

# REFORESTING DEGRADED LANDS IN CHILE THROUGH THE USE OF MYCORRHIZAL INOCULATION

Prepared for Mikro-Tek by TerraCarbon LLC

**Mikro-Tek Inc.**<sup>1</sup>  
115 Sandy Falls Road  
Timmins, Ontario P4N7X8  
Canada

**TerraCarbon LLC**<sup>2</sup>  
5901 N. Sheridan Rd.  
Peoria, Illinois 61614  
U.S.A.

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|----------------------|-------------------------------------------------------------------------------------|
| <b>Project Title</b> | Reforestation Degraded Lands in Chile through the use of Mycorrhizal Inoculation    |
| <b>Version</b>       | Version 1.4                                                                         |
| <b>Date of Issue</b> | 19-April-2013                                                                       |
| <b>Prepared By</b>   | James Eaton <sup>2</sup> , David Shoch <sup>2</sup> , Mark Kean <sup>1</sup>        |
| <b>Contact</b>       | Mikro-Tek Inc., P.O. Box 2120, 115 Sandy Falls Rd., Timmins, Ontario P4N7X8, Canada |

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## 1.0 Project Details

### 1.1 Summary Description of the Project

In 2003, Mikro-Tek initiated the grouped project “Reforestation Degraded Lands in Chile through the use of Mycorrhizal Inoculation”. In this reforestation project, Mikro-Tek works with local land owners and provides an advanced propagation technology, mycorrhizal inoculation, to help restore and convert degraded grassland (Figure 1.1) into productive forests in several regions of Chile. The application of this technology, funded by Mikro-Tek’s investment, permits successful plantation establishment on sites that would otherwise not be sufficiently productive to incentivize reforestation efforts by landowners. This grouped project promotes reforestation of land that would remain as degraded grassland in the absence of carbon finance. Working with small and medium-scale landowners, Mikro-Tek’s project has so far led to the reforestation of 2,010.1 ha of land with *Pinus radiata* and an additional 996.8 ha of land with *Eucalyptus globulus* since 2003.

Figure 1.1. Photograph of Lote N°4 Fundo Nerquihue, MikroTek0048.



As discussed below in Section 1.12.3, part of the above project area was registered as part of the CDM project<sup>1</sup> “Nerquihue Small-Scale CDM Afforestation Project using Mycorrhizal Inoculation in Chile”. This project document has been developed in consultation with information originally provided in the CDM project design document.

The project is situated in an extremely dry area with degraded soils due to a long history of agriculture. The project area was previously used for small-scale agriculture production, but production ceased due to soil impoverishment. Prior to project initiation, project land was unmanaged abandoned grassland where

<sup>1</sup> Bird, D. and M. Kean. 2010. Nerquihue Small-Scale CDM Afforestation Project using Mycorrhizal Inoculation in Chile. Version 7. CDM Executive Board.

natural seed sources were lacking and natural regeneration does not occur. The project activity creates forest plantations on land with degraded soil that is currently no longer suitable for agriculture. Although plantation establishment is practiced in Chile, it is not widespread on lands similar to the project sites due to poor soils and the dry climate. Reforestation in the project region using traditional planting techniques has a high chance of failure due to poor environmental conditions.

This project involves the application of mycorrhizal inoculants to containerized seedlings prior to planting to reduce mortality and stimulate tree growth by enhancing nutrient and water uptake. Under normal conditions, adequate mycorrhizal formation usually occurs naturally. However, many industrial sites such as forestry cutovers, heavily used agricultural soils (such as these sites), nutrient-poor industrial waste sites, or sites where natural topsoil has been over used, disturbed or eroded away, are deficient in mycorrhizal fungi. In these cases, specifically chosen strains and species of mycorrhizae can be introduced to the soil to enhance the health and growth rates of the target plant community. This technology was not commercially available in Chile prior to Mikro-Tek's initial work to isolate local mycorrhizal species and strains, screen for effectiveness for enhanced nutrient uptake and vigor, and test the species with the most beneficial effect on targeted host tree species, which began in 1999.

The grouped project area includes sites where the combination of low rainfall and degraded nutrient poor soils make the application of this mycorrhizal inoculation technology essential to establishment of plantations with sufficient productivity to be financially attractive to landowners. Mikro-Tek has invested its own funds to develop and manufacture the mycorrhizal inoculation in return for the rights to the carbon credits generated by the reforestation project (subject to revenue sharing arrangements with the landowners). This initial investment by Mikro-Tek allows for a technological (and investment) barrier to be overcome. Without Mikro-Tek's involvement, strong environmental barriers would continue to prevent plantation establishment on the project lands.

In the course of the project, small and locally operated nurseries were used to produce containerized *Pinus radiata* and *Eucalyptus globulus* seedlings, which were inoculated with mycorrhizae supplied by Mikro-Tek. Mikro-Tek also supplied the inoculation procedures and worked directly with these nurseries to train personnel in quality-control aspects of mycorrhizal inoculation.

Individual land owners are responsible for planting and forest management practices, as approved by Corporacion Nacional Forestal (CONAF). Sub-soiling is carried out using either a tractor or animals (horses or oxen), depending on the slope of the land. The mycorrhizal inoculated seedlings are then planted along the sub-soil plow lines at an overall planting density of 1,250 trees per hectare. Harvesting occurs around year 20 for *Pinus radiata* and year 10 for *Eucalyptus globulus*. As specified in the Law 701 (see Section 1.11) which guides CONAF's approval of the forestry plans, each harvested stand must be replanted after harvest using the same species and planting density.

The initial project instances enrolled in the Reforesting Degraded Lands in Chile through the use of Mycorrhizal Inoculation grouped project consists of 3,007 hectares (ha) comprised of one or several fields planted for each project instance (see Table 1.1). Additional project areas will be added to this grouped project over time.

Table 1.1. Project instance information.

| Project Instance-Number | Region | Province      | Commune    | Owner         | Planting Year(s) | Species Planted     | Total Area (ha) |
|-------------------------|--------|---------------|------------|---------------|------------------|---------------------|-----------------|
| MikroTek0001            | VI     | Colchagua     | Lolol      | Harris-Correa | 2003             | Pinus radiata       | 0.5             |
| MikroTek0002            | VI     | Colchagua     | Lolol      | Nitsche       | 2003             | Eucalyptus globulus | 0.2             |
| MikroTek0003            | VII    | Curico        | Vichuquen  | Toledo        | 2004             | Eucalyptus globulus | 48.9            |
| MikroTek0004            | VI     | Colchagua     | Pumanque   | Hernandez     | 2004             | Eucalyptus globulus | 4.8             |
| MikroTek0005            | VI     | Colchagua     | Pumanque   | Hernandez     | 2004             | Eucalyptus globulus | 9.7             |
| MikroTek0006            | VI     | Cardenal Caro | Paredones  | Barroiht      | 2004             | Eucalyptus globulus | 25.2            |
| MikroTek0007            | VII    | Curico        | Vichuquen  | Cuevas        | 2004             | Eucalyptus globulus | 26.2            |
| MikroTek0008            | VI     | Colchagua     | Santa Cruz | Harris-Correa | 2006             | Pinus radiata       | 28.0            |
| MikroTek0009            | VI     | Colchagua     | Lolol      | Garces        | 2004             | Pinus radiata       | 299.1           |
| MikroTek0010            | VI     | Colchagua     | Lolol      | Harris-Correa | 2003             | Eucalyptus globulus | 24.8            |
| MikroTek0011            | VI     | Colchagua     | Lolol      | Harris-Correa | 2004             | Pinus radiata       | 26.8            |
| MikroTek0012            | VI     | Colchagua     | Lolol      | Harris-Correa | 2003             | Pinus radiata       | 30.4            |
| MikroTek0013            | VI     | Colchagua     | Lolol      | Harris-Correa | 2004             | Eucalyptus globulus | 7.1             |
| MikroTek0014            | VI     | Colchagua     | Pumanque   | Harris-Correa | 2005             | Pinus radiata       | 17.3            |
| MikroTek0015            | VI     | Colchagua     | Pumanque   | Harris-Correa | 2005             | Pinus radiata       | 99.0            |
| MikroTek0016            | VI     | Colchagua     | Pumanque   | Hernandez     | 2004             | Eucalyptus globulus | 14.5            |
| MikroTek0017            | VI     | Colchagua     | Lolol      | Giglio        | 2004             | Eucalyptus globulus | 58.8            |
| MikroTek0018            | VI     | Colchagua     | Pumanque   | Hernandez     | 2004             | Pinus radiata       | 1.5             |
| MikroTek0019            | VI     | Colchagua     | Lolol      | Harris-Correa | 2003             | Eucalyptus globulus | 34.8            |
| MikroTek0020            | VI     | Colchagua     | Lolol      | Nitsche       | 2004             | Eucalyptus globulus | 16.8            |
| MikroTek0021            | VI     | Colchagua     | Lolol      | Harris-Correa | 2003             | Pinus radiata       | 72.5            |
| MikroTek0022            | VI     | Colchagua     | Lolol      | Giglio        | 2004             | Pinus radiata       | 51.9            |
| MikroTek0023            | VI     | Colchagua     | Lolol      | Nitsche       | 2004             | Pinus radiata       | 49.3            |
| MikroTek0024            | VI     | Colchagua     | Lolol      | Nitsche       | 2003             | Eucalyptus globulus | 63.5            |
| MikroTek0025            | VI     | Colchagua     | Lolol      | Nitsche       | 2003             | Pinus radiata       | 185.7           |
| MikroTek0026            | VI     | Colchagua     | Lolol      | Harris-Correa | 2004             | Eucalyptus globulus | 13.5            |
| MikroTek0027            | VI     | Colchagua     | Lolol      | Nitsche       | 2003             | Pinus radiata       | 42.1            |
| MikroTek0028            | VI     | Colchagua     | Lolol      | Nitsche       | 2004             | Eucalyptus globulus | 36.5            |
| MikroTek0029            | VI     | Colchagua     | Lolol      | Nitsche       | 2004             | Pinus radiata       | 133.5           |
| MikroTek0030            | VI     | Colchagua     | Pumanque   | Hernandez     | 2004             | Eucalyptus globulus | 12.3            |
| MikroTek0031            | VI     | Cardenal Caro | Litueche   | Bulnes        | 2009             | Eucalyptus globulus | 17.4            |
| MikroTek0032            | VI     | Colchagua     | Lolol      | Harris-       | 2004             | Pinus radiata       | 113.1           |

|              |      |               |             |           |      |                     |       |
|--------------|------|---------------|-------------|-----------|------|---------------------|-------|
|              |      |               |             | Correa    |      |                     |       |
| MikroTek0033 | VI   | Cardenal Caro | Litueche    | Bulnes    | 2007 | Eucalyptus globulus | 29.1  |
| MikroTek0034 | VI   | Cardenal Caro | Paredones   | Barroiher | 2004 | Eucalyptus globulus | 0.8   |
| MikroTek0035 | VI   | Cardenal Caro | Litueche    | Bulnes    | 2007 | Eucalyptus globulus | 114.2 |
| MikroTek0036 | VI   | Cardenal Caro | Litueche    | Bulnes    | 2009 | Eucalyptus globulus | 37.3  |
| MikroTek0037 | VI   | Cardenal Caro | Litueche    | Bulnes    | 2006 | Eucalyptus globulus | 103.9 |
| MikroTek0038 | VI   | Cardenal Caro | Paredones   | Catalan   | 2004 | Eucalyptus globulus | 70.9  |
| MikroTek0039 | VII  | Curico        | Vichuquen   | Cuevas    | 2006 | Eucalyptus globulus | 47.7  |
| MikroTek0040 | VIII | Bio Bio       | Quilleco    | Baztan    | 2009 | Pinus radiata       | 473.7 |
| MikroTek0041 | VI   | Colchagua     | Lolol       | Ulloa     | 2003 | Pinus radiata       | 86.3  |
| MikroTek0042 | VI   | Cardenal Caro | Litueche    | Bulnes    | 2009 | Eucalyptus globulus | 6.4   |
| MikroTek0043 | VI   | Cardenal Caro | La Estrella | Bulnes    | 2004 | Eucalyptus globulus | 11.8  |
| MikroTek0044 | VIII | Bio Bio       | Quilleco    | Baztan    | 2009 | Pinus radiata       | 121.6 |
| MikroTek0045 | VI   | Cardenal Caro | Paredones   | Barroiher | 2004 | Eucalyptus globulus | 0.9   |
| MikroTek0046 | VI   | Cardenal Caro | La Estrella | Bulnes    | 2004 | Eucalyptus globulus | 124.6 |
| MikroTek0047 | VI   | Cardenal Caro | Paredones   | Barroiher | 2004 | Eucalyptus globulus | 34.3  |
| MikroTek0048 | VI   | Colchagua     | Lolol       | Ulloa     | 2003 | Pinus radiata       | 177.8 |

A schedule of the important aspects of the grouped project is listed in chronological order in Table 1.2, below.

