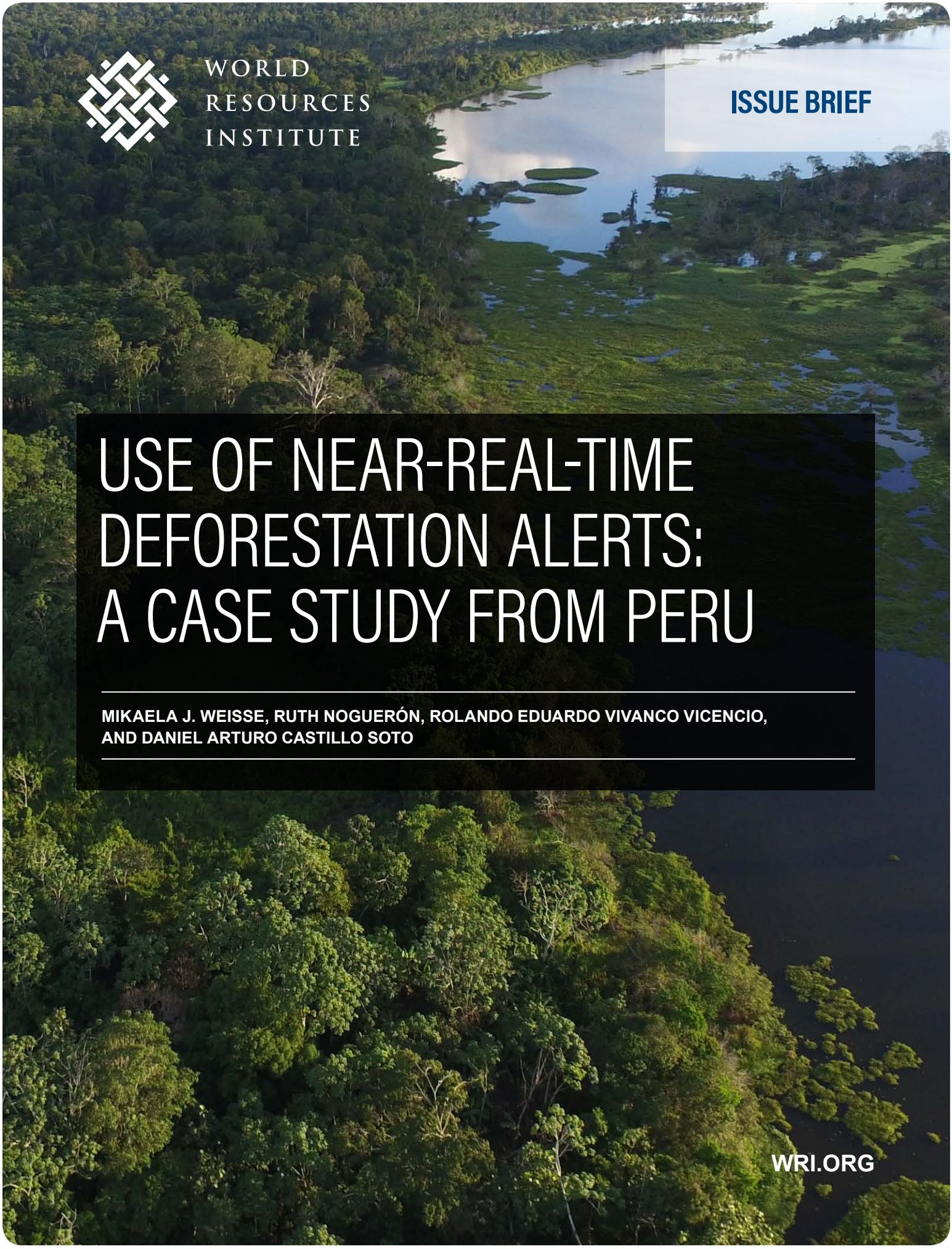

WORLD RESOURCES INSTITUTE

ISSUE BRIEF

USE OF NEAR-REAL-TIME DEFORESTATION ALERTS: A CASE STUDY FROM PERU

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HIGHLIGHTS

- Near-real-time (NRT) deforestation monitoring allows forest managers and law enforcement personnel to respond quickly to illegal deforestation and is increasingly seen as a valuable tool for reducing deforestation. This study describes how NRT alert systems are being used to combat deforestation in Peru.
- Many Peruvian government and civil society actors use NRT alerts to investigate illegal activities, manage protected areas (e.g., planning and control activities), assert land rights, enforce conservation agreements, and raise public awareness of illegal deforestation. NRT alerts provide a new source of information on deforestation and allow these institutions to monitor more efficiently larger areas of forest.
- Early adoption of alerts by a few influential institutions and the high level of technical capacity across the country have facilitated wide use of the alerts in Peru. Those institutions making the most use of the alerts also cooperated with others and had strong internal protocols and clear jurisdiction in the areas in which they work.
- Technical limitations of the NRT alerts, such as delays in detection due to cloud cover, have hampered their use in some situations, and there are opportunities for improvements both to the alert systems themselves and to their delivery. However, a bigger challenge to effective use of NRT alerts are governance issues—for example, limited funding for field visits for control actions, corruption, and lack of clarity about agency responsibilities.

EXECUTIVE SUMMARY

About This Issue Brief

The high frequency of near-real-time (NRT) deforestation alerts make these systems an important tool for controlling illegal deforestation. In Brazil, the incorporation of NRT alerts into law enforcement investigations was partially responsible for the decline in deforestation in the early 2000s, and many other countries looking to follow Brazil's example are creating their own NRT alert systems. In Peru, the use of NRT alerts has increased greatly since 2016, when the University of Maryland's weekly, 30-meter-resolution GLAD alert system (named after the Global Land Analysis & Discovery lab) first became operational and the subsequent start of a similar, national system created by the Ministry of the Environment.

While several NRT alert systems have been developed across the tropics, very little research has focused on how these systems are used to combat deforestation. In this issue brief, we document the use of NRT deforestation alerts in Peru, the conditions that enabled their widespread adoption, and the limitations to their application. The findings are based on interviews with and surveys of Peruvian stakeholders who use NRT alerts and the authors' own experience. The long-term goal of this work is to evaluate the effectiveness of NRT alert systems in reducing deforestation. It is too soon after the introduction of the alerts in Peru to quantitatively assess their impact in this regard, but we hope to draw some lessons from Peru's early experience to provide a useful starting point for other countries considering the use of NRT alerts.

Key Findings

Several national and subnational government agencies in Peru rely on NRT deforestation alerts for their work. For agencies tasked with conducting satellite analyses, NRT alerts allow them to spend less time downloading and analyzing imagery and to monitor more easily larger areas. On-the-ground organizations use the alerts to prioritize and focus their management and enforcement activities, which improves the efficiency of field efforts.

Broadly, the uses of NRT alerts in Peru fall into the following categories:

- **Investigating illegal activities.** Law enforcement bodies use NRT alerts to prioritize areas for control activities, plan field patrols, and provide additional evidence in legal cases.
- **Managing protected areas.** The National Service for Natural Protected Areas (Servicio Nacional de Áreas Naturales Protegidas por el Estado; SERNANP) regularly uses NRT alerts at both the local and the national level. Local park guards use the alerts to identify threats and plan patrols, coordinate with local stakeholders, and monitor potential violations of conservation commitments from communities around and within protected areas. National staff use the alerts to monitor forest cover across the system, prioritize activities and resources for control actions, and verify reports from field activities.
- **Asserting land rights.** Indigenous communities and private landholders use the alerts to monitor and protect their lands.
- **Monitoring and enforcing conservation agreements.** Two government-led programs use the alerts to monitor indigenous communities' compliance with a compensation scheme that rewards land conservation and a mechanism for indigenous communities to pay forest management–related fines through forest conservation.
- **Raising public awareness of deforestation.** Organizations like Amazon Conservation use the alerts to bring media attention to deforestation in the Peruvian Amazon.

Influential early adopters and the high geographic information systems (GIS) capacity contributed to the rapid uptake of NRT deforestation alerts in Peru. The Ministry of Environment featured the alerts on its Geobosques web platform, which encouraged other government agencies to use them. Amazon Conservation's high-profile media stories, which used the alerts, introduced the data to many organizations. The high level of GIS and remote sensing capacity throughout the country also facilitated uptake by many.

Clear institutional mandates and internal protocols led to more effective use of the alerts. Many of the successful cases of implementing

the alerts came from organizations like SERNANP, which has clearly defined responsibilities in protected areas. Incorporation of the alerts into existing internal protocols increased the likelihood of positive results, as it encouraged regular follow-up and promoted the systematic use of alerts across the organization.

The technical limitations of the NRT alerts impeded their use. The time lag between deforestation events and detection due to cloud cover was identified as a top limitation in the use of NRT alerts. Other concerns with the alerts included the inability to distinguish the cause of deforestation (natural or anthropogenic) and the long-term sustainability of NRT alert systems. Those working in remote areas also reported difficulty accessing NRT alerts due to poor internet connectivity.

Governance and capacity issues were the greatest obstacles in the effective use of NRT deforestation alerts. Despite the availability of quality alert data, organizations reported many barriers to their use, including corruption, lack of political will, poor interinstitutional coordination, and inadequate resources for field activities. Further, the use of the alerts requires trust in the accuracy, quality, and applicability of the data, and this may require organizations to develop their technical capacity. Organizations also need to develop trust in each other to improve coordination. Some respondents suggested that public trust in institutions declines when authorities are unable or unwilling to respond to NRT alerts.

Conclusions

Some of the alerts' limitations can be resolved to some extent through technological advances, such as detecting deforestation even under cloudy conditions with multisensor approaches (particularly with radar data in flat terrains), incorporating complementary datasets such as boundaries of forest management areas to determine legality, and improving how deforestation drivers are distinguished to aid alert prioritization. The development of mobile apps and other solutions for offline access can also help make NRT alerts available in remote areas.

Systemic issues such as lack of coordination, lack of resources, and poor governance are more difficult to overcome. However, in Peru, additional training for subnational governments, prosecutors, and indigenous communities did help improve coordination between some government agencies. Allocating enough resources to support field visits and on-the-ground law enforcement actions would also increase the effective use of NRT deforestation alerts.

The experience in Peru offers valuable lessons about the enabling conditions for the successful uptake of NRT alert systems, which can serve those interested in applying NRT deforestation alerts elsewhere. These lessons include the following:

- Buy-in by a small number of important institutions early on can lead to widespread uptake of NRT alerts.
- Institutionalizing the use of alerts into existing platforms and protocols makes it more likely that NRT information will be used effectively.
- Proactive training for and building the capacity of on-the-ground actors is essential to build trust in and understanding of NRT alerts.
- NRT data are most useful in situations where land zoning and agency responsibilities are clear.
- Institutions using NRT alerts must have adequate financial support for field visits and control actions, which are critical for investigating and responding to activity identified by the alerts.
- Public pressure around recent NRT alerts can encourage effective law enforcement efforts. This highlights the importance of making such alerts publicly available and supporting use by civil society organizations.

