# WORKING PAPER

# Leakage from an Avoided Deforestation Compensation Policy: Concepts, Empirical Evidence, and Corrective Policy Options

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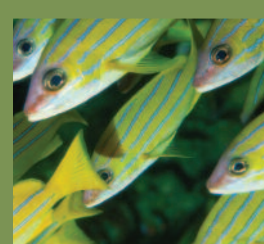
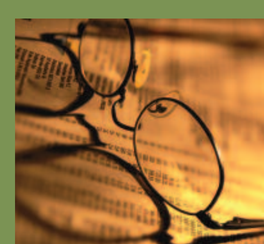
June 2008
NI WP 08-02



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This paper is a longer version of a chapter of the forthcoming book, *Avoided Deforestation: Prospects for Mitigating Climate Change*, C. Palmer and S. Engel, eds. (Oxford, UK: Routledge, 2009).

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## 1. Introduction

The accumulation of greenhouse gases (GHGs) in the atmosphere is inextricably linked to activities on the ground via the global carbon cycle. Activities in land use, land-use change and forestry (LULUCF) remove carbon dioxide ($CO_2$) from the atmosphere by sequestering carbon in trees, other vegetation, and soils, but can also increase GHG concentrations through the release of carbon stored in forested ecosystems via deforestation. The main ways in which forestry can mitigate GHGs and thereby reduce the threat of climate change can be classified as follows:

1. *Afforestation and Reforestation (AR)*: Building new terrestrial carbon stocks by establishing trees on non-forest land through afforestation or reforestation (AR)
2. *Forest Management (FM)*: Enhancing existing forest carbon stocks through changes in management practices
3. *Avoided deforestation (AD)*: Reducing the incidence and emissions from the conversion of forest cover to less carbon-intensive land cover.

Some also include reduced emissions from forest *degradation* in this list of LULUCF mitigation activities.[1] The collective term for this activity is reduced emissions from deforestation and degradation (REDD).

Deforestation, most of which takes place in tropical countries, is by far the largest source of emissions from the LULUCF sector. Tropical deforestation accounts for up to about one-fifth of global anthropogenic GHG emissions (Gullison et al 2007). Developing countries are not subject to binding GHG reduction commitments under the UN Framework Convention on Climate Change (UNFCCC) at this time and thus deforestation and its corresponding emissions remain largely outside of global climate policy targets. An initial proposal to include avoided deforestation emissions into the UNFCCC process was advanced at the UNFCCC 11th Conference of Parties meeting in Montreal in 2005. The proposal, made on behalf of Papua New Guinea by a

[1] The Food and Agricultural Organization (FAO) defines forest degradation as "changes within the forest class (from closed to open forest), which negatively affect the stand or site and, in particular, that lower the biological productivity capacity and diversity." (FAO Forest Resources Assessment 2000 definitions, http://www.fao.org/docrep/003/x6896e/x6896e0e.htm)

Coalition of Rainforest Nations (CFRN) would allow developed (Annex I) countries faced with GHG emission commitments to meet part of their commitments by paying non-regulated (non-Annex I) countries, largely from the developing world, to reduce emissions from deforestation. Alternative proposals, discussed toward the end of the chapter, separate REDD compensation from the international commitments and carbon market, but the basic principles of targeted compensation and leakage risks discussed herein would still be relevant nonetheless.

This is not the first time that the international community has considered ways to compensate parties for REDD activities. The first such approach was during the design stages of the Kyoto Protocol, the component of the UNFCCC that imposes binding emission commitments for Annex I countries. Those commitments can be met in part by the development of GHG ("carbon") offset projects producing emission reductions or sequestration of carbon from uncapped sources (countries or sectors). Under a project-based system, emission reduction activities are undertaken by entities that are not otherwise required to cut their emissions. These projects involve purposeful action to reduce net emissions below some level. The amount of the reduction can then be used to offset emissions from capped sources. Compensation is usually paid to the project developer when the emission offset they create can be used as a compliance mechanism by the capped entity, thereby allowing them to forego their own emission reduction while meeting the overall emissions cap. In the case of LULUCF, emissions and carbon storage are likely to remain outside of any national caps, due to their dispersed nature.

Under the Kyoto Protocol, project-level participation by non-Annex I countries occurs primarily through the *Clean Development Mechanism* (CDM).[2] The purpose of the CDM is to allow participation of developing countries in climate mitigation on a voluntary, incentive-based (rather than penal) foundation, while creating economic and sustainable development opportunities for developing countries and low-cost mitigation options for Annex I countries facing GHG caps. CDM projects can occur

[2] Projects may also take place in uncapped sectors in Annex I countries under the Joint Implementation (JI) provisions of the Kyoto Protocol, but given the primary incidence of deforestation in developing countries, the Clean Development Mechanism (CDM) is the relevant focus here.

in most emitting sectors, but in the LULUCF sector, activities are currently limited to afforestation and reforestation (AR).

After much deliberation, avoided deforestation was not included as a CDM activity in the first phase of the Kyoto Protocol. The exclusion of avoided deforestation from the CDM can be attributable to two main factors:

> ***Sovereignty*****:** the concern that avoided deforestation projects arranged between internal and external entities might undermine the economic development and land use plans of the host country
>
> ***Integrity*****:** the notion that emission reductions from avoided deforestation will be difficult or impossible to measure, monitor, and demonstrate that they are real reductions

The *sovereignty* issue stems from concerns that nations may forego control of their own land use and economic planning by allowing locals to negotiate compensation for forest protection through REDD projects (World Agroforestry Centre; Peskett et al, 2006). Even a voluntary action to avoid deforestation that produces payments to and positive profits for landowners within a country might create negative externalities for other economic stakeholders within the country. For instance, those who might earn a living harvesting the forest or producing agricultural goods on the deforested land may not be compensated for their foregone opportunities even if the landowner is compensated for foregone revenue. Moreover, countries may have well-developed economic and land use plans that target certain areas for clearing and other areas for protection that could be undermined by a decentralized project-based system. Many of these problems, of course, could also be attributed to A&R CDM projects, which ultimately were allowed under the Kyoto Protocol, or could be addressed by central coordination of projects and ensuring consistency with national land use plans. Nonetheless, avoided deforestation projects alone were perceived as a threat to sovereignty by some, and this concern was instrumental in their exclusion from the CDM.

