# Moldova Soil Conservation Project Monitoring Plan

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## 1.0 Objective and components of the Monitoring Plan

The monitoring plan is intended to facilitate monitoring, recording, reporting, and verification activities necessary for assessment of the project performance and determination of the achieved emissions reductions in compliance with the approved methodology AR-AM0002 under the Clean Development Mechanism of the Kyoto Protocol's Article 12 and other applicable requirements.

The following components are addressed in the monitoring plan (MP) for quantifying the carbon sequestered under the Moldova Soil Conservation Project:

- Project boundary
- Baseline scenario
- Sources of variability and management of heterogeneity in biomass pools via stratification
- Procedures for monitoring of the carbon pools
- Determination of sampling intensity required to achieve a desired precision.
- Allocation of sample plots over the project area
- Measurement and calculation of changes in carbon pools
- Scheduling of monitoring, measurement and verification
- Implementation of quality assurance procedures
- Verification of results by a third party
- Indicators for monitoring of soil conservation, biodiversity, and socio-economic status of the project

**2.0 Project boundary**

The project boundary is delineated to cover all land parcels of the project and the boundaries of the parcels are demarcated using global positioning system (GPS) and verified through field surveys. Project boundary will be periodically verified and any change (e.g., due to land slides, soil erosion etc.) is measured and recorded in the project database for submission to the DOE at the time of next verification.

**3.0 Baseline conditions**

The baseline provides the “business-as-usual” scenario, against which carbon accruing to the project is measured. In the areas falling under the project, no project lands have supported woody vegetation since 1990 and none were previously orchards. Furthermore, no natural forest regeneration has been witnessed on any of the project lands.

**Table 1: Initial conditions of afforestation/reforestation sites**

| Initial conditions | Hectares |
|---|---|
| Degraded | 4,623.3 |
| Pastures | 11,789.0 |
| Arable | 597.1 |
| Glades and open spaces | 3280.5 |
| TOTAL | 20289.9 |

There is some overlap in the definitions of initial conditions outlined in Table 1. “pasture” and “degraded lands”, for example, are not distinguished based on initial state of the land or any quantifiable conditions, but represent land-use designation. Therefore, these baseline categories were combined as they did not differ appreciably in initial soil carbon content. The sites were categorized under *rich* and poor *soils* based on the humus level that highlight the initial soil condition.

In two extensive reviews of study results from throughout the world, both including sites in the former Soviet Union with Chernozem and “Gray forest” soils typical of Moldova, Mann (1986) and Davidson and Ackerman (1993) found mean losses of 20 % and 24 %, respectively, of soil carbon inventories, expressed as mass C per unit area (equal weights sampled), in the top 30 cm following cultivation of previously un-cultivated lands. *Most of these losses occurred over the first five to twenty years following conversion*. As all project sites have been free of forest vegetation for similar or longer time periods, the depletion of original forest soil carbon stocks resulting from conversion to cultivation has likely already occurred and soil carbon has reached a new low steady state. Accordingly, soil carbon stocks witnessed on baseline case sites such as those described above are presumed to be static over the project lifetime *where land use remains constant*.

The results of the baseline study show that the degraded and pasture lands either lack vegetation or have insignificant vegetation, which could degrade further losing more carbon over time in the absence of restoration interventions. Therefore, as a conservative approach, the baseline net GHG removals by sinks from such lands are assumed to remain zero during the crediting period.

As small rates of pre-project afforestation was undertaken in the degraded and pasture lands in the country, the project will seek to implement the pre- project afforestation/reforestation to satisfy the baseline A/R rate as per the guidelines of the approved methodology - AR AM0002. As the project is undertaken on the public and community lands, for the purpose of assessing the pre-project A/R rate, annual afforestation and reforestation area of the public and community lands in the country during 10 years prior to the project from 1992 to 2001 was calculated.

As Moldsilva is the only public agency responsible for afforestation/reforestation in the country, the pre-project A/R of the country and of Moldsilva is expected to the same. The data on 10-year history of

afforestation and reforestation prior to the implementation of the project is used to calculate the rate of pre-project planting. The low planting rates without any significant trends for improvement demonstrates the project entity's inability to restore degraded lands by following the historic rates of planting. The total pre-project area afforested/reforested during 1992 to 2001 is 2003 hectares, at an average of 319.9 ha per year. This rate is applicable to the total area of degraded land of 85,700 (ha) available for restoration through afforestation and reforestation activity at the national level in 2002. This translates into an annual pre-project A/R rate of (319.9/85,700 ha) 0.373%. This rate is applied to the area included in the project in order to calculate the baseline (business-as-usual) scenario as per the provisions of the Section II.5 of the approved methodology AR AM0002. Table 2 (a) presents details of calculation of the baseline A/R rate.

**Table 2 (a): Baseline afforestation/reforestation rate in Moldova in 1992-2001**

| Reference year | Area (ha) afforested during the pre-project period |
|---|---|
| 1992 | 682.2 |
| 1993 | 514.3 |
| 1994 | 452.1 |
| 1995 | 426.1 |
| 1996 | 282.1 |
| 1997 | 204.0 |
| 1998 | 186.1 |
| 1999 | 165.1 |
| 2000 | 61.3 |
| 2001 | 226.6 |
| Average annual pre-project AR undertaken in the country over 10-year period prior to the project | 319.9 |
| Total area of degraded land (ha) available for restoration through afforestation and reforestation activity at the national level in 2002 | 85,700 |
| Annual pre-project AR rate (average annual pre-project AR area /Total area of degraded land available at the national level). This annual pre-project AR rate is applied to the area under project to calculate the baseline AR relevant for the project. | 0.373% |
| Area afforested under the project out of the total available degraded land of 85,700ha at the national level in 2002 | 20,289.91 |
| **Average annual rate of pre-project AR applicable as the baseline AR to the project context** | 0.373% of 20,289.91ha = **75.7 ha** |

The baseline (pre-project) A/R rate estimated at 75.7 ha per year is applied to each of the 20 years of the first crediting period (Table 2b). The net GHG removals by sinks from the baseline afforestation are calculated by applying the steps of AR AM0002 methodology.

**Table 2(b): Pre-project A/R in hectares applicable as the baseline A/R rate (ha)**

| *Year* | **Annual baseline AR rate applicable to the project (ha)** |
|---|---|
| 2002 | 75.7 ha |
| 2003 | 75.7 ha |
| 2004 | 75.7 ha |
| 2005 | 75.7 ha |
| 2006 | 75.7 ha |
| 2007 | 75.7 ha |
| 2008 | 75.7 ha |
| 2009 | 75.7 ha |
| 2010 | 75.7 ha |
| 2011 | 75.7 ha |
| 2012 | 75.7 ha |
| 2013 | 75.7 ha |
| 2014 | 75.7 ha |
| 2015 | 75.7 ha |
| 2016 | 75.7 ha |
| 2017 | 75.7 ha |
| 2018 | 75.7 ha |
| 2019 | 75.7 ha |
| 2020 | 75.7 ha |
| 2021 | 75.7 ha |
| 2022 | 75.7 ha |

Monitoring of the project sites for afforestation and performance of the afforested areas will be accomplished in one or more of the three following ways:

1. Site visits with photographic documentation—this is the lowest technological method and should suffice. The total area planted by each region should be thoroughly inspected and a selection of photographs taken and dated. The field reports and photos should be part of the permanent record.
2. Photographic evidence of each planted area and documentation should be part of the projects records.
3. Use of geographic information systems to scan and store the project data in a readily retrievable database. This implies that Project Implementation Unit (PIU) is equipped with the software, hardware and trained personnel to manage the project database.

## 4.0 Sources of variability and stratification for aboveground biomass pools

The procedures of *ex post* stratification of the project are outlined in the PDD. Sources of variability within project lands are managed by stratification, whereby the project is divided into a reasonable number of relatively homogeneous units in order to reduce the number of plots needed for monitoring. The following sources of variability are considered.

*Management*

Management is intended to be similar across project lands throughout the project lifetime. Prior to planting, rows are tilled either mechanically or manually. No grazing will be allowed. Weed control is undertaken with the application of weedicides. Thinning interventions are programmed for age ~ 5 to 7 on Robinia and Populus sites, and age ~ 7 years on Quercus sites. Harvested biomass from thinning will be utilized to meet the fuelwood requirements of local communities.

*Timing of planting*

The area afforested/reforested under the project over a five-year period from 2002 to 2006 is presented in Table 3. If notable differences result over time, age cohorts based on year planting will be designated as sub-strata *a posteriori* (post-stratification) to manage this source of variability.

**Table 3: Year-wise project afforestation/reforestation area**

| Year | Hectares |
|---|---|
| 2002 | 5,301.5 |
| 2003 | 5,098.2 |
| 2004 | 4,620.4 |
| 2005 | 4,246.6 |
| 2006 | 1,023.3 |
| TOTAL | 20,289.9 |

*Species composition and productivity class*

The four major species groups – *Robinia, Quercus, Populus and Pinus* - are planted either as sole or mixed species stands involving associate and secondary species. Depending on the dominant major speces, mixed species stands are categorized under each of the four major species for monitoring purposes. Mixed species stands improve the diversity and contribute to biodiversity value of the forests established under the project.

- Robinia speices group: *Robinia pseudoacacia, Gleditsia triacanthos, Sophora, Ulmus, Acer, Cornus, Corylus*
- Populus species group: *Populus alba, P. nigra, Salix, Ulmus, Acer, Sambucus, Corylus, Sorbus, Viburnum*
- Pinus species group: *Pinus nigra, P. silvestris, Acer, Cotinus, Eleaegnus, Tamarix, Rosa, Crataegus, Prunus, Rubus*
- Quercus species group: *Quercus rubra, Q. rober, Q. petraea, Fraxinus, Carpinus, Tilia, Acer, Cornus, Prunus, Pyrus, Corylus, Viburnum, Sambucus*

Site productivity class (Table 4) is based on age: height combination and is predicted based on soil type and land-use history.

**Table 4: Potential strata at age 30 based on data from Romanian & Ukrainian stand tables**

| Species / productivity class | Volume ($m^3$/ha) | Wood specific gravity ($Mg/m^3$) | Aboveground biomass (Mg/ha) | Aboveground carbon (Mg/ha) |
|---|---|---|---|---|
| Robinia III | 235 | 0.695 | 163 | 82 |
| Robinia IV | 144 | 0.695 | 100 | 50 |
| Populus III | 272 | 0.510 | 138 | 69 |
| Pinus III | 100 | 0.535 | 54 | 27 |
| Pinus IV | 72 | 0.535 | 39 | 20 |
| Quercus III | 107 | 0.835 | 89 | 45 |
| Quercus IV | 89 | 0.835 | 74 | 37 |

**Note**: As rich and poor strata reflect the site productivity, which is further based on soil organic matter, most site productivity III classes correspond to rich soils and site productivity IV classes correspond to poor soils, However, in some cases site class III sites could fall under poor strata and site class IV sites could fall under rich soil strata.

For project stratification, the major species categories - *Robinia, Populus, Pinus, and Quercus planted in the rich and poor soils are recognized as the strata.* Therefore, ***fourteen*** project strata as outlined below are adopted in the project.

1) Pinus_Rich Soils (not categorized into age class because of small area planted under the species)
2) Pinus_Poor Soils (not categorized into age class because of small area planted under the species)
3) Populus_Rich Soils_Ageclass0-3yr
4) Populus_Rich Soils_Ageclass > 3yr
5) Populus_Poor Soils_Ageclass0-3yr
6) Populus_Poor Soils_Ageclass > 3yr
7) Quercus_Rich Soils_Ageclass0-3yr
8) Quercus_Rich_Soils_Ageclass0- 3yr
9) Quercus_Poor Soils_Ageclass0-3yr
10) Quercus_Poor Soils_Ageclass0-3yr
11) Robinia_Rich Soils_Ageclass0-3yr
12) Robinia_Rich Soils Ageclass > 3yr
13) Robinia_Poor Soils_Ageclass0-3yr
14) Robinia_Poor Soils_Ageclass > 3yr

### 4.1 Sample size

The sample size determines the number of plots needed in each stratum to reach targeted precision levels taking into account the variance of each stratum and the area of the stratum. This means that highly variable strata covering small areas will have less influence on the total number of plots needed than those strata that cover larger areas. Based on empirical experience, it is recommended that a targeted total precision level of about +/-10% of the mean at the 95% confidence level can be obtained at a modest cost.

