GREENHOUSE GAS PROTOCOL

WORLD RESOURCES INSTITUTE

Policy and Action Standard

Agriculture, Forestry, and Other Land Use (AFOLU) Sector Guidance

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Introduction

This document provides sector-specific guidance to help users implement the GHG Protocol *Policy and Action Standard* in the Agriculture, Forestry, and Other Land Use (AFOLU) sector. The AFOLU category combines the two sectors: LULUCF (Land Use, Land Use Change and Forestry) and Agriculture. Land use and management influence a variety of ecosystem processes that affect greenhouse gas fluxes such as photosynthesis, respiration, decomposition, nitrification/denitrification, enteric fermentation, and combustion. These processes involve transformations of carbon and nitrogen that are driven by the biological (i.e., activity of microorganisms, plants, and animals) and physical processes (combustion, leaching, and run-off). The key greenhouse gases of concern are CO_2, N_2O and CH_4. The AFOLU sector faces some unique challenges with respect to GHG accounting. There are many processes leading to emissions and removals of greenhouse gases, which can be widely dispersed in space and highly variable in time. The factors governing emissions and removals can be both natural and anthropogenic (direct and indirect) and it can be difficult to clearly distinguish between causal factors.

Users should follow the requirements and guidance provided in the *Policy and Action Standard* when using this document. The chapters in this document correspond to the chapters in the *Policy and Action Standard*. This document refers to Chapters 5–11 of the *Policy and Action Standard* to provide specific guidance for the AFOLU sector. The other chapters have not been included as they are not sector-specific, and can be applied to the AFOLU sector without additional guidance. Chapters 1–4 of the *Policy and Action Standard* introduce the standard, discuss objectives and principles, and provide an overview of steps, concepts, and requirements. Chapters 12–14 of the *Policy and Action Standard* address uncertainty, verification, and reporting. The table, figure, and box numbers in this document correspond to the table, figure, and box numbers in the standard.

To illustrate the various steps in the standard, this guidance document uses a running example of a hypothetical boreal forest reforestation policy.

We welcome any feedback on this document. Please email your suggestions and comments to David Rich at drich@wri.org.

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Chapter 5: Defining the policy or action

In this chapter, users are required to clearly define the policy or action that will be assessed, decide whether to assess an individual policy or action or a package of related policies or actions, and choose whether to carry out an ex-ante or ex-post assessment.

5.1 Select the policy or action to be assessed

Table 5.1 provides a non-exhaustive list of examples of policies and actions in the sector for which this guidance document will be useful by policy/action type.

Table 5.1a Examples of policies/actions in the forestry sector by policy/action type

Type of policy or action	Examples
Regulations and standards	• Regulations aimed at reducing the proximate causes of deforestation, such as regulating against conversion of forest land to agricultural use (e.g. Indonesia Forest Moratorium, which prohibits new permits for palm plantations on peatland and primary forest; and Brazil's Forest Code, which requires that landowners maintain a percentage of their land as forest). • Regulations aimed at reducing the underlying drivers of deforestation, such as regulating against the import of illegally sourced timber (e.g. the EU Timber Regulations, which prohibit the placement of illegal timber and timber products on the EU market). Often deforestation occurs where existing legislation is not well enforced, and policies to enforce existing legislation can be effective in reducing deforestation. • Enabling measures, such as the establishment or enforcement of land tenure rights (where insecure land tenure leads to deforestation), and land-use planning (e.g. Indonesia's One Map establishes a single map of land categorizations and jurisdictions to avoid conflicting land use claims).
Taxes and charges	• -

Subsidies and incentives	• Payments for reducing deforestation, or for afforestation/reforestation
	Examples:
	  ◦ China's Sloping Land Conversion Program which involved payments for reforestation/afforestation on over 10 million hectares of sloping or degraded land;
	  ◦ The US Conservation Reserve Program, which is an incentive payment program for retiring land from agricultural use, and planting alternative vegetative cover;
	  ◦ The Norway-Guyana Partnership on Climate and Forests which involves results-based payments for reduced emissions from deforestation and forest degradation (REDD+).

Tradable permits	• -

Type of policy or action	Examples
Voluntary agreements	• Voluntary agreements involve entities agreeing to undertake actions for reducing deforestation, or for undertaking afforestation/reforestation (e.g. Voluntary Partnership Agreements under the Forest Law Enforcement, Governance and Trade (FLEGT) Action Plan involve partner countries voluntarily introducing certification schemes for legally harvested timber).
Information instruments	• Information instruments that allow consumers to choose products which avoid deforestation (e.g. Forest Stewardship Council certification, Roundtable on Sustainable Palm Oil certification, and Roundtable on Sustainable Soy certification).
Research and development (R&D)	• Research and development within the agricultural sector can be used to increase yields and reduce the expansion of agriculture into forested areas (or increase the amount of set-aside land available for afforestation/reforestation). For example, TSH Resources Bhd and the Malaysian Palm Oil Board have invested in developing an oil palm clone which may achieve yields of 10 tonnes crude palm oil/hectare compared to an average in Malaysia of 4.5 tonnes crude palm oil/hectare.
Public procurement policies	• -
Infrastructure programs	• -
Implementation of new technologies, processes, or practices	• The deployment of new technologies and practices within the agricultural sector can be used to reduce the expansion of agriculture into forested areas (or increase the amount of set-aside land available for afforestation/reforestation). Measures which increase agricultural yields should reduce the demand for new agricultural land (e.g. International Plant Nutrition Institute's Best Management Practice (BMP) pilot plots illustrate the potential yields from implementing BMPs).
Financing and investment	• Financing for improved agricultural productivity can reduce the expansion of agriculture into forested areas (or increase the amount of set-aside land available for afforestation/ reforestation). For example, the Indonesian Government has implemented a Plantation Revitalization Program, which provides improved seeds and low interest credit to support plantation owners during the period between replanting and when new trees reach maturity and produce a crop.

Table 5.1b Examples of policies/actions in the agriculture sector by policy/action type

Type of policy or action	Examples
Regulations and standards	• Regulations on limits of total applied nitrogen and the enforcement of closed periods for the application of slurries and manures (e.g., E.U. Nitrates Directive) • Production standards for concentrated production operations, such as feedlots • Zoning regulations for the expansion of agriculture (e.g., Brazil's National Agro-Ecologic Zoning Program)
Taxes and charges	• Agriculture can be affected by multi-sectoral/economy-wide polices such as cap and trade. • There is a generally a reluctance to use carbon taxes as a policy instrument in the agriculture sector. However, the sector is a significant user of fossil fuels (mostly through production of fertilizers, but also through the direct use of fossil fuels on farms), so would be affected by fuel taxes • Output taxes that differentially tax agricultural products based on their GHG intensity (e.g., beef products are levied with a higher tax)
Subsidies and incentives	• Payments for foregone income from: setting aside agricultural land as buffer strips and arable field corners; entering land into agricultural conservation easements; and preserving woodland and wetlands. • Payments for changes in existing production practices (e.g., adoption of conservation tillage, enhanced hedgerow management, enhanced nutrient management, etc.). • Subsidies for increasing production of goods viewed as less GHG-intensive (e.g., bioenergy crops) • Subsidies for the development of on-farm sources of energy (e.g., biodigesters)
Tradable permits	• Nutrient trading programs focused on specific watersheds • The linking of on-farm renewable energy generation with renewables obligations (e.g., farmers selling RE certificates into a mandatory market)
Voluntary agreements	• Conservation easements (linked to possible tax benefits or direct payments) • Voluntary reporting of agricultural GHG data (e.g., the now defunct DOE 1605(b) program included guidance for agriculture and forestry)
Information instruments	• Direct provision of training and advice to farmers on adoption of GHG mitigation measures; extension services; etc.
Research and development (R&D)	• Research programs targeting major emissions sources. Some examples: Enteric fermentation: improved livestock genetics, methanogen inhibitors, vaccine development, diet manipulation, etc. • Soil N_2O: nitrification inhibitors, plant breeding/selection, technologies/practices that lower the N_2O/N_2 ratio during nitrification, etc.
Public procurement policies	• -
Infrastructure programs	• -

Type of policy or action	Examples
Implementation of new technologies, processes, or practices	• Linked to R&D activities above
Financing and investment	• Low-interest loans for the adoption of GHG mitigation practices • Loan guarantees and payments for energy audits, energy efficiency improvements, installation of renewable energy systems, etc.