The *integrity* issue alludes to the difficulty in determining whether a project produces real reductions. Regardless of whether the compensated reduction of deforestation emissions is tied to a global carbon market— but perhaps emphatically if it is—it is important to ensure that compensation is paid for real emission reductions only. The first order of business in determining "real" reductions is that they should be measured, monitored, and verified using scientifically valid methods and data of an appropriately high quality (Brown et al, 2007; Defries et al, 2006; Olander et al, 2008). But the focus of this chapter is on accounting dimensions of the problem rather than on measurement and monitoring, though the two are clearly related.

The core of the real reductions issue is that while a project accounting system can be set up to adequately track emissions for the project area for a given period of time, it may not capture factors that are out of a project's direct control, even though they affect the project's net GHG benefits. To demonstrate that emission reductions are real, a project's emission reductions receiving credit or payments within the system should have the following characteristics:

- ***Additionality*:** emissions are below what they otherwise would be without the policy,
- ***Permanence*:** deforestation emissions are reduced for good and not simply shifted to another period
- ***Absence of leakage*:** emissions are not simply shifted to another location or sector where they remain uncontrolled or uncounted

The concepts of additionality, permanence, and leakage have been cornerstone concerns for project-based GHG mitigation policy almost since its inception, particularly in the LULUCF sector (IPCC 2000; Murray et al, 2007). These issues have been dealt with adequately in some sectors, as project-based methodologies have been tested, approved, and implemented in the field across several different sectors and regions. However, the CDM has had very limited success in the LULUCF sector, with only one of the nearly 800 approved projects being an LULUCF afforestation project (CDM Statistics). Meanwhile, deforestation continues to mount in developing countries, as efforts to reverse it cannot overcome the various economic and institutional factors driving the trend. Given the exclusion of deforestation from the CDM and the failure of the CDM to substantially enhance forest carbon sequestration, it is no surprise that new approaches are now being considered to provide substantial incentives for reducing emissions from deforestation and forest degradation (REDD) as part of the international climate policy framework.

Current proposals for including avoided deforestation emissions in international climate policy regimes, including the proposals now being considered in the UN Framework Convention on Climate Change (UNFCCC) have focused on national-level approaches in part to combat the leakage problems found in the project-based approaches. Nonetheless, leakage risks still persist with a policy that will likely only have partial international coverage and they should be addressed in developing avoided deforestation compensation policies. Policy development is moving ahead with the somewhat vague notion that leakage is problematic and needs to be addressed, but with a less than complete picture of why it occurs, how big a problem it might be, and what can be done to minimize its impact on the success of the policy. The purpose of this chapter is to shed some light on these issues.

The chapter continues with a discussion of leakage concepts and their economic roots. This is followed by a synthesis of the empirical evidence to date from studies that have directly or indirectly estimated leakage magnitude for avoided deforestation policies. A discussion of how policies can reduce leakage opportunities and deal with the leakage that remains in the system follows.

## 2. Leakage Concepts

In the context of GHG controls, leakage occurs when efforts to control emissions in one place cause emissions to shift to another place that is not subject to the policy. The potential for leakage arises when rules, regulations, and incentives for action affect only part of the potential participants. A REDD program is likely to be limited in coverage. In particular, most policy proposals are being targeted exclusively at tropical forest nations that have not signed up to binding GHG reduction targets under the Kyoto Protocol. The REDD policy is likely to be voluntary, meaning countries can opt out and not be subject to compensation and the terms thereof. If a country does not opt into the program, it cannot receive compensation for reducing deforestation. But it will also not be penalized for any deforestation that occurs. In that case, they have neither positive nor negative incentives to reduce deforestation.

See Figure 1. Under the circumstances just described, leakage can occur when forests are protected in Country A via a REDD-compensated reductions program, but the activity that placed pressure on the forest (e.g., land-clearing for agriculture) and the corresponding emissions gets shifted to Country B, which is not covered by the program. Suppose Country A worked hard to develop, implement, and enforce policies and market institutions that reduce deforestation by 1 million hectares per year and reduce emissions by 100 million tons of $CO_2$. But if the deforestation what would have occurred in Country A (e.g., to supply global timber or agricultural markets) moves some of this activity (e.g., 0.4 million ha of deforestation, generating 40 million tons of $CO_2$ emissions) this can clearly undermine the success of the compensated reduction policy and undermine its integrity if it is not properly accounted for.

### *Economic Foundations of Leakage*

The primary drivers of leakage are economic. LULUCF activities have special characteristics that not only make leakage an important factor to consider, but that also make it complicated to estimate. First, society places demands on the goods and services produced by land, but the amount of land available to produce them is fixed. Land use economics studies have clearly shown that policy-targeted changes on land use in one place are quite likely to cause a reallocation of land use—i.e., a shift between forest and agricultural land—on the rest of the landscape unless specifically and effectively prohibited by the policy (e.g., Wear and Murray, 2004; Wu 2000). Second, agriculture and forest commodities produced on land are likely to be traded in markets that operate at local, regional, national, or global scales. Therefore, market forces may translate changes in the supply of commodities in one part of the landscape into changes in the demand for and supply of commodities in other, distant locations. Markets tend to expand the spatial impact of seemingly localized actions. Third, there is a complex dynamic adjustment pattern associated with the management of different types of land, and in particular with respect to forestry. Trees store different levels of carbon at different ages in their life cycles. Any adjustments in prices resulting from carbon policies today have a time path of impacts on forest inventories. To the extent that society values carbon sequestration that occurs in the present, more than that which occurs in the future, all else equal (i.e., it discounts future carbon benefits relative to current carbon benefits), the measurement of leakage can become complicated.