The recommended targeted precision level is based on the sampling error only. Other sources of error include measurement error and model error (e.g. application of regression equations to field data). Sampling error is the largest source of the total error and usually accounts for more than 80% of the total error. Thus, it is recommended that to attain a targeted total error of about +/-10% of the mean, the targeted sampling error is set to a value less than this. For monitoring tree biomass, the targeted sampling error is a 95% confidence interval of +/- 7% of the mean (Table 5). The sample size calculated here is sufficient to resolve the narrowest absolute anticipated confidence interval (i.e. +/- 7 % of anticipated

lowest mean yield at 15 years, or 20tC/ha). Some strata will have higher yields, but the monitoring framework must be able to resolve the smallest anticipated changes. Thus, as the mean increases over time, the precision is expected to improve.

A variety of proxy sites were measured in 2003 as part of the baseline assessment coordinated by GFA Terra Systems to assess the carbon sequestration potential of project plantings and to determine the variability within stands (Kapp et al., 2003a and 2003b). The variability in the carbon stocks could be minimized by adopting a sampling frame that optimizes the number of plots needed to attain the targeted precision level.

From the sample plot measurements, above ground carbon stock was assessed in a three-step process:

1. Stem volume was calculated from diameter at breast height (dbh) and mean tree height using allometric relationships developed by Giurgiu (1990). Note this is a conservative estimate as stem volume is less than total volume.
2. Dry biomass was calculated from tree volume using preliminary estimates of mean wood densities determined in the baseline study for *Populus alba*, *Robinia pseudoacacia*, *Quercus robur*, *Pinus nigra*, *Sophora*, and *Gleditsia* (Kapp et al., 2003a and 2003)
3. Carbon was calculated as 50% of dry biomass.

Individual tree calculations were summed to derive an estimate of carbon stock per unit area (t C/ha) for each plot, from which mean and associated statistics were derived (Table 5).

**Table 5: Reference forest sites measured in 2003 in fixed area 250m$^2$ plots. (CV= coefficient of variation, SD = standard deviation, SE = standard error, CI = confidence interval).**

| Measure | Robinia IV 40 years tC/ha | Robinia III 23 years tC/ha | Populus III 15 years tC/ha | Pinus III 33 years tC/ha | Pinus IV 25 years tC/ha | Quercus III & IV 35 & 31 years tC/ha | Quercus II 43 years tC/ha |
|---|---|---|---|---|---|---|---|
| **Mean** | *66.0* | *76.3* | *49.1* | *71.8* | *14.0* | *44.3* | *82.2* |
| **Variance** | 135.8 | 155.5 | 68.0 | 44.6 | 27.9 | 321.4 | 1067.9 |
| **SD** | 11.7 | 12.5 | 8.2 | 6.7 | 5.3 | 17.9 | 32.7 |
| **CV(%)** | *17.6* | *16.3* | *16.8* | *9.3* | *37.6* | *40.5* | *39.8* |
| **SE** | 6.7 | 7.2 | 4.8 | 3.9 | 3.0 | 7.3 | 13.3 |
| **95% CI** | +/-28.9 | +/-31.0 | +/-20.5 | +/-16.6 | +/-13.1 | +/-20.3 | +/-37.0 |
| **n** | 3 | 3 | 3 | 3 | 3 | 6 | 6 |

**Note**: The standard deviation and coefficient of variation observed on the measured plots of Robinia were found to be small as the number of available measurements is few for mature ages (e.g., *Robinia* at 40 years). The standard deviation and coefficient of variation for young *Robinia* reported in the literature is high. Therefore, literature reported standard deviation that is applicable to the project sites is used to calculate the sample size, which increases the sample size and is also expected to reduce variability of measured biomass of *Robinia sp*.

The required sample size calculations referenced a limited set of forest measurements from each strata (e.g. n=3 and n=6). The coefficient of variation (CV) for Quercus III and IV is derived from a dataset covering a range in stand age (+/- 4 years) comparable to staggered project plantings, and allows consideration of a monitoring design in which all project sites are treated as a single age cohort. Again, emerging differences related to age or a "year factor" (varying conditions for a given stage of growth) could be post-stratified.

The effect of adjusting plot area on required sampling intensity was assessed. Time and effort spent in field measurement depends both on sample size (number of plots) and plot area. While increasing sample

size increases precision, increasing plot area decreases variability between samples according to the relationship derived by Freese (1962),

$$CV_2^2 = CV_1^2 * \sqrt{(P_1 / P_2)}$$

Where, "CV" is the coefficient of variation, "P" is plot area, and 1 and 2 represent different plot areas and corresponding CVs. Thus, by increasing plot area, variation among plots is reduced, which allows for a smaller sample size while targeting the same precision level.

**Table 6: Parameters used to calculate the required sample size. Target 95% confidence interval = +/- 1.4 t C/ha (= 7% of 20 t C/ha; predicted lowest mean yield at 15 years). (CV = coefficient of variation, SD=standard deviation).**

| | | Plot area (square meters) | |
|---|---|---|---|
| | | 250 | 1000 |
| Strata | Area (ha) | CV | Inferred CV |
| *Robinia* | 18,107.9 | 0.18 | 0.13 |
| *Populus* | 425.2 | 0.17 | 0.12 |
| *Pinus* | 18.8 | 0.38 | 0.27 |
| *Quercus* | 1728.0 | 0.41 | 0.29 |
| | 20,289.9 | | |

A required sample size is calculated for individual plot area of 250 $m^2$ (Table 6). A plot area of 1,000 $m^2$, compared with the 250 $m^2$ Moldsilva inventory standard, reduces the anticipated variability and the required sample size. However, as the project sites are small and scattered over a large area, the small sample plots of 250 $m^2$ is preferred to allow for covering more project sites.

*Sample size for measuring changes in the above ground biomass pools*

The area covered under major species is used to calculate the sample size of the project. The equations M1 and M2 of the approved methodology AR AM0002 are used to calculate the sample size. A sample size of 209 permanent sample plots is estimated as the sample size required for monitoring the aboveground biomass. The sample size estimation assumes a standard deviation of 30% to 40% for *Robinia* (a major species of the project). Taking into account lack of empirical data on biomass estimates in the early stages of the species, its fast growth and degraded nature of soils, this assumption is reasonable and conservative as it increases the sample size and reduces variability in the carbon stock and its change.

The sample size estimation procedures of the monitoring plan allows for increasing the sample size taking into account further variability observed in the biomass estimates. The allocation of plots to measure above ground biomass will be completed as per the guidelines of AR AM0002. **Table 7(a)** and **Table 7(b)** present the number of sample plots calculated for monitoring carbon stock changes in the above ground biomass.

**Table 7(a): Number of sample plots for measuring the changes in above ground biomass pools**

| Stratum no. | Project Stratum | Number of sample plots |
|---|---|---|
| 1 | Pinus_RichSoil | 1 |
| 2 | Pinus_PoorSoil | 1 |
| 3 | Poplar_RichSoil_Age0-3 | 1 |
| 4 | Poplar_RichSoil_Age>3 | 1 |
| 5 | Poplar_PoorSoil_Age0-3 | 0 |
| 6 | Poplar_PoorSoil_Age>3 | 1 |
| 7 | Quercus_RichSoil_Age0-3 | 3 |
| 8 | Quercus_RichSoil_Age>3 | 4 |
| 9 | Quercus_PoorSoil_Age0-3 | 1 |
| 10 | Quercus_PoorSoil_Age>3 | 2 |
| 11 | Robinia_RichSoil_Age0-3 | 81 |
| 12 | Robinia_RichSoil_Age>3 | 61 |
| 13 | Robinia_PoorSoil_Age0-3 | 19 |
| 14 | Robinia_PoorSoil_Age>3 | 33 |
| Total | | 209 |

**Table 7(b): No. of sample plots for measuring changes in above ground biomass by forest enterprise**

| Forest Enterprise | *Robinia sp* | *Quercus sp* | *Populus sp* | *Pinus sp* |
|---|---|---|---|---|
| Şoldăneşti | 4 | | | |
| Tighina | 22 | 2 | 1 | |
| Pădurea Domnească | 2 | | | |
| Cimişlia | 9 | | | |
| Glodeni | 13 | | | |
| Hânceşti | 7 | | | |
| Nisporeni | 6 | | | |
| Codrii | 1 | | | |
| Comrat | 19 | | | |
| Chişinău | 9 | 1 | | 1 |
| Plaiul Fagului | 2 | | | |
| Ialoveni | 7 | | | |
| Străşeni | 4 | | 1 | |
| Silva-sud | 15 | 4 | 3 | |
| Călăraşi | 3 | | | |
| Iargara | 15 | 1 | | |
| Teleneşti | 4 | | | |
| Ungheni | 13 | | | |
| Manta-V | 7 | | | |
| Bălți | 9 | | | |
| Orhei | 7 | | | |
| Soroca | 8 | 1 | | |
| Edineț | 8 | | | |
| **Total** | **194** | **10** | **4** | **1** |

## 5.0 Soil carbon

### 5.1 Potential sources of variability and stratification for soil carbon monitoring

A range of soil types is found across the project area, contributing to the high levels of variability witnessed. To simplify, *soils have been stratified into two generalized soil classes: "rich" (> 70 tC/ha) and "poor" (≤ 70 tC/ha),* which correspond with soil carbon baseline conditions and anticipated capacity to produce, incorporate, and retain new soil organic matter.

### 5.2 Sample size calculation for assessing the changes in soil carbon pool

The objective in soil carbon monitoring is to estimate the *change* in stocks, not the stocks at a given point in time. As the same soil sample cannot be monitored over time as it is destroyed in the analysis, change is best quantified by comparing mean soil carbon between two temporally-separated sample pools, via the Reliable Minimum Estimate (RME) approach (Dawkins, 1957). As variability among samples is high even at small spatial scales, the statistical concept of paired samples, even if collected only centimeters apart, cannot be reliably employed. The objective is not to establish that the two means are significantly different, but rather to estimate with 95% confidence the *minimum* change in mean soil carbon that has taken place from one monitoring event to the next. For the RME approach, the monitoring results from plots are pooled to derive a mean for the sample population at time "two", then the 95% confidence interval is subtracted to establish a minimum estimate of the population mean. Change in soil carbon is calculated by subtracting the maximum estimate of the population mean at time "one" (mean at time 1 plus 95% C.I.) from the minimum mean estimate at time "two". The resulting difference represents, with 95% confidence, the minimum change in mean soil carbon from time "one" to time "two".

A total of 151 proxy sites were measured in March 2003 (Table 8) as part of the baseline assessment to evaluate the soil carbon sequestration potential of project plantings to determine variability and to calculate the required sample size. The GFA Terra Systems (Kapp et al., 2003a 2003b) coordinated the collection of data as part of the baseline assessment..