INTRODUCTION

Forests are critical for the global environment, storing hundreds of gigatons of carbon (Pan et al. 2011), serving as a habitat for 80 percent of terrestrial biodiversity (UN n.d.), and providing livelihoods to around 1.6 billion people (Chao 2012). However, the world's forests are under pressure: global tree cover loss reached a record 29.7 million hectares in 2016 (Weisse and Goldman 2017), illegal logging accounts for 50–90 percent of timber production in key producer tropical countries (INTERPOL and World Bank 2009), and some research (Baccini et al. 2017) suggests that tropical forests are now emitting more carbon than they remove from the atmosphere due to the high rate of deforestation.

There is strong interest in reducing deforestation globally, with many international actors making commitments to that end. Most countries with high forest cover include or plan to include emissions from forests in their Nationally Determined Contributions to the Paris Agreement (Lee and Sanz 2017). Many countries with tropical forests are also working toward results-based payments for forest emissions reductions as part of their Reducing Emissions from Deforestation and Degradation (REDD+) strategies. A total of 36 countries and 52 private companies are signatories to the New York Declaration on Forests, which aims to end natural forest loss by 2030 (UN Climate Summit 2014), and the Sustainable Development Goals and Aichi Targets set out similar ambitions for reducing deforestation around the world.

Satellite-based forest monitoring has become an integral part of these commitments, particularly as part of the measurement, reporting, and verification (MRV) process. MRV systems measure progress against a baseline in the reduction of deforestation and, in some cases (such as for REDD+), serve as the basis for results-based payments. Much of the MRV process focuses on annual or biennial monitoring of forest change (e.g., Climate Focus 2015; GFOI 2016; Potapov et al. 2014; UNFCCC 2014). This is useful for tracking progress on commitments, but it only detects deforestation ex post facto.

However, forest monitoring also has the potential to become a tool for implementing these commitments. Near-real-time (NRT) deforestation monitoring can detect deforestation immediately, with operational systems updating on a daily, weekly, or monthly basis (Box 1). This makes it possible for law enforcement

BOX 1

NEAR-REAL-TIME DEFORESTATION MONITORING

For the purposes of this issue brief, near-real-time (NRT) deforestation monitoring refers to the periodic (daily, weekly, or monthly) identification of tree cover loss based on the interpretation (manual or automated) of satellite imagery.

Previously, most NRT deforestation alert systems used low-resolution satellite imagery with daily global coverage such as MODIS (e.g., Diniz et al. 2015; Reymondin et al. 2012; Souza et al. 2009; Wheeler et al. 2017). Advances in cloud computing and algorithm development have made it possible to process medium-resolution imagery on a large scale to detect changes with greater detail. This is crucial as more than 70 percent of deforestation in Peru is smaller than 5 hectares (Finer and Novoa 2016), while a single MODIS pixel is 6.25 hectares.

This issue brief focuses on two moderate-resolution NRT deforestation alerts systems: the Global Forest Watch GLAD deforestation alerts and the Geobosques Early Warning alerts by the Peruvian Ministry of Environment's National Forest Conservation and Climate Change Mitigation Program (Programa Nacional de Conservación de Bosques para la Mitigación de Cambio Climático; PNCBMCC). Not all the loss detected by these systems is of anthropogenic origin, results in a change in land use, or occurs in natural forests, but they are built to indicate where deforestation activity may be occurring.

The GLAD deforestation alerts created by the University of Maryland are the first large-scale system to use medium-resolution imagery, in this case from Landsat, to detect potential deforestation at 30-meter resolution (Hansen et al. 2016). New images are processed by the system daily, with the time between satellite passes being around eight days for any point on Earth. The GLAD alerts were first developed in Peru, the Republic of the Congo, and Indonesia and have since been expanded to cover the tropics. The alerts are distributed through the Global Forest Watch platform (www.globalforestwatch.org) and associated tools.

The PNCBMCC alerts are similar in scope to the GLAD alerts, also detecting tree cover loss with Landsat 7 and 8 imagery. However, they consider only Peru's primary tropical forests and are more sensitive to smaller disturbances down to 10 percent of a Landsat pixel (Vargas et al. in review). PNCBMCC's alerts are updated weekly and are made available through the Ministry of Environment's Geobosques platform (http://geobosques.minam.gob.pe).

or other actors to respond rapidly to recent deforestation events, potentially stopping further expansion of forest clearing.

Brazil has long been touted as an example of the use of NRT monitoring as a tool for rapid response to deforestation. Deforestation rates decreased 70 percent in the Brazilian Amazon from 2005 to 2013, due in part to the incorporation of NRT monitoring into law enforcement protocols (Nepstad et al. 2014). Brazil's official NRT deforestation monitoring system, Sistema de Detecção de Desmatamentos em Tempo Real (DETER), provides law enforcement agencies with credible information about where deforestation is happening, allowing them to intervene. Assuncão et al. (2013) estimate that the adoption of the DETER system for law enforcement prevented approximately 6 million hectares of forest clearing in the Brazilian Amazon between 2007 and 2011. Critically, the NRT alert system was accompanied by additional clarity in the country's forest laws, efforts to formalize land tenure, and funding for law enforcement actions.

Based on the success in Brazil, there is increasing momentum and interest in using NRT deforestation monitoring as a tool to control deforestation and illegal logging (e.g., GFOI et al. 2015; Sizer 2014). If other tropical forested countries could leverage NRT alerts to achieve a similar decline in deforestation rates as in Brazil, it would prevent the conversion of millions of hectares of forests per year, along with associated carbon stocks, and bring countries and the world closer to meeting their commitments to stopping deforestation.

Several NRT deforestation monitoring systems are currently operational (Petersen et al. 2018). Some systems cover all the tropics (e.g., Hansen et al. 2016; Reymondin et al. 2012; Wheeler et al. 2017); others focus on particular countries (e.g., Diniz et al. 2015; Souza et al. 2009; Vargas et al. in review). The governments of Brazil, Colombia, and Peru have developed national systems, and other countries have expressed interest in following suit.

Despite the increasing proliferation of and interest in NRT alert systems, there has been little study of how these systems are incorporated into law enforcement actions or of best practices for their use. Finer et al. (2018) set out a theoretical protocol for the use of NRT alerts but do not explore in depth the enabling conditions for and challenges to its use. This case study seeks to

fill this gap by exploring the use of NRT deforestation monitoring systems in the context of Peru—specifically, the GLAD deforestation alerts and the PNCBMCC Early Warning alerts (see Box 1).

Peru was one of the first countries where GLAD alerts became available in March 2016, and by 2017, when the interviews and surveys for this case study were conducted, there was widespread adoption among government agencies and civil society organizations (CSOs). This case study uses information gathered from stakeholder interviews, surveys, and the authors' own experience to do the following:

- Describe how these NRT deforestation monitoring systems are used by various institutions to reduce deforestation in Peru.
- Identify enabling conditions, best practices, and challenges those institutions have experienced around NRT alerts.
- Reflect on lessons learned for the uptake of NRT deforestation alerts around the world.

BACKGROUND

Forests and Related Commitments in Peru

Peru has the fourth-largest tropical forest area of any country in the world. Fully 56 percent of the country, or 72 million hectares, is covered by forests, of which 68 million hectares is in the Amazon (MINAM 2016). According to official government data, the Peruvian Amazon experienced 1.97 million hectares of forest loss during 2001–2016 (MINAGRI-SERFOR and MINAM-PNCBMCC 2017). The principal, direct drivers of deforestation in Peru are agricultural expansion, illegal or informal extractive activities, and infrastructure expansion. But these are underlaid by a complex set of indirect drivers, including demographic, economic, technological, political, and cultural factors (MINAM 2016).

Peru has made several national-level commitments to reduce the rate of deforestation. The Peruvian government proposed the conservation of 54 million hectares of forest (34 percent of which are in protected areas) to the United Nations Framework Convention on Climate Change (UNFCCC) in Poznan in 2008, and, in 2010, submitted a pledge to achieve net-zero deforestation in primary and natural forests by 2021 as part of the Copenhagen Accord (MINAM 2010; Embassy of Peru – Berlin 2010). Peru is a signatory to the New York Declaration on Forests, which aims to halve natural forest loss by 2020 and end it by 2030 (UN Climate Summit 2014). Peru has also been active in REDD+ initiatives, partnering with Norway and Germany in 2014 to reduce forest-related emissions in exchange for payments for verified results (Office of the Prime Minister 2014). It is also a participant in the World Bank's Forest Carbon Partnership Facility Readiness Fund.

Peru has a long history of mapping forests and deforestation to support national land-use planning.

In 2010, the Peruvian government created PNCBMCC to help achieve these targets. The specific objectives of PNCBMCC, which sits within the Ministry of the Environment (MINAM), are to identify and map areas for forest conservation, promote the development of sustainable productive systems based on forests to assist local communities, and strengthen the capacity of regional and local governments and communities (Supreme Decree Nº 008-2010-MINAM).

Forest Monitoring in Peru

Peru has a long history of mapping forests and deforestation to support national land-use planning. The first map of Peru's forests, created using aerial photographs, was produced in 1975 (Malleux 1975), with more regular mapping efforts in the 1990s and 2000s (MINAGRI-SERFOR and MINAM-PNCBMCC 2015), and in 2013, a joint effort to map forest cover and annual deforestation began, with participation from PNCBMCC, the Forest Service (Servicio Nacional Forestal y de Fauna Silvestre; SERFOR), and the Amazon Cooperation Treaty Organization.

The joint effort mapped forests in the year 2000 and annual humid Amazon forest loss during 2001–2011, and this data set has since been updated through 2016 (MINAGRI-SERFOR and MINAM-PNCBMCC 2015; MINAGRI-SERFOR and MINAM-PNCBMCC 2017). This effort also marked the beginning of a technical collaboration between PNCBMCC and the University of Maryland (UMD) on annual deforestation monitoring (Potapov et al. 2014). After the publication of the forest loss data in 2015, PNCBMCC experienced increasing demands from other government agencies for access to the spatial data and began building an online geospatial platform, called Geobosques, to publicly share the results.

In March 2016, UMD launched the GLAD alerts, in collaboration with the PNCBMCC team, who validated the data (Hansen et al. 2016). After testing the alerts in selected areas, PNCBMCC adopted the alerts to monitor their program of financial compensation to indigenous communities for forest conservation (known as the Direct Conditional Transfer program) and incorporated them into the Geobosques platform, which launched publicly in July 2016. By including the GLAD alerts in Geobosques and promoting their use, PNCBMCC officially endorsed the alerts, which facilitated uptake among Peruvian stakeholders—particularly those in other government agencies. The alerts also received early exposure from an international CSO, Amazon Conservation, which began using the alerts soon after they launched in published analyses of deforestation events in the country. This encouraged wider uptake by various government agencies and CSOs.