5.2 Clearly define the policy or action to be assessed

A key step in Chapter 5 is to clearly define the policy or action. Chapter 5 in the standard provides a checklist of information users should report. Table 5.2 provides an example of providing the information in the checklist using the example of a hypothetical boreal forest reforestation policy.

Table 5.2 Checklist of information to describe the example policy

Information	Example
The title of the policy or action	Boreal Forest Reforestation
Type of policy or action	Implementation of new technologies, processes, or practices
Description of the specific interventions included in the policy or action	The policy goals call for reforestation of 5% of high site class lands by 2010; 15% by 2015; and 25% by 2025. "Site class" refers to forest areas impacted by wildfire. A high site class is an area that experienced the highest burn severity[1].
The status of the policy or action	Accepted by the Climate Change Mitigation Advisory Group
Date of implementation	2010
Date of completion (if applicable)	N/A
Implementing entity or entities	Government
Objective(s) of the policy or action	Reforestation of high site class lands spurs higher levels of carbon sequestration since these areas will not go through the expected successional phases of grassland to mixed hardwood to conifer (lasting many decades). In particular, grasslands often dominate a high-severity burn area for many years which limits carbon sequestration potential. The policy intervention here is to bypass this grassland successional phase in burn areas dominated by grasses through replanting with mixed hardwood species. These mixed hardwood stands provide much higher sequestration potential than grasslands.
Geographical coverage	State of Alaska boreal forests
Primary sectors, subsectors, and emission	Terrestrial carbon sequestration

[1] The objective of the assessment is to estimate the level of emission reductions achievable if policy goals are achieved.

<table>
<tr><th>Information</th><th>Example</th></tr>
<tr><td>sources or sinks targeted</td><td></td></tr>
<tr><td>Greenhouse gases targeted</td><td>Carbon dioxide</td></tr>
<tr><td>Other related policies or actions</td><td>Forest management policies addressing thinning or other treatment of burn areas.</td></tr>
<tr><th colspan="2">Optional information</th></tr>
<tr><td>Key performance indicators</td><td>Annual reforested area, forest biomass (forest carbon)</td></tr>
<tr><td>Intended level of mitigation to be achieved and/or target level of other indicators</td><td>Based on historical wildfire data, on average, 260,000 acres of high-severity burn area is created each year in the boreal forest. The table below shows the reforestation targets for the policy based on the goals stated above. Over 15 years, a total of nearly 700,000 acres would be reforested.
Boreal Forest Reforestation Targets
<table>
<tr><th>Year</th><th>Acres Replanted</th><th>Incremental C Accumulated (tCO_2)</th></tr>
<tr><td>2010</td><td>13,152</td><td>30,757</td></tr>
<tr><td>2011</td><td>18,413</td><td>43,060</td></tr>
<tr><td>2012</td><td>23,674</td><td>55,363</td></tr>
<tr><td>2013</td><td>28,935</td><td>67,666</td></tr>
<tr><td>2014</td><td>34,196</td><td>79,969</td></tr>
<tr><td>2015</td><td>39,457</td><td>92,272</td></tr>
<tr><td>2016</td><td>42,087</td><td>98,424</td></tr>
<tr><td>2017</td><td>44,718</td><td>104,575</td></tr>
<tr><td>2018</td><td>47,348</td><td>110,727</td></tr>
<tr><td>2019</td><td>49,979</td><td>116,878</td></tr>
<tr><td>2020</td><td>52,609</td><td>123,030</td></tr>
<tr><td>2021</td><td>55,240</td><td>129,181</td></tr>
<tr><td>2022</td><td>57,870</td><td>135,333</td></tr>
<tr><td>2023</td><td>60,501</td><td>141,484</td></tr>
<tr><td>2024</td><td>63,131</td><td>147,636</td></tr>
<tr><td>2025</td><td>65,761</td><td>153,787</td></tr>
<tr><td>Totals</td><td>697,072</td><td>1,630,147</td></tr>
</table></td></tr>
<tr><td>Title of establishing legislation, regulations, or other founding documents</td><td>Alaska Climate Change Action Plan, Policy Option FAW-1 “Forest Management for Carbon Sequestration”, Element D “Boreal Forest Reforestation After Fire or Insect and Disease Mortality”.</td></tr>
<tr><td>MRV procedures</td><td>-</td></tr>
<tr><td>Enforcement mechanisms</td><td>-</td></tr>
<tr><td>Reference to relevant guidance documents</td><td>Climate Change Action Plans</td></tr>
<tr><td>The broader context/significance of the policy or action</td><td>As described above, the policy intervention promotes higher levels of carbon sequestration (forest biomass accumulation) than would be experienced under business as usual (BAU or baseline) conditions in high-severity burn areas of Alaska’s boreal forests.</td></tr>
<tr><td>Outline of non-GHG effects or co-benefits of the policy or action</td><td>Improved wildlife habitat;
Future timber/other biomass harvest value (note that biomass</td></tr>
</table>

Information	Example
	removals were not considered during the quantification of net GHG benefits); • Employment opportunities; • Reduced erosion in riparian areas.
Other relevant information	-

5.3 Decide whether to assess an individual policy/action or a package of policies/actions

Chapter 5 also provides a description of the advantages and disadvantages of assessing an individual policy/action or a package of policy actions. Steps to guide the user in making this decision based on specific objectives and circumstances include identifying other related policies/actions that interact with the initial policy/action.

The user would need to undertake a preliminary analysis to understand the nature of these interactions and determine whether to assess an individual policy/action or a package of policy actions. This analysis can be brief and qualitative, since detailed analysis of interactions would be taken up in subsequent chapters. An illustrative example for the boreal forest reforestation policy is provided below.

Table 5.5 Mapping policies/actions that target the same emission source(s)

Policy assessed	Targeted emission source(s)	Other policies/actions targeting the same source(s)	Type of interaction	Degree of interaction
Boreal Forest Reforestation	Increased carbon sequestration in high-severity burn areas	Changes to forest harvest practices (e.g. rotation schedules) to achieve greater sequestration levels	Neutral	-
		Any forest management policy that targets high-severity burn areas in the boreal forest of Alaska	Counteracting	Uncertain

Table 5.6 Criteria to consider for determining whether to assess an individual policy/action or a package of policies/actions

Criteria	Questions	Guidance	Evaluation
Use of results	Do the end-users of the assessment results want to know the impact of individual policies/actions, for example, to inform choices on which individual policies/actions to implement or continue supporting?	If "Yes" then undertake an individual assessment	Yes
Significant interactions	Are there significant (major or moderate) interactions between the identified policies/actions, either overlapping or reinforcing, which will be missed if policies/actions are assessed individually?	If "Yes" then consider assessing a package of policies/actions	No

Feasibility	Will the assessment be manageable if a package of policies/actions is assessed? Is data available for the package of policies/actions? Are policies implemented by a single entity?	If “No” then undertake an individual assessment	No
	For ex-post assessments, is it possible to disaggregate the observed impacts of interacting policies/actions?	If “No” then consider assessing a package of policies/actions	Yes

<u>Recommendation for the boreal forest reforestation policy</u>

The policy design which focuses on high-severity burn areas, limits the potential for interaction with other policies, hence the policy can be analyzed individually.

Chapter 6: Identifying effects and mapping the causal chain

In this chapter, users are expected to identify all potential GHG effects of the policy or action and include them in a map of the causal chain.

