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USAID LEAF TECHNICAL GUIDANCE SERIES FOR THE DEVELOPMENT OF A FOREST CARBON MONITORING SYSTEM FOR REDD+

Module EN: Developing a Reference Level for Carbon Stock Enhancements

WINROCK INTERNATIONAL

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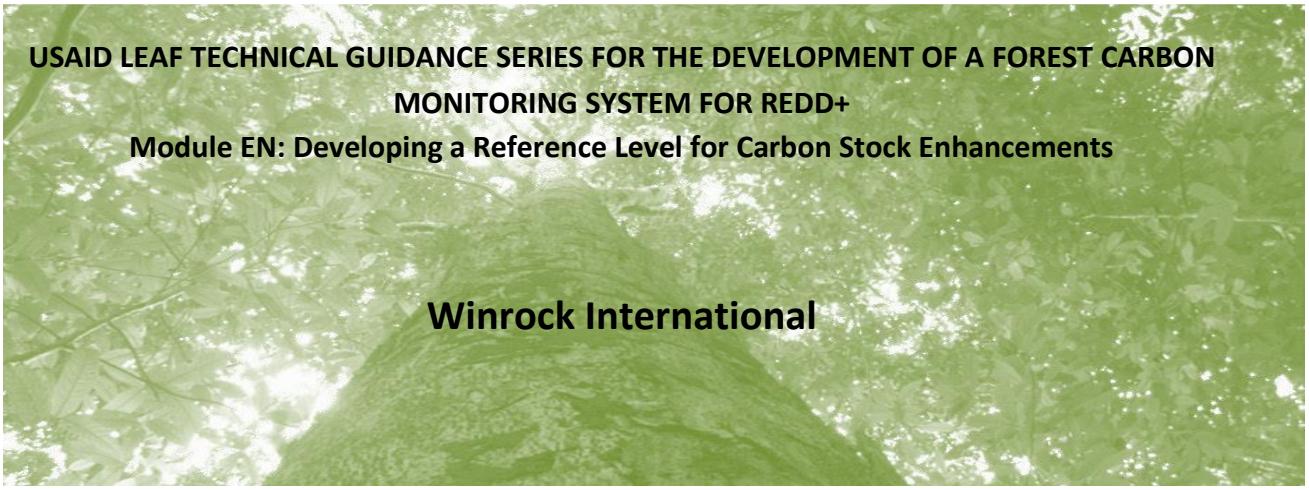

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Module EN: Developing a Reference Level for Carbon Stock Enhancements

Winrock International

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	A key technical step that must be accomplished before moving forward.
	The need for personnel with specified skill set
	An example
	A key term described in the framework
	A reference to relevant resource

1. SCOPE

Carbon stock enhancement refers to the creation or improvement of the capacity of carbon pools and reservoirs to store and sequester carbon. Within the REDD+ context, activities that are considered carbon stock enhancement[1] include afforestation/reforestation and forest management interventions to restore degraded forests. Under the category, removals associated areas that have changed from non-forest to forest are included. To include carbon stock enhancement within a national/subnational REDD+ program, the increase in the rate of sequestration resulting from activities introduced as part of the REDD+ program relative to historical or business as usual sequestration must be demonstrated.

This module offers a practical framework for developing a reference level (RL) under a REDD+ program against which management interventions that promote carbon stock enhancements can be assessed and credited. This module will offer a framework and general guidance on developing removal factors (RFs) for enhancement activities, as well as how to pair activity data (AD) from enhancement activities with RFs to produce estimates of carbon removals over time. The creation of AD for enhancement activities will also be discussed, but given the great diversity and complexity of practices that can be considered enhancement activities, this document does not offer proscriptive guidance on this.

[1] The UNFCCC describes five mitigation activities under the forestry sector: (1) Reducing emissions from deforestation, (2) Reducing emissions from degradation, (3) Conservation of forest carbon stocks, (4) Sustainable Forest Management, and (5) Enhancement in forest carbon stocks.

This guidance assumes that key prerequisite decisions, data and technical capacity (e.g. hardware, software, and experts) are fulfilled as described in the Technical Guidance for the Development of a Terrestrial Carbon Monitoring System for REDD+ Framework document.[2]

2. PRODUCTS

The output of this module is a framework for building a reference level for historical removals from enhancement activities at national or subnational level, across all strata and carbon pools, reported on annual basis (t $CO_2e.yr^{-1}$).