Table 1.2. Schedule of grouped project activities.

| Project activity                                             | Date                   | Source/Notes                                              |
|--------------------------------------------------------------|------------------------|-----------------------------------------------------------|
| Grouped project start date and start of the crediting period | June 1, 2003           | Time of planting of the initial project instance.         |
| Validation of the grouped project                            | Anticipated 2013       |                                                           |
| Registration of grouped project                              | Anticipated 2013       |                                                           |
| Monitoring and Verification                                  | September/October 2012 | Starting in 2012 and at least every five years thereafter |
| Expected grouped project longevity                           | 40 years               | June 1, 2003 to May 31, 2043                              |
| Expected grouped project termination date                    | May 31, 2043           |                                                           |

## 1.2 Sectoral Scope and Project Type

This project is to be registered under the Verified Carbon Standard (VCS) as an Afforestation, Reforestation and Revegetation (ARR) project and has been developed in compliance with the Verified Carbon Standard<sup>2</sup> and VCS AFOLU Requirements<sup>3</sup>. The project entitled Reforesting Degraded Lands in Chile through the use of Mycorrhizal Inoculation is a grouped project.

<sup>2</sup> VCS. 2012 VCS Standard. Version 3.3, 04 October 2012. Verified Carbon Standard, Washington, D.C.

<sup>3</sup> VCS. 2012 Agriculture, Forestry and Other Land Use (AFOLU) Requirements. Version 3.3, 04 October 2012. Verified Carbon Standard, Washington, D.C.

## 1.3 Project Proponent

The grouped project is implemented by Mikro-Tek in association with the land owners. Roles and responsibilities of the project proponent and supporting entities are elaborated in Tables 1.3 and 1.4 below.

Table 1.3. List of project proponents.

| Roles and Responsibility                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Personnel/Position      | Contact Details                                                                                                  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|------------------------------------------------------------------------------------------------------------------|
| Supply the mycorrhizal inoculum, as well as the associated technologies for their application and management. Project management, implementation, and registration including budgeting, hiring of project personnel and contractors. Implement monitoring and verification plan, including the hiring of monitoring/inventory staff, technical consultants and VCS verifiers, as needed. Ensuring that offsets are registered following verification, investor relations, and marketing. Maintain electronic database of GIS coverages detailing parcel boundaries and plot locations, archive raw field measurements and analysis in hard and electronic copies. | Mark Kean,<br>President | Mikro-Tek Inc.<br>P.O. Box 2120<br>115 Sandy Falls<br>Road, Timmins,<br>Ontario<br>P4N7X8Canada<br>+705 268 3536 |

## 1.4 Other Entities Involved in the Project

Table 1.4. List of other entities involved in the project.

| Roles and Responsibility                                                                                                                                                                                                                                                                                                                                                                                  | Personnel/Position                                                                                                                                       | Contact Details                                                                              |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|
| Ongoing management of the project area. Oversee contracted monitoring and inventory staff in the field. Serve as a liaison and translator for the landowners and Mikro-Tek, including establishing meetings with landowners and relevant stakeholders, arranging site visits, providing information and documentation such as previous studies, photographs, and satellite images related to the project. | Alfredo Unda,<br>Forester, Manager<br>Chile Projects.                                                                                                    | Diego de Almagro,<br>2081, Ste. #64<br>Providencia, Santiago<br>Chile<br>562-899-69931       |
| Develop PDD and design monitoring plan in consultation with Mikro-Tek staff.                                                                                                                                                                                                                                                                                                                              | James Eaton,<br>Senior Manager,<br>Forestry and<br>Technical<br>Services<br><br>David Shoch,<br>Senior Manager,<br>Forestry and<br>Technical<br>Services | TerraCarbon LLC<br>5901 N. Sheridan Rd.<br>Peoria, Illinois 61614<br>U.S.A.<br>+434 326 1144 |
| Owners of project property responsible for managing and conducting all silvicultural and forestry aspects of the project in accordance with the approved CONAF Forestry Plan and the Business Collaboration Agreement with Mikro-Tek, the Project Proponent.                                                                                                                                              | Individual property owners                                                                                                                               | Located in project database in the Business Collaboration Agreement.                         |

## 1.5 Project Start Date

The grouped project has a project start date of June 1, 2003 marking the start of planting of the first project instance by Mikro-Tek.

## 1.6 Project Crediting Period

The Reforesting Degraded Lands in Chile through the use of Mycorrhizal Inoculation project has a crediting period of 40 years. It is set to start June 1, 2003 and continue through May 31, 2043.

## 1.7 Project Scale and Estimated GHG Emission Reductions or Removals

The total amount of emission reductions, including the non-permanence risk buffer, generated over the 40 year crediting period is estimated to reach 674,554 tons of CO<sub>2</sub> (Table 1.5). On average, this will yield 16,864 tCO<sub>2</sub> equivalent (e) emissions reductions per year. The project is not a large project (> 300,000 tons of CO<sub>2</sub> per year).

Table 1.5. Estimated periodic (annual) net emissions reductions (t CO<sub>2</sub>-e) generated by the Reforesting Degraded Lands in Chile through the use of Mycorrhizal Inoculation project over the 40 year crediting period for the initial project instances.

| Year | Annual estimates of net emission reductions (t CO <sub>2</sub> ) |
|------|------------------------------------------------------------------|
| 2003 | 0                                                                |
| 2004 | 2,515                                                            |
| 2005 | 10,247                                                           |
| 2006 | 20,015                                                           |
| 2007 | 30,391                                                           |
| 2008 | 41,851                                                           |
| 2009 | 52,806                                                           |
| 2010 | 58,835                                                           |
| 2011 | 62,476                                                           |
| 2012 | 75,240                                                           |
| 2013 | 82,366                                                           |
| 2014 | 70,521                                                           |
| 2015 | 40,092                                                           |
| 2016 | 23,031                                                           |
| 2017 | 25,229                                                           |
| 2018 | 29,641                                                           |
| 2019 | 33,090                                                           |
| 2020 | 16,208                                                           |
| 2021 | 0                                                                |
| 2022 | 0                                                                |
| 2023 | 0                                                                |
| 2024 | 0                                                                |
| 2025 | 0                                                                |
| 2026 | 0                                                                |
| 2027 | 0                                                                |
| 2028 | 0                                                                |
| 2029 | 0                                                                |

|                                       |         |
|---------------------------------------|---------|
| 2030                                  | 0       |
| 2031                                  | 0       |
| 2032                                  | 0       |
| 2033                                  | 0       |
| 2034                                  | 0       |
| 2035                                  | 0       |
| 2036                                  | 0       |
| 2037                                  | 0       |
| 2038                                  | 0       |
| 2039                                  | 0       |
| 2040                                  | 0       |
| 2041                                  | 0       |
| 2042                                  | 0       |
| 2043                                  | 0       |
| Total net emission reductions (t CO2) | 674,554 |
| Number of crediting years             | 40      |

## 1.8 Description of the Project Activity

The Reforesting Degraded Lands in Chile through the use of Mycorrhizal Inoculation project will achieve GHG removals by planting trees that sequester atmospheric CO<sub>2</sub> in live aboveground biomass, belowground biomass, and soil. The project activity involves site preparation and planting of mycorrhizal inoculated trees.

Mycorrhizae provide a natural, biological means of maintaining plant health, increasing the plant's resistance to soil-borne pathogens, and reducing the need for chemicals and fertilizers. A large body of published scientific literature, and experimental trials, have shown that plants colonized by mycorrhizal fungi are generally larger, healthier and better able to withstand environmental stresses such as cold or heat, transplant shock, moisture excess, and drought. In addition, mycorrhizae improve plant nutrition and therefore play a significant role in high yield crop production thus limiting environmental problems associated with crop production such as soil erosion, soil nutrient depletion and water pollution with fertilizers, use of pesticides and animal wastes.

Mycorrhizal inoculation technology was not commercially available in Chile prior to 1999. In that year, Mikro-Tek undertook a project to isolate local mycorrhizal species and strains and screen for effectiveness for enhanced nutrient uptake and seedling vigor. Vigor was assessed using Mikro-Tek's chlorophyll fluorescence stress test procedures as described in the Ontario Ministry of Natural Resources Forest Research Report<sup>4</sup> No. 145. The most beneficial mycorrhizal strains, selected through this process, were then field tested for effectiveness on the target host tree species. The initial tree species tested (Radiata Pine, Eucalyptus, and Quillay) were identified in consultations with the Chilean forestry organizations, Corporacion Nacional Forestal (CONAF) and Instituto Forestal (INFOR) as well as with forestry companies and small-scale local landowners. A complete technical description, and the three-

<sup>4</sup> Smith W., and Mohammed, G.H. 1997. Inoculation with mycorrhizal fungi (*Hebeloma spp.*) can increase drought stress resistance and improve field performance of jack pine, black spruce and white spruce – Ontario Forest Research Report No. 145. Ontario Ministry of Natural Resources.

year results of field trials in which Mikro-Tek's selected mycorrhizal strains were used, are presented in a report entitled "Demonstration of Increase in Carbon Sink in Chilean Forestry Plantations Using Mycorrhizal Inoculation, Years 1 to 3 – Field Results – Jan 2006".

The project areas are in extremely dry areas that lack natural seed sources. Forest establishment using traditional planting techniques has a high chance of failure due to dry conditions. These conditions will be offset by implementing the above described mycorrhizal inoculation technology through a technology transfer arrangement between Mikro-Tek and the various landowners. By using mycorrhizal inoculated seedlings, the cost of which is funded by Mikro-Tek in exchange for the resulting carbon credits (subject to a revenue sharing arrangement with the landowner), plantation establishment becomes an attractive land use option to landowners. The project promotes reforestation on land that would otherwise remain as degraded grassland.

Production of containerized seedlings is a process that takes place prior to the targeted planting months of June, July and August in an off-site nursery complex. It takes approximately six months to grow the seedlings and during that time, the mycorrhizal inoculum is applied following Mikro-Tek's inoculation procedures.

Sub-soiling is carried out using either a tractor or animals (horses or oxen), depending on the slope of the land. This involves the drawing of a single plow blade through the soil, to loosen a section 15 cm wide by 30 cm deep, following the general contour of the site. On relatively flat land, the sub-soil contour ditches are spaced approximately 4 meters apart, and on steeper slopes where animals are used, they are spaced approximately 3 meters apart. The mycorrhizal inoculated seedlings are then planted along the sub-soiling ditches at spacing intervals ranging from 2 meters to 2.7 meters in order to obtain an overall targeted planting density of 1,250 trees per hectare.