In March 2017, the GLAD alerts were unavailable for several months due to personnel-related issues. Responding to user demand, and to address concerns about the reliability of the GLAD alerts system, PNCBMCC began producing their own NRT alerts as a stopgap measure. Since late April 2017, these PNCBMCC alerts have been featured on Geobosques in place of the GLAD alerts. Most of the interviews and surveys for this case study were conducted around the time the new alert system began, so the bulk of the experiences featured herein refer to the GLAD alerts.

More recently, PNCBMCC and SERFOR have been collaborating with the Japanese International Cooperation Agency on early warning alert systems using radar data (MINAM 2018). The agency's JJ-FAST alerts were incorporated into the Geobosques platform as a beta in January 2019, after the interviews for this case study were completed.

Institutional Arrangements for Forest Governance

There are six primary government institutions involved in the management and conservation of forest resources in Peru:

- **Peruvian Forest Service (Servicio Nacional Forestal y de Fauna Silvestre; SERFOR).** Under the Ministry of Agriculture, SERFOR is the national forest authority responsible for planning, oversight, control, and implementation of forest laws at the national level, as well as being responsible for the management and oversight of forest resources. In addition, in regions where the forest sector has not been decentralized (Cajamarca, Cusco, Huancavelica, Junín, Pasco, Piura, and Puno), SERFOR is responsible for the management of forest resources at the subnational level through its decentralized technical forest and wildlife management units.
- **Regional governments.** Nine regions (Amazonas, Loreto, Madre de Dios, San Martín, and Ucayali within the Peruvian Amazon, and La Libertad, Ayacucho, Tumbes, and Huánuco in the rest of the country) are responsible for the management of forest resources at the subnational level. Their responsibilities include the authorization, control, and oversight of forest management activities, and primary processing and trade in forest products within their regions. However, capacity gaps, financial and infrastructure resources gaps as well as limited institutional independence greatly limit these governments' abilities to fulfill effectively their responsibilities (Che Piu Deza 2019).
- **Agency for the Supervision of Forest Resources and Wildlife (Organismo de Supervisión de los Recursos Forestales y de Fauna Silvestre; OSINFOR).** OSINFOR, an agency at the level of a Ministry, supervises and oversees the implementation of forest management plans approved by SERFOR or the regional governments. OSINFOR staff, both in the headquarters in Lima and in regional offices, conduct field verification of forest management activities once they receive clearance and documentation from the

respective forest management authority (e.g., regional government or SERFOR). They also work closely with communities in the implementation of a relatively new program to allow communities to pay fines for violations to forest management plans through forest conservation activities.

- **Ministry of Environment (Ministerio del Ambiente; MINAM).** As the national environmental management authority, MINAM is responsible for the formulation and implementation of the country's environmental policies, as well as enforcement actions to ensure compliance with those policies.
- **Protected Areas Service (Servicio Nacional de Areas Naturales Protegidas por el Estado; SERNANP).** Under MINAM, SERNANP is responsible for managing protected areas, which encompass 17 percent of Peru's forest cover. SERNANP headquarters in Lima coordinates closely with its field offices, including protected areas management offices. SERNANP also works in close partnerships with communities in or around protected areas' buffer zones.
- **National Forest Conservation and Climate Change Mitigation Program (Programa Nacional de Conservación de Bosques para la Mitigación de Cambio Climático; PNCBMCC).** Also under MINAM, PNCBMCC is responsible for implementing a program of payments for forest conservation in communities, which is part of the national climate change strategy. PNCBMCC establishes direct relationships with its partner communities.

Interagency coordination and collaboration can be challenging, and redundancy and inefficiencies occur. The Peruvian law established the National Forest and Wildlife Management System (Sistema Nacional de Gestión Forestal y de Fauna Silvestre), convened by SERFOR, as an intergovernmental platform to facilitate coordination among the different agencies. Agencies also establish bilateral agreements to strengthen one-on-one

collaborations. For instance, PNCBMCC has established bilateral collaboration agreements with SERNANP, OSINFOR, SERFOR, and various regional governments (Andina 2017; PNCBMCC 2019a; PNCBMCC 2019b). SERFOR has also signed agreements with OSINFOR, SERNANP, and regional governments (OSINFOR 2019; SERFOR and SERNANP 2018; SERFOR 2019).

In addition to the institutions mentioned, other government agencies are also involved specifically in forest law enforcement and control activities. These include independent environmental prosecutors (Office of the Environmental Prosecutor (Fiscalia Especializada en Materia Ambiental; FEMA, under the Public Ministry), the Environmental and the National Police, the Customs and Tax Service (Superintendencia Nacional de Aduanas y de Administración Tributaria; SUNAT, under the Ministry of Economy). The Peruvian army and the coast guard can also be involved, depending on the enforcement actions.

Coordination for specific law enforcement and control actions is meant to be facilitated through the emerging National Forest and Wildlife Monitoring and Control System (Sistema Nacional de Control y Vigilancia de Flora y Fauna Silvestre; SNCVFFS), which is also convened by SERFOR. However, FEMA is free to operate independently and bring and prosecute illegal logging and deforestation cases. SUNAT is also able to work independently and investigate and penalize illegal logging and deforestation cases as they relate to tax and revenue laws. In fact, both FEMA and SUNAT have collaborated with OSINFOR in forest law enforcement actions (OSINFOR 2016).

METHODOLOGY

Information for the case study was gathered via interviews with key informants, an online survey of those receiving alerts via the Geobosques platform, and the authors' experiences in providing training on NRT alerts in Peru.

The interview and survey questions focused on the following themes:

- The reliability, availability, accessibility, and limitations of NRT deforestation data.
- How NRT data has been incorporated into institutional workflows and its perceived usefulness.
- Examples and experiences highlighting the use of the NRT data and concrete outcomes.

Sixteen interviews (questions in Appendix A) were conducted, in person and by video call, between February and November 2017. All those interviewed were users of NRT deforestation alerts at the time of the interview. Potential interviewees were identified using the authors' firsthand knowledge of users of the Geobosques and Global Forest Watch platforms, and recommendations from other interviewees. Interviewees included high-level decision-makers who use the NRT alerts to inform decision-making processes, technical users (e.g., data analysts), and users in the field (e.g., communities, park rangers, and organizations working with concessionaires). Interviewees came from national and subnational government agencies, CSOs, and the private sector (Figure 1). The list of institutions interviewed can be found in Appendix C.

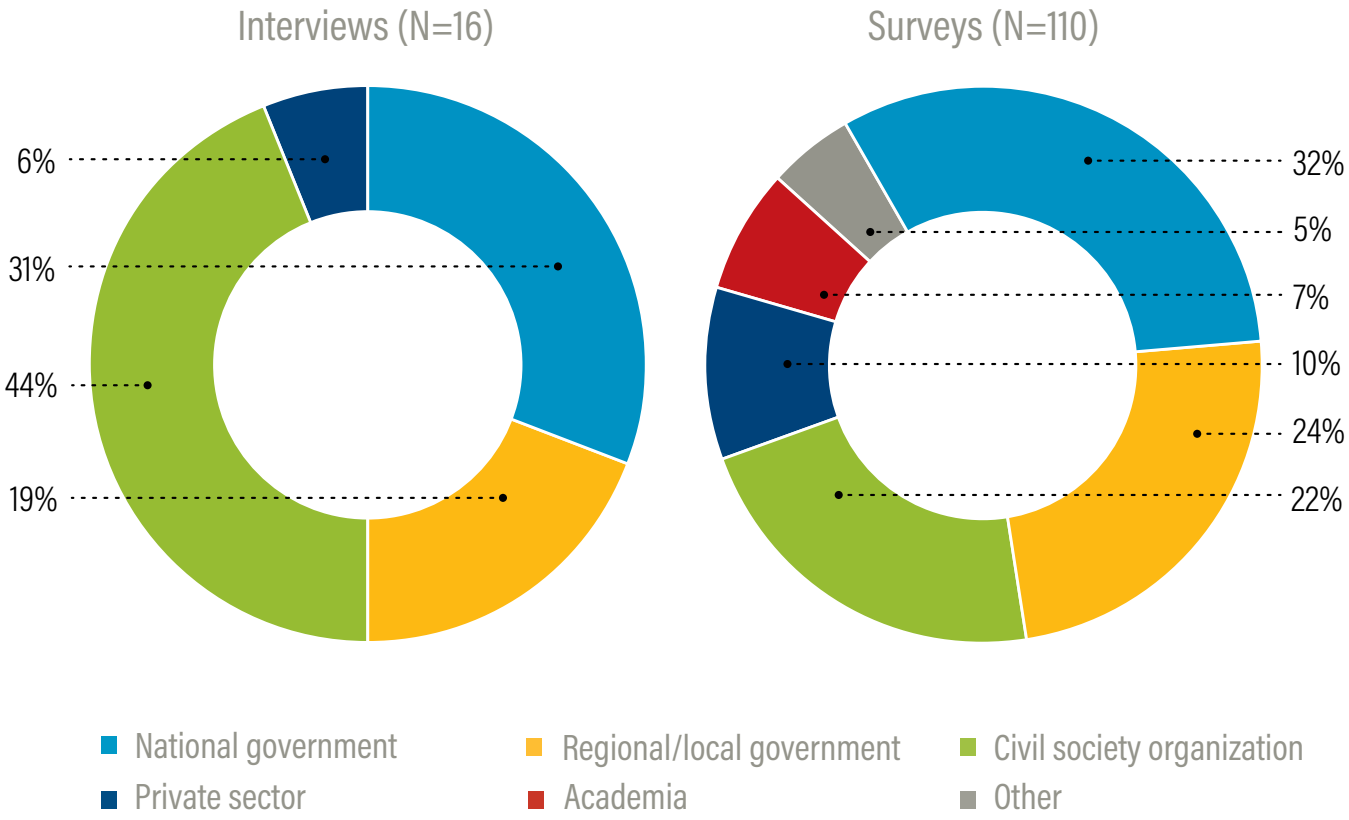
Interviews were conducted primarily in Spanish, then transcribed into English, with statements sorted by topic to allow easier synthesis. Throughout the text, endnotes denote the key information interview (as listed in Appendix C) that served as the source for a particular observation or claim.

The survey (see Appendix B) was sent in July 2017 to all those subscribed to alert data via PNCBMCC's Geobosques platform. The survey had 110 responses, representing a response rate of approximately 14%. Most survey respondents (57%) corresponded to either national or subnational agencies, with other respondents corresponding to CSOs, the private sector, and academia (Figure 1).