3. INTRODUCTION

As with the development of a RL for deforestation and degradation under a REDD+ program, estimating historical carbon removals from enhancement activities involves the pairing of activity data (AD) which describes the extent of the activity over a defined historical period, with the magnitude of the carbon impact of that activity per unit of area. As deforestation and degradation activities result in emissions, the magnitude of their carbon impact per unit of area is called an emission factor (EF). Carbon stock enhancements result in the removal of carbon dioxide from the atmosphere, and therefore the magnitude of the carbon impact per unit of area of this activity is called a removal factor (RF).

Tracking and measuring impacts of carbon stock enhancement activities over time presents unique challenges for REDD+ Measurement, Reporting, and Verification (MRV) Systems. This is because carbon stock enhancement activities include a wide range of management practices ranging from reforesting unproductive and degraded grasslands, to intensifying tree planting within managed natural forests, to understory planting and restocking of degraded forests, to expanding agroforestry practices within a

Box 1: Defining Carbon Stock Enhancements

Under the UNFCCC, carbon stock enhancements are defined as the creation or increase forest carbon stocks resulting from a change of land use from non-forest to forest and in forests remaining forests.

Careful consideration should be dedicated to defining exactly what can be considered carbon stock enhancements with the REDD+ program. For example, stock enhancements in forest remaining forests subject to formal management such as production forestry or conservation processes should not considered in this activity, since they are accounted for in the other REDD+ activities defined formally by the UNFCCC (i.e. the 'sustainable management' and 'conservation' mitigation activities).

Furthermore, while changes from homogenous (or monospecific) forest plantations to native forest or biologically diverse plantations should be considered in this activity, any enhancements occurring in areas converted from native forests to monospecific or biologically diverse forest plantations should not. It may be more appropriate to consider the latter as forest degradation.

[2] Available on the USAID LEAF website here: http://www.leafasia.org/library/technical-guidance-series-framework-document

province. These different activities sequester carbon from the atmosphere at different rates and are highly dependent on management and species composition.

Furthermore, in contrast with deforestation/degradation events where emissions are typically assumed to occur immediately allowing a single emission factor to be applied per unit of activity data, carbon removals from tree establishment and growth happen gradually over time. While the concept of 'committed sequestration' could theoretically be applied to enrichment or enhancement activities, this ignores the reality that carbon stock enhancement activities may fail due to unforeseen natural or anthropogenic events. As such, enhancement activities must be monitored over time, and business as usual cannot be assumed to uniformly follow an anticipated path.

Another important consideration is the fact that the rate of carbon removals from enhancement activities is also not typically constant or linear. For example, the carbon sequestration rate for a mangrove afforestation project on 30 hectares between years 0-5 will be considerably different than the same afforestation project over the same area between years 15-20.

Approaches for developing a reference level for removals

A RL will generally be set for a defined period, i.e. 5 or 10 years. It may be based on the **average historical carbon sequestration rate of enhancement activities** over, for example, a ten year historical reference period.

Alternatively, a **dynamic RL that reflects the actual accumulated stocks** in the trees planted through the enhancement activity could be generated. It would track removals by pairing the area planted (AD) during the historical reference period with the modeled growth rates of the enhancement type which may be derived from the IPCC and literature. During the crediting period, enhancement activities would need to be undertaken at a rate exceeding the historical rate to achieve additional sequestration (occurring after