**Table 8: Mineral soil carbon on reference sites (top 30 cm). (CV= coefficient of variation, SD = standard deviation, SE = standard error, CI = confidence interval).**

| | Poor Sites | | | Rich Sites | |
|---|---|---|---|---|---|
| | Degraded & pasture tC/ha | Hardwood 20 tC/ha | Pine 20 tC/ha | Degraded & pasture tC/ha | Hardwood 100 tC/ha |
| **mean** | *59.5* | *70.3* | *54.5* | *91.9* | *128.7* |
| **variance** | 1053.4 | 986.1 | 314.2 | 1149.0 | 625.3 |
| **SD** | 32.5 | 31.4 | 17.7 | 33.9 | 25.0 |
| **CV(%)** | *54.5* | *44.6* | *32.5* | *36.9* | *19.4* |
| **SE** | 4.4 | 10.5 | 7.9 | 4.2 | 11.2 |
| **95% CI** | +/-8.8 | +/-24.1 | +/-22.0 | +/-8.3 | +/-31.0 |
| **n** | 55 | 9 | 5 | 66 | 5 |

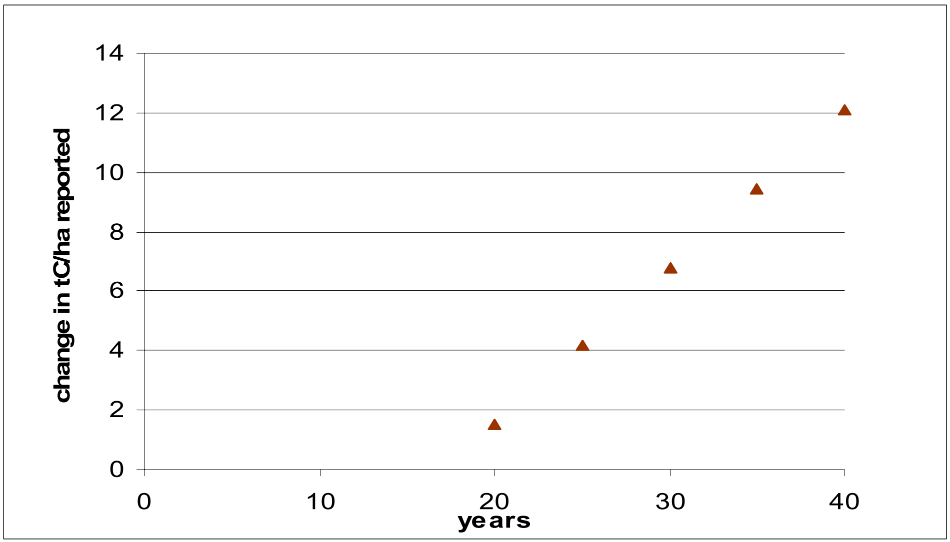
Based on results from this study and evidence from other investigations, monitoring of changes in soil carbon on sites planted with pine is not recommended. After 20-year growth of *Pinus nigra*, soil carbon stocks remain statistically indistinguishable from assumed baseline conditions (Table 8). Richter et al. (1999) report a very low rate of soil carbon accrual, 0.04 t C/ha/year (top 60 cm), from measurements of 35 years of growth of *Pinus taeda*. Sampling soils throughout the top 50 cm under *Pinus palustris* stands of different ages growing on formerly cultivated soils. Markewitz et al. (2002) were unable to detect any significant changes in soil carbon in a chronosequence spanning 14 years of growth. These low rates of soil carbon accumulation observed are probably attributable to the sandy-textured soils typical of pine sites, as well as the low inputs to soil organic matter typical of pine and their shallow root system (much of soil carbon inputs are derived from turnover of root biomass).

A rate of accrual of soil carbon following hardwood establishment can be inferred from the chronosequence of sites of known age measured in this investigation. Assuming a constant rate, restoration of degraded lands to hardwoods could sequester 0.5 Mg/ha.yr ((70.3 t C/ha – 59.5 t C/ha) / 20 years) of additional soil carbon in the top 30 cm on poor soil site classes. On rich sites, hardwood growth can likewise result in 0.4 Mg/ha.yr ((128.7 t C/ha – 91.9 t C/ha) / 100 years). Annual rates on rich sites will likely be higher than this 100-year mean early on, as most gains in soil carbon attributed to forest restoration occur in the first ~ 30 to 40 years following forest establishment, and would in fact be expected to exceed rates on poor sites given the presumed greater capacity of rich sites (soils) to produce and retain organic matter.

A model using the RME approach (Figure 1) was developed to predict measurable gains in soil carbon on the project and to optimize sample size. The following parameters were incorporated:

- Rich soil strata = 14,277.4 hectares
- Poor soil strata = 6,012.5 hectares
- Rate of accumulation on rich strata to 30 cm = 0.6 t C/ha.yr
- Rate of accumulation on poor strata to 30 cm = 0.5 t C/ha.yr
- Initial soil carbon on rich strata = 91.9 t C/ha
- Initial soil carbon on poor strata= 59.5 t C/ha
- CV rich strata = 36.9 %
- CV poor strata = 54.5 %
- Level of confidence = 95 %

**Figure 1: Predicted change in soil carbon reportable on the Moldova SCP (top 30 cm, rates of accrual 0.5 and 0.6 t C/ha.yr and CVs 55 and 37% (poor and rich strata), 95 % CI)**




Sample size and sampling frequency have major role in the monitoring of soil carbon under the project and must be taken into consideration when attempting to assess changes in soil carbon over time. Increasing sample size serves to refine the estimates around the means separated in time, and better distinguish change that takes place. The resolution of change detection also depends on the magnitude of the change itself, and as this is time dependent, it is appropriate to consider frequency of sampling. Increasing sampling frequency serves to increase the magnitude of change that takes place, which is quantified as the difference between the lower bounds of the estimate at time "two" minus the upper bounds of the estimate at time "one". The latter is an important consideration, in that small changes may be undetectable, even with high sampling intensity.

To reduce costs, this monitoring plan limits the soil carbon measurement to two (2) events, one conducted as part of the baseline soil carbon measurement at the beginning of the project and one between 10 and 20 year period prior to the completion of the crediting period. The sample size estimated for rich and poor soils is presented in Table 9.

**Table 9: Sample size for measuring the change in soil organic carbon under the project**

| Forest Enterprise | Rich soils | Poor soils |
|---|---|---|
| Comrat | 7 | 4 |
| Orhei | 4 | 1 |
| Cimişlia | 5 | 0 |
| Teleneşti | 2 | 1 |
| Hânceşti | 2 | 3 |
| Plaiul Fagului | 1 | 0 |
| Şoldăneşti | 2 | 1 |
| Pădurea Domnească | 1 | 0 |
| Chişinău | 4 | 2 |
| Silva-sud | 10 | 4 |
| Soroca | 3 | 3 |
| Edineț | 4 | 0 |
| Glodeni | 7 | 2 |
| Iargara | 8 | 2 |
| Străşeni | 1 | 1 |
| Tighina | 11 | 5 |
| Manta-V | 3 | 1 |
| Ialoveni | 4 | 1 |
| Nisporeni | 2 | 2 |
| Bălți | 5 | 0 |
| Călăraşi | 1 | 0 |
| Codrii | 0 | 1 |
| Ungheni | 6 | 4 |
| **Total** | **93** | **38** |

### 6.0 Allocation of permanent measurement plots

The sample plots will be designated systematically to cover the land parcels. Plots are assigned to forest enterprises and designated systematically by selecting a random start from the list, and consecutively assigning the plots. Within each planting site, plot locations have equal chance of representing the site.

The aboveground biomass and soil carbon sampling require separate monitoring frameworks. The permanent sample plots will be used for monitoring aboveground biomass. Each plot will have its coordinates recorded using a GPS. The plot corners of rectangular plots (5 m x 50m) will be located and the GPS coordinates are noted. Plot markers will not be prominently displayed to ensure that permanent plots do not receive differential treatment from forestry personnel.

Temporary sample plots will be used for monitoring changes in the soil carbon. It is not necessary that the same plots be revisited over time as soil carbon monitoring will focus on comparing the mean stocks of

two *independent*, temporally-separated pools, therefore temporary plots can be used. Thus, location of soil carbon plots will not be permanently marked.

During the sample plot establishment the field crew will follow a protocol in which all steps are recorded beginning with the starting point, surveying sample plots, recording azimuth and horizontal distance and polygonal layouts and fixed points in the surrounding are recorded.

## 7.0 Scheduling of measurement, reporting, and verification events

Frequency of monitoring is related to expected changes in the carbon stocks through time—the smaller the expected change the greater potential for less frequent monitoring to detect significant changes in carbon stocks and vice versa. Monitoring intervals reflect the sequence of verification events over the project period of three crediting periods. Table 10 outlines the proposed monitoring events over the project period.

**Table 10: Schedule of carbon measurement events through 2062**

| Year | Stage of planting | Measurement and verification activity |
|---|---|---|
| 2002 | Initiation of planting | Baseline study covering biomass and soil measurement |
| 2003-05 | Gap filling and survival check | |
| 2006 | Completion of planting | |
| 2007 | | Aboveground biomass |
| 2012 | | Aboveground biomass |
| 2017 | | Aboveground biomass |
| 2022 | | Soil and aboveground biomass |
| 2027 | | Aboveground biomass |
| 2032 | | Aboveground biomass |
| 2037 | | Aboveground biomass |
| 2042 | | Soil and aboveground biomass |
| 2047 | | Aboveground biomass |
| 2052 | | Aboveground biomass |
| 2057 | | Aboveground biomass |
| 2062 | | Soil and aboveground biomass |

The project will be verified at the end of each measurement period, that is every 5 years after the first verification that could scheduled between 3 to 5 years from the start of the project. Verification at the beginning of the project will establish the initial conditions of the project. Subsequent periodic verifications will serve to ensure that the project has accrued the carbon credits and to verify the “true-up” of project accounting based on the field measurement results.

The verification has several components: verification of field data collection, data analyses, documentation and record keeping, data storage protocols, and project compliance. The Quality Assurance / Quality Control (QA/QC) plan is designed to provide internal verification, whereas DOE verification is the external auditing of the measurements and the calculations of net GHG removals by sinks.

## 8.0 Monitoring of the forest establishment and management

The early stage project monitoring covers collection of data on delineation of the project boundary, site preparation, forest establishment and forest management.

*Monitoring of project boundary*

- Field surveys will be conducted at periodic intervals to verify that the permanent markers used to delineate the project boundary can be located on the ground;
- The project boundary is delineated using the GPS by measuring and recording the latitude and the longitude of polygons that represent the geographical positions. Furthermore, field surveys are used to verify that the actual project boundary is consistent with the GPS coordinates and boundaries of respective sites, and species planted on them could be verified from the GPS and the field survey data;
- The information from monitoring of the project boundary would ensure that the land use and economic activities outside the project are easily identified;
- Monitoring measures to assess the risk of fire and other natural events that occur within and outside the project boundary will be monitored as per the monitoring provisions on emergencies outlined in the monitoring plan;
- Personnel involved in the monitoring will be trained to identify the changes in the boundary and to record those changes in the project database for reporting at the project verification.

*Monitoring of site preparation and planting activities*

- The monitoring of site preparation activities cover the aspects related to site preparation and amount of vegetation affected.
- Information on planting schedule, location, area, species planted will be recorded in plot journals and archived in the project database
- Information on the age class-wise area planted in each stratum and sub-stratum are confirmed through field surveys.
- Information on species composition and characteristics of planted species and as well as pre-existing vegetation, if any observed on the strata are recorded;• The spacing adopted and characteristics of the stand models are recorded in the project database;
- Survival rates of planted trees and shrubs are counted during the three months of the planting and replanting is done fill the gaps and the area and location of supplemental plantings undertaken to fill the gaps and recorded in the project database and identified on the strata maps;

*Monitoring of post-planting activities to demonstrate the forest establishment*

- Information on drainage, frost, and other climatic extremes that can impact stand establishment and stand growth will be recorded;
- Surveys will be conducted annually for first 3-years to evaluate the survival rates of planted stock and to fill the gaps caused by seedling mortality.
- Final survival check is conducted in the permanent sample plots at the end of third year of the plantation and survival percent estimated from the surveys conducted at the end of 3 rd year is recorded in the project database. The survival percent established after the 3rd year will be updated and reported for verification purposes.
- The number and periodicity of weeding and tending practices and the frequency of herbicide use will be monitored and recorded.
- If plantings on certain lands within the project boundary fail after 3$^{rd}$ year, the information will be documented and excluded from the project *ex post* carbon calculations.
- Information on the occurrence of droughts and floods and other emergencies will be monitored and recorded and the area affected will be taken into account in the *ex post* calculations of carbon stock changes.
- In case of fire, the causes, area affected, season, and duration of fire occurrence shall be recorded and the emissions associated with the burning of biomass shall be calculated and accounted as part of project emissions.