The interviews and surveys were supplemented with the authors' own expertise, gained through providing technical support on the use of GLAD and PNCBMCC alerts in the country since they first became available. The authors have conducted many trainings on the alerts for a variety of government and CSOs and have also participated in meetings to discuss issues related to the alerts, including meetings of the Technical Working Group on Near-Real-Time Monitoring in Peru, organized by Amazon Conservation US, in October 2016 and February 2017, and the International Forum on Forest Early Warning, organized by the World Resources Institute (WRI), in July 2018.

FIGURE 1

AFFILIATION OF INTERVIEWEES AND SURVEY RECIPIENTS



Source: Authors.

RESULTS AND DISCUSSION

Use of the Alerts

The interviews and surveys indicate that several government agencies and CSOs in Peru have incorporated the GLAD alerts into their regular operations. Of survey recipients, 41 percent (45 respondents) reported using the alerts on at least a monthly basis, with 65 percent of the regular users coming from national or regional government. Most of this use focused on the Amazonian regions of Loreto, Madre de Dios, and Ucayali[1] as the alerts are best suited for monitoring dense tropical forests, but San Martín[2] and Huánuco[3] were also represented. Many of the national government agencies used the alerts both in their headquarters in Lima and in decentralized locations in the Amazon.[4]

Overall, those interviewed and surveyed consider the alerts a useful tool. For those who previously did their own satellite analyses and monitoring, the GLAD alerts saved them time downloading and analyzing images and allowed them to monitor larger areas more often.[5]

For those who previously did their own satellite analyses and monitoring, the GLAD alerts saved them time downloading and analyzing images and allowed them to monitor larger areas more often.

Even though some agencies continue to do their own satellite analysis, they still use the alerts to prioritize specific areas or timeframes.[6] For those that did not use satellite monitoring before, the alerts provide them with a new tool to prioritize field patrols, verify claims and complaints, and strengthen legal cases.[7] Most found the alerts detailed and accurate enough to be useful, particularly for identifying roads[8] or larger clearings.[9]

Broadly, the different uses of the alerts fall into the following five categories:

- **Investigating illegal activities and coordinating response.** Government law enforcement bodies use NRT alerts to help prioritize areas for law enforcement action, plan field patrols, and serve as additional evidence in legal cases.[10] For example, OSINFOR staff use GLAD alerts to help prioritize regular supervisory patrols of forest concessions as well as to determine fines (based on the size of clearing) for those in violation of their concession agreements.[11] SERFOR is incorporating GLAD and PCNBMCC's alerts into the SNCVFFS, which aims to coordinate government agency response to illegal deforestation.[12] Members of the Satellite Monitoring Unit in FEMA have also begun using the GLAD alerts, along with satellite imagery analysis, to create reports to document and validate public complaints and ongoing legal cases.[13] Prosecutors use these reports to prioritize and guide field interventions, identify new cases for prosecution, and as an additional source of evidence.[14]
- **Managing protected areas.** The National Service of Natural Protected Areas (Servicio Nacional de Áreas Naturales Protegidas por el Estado; SERNANP) uses NRT alerts at both the national and local level. At the local level, protected area managers use alerts to identify threats, prioritize patrolling activities, document outcomes of their control activities, and coordinate with local communities and other stakeholders.[15] At the national level, SERNANP staff use NRT alerts to monitor forest cover across the system (one of their indicators), verify the management and control activities of individual parks, and allocate additional financial resources to those areas where they are most needed.[16] National-level SERNANP staff are also increasingly looking to incorporate the alerts into management planning processes to ensure adequate responses. They have begun analyzing trends in alerts to plan for budgetary, personnel, and logistical needs for management and control activities across the protected area system.[17]
- **Asserting land rights.** Indigenous communities and concession holders, supported by CSOs such as Rainforest Foundation US (RFUS), the Peruvian Society for Environmental Law (Sociedad Peruana de Derecho Ambiental; SPDA), Amazonians for the Amazon (Amazónicos por la Amazonía; AMPA), and Amazon Conservation, use the alerts to monitor and manage their lands. The private sector actor interviewed for this study likewise uses NRT alerts to detect illegal activity in and around their forest concessions.[18] These landholders use the alerts to identify outside encroachment to their lands and petition support from the appropriate authority.[19]
- **Enforcing conservation agreements.** PNCBMCC uses the alerts to monitor their Direct Conditional Transfers program, which provides a financial incentive to indigenous communities in exchange for forest conservation efforts. The alerts are used to monitor communities' compliance with the program, which includes directing field visits to verify alerts and document deforestation activity within designated conservation areas.[20] OSINFOR

also has a program in which native communities can pay fines resulting from improper forest management by conserving a portion of their forests. The GLAD alerts are used to identify areas for conservation and to monitor compliance with commitments, with the appearance of alerts triggering a visit by OSINFOR staff.[21] Similarly, SERNANP uses NRT alerts to indicate potential violations of conservation agreements in communal reserves and buffer zones, which are then investigated in the field or with high-resolution imagery.

- **Raising public awareness.** Amazon Conservation, an international CSO, uses the alerts as an input to their Monitoring of the Andean Amazon Project (MAAP, http://maaproject.org/en). Through the project, they publish online reports and generate national and international media attention around the issue of deforestation in the Peruvian Amazon.[22] PNCBMCC also encourages public access to information through their online platform, Geobosques.[23]

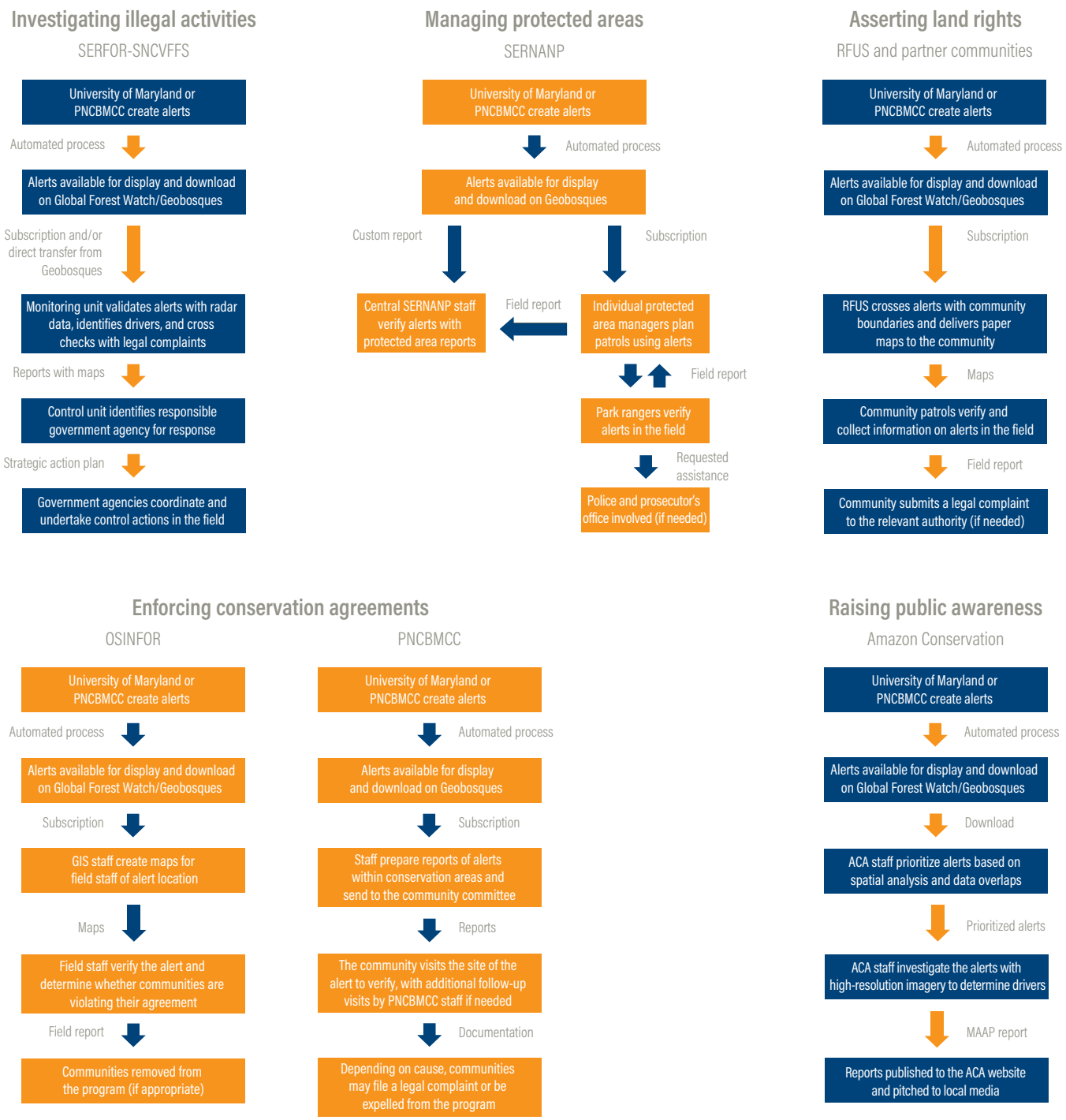
Figure 2 shows examples workflows, discussed during the interviews, for each of the use cases. Finer et al. (2018) suggest a process for the use of NRT alerts for on-the-ground action, including prioritization of alerts, identification of drivers and context, and effective communication. While many of the institutions generally follow those steps, the interviews suggest that each user's workflow varies depending on technical capacity, the purpose of monitoring, and the feasibility of field visits.

Some users rely on maps and automated analysis provided by Global Forest Watch and Geobosques,[24] while many have GIS staff on hand to further analyze the alerts and overlay them with property boundaries to create custom reports and maps.[25] In several of the cases illustrated in Figure 2—and for many other organizations—field visits to the site of the alert are an important part of the workflow.[26] Field visits provide additional information, such as the identities of those causing the clearing, which can be presented to the authorities or used in legal cases. Other users operate at larger scales and use the alerts to publicize recent deforestation (e.g., Amazon Conservation),[27] publish periodic informative bulletins (e.g., PNCBMCC),[28] or verify reports from field staff (e.g., SERNANP headquarters).[29]

Box 2 highlights an example of a successful application of the alerts. Others interviewed for this study noted that their use of the alerts has facilitated the removal of illegal actors from protected and indigenous areas,[30] helped assign fines for illegal activities,[31] served as the basis of negotiations over landownership,[32] and helped to protect a new indigenous reserve.[33] While these examples are promising, it is too early to assess whether the new monitoring workflows have had an impact on deforestation levels throughout the country as they have for Brazil, where the government has had an official NRT system in place since 2004 (Assunção et al. 2013; Nepstad et al. 2014). At the very least, the local impacts identified here show that the alerts have assisted the work of several Peruvian government agencies and CSOs.

FIGURE 2

EXAMPLES OF WORKFLOWS FOR USING THE ALERTS FOR EACH OF THE FIVE USE CASES



Source: Authors. Based on information gathered during interviews for this study.