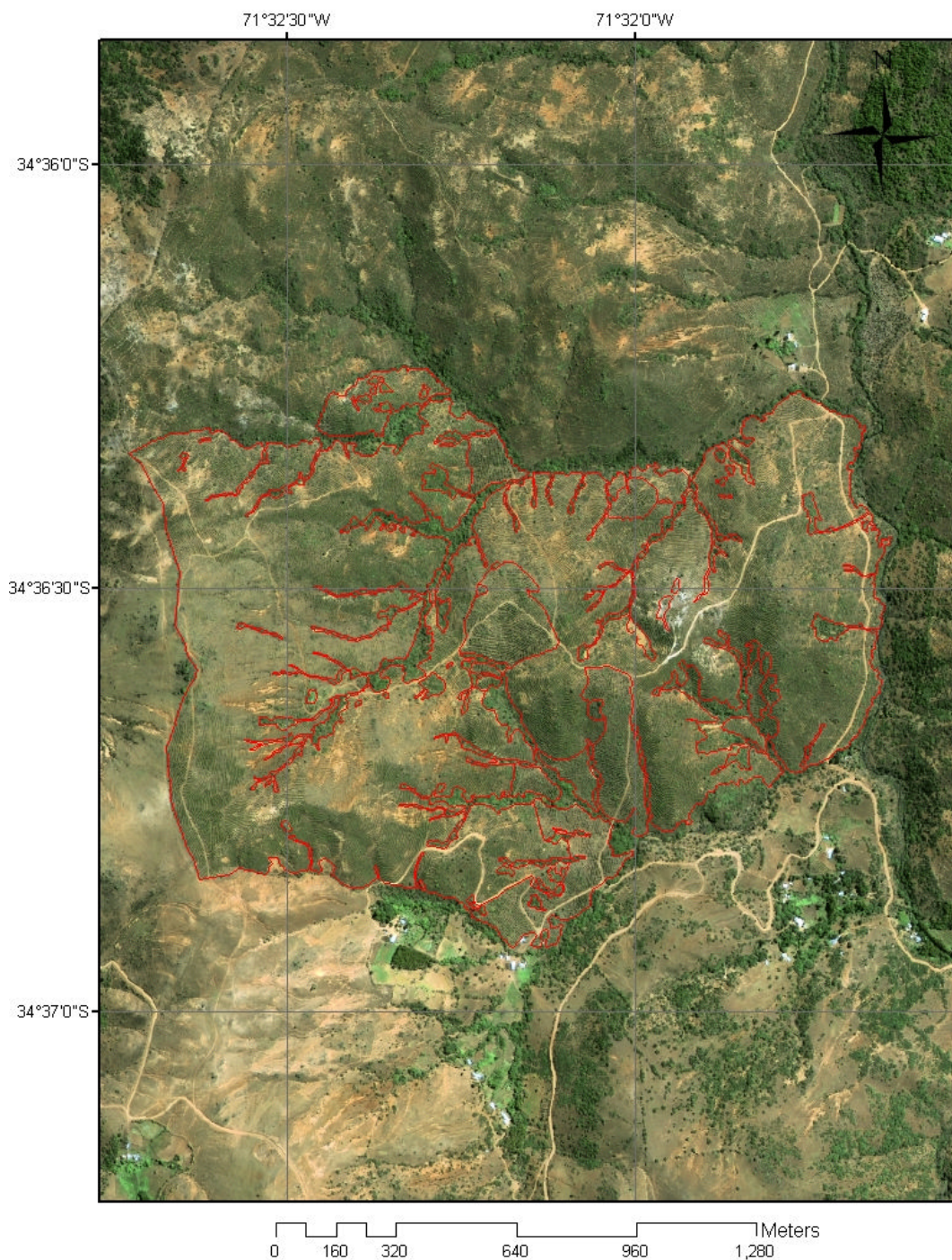
For *Pinus radiata*, harvesting is expected to occur at year 20 followed by complete replanting using the same species and the original planting density of 1,250 trees per hectare. *Eucalyptus globulus* is harvested around year 10, and reestablished either through coppicing or replanting at the original planting density of 1,250 trees per hectare.

While the crediting period of this project is 40 years, the project area will be continually managed as forest land in conformance with the CONAF requirement that reforestation is mandatory after harvest.

## 1.9 Project Location

The initial project instances, as listed in Table 1.1, are located in Region VI, VII, and VIII in the communes of Lolol, Estrella, Vichuquen, Pumanque, Quilleco, Hualane, and Chepica. The project boundaries for the sites MikroTek0026 and MikroTek0032 can be found in Figure 1.2. Detailed project instance boundaries for all sites will be archived as GIS files located in the project database.

Figure 1.2. Map of detailed project instance boundaries.



The entire grouped project area will be located within Region RM, V, VI, VII, and VIII. An overview of the geographic boundary of the grouped project can be found in Figure 1.6 below. All additional project instances will be located within this geographic boundary.

## 1.10 Conditions Prior to Project Initiation

### 1.10.1 Historical conditions in the project region

The climate in the planted areas is typical of the “Depresión Intermedia”, Chile’s central valley. It is predominantly a warm temperate Mediterranean-type climate (Csb) with winter rains typically about 450 mm per year. Mean annual temperature is 12.8° C<sup>5</sup>. The soils<sup>6</sup> in the project region have been classified as Alfisoles and Inceptisoles by the FAO. The planted areas were dry grasslands that were under intensive agriculture in the early 1900s followed by intermittent grazing until the 1990s. An excerpt from Prado and Weber<sup>7</sup> summarizes the land use history in the region.

By the middle of the 17th Century there was a considerable increase in wheat production, both for domestic consumption and for export to Peru. In the 19th Century, the gold rushes in California and New South Wales, Australia, generated a huge increase in wheat production, achieved at the expense of clearing vast extensions of land in the Coastal cordillera of Regions VI to VIII which were covered by dense forests with predominance of *Nothofagus* species. Hundreds of thousands of hectares of forests were devastated in order to sow wheat, without considering that in most cases the soils were not fit for agriculture. This led to a rapid loss of productivity and to degradation, as a result of which further lands were cleared. Another important factor in the loss of natural forests was the colonization of the present Araucanía and Los Lagos Regions, which began in the middle of the 19th Century. The settlers, mainly Germans, cleared lands for agriculture and pasture lands in areas covered by dense temperate rainforests. As a result of these deforestation processes, by the year 1900, practically 50% of the forests in central Chile had disappeared, giving way to agricultural and grazing activities.

### 1.10.2 Conditions on project area prior to planting

The project area is situated in an extremely dry area with degraded soils (Figure 1.3). Rolling hills with intermittent erosion gullies characterize the landscape. The project region is classified as degraded using the CDM tool<sup>8</sup> for the identification of degraded lands. Project instances qualify as degraded under Stage 2a and III(c.ii), of the CDM tool due to the clear “reduction in plant cover or productivity due to overgrazing or other land management practices”. As the project instance baseline is grassland, there is a clear “reduction in plant cover” due to “land management practices”, as the native vegetation prior to human land management practices was Chilean Matorral including Sclerophyll forests.

<sup>5</sup>Average yearly temperatures for weather stations within the project region for the latest period for which data is available, May 2007 through April 2008. From: ANUARIO AGROMETEOROLOGICO REGIONES IV, V, METROPOLITANA, VI Y VII. DIRECTOR RESPONSABLE: ALEJANDRO MUÑOZ M. DIRECCION METEOROLOGICA DE CHILE. CASILLA 140, SUCURSAL MATUCANA, ESTACION CENTRAL. FONO 4364501 Accessed at: [http://www.meteochile.gob.cl/agrometeorologia/documentos/Anuario\\_Agro\\_%202007-2008%28Agrometeorologia%29.pdf](http://www.meteochile.gob.cl/agrometeorologia/documentos/Anuario_Agro_%202007-2008%28Agrometeorologia%29.pdf)

<sup>6</sup>FAO. 2006e. Chile – Suelos. [http://www.rlc.fao.org/proyecto/gcp/rla/126/jpn/ciren/chi\\_soils.htm](http://www.rlc.fao.org/proyecto/gcp/rla/126/jpn/ciren/chi_soils.htm) Accessed 1 April 2006.

<sup>7</sup>Prado, JA, and Weber C. 2003. Facilitating the Way for Implementation of Sustainable Forest Management. The Case of Chile. Instituto Forestal (INFOR), Corporación Nacional Forestal (CONAF), Santiago, Chile.

<sup>8</sup>CDM Executive Board. 2008. Tool for the identification of degraded or degrading lands for consideration in implementing CDM A/R project activities - Version 01. UNFCCC, Bonn, Germany.

While some woody vegetation does occur in the region, it is present in very low stem densities and most often restricted to steeper slopes and ravines. Further, the project area has been delineated to exclude area with significant woody vegetation. Given the dry climate and the fact that native seed sources are generally lacking across the landscape, natural regeneration is extremely limited.

Due to the low rainfall in the region, much of the existing land use is abandoned pasture.

Figure 1.3. Photograph at the Los Laureles site (MikroTek0011) after two years.



### 1.10.3 Eligibility

Eligibility as an ARR project was determined with reference to the VCS AFOLU Requirements guidance<sup>9</sup>. Project implementation did not lead to the conversion of any native ecosystems (within the 10 years prior to planting) and does not lead to the violation of any law. Further, no project activities drained native ecosystems or degraded hydrological functions to generate GHG credits. As all project sites have received CONAF subsidies, CONAF has reviewed and approved the forestry plan for all project areas. Part of CONAF's review was to ensure that the land is suitable<sup>10</sup> for forestry (i.e. it is not currently forested), including limiting the planted areas to areas without native forest cover.

These eligibility criteria were assessed for each project instance when CONAF ensured the proposed planting location meets the requirements of the Forestry Law 701 (see Section 1.11).

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<sup>9</sup> VCS. 2012 Agriculture, Forestry and Other Land Use (AFOLU) Requirements. Version 3.3, 04 October 2012. Verified Carbon Standard, Washington, D.C.

<sup>10</sup> Morales, E. 2003. Changing Ownership and Management of State Forest Plantations: Chile. International Institute for Environment and Development (IIED), p14.

## 1.11 Compliance with Laws, Statutes and Other Regulatory Frameworks

The project proponent has, to the best of their knowledge, complied with all relevant local and national laws in the course of project implementation.

The most important laws of note are those pertaining to Chilean forestry practices. Chilean Law No.: 701, created in 1974, which expired in 1994, preserved existing forests and subsidized the conversion of non-forest land to forests specifically on lands that had a preferential aptitude towards forests or had degraded soils with the exception of lands that are used for intensive agriculture, orchards or ranching. In 1998 Law No.: 19.561 replaced<sup>11</sup> Law No. 701 but continued the preservation of existing forests and subsidized plantation development on lands with degraded and fragile soils and steep slopes.

Under Forestry Law 701, landowners can establish forestry projects on their marginal agricultural and grazing land. To encourage forestation, under this law, the government loans<sup>12</sup> 75% of the costs of forest establishment to large landholders (i.e., someone with >200 ha who has the professional capacity to manage and optimize production but works elsewhere), and 90% to small landholders (i.e., a poor farmer who lives from, and on, his land). Government subsidies are paid on successful establishment of sites, as per approved CONAF forestry plan, and have to be paid back at first harvest. There is a new portion of the law, which provides additional funds for recovering badly eroded land, but there is little experience with it to date. Currently there are 800,000 to 1,000,000 ha in Region VIII alone in various levels of erosion that would qualify under this initiative. Hans Grosse Werner, Director of INFOR, VIII Región, Concepción, commented that most of the land in Chile suited to forestry is now planted, so for the most part only marginal land is available, which makes increased survival and growth as a result of mycorrhizal inoculation even more important.

Relevant portions of Forestry Law 701, including those related to permanence, are translated below; however the full text is available online<sup>13</sup>.

Article 32. Harvesting or exploitation of native forests on any type of sites or PLANTATIONS located in sites of mainly forest suitability, with the exception of short intermediate cuttings activities, oblige the owner of the respective lands to reforest sites at least of the same size of the harvested or cut sites following the conditions referred to in the management plan approved or registered by the Corporation, as appropriate.

When harvesting subsidized plantations, located on land that is not mainly suitable for forest, with the exception of those established on soils referred in the letter e) of article 4 °, the obligation to reforest will be valid until the soil has recovered from degradation, situation that will be credited in the respective management plan.

<sup>11</sup> While No.: 19.561 replaced Law No. 701, it is still referred to as Forestry Law 701 in most documents.

<sup>12</sup> For more about the CONAF subsidy, please visit [http://www.conaf.cl/cms/editorweb/normativa/tabla\\_costos2009-2010.pdf](http://www.conaf.cl/cms/editorweb/normativa/tabla_costos2009-2010.pdf), accessed October 17, 2012.

<sup>13</sup> Forestry Law 701 - <http://www.conaf.cl/cms/editorweb/normativa/DL-701.pdf>, accessed October 17, 2012.

Article 33. When the reforestation is carried out in a field other than the one where the harvesting or intervention was carried out, this must be done on land suitable for forests that it is without trees or shrub species or that remaining covered by such vegetation it is not likely to be managed to form a tree or shrub mass for purposes of preservation, protection and production. The area where the reforestation is carried out must be located preferably within the province where the harvesting is carried out.

The obligation to reforest may be replaced by recovery for agricultural purposes in the harvested site, only when the change of land use is not at the expense of the soil quality and be credited in the management plan that the area to be intervened satisfies these objectives, specifically pointing the term and the farming activities to be performed. For these purposes are not considered farm activities the plantations established with forest species.