6.1 Identify potential GHG effects of the policy or action

Using reliable literature resources (such as those mentioned in Box A, combined with professional judgment or expert opinion and consultations etc. users can develop a list of all potential GHG effects of the policy or action and separately identify and categorize them in two categories: In-jurisdiction effects (and sources/sinks) and out-of-jurisdiction effects (and sources/sinks). In order to do this, users may find it useful to first understand how the policy or action is implemented by identifying the relevant inputs and activities associated with the policy or action. For the given policy example, an illustrative list of indicators and possible effects for the policy (by type) is provided below.

Table 6.1 Summary of inputs, activities, and effects for the example policy

Indicator types	Examples for boreal reforestation policy
Inputs	Spending on staff and material in boreal forest reforestation activities using mixed hardwood stock
Activities	Produce re-planting stock Conduct forest plantings Manage/survey reforested areas
Intermediate effects	Trees planted Emissions at nursery operations (energy and fertilizer consumption) Transport of materials and manpower Higher biomass accumulation over baseline conditions
GHG effects	Increase in CO_2, CH_4, and N_2O emissions Terrestrial carbon sequestration

Quantitative information may not be available for all elements identified in the table at the point of assessment and not all elements are relevant for the determination of the causal chain. However, creating a comprehensive list will not only provide support for the identification of effects, but will also help to design a robust performance monitoring (see Chapter 11).

In the next step a comprehensive list of expected effects, based on the understanding of the design of the policy, is developed.

Table 6.2 Illustrative example of various effects for the example policy

Type of effect	Effect
Intended effect	• Sequestration due to increase in biomass accumulation levels above baseline
Unintended effect	• Increased emissions from nursery and planting operations
In-jurisdiction effect	• Upstream emissions due to increased electricity production for nursery energy consumption • Upstream emissions due to increased fuel supply for nursery energy consumption
Out-of-jurisdiction effect	• Upstream emissions due to increased production of nutrients and containers
Short-term effect	• Increase in emissions due to fuel consumption during site surveys

	• Increase in emissions due to fuel consumption during site plantings
Long-term effect	None identified

6.2 Identify source/sink categories and greenhouse gases associated with the GHG effects

Users are also expected to identify and report the list of source/sink categories and greenhouse gases affected by the policy or action.

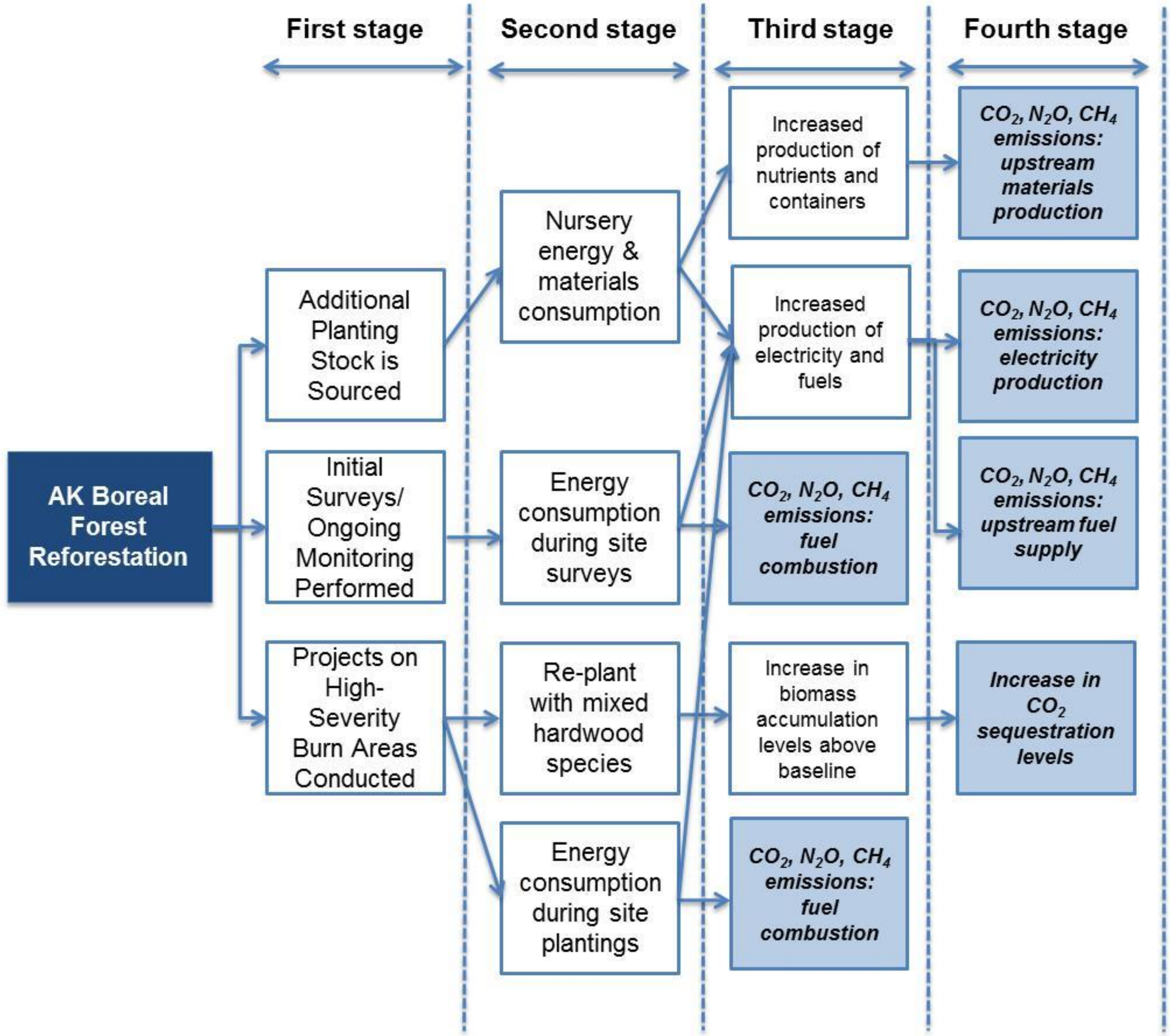
Table 6.3 Sources/sinks and greenhouse gases affected by the example policy

Source/sink category	Description	Examples of emitting equipment or entity	Relevant greenhouse gases
Sequestration	Sequestration due to increase in biomass accumulation levels above baseline	Biomass	CO_2
Production of nutrients and containers	Production of nutrients and containers	Production units	CO_2, CH_4, N_2O
Electricity production	Electricity production for nursery energy consumption	Power plants	CO_2, CH_4, N_2O
Fuel consumption	Increased fuel supply for nursery energy consumption	Stock nursery	CO_2, CH_4, N_2O
Fuel consumption	Fuel consumption during site surveys	Survey and monitoring equipment	CO_2, CH_4, N_2O
Fuel consumption	Fuel consumption during site plantings	Site planting equipment	CO_2, CH_4, N_2O

6.3 Map the causal chain

Once effects have been identified, developing a map of the causal chain allows the user and relevant stakeholders to understand in visual terms how the policy or action leads to changes in emissions. Figure 6.3 presents a causal chain for the example policy based on the effects identified above.

Figure 6.3 Mapping GHG effects by stage for the example policy



For this chapter, there are a number of sector-specific resources such as guidance documents, tools, databases of projects etc. that can be referred to while brainstorming possible effects of policies in the sector, however the extent of available literature and resources varies by policy type and geography. Some examples of these resources are provided in the methods and tools database on the GHG Protocol website, which can be filtered by sector. Most of these resources will not be applicable in their entirety, however select sections of these resources could provide a preliminary basis for further brainstorming and analysis.