BOX 2

RAINFOREST FOUNDATION US: A SUCCESSFUL CASE OF APPLYING NRT ALERTS WITH INDIGENOUS COMMUNITIES IN PERU

Rainforest Foundation US (RFUS) is an international nongovernmental organization that works with indigenous peoples to protect tropical rainforests. Since 2016, RFUS has provided training to two indigenous communities in central Peru, Nuevo Saposoa and Patria Nueva Mediación de Callería, to apply the weekly GLAD deforestation alerts within their territories (see Figure B.1). These two Shipibo communities have faced strong threats to their territory from the invasion of illegal logging and illegal coca cultivation, which also resulted in a community member's murder.

The communities now use GLAD alerts to identify potential encroachment of illegal activities. RFUS supplies the coordinates of recently detected alerts on paper maps showing the alerts within the territory's boundaries. The community's monitors then develop patrol plans to investigate the recent alerts. They use the global positioning system (GPS) capabilities in smartphones to navigate to alert locations and take precise coordinates of the deforestation area. The monitors also use their smartphones to record photos and videos of the area, as well as contextual information about the causes of change. To do this, the communities and RFUS have designed data capture templates to ensure information is recorded methodically and in a way that can be used in legal complaints. The monitors take the information back to the community assembly and, where necessary, use it to file a formal legal complaint with the relevant authority.

Since the project began, monitors in these two communities have completed hundreds of patrols and submitted four legal complaints to the authorities. In the most recent case, authorities including FEMA, the national police, and the marines completed an intervention in the community of Nuevo Saposoa in May 2018 to confront illegal logging. The logger was found and arrested, and the seized timber placed under the watch of the community. However, it was later determined that the logger had been granted a permit by another authority—something that should not have happened given that the area in question is within an indigenous territory. As of November 2018, the logger had been freed, and authorities were investigating the government representative responsible for issuing the questionable permit.

Community patrols have also successfully controlled deforestation through other channels. For example, using the GLAD alerts, monitors in Patria Nueva discovered three illegal farmers on the outskirts of their land. They explained the monitoring system to the farmers and were able to negotiate their removal from the territory after the growing season ended. The monitoring system has also served as a check for members of the community who may be engaging in deforestation without permission from the community assembly.

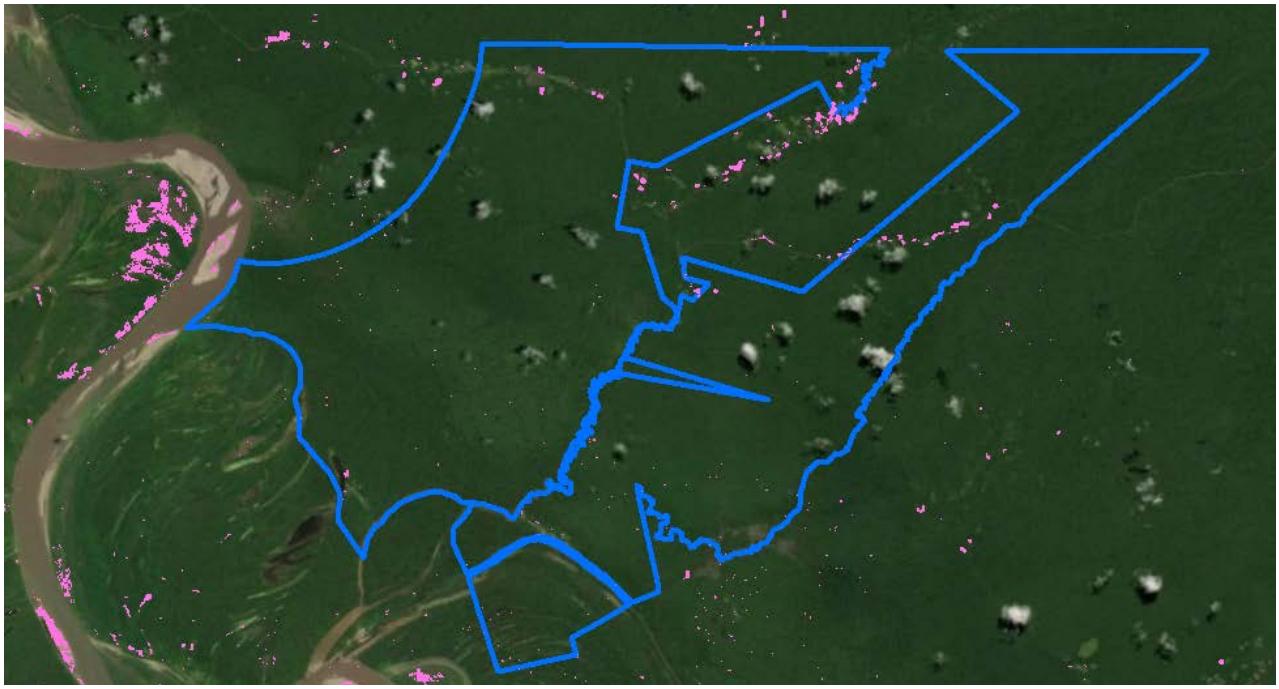
The use of NRT data has resulted in some unexpected benefits. The communities credit the monitoring program with helping to secure legal approval for a land title expansion, which had been in process for nine years. They used the annual tree cover loss data from the UMD, accessed through their patrol programs, to refute invaders' land claims. The communities demonstrated that the invaders arrived more recently than they claimed, as evidenced by the lack of tree cover loss due to human settlements (RFUS 2017).

The monitors' work was formally recognized by the authorities, with the Ucayali Regional Forest Service officially designating them as "Forest Custodians." This designation grants them authority to confront illegal activity and decommission illegally obtained natural resources and gives them direct access to relevant authorities such as FEMA and the military (Weisse and Noguerón 2017). Finally, the monitoring program helped the communities come to the attention of PNCBMCC, and since 2017 they have taken part in the Direct Conditional Transfer program, which provides payments to the communities in exchange for conserving their forests. With the funding provided by the program, the communities have decided to invest further in monitoring, which has included purchasing their own drone.

Since monitoring began, the number of GLAD alerts in the two communities has dropped to near zero. Given these successes, RFUS is expanding the work to 36 additional communities in the Peruvian Amazon and will conduct a rigorous quantitative assessment of the impacts of the program on deforestation.

FIGURE B.1

MAP OF GLAD ALERTS WITHIN AND AROUND THE COMMUNITIES OF NUEVO SAPOSOA AND PATRIA NUEVA



Notes: GLAD alerts from 2016 and 2017 (pink) in and around the communities of Patria Nueva and Nuevo Saposoa (outlined in blue).
Source: GLAD alerts from Hansen et al. 2016; community boundaries from RFUS.

The following sections provide more detail on the factors that have enabled or limited the effective use of NRT alerts in Peru.

Enabling Conditions

From the interviews and surveys, several enabling conditions were identified that have facilitated widespread uptake of NRT alerts among Peruvian actors and produced early successes in data use. These conditions include buy-in and dissemination by early adopters, relatively high levels of technical capacity, clear land zoning and mandate, institutionalized protocols, and interagency cooperation.

Early Adopters Engender Trust by Other Organizations

Interviews suggest that many organizations began using the alerts only after hearing about the use by early adopters Amazon Conservation and PNCBMCC.[34] Both Amazon Conservation and PNCBMCC had previous experience with Global Forest Watch and UMD data products,[35] which likely led to their initial interest and trust in the alerts.

Amazon Conservation was the first major user of GLAD alerts in Peru, using the alerts starting in March 2016 to regularly identify and report on deforestation events

as part of the MAAP.[36] These well-publicized reports were the first encounter with GLAD alerts for many government institutions and civil society groups in Peru.

PNCBMCC also began using the alerts to monitor their payment for conservation sites soon after they became available, and, crucially, added the alerts to the Geobosques platform.[37] Having the alerts on a government portal made them, ipso facto, official data. In the eyes of other institutions, this gave the alerts credibility and legitimacy.[38] The alerts and Geobosques platform also transformed PNCBMCC: shortly after adopting the alerts, PNCBMCC was officially designated the forest monitoring agency (Ministerial Resolution Nº 324-2015-MINAM). As part of this new mandate, PNCBMCC began offering trainings on how to use Geobosques and the alerts, which increased uptake by FEMA, SERNANP, and regional government agencies.[39]

Technical Capacity Facilitates Adoption of NRT Alerts

Existing technical capacity and capacity-building efforts led by PNCBMCC have also been crucial for the use of the alerts in Peru. Interviews indicate that the alerts are easiest to use when organizations have GIS staff that can access and manage the spatial data.[40] Compared to other tropical countries, GIS capacity is quite strong in Peru (e.g., Joseph et al. 2013).

Many of the organizations interviewed for this study already had technical staff able to cross-reference alerts with other contextual data sets (like concession boundaries), make custom maps, and create individualized reports.[41] PNCBMCC also provides technical trainings and support on GIS data management and remote sensing analyses to a handful of government agencies, including SERNANP (both central and regional offices), FEMA, and regional governments.[42] These analyses also require access to contextual data sets;[43] though some gaps remain, Peru has relatively open access to concession and landownership boundaries (Webb et al. 2017), which allows users to combine alerts with other data.

Non-GIS staff also require capacity-building to understand what the alerts mean and learn how to access and respond to them. PNCBMCC conducts regular trainings on how to use the alerts through the Geobosques platform, which have been widely attended by SERNANP protected area managers among others.[44] Trainings involve background information on the alerts and instructions on how to subscribe to email notifications for an area of interest. Whenever possible, PNCBMCC pairs the trainings with field visits to recent alerts, so participants can verify the accuracy of the alerts and understand better how alerts correspond to change on the ground. Despite these efforts, the capacity to use alerts is stronger in the capital city Lima than in the more remote Amazonian provinces. Regional government agencies require additional training on how to use NRT alerts in their work.

Much of the work to empower local landholders to assert their land rights also involves capacity-building efforts,[45] such as explaining what the alerts mean, training on maps and GPS equipment, and information collection in the field.

Institutionalized Protocols Encourage Uptake within Organizations

Agencies that build NRT alerts into institutional protocols seem to have the most success in applying them in their work. For example, SERNANP, which previously had individual park headquarters using the alerts on an ad hoc basis,[46] now incorporates the alerts into their existing monitoring methodology (Figure 2), whereby each protected area is divided into grid cells to assess where threats are occurring and determine future action.[47] The alerts serve as an input to the grid, and are used systematically across forested protected areas, contributing to several successful cases of halting illegal activity.[48] PNCBMCC has also defined a protocol around monitoring and verifying alerts within the communities that are part of their payments for the conservation program.[49]

Those organizations involved in empowering landholders to assert land rights and enforcing conservation agreements have similarly implemented protocols for responding to alerts (see example workflows in Figure 2).[50] This ensures that all alerts are assessed and, if deemed necessary, investigated in the field.