All project lands have received the aforementioned CONAF subsidy, have had their forest management plans approved by CONAF and are in compliance with the Chilean Forestry Law 701.

## 1.12 Ownership and Other Programs

### 1.12.1 Right of Use

The project area of each project instance is under clear title as outlined in the Business Collaboration Agreement, and land ownership documentation has been check by CONAF as a prerequisite<sup>14</sup> for the CONAF subsidy. Mikro-Tek has reserved the rights to forest carbon in the project area through a Business Collaboration Agreement between Mikro-Tek and the landowners<sup>15</sup>. Relevant language demonstrating the transfer of carbon rights from the land owner to Mikro-Tek as found in each Business Collaboration Agreement includes:

The land owners agree to "To transfer the rights to all Emission Reductions to be generated by the Project to Mikro-Tek" and

Mikro-Tek and the landowners agree that "Mikro-Tek shall have full title to the Emissions Reductions generated by the Project and the exclusive right to sell all or part of these Emission Reductions".

Further, the Business Collaboration Agreement sets forth the terms of the revenue sharing agreement between the land owner and Mikro-Tek.

As a compensation for the joint business activity set forth herein, Mikro-Tek and the [land owner] agree to equally share (50/50%) the Net Proceeds effectively received through the sale of Emissions Reductions generated by the Project.

A copy of the Business Collaboration Agreement and the site map from the CONAF approved forestry plans for each project property is contained in the project database.

### 1.12.2 Emissions Trading Programs and Other Binding Limits

No emission reductions generated by the project are part of an emissions trading program.

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<sup>14</sup> Morales, E. 2003. Changing Ownership and Management of State Forest Plantations: Chile. International Institute for Environment and Development (IIED), p14.

<sup>15</sup> The owners of each project instance are identified in Table 1.1.

### **1.12.3 Participation under Other GHG Programs**

Project Instances MikroTek0041 and MikroTek0048 has been registered under the CDM, however no emission reductions (tCERs or ICERs) have been issued or will be applied for. No other project lands have been registered, nor is registration under any other GHG program being sought.

### **1.12.4 Other Forms of Environmental Credit**

The project has not created wetland mitigation, water quality, air pollution, other non-VCS GHG emission reduction, or any another form of environmental credit.

### **1.12.5 Projects Rejected by Other GHG Programs**

The project has not been rejected from any other greenhouse gas program.

## **1.13 Additional Information Relevant to the Project**

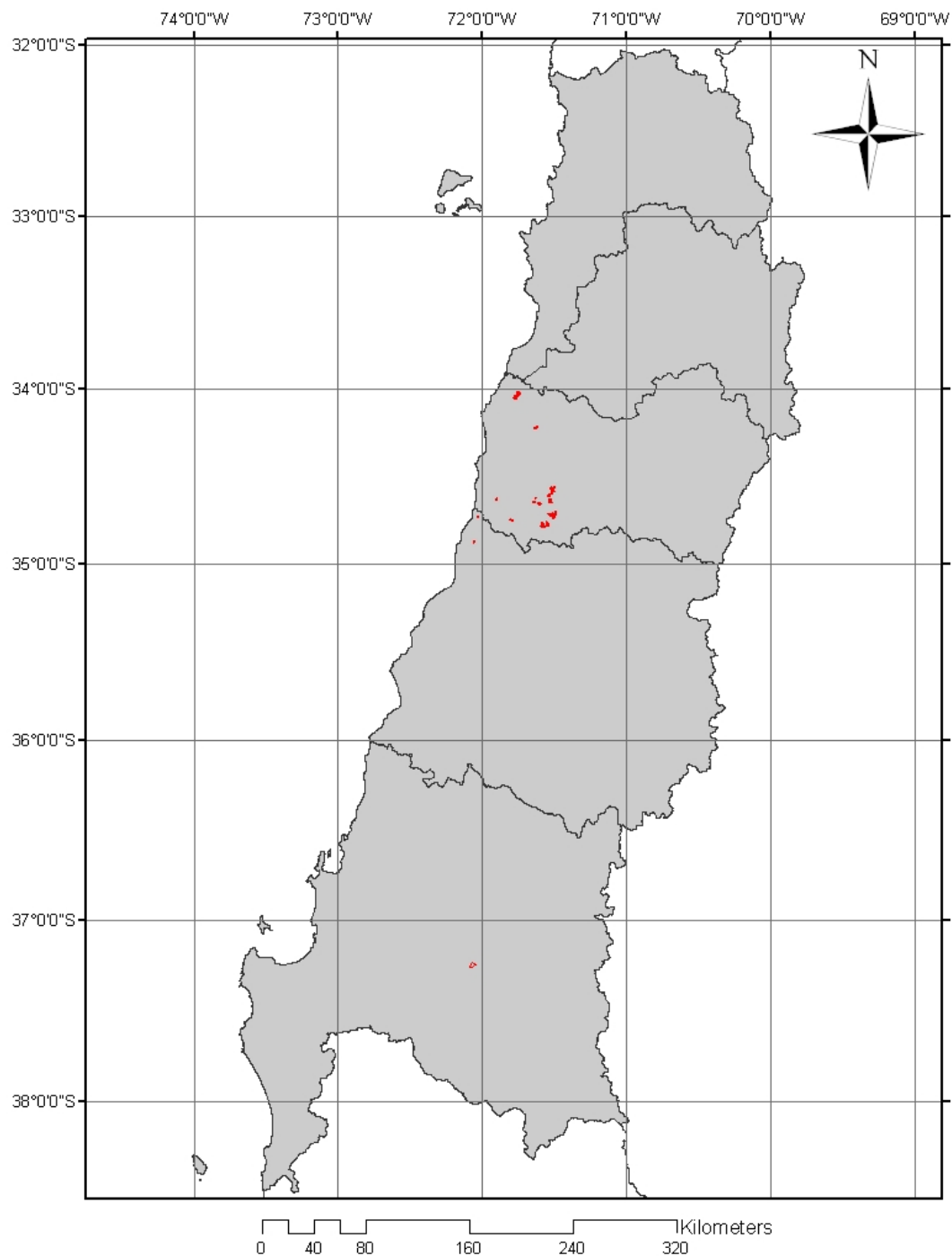
### **1.13.1 Eligibility Criteria for Grouped Project**

The following conditions will be met to demonstrate additional project instances, added to the project after project validation, are eligible for inclusion in this VCS ARR project.

#### 1.13.1.1 Geographic Boundary

All project instances will be located on degraded lands within the geographic boundary of the following Chilean Regions RM, V, VI, VII, and VIII, as displayed in Figure 1.6.

Figure 1.6. Grouped project geographic region (in gray) and current project instances (in red).



### 1.13.1.2 Eligibility requirements and applicability conditions

Grouped projects provide for the inclusion of new project instances subsequent to the initial validation of the project.

New project instances will demonstrate compliance with the following criteria.

1) Compliance with all eligibility requirements from the VCS AFOLU Requirements document version 3.3, applicability conditions of methodology AR-ACM0003 version 1.0, and conditions permitting accounting for soil carbon using the CDM “Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities”:

- The grouped project instance area was not cleared of native ecosystems within the 10 year period prior to the project start date.
- The grouped project instance area was not forested at the time of planting.
- Implementation of the grouped project instance activity does not violate any law.
- Clear title and rights to carbon are demonstrated for each grouped project instance.
- In order to participate in the CONAF (Corporacion Nacional Forestal) subsidized forestry program, each grouped project instance has the title and forestry plan approved by CONAF. This approval process ensures that in part that project lands will be replanted after harvest and thus project lands will be maintained as forest into the future.
- The grouped project instance activity is implemented on degraded lands, which are expected to remain degraded or to continue to degrade in the absence of the project; hence the land cannot be expected to revert to a non-degraded state without human intervention. Degraded status will be demonstrated by applying the CDM tool<sup>16</sup> for the identification of degraded lands.
- The grouped project instance activity involves machine or hand planting, with or without site preparation. Encroachment of natural tree vegetation that leads to the establishment of forests is not expected to occur.
- No project instances will use flooding irrigation as part of the project activity.
- The grouped project instance is not located on organic soils.
- No project instances will lead to a decrease in the availability of fuelwood.
- The grouped project instance does not fall into the wetland category, as defined by the IPCC<sup>17</sup>.
- Organic litter from vegetation will remain on site and will not be removed.
- Any site preparation involving ploughing/ripping/scarification, implemented as part of the grouped project instance activity, will:

<sup>16</sup>CDM Executive Board. 2008. Tool for the identification of degraded or degrading lands for consideration in implementing CDM A/R project activities - Version 01. UNFCCC, Bonn, Germany.

<sup>17</sup> The IPCC describes a wetland as “land that is covered or saturated by water for all or part of the year (e.g., peatland) and that does not fall into the forest land, cropland, grassland or settlements categories.” IPCC 2003. Good Practice Guidance for Land Use, Land-Use Change and Forestry (GPG-LULUCF).

- a. Be done in accordance with appropriate soil conservation practices (e.g., follows the land contour);
- b. Be limited to the first five years from the year of initial site preparation;
- c. Not be repeated, if at all, within a period of 20 years; and
- d. Not cover more than 10 per cent of area in each of the following types of land:
  - i. Land containing organic soils; and
  - ii. Land which, in the baseline, is subjected to land-use and management practices and receives inputs as listed in appendices 1 and 2 of AR-ACM0003 methodology.

2) Use mycorrhizal inoculated seedlings for planting with specific mycorrhizal inoculum supplied by Mikro-Tek and applied as per their directions.

3) The pre-existing land use of the grouped project instance area is either pasture/grassland, cultivation, or abandoned nonforest lands which have previously been in agriculture.

4) Face investment and/or technological barriers to reforestation, demonstrated through a barriers analysis.<sup>18</sup>

5) If new project instances are added which use biomass burning during the course of site preparation or as a forest management activity, emissions from biomass burning will be accounted for appropriately using the CDM Tool “Estimation of non-CO2 greenhouse gas (GHG) emissions resulting from burning of biomass attributable to an A/R CDM project activity”.

### 1.13.1.3 GHG Information Tracking System

Each new grouped project instance will be given a unique identifier and incorporated into the overall project accounting tracking system. The project maintains an electronic database of GIS coverages detailing parcel boundaries and monitoring plot locations (once established), and maps archived in both digital and hard copy form. Original field monitoring data sheets, GIS data layers, reports of analyses and supporting spreadsheets will be stored in both hard copy and digital form at the Mikro-Tek Office in Timmins, Ontario for at least 2 years beyond the project crediting period. Given the extended timeframe and the pace of production of updated versions of software and new hardware for storing data, electronic files will be updated periodically or converted to a format accessible to future software applications. Adherence to these procedures will ensure smooth transitions and maintain “institutional memory” in the event of changes in personnel responsible for the monitoring plan.

### **1.13.2 Leakage Management**

There is no leakage attributable to the project activity since there is no displacement of agricultural production or displacement of households from within the project boundary.

### **1.13.3 Commercially Sensitive Information**

No commercially sensitive information has been excluded from this project description.

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<sup>18</sup> Approved CDM “Combined tool to identify the baseline scenario and demonstrate the additionality in A/R CDM project activities, Version 1”.

### **1.13.4 Further Information**

Not applicable.

## 2.0 APPLICATION OF METHODOLOGY

### 2.1 Title and Reference of Methodology

This project uses approved Clean Development Mechanism (CDM) afforestation/reforestation methodology AR-ACM0003 “Afforestation and reforestation of lands except wetlands” - Version 1.0, together with the following tools:

- Approved CDM “Combined tool to identify the baseline scenario and demonstrate the additionality in A/R CDM project activities, Version 1”;
- Approved CDM tool “Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities in A/R CDM project activity”;
- Approved CDM tool “Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities”; Version 3.0
- Approved CDM tool “Demonstrating appropriateness of allometric equations for estimation of aboveground tree biomass in A/R CDM project activities and”;
- Approved CDM “Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities”, Version 01.1.0.

The following tool was also used:

- Approved CDM “Tool for the identification of degraded or degrading lands for consideration in implementing CDM A/R project activities”, Version 1.

### 2.2 Applicability of Methodology

The grouped project instances meet the applicability conditions of methodology AR-ACM0003 as demonstrated in Table 2.1 below.