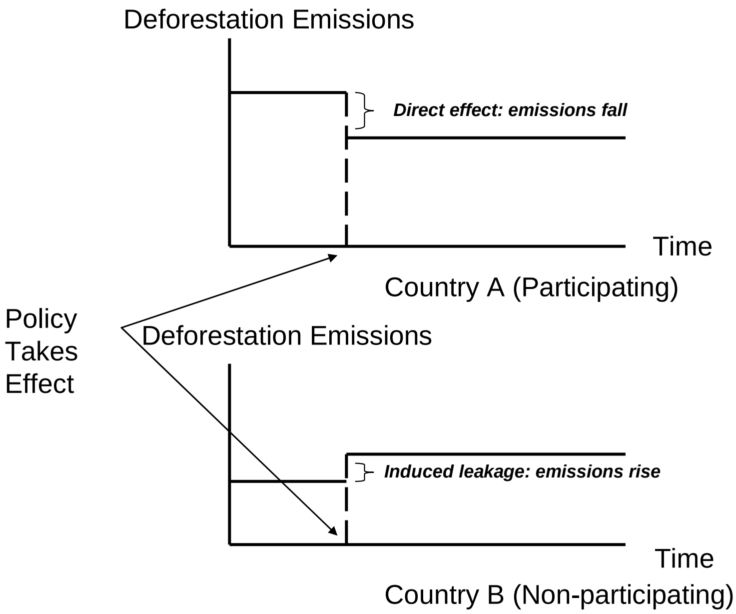


**Figure 1. Leakage between Countries.** *Leakage occurs when actions taken in one country (A) to cut emissions cause a shift in activity and emissions to another country (B) not covered by the policy.*

Leakage from tropical deforestation depends on the factors underlying deforestation in the first place and the extent to which those factors are mobile. Agricultural expansion is the most significant determinant of deforestation across the tropics (Barbier, 2001). Reducing this activity in one country might shift expansion to another country, particularly if land-clearing was for the purposes of cash crop production for global commodity markets. But if subsistence agriculture or local market production is the driver of a country's deforestation, reducing deforestation there may not cause much international leakage unless it heightens reliance on cash crops produced abroad.

Other significant drivers of deforestation include logging for timber resources and fuelwood (Kohlin and Parks, 2001; Bashaasha et al, 2001), road building, and human settlement (Cropper et al, 2001), each of which has different spatial and market feedback implications for leakage. Reducing logging in one location often just shifts it either to another location within the country (Wear and Murray, 2004) or to other countries (Gan and McCarl 2007), and thus leakage potential can be high if no counteracting provisions are put in place (Sohngen and Brown, 2004; Murray et al, 2004).

Leakage need not be produced by a corresponding increase in deforestation elsewhere. It can be produced by other forms of land use changes or management. For instance, if deforestation avoided in Country A reduces agricultural output there and increases production in Country B, this may be met by clearing of grasslands or increased intensification of agricultural inputs in Country B, neither of which involve deforestation, but both of which have GHG effects that can contribute to leakage.

Figure 2 gives a simple depiction of market phenomena producing leakage. Assume that "Country A" represents all countries adopting the avoided deforestation policy and "Country B" reflects all those that do not. Avoided deforestation in Country A leads to the contraction of commodity supply (e.g., timber or agricultural good produced via deforestation in Country A), which is depicted by the inward shift in Country A's supply function from $S^A_0$ to $S^A_1$ in Panel (a) of Figure 2. Countries A and B together make up the world market depicted in Panel (c). The contraction of world supply through Country A's actions is depicted by the shift in world supply from $S^W_0$ to $S^W_1$. Given world demand represented by $D^W$, the global price of the commodity rises, which induces a supply response from Country B, going from $Q^B_0$ to $Q^B_1$ in Panel (b). This supply response, and corresponding GHG emissions, comprise the external leakage induced by Country A's actions. There can also be some internal response in Country A ($Q^A_{01}$ to $Q^A_1$), which is the increase in supply from Country A's (contracted) supply function in response to the rise in the world price, but this response and any associated emissions should be captured with a national accounting system and therefore does not constitute leakage (in a project-based system, this intra-national response would be unaccounted for, and hence would constitute leakage).[3] Only the response in terms of associated emissions from non-participating countries produces leakage, since these remain unaccounted for in the system.

## 3. How Important Is Leakage Empirically?

The previous section creates the case that leakage is relevant in concept, but how quantitatively important is it likely to be in the policy setting of interest? In contrast to biophysical phenomena in land use change, there are no special sensors that detect leakage. Leakage is not directly observable. Rather, it is a market phenomenon that must be estimated using economic data and models.

The magnitude of leakage is typically expressed in proportional or percentage terms for the following relationship.

$$\textbf{Leakage} = \frac{\textbf{(GHG emissions shifted elsewhere)}}{\textbf{(GHG directly reduced by the policy)}} \qquad \textbf{[1]}$$

So if a policy achieves 1 million tons of reduction in Country A but induces 200,000 tons of emissions in other countries, leakage is 20 percent.

Estimating leakage values in real market settings requires some analytical device to characterize market behavior and responses. Ideally, this would come through the use of sophisticated economic models of the relevant markets and regions. That approach has been used in some applications and the results of those studies are highlighted below. However, in cases where no studies have been conducted, or models are not readily available, a general analytical approach building on the shifting supply and demand functions of Figure 2 can be employed to develop a rough estimate of leakage potential.[4] This is the approach outlined in the next section.

[3] Leakage involves unaccounted emissions only. If a country reports all of its deforestation emissions, then all internal responses to deforestation are included and this internal response does not contribute to leakage.

[4] Note that Figure 2 depicts a partial equilibrium view, focusing on activity shifting within the forest and land use sectors only and ignoring possible feedback effects in other sectors (e.g., demand for

