARC may become targets for investment by national and international corporations interested in expanding their agricultural and mining activities (Clerici et al. 2016). After the resolution of long conflicts, countries tend to prioritize social and economic factors, and environmental considerations are often disregarded (Panel 1). In Colombia, deforestation increased by 44% during the year the peace agreement was signed (IDEAM 2016). This deforestation will likely accelerate unless the Colombian government aggressively enforces the country’s environmental laws, makes efforts to replace illegal economies with sustainable livelihoods, and promotes a socially inclusive environmental governance of the territories previously affected by the conflict (Panel 1). The drive for rapid economic growth in rural areas poses major challenges to the conservation of ecosystems and biodiversity.

A new biophysical climate in Colombia

In the coming decades, Colombia is projected to become warmer, and water-insecure regions such as the northern coast are projected to become drier (Figure 2). By midcentury, mean temperatures across Colombia are forecast to increase by as much as 3–4°C under a no-mitigation scenario (RCP8.5; IPCC 2013) or by 1–1.5°C under an ambitious mitigation scenario (RCP2.6; Figure 2). Over the same period, annual precipitation is projected to decline in several regions of the country, including the Amazon (Figure 2). Together, warming and altered precipitation patterns will likely suppress productivity and reduce the country’s capacity to sequester greenhouse gases (GHGs) (Figure 3; a more detailed description of Colombia’s current and future biophysical climate can be found in WebPanel 1).

Adapting to Colombia’s changing political and biophysical climates

Five factors can strongly influence the ecological and socioeconomic future of Colombia and other societies recovering from conflict: the environmental context, migration of vulnerable populations, the effectiveness of environmental policy instruments, the availability of scientific support for decision makers, and the approach to incentivizing rural development. We discuss each of these below.

Land-use transformation (deforestation), emissions, ecosystem services, and biodiversity

The disarming of FARC in the wake of the peace agreement could unintentionally accelerate deforestation in Colombia. Tropical regions account for 58% of recent net global forest loss (Ferretti-Gallon and Busch 2014), with most of this deforestation occurring in humid tropical forests (Kim et al. 2015). Colombia’s tropical forest covers circa 460,000 km² (Figure 1). Between the years 1500 and 2000, national deforestation rates rose from an estimated 100 km² yr⁻¹ to more than 2300 km² yr⁻¹ (Etter et al. 2008), second only to Brazil among all Latin American countries (Kim et al. 2015). In the Colombian Andes, deforestation had removed 80% of the natural vegetation by the year 2000 (Etter et al. 2008), although some regrowth has been documented (Sánchez-Cuervo et al. 2012). With market forces incentivizing resource extraction, many ecologically diverse tropical forests have been transformed into ecologically simplified rangelands and crop areas. Cattle grazing is now the most widespread land use in the Colombian Andes.
The peace process and the disarming of FARC could impact Colombia’s biodiversity in unexpected ways. If the peace agreement enhances access to forest resources, deforestation rates and habitat fragmentation could spike (Clerici et al. 2016). As natural habitat is fragmented or lost, species will face elevated risks of population decline and extinction. Concurrent with habitat loss and extinctions, ecosystems will be increasingly affected by climate change. In the Colombian Andes, for instance, many species are endemic or restricted to small geographic ranges (Duque et al. 2015), and as climatic conditions change, many species will be forced to shift their ranges to higher elevations (Duque et al. 2015). The ability of species to migrate will be hindered by the degradation, fragmentation, and loss of natural habitats. Moreover, climate change and deforestation are not the only threats facing Colombia’s biodiversity. Introduction of invasive species and pests, pollution, hunting, and altered fire regimes are all examples of disruptive anthropogenic forces that increase the risks of species loss (Peres et al. 2010).

When increased ecological vulnerability associated with ecosystem degradation is combined with higher social vulnerability in natural/rural areas of the country, the ability of ecosystems to provide services to society is potentially highly threatened due to reductions in or loss of ecological integrity (Berrouet et al. 2018). This is particularly relevant when the effects of global change overlap with major social transformations. Therefore, integrated assessments of social and ecological vulnerability to global change could help to identify land-use policies and biodiversity conservation strategies that can boost the production and distribution of ecosystem services during the implementation of the peace agreement.

Migration of vulnerable populations

The combination of new political and biophysical climates will likely alter the population dynamics of Colombia’s people, with particularly dramatic impacts on victims and vulnerable populations, and potentially contrasting effects on the environment. Forced displacement in Colombia soared because of the internal conflict (Ibáñez and Vélez 2008). The new political climate may substantially reduce conflict-driven migration, or even reverse the process (eg allow people to return to rural areas), whereas the changing biophysical climate will potentially produce climate migrants (eg people who leave water-insecure regions). A decline in forced displacement could reduce pressure on biodiversity.
in urban areas while at the same time increasing pressure in rural areas, likely exacerbating deforestation.

Gender inequality increased during the armed conflict with FARC (Salcedo 2013), a typical effect of this type of internal conflict (Jansen 2006). Among the victims, African-descendant, indigenous, and poor rural communities in general have been widely recognized as highly vulnerable populations, along with women and children (Mazurana and Carlson 2006; Alzate 2008). Because the armed conflict was concentrated primarily in rural areas in which government presence is weak, the threat of violence to these populations will likely decline in its aftermath. New opportunities for vulnerable populations will depend on the implementation of effective governance in regions where FARC formerly had a strong influence, as well as on the participation of these communities in the implementation of the peace agreement (ie giving communities a strong voice in decision-making processes).