Table 2.1. Applicability conditions for CDM AR-ACM0003 methodology.

|                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                            |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| The land subject to the project activity does not fall in wetland <sup>19</sup> category;                                                                                                                                                                | The project instance area is not considered to be a wetland as defined by the Intergovernmental Panel on Climate Change. The project instance area prior to reforestation was used for agriculture and thus is not considered to be a wetland, as per the IPCC definition. |
| Soil disturbance attributable to the afforestation and reforestation (A/R) clean development mechanism (CDM) project activity does not cover more than 10 per cent of area in each of the following types of land:<br>(i) Land containing organic soils; | Sub-soiling results in an area of disturbance less than 15 cm wide and is done every 3 to 4 meters, resulting in a disturbance of 5% (or less) of the soil surface.<br><br>The project area does not include any organic soils (see Figure 3.1). Further, a local forester |

<sup>19</sup> The IPCC describes a wetland as “land that is covered or saturated by water for all or part of the year (e.g., peatland) and that does not fall into the forest land, cropland, grassland or settlements categories.”

|                                                                                                                                                                    |                                                                                                                                                    |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|
| (ii) Land which, in the baseline, is subjected to land-use and management practices and receives inputs as listed in appendices 1 and 2 of AR-ACM0003 methodology. | familiar with all of Mikro-Tek's planted sites has confirmed that "there are no organic soils present in the project area" (I. Fazzi, pers. comm). |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|

## 2.3 Project Boundary

Identification of GHG sources and sinks follows methodology AR-ACM0003 Version 1.0 and relevant VCS guidance. Selection of terrestrial carbon pools and GHG sources for inclusion in the project boundary is summarized in Table 2.2 below. None of these pools is expected to be a source of emissions in the with-project case.

Table 2.2. GHG sources and sinks for inclusion in the project boundary.

| Table 2.2: GHG sources and sinks for inclusion in the project boundary. |                          |                 |           |                                                                                                                                                                                                                                                                                                                                    |
|-------------------------------------------------------------------------|--------------------------|-----------------|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Source                                                                  |                          | Gas             | Included? | Justification/Explanation                                                                                                                                                                                                                                                                                                          |
| Baseline                                                                | Above-ground biomass     | CO <sub>2</sub> | No        | The project area was delineated in such a way as to exclude existing baseline tree biomass. Baseline shrub biomass was demonstrated to compose less than 5% of crown cover and is thus negligible as per the CDM tool “Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities”. |
|                                                                         | Below-ground biomass     | CO <sub>2</sub> | No        | The project area was delineated in such a way as to exclude existing baseline tree biomass. Baseline shrub biomass was demonstrated to compose less than 5% of crown cover and is thus negligible as per the CDM tool “Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities”. |
|                                                                         | Dead-wood                | CO <sub>2</sub> | No        | Assumed to be equal to zero for the life of the project.                                                                                                                                                                                                                                                                           |
|                                                                         | Litter                   | CO <sub>2</sub> | No        | Assumed to be equal to zero for the life of the project.                                                                                                                                                                                                                                                                           |
|                                                                         | Soil organic carbon      | CO <sub>2</sub> | No        | Assumed to be equal to zero for the life of the project. Soil organic carbon stocks are expected to remain at a steady state or decrease in the baseline scenario.                                                                                                                                                                 |
|                                                                         | Burning of woody biomass | CO <sub>2</sub> | No        | GHG emissions in the baseline can be conservatively ignored.                                                                                                                                                                                                                                                                       |
|                                                                         |                          | CH <sub>4</sub> | No        |                                                                                                                                                                                                                                                                                                                                    |
| N <sub>2</sub> O                                                        |                          | No              |           |                                                                                                                                                                                                                                                                                                                                    |
| Project                                                                 | Above-ground biomass     | CO <sub>2</sub> | Yes       | Required. Largest pool affected by project activity.                                                                                                                                                                                                                                                                               |
|                                                                         | Below-ground biomass     | CO <sub>2</sub> | Yes       | Required. Expected to increase due to project activity.                                                                                                                                                                                                                                                                            |
|                                                                         | Dead-wood                | CO <sub>2</sub> | No        | This pool is not expected to decrease, or increase less, due to the project activity.                                                                                                                                                                                                                                              |
|                                                                         | Litter                   | CO <sub>2</sub> | No        | This pool is not expected to decrease, or increase less, due to the project activity.                                                                                                                                                                                                                                              |

|                          |                  |     |                                                                                                                                                                                                                                                                             |
|--------------------------|------------------|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Soil organic carbon      | CO <sub>2</sub>  | Yes | This pool is included and expected to increase due to project activity. Numerous studies have demonstrated that comparable reforestation activities lead to increased soil organic matter, and thus this pool should not be a source of emissions in the with-project case. |
| Burning of woody biomass | CO <sub>2</sub>  | No  | No burning was involved as part of project implementation. Hence, in conformance with the methodology, no emission sources are included in the project boundary.                                                                                                            |
|                          | CH <sub>4</sub>  | No  |                                                                                                                                                                                                                                                                             |
|                          | N <sub>2</sub> O | No  |                                                                                                                                                                                                                                                                             |

As per the methodology AR-ACM0003 Version 1.0,

“GHG emissions resulting from removal of herbaceous vegetation, combustion of fossil fuel, fertilizer application, use of wood, decomposition of litter and fine roots of N-fixing trees, construction of access roads within the project boundary, and transportation attributable to the project activity shall be considered insignificant and therefore accounted as zero.”

Further, as per VCS AFOLU Requirements, version 3.3:

“Further, the following GHG sources may be deemed de minimis and need not be accounted for:

- 1) ARR, IFM and REDD: N<sub>2</sub>O emissions from project activities that apply nitrogen containing soil amendments and N<sub>2</sub>O emissions caused by microbial decomposition of plant materials that fix nitrogen. ALM projects that apply nitrogen fertilizer and/or manure or plant nitrogen fixing species shall account for N<sub>2</sub>O emissions.
- 2) ARR, IFM, REDD, ACoGS and WRC: GHG emissions from the removal or burning of herbaceous vegetation and collection of non-renewable wood sources for fencing of the project area.
- 3) ARR, IFM, REDD, ACoGS and WRC: Fossil fuel combustion from transport and machinery use in project activities. Where machinery use for selective harvesting activities may be significant in IFM project activities as compared to the baseline or where machinery use for earth moving activities may be significant in WRC project activities as compared to the baseline, emissions shall be accounted for if above de minimis, in accordance with this Section 4.3.3. Fossil fuel combustion from transport and machinery use in rewetting of drained peatland and conservation of peatland project activities need not be accounted for.”

The only emission source that must be included in the project boundary is methane and nitrous oxide emissions resulting from burning of woody biomass (excluding herbaceous biomass). No burning was involved as part of project implementation. Hence, in conformance with the methodology, no emission sources are included in the project boundary.

Site preparation prior to planting involved sub-soiling, running a plow set on 3 meter or 4 meter spacing to break the compacted subsurface soil layer. While soil disturbance was minimal, some small amount of emissions from the soil organic carbon pool is likely to have resulted from ripping/sub-soiling. However, any emissions should be quickly recovered by accumulation of new soil organic matter from forest growth and thus there should be no long-term emissions associated with site preparation activities. A meta-

analysis of 43 studies worldwide found no difference in change in soil carbon post-afforestation between high/medium disturbance (e.g., mounding, ripping, disking) and low/no disturbance site preparation. While afforestation tends to result in short term net emissions of soil carbon, attributed by the authors to low organic matter inputs during the early stages of stand development, rather than emissions resulting from site preparation or planting practices, short-term losses are regained on afforested sites<sup>20</sup>. No long-term emissions are expected from the soil carbon pool in the with-project case; substantiated by meta-analyses of numerous land-use change studies (IPCC 2006GL, Guo and Gifford 2002). Furthermore, the project applies the CDM “Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities”, which applies a soil carbon loss value of zero for sites with more than 10% of the area subject to ploughing/ripping/scarification (Step 3); the project instance area was ripped with a chisel plow, producing a 15 cm wide rip on a 3 meter or 4 meter spacing, resulting in <10% of the surface disturbed.

## 2.4 Baseline Scenario

The CDM “Combined tool to identify the baseline scenario and demonstrate the additionality in A/R CDM project activities” is applied to identify the baseline scenario and assess additionality. The project meets the applicability conditions: the project activity does not lead to violation of any applicable law and the project follows a large-scale CDM A/R methodology.

### STEP 0: Preliminary screening based on the starting date of the project activity

The project started on June 1, 2003, thus meeting requirement of a start date for the reforestation activity after 31 December 1999.

Further, the incentive from the planned sale of GHG allowances was considered in the decision to proceed with this project as outlined in the document entitled “Carbon Sequestration through Mycorrhizal Inoculation of Afforestation and Reforestation Projects in Chile Small and Medium-Scale Projects” – Mikro-Tek’s Draft Concept Outline - November 2002”. Further, it is clear in the Business Collaboration Agreement between Mikro-Tek and each land owner, that the reforestation project would not have taken place without the transfer of carbon rights to Mikro-Tek

### STEP 1: Identification of alternatives to the project activity consistent with current laws and regulations

Table 2.3 uses data derived from the Chilean National Institute of Statistics (INE<sup>21</sup>) for Region V, VI, VII, and VIII, and RM indicates the relative abundance of each land use class in the project region.

Table 2.3. Land uses as a percentage of the project region.

| Land Uses        | Percent of Total Land Use |
|------------------|---------------------------|
| Cultivated Soils | 16.1                      |
| Improved Pasture | 2.8                       |

<sup>20</sup> Paul KI, Polglase PJ, Nyakuengama JG, Khanna PK. 2002. Change in soil carbon following afforestation. *Forest Ecology and Management* 168:241-257.

<sup>21</sup> Instituto Nacional de Estadísticas (INE). 2007. Censo Agropecuario 2007.

[http://www.ine.cl/canales/chile\\_estadistico/censos\\_agropecuarios/censo\\_agropecuario\\_07\\_comunas.php](http://www.ine.cl/canales/chile_estadistico/censos_agropecuarios/censo_agropecuario_07_comunas.php)  
Accessed: 17 July 2012

|                   |      |
|-------------------|------|
| Natural Pasture   | 28.5 |
| Forest Plantation | 6.5  |
| Natural Forests   | 14.1 |
| Mattoral          | 12.7 |
| Infrastructure    | 1.6  |
| Barren Land       | 17.7 |

Sub-step 1a: Identify credible alternative land use scenarios to the proposed CDM project activity

1. Continuation of the pre-project land use – abandoned (i.e., natural) pasture;
2. Productive agricultural land, including cropland and managed (i.e., improved) pasture; and
3. Reforestation without incentives from carbon credits.

None of the above identified land use scenarios are mandated by law. Section 1.11 provides an overview of the pertinent laws affecting forestry (and land use) in the region. The three scenarios identified above represent credible and realistic land use conversions from abandoned pasture (i.e., natural pasture). Other land use conversions from natural pasture are unlikely. Conversion from abandoned/natural pasture to infrastructure is highly unlikely given the remoteness of the project areas and the steepness of the terrain. Barren land (sandy, rocky, “sterile” land) is unsuitable for plants and trees.

Sub-step 1b: Consistency of credible alternative land use scenarios with enforced mandatory applicable laws and regulations

None of the above identified land use scenarios are illegal, and hence all are considered here as plausible alternatives for consideration. Section 1.11 provides an overview of the pertinent laws affecting forestry (and land use) in the region.

## 2.5 Additionality

Additionality is demonstrated for the grouped project instances through the use of the approved CDM “Combined tool to identify the baseline scenario and demonstrate the additionality in A/R CDM project activities” as cited in the CDM methodology AR-ACM0003.

Following the identification of the alternative land use scenarios (above in Section 2.4) a barriers analysis was performed. Step 2 of the tool identifies several barriers preventing the alternative land use scenarios. Finally, it is demonstrated that reforestation in the project region is not common practice (Step 4) and would not have occurred on these privately owned lands without carbon finance funding the mycorrhizal inoculation and thus overcoming a technological barrier (and related investment barrier).

### STEP 2: Barrier analysis

Sub-step 2a: Identification of barriers that would prevent the implementation of at least one alternative land use scenario

The following barriers, from the approved CDM “Combined tool to identify the baseline scenario and demonstrate the additionality in A/R CDM project activities” are relevant to the project activity:

1. Technological barriers;
2. Barriers due to local ecological conditions; and
3. Investment barrier.

Related to reforestation, these barriers are inter-related - constraining ecological conditions can only be surmounted by the application of new technology and practices to improve productivity to a level to incentivize investment in reforestation by small property holders. At the root is the technological barrier, which, on application, eliminates, or mitigates, the constraining ecological conditions barrier.

