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論 文 内 容 要 旨

Regulatory enforcement for forest conservation efforts in Brazil often failed to prevent large scale deforestation in the Amazon. However, a turning tide occurred in 2005, when a combination of unfavorable economic conditions and an unprecedented coordinated effort between governmental institutions resulted in a consistent deforestation decrease. Continuing decreasing deforestation in an environment of economic recovery and expansion suggests that regulatory enforcement has achieved a measure of success hitherto not experienced. Understanding the determinants and requirements of effective law enforcement is necessary as a precondition to preserve forests and prevent emissions from deforestation and degradation, as well as precondition for an effective implementation of newer forms conservation efforts such as payment for environmental services.

The present research analyses the way in which administrative sanctions and measures to improve territorial management impacted deforestation. We do so by first reviewing theoretical frameworks that allow for an in-depth analysis of law enforcement, focusing mainly on the theory of institutions, the law enforcement theory, and in the case of Brazil, the socio-environmental function of rural properties and the theory of the Commons. With regard to law enforcement, we review that from an instrumental point of view, crime deterrence is commonly seen as a function of the expected profit earned from the illegal criminal activity,

minus the product of the magnitude of the sanction for the illegal activity times the probability of detection. The main issue with crime deterrence is thus two-fold: first, considering the limited resources at the disposal of law-enforcing agents, should there be an emphasis on increasing the magnitude of the sanctions, or an increase in the probability of detection of the criminal activity. Secondly, once the criminal activity has been detected and the sanction applied, is the application of sanction perfect, or are there elements that hinder the complete application of the sanction?

After laying down the theoretical framework, the research moves on to provide an extensive historical review on the development initiatives pursued by Brazilian authorities to colonize, integrate and economically develop the Amazon region. We show how since at least the 1950s until roughly the early 1980s, the Brazilian government took the leading role in building transportation and communication networks to integrate the Amazon to the rest of the country, providing large benefits for the promotion of large scale agriculture and bovine livestock production, as well as promoting colonization of capitalized farmers from the southeast and southern regions of the country, as well as masses of landless farmers from the poor northeast region. In order to guarantee an orderly process of economic development and colonization in the region, the government also passed various environmental and land-tenure related legislation, but inability of the very government in enforcing the proper implementation of these rules led to low levels of compliance, resulting in grave land conflict and environmental damage. With regard to land conflicts, lack of reliable land registry and land cadaster systems resulted not only in conflicting landownership claims between private landowners, but also large scale land grabbing and the effective illegal occupation of public lands. With regard to environmental damage, forest legislation in force since the early 1960s made compulsory the protection of a percentage of every rural property in the Amazon. Until 1996, such percentage was set at 50% of the property area, but such legislation was often disrespected by landowners, due to a combination of favorable prices of agricultural commodities and the inability of government environmental agencies to enforce the limitations set in the forest law. With the economic difficulties faced by the Brazilian government after the Second Oil Shock, resources available to guarantee that the economic development of the region did not occur at the expense of forests that should be protected decreased drastically, and increased illegal deforestation became outside the control of the government. After the first third of the 2000s, however, a combination of unfavorable economic conditions for beef and soy

beans, and a coordinated effort within various levels of public administration resulted in a consistent decrease in annual deforestation rates. Among the various measures taken within the scope of the so-called Action Plan for the Prevention and Control of Deforestation in the Amazon, those related to stricter deforestation monitoring and control were considered to be the most effective, followed by measures to improve territorial management.

While the growing literature that attempts to explain the extent to which government efforts to reduce deforestation since the mid-2000s focuses solely on the role of fines and the economic variables, the present research goes various steps further by also analyzing the effect of other types of administrative sanctions at the disposal of the environmental agencies to combat illegal deforestation, and by analyzing the impact of better private rural land management on deforestation. We do so by first exploring public datasets on the number and magnitude of fines imposed for illegal deforestation in the Amazon. Next, we develop a novel approach to calculate the impact that the imposing of embargoes on rural private properties have on deforestation rates in the neighboring areas of the embargoed property, as well as within its limits. We also conduct analysis on previously unavailable data on the confiscation of means of production used in illegal deforestation and of the produce derived from the illegal deforestation. With regard to better territorial management efforts, we analyzed the pace of implementation of the first georeferenced based national rural land cadaster in the state of Mato Grosso, investigating the economic determinants for private property registration in the said cadaster. We also analyze the relation between deforestation decrease and an increase in the number of rural properties in Mato Grosso whose perimeter is registered in a georeferenced land cadastre, by comparing deforestation inside georeferenced properties and non-georeferenced properties.

Our investigation was conducted relying mostly on regression analyzes and on geographical information system (GIS) based spatial-temporal analyses. The results show that the decrease in deforestation experienced in the Brazilian Amazon and in Mato Grosso state is strongly associated with heavier fines; however, the effective collection rates of these fines is extremely low, due to a generally long defense analysis period that results in the law offender being able to discount the present value of the punishment to a distant future; this in turn diminishes the coercive effect of fines. The other forms of administrative sanctions, namely the confiscation of means of production and produce and embargoes, were found to be more effective forms of sanctions, particularly in terms of deforestation within the borders of the embargoed

property. This happens because the economic impact faced by the law offender is more immediate and direct, both in the form of inability to generate wealth from the property in the present (because the farm is embargoed or because the means of production have been confiscated), as well by not having access to rural credit (in the case of embargoed farms).

When turning our attention to the implementation of georeferenced land cadaster, we demonstrated a correlation between the level of cattle farming and soy beans expansion and registration of rural private properties in the said cadaster. We have also shown how, similar to the effect found inside embargoed farms, forest loss inside georeferenced properties is smaller than in non-georeferenced properties, although this effect is uneven across municipalities where deforestation pressure is strong.