*Monitoring of forest establishment*

- Information on silvicultural management activities such as thinning, tending, harvesting, and other silvicultural operations that influence the GHG removals by sinks will be monitored and the information collected is recorded in the project database.
- Biomass removed in the disturbance associated with silviucultural activities such as thinning and harvesting will be monitored and recorded;
- Quantity of fossil fuels used in silvicultural operations, transport of equipment and personnel and other management activities carried out in the project boundary will be monitored and recorded and the quantity of fossil fuels used in the operations will be calculated and archived;
- As the project does not use fertilizer, GHG emissions related to fertilizer application will not be monitored and the emissions from this source are treated as zero in the project database.
- Information on the occurrence of fires or other natural or human induced disturbances and the area and biomass affected shall be recorded and reported;
- Deviations in forest management activities implemented in the field and the ones outlined in the project design document will be monitored, and reasons for deviations will be recorded.

## 9.0 Monitoring and measurement of carbon pools

The monitoring plan implements the steps, equations and procedures outlined in Section III of the approved methodology AR-AM0002 to calculate the carbon stock changes of the project.

Above-ground tree vegetation will be monitored over time by measuring the growth of individual trees in permanent sample plots at fixed intervals, keeping track of growth, ingrowth, and mortality and changes in carbon of individual trees. The changes in carbon stocks of dead wood will be measured taking into account the respective characteristics of standing and lying dead.

Litter monitoring is conducted using temporary sample plots and fixed-area sampling frame placed four times at random locations within the sample plots selected for the purpose. The litter (leaves, fruits, small wood, etc.) that falls in the frame will be collected and oven dried to determine dry mass.

Soil carbon will be measured using temporary plots by taking soil samples to a depth of 30 cm. The soil sampling will cover both rich and poor strata and the sample size calculated ensures the quality assurance and cost effective measurement of changes in the soil carbon.

The detailed procedures for monitoring of carbon pools and their measurement are presented below. The results of the monitoring and measurement will be used in the calculation of carbon stock changes in the project area. The procedures for measurement /sampling are summarized in Table 11.

The illustrative formats for use in inventory and field data collection are presented in **Appendix I** of this Monitoring Plan. The inventory format should be amended as necessary during the monitoring process so as to collect the relevant information needed for calculation of net anthrpogenic GHG removals by sinks under the project.

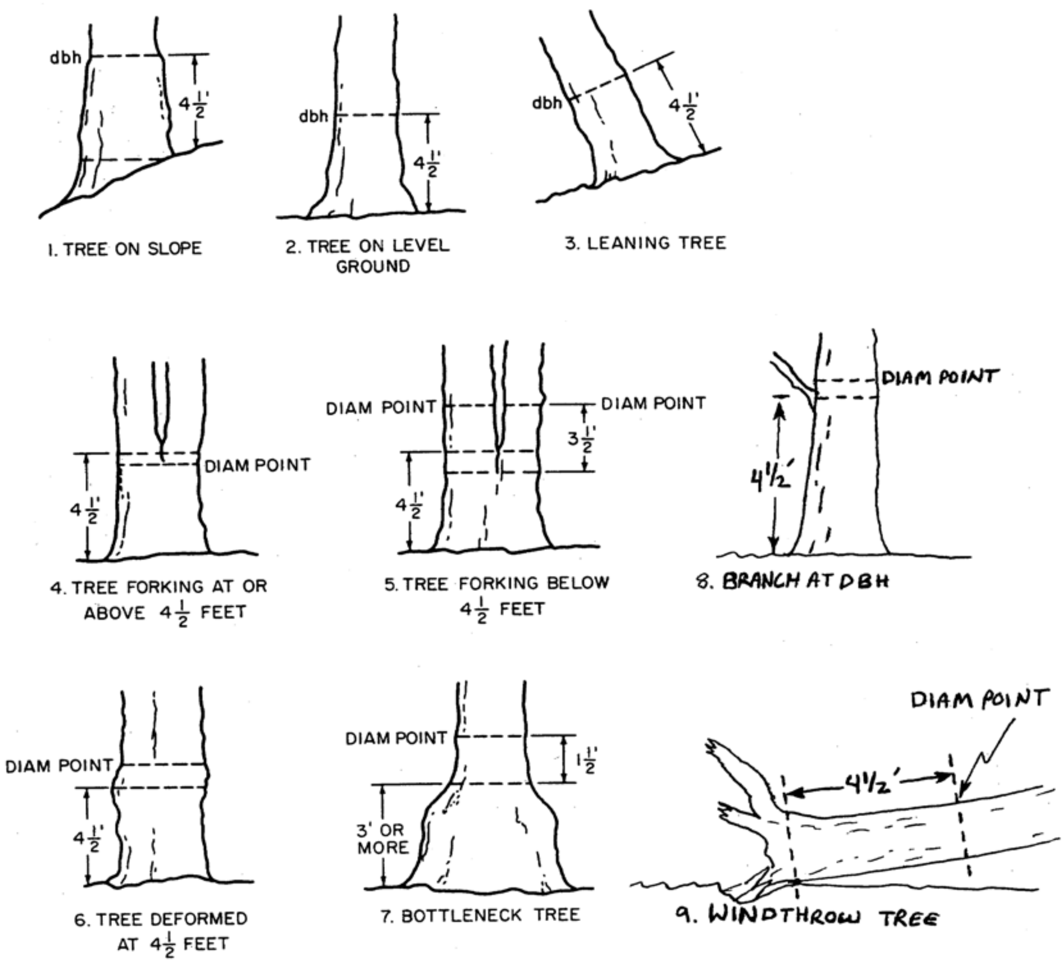
### 9.1 Tree biomass

Tree biomass will be monitored over time by measuring the growth of individual trees in permanent sample plots at fixed intervals, keeping track of growth, in-growth, and mortality and associated changes in carbon stock of trees.

All living trees are measured in a clockwise manner. The measurement of diameter at breast height (DBH or 4.5 feet above ground) is recorded. The DBH position should take into account the tree form and topography. The number and location of tree and its DBH measurement should be recorded. The height, form and defect information is collected for every fifth tree of the species measured on the plot (tree 1, 6, 11) should be collected. The procedures to be followed in the DBH measurements of trees on different topographic setting and with different irregularities is summarized in **Figure 2**.The dot and tally system

could be used to record trees in the sub-plot section of the form. A separate tally should be used for dead stand or lying trees with diameter greater than the minimum diameter.

**Figure 2: Implementation of DBH measurements taking into account the topography or tree irregularities (based on T. E. Avery, and H. E. Burkhart, 1983, *Forest Measurements*).**




Changes in carbon stocks in dead wood and litter will also be measured and added to those for trees to calculate net carbon accumulation on a per plot basis. Carbon accumulation will thus be calculated

directly for each sample unit, rather than by subtracting two pools from each other to derive an estimate. It is expected that the targeted precision will be met by this approach. Results expressed as estimated mean change in carbon per unit area will then be extrapolated across the entire project area to estimate total quantity of carbon accrued.

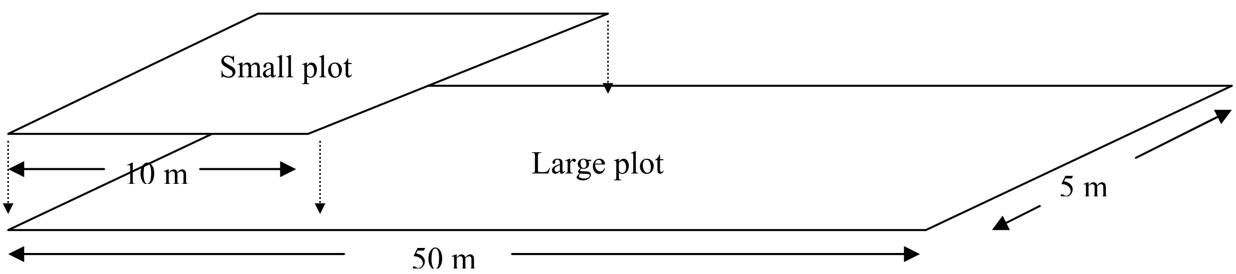
Nested plots will be used, which are better suited to changing diameters and stem densities that take place over time (Table 10) than are fixed-area plots. In the large plot, all stems > 10 cm dbh will be measured and recorded. The large plot should "capture" at least 10 stems on the lightest-stocked stand (~ 400 stems per hectare). This represents an area of 250 $m^2$ (10 X 25 $m^2$ per stem), which is the size of the fixed-area plots (5m X 50m) currently used in Moldsilva's forest inventories. This existing plot design will be adopted for project monitoring which will allow for expanded utility of plot measurements beyond carbon monitoring alone (e.g. augment national forest inventories). To reduce measurements of abundant small stems to a feasible level, a small plot will be nested within the large plot to record small dimension stems ($\leq$ 10 cm dbh, $\geq$ 2 cm basal diameter). Likewise, the small plot should capture at least 10 of the appropriate dimension stems, again referencing the lightest predicted stocking for this size class (~ 2,000 stems per hectare). This requires a small plot size of 50 $m^2$ (10 X 5 $m^2$ per stem), or 5m X 10m (Figure 3). As both plot sizes target an equal number of predicted measurements per plot, potential inter-plot variability in equivalent calculated t C/ha is assumed to be the same for both plot sizes.

**Table 10: Observed mean stem densities (stems per hectare) at different ages**

| Species type | Planting density | 15-20 years | 21-25 years | 26-30 years | 31-35 years | 36-40 years | 41-45 years |
|---|---|---|---|---|---|---|---|
| Robinia | 5,000 (range: 3,600 to 6,000) | | 827 | | | 653 | |
| Populus | 2,200 | 1,933 | | | | | |
| Pinus | 3,000 | | 387 | | 587 | | |
| Quercus | 5,000 | | | | 840,520 | | 460 |

Values do not represent a succession of measurements from the same stand, but rather an implied chronosequence from one-time measurements of stands of various ages Reduction in stem density over time is reflective of silvicultural treatments (density management guidelines) and natural mortality.

## Figure 3: Layout of nested plots (not to scale)




If the permanent plot is located on a slope that is >10%, the slope should be measured and an adjustment made to the plot length or width using the formula:

$$L = Ls \; / \; \cos S$$

Where $L$ is the plot length or width to be measured in the field along the slope, $Ls$ is the standard (true horizontal distance) plot length (50 m) or width (5 m), $S$ is the slope in degrees or percent (which must be converted to radians), and cos is the cosine of the angle. The adjusted length and/or width will be

permanently marked in the field with metal stakes to guide future monitoring efforts in delimiting plot boundaries.

All tree diameters (basal diameter or diameter at breast height) will be measured and recorded. All trees will be permanently marked at the first aboveground biomass measurement with the placement of an aluminum tag inscribed with a unique number nailed into the stem at 1.2 meters height (10 cm below breast height); the dbh will then be measured at exactly 10 cm above the nail. If stems are not of sufficient size to support a nail (i.e. < 10 cm dbh), plastic ribbon will be tied around the base of the stem with a numbered aluminum tag. Regression equations for each site class/and species group will be developed to relate diameter (whether dbh or basal diameter) to aboveground biomass.

The earliest measurement and reporting event will be between 3 and 5 years, at which stage many species stands, apart from *Robinia* or *Populus* stands on productive sites, will not evidence a measurable diameter at breast height. Likewise, small dimension shrubs without well-defined central stems will represent a significant component of the project throughout the life of the project. The first biomass regressions, for shrubs and small diameter stems, will be developed during the thinning operations at age ~5 prior to the first measurement event. A subset of stems harvested in the course of the first thinning intervention will be measured to develop allometric relationship between basal diameter and total dry biomass, as well as diameter at breast height (if measurable) and total dry biomass. The sample stems will be from tree and shrub species collected from a range of sites distributed across the project area to ensure their representation. Biomass regressions will be refined over the life of the project where periodic harvests provide opportunities to generate and incorporate new data.

***Data on yield parameters for calculation of above ground tree biomass***

Data for calculation of change in the above ground carbon stock would be based on biomass measurements of permanent sample plots. The calculations from plot measurements would be compared with data from the following yield tables used for ex ante estimation of actual net GHG removals by sinks. The copies of yield tables are presented in **Appendix II** of this Monitoring Plan.

Giurgiu, V. 1990. Ecuatia de regresie a volumului la arborii forestieri din Romania. Revista Padurilor 105 (3-4):145-150.