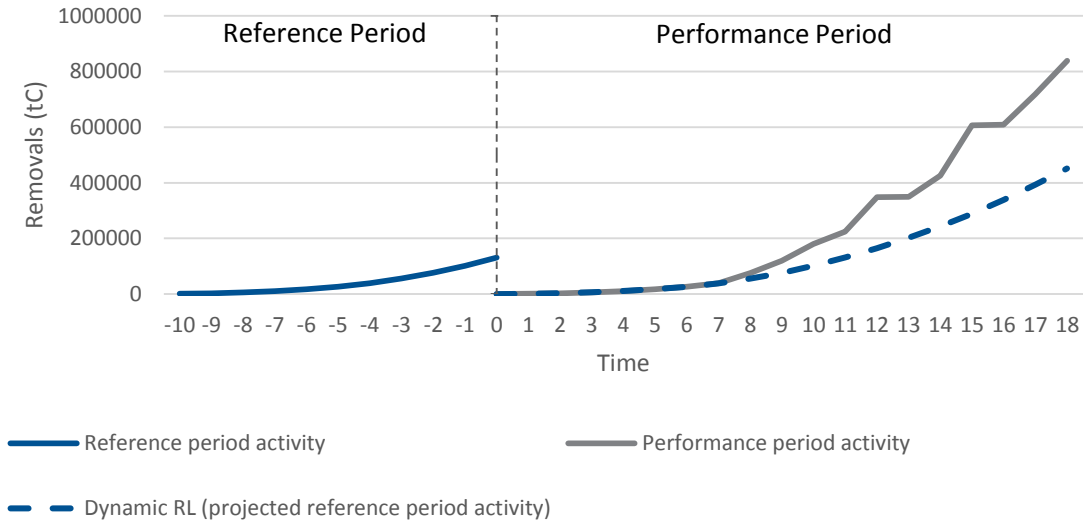

Figure 1 Schematic of a dynamic reference period

year 7 in Figure 1). This approach could be taken, yet would likely prove overly burdensome to realize in a MRV system and would not be considered by many be a true RL.

As such, this document will describe the development of a RL based on **historical average carbon sequestration rates** over a historical reference period.

Selecting Enhancement Activities to Include

An essential step in developing a carbon accounting approach for forest enhancement activities is defining the enhancement classes that will be included. As discussed in the introduction of this module, different management practices and species compositions can be considered forest enhancement activities and may have distinct measurement and monitoring implications. Therefore, enhancement activities to include within a REDD+ MRV system must be carefully considered.

Establishing which enhancement activities to include and how/if they will be categorized (e.g., by management practice, by species or species groups, or crop systems planted) will depend on national circumstances, an assessment of where the greatest opportunities for removals are under a REDD+ program, and the availability of resources for measuring and monitoring impacts from carbon stock

Box 2: Vocabulary

Establishment vs. Enrichment

There are two main categories that carbon enhancement activities fall into based on the distinct measuring and monitoring requirements involved:

Establishment of new areas of trees on previously *non-forest lands* (either tree planting or natural regeneration). Examples of establishment activities include planted forests and woodlots as well as assisted natural regeneration.

Enrichment of carbon stocks by increasing the stocking and growth of trees in areas that are already forest. Examples of enrichment activities are increasing the stocking and planting trees in degraded systems with arrested succession.

Some activities may fall into either category, including agroforestry, restoration.

Afforestation vs. Reforestation

While both terms refer to tree establishment on non-treed land and are treated equally in terms of accounting, there is a distinction:

Afforestation refers to the establishment of forest through planting and/or deliberate seeding on land that, until then, was not classified as forest.

Reforestation refers to the establishment of forest cover on land that had recent tree cover.

enhancement activities. This process should also consider the monitoring and measuring differences between forest establishment and forest enrichment activities (see box 2).

4. DEVELOPING HISTORICAL RATES OF CARBON STOCK ENHANCEMENT

To develop historical rates of carbon stock enhancements, it is necessary to examine the extent of enhancement activities over time for each category of carbon stock enhancement of interest (e.g., degraded grassland restoration, enhancement plantings in degraded forests, agroforestry and silvopasture establishment, etc.). This involves assessing enhancement activities undertaken historically and determining whether enough data exist to support the development of RFs and historical AD.

Choosing a Historical Reference Period

The determination of a historical reference period is highly dependent on national circumstances and data availability. The historical reference period for carbon stock enhancements should capture any significant enhancement activities, and the success (i.e., survival rates) of those activities, taking place in the recent past. This will inform the development of a RL that reflects business as usual carbon emissions or removals that would happen in the absence of REDD+ interventions to allow for accurate crediting of removals that can be attributed to the REDD+ program.

The historical reference period should be the roughly ten-year period before the start of the REDD+ program initiation[3], although important considerations must be made to ensure the reference period accurately reflects business as usual circumstances. A careful evaluation of public or private initiatives to establish tree cover should be undertaken. For example, if a government program to incentivize tree planting to combat desertification has been ongoing for the past seven years, the historical reference period should at least include those seven years. Furthermore, there must be sufficient data on forest enhancement activities from the historical period. Ideally, the data for each enhancement category should come from at least three well-distributed points in time within the historical reference period selected.