Sub-step 2b: Elimination of land use scenarios that are prevented by the identified barriers.

#### **Continuation of the pre-project land use- abandoned pasture**

The only plausible alternative land use scenario which does not face a barrier is the pre-project land-use of abandoned pasture. Therefore without the aid of carbon finance the most likely land use for the project area is continuation of the pre-project land use.

#### **Productive agricultural land, including cropland and managed pasture**

Conversion of the project area to productive agricultural land, including cropland and managed pasture, faces two barriers including local ecological conditions and investment. The local ecological conditions, including degraded soils and the dry climate, present a significant risk of failure to these activities, resulting in a strong barrier to all forms of productive agriculture, as it does for reforestation. Conversion to productive agriculture consequently faces a significant investment barrier for landowners, such that initiation of these activities in the project region is the exception rather than the norm.

#### **Reforestation**

At the start of this reforestation project in 2003, Sanhueza et al.<sup>22</sup> stated that:

Barriers for the implementation of CDM projects exist above all for the forestation of small farms. Farmers usually have a low level of education and a strong agricultural tradition. They use traditional production techniques and have poor technical and commercial knowledge and little access to state-sponsored training systems. The small farmer is generally located in dry lands and mountain slopes, which have serious restrictions for the traditional agricultural crops of the region...small farmers hardly benefited from state incentives in the past. As a consequence, in 1998 Chilean legislation (DL 701) was modified in order to provide a preferential treatment for small farmers. Nevertheless, in practice this appears insufficiently attractive, since forestation rates of small farms are still quite low.

Reforestation of the project area faces ecological and technological barriers, as noted above. The local ecological conditions (degraded soils, no natural seed sources, and dry climate) create a strong barrier to reforestation, including natural regeneration and establishment of commercial plantations using standard planting techniques. The local ecological conditions are overcome in the project through the use of an

<sup>22</sup> See section 6.5 of Sanhueza et al. 2003. National Strategy Study for the CDM in Chile, GTZ.

improved technology (i.e., mycorrhizal inoculation), which permits successful plantation establishment on sites that would otherwise not be sufficiently productive to incentivize reforestation efforts by landowners.

Even where some subsidies have been made available for reforestation (see review of Forestry Law 701 in Section 1.11), this has not led to significant adoption of this activity by landowners in the project region due to the aforementioned ecological barriers and high risk of failure (and consequent risk of cost recovery as subsidies are paid one year after successful plantings). In a Chilean study for the CDM, Sanhueza et al.<sup>23</sup> states that in respect to reforestation of deteriorated soils “the simple existence of current forestry incentives is not a sufficient stimulus for landowners to reforest these terrains.” Significant plantation establishment activities in Chile have typically been carried out as industry scale activities, with most of these plantations in regions further south in Chile where higher rainfall lends to conditions more conducive to forest production.

The present analysis of barriers is also supported by a September 21, 2007 communication of the Government of Chile<sup>24</sup> to the Subsidiary Body for Scientific and Technology Advice entitled, “Views on the implications of possible changes to the limit established for small-scale afforestation and reforestation clean development mechanism project activities under decision 6/CMP.1” (p. 3):

Chile has a long tradition in afforestation and reforestation activities that has led to a surface of more than 2 million hectares afforested with planted forests in 2006. Nevertheless, more than 90% of the planted area is owned by big forest enterprises or large land owners. The Chilean government has made efforts to foster the incorporation of small land owners in afforestation activities, but there are several barriers that hinder the participation of small land owners in these activities.

There have been several attempts in order to formulate AR-CDM project activities involving small land owners in Chile, that have been hindered by the barriers related to the limited surface and dispersal of the properties, scarce knowledge of the technical aspects of afforestation and the forest business, limited access to loans and other barriers such as the well-known complicated and expensive procedures of the AR-CDM projects formulation.

The technological barrier faced by this land use scenario is the lack of access to mycorrhizal inoculation technology which helps ensure tree establishment and productivity on dry and degraded soils. Local ecological conditions can be overcome through the use of mycorrhizal inoculation, an improved propagation technology, provided by the project proponent.

Furthermore, this assessment is corroborated by previous audit findings. During the validation of the Nerquiue CDM project, part of the project area, Tüv Süd (2010), the validators, stated:

The technological barrier is of elevated relevance for this project, since only the mycorrhizal inoculation enables the reforestation of the degraded project area. The audit team considers this barrier to be clearly prohibitive in the project context. It is credible that this barrier was only

<sup>23</sup> See section 6.3.3 of Sanhueza et al. 2003. National Strategy Study for the CDM in Chile, GTZ.

<sup>24</sup> <http://unfccc.int/resource/docs/2007/sbsta/eng/misc19.pdf>

surpassed due to the technological inputs by Mikro-Tek which constitutes the core element of this project activity.

### STEP 3: Investment analysis

An investment analysis is not required as there is only one scenario, continuation of pre-project land use (abandoned pasture), that remains after barrier analysis.

### STEP 4: Common practice analysis

Industrial plantation forests are established throughout the country from Region V to Region X, with Radiata Pine and Eucalyptus being the most common forestry species. Plantation forest in the project region as a percentage of the total land<sup>25</sup> account for: 3.4% of the land in Region V, 6.5% in Region VI, 9.2% in Region VII, 13.0% in Region VIII, and 0.6% in the Metropolitan Region. Mikro-Tek's project boundaries are set within this range from Region V to VIII.

Plantation establishment in the project region is not common practice, despite past subsidies by the Chilean government, as mentioned above. Rates of conversion from 1997 to 2007 for both eucalyptus and Pinus radiata are listed in Table 2.4, below. In general, these rates are less than 1% a year or less except in the case of Region VIII, which is the most important region in Chile for industrial forest production. The vast majority (78%) of reforestation in Region VII and VIII is attributable<sup>26</sup> to industrial forestry operations..

Table 2.4. Annual rate of conversion of pasture to forest plantations.

| Region              | Area of Improved Pastures in 1997 (ha) | Area of Natural Pastures in 1997 (ha) | Increase in Eucalyptus plantation area (ha) 1997-2007 | Annual Rate of Pasture Conversion to Eucalyptus plantation (%) | Increase in Pinus radiata plantation area (ha) 1997-2007 | Annual Rate of Pasture Conversion to Pinus radiata plantation (%) |
|---------------------|----------------------------------------|---------------------------------------|-------------------------------------------------------|----------------------------------------------------------------|----------------------------------------------------------|-------------------------------------------------------------------|
| Region V            | 13,232                                 | 774,932                               | 957                                                   | 0.0                                                            | -2,352                                                   | 0.0                                                               |
| Region VI           | 18,316                                 | 515,564                               | 7,252                                                 | 0.1                                                            | 11,694                                                   | 0.2                                                               |
| Region VII          | 89,222                                 | 835,844                               | 10,841                                                | 0.1                                                            | -4,360                                                   | 0.0                                                               |
| Region VIII         | 75,746                                 | 713,137                               | 150,101                                               | 1.9                                                            | 209,242                                                  | 2.7                                                               |
| Metropolitan Region | 14,257                                 | 269,567                               | 621                                                   | 0.0                                                            | 5                                                        | 0.0                                                               |

Land use data on natural pastures comes from Table 4.01 Land Use by Region, INE 1997.

Species specific 1997 plantation data comes from Table 16.08, INE 1997.

Species specific 2007 plantation data comes from Table 17, INE 2007, Accessible at [http://www.ine.cl/canales/chile\\_estadistico/censos\\_agropecuarios/censo\\_agropecuario\\_07\\_comunas.php](http://www.ine.cl/canales/chile_estadistico/censos_agropecuarios/censo_agropecuario_07_comunas.php)

Calculations conservatively assume all new plantations come from abandoned/natural or improved pasture, even though prior to passage of the 2008 Forest Law plantations could be legally converted from native forest.

<sup>25</sup> Table 2 Land Use by Region, INE 2007, Accessible at

[http://www.ine.cl/canales/chile\\_estadistico/censos\\_agropecuarios/censo\\_agropecuario\\_07\\_comunas.php](http://www.ine.cl/canales/chile_estadistico/censos_agropecuarios/censo_agropecuario_07_comunas.php)

<sup>26</sup> See Table 19 in the CDM project "Restoration of Degraded Lands of Small and Medium Farmers through Afforestation and Reforestation in Central Chile" which reports that a total of 28,434 ha out of 36,340 ha of land reforested for several districts in Region VII and VIII from 1994 to 2009 was done so by forestry companies rather than small land owners.

Raw data can be found in the project database.

Although there have been other forestry projects established in the area, particularly by large well financed forestry companies, small-scale landowners with smaller parcels have been reluctant to initiate projects given limited financial resources and the associated risks of establishing forestry plantations on such lands. As stated above, "the simple existence of current forestry incentives is not a sufficient stimulus for landowners to reforest" (Sanhueza. et al., 2003). This is demonstrated by the very low rates of reforestation in Table 2.4. Landowners in the project are unwilling to undertake the financial risk for plantation development given the uncertainty of plantation establishment and the delay in receiving the government subsidy until plantation establishment can be confirmed one year after planting. Mikro-Tek surmounts this barrier by financing and providing mycorrhizal inoculants. The mycorrhizal technology improves successful plantation establishment thereby reducing the risk of planting failure and the risk of cost recovery on the part of the landowners.

Predominately, reforestation in these regions that takes place without the incentives provided by carbon credits is carried out by industrial forest owners or landowners with more ability and or willingness to absorb the risk associated with a failed planting that are distinguished from the landowners Mikro-Tek is working with by having significant available financial and technological resources, and a business-driven mandate to grow timber. This last item is a critical distinction, in that the land managers of the Mikro-Tek project area have not traditionally focused on forestry, as also described by Sanhueza et al above, and are averse to committing their limited financial resources to engaging in a new and potentially risky land use practice.

## 2.6 Methodology Deviations

No methodology deviations were applied.

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## 3.0 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

### 3.1 Baseline Emissions

Baseline net GHG removals by sinks ( $\Delta C_{BSL,t}$ ) equals the sum of changes in carbon stocks in tree ( $\Delta C_{TREE-BSL,t}$ ) and shrub ( $\Delta C_{SHRUB-BSL,t}$ ) biomass. Dead wood ( $\Delta C_{DW-BSL,t}$ ), and litter ( $\Delta C_{LI-BSL,t}$ ) biomass are excluded from the project boundary.

There are four native woody species encountered in and around abandoned pastures in the project region including: *Acacia caven* (Espino), *Peumus boldus* (Boldo), *Cryptocarya alba* (Peumo), and *Quillaja saponaria* (Quillay). *Peumus boldus*, *Cryptocarya alba*, and *Quillaja saponaria* are native trees protected by CONAF agreements, typically growing in discrete copses and were readily delineated and removed from the project boundary. Thus, tree biomass is zero in the project area.

The fourth woody species, *Acacia caven* is a woody species sparsely encountered in the project area. It does not exceed the stature of a shrub, not exceeding 2-3 m height, in the project region<sup>27, 28</sup>. Due to its dispersed occurrence in abandoned pasture, it was not possible to delineate the project boundaries to exclude every instance of the species. *Acacia caven* stem density<sup>29</sup> is estimated at 2.6 stem/ha, accounts for less than 5% crown cover<sup>30</sup>, and is not expected to grow beyond its current stature in the baseline scenario. Shrub biomass can be considered negligible as per the CDM tool “Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities” and the sum of changes in baseline shrub biomass is therefore zero.

As each of these components is equal to zero in the baseline, baseline net GHG removals by sinks are also considered to be zero for the life of the project.

### 3.2 Project Emissions

#### 3.2.1 Ex-ante estimates of aboveground and belowground biomass

Ex-ante estimates of the GHG removal enhancements by trees in the project are derived from measurement data from known age stands in the project region (full analysis detailed in Annex 1).

##### 3.2.1.1 *Pinus radiata* ex-ante estimates for plantation

The final estimated above-ground and below-ground biomass per hectare is displayed in Table 3.2, with maximum above and belowground biomass carbon stock achieved at rotation age (in 20 years) of 163.5 t

<sup>27</sup> Donoso Zegers, C. 2007. Árboles Nativos de Chile- Guía de Reconocimiento. 12th edition. Marisa Cuneo Ediciones, Valdivia, Chile, p 48-49.