Giurgiu, V., Decei, J. and Armasecu. S., 1973: Biometria Arborilor Si Arboretelor Din Romania – Table Dendrometrice-. Editura "CERES", Bucuresti

Gosudarstvennyi Komitet SSSR po lesnomu hozeastvu. 1987. Normativno-spavochnye materialy dlea taksatstyi lesov Ukrainy I Moldavii. Kiev "Urojai"

## 9.2 Below ground biomass

Because collection of samples for estimating root biomass is expensive and time consuming, data on belowground biomass would be collected from the local forestry inventory data and Good Practice Guidance on land Use, Land Use Change and Forestry (IPCC 2004) and published literature. Field sampling would be conducted on selective basis to verify the reported data.

## 9.3 Standing and lying dead wood

Given the sparse nature of lying dead wood pool (high variability and relatively low quantities per unit area) typical of the early stages of forest development, lying dead wood will not be monitored with the frequency of tree biomass. In the first few decades it is likely that this pool will be very small and have little value for measuring—as the stands age, the lying dead wood pool will take on more significance. An initial measurement/visual inspection will be taken at the outset to establish a reportable baseline. In

the event that substantial accumulation of lying dead wood is seen over the course of time, measurements will be re-instituted to quantify the change in stocks that has taken place.

Standing dead trees will be measured according to the same criteria and monitoring frequency as live trees, additionally noting the relative state of decomposition that corresponds with a determined percent of original living biomass discounted. Decomposition classes for standing dead wood are defined as follows:

1. Tree with branches and twigs and resembles a live tree (except for leaves)
2. Tree with no twigs but with persistent small and large branches
3. Tree with large branches only
4. Bole only, no branches

Where only a bole is remaining, volume is estimated using dbh and height measurements and an estimate of the top diameter. Volume is converted to dry biomass using an appropriate dead wood density class.

Lying dead wood in the forest plots will be sampled using the line intersect method (Harmon and Sexton, 1986). Two 50 meter length lines are established bisecting each plot along a random bearing, and the diameters of lying dead wood (≥ 5 cm diameter) intersecting the lines are measured at the point of intersection. Smaller diameter pieces will be sampled as part of the litter (see Section 7.4). Volume per unit area is calculated using the equation (Warren and Olsen, 1964).

$$Volume\ (m^3/m^2) = 9.869 * \sum(diameter(m)^2 / 8 * transect\ length(m))$$

To convert volume to mass per unit area, mean density of lying dead wood is calculated from a representative sub-sample.

## 9.4 Litter

Litter will be sampled using a fixed-area sampling frame of 0.28 $m^2$ (30 cm radius ring), placed four times at random locations within a small plot (5m X 10m). At each location, all litter (leaves, fruits, small wood, etc.) that falls inside the frame will be collected and oven dried ($80^o$ C) to a constant weight to determine dry mass.

In cases where sample bulk is excessive, the fresh weight of the total sample will be recorded in the field, and a sub-sample taken for moisture content determination, from which the total dry mass can be calculated. In the event that substantial accumulation of litter is seen over the course of time, measurements will be re-instituted to quantify the change in stocks that has taken place. It is important that litter is sampled at the same time of year at each census to eliminate seasonal effects.

## 9.5 Herbaceous vegetation

Herbaceous vegetation typically represents a small proportion (1 to 3 %) of ecosystem biomass and will likely be comparable among with- and without-project sites. Herbaceous vegetation will not be measured in the monitoring effort.

## 9.6 Soil carbon sampling and analysis

The information on soil depth and the range in depth observed for each soil horizon should be recorded. The soil color can be determined by using Munsell soil color chart. The color reflects organic matter accumulation, degree of weathering, drainage conditions and other properties.

Information on soil texture should be collected taking into account the percent sand, silt and clay estimated at different moisture states. Higher amount of organic matter makes texture feel like soil has more silt. Sand feels gritty, silt feels slick or buttery, and clay fells sticky and plastic.

Mineral soil carbon (particle size < 2mm) will be measured to a depth of 30 cm, collecting samples with a soil corer. For carbon analysis, four cores taken 5 meters from the plot center in each of the four cardinal directions will be collected and aggregated for each permanent plot. The composite sample thus captures the range of inter-microsite variability in soil carbon and serves to reduce inter-sample variability.

The composite sample is placed on a plastic sheet where coarse fragments are removed by sifting the soil through a 5 to 10 mm screen and then sieved through a 2 mm screen. In this process, the four component cores must be mixed thoroughly to a uniform color and consistency to ensure that a representative sample is collected for analysis. From the composite sample, a sub-sample of approximately 50 grams is collected and air-dried for laboratory analysis.

It is preferred that the soil is analyzed using a dry combustion carbon analyzer such as a Leco or other machine that determines the carbon in the soil by complete combustion in a stream of oxygen. This method heats the soil sample to a very high temperature and oxidizes the carbon to carbon dioxide.

For bulk density analysis, a single core will be taken next to one of the carbon analysis cores. If during the soil sampling work it becomes apparent that the soils within the plot are different with respect to color and texture, additional samples should be collected for bulk density determination. Bulk density samples will be oven dried ($105^o$ C) to constant weight.

Mass of carbon per unit volume is calculated by multiplying carbon concentration (reported as percent mass) times bulk density ($g/cm^3$). Bulk density equals the oven dry weight of the soil core divided by the core volume, discounting volume of coarse (>2 mm) fragments. Referencing the sample depth, mass per unit area is calculated, which represents a corresponding volume of soil.

The steps, equations and procedures outlined for soil carbon measurement in Section III of the approved methodology AR-AM0002 will be used to calculate the carbon stock changes in the soil.

## 10. Monitoring of project emissions

The major sources of emissions under the project are from the use of fossil fuels in AR activities, loss of non-tree biomass in site preparation and biomass burning practices. As the project does not use fertilizers, no GHG emissions from this source will be expected.

*Emissions from use of fossil fuels*

Project emissions associated with the use of fossil fuels in A/R project activities such as site preparation, transportation, and silvicultural activities would be calculated taking into account time and duration of project activities. The GHG emissions from fossil fuels would be calculated based on the data collected on the use of fossil fuels. The monitoring of fossil fuel use and collection of relevant information for calculation of GHG emissions from fossil fuel use would cover the following aspects

- Characteristics of machinery, vehicles and equipment and their periodicity of use in the project boundary.
- Categories of vehicle and machinery used in the project along with technical and operational efficiency measures.
- Amount of fuel used in each type of vehicle, machinery and equipment for completing unit project activity
- Quantity of fuel usage in the pre-project activities such as site preparation, nursery and planting stock development and project activities

- Data and information on the fuel use for specific project activities such as thinning, harvesting and other silvicultural activities by machinery and equipment type
- Assumptions on machinery and equipment use and default parameter values on GHG emissions from burning fossil fuels

The data on the use of fossil fuels in the operation of machinery and transport would be collected. The data on fossil fuel use, distance traveled by the project transport fleet, types of vehicles and equipment involved would be recorded in the project database at monthly intervals. The calculation of GHG emissions from fossil fuels would be done as per the equations of monitoring methodology. Assumptions used in the ex ante estimation of fossil fuels in plantation works and silvicultural operations are summarized below. These values would be compared with the actual fossil fuel consumption values and ex post data on fossil fuel consumption would be revised.

*Assumptions on the use of fossil fuel in the plantation works*

| *Fossil fuel use* | *Planting* | *Works M1* | *Works M2* | *Works M3* | *Works M4* | *Works M5* | *Works M6* |
|---|---|---|---|---|---|---|---|
| *Diesel (litres/ha)* | *280.8* | *116.6* | *80.3* | *66.7* | *53.1* | *39.8* | *25.9* |
| *Petrol (litres/ha)* | *6.97* | *48.9* | *1.99* | *1.66* | *1.32* | *0.98* | *0.64* |

*Assumptions on the use of fossil fuel in silvicultural operations*

| *Species/year* | *Qty of thinning* ***(m3/ha)*** | *Petrol consumption in thinning (litres/m3)* | *Per trip volume transported by vehicle (m3/trip)* | *Diesel consumption in transport (litres/m3)* | *Distance to market / depot (km)* |
|---|---|---|---|---|---|
| *Robinia* | | | | | |
| *Yr 5 -10* | *2.5* | *2* | *5* | *1* | *15* |
| *Yr 10 -15* | *5.0* | *2* | *5* | *1* | *15* |
| *Yr 15 - 20* | *8.5* | *2* | *5* | *1* | *15* |
| *Poplar* | | | | | |
| *Yr 10 -15* | *10* | *1.6* | *5* | *1* | *15* |
| *Yr 20* | *15* | *1.6* | *5* | *1* | *15* |
| *Quercus* | | | | | |
| *Yr 15 - 20* | *8* | *1* | *5* | *1* | *15* |

***Emissions from site preparation activities***

Emissions from site preparation activities would be assessed as per the steps below

*Step 1*: The biomass affected in the site preparation activities would be calculated using sampling methods or estimated taking into account the spacing used in the stand models of AR activities.

- Area affected in the site preparation is assessed using sampling frame and as well as field surveys
- Amount of non-tree biomass associated with the area affected during site preparation is recorded.

*Step 2*: Amount of biomass lost is calculated by multiplying the area affected in the site preparation with the biomass of the unit area affected by the fire and the carbon fraction of the biomass.

## *Emissions from natural fires*

In compliance with national policy of Republic of Moldova, no burning of biomass is anticipated within the project boundary. Furthermore, considering the limited combustible material in degraded lands, fire is not likely to be a major source of project emissions. However, as risk of natural fire exists, fire control

measures will be implemented and the area affected in the natural fires will be monitored and accounted as part of project emissions. The fire monitoring and fire control measures are outlined in the monitoring plan. As per the AR AM0002, The parameters on the GHG emissions from biomass burning are based on the Tables of Chapter 3 of Good Practice Guidance on LULUCF.

*Step 1*: The area subjected to biomass burning would be assessed using sampling methods and/or field survey methods and recorded in the project database.

*Step 2*: The amount of non-$CO_2$ emissions is assessed based on the $CO_2$ emissions from biomass burning, therefore, $CO_2$ emissions from biomass burning would be estimated as precursor to the estimation of non-$CO_2$ emissions.

*Step 3*: Data on combustion efficiencies are adopted from the Tables 3A.1.12, 3A.1.14 GPG/LULUCF) and data on emission factors of non-$CO_2$ gases are adopted from Tables 3.A 15 and 3.A.16 of GPG-LULUCF to estimate the emissions. The mean emission factors of CH4 (0.012) and N2O (0.007) that are released from biomass burning should be used.

*Step 4*: the amount of non- $CO_2$ emissions from the natural fires are calculated.

**11. Monitoring of leakage from transport of personnel and products**

The leakage from transport of project staff for activities associated with project and transport to areas outside the project boundary is calculated by monitoring the project activities that involve staff travel and product transportation to areas outside the project boundary. The project transport activities such as movement of nursery inputs, planting material from nursery to planting sites, translocation of labor, transport of harvested products to markets and for other end uses outside the project boundary are monitored and accounted. The leakage will be calculated as per the equations M.43 to M.44 outlined in the Section III of the approved methodology AR AM0002.

The fossil fuel emissions are proposed to be estimated based on the numbers of vehicles, distance traveled, fuel consumption, and emission factors. The data required for estimation of leakage such as the distance traveled by the project staff to areas outside the project each year and amount of fossil fuels consumed in the transportation of the project personnel would be collected from the project monitoring data. The data on the quantity of the thinned wood, distance traveled to the market for the sale of thinned wood, and the quantity of fossil fuels consumed in the travel would be collected from the project records. The annual leakage associated with the transportation of project personnel and products to areas outside the project would be calculated using the steps outlined below.

*Step 1***:** Collection of information on the distance traveled, vehicle type, and fuel consumption.