Historical Activity Data and MRV Considerations

An assessment should be conducted to determine whether there is capacity and/or technology to adequately estimate the historical extent of activity per enhancement type. Each enhancement type selected to be incorporated in the RL and MRV system will need to be defined and stratified. Furthermore, in accordance with the one of the core IPCC reporting principles of consistency, the application of any approaches and technologies for collecting such activity data must also be practicable under an MRV system implemented to track emissions under a REDD+ program.

[3] The Forest Carbon Partnership Facility (FCPF) Carbon Fund Methodological Framework stipulates that the start date the historical reference period should be about 10 years before the end date, although a start date exceeding 10 years is allowed if convincing justification is provided (but must still be within 15 years of the end date).

Under a REDD+ program, full accounting for enhancements would include removals from lands converted to forest before and during the reference period that continue to sequester carbon once the REDD+ program starts. This would support continued efforts to maintain enhancement activities that were undertaken before the REDD+ program initiated. However, data availability may not allow for this, as full accounting would require land cover maps representing enhancement activities undertaken during the reference period as well as for dates preceding the reference period as enhancement activities may continue to sequester carbon for extended periods of time.

Removals from areas converted into forest areas before the reference period could be ignored, yet respecting the IPCC principle of consistency, the accounting during the performance period would have to also exclude removals coming from converted forest during the reference period. The result would be a reference level that could not be reached during the early period of performance until enough removals have accumulated over several years (roughly half way through the performance period) to exceed the average reference period removals as shown in figure 2.

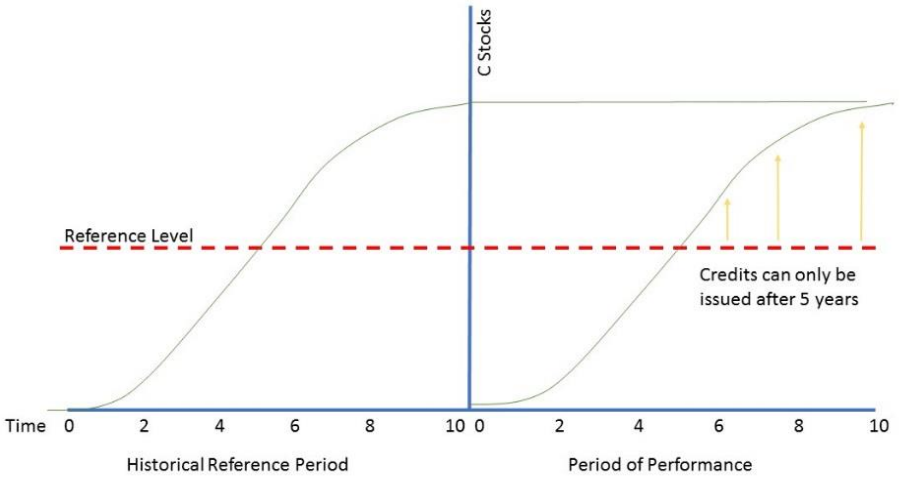

Figure 2 MRV accounting based on RL constructed using average removals

Nevertheless, enhancement activities undertaken within the historical reference period may still be considered under a REDD+ program under the category of 'forest remaining forest' and any losses in areas that previously included in the enhancement category be considered deforestation.

For the development of activity data for a reference level, the historical extent of enhancement types must be understood in a spatially explicit manner and it is likely that historic records of planting will be insufficient unless they include mapping inputs such as GPS coordinates. The following sources of data and technologies can applied to develop activity data:

Remote Sensing products can detect forest area changes[4], however, there are important limitations that must be accounted for. Currently, remote sensing is much more reliable for determining presence or absence of forest rather than the relative crown cover of forest. Even where enrichment shows up in remotely sensed imagery, determining whether natural forest recovery is being captured or forest restoration as a result of human intervention will remain a challenge[5]. Using higher resolution (and therefore higher cost) imagery would resolve some of these issues, but enrichment activities may necessitate a greater ground survey focus. See Annex 2 for important considerations in using remote sensing technology to track activity data for carbon stock enhancements.

A **ground-based survey** of historical annual rates of restored forest landscapes can be conducted through examination of historical records of forest enrichment or expansion. The records on forest enrichment/establishment should reflect data collected at regular intervals and should be geographically specific (spatially explicit). These data could go into a national/subnational database that will allow for the proper accounting of expansion or shrinkage of enhancement activities, and avoid either double counting or underestimation of areas restored in the past.