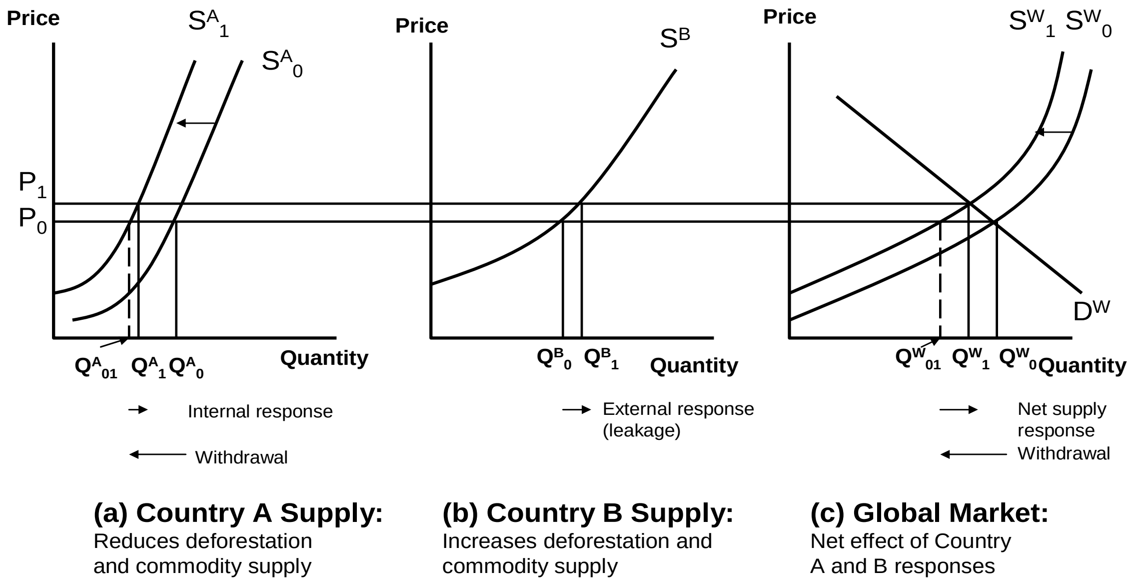


**Figure 2. Market Phenomena Causing Leakage**

***Analytical Approach: Parameterized Supply and Demand Shift***

Figure 2 illustrates the shifting in market output that creates leakage, but as Equation [1] shows, leakage is denominated in emission units, not timber or agricultural output units. Murray et al (2004) integrate parameters for the partial equilibrium market shifts implied in Figure 2 with the corresponding GHG effects to develop a more mathematically explicit variant on Equation [1].

$$\mathbf{L} = \frac{\mathbf{100 * e * C_B}}{\mathbf{[e - E*(1+\Phi_A)]\ C_A}} \qquad \mathbf{[2]}$$

where **e** and **E** represents the elasticities of supply and demand, respectively, in the commodity markets of interest[5], $\mathbf{C_B}$ reflects the emissions caused by an increase in

substitute goods of steel and cement) and factor markets such as labor and capital. These secondary effects are assumed to be small relative to the direct impacts in the forest sector.

[5] Elasticity of supply (e) represents the relative responsiveness of suppliers to a change in price, and roughly captures the steepness of the slope of the supply function in Figure 2. The value is generally positive. If e = 0.5, this means that a 10 percent increase in price would induce a 5 percent increase in

output (e.g., harvests) in countries not subject to the compensated reductions policy, measured in tons of emissions per year, $\mathbf{C_A}$ reflects the emissions avoided by reducing output in the countries subject to the policies, and $\mathbf{\Phi_A}$ is the ratio of the supply removed from the market by Country A's action divided by the quantity supplied by the rest of the world. If Country A is just a small supplier in world markets or if Country A's policy produces just a small shift in world markets, the value of $\Phi_A$ is close to zero. As Country A becomes a larger share of global output, $\Phi_A$ approaches infinity.

Murray et al (2004) provide an example of the following parameter values: unitary elasticities of supply (e = 1.0) and demand (E = −1.0), equal carbon sequestration rates per unit by country ($C_A$=$C_B$), and the ratio of market output produced by policy participants relative to non-participants is somewhat modest ($\Phi_A$ = 0.10). The leakage estimate in this case is L = 47%; in other words, about half of the emission reduction benefits in participating countries are countered by emissions diverted to non-participating countries. Comparative static analysis can show that leakage is amplified under the following conditions:

- relatively inelastic demand (low absolute value for E)
- carbon losses per unit of output are greater in the uncovered countries ($C_B$) than in the covered countries ($C_A$)
- covered countries have a small share of the world market (lower values of $\Phi_A$)

Inelastic demand implies that the market will be inclined to seek supplies from any sources that will supply it rather than simply cut consumption or switch to other commodities in response to the price rise. This exacerbates the market forces that lead to leakage. Murray et al (2004) provide an example with timber as the commodity driving deforestation. Their analysis shows that leakage can diminish if the timber potentially supplied from Country B is a poor demand substitute for the timber preserved in Country A. In this case, the market is less likely to move toward Country

quantity supplied from the market. Elasticity of demand (E) gives the relative responsiveness of demanders to a change in price. The value is generally negative, indicating that an increase in price leads to a decrease in quantity demanded. For example, E = -0.3, means a 10% increase in price causes a 3% reduction in the quantity demanded. Because E is negative, the leakage term is positive. Values of e and E that are greater than 1.0 in absolute value are termed "elastic," while absolute values less than 1.0 indicate inelastic responses.

B supplies when Country A product is removed from the market. This does not completely eliminate leakage tendencies, as there could be substitution away from, say tropical hardwoods to other materials that have potentially higher GHG emissions in their production. If these products are supplied through manufacturing processes not subject to a GHG cap, then intersectoral leakage can occur. A more general equilibrium analysis would be required to capture all secondary sources of leakage, though such models capable of capturing all economic and GHG flows, along with the nuances of deforestation and carbon dynamics do not exist at this time.

When leakage causes supply shifts to countries that incur relatively high emissions per unit of product produced, this too enhances leakage. Alternatively, if carbon-rich forests protected in one place shift timber harvesting to locations managed sustainably with little net loss of carbon over time, then this can greatly diminish leakage.

Finally, when the avoided deforestation actions of the covered countries have a collectively small impact in the global market, the supply contraction is easily replaced by increased supply elsewhere, thereby creating leakage. This is often a misunderstood point. Some would argue that leakage is inconsequential when only a small part of the market is affected. That is because small market disruptions have virtually no effect on market prices. With no market price change, the argument goes, how can leakage occur? The critical point here is that the reason that no market price effects occur is that the rest of the market can easily fill the supply gap produced by reduction of Country A's supply, when that supply is a small share of the world market. In other words, it is the realization of leakage that fills the supply gap and reduces pressure on the market price. On the other side of the spectrum, leakage dissipates the larger the share of the world market that is covered by avoided deforestation policies. The policy implication, discussed further below, is that including all of the world's deforesters or potential deforesters in a REDD policy can greatly diminish leakage and improve policy effectiveness. In the limit, if all countries are covered by the policy, leakage is zero as all emissions are accounted for.[6]

[6] As more countries enter the program, the market participation ratio parameter ($\mathbf{\Phi_A}$) from Equation 2 approaches infinity and leakage approaches zero. In the limit (full participation), leakage is eliminated.

The example above, though helpful for providing basic conceptual and empirical insight into how leakage works its way through a single commodity market is a partial equilibrium view focusing on traded commodities, and on only one commodity. In reality, leakage might still occur in cases when traded commodity production may not be directly affected (e.g., in subsistence settings, where subsistence activity shifts elsewhere). Moreover, even in a market setting, changes in land use often affect the production of multiple commodities in multiple regions. The next section provides an extension into these more complicated cases.