Chapter 7: Defining the GHG assessment boundary

Following the standard, users are required to include all significant effects in the GHG assessment boundary. In this chapter, users determine which GHG effects are significant and therefore need to be included. The standard recommends that users estimate the likelihood and relative magnitude of effects to determine which are significant. Users may define significance based on the context and objectives of the assessment. The recommended way to define significance is "In general, users should consider all GHG effects to be significant (and therefore included in the GHG assessment boundary) unless they are estimated to be either minor in size or expected to be unlikely or very unlikely to occur".

7.1 Assess the significance of potential GHG effects

Many agricultural practices can potentially mitigate GHG emissions, the most prominent of which are improved cropland and grazing land management (leading to decreased N_2O emissions and increased soil carbon sequestration) and restoration of degraded lands and cultivated organic soils (leading to soil carbon sequestration). Lower but still significant mitigation potential is provided by water and rice management (reduced N_2O and CH_4 emissions), activities resulting in soil carbon sequestration, land use change and agroforestry (primarily carbon sequestration), and livestock management and manure management (reduced N_2O and CH_4 emissions). Estimates vary, but most of the global mitigation potential of agriculture (about 89%) rests in soil carbon sequestration. About 9% and 2% rests in reducing methane and soil N_2O emissions, respectively.

Rebound effects are very prevalent, which lead to substitution of one type of GHG emissions with another. For instance:

- Measures taken to enhance soil carbon sequestration (e.g., no till-practices or increased irrigation) can lead to increased soil N_2O emissions
- Wooded riparian buffer zones can increase carbon sequestration but lead to increased soil N_2O emissions, compared to field margins.
- Aerating a manure lagoon to reduce CH_4 emissions will increase N_2O emissions.
- Removal of straw from flooded rice paddies to reduce CH_4 emissions can lead to the requirement for more fertilizer and increased N_2O emissions.
- The application of N-transformation inhibitors to soils to reduce the leaching of some N_2O precursors may increase that of others.

These cases demonstrate the need to identify trade-offs and consider multiple sources and GHGs in tandem when evaluating possible mitigation measures. A whole-systems approach avoids potentially ill-advised policies based on preoccupation with one individual practice.

For the forestry sector specifically, displacement or leakage effects are likely to be significant for:

a. Avoided deforestation policies that do not also address the provision of the services/products that would have been provided by the deforested land in the baseline.
b. Afforestation/reforestation policies that do not also address the provision of the services/products that would have been provided by the afforested/reforested land in the baseline.

For the boreal forest reforestation policy, an illustrative assessment boundary is described below.

Table 7.3 Example of assessing each GHG effect separately by gas to determine which GHG effects and greenhouse gases to include in the GHG assessment boundary for the example policy

GHG effect	Likelihood	Relative magnitude	Included?
Sequestration due to increase in biomass accumulation levels above baseline			
CO_2	Very likely	Major	**Included**
Upstream emissions due to increased production of nutrients and containers			
CO_2	Very likely	Minor	Excluded
CH_4	Very likely	Minor	Excluded
N_2O	Very likely	Minor	Excluded
Upstream emissions due to increased electricity production for nursery energy consumption			
CO_2	Very likely	Minor	Excluded
CH_4	Very likely	Minor	Excluded
N_2O	Very likely	Minor	Excluded
Upstream emissions due to increased fuel supply for nursery energy consumption			
CO_2	Very likely	Minor	Excluded
CH_4	Very likely	Minor	Excluded
N_2O	Very likely	Minor	Excluded
Emissions due to fuel consumption during site surveys			
CO_2	Very likely	Moderate	**Included**
CH_4	Very likely	Minor	Excluded
N_2O	Very likely	Minor	Excluded
Emissions due to fuel consumption during site plantings			
CO_2	Very likely	Moderate	**Included**
CH_4	Very likely	Minor	Excluded
N_2O	Very likely	Minor	Excluded

Figure 7.3 Assessing each GHG effect to determine which GHG effects to include in the GHG assessment boundary: Boreal reforestation policy

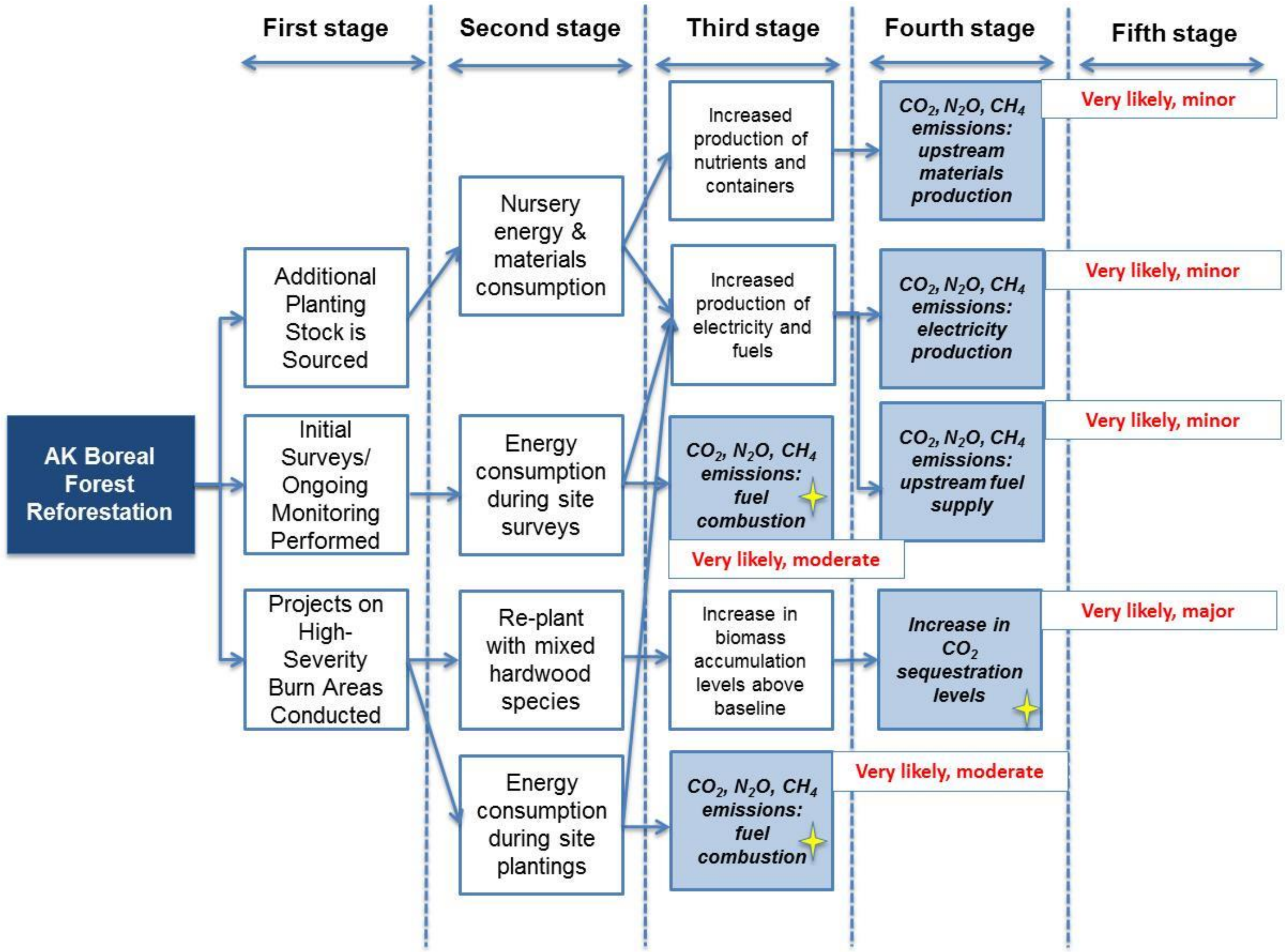


Table 7.4 List of GHG effects, GHG sources and sinks, and greenhouse gases included in the GHG assessment boundary for the example policy

GHG effect		GHG sources	GHG sinks	Greenhouse gases
1	Sequestration due to increase in biomass accumulation levels above baseline	Sequestration due to increase in biomass accumulation levels above baseline	N/A	CO_2
2	Emissions due to fuel consumption during site surveys	Fuel consumption during site surveys	N/A	CO_2
3	Emissions due to fuel consumption during site plantings	Fuel consumption during site plantings	N/A	CO_2

The 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, Chapter 4, has default values for above-ground biomass for different forest types, and also default carbon-density factors for biomass. These default data can be used, together with estimates of the area of forest (either protected or created), to estimate avoided emissions or the enhancement of sinks.