5. DEVELOPING REMOVAL FACTORS

Data for Removal Factors

To develop the average removal factors, sufficient data must be available that describe the typical lifespan of enhancement types as well as the average maximum amount of carbon an enhancement type may accumulate over its lifetime per a defined area (e.g., t C/ha).

The data needed to construct the average carbon accumulation of enhancement types can be sourced from existing data, although it is likely that studies will need to be conducted to assess the carbon sequestration patterns of at least some of the enhancement activities for which a performance threshold will be developed. Some common approaches for collecting data on carbon stock accumulation in enhancement types are outlined below.

Permanent plots: The establishment of permanent sampling plots in areas where enhancement activities are taking place can allow for the measurement of standing carbon stocks at regular intervals. If they are to be used to develop removal factors, the permanent sampling plots must be established following an appropriate sampling design per forest type stablished. In general, permanent plots are very costly to maintain and monitor in the REDD+ context, but may be worth exploring if there are appropriate existing data from permanent plots.

Chronosequence sampling: The establishment of temporary sampling plots in each enhancement forest type across various ages of development can be used to estimate carbon sequestration. Under this approach, stands of each forest type/enhancement activity included in the RL at various ages of

[4] Within a national MRV system, the same remote sensing products that are used for measuring forest loss (deforestation) can be used to measure forest gain, with a few caveats - see Annex 1.

[5] Enhancement activities included within a REDD+ program must be anthropogenic.

development (i.e. years since establishment) must exist to permit sampling each of the forest types at different ages. If this approach for collecting data to contribute to the development of RFs is taken, the age of forest areas being sampled must be known so that carbon stocks data can be associated with a given age for derivation of a curve of carbon sequestration.

Published models or data: This approach relies on the existence of previous published studies on carbon accumulation rates or the use of IPCC tier 1 default rates of carbon accumulation from IPCC (2006). Only reliable and published growth models and/or carbon accumulation data, which are representative of the enhancement activity(ies) can be used to estimate the carbon sequestration potential. This presents the lowest cost option but relies on pre-existing data and analyses.

The data on carbon content of enhancement types used to construct removal factors data must reflect at least the aboveground biomass content of the enhancement type as it will comprise the most significant carbon pool in most forest types. Other carbon pools may be included such as belowground biomass, but the inclusion and exclusion of carbon pools must be consistent across all enhancement types included in the reference level for carbon stock removals.

Removal Factor Construction

As discussed above, the development of removal factors for carbon stock enhancement activities presents a particular challenge due to the fact that carbon removals for the range of enhancement categories may occur at different rates through time. Therefore, it is reasonable to simplify it as an average rate of carbon accumulation over the lifetime of the enhancement type. This is demonstrated in Figure 3 where the actual carbon accumulation (blue line) and average carbon accumulation rate (red line) of carbon stock enhancements type x is demonstrated.

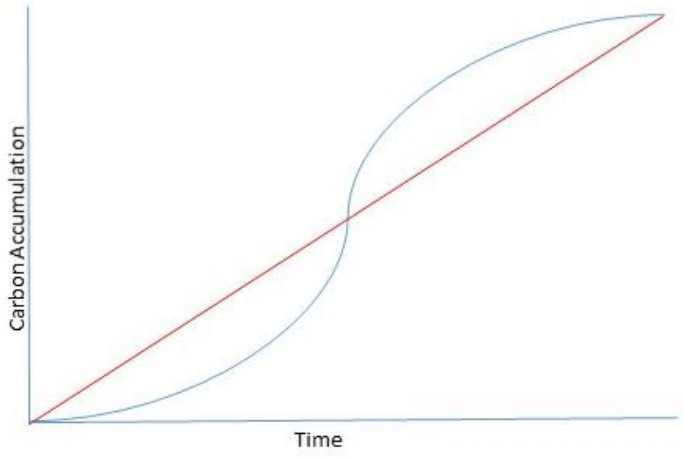

Figure 3 Schematic of the average carbon stock accumulation of enhancement type x

The average carbon accumulation rate can be described by applying the following formula:

$$RF_i = C_i/t * \frac{44}{12}$$

Where:

RF_i	Averaged removal factor for stratum *i*, t CO_2e/ha
C_i	Total carbon stocks for stratum *i,* per hectare
t	The number of years in the average lifetime of stratum *i*

6. CONSTRUCTING A REFERENCE LEVEL

The basic methodology used to calculate removals for each enhancement type is to multiply activity data per enhancement type by its corresponding removal factor.