Clear Mandates Enable Effective Response to Alerts

Use of alerts was often most successful in areas where land zoning and the relevant land management agency responsibilities are clear. OSINFOR, for example, has successfully used NRT alerts for patrols and in legal cases, in part because their purview over areas under forest management is well established.[51] SERNANP has also had success applying alerts within protected areas, where there is little ambiguity on the illegality of forest clearing by outsiders, and where SERNANP has the authority to enforce the law.[52]

Interorganizational Cooperation Creates Accountability

Interorganizational cooperation has also led to more effective use of the alerts. Some of the most promising examples occurred when landowners worked with authorities to combat illegal activity. For example, the communities of Nuevo Saposoa and Patria Nueva collect information on illegal invasions of their land, which is then passed on to FEMA as part of formal legal complaints (see Box 2).[53] FEMA has responded to these formal complaints by launching investigations in the field.

Even in cases where there is no formal collaboration between governments and CSOs, civil society use of NRT alerts has sometimes improved government response to the alerts and underlying deforestation. For example, when Amazon Conservation's MAAP reports first began, SERNANP felt blindsided by the negative attention in the media regarding deforestation inside protected areas. Now, the two collaborate and share data and imagery, which helps SERNANP address illegal deforestation within protected areas and in neighboring buffer zones. In addition, Amazon Conservation now shares reports with SERNANP before they are published, giving its staff an opportunity to investigate allegations of illegality.[54]

The emerging SNCVFFS is a promising initiative to bring government agencies together to more proactively and efficiently tackle illegal forest activities. Under the SNCVFFS eight national-level and more than 30 subnational agencies could share information and implement a coordinated response concerning areas of clearing.[55]

Limitations

Though Peru has already seen widespread uptake of the alerts into its institutional processes and early successes, there are several factors that limit the use of and response to NRT deforestation alerts.

Data Shortcomings Hamper the Usefulness of NRT Alerts

The most prevalent limitations identified by the survey results (Figure 3) are related to limitations of the alert data itself. These are

- cloud cover hampering the coverage of alerts (66 of respondents said it is "a significant limitation");
- inability of alerts to distinguish natural from anthropogenic change, particularly in remote locations (55 said it is "a significant limitation"); and
- inability of alerts to distinguish among different types of vegetation (53 said it is "a significant limitation").

Interestingly, though the survey indicated technical weaknesses as the biggest limitations to use of the alerts, interviews suggested that governance and resource constraints were more pressing. The difference in responses may be related to the fact that the survey was sent to Geobosques subscribers, who might be more focused on the technical aspects of the alerts or factors that PNCBMCC can control.

Nevertheless, the top two limitations identified by the survey were also mentioned repeatedly by interviewees. Several interviewees worked in areas obscured by cloud cover most of the time, resulting in less frequent detection of alerts and thus limiting the potential for law enforcement action.[56] Also, some agencies rely on the date of the alerts in legal cases,[57] and cloud cover increases the time lag between the date deforestation happens and the date it is detected.

Although other organizations expressed concerns about the inability of the alerts to distinguish between anthropogenic and natural change,[58] this was one of the biggest limitations for SERNANP.[59] Given limited resources, park managers prioritize field visits to areas of anthropogenic change. However, they have found that many of the alerts detected within protected areas are due to natural causes (e.g., river meanderings, blow-down

events, etc.).[60] Staff within individual protected areas have developed protocols to get around this limitation, such as examining nearby threats, accessibility of the alert site, and recent satellite imagery.[61] In SERNANP headquarters, the ability to determine the origin of the change has improved over time as staff become more experienced in the use of alerts and use existing field knowledge.

Poor Internet Connection Limits Data Access

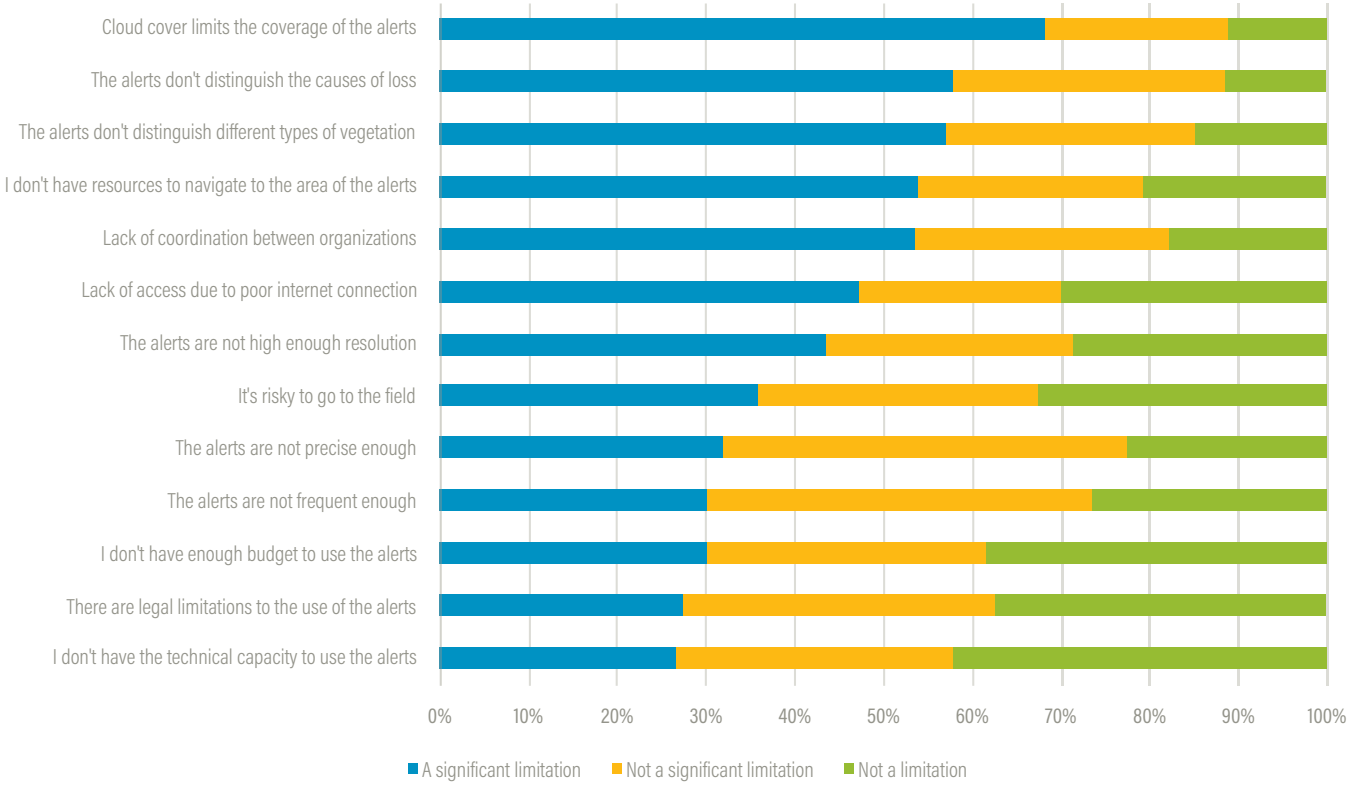
Access to the alerts in the field was also identified as a concern, particularly for protected area management and work with local landholders. Geobosques and Global Forest Watch make the alerts available to the public through online portals, but users are often in remote areas with limited internet connection, and therefore have trouble accessing the alerts.[62]

The lack of internet access creates a need for intermediaries to transfer data to local landholders and communities. Several of the CSOs interviewed for this study hoped that the landholders with whom they worked would be able to access alerts without their support, but cited lack of internet access as a major barrier.[63]

Poor internet access was less of a concern for agencies involved in enforcement and control,[64] as these agencies generally have their offices in, and plan field visits

FIGURE 3

SURVEY RESPONSES TO THE QUESTION "WHAT FACTORS LIMIT EFFECTIVE USE OF THE ALERTS IN YOUR WORK?" (N = 107)



Source: Authors, based on survey responses.

Though Peru has already seen widespread uptake of the alerts into its institutional processes and early successes, there are several factors that limit the use of and response to NRT deforestation alerts.

from, regional capitals, which have better connectivity. However, even in regional capitals, it can be challenging to download satellite imagery for additional analysis.[65]

Mistrust of Data Limits Uptake

As illustrated by the importance of early adopters in this case study, trusting the data is crucial for adoption of NRT alerts. At the time of the interviews, the GLAD alerts were transitioning to a new system and were not operational for a three-month period. This was of grave concern to those users that had developed internal protocols around the alerts and relied on them for their work.[66]

Because of the suspension of the GLAD alerts, PNCBMCC developed a similar methodology to create their own alert system.[67] Though the GLAD alerts have been back online since June 2017, PNCBMCC continues to operate their alert system, which is now in use by many of the government agencies interviewed in this case study. Several of the participants interviewed in this study now use both systems to corroborate results.

Users of the alerts find them useful and credible in general, but it has taken some time in the legal system to trust the data.[68] In a recent legal case in Sierra del Divisor National Park, for instance, one judge questioned the reliability of satellite analysis that showed the date of a road expansion.[69] Only by presenting multiple corroborating sources were prosecutors able to win the case. All this is changing, however, and actors in the legal system trust more the alerts and satellite data.

Safety Concerns Prevent Field Visits

Another limiting factor expressed by study participants was concern about their safety when responding to alerts in the field. Several of those interviewed said they had to avoid following up on alerts in certain cases due to safety concerns.[70] A third of survey respondents also cited personal safety as a major limitation to their use of NRT alerts. According to a report by Global Witness (2018), Peru had eight killings of land and environmental defenders in 2017.

Resources Constrain Follow-up Action to Alerts

A major limitation on the use of NRT alerts for law enforcement and control actions is the lack of financial and human resources for field operations. According to one prosecutor, "We have the information. . . the problem is getting there. The problem is action."[71] Field visits are often necessary for law enforcement; after all, the alerts cannot identify who is behind the deforestation or make arrests. For prosecutors in FEMA, field visits can be a major operation, involving the prosecutors, the competent authority (depending on the land management type), the police, and, depending on the specific case, the navy and the coast guard.[72] The law requires prosecutors to catch the perpetrator(s) in the act, so they often prioritize cases according to their ability to travel to the location and the possibility of finding the perpetrators at the location.[73] Regional government officials say the recent emergence of NRT alerts increases the pressure on them to respond, but without any additional resources to do so.