*Assumptions with regard to distance of travel and use of vehicle types*

| **Number of land parcels** | **Travel for field surveys & inventory (km) per parcel** | **Fuel consumption in field surveys and inventory (litres/km)** | **Travel related to protection & operations (km per parcel)** | **Fuel consumption in field surveys and inventory (litres/km)** | **Travel associated with project management & monitoring (kilometers for total project per year)** | **Fuel in project management & monitoring consumption (litres/km)** |
|---|---|---|---|---|---|---|
| 2421 | 15 | 0.13 | 15 | 0.13 | 100,000 | 0.1 |

*Parameter values*

| Fossil fuels | Emission factors (kg/litre) CO2e |
|---|---|
| Diesel | 2.63 |
| petrol | 2.40 |

The additional parameters from local studies, IPCC default factors and God Practice Guidance on LULUCF and Energy projects and published literature relevant to the project context would be used as required.

*Step 2***:** Adoption of emission factors for different types of fuel types

*Step 3***:** Estimation of $CO_2$ emissions using bottom-up approach outlined in Good Practice Guidance for energy sector (IPCC 2000)

The project is not subject to other types of leakage such as grazing as clarified in detail under the applicability conditions of the approved methodology. In order to demonstrate the prevention of grazing leakage, the project implemented leakage prevention measures. The project seeks to monitor and evaluate the effectiveness of the leakage prevention measures.

### *Monitoring of leakage prevention measures*

The project is not expected to result in leakage from the displacement of pre-project grazing and other economic activities as the project design incorporated measures to enhance the socioeconomic status of communities and ensure that the pre-project activities such as grazing are not displaced to areas outside project. In order to ensure that pre-project grazing and other economic activities are not displaced, the project implemented socioeconomic measures outlined below. The leakage prevention measures implemented would be monitored during the project implementation period.

- Implementation of livestock improvement and pasture management programs to improve livestock and pasture productivity and to avoid the displacement of low productive livestock.
- Benefit-sharing arrangements in the project area to ensure legally binding commitments of local stakeholders to prevent leakage from grazing and economic activities
- Assistance to livestock holders and improvements to the livestock/pasture management are intended to prevent leakage
- Implementation of participatory land-use planning intended to avoid land-use conflicts resulting from grazing and other forms of leakage
- Incentives to households to pursue improved land use alternatives on the existing lands
- Imparting training in skill development programs to promote alternative livelihood opportunities.

## 12.0 Procedures in project implementation and monitoring

Monitoring procedures are designed to ensure accurate measurement and reporting at the project level. For the purpose of project monitoring and inventory, field crew should be organized into teams with one-person assigned as a team leader. The number of members in a team and number of teams depends on the strata, administrative unit and sample size. Team leaders should be made responsible for organizing the field work. The overall organization of monitoring team is the responsibility of the project coordinator. The monitoring will be based on the project data and information collected from project operations. The procedures to be followed in project implementation and monitoring are outlined in the sections below.

### 12.1 Procedures for training of monitoring personnel

Training of project monitoring personnel is a key step in ensuring the quality of data collection and accurate assessment of *ex post* carbon stock.  Training helps in improving the technical skills of the project personnel. The training of monitoring personnel should cover the following technical aspects.

- The monitoring teams should be trained in the use of maps such as topographic and stratification maps and other physical and vegetation maps. The training should cover interpretation of maps

and photo features and relating these to vegetation and other geographic features on the ground and conversion of map scales to actual measurements on the ground.

- The training would cover the use of Global Positioning System (GPS), and instructions in the use of GPS, creating waypoints and data collection and use of the GPS in conjunction with compass, maps and field data collection techniques.

- Training to monitoring teams would be provided on the procedures for measuring forest growth and yield using permanent sample plots (PSPs).

- Training should also cover skills in identifying vegetation, species characteristics, sample plot location, codes and recommended practices of the inventory.

- Monitoring team members should be trained in the use of safety features such as the use of safety glasses, first aid kit, hand radio etc.

- The training should also cover the assessment of natural and anthropogenic risks and activities to be implemented in response to the risks of fire, floods, droughts, pests etc.

- Training would cover the significance of meteorological data, such as maximum and minimum temperature, humidity, maximum wind velocity and average rainfall, interpretation of meteorological information and response to be implemented to address weather related emergencies.

**12.2 Procedures for emergency preparedness for cases where emergencies could cause unintended emissions**

- *Procedures to assessment GHG emissions due to fire in the boundary*
  The project would implement fire management plan taking into account the recommendation of Moldsilva or the forest management agency of the local council. The fire management plan would implement prevention measures such as establishment of firelines, reduction in fuel load, clearance of bushwood and dry vegetation close to the project parcels. The project would further implement rapid response fire suppression measures.

  In case of accidental fires, the area affected would be assessed by surveying the area and carbon stock affected. The procedures used for calculation of GHG emissions from natural fires under the project emissions would adopted to account the emissions and recorded in the project database.

- *Procedures to assess the impact of land slides and soil erosion*
  As the project faces significant risks from land slides and soil erosion, project monitoring procedures require the assessment of the occurrence of land slide and erosion events and extent of their impact in the project area. The project is expected to implement land slide and erosion prevention measures and their effectiveness is recorded. The information from field surveys will be used to assess the area affected in the soil slides and severe form of soil erosion such as gully erosion. The biomass and carbon stock of the affected area is calculated by applying the average non-tree biomass of the project area.

- *Procedures to assess the impact of pest infestation on the carbon stock of the project*
  In case of pest damage, monitoring team would assess the area and carbon stock of the affected area and implement pest management measures to minimize negative impacts on the remaining carbon stock in the project boundary and to prevent the spread of infestation to areas outside project boundary.

- *Impact of droughts and floods on carbon stocks in the project boundary*
  Procedures would be implemented to assess the weather related natural hazard events such as droughts and floods in the project area and survival of plantations in the affected areas. The data from field surveys of the affected areas would be used to assess the impact of droughts and floods on the carbon stocks of the project.

**12.3 Equipment used in inventories and calibration procedures for measurement accuracy**

The equipment to be used in fieldwork should withstand the rigors of field use under adverse conditions. To avoid errors in the measurement of carbon stock, the following equipment used in monitoring and inventory activities would be calibrated using standard forest management and inventory operating procedures of the local forestry agency. .

*Equipment for use in inventory*

– Maps of the project area, stratum and planting site with GPS coordinates
– Compass for measuring bearings
– Fibreglass or metal tapes (100m and 30m) for measuring distances
– Global Positioning System (GPS) for locating plots
– Plot centre marker (rebar/PVC tubing) for marking plots
– Metal detector for locating belowground plot markers
– Aluminium nail and number tags for marking trees
– Tree diameter at breast height (dbh) tape for measuring trees
– Hyspometer
– Diameter tape
– Pocket calculator
– Clinometers (percent scale) for measuring tree height and slope
– Coloured rope and pegs or a digital for marking plot boundaries measuring device (DME)
– 100m line or two 50m lines for measuring dead wood
– Calipers for measurement of dead wood
– Hand saw for collecting dead wood samples and cutting destructive samples
– Spring scales (1kg and 300g) for weighing destructive samples
– Large plastic sheets for mixing forest floor/under storey sample
– Soil sampling probes for sampling soil
– Rubber mallet for inserting soil probes
– Cloth (for example, Tyrek) or paper bags for collecting soil and under storey samples
- Tree caliper, graduated in centimeter graduated in diameter classes of 5 cm
- Wood plank and accessories (cord, grip, rubber band, etc),
- Plastic file folder to put essential inventory documents, tables of correction for slope, etc,
- Pencil of average hardness (HB), a gum, and a penknife

**12.4 Procedures for maintenance of monitoring equipment and installations**

The common procedures to be followed in the maintenance of monitoring equipment are outlined below. In case no ready guidance, the recommendations of local forest management agency shall be followed.

- When compass is used in the field, it is calibrated to compensate for the local difference between magnetic and true north (magnetic declination) and adjustment is made in order to facilitate the recording of accurate bearing.

- The aspect measurements should be recorded to the nearest eight directions: N, S, E, W, NE, SE, NW and SW. The same procedure is used to determine the azimuth to any desired target object such as a tree and the azimuth value should be recorded to the nearest percent, The azimuth direction is expressed in degrees: North at 360 (zero) degrees, East at 90, South at 180, and West at 270.

- It is recommended to use DBH tapes made of steel or aluminum. Cloth tapes should be avoided considering their propensity for wear and tear that could result in measurement inaccuracies.

- Pacing can be useful to establish the relationship between map and photo information with the measurements on the ground. One step represents half of a pace, two steps is one pace. Therefore, crew should be trained in pacing on flat ground.

- For collecting soil samples, cloth bags should be used and the use of plastic bags is avoided as they do not allow for the samples to dry, which can result in inaccurate results.

**12.5 procedures for handling of records and storage and process performance documentation**

The project information is stored in paper and electronic formats. The Project Implementation Unit (PIU) has developed standardized operating procedures for collection, reporting, filing and archival of the project data and information. The reporting arrangements for handling of project documents and communications is aimed at continuous update of the operating procedures and communicating them widely to the project staff in the field so that project information is regularly updated and procedures for data storage and retrieval are updated as per the project requirements.

**12.6 Procedures for reconcile inventory data and to address uncertainties**

The following procedures are implemented to reconcile the inventory data and to address uncertainties in the data collected.

- A program of field checks will be implemented to insure that the field work is performed accurately and adjustments are made to the monitoring data and information at specified intervals before the data are archived in the database.

- The guidelines of local forest management agency shall be used to make adjustments to inventory data, e.g. determination of borderline trees for measurement.

- To make adjustments arising out of unforeseen adjustments for which procedures are not readily available with the project implementation unit, the guidance of local forest agency for similar situations will be followed.

- The steps and procedures of AR AM0002 shall be used to address the uncertainties in the carbon stock assessments.

**12.7 Procedures identified for review of reported results/data**

The project implementation unit is expected to verify the plot data and decide on the need to return to the plot to re-measure the carbon pools. Prior to leaving a completed plot, the monitoring team would review plot data form to insure all data are properly collected and recorded. The review would include checks of equipment calibration to ensure accurate measurements and random checks of the collected data to ensure the accuracy of reported measurements in the project database.

The reviewers of the data are expected to present their independent report to the project coordinator so that review feedback is shared with the monitoring team and suitable corrective measures are implemented.

**12.8 procedures identified for internal audits of GHG project compliance with operational requirements**

The Project Implementation Unit would implement the internal audit in order to ensure that the project complies with the regulatory requirements in terms of meeting the requirements of approved methodology AR AM0002 and the guidance of the CDM Executive Board. The internal audits would focus on the following aspects of the project

- Semi-annual and annual assessment of project documentation and reporting requirements to ensure compliance with the regulatory requirements.

- Arrangements for independent checks of the monitoring and inventory fieldwork over 10 % of the plots to ensure that the project data are collected and archived consistently following the standard procedures and the errors noticed are corrected and recorded.

- Audit of the procedures used in assessing the carbon stock changes based on the field data measurements

- Assessment of biodiversity impacts of the project, especially on threatened, endangered and weed species.

- Analysis of the effectiveness of the leakage prevention measures and improvements implemented to enhance the efficacy of leakage prevention measures.

**12.9 procedures identified for project performance reviews before data is submitted for verification**

The project implementation unit (PIU) is expected to review the project performance based on the reports of project implementation and inventory. The project coordinator in charge of PIU is expected to certify the compliance of the project with the steps of the approved methodology AR AM0002 and guidance of the CDM Executive Board. The **Appendix I** of this monitoring plan presents the initial formats proposed for use in project monitoring purposes. The formats would be modified based on the reporting and regulatory requirements at each verification interval.

**12.10 procedures identified for corrective actions in order to provide for more accurate future monitoring and reporting**

The corrective action procedures ensure accurate monitoring and reporting on the project. The following procedures illustrate the corrective action procedures envisaged under the project.

The project coordinator or staff of the project implementation unit (PIU) could accompany monitoring teams to assist in the field measurements. The coordinator is expected to conduct random inspections to identify errors and make decisions on the re-measurement of sample plots in case errors are observed.

Disagreements on inventory approaches would be discussed among the monitoring teams and consensus on monitoring and inventory procedures achieved would be implemented throughout the project area. The procedures at each inventory are recorded in the project database

The flora that is difficult to identify at the time of inventory, would be recorded based on its characteristics, and a leaf/branch sample is collected and its identification is undertaken after the plot inventory.

At each monitoring event, data from previous and current inventories would be compared in order to make an accurate assessment of in-growth, existing trees, and mortality.