This approach can be used to estimate both the primary emission reductions/sink enhancements of a policy, and also the magnitude of leakage effects (i.e. by estimating the displaced area of deforestation, or foregone afforestation/reforestation).

Chapter 8: Estimating baseline emissions

In this chapter, users are expected to estimate baseline emissions over the GHG assessment period from all sources and sinks included in the GHG assessment boundary. Users need to define emissions estimation method(s), parameter(s), driver(s), and assumption(s) needed to estimate baseline emissions for each set of sources and sinks.

8.3 Choose type of baseline comparison

A challenge to applying the comparison groups approach for this sector would be identifying control groups in other regions that offer analogous environmental conditions. GHG emissions in the sector are heavily affected by environmental factors such as temperature, rainfall, soil pH, slope, etc.

8.4 Estimating baseline emissions using the scenario method

8.4.1 Define the most likely baseline scenario

Users need to identify other policies and non-policy drivers that affect emissions in the absence of the policy or action. Examples of other policies and non-policy drivers are provided in Table 8.3 and Table 8.4.

Table 8.2 Examples of other policies or actions in the AFOLU sector that may be included in a baseline scenario

Forestry Sector

Examples of other policies	Sources of data for developing assumptions
Level of enforcement of protected areas	No central source and specific to each country.
Permitting for land conversion	No central source and specific to each country.
Biofuel policies (e.g. EU Renewable Energy Directive, and US Renewable Fuel Standard)	No central source and specific to each country.
Agricultural production subsidies	www.fao.org and www.ifpri.org

Agriculture Sector

Examples of other policies	Sources of data for developing assumptions
North America Environmental Quality Incentives Program (EQIP)—cost-sharing and incentive payments for conservation practices on working farms (USA)	Equilibrium models forecasting commodity/input prices and land demand
The Natural Resources Conservation Service (NRCS) – rewards and recognizes actions that provide GHG benefits – improved N use efficiency rewarded (USA)	
The Conservation Reserve Program (CRP)—environmentally sensitive land converted to native grasses, wildlife plantings, trees, filter strips, riparian zones (USA)	
The Conservation Security Program (CSP)—(voluntary) assistance promoting conservation on cropland, pasture, and range land (and farm woodland) (USA)	
Greencover in Canada and provincial initiatives—encourages shift from annual to perennial crop production on poor quality soils (Canada - defunct)	

USDA renewable energy initiatives in 26 States (USA) - Provide loan guarantees and payments for e.g., RE installations	
EU CAP payments for set-asides	
Laws on nutrient management and water quality (e.g., EU Water Framework Directive, Water codes of the Russian Federation, etc.)	
Bans on agricultural activities (e.g., open burning of crop residues) that impair air quality	
EU ban on dumping at sea of sewage sludge, leading to more sewage being applied on farms	
Regulations to promote conversion of degraded lands to set-asides or more productive agricultural land (e.g., eastern Europe and China)	

Table 8.4 Examples of non-policy drivers that may be included in a baseline scenario

Forestry Sector

Non-policy drivers	Sources of data for developing assumptions
Population growth	World Bank: http://data.worldbank.org/indicator/SP.POP.GROW
Economic growth	World Bank: http://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG
Changing patterns in demand for agricultural commodities (e.g. increased demand for animal protein in developing countries)	www.fao.org and www.ifpri.org
Agricultural yields	www.fao.org

Agriculture Sector

Non-policy drivers	Sources of data for developing assumptions
Shifts in consumer preferences (e.g., growing demand for meat)	Surveys
Changes in prices of energy and agricultural commodities	National statistics
Changes in weather and climate	Climate models
Water availability	National statistics
Changes in use of land base (e.g., urbanization, deforestation, agricultural intensification/industrialization) due to demographic/economic changes and advances in technology	Equilibrium models, land cover data sets

8.4.2 Select a desired level of accuracy

There are different methodological choices related to the level of accuracy of an assessment. Simplified methods can be used, such as IPCC Tier 1 methods, or more complex methods, such as IPCC Tier 3. The methods by which the parameter values of the selected method are derived also impacts the accuracy of the analysis. A further important factor is the source of data, where internationally applicable default values constitute lower levels of accuracy than jurisdiction or source specific data.

Further, emission factors can be static (calculated upfront and applied for the duration of the assessment) or dynamic (updated over time to reflect changes in recycling, compost, or electricity markets) and that can be another means of making the distinction. A low accuracy method could have the option of applying a static emission factor and higher accuracy methods could update emission factors on a regular basis to maintain accuracy.

For the example of the boreal forest reforestation policy, examples for different levels of accuracy based on the number of effects to include are provided below.

Low accuracy: Section 8.4.3 below provides an example for estimating only one effect: net carbon sequestration. The calculation is provided for one year of reforestation projects (2010: totaling 13,152 acres).

Although not conducted for this example, an **intermediate accuracy** assessment could also capture energy consumption related emissions for initial surveys and periodic monitoring, as well as the energy consumed due to transport materials and personnel to reforestation sites. Data would need to be gathered from state forestry experts, including the mode (air or road) and distance of transport, and schedule for periodic monitoring. After estimating the annual vehicle or air kilometers of travel, literature data or refined transport models (e.g. the U.S. EPA's MOVES model) could be used to determine fuel consumption (e.g. diesel and/or aviation gasoline). Standard IPCC emission factors could then be used to estimate emissions of CO_2, CH_4, and N_2O.

High accuracy: A high accuracy assessment would also include additional energy consumed during re-planting stock production and the upstream GHG emission estimates for fuel consumption, nutrient consumption, and electricity consumption. Upstream GHG emission factors for fuels (addressing extraction, processing/refining, and distribution) would need to come from literature sources or available models. In the U.S., the Department of Energy, Argonne National Laboratory (ANL) and several state agencies maintain models for estimating these full energy-cycle emissions (e.g. ANL's GREET Model). Use of energy and fertilizer for planting stock at nurseries, as well as information on the upstream emissions for fertilizer consumption would need to be obtained through a review of the current literature. For any electricity consumed, existing protocols, such as The Climate Registry's General Reporting Protocol (covering North America), as well as emission factor databases such as eGRID for the United States would be a source of information for the carbon intensity of grid-based electricity.

8.4.3 Define the emissions estimation method(s) and parameters needed to calculate baseline emissions

The annual carbon stock changes for the entire AFOLU sector can be estimated as the sum of changes in all land-use categories:

Equation 1 Estimating carbon stock changes for the AFOLU sector

$$\Delta C_{AFOLU} = \Delta C_{FL} + \Delta C_{CL} + \Delta C_{GL} + \Delta C_{WL} + \Delta C_{SL} + \Delta C_{OL}$$

Where:

ΔC = carbon stock change
AFOLU = Agriculture, Forestry and Other Land Use
FL = Forest Land
CL = Cropland
GL = Grassland
WL = Wetlands
SL = Settlements
OL = Other Land

As an example, the baseline calculation method for emissions associated with the sequestration due to increase in biomass accumulation levels (one of the identified sources in the assessment boundary of the policy example of boreal forest reforestation) is demonstrated below:

Baseline boreal grassland CO_2 sequestration:

Equation 2 Estimating baseline emissions for net carbon sequestration

Baseline $emissions_{year}$ = (Replanted area x carbon accumulation rate by cover type x 44/12) x (-1)

Table A[2] Examples of determining baseline values from published data sources

Parameter	Sources of published data for baseline values
Carbon accumulation rate by cover type	IPCC Guidelines, national forestry agencies, national/local studies, local measurement
Replanted area (Average wildfire activity)	National/regional statistics

Table 8.2 Examples of typical other policies and actions, and related data sources for developing assumptions (for developing new baseline values) for each parameter

Parameter	Relevant polices	Sources of data for developing assumptions
No other policies were identified for this reforestation example.		