<sup>28</sup> Donoso Zegers, C. 1993. Bosques templados de Chile y Argentina: Variación, estructura y dinámica. 1st edition. Editorial Universitaria, Santiago, Chile, p 102.

<sup>29</sup> Data on stem density counts were collected in 49 5-m radius plots in June/July 2012, where only 1 native stem was encountered.

<sup>30</sup> Crowns were estimated as 3-3.5 meters in width by Donoso Zegers (1993). Even if crowns were assumed to be 4 meter wide, crown cover is less than 2% given 3 stems/ha.

C/ha. The below ground biomass for *Pinus radiata* is estimated using a constant root-shoot ratio<sup>31</sup> of 0.2543.

Table 3.2. Ex-ante *Pinus radiata* estimates of cumulative carbon sequestered per ha on project lands, over 1 rotation.

| Stand age | Aboveground live tree biomass (tC/ha) | Belowground live tree biomass (tC/ha) |
|-----------|---------------------------------------|---------------------------------------|
| 0         | 0.0                                   | 0.0                                   |
| 1         | 0.1                                   | 0.0                                   |
| 2         | 0.3                                   | 0.1                                   |
| 3         | 0.8                                   | 0.2                                   |
| 4         | 2.0                                   | 0.5                                   |
| 5         | 4.5                                   | 1.1                                   |
| 6         | 9.0                                   | 2.3                                   |
| 7         | 15.9                                  | 4.0                                   |
| 8         | 25.3                                  | 6.4                                   |
| 9         | 36.8                                  | 9.3                                   |
| 10        | 49.7                                  | 12.6                                  |
| 11        | 63.0                                  | 16.0                                  |
| 12        | 76.0                                  | 19.3                                  |
| 13        | 87.0                                  | 22.1                                  |
| 14        | 98.5                                  | 25.0                                  |
| 15        | 107.6                                 | 27.3                                  |
| 16        | 115.2                                 | 29.3                                  |
| 17        | 121.4                                 | 30.8                                  |
| 18        | 126.4                                 | 32.1                                  |
| 19        | 130.4                                 | 33.1                                  |

### 3.2.1.2 *Eucalyptus globulus* ex-ante estimates for plantation

The final estimated above-ground and below-ground biomass per hectare is displayed in Table 3.3, with maximum above and belowground biomass carbon stock achieved at rotation age (in 10 years) of 72 t C/ha. The below ground biomass for *Eucalyptus globulus* is estimated using a constant root-shoot ratio<sup>32</sup> of 0.2159. As well, it is assumed that eucalyptus will be harvested every 10 years and reestablished via coppicing; hence below-ground biomass is not lost when the above-ground biomass is harvested. As long

<sup>31</sup> Gayoso, J. 2008b. *Pinus radiata*. Resultados Proyecto FONDEF D98i1076 “Medición y Monitoreo de la Captura de Carbono en Ecosistemas Forestales y Promoción en el Mercado Mundial del Carbono”. Bosque PROCARBONO, Universidad Austral de Chile.

[http://www.uach.cl/procarbono/pdf/fichas/ficha\\_pinus\\_radiata.pdf](http://www.uach.cl/procarbono/pdf/fichas/ficha_pinus_radiata.pdf) Accessed 21 July 2011.

<sup>32</sup> Gayoso, J. 2008a. *Eucalyptus* sp. Resultados Proyecto FONDEF D98i1076 “Medición y Monitoreo de la Captura de Carbono en Ecosistemas Forestales y Promoción en el Mercado Mundial del Carbono”. Bosque PROCARBONO, Universidad Austral de Chile.

[http://www.uach.cl/procarbono/pdf/fichas/ficha\\_eucalyptus\\_sp.pdf](http://www.uach.cl/procarbono/pdf/fichas/ficha_eucalyptus_sp.pdf) Accessed 21 July 2011.

as the above-ground biomass is allowed to regrow, the below-ground biomass is assumed to remain constant at the amount pre-harvest.

Table 3.3. Ex-ante *Eucalyptus globulus* estimates of cumulative carbon sequestered per ha on project lands, over 2 rotations with re-establishment via coppicing.

| Stand age | Aboveground live tree biomass (tC/ha) | Belowground live tree biomass (tC/ha) |
|-----------|---------------------------------------|---------------------------------------|
| 0         | 0.0                                   | 0.0                                   |
| 1         | 1.4                                   | 0.3                                   |
| 2         | 6.2                                   | 1.3                                   |
| 3         | 13.8                                  | 3.0                                   |
| 4         | 22.8                                  | 4.9                                   |
| 5         | 31.9                                  | 6.9                                   |
| 6         | 40.4                                  | 8.7                                   |
| 7         | 47.8                                  | 10.3                                  |
| 8         | 54.1                                  | 11.7                                  |
| 9         | 59.2                                  | 12.8                                  |
| 10        | 0.0                                   | 12.8                                  |
| 11        | 1.4                                   | 12.8                                  |
| 12        | 6.2                                   | 12.8                                  |
| 13        | 13.8                                  | 12.8                                  |
| 14        | 22.8                                  | 12.8                                  |
| 15        | 31.9                                  | 12.8                                  |
| 16        | 40.4                                  | 12.8                                  |
| 17        | 47.8                                  | 12.8                                  |
| 18        | 54.1                                  | 12.8                                  |
| 19        | 59.2                                  | 12.8                                  |

### 3.2.2 Ex-ante estimates of soil carbon stocks

Ex-ante estimates of soil carbon stocks were generated using the CDM “Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities” Version 01.1.0, as permitted by the CDM Methodology AR-ACM0003, Version 1.0. Applicability conditions for use of this CDM tool are listed in Table 3.4.

Table 3.4. Conditions for using the CDM “Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities.”

| Applicability condition                                            | Project instances condition                                   |
|--------------------------------------------------------------------|---------------------------------------------------------------|
| The area of land does not contain organic soils (e.g., peat-land). | The project instance area does not contain any organic soils. |

|                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                    |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| The land does not fall into wetland <sup>33</sup> category.                                                                                                                                                                                                                                                                                       | The project instance area is not considered to be a wetland as defined by the Intergovernmental Panel on Climate Change. The project instances area prior to reforestation was grassland and thus is not considered to be a wetland, as per the IPCC definition.                                   |
| Litter shall remain on site and not be removed in the A/R VCS project activity.                                                                                                                                                                                                                                                                   | No litter will be removed from the project area.                                                                                                                                                                                                                                                   |
| Ploughing/ripping/scarification attributable to the A/R VCS project activity, if any, is: (i) Done in accordance with appropriate soil conservation practices, e.g. follows the land contour; and (ii) Limited to the first five years from the year of initial site preparation; and (iii) Not repeated, if at all, within a period of 20 years. | Sub-soiling occurs prior to planting. As sub-soiling is associated with initial planting, it occurs only once. Where the project area is not uniformly level terrain, all sub-soiling follows the contour of the land. Further, site preparation and planting occur within one year of each other. |

With a mean annual temperature of 12.8° C<sup>34</sup>, the climate region for the project instances is classified<sup>35</sup> as the warm temperate. IPCC default soil classes were determined using GIS by overlaying the project areas over a spatially explicit map of IPCC soil types<sup>36</sup> (See Figure 3.1). While the project instances are dominated by high activity clays soils, two project instances, MikroTek0040 and MikroTek0044 in Region 8, are classified as having volcanic soil.

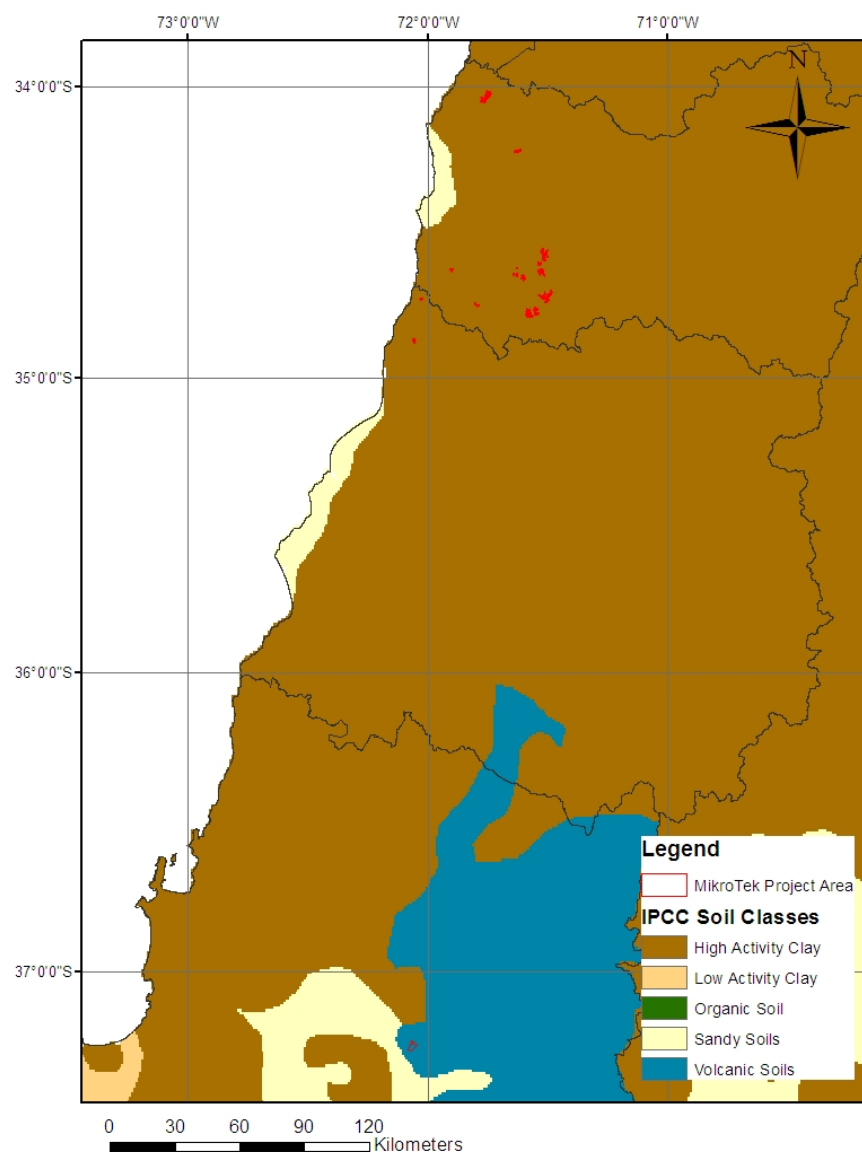
<sup>33</sup> The IPCC describes a wetland as “land that is covered or saturated by water for all or part of the year (e.g., peatland) and that does not fall into the forest land, cropland, grassland or settlements categories.”

<sup>34</sup> Average yearly temperatures for weather stations within the project region for the latest period for which data is available, May 2007 through April 2008. From: ANUARIO AGROMETEOROLOGICO REGIONES IV, V, METROPOLITANA, VI Y VII. DIRECTOR RESPONSABLE: ALEJANDRO MUÑOZ M. DIRECCION METEOROLOGICA DE CHILE. CASILLA 140, SUCURSAL MATUCANA, ESTACION CENTRAL. FONO 4364501 Accessed at: [http://www.meteochile.gob.cl/agrometeorologia/documentos/Anuario\\_Agro\\_%202007-2008%28Agrometeorologia%29.pdf](http://www.meteochile.gob.cl/agrometeorologia/documentos/Anuario_Agro_%202007-2008%28Agrometeorologia%29.pdf)

<sup>35</sup> See Figure 3A.5.2 Classification scheme for default climate regions. IPCC 2006 Guidelines for National Greenhouse Gas Inventories and IPCC Good Practice Guidance.

<sup>36</sup> Batjes, N.H. 2010. IPCC default soil classes derived from the Harmonized World Soil Data Base (Ver. 1.1). Report 2009/02b, Carbon Benefits Project (CBP) and ISRIC- World Soil Information, Wageningen. <http://www.isric.org/data/ipcc-default-soil-classes-derived-harmonized-world-soil-data-base-ver-11>, accessed January 16, 2013.

Figure 3.1. IPCC soil class map of the project area.