Several of the organizations working with local land-holders and communities also cited lack of resources for field visits as a limitation.[74] Boat fuel and other logistical costs can be prohibitively expensive,[75] as is necessary equipment such as GPS units.[76]

Notably SERNANP and OSINFOR, which both have regular field patrols in their relevant areas, did not identify lack of resources for field visits as a limitation.[77] SERNANP has begun to include field interventions based on alerts as part of their budget planning process.[78]

Governance Issues Prevent Positive Outcomes in the Use of Alerts

There are significant limitations related to the governance of the forest sector. There is mistrust of and lack of faith in the legal system and government institutions because of the inability to respond to legal complaints, and to corruption in general.[79] For example, when communities and concession holders use the alerts to document illegal activity and make formal complaints, and there is no response from the authorities, it reduces trust between actors and disincentivizes landholders to report illegal activities.[80]

As already noted, clear jurisdiction, government mandates, and effective interagency coordination enable successful use of the alerts. However, the forest governance structure in Peru is complex, with different government agencies involved at the national and subnational levels, which can lead to duplication and unclear responsibilities. For example, there seems to be very little clarity regarding which agency is responsible for controlling the expansion of logging roads in unzoned areas.[81] This is also true in Madre de Dios, where little action has been taken to remove illegal gold miners from the buffer zone of the Tambopata Reserve, in part because of unclear institutional responsibilities and jurisdictions in that situation (Weisse and Naughton-Treves 2016). Complex governance structures can also result in bureaucracy, poor coordination, and sluggish responses overall.

Finally, corruption is a key issue in Peru, with interest groups that benefit from maintaining the status quo. For example, in Madre de Dios, illegal miners are often tipped off about FEMA operations ahead of time and can hide themselves and their equipment (Weisse and Naughton-Treves 2016).

RECOMMENDATIONS

Improving Alerts and Access

The case study reveals several opportunities for improving the alerts themselves to make them more useful for law enforcement in Peru. According to survey respondents, lag-time of alerts due to cloud cover was the top limitation to their use—and is a common problem across tropical countries. Incorporating new satellite information, such

as the European Space Agency's Sentinel-2 satellites, could increase the frequency of monitoring, increasing the chances of cloud-free images. Efforts to incorporate Sentinel-2 data into GLAD alerts are already under way. Ground-based information and NRT fire hotspots data are additional inputs that could increase alert frequency.

The use of radar data, which can pierce cloud cover, is one potential solution to improve the time lag of NRT alerts. The European Space Agency's Sentinel-1 satellites, launched in 2013, represent the first freely available radar data source with consistent global coverage (Torres et al. 2012). Preliminary assessments in Bolivia suggest that using Sentinel-1 data can result in deforestation detection an average of 19 days earlier than GLAD alerts, and that combining Sentinel-1 with other data sources can decrease the time lag even further (Reiche et al. 2018). However, the complex topography of Peru creates noise in radar data that can make it unreliable, particularly in higher elevations and in the transition between the Andes and the Amazon.[82] PNCBMCC has participated in two independent initiatives testing radar monitoring, but so far neither has produced reliable results.[83] Additional research is needed, and work is under way to continue evaluating the options for incorporating radar data into monitoring in Peru.

In addition to cloud cover, another data limitation flagged by surveyed users is the inability to distinguish the cause of the alerts, particularly whether the change was natural or anthropogenic. Current automated methods for distinguishing drivers include analysis of

land-cover and land-use maps (e.g., Graesser et al. 2015) and pattern analysis (e.g., Curtis et al. 2018). However, as far as the authors are aware, these methods have not been applied successfully to NRT data. In the absence of automated methods, visual inspection of satellite imagery can help users better understand the alerts. Daily high-resolution (five-meter) images from the private satellite company Planet are helpful and used by several of those interviewed to determine drivers of deforestation based on visual inspection,[84] but require a paid subscription. Freely available Sentinel-2 images can also provide important information regarding drivers, though at a slightly lower resolution (10 meters) and frequency (every five days).

Data ownership and sustainability were mentioned often by interviewees, especially given that the pause in GLAD alerts during the study period. After the pause, the GLAD alerts are now operating automatically in Google Earth Engine, which should reduce the reliance on any one person. However, the pause highlights the need for back-up systems and processes, given so many institutions rely on the alerts. Interviewees were also concerned about what would happen if the funding for the alerts stopped. While this is unlikely in the short-term, it points to a need for long-term funding and operational commitments for a public good such as the GLAD alerts. PNCBMCC created its own alert system during the GLAD alert pause to have increased control over the system. In addition to running fully within PNCBMCC, the new system is also tailored specifically to Peru's forests, focusing only on primary forest areas and detecting changes at the subpixel level, which can better identify selective logging (Vargas et al. in review).

Finally, users cited the lack of internet access as a barrier to use of the alerts, especially for those in remote forested areas. The Forest Watcher mobile app from Global Forest Watch partially closes this gap by allowing users to download alerts on their phones, navigate to alerts offline, provide information on them, and upload the reports when they return to internet access. However, the most remote users do not have enough internet access to download the alerts in the first place or upload completed reports. Lack of internet access also makes it difficult to view high-resolution images for verification, as recommended. Geobosques and Global Forest Watch should continue to think creatively about how to ensure access to alerts and imagery for those in low-connectivity areas.

In addition to cloud cover, another data limitation flagged by surveyed users is the inability to distinguish the cause of the alerts, particularly whether the change was natural or anthropogenic.

Increasing Effective Use of NRT Alerts in Peru

The experience in Peru clearly demonstrates that NRT deforestation monitoring systems alone are not sufficient to precipitate action and response. Even a perfect monitoring system with accurate and consistent delivery would face challenges related to a lack of clarity about the responsibilities and jurisdiction of government agencies, limited capacity to use and understand the alerts, and a lack of resources to respond to them.

Based on the findings of this case study, we offer the following recommendations to increase the uptake of NRT systems in Peru and improve the outcomes from follow-up on alerts:

- **Increase and streamline interagency coordination.** Better information sharing and coordinated follow-up actions in the field between government agencies would improve responses to alerts, particularly in areas where jurisdictions are less clear. The SNCVFFS presents a potential new space for coordination between the various national and regional government agencies involved in forest law enforcement, and it will be an important test of how these agencies can work together efficiently and effectively. Further clarification of roles and responsibilities within the law would also greatly improve agencies' ability to act upon NRT alerts.

- **Increase resources and logistical capacity to support fieldwork.** While the government of Peru has expressed a strong interest in preserving forests and receives significant funding to do so (e.g., Office of the Prime Minister 2014), resources to support work on the ground are lacking. Increasing resources to both build capacity at the local level and respond to NRT deforestation alerts in the field could help alleviate a current bottleneck in the application of NRT data. Positive results from early use of NRT alerts may help provide justification for increasing resources devoted to field patrols and other enforcement activities in the future.
- **Strengthen technical capacity and alert institutionalization in regional governments and additional law enforcement agencies.** Regional governments are heavily involved in the management and control of Peru's forests but generally have lower technical capacity and resources than their counterparts in Lima. Additional technical training on the alerts and support for regional government agencies in developing protocols to streamline alert use and response could improve local efforts to tackle illegal logging and deforestation. For these actors, additional training on on and explanation of NRT systems could similarly increase their uptake and facilitate the use of alerts and other imagery as conclusive evidence in prosecuting environmental crimes.
- **Promote and strengthen the uptake of NRT alerts by indigenous and local communities.** The work of RFUS has demonstrated the potential of using NRT data and tools within indigenous communities in Peru. Programs aimed at communities, such as those operated by PNCBMCC and OSINFOR, should consider training the communities themselves to use NRT alerts to manage their lands. Further training on NRT alerts should also be paired with trainings to build communities' capacities for forest management generally and to provide access to additional sources of revenue to sustain their livelihoods, such as PNCBMCC's performance payment program.

Six Lessons for Other Geographies

As seen through the work of this study's authors, other national governments, conservation CSOs, and stakeholders involved in international commitments to reduce deforestation are interested in learning from the experience of Peru to use and create NRT deforestation monitoring systems. This topic is especially relevant now that the weekly GLAD alerts are available for the entire tropics, providing a wide variety of actors across the world with a potential tool for combating illegal deforestation.

Of course, the deforestation context differs between and even within countries, meaning what has worked in Peru may not work elsewhere. Nevertheless, we believe the experience of those using NRT alerts in Peru can provide useful insights for others interested in applying NRT monitoring as a tool to combat illegal deforestation in other countries and contexts.

The experience in Peru offers the following six lessons:

- **Buy-in by influential organizations can lead to widespread uptake.** Focusing on a small number of institutions that have the potential to spread the use to others can have an outsized impact. If the alerts are presented as part of an official government monitoring system, other government agencies may use them more freely and with confidence. In Peru, personal relationships between UMD and PNCBMCC staff facilitated the uptake of alerts as official data, suggesting that relationships and trust are key to early buy-in. CSOs are also important early adopters, as they are often more innovative and nimbler than government agencies.
- **Information use needs to be institutionalized.** Organizations that had protocols in place around use of NRT alerts made better use of them than those that used them on an ad hoc basis. It is worth investing the time to help organizations develop internal procedures and best practices around the alerts, as implementing protocols helps ensure that all staff are aware of the alerts and that their use continues over time.
- **Proactive training and capacity-building is essential.** Field visits are particularly useful for showing concrete examples of NRT alerts on the ground and helping potential users realize the potential of NRT alerts in their work. Capacity building is essential for both value-added GIS analysis and for responding to alerts in the field. Repeated trainings and access to technical support helps to ensure use, especially if in-country actors (such as those identified in lesson 1) are available for peer-to-peer experience sharing.
- **Clear land-zoning and agency responsibilities support effective monitoring.** Clear land allocation, laws regarding clearing, and agency responsibilities greatly increase the likelihood of an effective response to NRT alerts. Areas with clear forest zoning (such as protected areas and titled indigenous lands in Peru) represent "low-hanging fruit" for using NRT alerts. In addition, transparent spatial data on landownership can help organizations better understand and act appropriately regarding alerts.
- **NRT development should be paired with adequate resources to respond.** Although NRT alerts provide intelligence on where forests are changing at a previously unavailable scale, frequency, and level of detail, field visits are often required to fully understand the situation on the ground. Moreover, law enforcement agencies need to be properly funded and staffed to intervene in response to forests loss connected to illicit activities, particularly in remote forested areas.
- **NRT alerts can be a tool for building public pressure on law enforcement.** Civil society can use NRT alerts to put public pressure on law enforcement agencies to improve their performance. In places where government agencies are unwilling to act, engaging in advocacy and publicity around illegal or unsustainable deforestation detected by NRT alerts can increase pressure on law enforcement to respond. For this reason, it is crucial that NRT alert systems are open to the public and that CSOs have the capacity and funding necessary to make use of these systems.

APPENDIX 1: INTERVIEW QUESTIONS

Data

- How did your organization find out about GLAD alerts?
- How is your organization receiving GLAD alerts? What format do they come in? How often do you receive new alerts?
- What additional information do you use to contextualize the alerts and what level of detail (e.g., forest management polygons, who owns the property, what type of land use is authorized, etc.)? Do you need additional information?
- How often are there new GLAD alerts that you care about?
- Do you think GLAD alerts detect too much detail, not enough, or just right?
- Have you ever experienced a GLAD alert that is totally wrong about deforestation?
- Why do you use GLAD alerts in your work?
- What did you use before GLAD alerts?