Table 8.4 List of typical non-policy drivers and related data sources for developing assumptions (for developing new baseline values) for each parameter

Parameter	Typical non-policy drivers	Sources of data for developing assumptions
Replanted Area	• Climate change-induced drivers, including increases in wildfire occurrence in areas affected by severe burns are important.	• Secondary sources of data including state/provincial natural resource inventories, greenhouse gas inventories, or regional planning organizations (e.g. air quality planning organizations).

8.4.4 Estimate baseline values for each parameter

The following table provides an overview of the parameter values used for the baseline calculation.

[2] Table numbering differs, as there is no corresponding table included in the standard. The table is adapted from table 8.7 in the standard.

Table 8.7 Example of reporting parameter values and assumptions used to estimate baseline emissions for the food waste diversion policy

<table>
<tr><th>Parameter</th><th>Baseline value(s) applied over the GHG assessment period</th><th>Methodology and assumptions to estimate value(s)</th><th>Data sources</th></tr>
<tr><td>Carbon accumulation rate</td><td>0.010 tC/acre-yr (boreal grassland)</td><td>The assumption is that without the policy, area affected by wildfires would be covered by boreal grassland.
IPCC above-ground biomass value for boreal grasslands is 1.7 t dry mass/hectare: http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_06_Ch6_Grassland.pdf.
Assume dry mass is 50% carbon by weight; 35 years time for mixed hardwood forest to reach maturity (grassland likely reaches maturity well before 35 years).</td><td>IPCC 2006 Guidelines</td></tr>
<tr><td>Mixed hardwood sequestration rate</td><td>0.648 tC/acre-yr</td><td>Unpublished value: Assumes forest regeneration with Balsam Poplar, which yields 30 cords/acre over 35 years.</td><td>AK Division of Forestry staff communication.</td></tr>
<tr><td>Replanted area</td><td colspan="2">Boreal Forest Reforestation Targets
<table>
<tr><th>Year</th><th>Acres Replanted</th><th>Incremental C Accumulated (tCO_2)</th></tr>
<tr><td>2010</td><td>13,152</td><td>30,757</td></tr>
<tr><td>2011</td><td>18,413</td><td>43,060</td></tr>
<tr><td>2012</td><td>23,674</td><td>55,363</td></tr>
<tr><td>2013</td><td>28,935</td><td>67,666</td></tr>
<tr><td>2014</td><td>34,196</td><td>79,969</td></tr>
<tr><td>2015</td><td>39,457</td><td>92,272</td></tr>
<tr><td>2016</td><td>42,087</td><td>98,424</td></tr>
<tr><td>2017</td><td>44,718</td><td>104,575</td></tr>
<tr><td>2018</td><td>47,348</td><td>110,727</td></tr>
<tr><td>2019</td><td>49,979</td><td>116,878</td></tr>
<tr><td>2020</td><td>52,609</td><td>123,030</td></tr>
<tr><td>2021</td><td>55,240</td><td>129,181</td></tr>
</table></td><td>Targets set</td></tr>
</table>

	2022	57,870	135,333		
	2023	60,501	141,484		
	2024	63,131	147,636		
	2025	65,761	153,787		
	Totals	**697,072**	**1,630,147**		

8.4.5 Estimate baseline emissions for each source/sink category

The final step is to estimate baseline emissions by using the emissions estimation method identified in Section 8.4.3 and the baseline values for each parameter identified in Section 8.4.4.

Baseline emissions_{2010} = (Replanted area x carbon accumulation rate x 44/12) x (-1)
= (13,152 acres x 0.010 tC/acre-yr x 44 tCO_2/12 tC) x (-1)
= - 482 tCO_2

The same calculations would need to be made for each year of the policy assessment period addressing this first year of reforestation projects and adding in the cumulative sequestration for the additional area reforested each year.

8.6 Aggregate baseline emissions across all source/sink categories

Table 8.9 provides an illustrative example of the results of the analysis for all effects included in the assessment boundary, assuming the calculation steps outlined in section 8.4, that were illustrated with effect 1, were carried out for each of the effects.

Table 8.9 Example of aggregating baseline emissions for the boreal forest reforestation policy[3]

GHG effect included in the GHG assessment boundary	Affected sources	Baseline emissions
1 Sequestration due to increase in biomass accumulation levels above baseline	Sequestration due to increase in biomass accumulation levels above baseline	- 482 t CO_2
2 Emissions due to fuel consumption during site surveys	Fuel consumption during site surveys	0
3 Emissions due to fuel consumption during site plantings	Fuel consumption during site plantings	0
Total baseline emissions		**- 482 t CO_2**

Note: The table provides data for the end year in the GHG assessment period (2025).

[3] Numbers for effects 2 and 3 are illustrative.

Chapter 9: Estimating GHG effects ex-ante

In this chapter, users are expected to estimate policy scenario emissions for the set of GHG sources and sinks included in the GHG assessment boundary based on the set of GHG effects included in the GHG assessment boundary. Policy scenario emissions are to be estimated for all sources and sinks using the same emissions estimation method(s), parameters, parameter values, GWP values, drivers, and assumptions used to estimate baseline emissions, except where conditions differ between the baseline scenario and the policy scenario, for example, changes in activity data and emission factors.

9.2 Identify parameters to be estimated

Data needs for emissions estimation vary with the type of policy / action being implemented. For example, the data needs for emissions estimation in case of afforestation and reforestation of lands (except wetlands) include change in carbon stock in tree biomass, change in carbon stock in shrub biomass, change in carbon stock in dead wood biomass, change in carbon stock in litter, change in carbon stock in soil organic carbon (SOC) and increase in non-CO_2 GHG emissions. The data needs for estimation of N_2O Emissions Reductions in Agricultural Crops through Nitrogen Fertilizer Rate Reduction (Approved VCS Methodology VM0022) are:

- Mass of project nitrogen (N) containing synthetic fertilizer applied,
- Mass of project N containing organic fertilizer applied,
- N content of project synthetic fertilizer applied,
- N content of project organic fertilizer applied,
- Emission factor for project N_2O emissions from N inputs,
- Project synthetic N fertilizer applied,
- Project organic N fertilizer applied,
- Fraction of all synthetic N added to project soils that volatilizes as NH_3 and NO_x,
- Fraction of all organic N added to project soils that volatilizes as NH_3 and NOx,
- Fraction of N added (synthetic or organic) to project soils that is lost through leaching and runoff, in regions where leaching and runoff occurs,
- Emission factor for project N_2O emissions from atmospheric deposition of N on soils and water surfaces and
- Emission factor for project N_2O emissions from N leaching and runoff.

Table A in Chapter 8 forms the basis for determining which parameters are affected by the policy. In case the determination of affected parameters is not straightforward, the methodology to determine significance outlined in Chapter 7 can be used. For the first effect of the policy 'sequestration', the only parameter from equation 2 affected by the policy is the carbon sequestration factor.

9.4 Estimate policy scenario values for parameters

Once the affected parameters are determined the parameter values for the policy scenario can be determined. All other parameters remain as in the baseline scenario. Table 9.2 provides an example.