Finally, we combined in one econometric model the three types of administrative sanctions against deforestation, the territorial management improvements both in terms of georeferenced private properties areas and in terms of newly established public protected areas, and the expansion of soy beans and bovine livestock. When controlling for the local differences across municipalities in Mato Grosso state, and within these municipalities that are targeted for stricter monitoring and deforestation control measures, we find that the average value of fines, the value of confiscations, the number of imposed embargoes, and the accumulated georeferenced private properties areas and public protected areas had a statistically significant negative impact on contemporary deforestation in the state between 2004 and 2012; the number of infractions issued was found to negatively impact future deforestation. It is worth noticing that the expansion of soy beans production in Mato Grosso was found to be statistically insignificant as a driver of deforestation, indicating that possibility of gains in productivity, or that soy expansion may have occurred in areas previously occupied by pasture lands, thus forcing cattle expansion on the forest.

Our results are relevant to both the academic community and policy makers alike. To our understanding, the analyses involving confiscations, embargoes, and georeferenced private properties are the first of their kind; with regard to our analyses on fines, we have showed that the low collection of fines is associated with the long defense analysis period within the federal environmental agency. It is thus necessary that policy makers take effective measures to speed up and increase the collection of the fines issued.

論文審査結果の要旨及びその担当者

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論文題目	Decreasing deforestation in the Brazilian Amazon - an impact analysis of enhanced management and control measures in the first decade of the 21 st century, with focus on Mato Grosso State (ブラジル・アマゾンにおける森林伐採の減速：21 世紀初頭 10 年のマツトグロッソ州における管理・統制強化手法の効果分析)
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論文審査結果の要旨

ブラジル・アマゾンでは、2005 年を転機として、森林の違法伐採が減速し始めた。本研究は、農牧場への転用圧力が維持される一方で伐採が減速した要因として、2004 年以降の省庁横断的な違法伐採対策等の管理・統制強化に注目し、その効果を計量的・空間的に検証するものである。アマゾン全域について違法伐採に対する罰金の効果を分析したのち、とくにマツトグロッソ州について、罰金に加え、農畜産物等の没収・搬出禁止措置の効果と、所有地の地籍 GIS 登記の効果を検討した。本論文の章構成と概要は、以下の通りである。

第 1 章では、罰金水準と違法行為抑制効果の関連をめぐる理論を整理し、違法な森林伐採を取り締まる制度の実効性を評価する観点を示すとともに、アマゾン地域の私有地内の森林が果たすべき社会的・環境的機能を定めたブラジル法制について、その思想的背景と、森林保全における制度の失敗を指摘した。

第 2 章はアマゾン開発を概観し、なかでも農牧業が盛んでこれまで森林伐採が著しく、かつ近年の伐採減速も顕著であったマツトグロッソ州を、詳細な検討対象とする意義について述べた。

第 3 章では、伐採に対する罰金の効果を州単位で検証した結果、取締強化による罰金対象件数の増加が違法伐採を減速させたという通説は支持できず、むしろ罰金の重さが効いたことを示した。また、罰金額が大きいと徴収手続きに時間がかかり、徴収不能で無効となる罰金例も増えて、伐採減速効果が弱まることを指摘した。

これを受けて、第 4 章では、並行して実施された他の手法の検討に転じ、まず違法伐採地からの農畜産物搬出禁止措置が伐採を抑制する効果を、マツトグロッソ州について分析した。空間的解析により、搬出禁止対象地の近隣で翌年の違法伐採が抑制されたことを、また対象地内での伐採も大きく抑制されたことを確認した。

続く第 5 章では、2004 年に導入された地籍 GIS が、登記された私有地内にある維持すべき森林部分を明確にして伐採を抑制する効果を吟味した。マツトグロッソ州では、登記地内の森林が未登記地の森林よりも保全されていることが確認された。しかし、伐採圧の高い地域では登記地での伐採も著しく、登記の説明力は限定的であった。

第 6 章は、前 3 章の知見を総合し、マツトグロッソ州において農牧業が拡大するなか、罰金額、違法伐採地での搬出禁止・没収措置、そして地籍 GIS 登記が違法伐採を有意に抑制することを、自治体単位の回帰分析によって確認した。だが、データ制約のため、措置翌年の伐採減少が措置対象地近隣における森林の全滅によるものであって伐採抑制の名に値しない可能性を排除できなかった。

そして第 7 章では、全体を総括し、課題と政策的含意に言及している。没収と搬出禁止の伐採抑制効果は即時に発揮されるのに対して、罰金の場合は高額になると徴収までの法的過程に手間取り効果が弱まるとしつつも、罰金徴収を迅速化し執行率を高めることの、また省庁間連携を改善することの効果は大きいであろうと論じている。

本研究は、農牧業をめぐる国際・国内経済の変動、市民社会の圧力等の要因や取締の質を分析に反映させることを課題として残している。また、違法伐採者となりうる土地所有者の政策認知や農牧業の現状を聞き取って補うべき部分も少なくない。空間データ解析についても、没収・搬出禁止措置が失わせた農牧業者の利益の規模が、次の違法伐採を抑制する効果を考慮すべきであった。しかし、新政策が違法伐採減速という新現象に寄与した程度を評価する数少ない体系的な試みとして、本研究を高く評価できる。とくに州当局との信頼関係を築き、データを入手して試みた空間的解析の新規性は高く、それによって一定の成果を得たことは特筆される。どの管理・統制手法が実効性をもつのかを詳細に検討したことによって、他国での森林管理にも貴重な知見を提供するものである。

よって、本論文は博士(環境科学)の学位論文として合格と認める。