Monitoring Action

- When you receive a new GLAD alert in an area of interest, what do you do?
- Do you visit or send someone to visit the location of the GLAD alert on the ground?
- What do you use GLAD alerts for?
- Have GLAD alerts changed the way you work? If so, how?
- How do the GLAD alerts improve the efficiency of your processes and financial and staff time resources?
- In your mind, what are the biggest obstacles to following up on GLAD alerts on the ground?

Coordination

- Do you send or otherwise distribute GLAD alerts to any other organizations, or to other people in your organization? If so, to whom, and how are they used?
- What other organizations do you know of that are also using GLAD alerts?
- Do you coordinate with any other organizations when responding to GLAD alerts, and, if so, how?
- In your mind, what are the biggest challenges to working with other agencies and producing results on the ground?

Response Action

- If you found a GLAD alert that you suspected was illegal activity, what would you do?
- Have you ever found illegal or controversial activity as a result of GLAD alerts? What happened?
- Do you know of any successful or unsuccessful cases of using GLAD alerts to hold those responsible for the tree cover loss accountable?
- In your mind, what are the biggest challenges to taking legal action as a result of information from GLAD alerts (capacity, financial, safety, etc.)?
- In your mind, what is the biggest potential for the use of GLAD alerts?
- Do you use GLAD alerts as evidence in official investigations or in court cases? Are GLAD alerts considered legally permissible evidence?

Impact

- Can you tell a specific story about using GLAD alerts in your work?
- Do you think GLAD alerts have helped to slow down deforestation in the areas you work? If so, How?
- In what situations or areas do you think GLAD alerts work the best?
- Do you believe illegal loggers or other perpetrators know they are being watched? What effect do you believe this has on their actions?

APPENDIX 2: ONLINE SURVEY QUESTIONS

1. What sector do you work in?

- ☐ Government (national)
- ☐ Government (subnational)
- ☐ Civil society
- ☐ Academia
- ☐ Private sector
- ☐ Financial sector
- ☐ Other

2. What is your main interest related to forests?

- ☐ Conservation
- ☐ Forest Management
- ☐ Production of non-timber forest products (e.g. cat's claw, Brazil nuts, rubber)
- ☐ Production of agricultural products (e.g. cacao, palm oil)
- ☐ Ecotourism
- ☐ Land tenure control
- ☐ Other

3. How do you use the alerts in Geobosques?

- ☐ I subscribe to the alerts using an area of interest already in Geobosques
- ☐ I visualize them
- ☐ I upload my own area of interest and subscribe
- ☐ I download the alerts
- ☐ Other

4. Do you use Global Forest Watch in addition to Geobosques?

- ☐ Yes, occasionally
- ☐ Yes, frequently
- ☐ No

5. How often do you access the alerts?

- ☐ Every day
- ☐ Weekly/monthly
- ☐ Rarely
- ☐ When I receive a notification through my subscriptions

6. Would you be interested in online courses/trainings?

- ☐ Yes
- ☐ No
- ☐ Maybe

7. What are the limitations for the effective use of the alerts in your work? [For each option select: not a limitation, not a significant limitation, it is a significant limitation, or not relevant.]

- ☐ The alerts don't distinguish vegetation types (e.g., primary forest vs. secondary vegetation)
- ☐ The alerts don't distinguish the causes of tree cover loss (e.g., natural vs. anthropogenic)
- ☐ The alerts are not high enough resolution
- ☐ The alerts are not frequent enough
- ☐ The alerts are not accurate enough
- ☐ Cloud cover limits the coverage of the alerts
- ☐ Lack of access due to poor internet connection
- ☐ I don't have the technical capacity to use the alerts
- ☐ I don't have enough budget to use the alerts
- ☐ I don't have resources to get to the site of the alerts
- ☐ There are legal limitations in the use of the alerts
- ☐ It's dangerous to go into the field
- ☐ Lack of coordination between organizations

8. Are there other limiting factors?

9. Describe briefly your use/application of the alerts.

10. What impact and results have you achieved through your use of the alerts?

11. Other feedback that you would like to share with us.

APPENDIX 3: LIST OF INTERVIEWS

1. Interview with Amazon Conservation, Lima, Peru, February 2017
2. Interview with the Peruvian Society for Environmental Law (Sociedad Peruana de Derecho Ambiental; SPDA), Lima, Peru, April 2017
3. Interview with Amazonians for the Amazon (Amazónicos por la Amazonía; AMPA), Lima, Peru, April 2017
4. Interview with the National Forest Conservation and Climate Change Mitigation Program (Programa Nacional de Conservación de Bosques para la Mitigación de Cambio Climático; PNCBMCC), Lima, Peru, April 2017
5. Interview with the Agency for the Supervision of Forest Resources and Wildlife (Organismo de Supervisión de los Recursos Forestales y de Fauna Silvestre; OSINFOR), Lima, Peru, April 2017
6. Interview with the National Protected Areas Service (Servicio Nacional de Áreas Naturales Protegidas por el Estado; SERNANP) Sierra del Divisor staff, Pucallpa, Peru, April 2017
7. Interview with SERNANP El Sira staff, Pucallpa, Peru, April 2017
8. Interview with Office of the Environmental Prosecutor (Fiscalia Especializada en Materia Ambiental; FEMA), Pucallpa, Peru, April 2017
9. Interview with Rainforest Foundation US, Pucallpa, Peru, April 2017
10. Interviews with Patria Nueva community patrol members, Pucallpa, Peru, April 2017
11. Interviews with Nuevo Saposoa community patrol members, Pucallpa, Peru, April 2017
12. Interview with SERNANP Office of Control, Lima, Peru, May 2017
13. Interview with SERNANP Office of Management and Information, Lima, Peru, May 2017
14. Interview with Green Gold, October 2017
15. Interview with the National Forest Service (Servicio Nacional Forestal y de Fauna Silvestre; SERFOR), Lima, Peru, November 2017
16. Interview with Amazon Conservation, Lima, Peru, November 2017

ABBREVIATIONS

AMPA	Amazonians for the Amazon (Amazónicos por la Amazonía)
CSO	civil society organization
DETER	Brazil's Real Time Deforestation Detection System (Sistema de Detecção de Desmatamentos em Tempo Real)
FEMA	Office of the Environmental Prosecutor (Fiscalia Especializada en Materia Ambiental)
GIS	geographic information system
GLAD	Global Land Analysis & Discovery lab of the University of Maryland
MAAP	Monitoring of the Andean Amazon Project
MINAGRI	Ministry of Agriculture and Irrigation (Ministerio de Agricultura y Riego)
MINAM	Ministry of the Environment (Ministerio del Ambiente)
MRV	monitoring, reporting and verification
NRT	near-real-time
OSINFOR	Agency for the Supervision of Forest Resources and Wildlife (Organismo de Supervisión de los Recursos Forestales y de Fauna Silvestre)
PNCBMCC	National Forest Conservation and Climate Change Mitigation Program (Programa Nacional de Conservación de Bosques para la Mitigación de Cambio Climático)
REDD+	Reducing Emissions from Deforestation and Degradation
RFUS	Rainforest Foundation US
SERFOR	National Forest Service (Servicio Nacional Forestal y de Fauna Silvestre)
SERNANP	National Protected Areas Service (Servicio Nacional de Áreas Naturales Protegidas por el Estado)
SNCVFFS	National Flora and Wildlife Monitoring and Control System (Sistema Nacional de Control y Vigilancia de Flora y Fauna Silvestre)
SPDA	Peruvian Society for Environmental Law (Sociedad Peruana de Derecho Ambiental)
UMD	University of Maryland
UNFCCC	United Nations Framework Convention on Climate Change
WRI	World Resources Institute

ENDNOTES

Key informant interview (KII) numbers can be found in Appendix 3

1. KIIs 2, 4, 5, 8, 14, 15, and 16.
2. KIIs 3 and 4.
3. KII 5.
4. KIIs 4, 5, 13, and 15.
5. KIIs 1, 3, 4, 5, and 9.
6. KIIs 5 and 8.
7. KIIs 2, 12, and 13.
8. KIIs 1 and 16.
9. KIIs 1, 3, 4, and 5.
10. KIIs 5, 6, 8, and 15.
11. KII 5.
12. KII 15.
13. KII 8.
14. KII 8.
15. KIIs 6, 7, and 12.
16. KIIs 12 and 13.
17. KII 12.
18. KII 14.
19. KIIs 2, 3, 9, 10, 11, 14, and 16.
20. KII 4.
21. KII 5.
22. KII 1.
23. KII 4.
24. KIIs 6 and 14.
25. KIIs 1, 3, 5, 8, and 9.
26. KIIs 2, 3, 8, 10, 11, and 16.
27. KII 1.
28. KII 4.
29. KII 13.
30. KIIs 1, 7, and 10.
31. KIIs 5 and 6.
32. KIIs 3 and 10.
33. KII 9.
34. KIIs 8, 9, 12, 13, 14, and 15.
35. KIIs 1 and 4.
36. KII 1.
37. KII 4.
38. KIIs 1, 8, and 16.
39. KII 4.
40. KIIs 2, 3, 6, and 9.
41. KIIs 1, 3, 4, 5, 8, 9, 12, 13, 14, and 16.
42. KII 4.
43. KIIs 1, 3, and 4.
44. KII 4.
45. KIIs 2, 3, and 9.
46. KIIs 6 and 7.
47. KIIs 6, 7, 12, and 13.
48. KII 13.
49. KII 4.
50. KIIs 2, 3, 4, 5, and 9.
51. KII 5.
52. KIIs 6 and 7.
53. KIIs 9, 10, and 11.
54. KII 13.
55. KII 15.
56. KIIs 6, 8, and 12.
57. KIIs 3 and 5.
58. KIIs 5 and 14.
59. KIIs 6, 7, and 13.
60. KII 13.
61. KII 7.
62. KIIs 3, 4, 6, and 9.
63. KIIs 2, 3, and 9.
64. KIIs 5, 12, and 15.
65. KII 8.
66. KIIs 4, 5, 8, 9, and 13.
67. KII 4.
68. KIIs 6 and 8.
69. KII 6.
70. KIIs 3 and 4.
71. KII 8.
72. KII 8.
73. KII 8.
74. KIIs 3 and 9.
75. KII 9.

76. KII 3.
77. KIIs 5 and 12.
78. KII 12.
79. KIIs 2, 3, and 9.
80. KIIs 3 and 9.
81. KII 6.
82. KII 4.
83. KII 4.
84. KIIs 1 and 4.

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PHOTOS

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FULL DISCLOSURE

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