### *Integrated Modeling*

The example above provides a fairly straightforward way to benchmark leakage potential given parameter values for supply and demand, carbon emission rates and market shares for a single commodity market. But in reality there may be multiple markets affected simultaneously by an avoided deforestation compensation system, especially forest and agriculture, but possibly other sectors as well (e.g., energy). This requires a more complex modeling framework, one that simultaneously solves for multiple markets and integrates carbon accounting with the simulated changes in market outcome. Relatively few studies to date have used these approaches to estimate leakage from avoided deforestation. Those that have are summarized in Table 1, along with studies of the closely related phenomena of forest preservation policies to set aside forest areas from logging.

The studies are divided between those that track the displacement of forest products as a result of restrictions in one location—the type of market behavior referenced in Figure 2—and those that track the emissions displacement associated with this product movement. The latter are the ultimate measure of interest because of their unit of measure, but the former studies provide a glimpse of the empirical magnitude involved in the economic forces underlying leakage.

Wear and Murray's (2004) econometric study of timber harvesting restrictions on U.S. federal lands in the Pacific Northwest starting in the late 1980's is unique in that it is the only study that estimated displacement effects after the fact (*ex post*) using observed market data from the period of interest rather than predict displacement or

**Table 1. Published Leakage Estimates from Avoided Deforestation or Forest Preservation Set-aside (Stop Logging) Policies.**

| Region | Policy Action | Modeling Approach | Estimated leakage magnitude (%) | Source |
|---|---|---|---|---|
| **Product Volume Displacement Estimates** | | | | |
| Temperate, Pacific Northwest U.S. | Stop Logging Public Lands | *Ex post* Partial Equilibrium Econometric Model of U.S. Timber Market. | Within region: 43<br>National: 58<br>Continental: 84 | Wear and Murray, 2004 |
| Global | Reduce forest output at national and regional level | *Ex ante* Global Computable General Equilibrium Model | 45–92 | Gan and McCarl, 2007 |
| **Carbon Emissions Displacement Estimates** | | | | |
| Temperate/U.S. regional | Avoid deforestation and logging set-asides on private lands (regional policies in isolation) | *Ex ante* Integrated model of U.S. forest and agricultural sectors | Avoided Defor.<br>Northeast: 41–43<br>Pacific NW: 8–9<br>Other regions: 0–92<br><br>Logging set-aside<br>Pacific NW: 16<br>South: 64 | Murray et al, 2004 |
| Tropics/Bolivia | Logging set-asides in National Park | *Ex ante* Partial Equilibrium Model of Bolivian Timber Market | 2–38 | Sohngen and Brown 2004 |
| Adapted from Sathaye and Andrasko (2007) | | | | |

leakage before the fact (*ex ante*) using predictive simulation. Their study estimates that about 43 percent of the foregone harvests on public lands in the Pacific Northwest were shifted to private lands within the region, another 15 percent shifted to other regions in the U.S., and another 26 percent to harvests in Canada, thereby providing strong empirical evidence that efforts to stem logging in one place do tend to shift harvests elsewhere. But as discussed above, and shown below, the emissions leakage effect may not be as strong as the product leakage if harvests are shifted to less carbon rich regions than the Pacific Northwest.

Gan and McCarl (2007) examine displacement potential internationally, simulating the effect of unilateral supply reductions by one country or multilateral reductions by regional groups of countries on the global distribution of forest product supply. This is the only study that gives an estimate of international leakage potential although, as mentioned, the displacement is a measure in product flow not emissions. The displacement potential they find is quite large. Countries acting unilaterally will generally find a majority of their reduced production shifted to other countries. Only Canada had leakage effects of less than 50 percent. When combined in regional coalitions, total displacement drops as expected, but not as dramatically as one might expect. The authors conclude it would take much larger international coalitions, rather than regional ones to substantially dampen leakage effects, as discussed in the previous section.

Studies showing emissions leakage are confined to the U.S (Murray et al, 2004) and Bolivia (Sohngen and Brown, 2004). The U.S. study simulates emissions leakage from logging set-aside and avoided deforestation policies using the FASOM model (Adams et al 1996). The Murray et al study looks at policies that would be implemented unilaterally by regions within the U.S. to examine how leakage fundamentals might vary by region. Such a regional policy, if implemented, would likely exacerbate leakage as shifts occur within the country. But actual policy implementation would likely not be confined to individual regions, but would be national or international in coverage. So the leakage estimates from the Murray et al study might be seen as high end estimates relative to a national or international program. That said, the regional estimates range from quite low (near zero) to extremely high (over 90 percent). Sohngen and Brown's study of the Noel Kempff Mercado National Park in Bolivia estimates the effects of a logging ban and how this might shift harvests and emissions within Bolivia. They find leakage estimates somewhat on the lower end of the range by other studies (less than 40 percent) and they also find that leakage in the short run is tied to capital constraints.

## 4. Policies to Address Leakage in an Avoided Deforestation Compensation System

The previous sections suggest that leakage is a real and present concern for the success of policies to combat deforestation and associated greenhouse gas emissions. While leakage results from natural economic forces that are difficult to restrain, the international system in which compensation for avoided deforestation emissions operates can be modified to reduce it and address it as a problem. Specific options are discussed below.

***Establish National Baselines that Encourage International Participation***

Leakage is one of the concerns that kept avoided deforestation out of the project-based CDM, but policy options now being proposed address some of these concerns by proposing national accounting rather than project-level accounting. This helps matters considerably, as the evidence discussed in the previous section suggests within-country leakage from project-based approaches can be a real problem. Yet there is still international leakage to contend with as emissions shift from participating countries with complete accounting of emissions to non-participating countries that remain outside of the system. Therein the focus must be on international engagement to address these concerns.

The Berlin Mandate, signed by the UNFCCC in 1995 stipulates that countries will have “common but differentiated” responsibilities in achieving climate goals. Right now, this means that emission reduction commitments are held by the developed countries that have ratified the Kyoto Protocol. Developing country participation is limited to voluntary measure such as hosting CDM projects. So developing country participation in an avoided deforestation compensation program would be, for all intents and purposes, on a voluntary basis. To increase participation, countries would need to expect that the benefits exceed the costs. For REDD compensation policies, this may boil down to the issue of the size of the baseline they are granted. Baselines determine the level of emissions below which a country can receive credits for their reductions (see Figure 3).