Table 9.2. Example of reporting parameter values and assumptions used to estimate ex-ante policy scenario emissions for the boreal forest reforestation policy

Parameter	Baseline Value	Policy Scenario Values	Trend over time for scenario value(s)	Time period of effect	Source(s) used	Comments / Explanation
Carbon accumulation	0.010 tC/acre-yr	0.648 tC/acre-yr	Unpublished value: Assumes		AK Division of Forestry staff	

rate	(boreal grassland)	(mixed hardwood)	forest regeneration with Balsam Poplar, which yields 30 cords/acre over 35 years.		communication.	
Area reforested	See table 8.7	Same as baseline values	Not affected			

9.5 *Estimate policy scenario emissions*

Once parameter values have been determined, the same equations as used for the calculation of baseline values can be used to derive the policy scenario values:

Policy intervention reforestation CO_2 sequestration:
Policy scenario emissions_{2010} = (Replanted area x carbon accumulation rate by cover type x 44/12) x (-1)
= (13,152 acres x 0.648 tC/acre-yr x 44 tCO_2/12 tC) x (-1)
= - 31,249 tCO_2

9.6 *Estimate the GHG effect of the policy or action (ex-ante)*

After determining the GHG emissions for the policy scenario for each source category, the change resulting from the policy can be determined. Table 9.3 provides an overview of the results.

Table 9.3 Example of estimating the GHG effect of the food waste diversion policy[4]

GHG effect included	Affected sources	Policy scenario emissions	Baseline emissions	Change
1 Sequestration due to increase in biomass accumulation levels above baseline	Sequestration due to increase in biomass accumulation levels above baseline	- 31,249 tCO_2	- 482 t CO_2	**- 30,767 tCO_2**
2 Emissions due to fuel consumption during site surveys	Fuel consumption during site surveys	157 tCO_2	0	**157 tCO_2**
3 Emissions due to fuel consumption during site plantings	Fuel consumption during site plantings	473 tCO_2	0	**473 tCO_2**
Total emissions / Total change in emissions		**- 30,619 tCO_2**	**- 482 t CO_2**	**- 30,137 tCO_2**

Note: The table provides data for the end year in the GHG assessment period (2020).

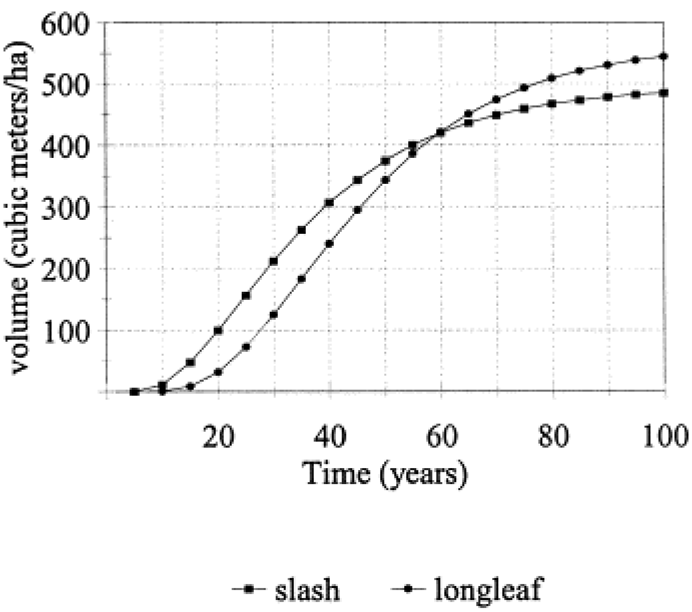
The primary parameters are the area of re-forestation each year, the above-ground carbon stocks for mature boreal grasslands and hardwood stands, and the time required for the new hardwood stands to reach maturity. [Note that below ground carbon stocks (roots, soil carbon) could also be important in an overall assessment of forest carbon benefits; however, good data for these carbon pools are often

[4] Numbers for effects 2 and 3 are illustrative.

lacking. For the example policy, below ground stocks for a mature hardwood stand would be expected to be higher than a grassland; therefore, the estimated GHG benefits are conservatively low].

The example provided uses a simplified method suitable for policy analysis. In addition to the area of reforestation projects, a key parameter is the rate of biomass (carbon) accumulation. The simplified method determines this annual average rate using an estimate of above-ground biomass density (e.g. cubic meters/hectare) for a given forest type, and then divides by the number of years expected for that reforested stand to reach maturity. In reality, the slope of accumulation is not linear as shown in the example chart below for two pine species. During the first 5 to 10 years, biomass accumulation rates would be expected to be fairly modest; once the stand is fully-established, then the accumulation rate increases significantly over the succeeding 30-50 years, before beginning to level off. In cases where more precise estimates are needed, use of a timber growth and yield model should be considered.

Source: Alavapati et al, 2002. http://www.sciencedirect.com/science/article/pii/S0921800902000125



Box B.1 Addressing policy interactions

There are likely to be overlapping effects between agricultural policies that reduce yields (as an unintended effect) and policies that aim to reduce emissions from deforestation or forest degradation (REDD+) – as reduced yields are likely to increase the total amount of agricultural land required. There are likely to be reinforcing effects between agricultural policies that increase yields and policies that aim to reduce emissions from deforestation or forest degradation (REDD+) – as increased yields are likely to reduce the total amount of agricultural land required. Similarly there are likely to be interactions between afforestation/reforestation policies that reduce agricultural production or the availability of agricultural land, and REDD+ policies which aim to reduce deforestation – as restrictions in the supply of agricultural commodities is likely to increase prices, and farmers may respond by converting more land to agricultural use.

The example policy did not have any interactive policies identified. However, a hypothetical example could be some promotion of timber harvests for either energy use or forest products (resulting in harvests above baseline conditions). With the exception of durable wood products (e.g. lumber for building structures, furniture), an increase above baseline for other forest product harvests should be subtracted from the future estimated carbon sequestration (in the year harvested). This assumes that the replanted stands are subject to future harvests. For example, based on the type of forest, time required for the stand to reach marketable diameter, and anticipated harvesting procedures (e.g. clear cut versus select removal); the amount of carbon in the above-ground live tree carbon pool harvested should be subtracted out of the cumulative forest carbon sequestered by that year. Average annual sequestration rates over that time period should then reflect only the net carbon remaining after harvests.

In the case of harvests for durable wood products, some fraction of the harvested biomass will remain stored in that product. Forest project protocols, similar forestry guidance, or local forestry experts should be consulted to establish a defensible fraction of carbon to be stored in these products (e.g. net of live tree carbon harvested minus forest harvest residue minus forest products industry waste).

Chapter 10: Monitoring performance over time

In this chapter, users are required to define the key performance indicators that will be used to track performance of the policy or action over time. Where relevant, users need to define indicators in terms of the relevant inputs, activities, intermediate effects and GHG effects associated with the policy or action.

10.1 Define key performance indicators

Some typical indicators for common policies in the sector are shown in the table below.

Table 10.1 Examples of indicators

	Moratorium on forest conversion	Enhanced forest management	Incentive payment for reforestation	Incentives for adoption of conservation tillage techniques (no-till, ridge-till and mulch-till, etc.)
Input indicators	• Financial and human resources for monitoring and enforcement	• Financial and human resources for enhanced forest management	• Financial resources committed to program	• Money, skills (agricultural extension services)
Activity indicators	• Provision of moratorium map, and number of prosecutions for breeches in moratorium	• Number of forest managers trained • Optimization studies on the volume and timing of fertilizer amendments	• Amount of incentive payments dispersed	• Methods used to cultivate agricultural soils
Intermediate effect indicators	• Area of land use change	• Area of forest land under improved management	• Area of land with successfully established trees	• Percentage of farmers using conservation tillage techniques or percentage of farmland under conservation tillage
GHG effects	• Gross GHG emissions or removals from the moratorium area	• Gross GHG emissions or removals from the forest land under management • Avoidance of the direct N_2O emissions from soils; avoidance	• Gross GHG emissions and removals from the land planted with trees	• Avoided soil CO_2 emissions and increased soil carbon sequestration

		of indirect N_2O emissions from the volaitization of N from soils and leaching/run-off of excess		
Non-GHG effects	None identified	• Employment generated	• Revenue generated	• Revenue generated

10.4 Create a monitoring plan

Although the example policy for Alaska did not provide details on monitoring, a monitoring program to fully measure and document the GHG effects could be implemented. Detailed measurement and monitoring procedures are available from forestry project offset protocols that could be adapted to monitor the policy's effects at the broader scale envisioned by the policy.