**Current and future environmental policy instruments**

Colombia’s plan to mitigate its impact on climate and to adapt to climate change is largely summarized in a set of ongoing policy instruments, including the Colombian Low Carbon Development Strategy (CLCDS), the National Strategy for Reducing Emissions from Deforestation and Forest Degradation (ENREDD+), the National Adaptation Plan to Climate Change (PNACC), and the Colombian Intended Nationally Determined Contribution (iND). Colombia’s biodiversity commitments largely relate to the UN Convention on Biological Diversity (CBD). The country’s most important climate-related targets include zero net deforestation in the Amazon by 2020, and a 20% reduction in GHG emissions below business-as-usual projections by 2030 (iND; see current emissions in WebFigure 1f). The potential for widespread, rapid, land-cover changes in post-conflict Colombia raises questions about how best to manage and maintain the nation’s commitments to biodiversity preservation and climate-change mitigation and/or adaptation. The effectiveness of these policies will likely depend on the ways in which rural areas that were previously affected by conflict are developed, managed, and/or conserved in the future (see section below: Rural development: the key?).

**Informing policy with science**

The efficacy of environmental policies and regulations cannot be assessed without extensive environmental monitoring. In tropical regions, such monitoring has historically been sparse and underfunded. To gain a better understanding of how major stressors, including global change and national post-conflict recovery, are affecting the functioning of tropical ecosystems, policy makers must invest in more intensive monitoring efforts (Sierra et al. 2017).

One particular challenge for monitoring ecosystem processes in Colombia is that many areas (eg those that are poorly developed because of intense and prolonged conflict) are logistically difficult to access. Remote-sensing approaches may be useful for monitoring ecosystem responses to changes in climate and land use/land cover in those areas. However, because the capabilities of remote sensing are limited (eg unable to measure belowground processes), thorough monitoring will also require long-term field measurements. Plans to establish a monitoring system that integrates remote sensing with in situ measurements are currently under development (Sierra et al. 2017), but the implementation of such a system may be too slow to record present-day environmental transformations.

Scientists should also engage with policy makers and other interested parties so that environmental monitoring is relevant to decision-making needs, and so that decisions are based on the best available scientific evidence. Although effective engagement can be challenging, a promising approach in this regard is the research for development (“R4D”) framework, which proposes that scientific research should not only be communicated but also designed with the active participation of relevant stakeholders (Laws et al. 2013). In Colombia, this would involve victims of the conflict, affected communities, the national government, and even former FARC rebels.

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Figure 4. Images from before the peace agreement of (a) a group of FARC rebels returning to their base camp, and (b) a rebel at a camouflaged FARC encampment.
Rural development: the key?

Some of the main principles of the peace agreement are related to land management and rural development (first chapter, www.altocomisionadoparalapaz.gov.co). The implementation of this part of the agreement will strongly influence the future biophysical and sociopolitical climates of Colombia. Rural development implies a series of trade-offs; for instance, the process is likely to increase economic opportunities for people in rural areas, thereby reducing the pressure on urban areas from rural displacement (which increased because of the armed conflict). At the same time, these opportunities may exacerbate pressure on rural forests. To protect Colombian forests and the valuable services they provide, one policy option would be to prioritize rural development in non-forested regions, which already cover half of Colombia (Figure 1). Such targeted development would complement the approach recently advanced by Baptiste et al. (2017), who suggested providing incentives to grow, manage, and protect forests. At the same time, local land-use planning and in situ work programs could be used to connect and designate new protected areas within the already fragmented (and at-risk) strategic natural areas. Such conservation initiatives and activities could be promoted through participatory approaches. Involving area residents in the planning would provide insights about local perceptions, land-use practices, and adaptive capacities that could increase the likelihood of local acceptance, and thus successful implementation, of these initiatives. Moreover, such efforts could improve the quality of life in rural areas by providing opportunities for new generations and encouraging social and gender equality.

Conclusions

Modern Colombia is currently experiencing two almost inevitable transformations: intensification of natural resource use and land-cover change in areas previously influenced by FARC, and climate change. These changes represent major challenges but also an opportunity for generations of Colombians that have only lived in a time of war. Wisely and effectively regulating deforestation in the face of political pressures to accelerate development will present a dilemma for some politicians, but an unregulated or poorly regulated intensification of natural resource use would magnify the pressure that climate change will place on the country’s ecosystems, with consequences for biodiversity, ecosystem services, and the well-being of the Colombian people.

At the same time, however, Colombia has also been given a momentous opportunity. If the Colombian people (1) take advantage of increased access to technology for monitoring climate, ecosystem processes, and various natural resource uses; (2) base their decisions on scientifically sound evidence; (3) effectively implement climate policies such as those from the iNDC; (4) prioritize efforts to help vulnerable populations displaced by conflict or climate; and (5) protect natural resources (eg forests, soils, biodiversity) that paradoxically are at increasing risk in these more peaceful times and that provide valuable products and ecosystem services, this transition from conflict to peace could not only improve the quality of life of millions of people in a sustainable way but would also serve as a historic example of how a society can end a war without endangering its own environment and ecosystems.

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