The following sections discuss several approaches for developing national baselines that have been submitted for consideration in UNFCCC deliberations (UNFCCC 2007).

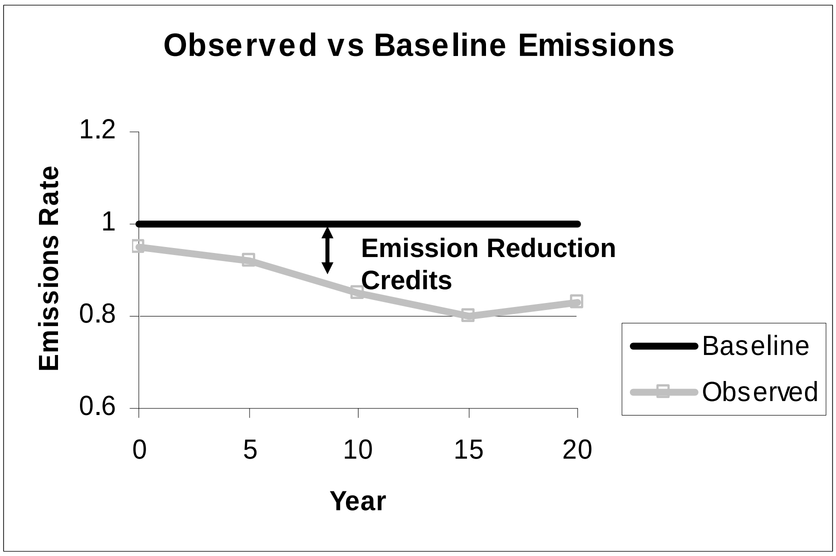


**Figure 3. Baselines, Additionality and Credits.** *Credits are generally assigned for emissions that fall below a baseline level. This creates incentives for countries to seek a high baseline.*

<u>Historical Reference Period Emissions: National</u>. This is the approach carrying most weight at this time. This approach sets a country's deforestation emissions baseline equal to its emissions observed or estimated during a historical reference period (e.g., a 5- or 10-year period before implementation of the program). Setting a future baseline emissions rate equal to the rate from a recent historical reference period is straightforward and has precedent for national GHG accounting. However, this takes a very static view of the conditions affecting deforestation that may not apply in many cases. The deforestation path is often not a linear process, depending on a number of factors including a country's position along its development path, shifts in commodity markets affecting a country's land use, and the size of the remaining forests subject to clearing. The past, even recent, may not be the best prediction of the future.

Historical Reference Period Emissions: Global Or Pan-Tropical. For the purposes of encouraging international participation, the biggest problem with the national historic reference period emissions approach is that countries with historically low emissions rates will have low baselines and little participation incentive. If the opportunity for generating sizeable credits is taken off the table, the country may opt not to participate in the compensation system and become a potential haven for leakage. One proposal to address this problem is to set a global or pan-tropical deforestation baseline as a point of reference for all countries in the system. This has been proposed as one means for differentiating between countries with high versus low deforestation rates relative to the global average. This effectively would adjust upward the national baselines for countries with lower than average historic deforestation as an incentive for maintaining these low deforestation rates (Santilli et al 2005; Mollicone et al. 2005). The problem is that such an approach could create "hot air" reductions—credit for no action from countries who have had their baselines inflated to the global/pan-tropical average. Also, if countries with historically above-average emissions are required to use average emissions rates for their baseline, this will require steeper cuts by them to generate credits than if they used their own historic baseline, a situation that could undercut their incentive to participate. In short, using a highly aggregated global or pan-tropical average for all countries and applying it as a baseline for each country may improve incentives for some countries, but it will reduce incentives for others and is likely an inefficient way to engage fuller participation.

Business-As-Usual (BAU) Projection. The previous two baseline approaches suggest a balancing act between creating incentives for both historically low and historically high emitters without giving windfall credits to either. One way toward this would be to let the baselines reflect more than just recent historical emissions and incorporate moving trends and factors expected to influence future emissions. This is sometimes called a projection or "business-as-usual" (BAU) baseline and is contrasted with an historic reference period (Figure 4). Countries with historically low rates of emissions might have their baseline adjusted upward above the historic reference rate if conditions with higher deforestation pressure are expected to emerge.[7] This would be more likely to engage the involvement of those countries. But the same principles also

[7] These adjustments could be made using formal land use economic modeling tools or informally negotiated by Parties using logical arguments and descriptive statistics.

apply to countries with historically high deforestation with opposite consequences. If the factors that have pressured deforestation historically are expected to decline or if the country has been heavily deforested to date and cannot be expected to yield as much deforestation in the future, then its historic emission baseline could be adjusted downward to avoid over-crediting.

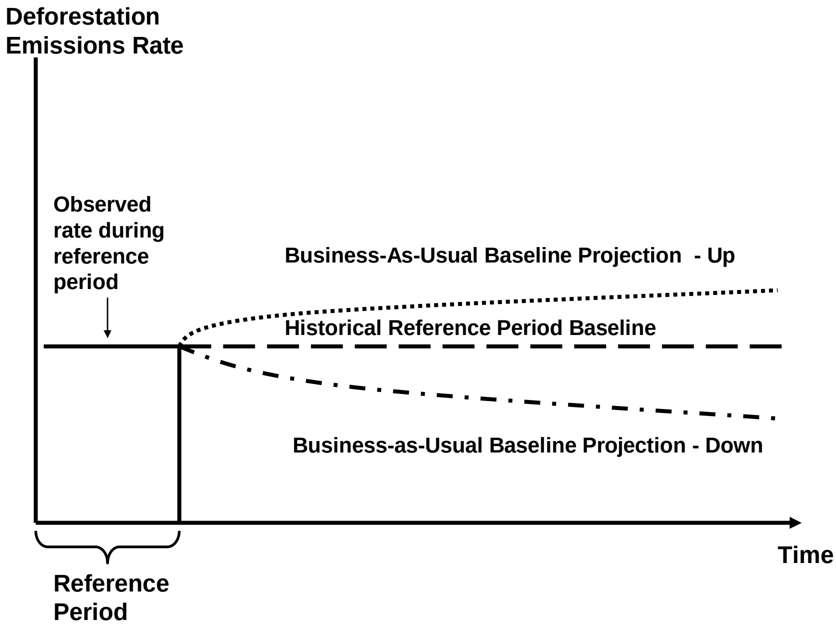


**Figure 4. Business-as-Usual vs Historic Reference Period Baselines**

The BAU projection can be developed using formal models incorporating the economics of land use, commodity markets, trade and related biophysical processes, or less formal (e.g., Delphi) methods using expert opinion forecasts of deforestation, or some combination of the above. Along these lines, Chomitz et al. (2006) recommends the use of a *normalized* baseline, which is based on standardized projections of agricultural land clearing, changes in productivity, and carbon content of forests on the agriculture land clearing margin for the country in question. This moves beyond the simple acceptance of past rates as indicative of the future and avoids creating perverse incentives for a country to ramp up deforestation emissions to artificially inflate their baseline and future credit-generating potential (see Palmer and Obidzinski 2008, for a discussion of baseline choice for Indonesia).