**Table 11: Procedures for the *ex post* measurement of the carbon pools**

| Carbon pool | Methodology/ Data sources | Frequency/ Dates of evaluations | Responsibility | Documentation |
|---|---|---|---|---|
| Aboveground tree biomass and standing dead wood | Systematic stratified sampling with fixed area plots, prediction of dry biomass as a function of direct diameter measurement | As per aboveground biomass carbon monitoring schedule | Director, Forest Enterprise; Project Implementation Unit; Forest Research Institute or contracted expertise; | Report to Moldsilva; Annual report from Moldsilva |
| Non-tree shrub biomass | Systematic stratified sampling with fixed area plots, prediction of dry biomass as a function of direct diameter measurement | As per aboveground biomass carbon monitoring schedule | Director, Forest Enterprise; Project Implementation Unit; Forest Research Institute or contracted expertise; | Report to Moldsilva; Annual report from Moldsilva |
| Lying dead wood | Systematic stratified sampling via line-intersect method, calculation of volume and conversion of volume to biomass | At project start and, if significant accumulations are noted, as per aboveground biomass carbon monitoring schedule | Director, Forest Enterprise; Project Implementation Unit; Forest Research Institute or contracted expertise; | Report to Moldsilva; Annual report from Moldsilva |
| Litter | Systematic stratified sampling for direct determination of dry mass | At project start and, if significant accumulations are noted, as per aboveground biomass carbon monitoring schedule Table 10 | Director, Forest Enterprise; Project Implementation Unit; Forest Research Institute or contracted expertise; | Report to Moldsilva; Annual report from Moldsilva |
| Soil carbon | Systematic stratified sampling for determination of mass soil carbon from bulk density and percent carbon analysis | As per soil carbon monitoring schedule | Director, Forest Enterprise; Project Implementation Unit; Forest Research Institute or contracted expertise; | Report to Moldsilva; Annual report from Moldsilva |

## 13.0 Quality Assurance and Quality Control Plan

To develop a credible plan for measuring and monitoring carbon on the afforestation/reforestation sites, steps must be taken to control for errors in sampling and data analysis. To provide confidence to all stakeholders that the reported carbon credits are reliable and meet minimum measurement standards, a quality assurance and quality control (QA/QC) plan is necessary. This plan includes formal procedures to verify methods used to collect field data and the techniques to enter and analyze data. To ensure continuity it is important that all data collected use the same procedures during the project life and is archived using acceptable standards by all partners involved in the project. Adhering to these procedures will ensure that in the event there is a change in personnel at Moldsilva, or if any of the people involved are questioned about any aspect of the project, all will be well informed. In addition to following the procedures outlined below, it is also important that a record be maintained to demonstrate that the steps are being followed; this needs to be done by developing a series of check sheets for each step.

The purpose of this section of the report is to describe the procedures for: (1) collecting reliable field measurements; (2) verifying methods used to collect field data; (3) verifying data entry and analysis techniques; and (4) data maintenance and archiving.

### 13.1 Field data collection

Measurement protocols detailed in the text of this monitoring plan would be adopted as Standard Operating Procedures (SOPs) so that field personnel can repeat the measurements at each monitoring intervals as in previous monitoring intervals. A certification document will be produced and filed that show that QA/QC steps have been followed.

Field crews of the Forest Research Institute will receive extensive practical training and would be fully cognizant of procedures in collecting data as accurately as possible. In addition, an audit program for field measurements and sampling will be established to audit data and to provide unbiased estimates of measurement variance. Any errors discovered will be expressed as a percentage of all plots that have been rechecked to provide an estimate of the measurement error.

### 13.2 Laboratory measurements

Analysis of soil samples for carbon should be preceded by calibration with standards of known carbon concentration. All calibration results should be documented and archived along with sample analysis results. Likewise all balances for measuring dry weights should periodically be calibrated against known weights. Where possible, 10-20 % of samples should be reanalyzed and reweighed to produce an error estimate.

### 13.3 Data entry

To produce reliable carbon estimates the proper entry of data into the data analyses spreadsheets is required. The spreadsheet are provided in the Excel sheet "Moldova tree biomass.xls" – this will eventually incorporate biomass regressions developed specifically for the project. It is important that steps are taken to ensure that errors are minimized. Common sense should be used when reviewing the results of the data analysis to make sure that they fit within the realm of reality. Communication between all personnel involved in measuring and analyzing data should be used to resolve any apparent anomalies before final analysis of the monitoring data can be completed. If there are any problems with the monitoring plot data (that cannot be resolved), the plot should not be used in the analysis. Errors can be reduced if the entered data is reviewed using expert judgment and, if necessary, comparison with independent data.

### 13.4 Data archiving

Because of the relatively long-term nature of forestry activities, data archiving (maintenance and storage) will be an important component of the work. Data archiving should take several forms and copies of all data should be provided to each project participant.

- Original copies of the field measurement (either data sheets or electronic files) and laboratory data should be placed in folders and on electronic media, and stored in a secure location, by the carbon measurement implementers.
- Copies of all data analyses, and models; the final estimate of the amount of carbon sequestered; any GIS products; and a copy of the measuring and monitoring reports should all be stored in a dedicated and safe place, preferably offsite.
- Considering the long time frame of project implementation and monitoring, the updated versions of data archival media (software and hardware) updated periodically or converted to a format that could be accessed by any future software application.

## 14.0 Soil conservation indicators and monitoring

For practical reasons of cost and complexity, three soil conservation indicators will be measured, bulk density, percent mineral soil carbon (as an indicator of organic matter accumulation), and rate of soil loss/accumulation, all of which will be measured concomitantly with soil carbon inventories (Table 12). Soil loss will be monitored by referencing the initial level of the soil surface, permanently recorded on each aboveground biomass plot marker. The plot marker consists of an iron bar inserted into the ground with the initial soil level permanently inscribed. In the course of monitoring, changes in the soil level relative to the initial mark will be measured and recorded. Results will be compared to results from a control marker on an adjoining site outside the project, likewise monitored over time.

**Table 12: Indicators and procedures for soil conservation indicators monitoring**

| Indicator | Methodology/ Data sources | Frequency/ Dates of evaluations | Responsibility | Documentation |
|---|---|---|---|---|
| Soil bulk density in project sites relative to initial conditions | As per soil carbon monitoring | As per soil carbon monitoring schedule Table 9 | Director, Forest Enterprise; Project Implementation Unit; Forest Research Institute or contracted expertise; | Report to Moldsilva; annual report from Moldsilva to PMU |
| Mineral soil carbon in project sites relative to initial conditions | As per soil carbon monitoring | As per soil carbon monitoring schedule Table 9 | Director, Forest Enterprise; Project Implementation Unit; Forest Research Institute or contracted expertise; | Report to Moldsilva; annual report from Moldsilva to PMU |
| Rate and amount of soil loss in project sites relative to control sites | Field surveys of established monitoring plots | As per soil carbon monitoring schedule Table 9 | Director, Forest Enterprise; Project Implementation Unit; Forest Research Institute or contracted expertise; | Report to Moldsilva; annual report from Moldsilva to PMU |

## 15.0 Biodiversity indicators and monitoring

As planting parcels are relatively small and scattered, it is unlikely that the project will contribute significantly to the direct connectivity of the existing forest patches in Moldova. Instead, the project will contribute forest patches enriching the overall landscape, which has been advanced as a greater determinant of biotic dispersal and habitat suitability for associated species than intact corridors per se (Franklin, 1993, Franklin et al, 1996).

The biodiversity indicators were selected on the basis of their immediate relevance to the specific objectives of the project as well as practical considerations such as the capability of field staff to use them and the time required for their monitoring and cost. Thus, baseline biodiversity indicators will include the floral and avian community richness and floral community dominance. Mammals and herpetofauna will not be monitored as their comparatively lower abundances and behavior call for much more intensive sampling as well as specialized and labor-intensive approaches (e.g. line-trapping for small mammals, night surveys for frogs and toads). Botanists and ornithologists will be required to assist forestry staff in conducting field surveys. A monitoring table for biodiversity issues is provided (Table 13).

The sample will cover a subset of 50 biomass measurements. Small sample plots will be selected at random, however, ensuring a minimum distance between points of 250 meters for floral and avian monitoring. For each plot, a control plot on an adjoining site will be monitored to establish baseline reference conditions and monitor the site over time. Floral and avian surveys will precede biomass measurements to avoid disturbance (trampling and noise) resulting from measurement activity.

***Flora***

The floral community will be assessed using the permanent small plots of 5 m x 10 m where all individuals are assigned to species and recorded. Observations and measurements of flora will be undertaken in the late spring and again in the fall to ensure that all species are noted. The Shannon index outlined below (H’) is an appropriate diversity index for random sampling (Brower et al, 1990).

$$H' = (N \log N - \sum n_i \log n_i) / N$$

where $n_i$ is the number of individuals of species i and N is the total number of individuals. The index value increases as total number of species increases and evenness of relative abundance of species increases. The Shannon diversity index will be used to monitor changes in floral and avifaunal biodiversity on project sites relative to baseline conditions.

Simpson’s dominance index (l) (Brower et al, 1990) is a measure of community diversity that can be used to monitor relative dominance of species within the community over time. The index represents the probability of drawing the same species from a random selection of a pair of individuals from the population;

$$l = \sum n_i(n_i - 1) \ / \ N(N - 1)$$

where $n_i$ is the number of individuals of species i and N is the total number of individuals. Monitoring this index value over time will serve to reveal any trends in species dominance within the community (project), for example, if one species increases in abundance at the expense of other species. The dominance index would be expected to begin at a relatively high value in a newly-initiated tree planting and then decrease over time as natural recruits are steadily introduced. Documenting that the dominance index does not increase on project as well as neighboring lands will serve to verify that the project is not a source of invasive species and is contributing to community diversity. For further resolution, the native:exotic species ratio of total number of individuals per plot at project and reference sites will also be tracked over time.

***Avifauna***

Birds will be monitored via the Indices ponctuels d'abondance (IPA), or point count method (Blondell et al, 1970). Point counts will be centered within the plots designated for floral inventories. The minimum distance of 250 meters between points will ensure that individuals are not double-counted from one point to the next; thus, the sampling regime is random without replacement. For each monitoring event, all birds detected (seen and/or heard) over a 5 minute time period will be recorded, following the European standard (Koskimies and Vaisanen, 1991), and within a 50 meter (estimated) radius of the point center, which should control for differences in detectability among species (Ralph et al, 1995). Multiple individuals are recorded only if detected simultaneously. Observations should be restricted to early morning when birdsong will be most prevalent and in the late spring (late May to June) at which time the avifaunal community is predominantly represented by locally-nesting individuals, which have the most relevance for determining project impact.

To ensure comparability of monitoring results, the same observer should record all observations for a given project site and adjoining control site. If bird densities are discovered to be low (i.e. significant number of point counts yields few registrations each), the monitoring plan may instead use permanently marked line transects traversing selected project and control sites (Bibby et al, 1992). As with flora, the Shannon diversity index will be used as the quantitative measure of avian biodiversity.

### Table 13: Indicators and procedures for biodiversity monitoring

| Indicator | Methodology/ Data sources | Frequency/ Dates of evaluations | Responsibility | Documentation |
|---|---|---|---|---|
| Floral species diversity in project sites relative to control sites | Field surveys of established monitoring plots | As per carbon monitoring schedule Table 9 (late spring and fall) | Director, Forest Enterprise; contracted expertise; PIU | Report to Moldsilva; annual report from Moldsilva to PMU |
| Avian species diversity in project sites relative to control sites | Field surveys of established point counts | As per carbon monitoring schedule Table 9 (late spring) | Director, Forest Exnterprise; contracted expertise; PIU | Report to Moldsilva; annual report from Moldsilva to PMU |
| Floral community dominance index and native:exotic species ratio in project site and adjacent control sites | Field surveys of established monitoring plots | As per carbon monitoring schedule Table 9 (late spring and fall) | Director, Forest Enterprise; contracted expertise; PIU | Report to Moldsilva; annual report from Moldsilva to PMU |

The monitoring procedures would ensure that the herbicides/weedicides used in the project would not have persistence as the herbicides/weedicides would be systemic and specifically targeted the weeds without leaving residues. Furthermore, the project monitoring teams would be trained in the correct methods of application and doses of herbcides in order to avoid the chances any unintended contamination or persistence effects.