When estimating historical removals it is important to ensure that:

- The units used for the removal factors (e.g. $tCO_2e.ha^{-1}$) and the units used for the activity data (e.g. $ha.yr^{-1}$) match so that emissions are expressed correctly in tonnes of carbon dioxide equivalent per year ($tCO2_e.yr^{-1}$).
- Historical removals are calculated by the identified strata (i.e., enhancement type).
- Removals for the selected stratum are summed across strata to provide total removals from enhancement activities.

The following formula may be applied to estimate the removals for enhancement types within the REDD+ program over the established historical reference period. This value will serve to indicate the average annual carbon removals that have been achieved during the reference period, and therefore can serve as the reference level.

To estimate the reference level per stratum:

$$RL_i = \sum_t (A_i * (RF_i * t))$$

Where:

RL_i	The reference level for stratum *i* (t CO_2e)

A_i	Mean annual area of stratum *i* establishment over the reference period (ha) **(AD)**
RF_i	The averaged removal factor for stratum *i*, t CO_2e/ha/yr **(RF)**
t	The number of years the reference period includes

ANNEX 1 –MONITORING REMOVALS ONCE REDD+ PROGRAM HAS INITIATED

During the REDD+ period of performance (i.e., monitoring period), the same RFs developed can be paired with monitored enhancement activities to quantify the impacts of enhancement activities introduced as part of the REDD+ program. Monitoring removals from carbon stock enhancements during the period of performance can be described by applying the following formula:

$$MRV_i = \sum_t (A_{i,tx} * (RF_i * t))$$

Where:

MRV_i	The measured sequestration for stratum *i*, t CO_2e/ha
A_{itx}	The measured area of REDD+ enhancement activities for stratum *i* in year *t*, ha
RF_i	Removal Factor for stratum *i,* t CO_2e/ha
t	The number of years for which removals are being calculated during the monitoring period.

ANNEX 2 – REMOTE SENSING PRODUCTS TO TRACK ENHANCEMENT ACTIVITIES

Several remote sensing products are available to measure forest area change. The same products that are used for measuring forest loss (deforestation) can be used to measure forest gain, with a few caveats.

When choosing a remote sensing product, it is important to take into account the forest definition of the targeted area. If the national forest definition determines that areas that are included as forest are smaller than can be determined from the resolution of the imagery used, then actual forest area and changes in forest area may not be fully accounted for using remote sensing products alone. For example, Rwanda's forest definition states that the minimum area of forest is 0.05 ha, which can only be fully detected where the remote sensing product has a cell size of ~22.4 m x 22.4 m or smaller. Broad scale imagery is typically inexpensive or free to attain, and inexpensive to analyze but will not have the resolution to capture small areas of forest restoration.

The scale of the area to be measured is also an important consideration when computing area of forest change. Ideally, the measurements would take into account the entire area (in the case of a jurisdiction or country, this would be a "wall-to-wall" approach). However, in the case of large jurisdictions or countries, or when using expensive imagery, it may be more appropriate to sample a fraction of the entire study site

for measurement. Samples can be selected based on a variety of criteria, but for measuring forest gains it is important to select a representative sample of the targeted area (i.e. that includes the same proportion of area for each stratum, or that present the same dynamics of forest gains across the entire targeted area).

Where the focus is on enrichment rather than expansion of forest areas, significant additional challenges arise for remote sensing. Currently, remote sensing is much more reliable for determining presence or absence of forest rather than the relative crown cover of forest. Using moderate resolution imagery, it may be difficult or at least require highly-advanced analysis to identify enrichment of a degraded forest. Most basic analysis techniques will classify such degraded lands as either non-forest (if highly degraded) or as forest. Recorded “non-forest” areas will subsequently see gain in forest cover as with forest area expansion but for areas recorded as “forest”, the enrichment will often not show up in remotely sensed imagery. Even where enrichment shows up in remotely sensed imagery the challenge will remain of determining whether natural forest recovery is being captured or forest restoration as a result of human intervention. Using higher resolution (and therefore higher cost) imagery would resolve some of these issues. Alternatively enrichment activities may have to have a greater ground survey focus.

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