Fixed Baseline with Negotiated Targets. Ultimately, the choice between the simpler but possibly flawed, historical reference period baseline and the more rigorous but complex BAU projection method could boil down to a political decision about whether the value of improved information in the latter method justifies the additional complexity, uncertainty, and cost. One option is to keep with the simpler approach, tie the baseline directly to the historic reference period emissions and then negotiate future targets based on national circumstances. For example, one country's observed emissions rate for the period 2000–2005 might be 50 million tons per year, but they might receive future credits only for emissions below 40 million tons. Another country might have a historic rate of 2 million tons per year, but receive credits for emissions below 3 million tons, and so on. This has precedent in the Kyoto Protocol, where all countries have an emissions baseline set at the 1990 level, but each has differentiated targets for emissions during the first commitment period. For instance, the EU-15 countries must collectively reduce emissions 8 percent below 1990 levels, while Iceland is allowed to increase emissions to 10 percent its 1990 level.[8] Presumably, these negotiated targets reflect the differentiated abilities of each country to meet or exceed their 1990 levels and similar logic could be applied to the historic deforestation emissions baseline.

To summarize, leakage is minimized when more countries participate in the compensation system. At this point, REDD participation is expected to be voluntary at the national level. Whether countries opt in could depend on rules for setting the national reference emissions baseline. A balance must be struck between making these rules flexible enough to allow countries with high deforestation potential to participate and ensuring that the rules do not allow for baseline inflation and over crediting of reductions.

***Core Participation Requirement***

One way to induce fuller participation would be to make the fungibility of REDD credits as in the global carbon market contingent upon some threshold participation of countries. Such a core participation requirement (Murray and Olander 2008) could work so that once a core level of participation of REDD source countries is met (e.g.,

[8] National targets for Kyoto Protocol first commitment found at the IPCC website (http://unfccc.int/kyoto_protocol/background/items/3145.php).

countries representing a significant majority of global REDD emissions), REDD credits would exchange freely with other emission sources in the global market. Until the participation threshold is met, the credits would have to trade at a discount to regular allowances to account for leakage potential of a more limited coverage system. There is precedent for such a threshold requirement in the original architecture of the Kyoto Protocol, which did not take effect until 55% of global emissions were covered.

### *Decouple REDD Compensation from GHG Target Compliance*

Alternative proposals have been advanced, most prominently by Brazil (UNFCCC 2007), that would similarly compensate non-Annex I countries for reducing their emissions from deforestation, but would not tie these reductions to Annex I country commitments or a global GHG market (see also Moutinho et al. 2008). In other words, REDD compensation would not be part of an international GHG offset market. The reasoning advanced by Brazil's proposal is that any emission reductions from deforestation ought to be supplemental to emission reductions in Annex I countries, rather than as an offset to them. There are also concerns in some corners that tying REDD compensation to the international GHG market might crowd out demand for existing and yet-to-be-developed CDM projects (Prior et al, 2007; Michaelowa and Dutschke, 2008).

Separating REDD compensation from international commitments directly reduces the problem of leakage undermining the environmental integrity of an international offset system simply by prohibiting the use of REDD credits as an offset mechanism. Therefore, this avoids the risk that an Annex I country increases their emissions by 10 million tons by purchasing 10 million REDD credits, only to realize that generating the REDD credits in participating countries has shifted some leaked emissions to non-participating countries, with the result that the overall "offset" transaction increased, rather than neutralized, emissions. Complete decoupling is certainly a clean, though not the only, way to deal with the environmental integrity problem of leakage. For instance, REDD credits could be bought and sold at a discount to reflect the leakage potential. This discount could be based on econometric modeling estimates of leakage such as those referenced in this chapter. For instance, if leakage is estimated at 40 percent, then a 40 percent discount could be applied to a REDD credit to account for the shortfall potential. To employ this approach, however, more empirical work in this area is needed to make these estimates more robust.

Decoupling REDD compensation from the international carbon market, however, could greatly reduce the scale of funds available to avoided deforestation efforts. The demand for REDD credits in an international carbon market could be in the tens of billions of dollars (Olander and Murray, 2007). It is unclear what type of funding a decoupled approach would be able to generate for avoided deforestation issues through the normal channels of official development assistance, NGO funding, and the like, but previous history suggests it would be difficult to match the numbers referenced above for the carbon market (see Rametsteiner et al. chapter 3, in this volume 2008).

Although decoupling funds for REDD compensation from the carbon market might address the integrity risks from leakage it will not necessarily eliminate leakage. As long as compensation is targeted for (or adopted by) a subset of the relevant countries, leakage is possible and it will undermine the effectiveness of the compensation program by producing less emissions reduction than what is paid for. So decoupling can best be viewed as a leakage management strategy, but not a leakage elimination strategy. Leakage potential cannot be eliminated, as long as countries are free to adopt in and out of a REDD system, but it can in principle be measured and accounted for to better assess the effects of global efforts to reduce deforestation and corresponding emissions.

### *Expand Scope of Policy Beyond Deforestation*

As discussed above, one key hindrance to voluntary adoption of REDD compensation is that countries with low deforestation rates have little scope for credits and little incentive to participate. As shown in Table 2, this may limit interest to a relatively small number of countries with high deforestation rates. Many countries, however, are on the other end of the spectrum, experiencing little deforestation and in many cases having reforested large areas of land in recent years. See Table 3.