## 16.0 Socio-economic indicators and monitoring

For monitoring project-attributable socio-economic benefits relative to baseline conditions, the following general indicators will be used:

1. Income generation
2. Employment
3. Community participation
4. Equity
5. Environmental awareness

Table 14 shows the specific indicators proposed for measurement and monitoring. The suggested methodology is to representatively select and carry out a comparative analysis of pairs of villages with approximately the same characteristics, one benefiting from the project, the other not.

**Table 14: Indicators and procedures for socio-economic monitoring**

| Indicator | Methodology /Data sources | Frequency/ Dates of evaluations | Responsibility | Documentation |
|---|---|---|---|---|
| Number of temporary jobs (e.g. seed collection for nurseries and tree planting) created per year (measured in person days) | Receipts of payment | Annually | Project management unit (PMU) | Project accountant delivers analysis |
| Number of permanent jobs created by year 1 and so forth (measured in person years) | Signed contracts, job descriptions | Annually | PMU | Project accountant delivers analysis |
| Amount of firewood in m3 of has been sold at a discounted price with X value of cost savings by Moldsilva to local population from the permanently transferred sites from project year 7 onwards | Firewood sale records | Annually after project year 7 | Moldsilva forest district heads | Annual report by Moldsilva forest districts to PMU |
| Number of ha of afforested land permanently transferred to Moldsilva, grazing is permitted from project year 10 onwards | Grazing permissions issued | Annually after project year 10 | Moldsilva forest district heads | Annual report by Moldsilva forest districts to PMU |
| Number of community-based forest user groups or forest management committees created annually and informed & trained by Moldsilva in soil conservation and forest management | Statutes and project records | Annually | PMU in cooperation with local councils | Village authorities report to PMU |

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## Appendix I

### FORMS USED FOR REPORTING ON PROJECT IMPLEMENTATION AND INVENTORY

**MP Format - A1**

**FORESTRY AGENCY "MOLDSILVA"**

**AFFORESTATION PROJECT**
**for spring/autumn of the year 20__**

State Forestry Enterprise ____________________________________________________
Forestry ____________________________________________________________
Plot ________________subplot______________________________________________

1. Area ____________________ ha
2. Land category (glades and gaps, degraded lands etc.) ___________________________________
3. Soil moisture ____________________________________________________________
4. Vegetation type (growing conditions) ___________________________________________________
5. Composition and age of the plantation
6. Deadlines for works execution and record of vehicle/machinery/equipment use:

| Nr. d/o | Title of works | Deadline for execution | Vehicle/machinery/ equipment use |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

7. Afforestation methods (through seedling plantation, through sowing – in lines, in nests, in clusters etc.) ____________________________________________________________________
8. Principal species planted ____________________________________________________________
9. Map of the plantation ______________________________________________________________
10.Spacing: distance between lines __________________m, distance between saplings (in line) ______________m.
11.Number of saplings per 1 ha ______thousand, number of saplings stipulated by standard for afforestation of unoccupied forest lands ____________________________thousand of saplings per 1 ha.
12.Seeding material necessary for 1 ha ___________; for whole area (by species) ____________________________________________________________________

13. Silviculture methods and measures, their periodicity:
   I year ____________________________________________________________________
   II year ____________________________________________________________________
   III year ___________________________________________________________________
   IV year ___________________________________________________________________
14. Measures against forest fires (width of belts against fires, of mineralized belts etc.) ____________________________________________________________________
15. Measures against disturbances from wild animals ____________________________________________________________________
16.Year of plantation transfer into category of lands covered by forests ____________________________________________________________________

Project concluded by
Forestry chief ______________________ "__"___________________a. 200_

Project verified by
Forest regeneration engineer ______________________ "__" __________________a. 200_

Project had been approved and following amendments were suggested : _________________________
_____________________________________________________________________________________

Forestry chief engineer _____________________ "__" _________________year 200_

Sketch for planting of forestry cultures

**MP Format - A2**

**Technical Report on Project Activities**

200_ „__” ________________ undersigned

________________________________________ мы, нижеподписавшиеся

________________________________________________________________________________

position, first name, name – фамилия, имя, отчество, должность

accomplished ________________________________________________________________
произвели приемку выполненных работ

________________________________________________________________________________

forestry enterprise, forestry - лесхозом, лесничеством

regeneration works in________________________________plot____________________________ subplot
лесокультурных работ в квартал

выдел

during the technical review has found to be :
при технической приемке установлено:

1.Completed on the land ____________________________________________________________________ha
работы выполнены на площади га

2. Period of execution, seeding, planting

________________________________________________________________

время проведения работ, посеву и посадке

________________________________________________________________________________

________________________________________________________________________________

(Start and end, reasons of delay– начало и конец, причины отставания)

3. Method of creation of forest crops (seeding, planting, in line, sketch of species allocation etc.) ______________

способ создания лесных культур (посадка, рядовой, двухстрочный, схема размещения пород и т.д.)

________________________________________________________________________________

________________________________________________________________________________

________________________________________________________________________________

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4. Period and method of site preparation (complete plough, deep autumn plough, deep complete plough, plough at > 40cm width, early fellow, partial in belts: furrows, grounds indicating width, length)– время и способ подготовки почвы (сплошная, плантажная, сплошная глубокая, зяблевая вспашка, ранний пар, частичная полосами (бороздами, площадками с указанием ширины, длины))______________________________________________________________

________________________________________________________________________________

________________________________________________________________________________

_________

5. Quality of site preparation (depth of ploughing, level of weeds, etc.) _____________________________
качество подготовленной почвы (глубина пахоты, засоренность, комковатость)

________________________________________________________________________________

________________________________________________________________________________

6. Quality of seeding material (age, standard), of seeds (origin, harvesting period, quality, N. and date of certificate), preparation before seeding - качество посадочного материала (возраст, стандартность), посевного материала (происхождение, время сбора, доброкачественность, № и дата сертификата)

________________________________________________________________________________

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7. Works were implemented (with planting vehicle, by horse seeding-machine etc.

работа прозведена (посадочной машиной, сеялкой конной, посадочным мечом и т.д.)

8. Quality of planting, seeding (depth, allocation, density of seeds, quality of marking etc)

качество работ по посеву, посадке (глубина заделки, плотность заделки, прямолинейность маркировки и т.д.)

9. Measures for improving soil structure and accumulation of organic matter (introduction of gypsum, snow, cultivation etc)

Мероприятия по улучшению структуры почвы и влагонакопления (внесение гипса, удобрений, снегозадержание, предпосевная культивация и т.д.)

10. Difference between project requirements and works implemented, __________________________________________

расхождение выполненных работ с техпроектом и их причины

11. Deficiencies in seeding and planting which may influence the quality of forest crops (volume, character etc.) – основные дефекты работ по посеву и посадке, которые могут отразиться на качестве лесокультур (объем, характер)__________________________________________________

12. Indication of expenditures ________________________________________

Мероприятия по исправлению допущенных дефектов с указанием стоимости

13. General estimation of accomplished works quality, taking into account foreseen root strike of forest crops (good, satisfactory, unsatisfactory) – Общая оценка выполненных работ с учетом ожидаемой приживаемости культур (хорошо, удовлетворительно, неудовлетворительно)

14. Works were accomplished by

Работу выполнили

15. Responsible person, manager of implementing plantation works ______________________________

Ответственный исполнитель, под руководством которого были выполнены лесокультурные работы

funcția, numele – должность, фамилия

Signature of commission members participating at works reception

Подписи членов комиссии, присутствующих при приемке работ

Signature of persons participating at works

Подписи лиц, присутствующих при приемке работ

___

___

___

Note of forestry enterprise on act control

___

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**MP Format - A3**

**REGISTER**

on technical reception of forest crops works, accomplished in ____________________y.200_

Рабочая ведомость

Технической приемки лесокультурных работ произведенных в _______________________200_

State Forestry Enterprise ______________________ Forestry _______________

Лесхоз_________________________________________________лесничество________________

| Nr. d/o | Protection group Группа лесов | Protection category Категория лесов | Plot, Квартал Forest massive урочище | Subplot Выдел | Sector area Площадь участка | Principle specie Главная порода | RESULTS OF TECHNICAL RECEPTION | | Observations and notes during reception Замечания и отметки о приемки культур |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Works quality Качество работ | Drawbacks of works Основные дефекты работ | |
| | | | | | | | | | |
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**MP Format - A4**

**SUMMARY ACT**
**on works of forest crops inventory**

"___"________________200_ Undersigned,

_______________________________________________________

On the basis of disposition ________________________________________ accomplished at State Forestry Enterprise

___________________________________________________________________________________

| Forest type | Plot, subplot | Principle specie | Area, ha | Dead, % | Survival % | | Planned measures |
|---|---|---|---|---|---|---|---|
| | | | | | Percent of survival by species % | average | |
| | | | | | | | |
| | | | | | | | |

Signatures of members:

___

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**MP Format – A5**

**ANNUAL PLAN OF PLANTATION ACTIVITIES**

| Nr. d/o | Way of administration | District | Administrative sector | Mayoralty/forestr y | Area, ha | N. of outline/ plot, subplot | Planned for planting for 200_ | Real planting during 200_ | Planned principle specie | Planted principle specie | Root strike, % | Completing during 200_ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
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**MP Format – A6**

**Outline of Sample Plot Inventory**

## Plot Data Form

| | | | |
|---|---|---|---|
| Stand /Plot ID | / | Overstory | / |
| Starting point | | Type class | / |
| Date | / / | Understorey | / / |
| Aspect/Slope | / | Groundcover | / / |
| Crew initials | | Weather | 1 2 3 4 |

**Plot Tree Talley**

| SNo | Spp | Crown class | DBH | Ht | | SNo | Spp | Crown class | DBH | Ht | |
|---|---|---|---|---|---|---|---|---|---|---|---|
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**MP Format – A7**

## Summary of Sample Plot Inventory

**Plot level information**

| | Plot coordinates | | | | | | | | | | | | | | Block No. | | | Plot boundary | | Date of Inventory | | | | | | Plot / Sub-plot | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Longitude | | | | | | | Latitude | | | | | | | | | | | | DD | | MM | | YYYY | | | | | | | | | | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
| A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

**Species level information**

| | Species | Measurements (ht) | | | | | | | | | | | | | Status (live/dea | | | Diamteter classes | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | 5 | | 10 | | 15 | | 20 | | 25 | | 30 | | 35 | | 40 | | 45 | | 50 | | 55 | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
| B | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| C | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| D | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| E | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| F | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| G | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| H | **9** | Non- tree vegetation | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| | Species | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | | | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 |
| I | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

**MP Format – A8**

**Format for recording project emissions form (to be filled in each planting site)**

To be filled out at each event (transport of materials, personnel, etc…)

| **Fossil fuel consumption (liters)**<br>**Planting site**<br>**Year of planting**<br>**Major species** | | | | | |
|---|---|---|---|---|---|
| **date** | **Plot/ sub-plot** | **Type of activity** | **Calculation method** | **Gasoline (liters)** | **Diesel (liters)** |
| | | | | | |
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**MP Format – A9**

**Format for recording leakage**

To be filled out at each event

| **Fossil fuel consumption for project activities that take place outside the project boundary**<br>**Planting site**<br>**Year of planting**<br>**Major species** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **date** | **Type of activity** | **Type of vehicle** | **Type of fuel** | | **Consumption (l/100km)** | **Distance traveled** km | **Percent product transported to total load transported** % |
| | | | **Gas** | **Diesel** | | | |
| | | | | | | | |
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**Form No. MP – A10**

**Monitoring of Project Implementation Progress**

| Nr. d/o | Date | Title of accomplished works | Title of confirmed documents | Forestry | Plot, subplot | Mayoralty | Number of outline | Area, ha | Areas included in the project | | | Note |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Expenditures | | | |
| | | | | | | | | | Total | including | | |
| | | | | | | | | | | wage | materials | |
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