A monitoring program would need to address both baseline conditions (i.e. high site class lands that will not be reforested) as well as replanted areas. This would involve establishing sample plots in both areas that will be monitored over at least several decades. The number of sample plots required is a function of the variability in initial carbon stocks and the level of precision needed for assessing GHG effects (see the cited protocols for additional details on establishing sample plots). A measurement frequency should also be established for both baseline and replanted sample plots. While project protocols might require this to be done annually or every few years, for a state-level policy, such as the example policy, once every 3-5 years is probably sufficient.

For each sample plot, biomass (carbon stocks) is measured for each of the carbon pools: e.g. above-ground live tree, standing dead trees, down dead trees, understory, forest litter, and possibly soil carbon. Offset protocols used as a model to develop a monitoring program may also contain methods to account for the carbon storage value of timber harvested during the monitoring period within durable wood products.

After each monitoring cycle, the measurement of carbon stocks could be transformed into annual estimates of carbon sequestered both within the baseline areas and the replanted areas. Offset protocols will often specify appropriate forest growth models that should be applied. This transformation would provide estimates of carbon sequestered per hectare/year, for example, in both baseline and replanted areas. The net benefit of the policy is the total carbon sequestered within the replanted areas minus the amount of carbon that would have been sequestered without the policy (i.e. baseline sequestration rate x replanted area). Added to this amount would be any additional carbon stored in durable wood products from timber harvests on replanted areas (this example assumes that the baseline areas would not also produce marketable timber within the monitoring period).

For Tier 2 or 3 assessments, in addition to the forest carbon measurements described above, there will be a need to maintain information on the energy consumed as a result of the replanting projects implemented through the policy and the overall monitoring program. The resulting net GHG effects will be the sum of carbon dioxide sequestered above baseline (a negative number) and the GHG emissions for energy consumed during replanting and monitoring.

Taking the example of a high accuracy ex-post GHG assessment, an illustrative example of a monitoring plan for the example policy is provided below.

Table 10.5. Example of information to be contained in the monitoring plan

Indicator or parameter (and unit)	Source of data	Monitoring frequency	Measured/modelled/ calculated/estimated (and uncertainty)	Responsible entity
Baseline sequestration rate	Forest growth models in offset protocols	Once every 3-5 years	Modeled	Implementing body
Replanted area	Policy implementation plan	Once every 3-5 years	Measured	Implementing body
Policy sequestration rate	Forest growth models in offset protocols	Once every 3-5 years	Modeled	Implementing body

Chapter 11: Estimating GHG effects ex-post

A number of ex-post assessment methods have been described in this chapter, which can be classified into two broad categories i.e. Bottom-up methods and top-down methods.

11.2 Select an ex-post assessment method

The applicability of individual ex-post quantification methods for the sector and illustrative sources of data are discussed in Table 11.1.

Bottom up methods are more applicable to REDD+ policies: the most common approach used for REDD+ projects and results-based payments at a national level involves the use of remotely sensed data and ground-based studies of land cover change (known as activity data) and data on carbon stocks for different types of land cover (known as emission factors). These data are then used to calculate total emissions from deforestation (removals from enhanced sinks). The impact of individual policies in achieving the observed level of deforestation might be estimated by adjusting the observed level of deforestation for other drivers in the baseline.

Table 11.1 Applicability of ex-post assessment methods in the forestry sector

Bottom up methods	Applicability
Collection of data from affected participants/ sources/other affected actors	• Applicable. Direct monitoring of emissions is not possible, but direct monitoring of parameters is common. • Additionally, aggregated data for observed deforestation, or area afforested/reforested, can be "cleansed" for background "noise" (e.g. spikes on agricultural commodity prices, or civil conflict) – alternatively, the baseline could be recalculated with these observed drivers factored in.
Engineering estimates	• An approach comparable to "engineering estimates" may be applicable to improved forest management policies, where a model for the enhancement of sinks may be used to estimate the impact of introducing improved forest management practices.
Deemed estimate	• Applicable
Methods that can be bottom-up or top-down depending on the context	**Applicability**
Stock modeling	• Applicable
Diffusion indicators	• Applicable
Top down methods	**Applicability**
Monitoring of indicators	• Applicable
Economic modeling	• N/A

Bottom up methods are more applicable for the agriculture sector.

Table 11.1 Applicability of ex-post assessment methods in the agriculture sector

Bottom up methods	Applicability
Collection of data from affected participants/ sources/other affected actors	• Many, but not all, agricultural emissions sources can be measured with in-situ measurement techniques (e.g., controlled livestock chambers for measuring enteric

	fermentation and flux chambers for monitoring the amount of N_2O and/or CO_2 emitted from plots of land). While useful for research, direct measurements are generally too expensive to be feasible for the purposes of ex-post evaluation. However, they can be used to improve more approximate estimation techniques, such as emissions factors, and to calibrate mechanistic (biogeochemical process) models.
Engineering estimates	• Biogeochemical process models link important biogeochemical processes that control the production, consumption, and emission of GHGs. They can account for the cumulative GHG impacts of a suite of management practices and other variables that affect GHG emissions, as long as the models are applied under the conditions for which they were developed (e.g., applied in regions and management systems for which calibrating data are available). Often, more field data sets may be required to support the implementation and expansion of models in policy analyses. Also, it is paramount that detailed consideration is given to the structural and input uncertainty related to the use of these models. The aggregate accuracy of models is likely to increase with spatial scale, as more combinations of environmental conditions are averaged over.
Deemed estimate	-
Methods that can be bottom-up or top-down depending on the context	**Applicability**
Stock modeling	-
Diffusion indicators	-
Top down methods	**Applicability**
Monitoring of indicators	-
Economic modeling	-

For the policy example, quantifying effects ex-post will require the use of bottom-up monitoring data as described above. Top-down data might include the total area reforested as a result of the policy; however, that alone will not be sufficient to derive GHG effects. Estimates of carbon accumulation within each of the forest carbon pools from on-site surveys will be needed in order to estimate the amount of carbon dioxide sequestered annually.

Table 11.1 Applicability of ex-post assessment methods

Bottom up methods	Applicability
Collection of data from affected participants/ sources/other affected actors	• Required as described
Engineering estimates	• Not applicable
Deemed estimate	• Not applicable
Methods that can be bottom-up or top-down depending on the context	**Applicability**
Stock modeling	• Required as described
Diffusion indicators	• Not applicable
Top down methods	**Applicability**
Monitoring or indicators	• Monitoring of areas replanted will need to be combined with

	bottom-up survey data
Economic modeling	• Not applicable

11.3 Select a desired level of accuracy

Examples of how to implement ex-post quantification methods using low to high accuracy level approaches for the policy example are described below:

Low accuracy
A low accuracy approach for the example policy would focus on the net increase in carbon sinks achieved by the policy. The approach could be based on a combination of on-site surveys and remote sensing (satellite imagery or aerial photos) to assess the health of reforested areas. The results of a limited number and/or frequency of forest biomass surveys would supply the carbon accumulation rates for reforested areas, while the imagery would be used to assess the relative health of all reforested areas.

Intermediate accuracy
An intermediate accuracy approach would also focus on carbon sequestration, however, here the number and frequency of on-site surveys would conform to a widely-accepted forest carbon accounting protocol. Per the protocol requirements, survey results of monitoring plots would be scaled-up in each year and used within the protocol's accepted yield models or equations to estimate accumulated carbon (and annual CO_2 sequestration).

High accuracy
For a high accuracy approach, other GHG sources would be added to the Tier 2 method above in order to provide a set of net sequestration values during each historical year. These additional sources could include energy consumption during survey activities (e.g. fuel combustion during transport of survey teams).