**Table 2. Non-Annex 1 countries with the highest deforestation rates, 2000–2005**

| **Country** | **Ha/yr** |
|---|---|
| Brazil | 3,103,000 |
| Indonesia | 1,871,000 |
| Sudan | 589,000 |
| Myanmar | 466,000 |
| Zambia | 445,000 |
| United Republic of Tanzania | 412,000 |
| Nigeria | 410,000 |
| Democratic Republic of the Congo | 319,000 |
| Zimbabwe | 313,000 |
| Venezuela (Bolivarian Republic of) | 288,000 |

Sources: Table 2.5 and 2.6 in FAO Forest Resource Assessment 2005[i]; and Annex 3: Table 4 in FAO report 147.

**Table 3. Reforestation rates, 2000–2005: Top 10 countries**

| **Country** | **Ha/yr** |
|---|---|
| China* | 4,058,000 |
| Viet Nam | 241,000 |
| Chile | 57,000 |
| Cuba | 56,000 |
| India | 29,000 |
| Rwanda | 27,000 |
| Algeria* | 27,000 |
| Côte d'Ivoire | 15,000 |
| Costa Rica | 3,000 |
| Egypt* | 2,000 |

Adapted from Olander and Murray, 2007
*Less than half of the country is considered tropical
Sources: Table 2.5 and 2.6 in FAO Forest Resource Assessment 2005[27]; and Annex 3: Table 4 in FAO report 147.

Given that none of the countries with high reforestation rates in Table 3 are also high deforestation countries in Table 2, a compensation system targeted at deforestation produces no incentive to maintain or expand the carbon stocks accumulating in the high reforestation countries or in countries with a relatively stable forest base. This not only creates leakage risks of the type described throughout this chapter, it could leave off the table a range of opportunities to expand carbon stocks through market-based incentives. One way to address this problem would be to expand compensated activities beyond deforestation to include potentially all sources of forest carbon stock changes at the national level. This would minimize leakages within the forest sector of participating countries by capturing forest degradation and management as well as deforestation. Moreover, it could greatly expand the number of countries interested in participating. Measurement and monitoring issues should be tractable, as methods exist at the international level through the IPCC Good Practices Guidelines (IPCC 2003) to do national-level forest carbon accounting. There may be concerns, however, that including all forest carbon stock changes could encourage the conversion of native ecosystems to non-native forest plantations, possibly undermining biodiversity and water resource provision (Jackson et al 2005). However, these concerns can be addressed via agreed-upon protocols (IPCC 2000). This broader, sector-based view of covering forest carbon in a post-Kyoto UNFCCC process was discussed at the Bali Conference of Parties in December 2007 and is under further consideration.

One final point to make on the option of including afforestation and reforestation (AR) activities in the compensation system is that these activities are already covered under the CDM. However, as referenced above, AR projects have been virtually non-existent under the CDM to date because of inherent difficulties in project-level implementation. There are reasons to expect that at least some of these issues (e.g., dealing with permanence, additionality, and leakage) can be better handled at a national level with more complete monitoring and accounting systems in place.

## 5. Conclusions

This chapter has focused on the importance of recognizing, estimating, and where possible, ameliorating the risks of leakage from REDD compensation policies that are likely to be applied to a subset of countries with deforestation potential. Key summary points include

- ***Fundamentally, leakage arises from economic processes.*** Leakage occurs when protective action in one place shifts problems to another. When taking action to reduce deforestation in one country or a subset of countries reduces the supply of certain globally traded commodities, the market will seek out suppliers unbound by those same constraints. This is natural and hard to confine.
- ***From a policy standpoint, leakage is an accounting problem.*** The fact that markets shift deforestation activity and emissions from place to place is not, in and of itself, a problem so long as all emission sources are governed by the same rules. Rather, it is the fact that deforestation emissions may be reduced in a country receiving compensation to offset emissions from a regulated country only to see emissions shifted to a country that is neither regulated nor subject to a national-level accounting of deforestation emissions. This means that emission reductions will appear larger on paper than they are in reality, thereby undercutting the climate and other environmental goals of the program.
- ***The empirical evidence to date suggests leakage from avoided deforestation policies could be substantial if not addressed in policy design.*** Unfortunately, the empirical evidence on leakage effects of avoided deforestation and forest conservation policies is somewhat thin and is not customized to address the specific compensation policies now at hand; nevertheless, the evidence suggests that leakage potential could be large and should be taken seriously by those charged with developing policy options.
- ***One way to take leakage seriously is to impose discounts that reduce the number of REDD credits issued to account for the leakage in the system.*** This will require more robust estimates of leakage than currently exist and should be re-evaluated over time as the policy evolves and leakage conditions

change. This form of discounting also reduces compensation and the incentive to participate, which could undermine efforts to expand program scope and combat leakage that way, as referenced in the next two points.

- ***One way to reduce leakage potential through policy design is to expand the scope of policy coverage as wide as feasible.*** The more at-risk forests that are covered by REDD compensation and accounting, the smaller the opportunity for leakage to undermine the system. Scope expansion could involve covering more countries or more activities.
- ***Scope expansion has its challenges.*** Expanding the number of countries involved in a voluntary system involves the delicate balancing act of enhancing incentives for their participation through, among other things, generous baselines making credits easier to generate and maintaining the environmental integrity of the system by not crediting "hot air" (would happen anyway) credits. Expanding the scope of activities covered beyond deforestation can both help lure countries with low baseline deforestation rates into the system and ensure that deforestation emission are not reduced at the expense of carbon losses elsewhere in the forest sector (e.g., degradation, reduced management, foregone afforestation, and reforestation). However, covering all forest carbon in an international compensation system raises some concerns about spurring land use changes that could undermine other environmental objectives such as biodiversity and water provision.

So leakage is a problem, potentially serious, and may not be so easy to solve. Yet the economic and environmental opportunities for using either markets or other sources of funds to reduce deforestation and its emissions may be too important to simply dismiss because of leakage concerns. Leakage should be taken seriously, addressed by policy design, enter into the accounting where possible and be closely monitored over time. It certainly warrants mentioning that REDD policy is not the only GHG policy situation in which leakage arises. All GHG policies now and for the foreseeable future face the same problem, due to incomplete coverage across countries and sectors. Leakage makes the job of reducing global GHG mitigation harder, but does not make it any less important. Once the problem of GHG concentrations and climate risks are accepted, the policy objective should be to cover as many sources over as long a time as possible, with as much flexibility as prudence allows. Until all sources are covered, we will have to live with the difficulties of incomplete coverage, design policies accordingly and adjust them in the future if the problem persists.

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