The rate of soil organic carbon accumulation ( $d_{SOC}$ ) has been calculated using Equations 3.1 and 3.2 for both high activity clay soils and volcanic soils for the project scenario. Ex-ante estimates of soil carbon accumulation use the area weighted mean<sup>37</sup> (0.665 t C ha<sup>-1</sup> yr<sup>-1</sup>) of the values calculated for high activity clay soils and volcanic soils, below. As the area subject to ripping is less than 10% of the area<sup>38</sup>, the term  $SOC_{loss}$  has been left out of equation 3.2 (equivalent to zero).

<sup>37</sup> The area weighted average is calculated using an area of 2411.7 ha for HAC soils and 595.3 ha for volcanic soils.

<sup>38</sup> Sub-soiling results in an area of disturbance less than 15 cm wide and is done every 3 to 4 meters, resulting in a disturbance of 5% (or less) of the soil surface.

$$\text{SOC}_{\text{initial}} = \text{SOC}_{\text{reference}} * f_{\text{LU}} * f_{\text{MG}} * f_{\text{IN}} \quad \text{Equation 3.1}$$

$$d_{\text{SOC}} = (\text{SOC}_{\text{reference}} - \text{SOC}_{\text{initial}})/20 \text{ years} \quad \text{Equation 3.2}$$

The terms in the above equations are defined as follows:

$\text{SOC}_{\text{initial}}$ , SOC stock at the beginning of an A/R VCS project activity; t C ha<sup>-1</sup>,

$\text{SOC}_{\text{reference}}$ , Reference SOC stock corresponding to the reference condition in native lands; t C ha<sup>-1</sup>,

$f_{\text{LU}}$ , Stock change factor for land-use; dimensionless,

$f_{\text{MG}}$ , Stock change factor for management; dimensionless,

$f_{\text{IN}}$ , Stock change factor for input of organic matter; dimensionless, and

$d_{\text{SOC}}$ , The rate of change in SOC stock; t C ha<sup>-1</sup> yr<sup>-1</sup>.

## 3.2.2.1 Ex-ante estimates of soil carbon stocks in high activity clay soils

Using equation 3.1,  $\text{SOC}_{\text{initial}}$  is calculated for grasslands with high activity clay soils as = 38.0 t C ha<sup>-1</sup> \* 1.0 \* 0.7 \* 1.0 = 26.6 t C ha<sup>-1</sup>.

As per the CDM, “Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities” the below parameters have been defined.

$\text{SOC}_{\text{reference}} = 38.0 \text{ t C ha}^{-1}$ . This value is the default SOC stocks referenced for high activity clay soils in the warm temperate dry climatic region in the default reference table in the above tool.

$f_{\text{LU}} = 1.0$ , as all grassland is assigned a land-use factor of 1;

$f_{\text{MG}} = 0.7$ , as project grasslands are considered severely degraded;

$f_{\text{IN}} = 1.0$ , as these grasslands had no (i.e., low) input of fertilizers.

Using equation 3.2,  $d_{\text{SOC}} = (38.0 \text{ t C ha}^{-1} - 26.6 \text{ t C ha}^{-1})/20 \text{ years} = 0.57 \text{ t C ha}^{-1} \text{ yr}^{-1}$ .

Using this tool, the soil carbon accumulation rate was calculated to be 0.57 t C ha<sup>-1</sup> yr<sup>-1</sup>. In accordance with the tool, this approach allows for reporting 0.57 tons C per hectare per year for 20 years for grassland with high activity clay soils in the project boundary. Soil organic carbon stocks are assumed to be at a steady state after 20 years.

## 3.2.2.2 Ex-ante estimates of soil carbon stocks in volcanic soils

Using equation 3.1,  $\text{SOC}_{\text{initial}}$  is calculated for grasslands with volcanic soils as = 70.0 t C ha<sup>-1</sup> \* 1.0 \* 0.7 \* 1.0 = 49.0 t C ha<sup>-1</sup>.

As per the CDM, “Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities” the below parameters have been defined.

$\text{SOC}_{\text{reference}} = 70.0 \text{ t C ha}^{-1}$ . This value is the default SOC stocks referenced for volcanic soils in the warm temperate dry climatic region in the default reference table in the above tool.

$f_{\text{LU}} = 1.0$ , as all grassland is assigned a land-use factor of 1;

$f_{\text{MG}} = 0.7$ , as project grasslands are considered severely degraded;

$f_{\text{IN}} = 1.0$ , as these grasslands had no (i.e., low) input of fertilizers.

Using equation 3.2,  $d_{SOC} = (70.0 \text{ t C ha}^{-1} - 49.0 \text{ t C ha}^{-1})/20 \text{ years} = 1.05 \text{ t C ha}^{-1}$ .

Using this tool, the soil carbon accumulation rate was calculated to be  $1.05 \text{ t C ha}^{-1} \text{ yr}^{-1}$ . In accordance with the tool, this approach allows for reporting 1.05 tons C per hectare per year for 20 years for grassland with volcanic soils in the project boundary. Soil organic carbon stocks are assumed to be at a steady state after 20 years.

### 3.2.3 Carbon sequestered

Both ex-ante and ex-post estimates of carbon sequestered will use the following equations derived from the CDM AR-ACM0003 methodology.

Actual net GHG removals by sinks ( $\Delta C_{ACTUAL}$ ) is calculated using Equation 3.3, below.

$$\Delta C_{ACTUAL} = \Delta C_P - GHG_E \quad \text{Equation 3.3}$$

where:

|                     |                                                                                                                                          |
|---------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| $\Delta C_{ACTUAL}$ | Actual net GHG removals by sinks; t CO2-e                                                                                                |
| $\Delta C_P$        | Sum of the changes the carbon stock in the selected carbon pools within the project boundary; t CO2-e                                    |
| $GHG_E$             | Increase in non-CO2 GHG emissions within the project boundary as a result of the implementation of the A/R CDM project activity; t CO2-e |

Please note that the increase in non-CO2 GHG emissions within the project boundary as a result of the implementation of the A/R CDM project activity ( $GHG_E$ ) equals zero for the life of the project as justified in Section 2.3.

The sum of the changes the carbon stock in the selected carbon pools within the project boundary ( $\Delta C_P$ ) is calculated using Equation 3.4, below.

$$\Delta C_P = \sum_{t=1}^{t^*} \Delta C_t \quad \text{Equation 3.4}$$

where:

|              |                                                                                                       |
|--------------|-------------------------------------------------------------------------------------------------------|
| $\Delta C_P$ | Sum of the changes the carbon stock in the selected carbon pools within the project boundary; t CO2-e |
| $\Delta C_t$ | Change in carbon stock in all selected carbon pools, in year t; t CO2-e                               |
| t            | 1, 2, 3, ... t* years elapsed since the start of the A/R project activity; yr                         |
| 44/12        | Ratio of molecular weights of CO2 and carbon; dimensionless                                           |

The Change in carbon stock in all selected carbon pools ( $\Delta C_t$ ) is calculated using Equation 3.5, below.

$$\Delta C_t = \Delta C_{TREE\_PROJ,t} + \Delta C_{SHRUB\_PROJ,t} + \Delta C_{DW\_PROJ,t} + \Delta C_{LI\_PROJ,t} + \Delta C_{SOC\_AL,t}$$

Equation 3.5

where:

|                            |                                                                                              |
|----------------------------|----------------------------------------------------------------------------------------------|
| $\Delta C_t$               | Change in carbon stock in all selected carbon pools, in year $t$ ; $t$ CO <sub>2</sub> -e    |
| $\Delta C_{TREE\_PROJ,t}$  | Change in carbon stock in tree biomass in project, in year $t$ ; $t$ CO <sub>2</sub> -e      |
| $\Delta C_{SHRUB\_PROJ,t}$ | Change in carbon stock in shrub biomass in project, in year $t$ ; $t$ CO <sub>2</sub> -e     |
| $\Delta C_{DW\_PROJ,t}$    | Change in carbon stock in dead wood biomass in project, in year $t$ ; $t$ CO <sub>2</sub> -e |
| $\Delta C_{LI\_PROJ,t}$    | Change in carbon stock in litter biomass in project, in year $t$ ; $t$ CO <sub>2</sub> -e    |
| $\Delta C_{SOC\_AL,t}$     | Change in carbon stock in SOC in project, in year $t$ ; $t$ CO <sub>2</sub> -e               |

Please note that the change in carbon stock in litter biomass in project ( $\Delta C_{LI\_PROJ,t}$ ), the change in carbon stock in shrub biomass ( $\Delta C_{SHRUB\_PROJ,t}$ ) and the change in carbon stock in dead wood biomass ( $\Delta C_{DW\_PROJ}$ ) equals zero as justified in Section 2.3. In summary in Table 3.5 and 3.6 the columns entitled "Metric tons of CO<sub>2</sub> (t CO<sub>2</sub>e/ha)"=  $\Delta C_{ACTUAL} = \Delta C_P = \text{Sum}(\Delta C_T)$

Ex-ante estimates on a per unit area basis are detailed in Table 3.5 and Table 3.6 below.

Table 3.5. Ex-ante *Pinus radiata* estimates of cumulative carbon sequestered per ha on project lands.

| Stand age | Aboveground live tree biomass (tC/ha) | Belowground live tree biomass (tC/ha) | Soil carbon <sup>1</sup> (tC/ha) | Total carbon density (tC/ha) | Metric tons of CO <sub>2</sub> (t CO <sub>2</sub> e/ha) | Adjusted long-term average GHG Benefit (t CO <sub>2</sub> e/ha) |
|-----------|---------------------------------------|---------------------------------------|----------------------------------|------------------------------|---------------------------------------------------------|-----------------------------------------------------------------|
| 0         | 0.0                                   | 0.0                                   | 0.0                              | 0.0                          | 0.0                                                     | 0.0                                                             |
| 1         | 0.1                                   | 0.0                                   | 0.7                              | 0.8                          | 2.9                                                     | 2.9                                                             |
| 2         | 0.3                                   | 0.1                                   | 1.3                              | 1.7                          | 6.3                                                     | 6.3                                                             |
| 3         | 0.8                                   | 0.2                                   | 2.0                              | 3.0                          | 11.0                                                    | 11.0                                                            |
| 4         | 2.0                                   | 0.5                                   | 2.7                              | 5.2                          | 19.0                                                    | 19.0                                                            |
| 5         | 4.5                                   | 1.1                                   | 3.3                              | 9.0                          | 32.9                                                    | 32.9                                                            |
| 6         | 9.0                                   | 2.3                                   | 4.0                              | 15.3                         | 56.0                                                    | 56.0                                                            |
| 7         | 15.9                                  | 4.0                                   | 4.7                              | 24.6                         | 90.2                                                    | 90.2                                                            |
| 8         | 25.3                                  | 6.4                                   | 5.3                              | 37.1                         | 135.9                                                   | 135.9                                                           |
| 9         | 36.8                                  | 9.4                                   | 6.0                              | 52.1                         | 191.2                                                   | 191.2                                                           |
| 10        | 49.7                                  | 12.6                                  | 6.7                              | 69.0                         | 253.0                                                   | 253.0                                                           |
| 11        | 63.0                                  | 16.0                                  | 7.3                              | 86.3                         | 316.6                                                   | 283.2                                                           |
| 12        | 76.0                                  | 19.3                                  | 8.0                              | 103.3                        | 378.8                                                   | 283.2                                                           |
| 13        | 87.0                                  | 22.1                                  | 8.6                              | 117.8                        | 431.8                                                   | 283.2                                                           |
| 14        | 98.5                                  | 25.0                                  | 9.3                              | 132.9                        | 487.1                                                   | 283.2                                                           |
| 15        | 107.6                                 | 27.4                                  | 10.0                             | 144.9                        | 531.4                                                   | 283.2                                                           |
| 16        | 115.2                                 | 29.3                                  | 10.6                             | 155.1                        | 568.8                                                   | 283.2                                                           |
| 17        | 121.4                                 | 30.9                                  | 11.3                             | 163.6                        | 599.8                                                   | 283.2                                                           |
| 18        | 126.4                                 | 32.1                                  | 12.0                             | 170.5                        | 625.2                                                   | 283.2                                                           |
| 19        | 130.4                                 | 33.2                                  | 12.6                             | 176.2                        | 646.1                                                   | 283.2                                                           |
| 20        | 0.0                                   | 0.0                                   | 13.3                             | 13.3                         | 48.8                                                    | 283.2                                                           |
| 21        | 0.1                                   | 0.0                                   | 13.3                             | 13.4                         | 49.2                                                    | 283.2                                                           |
| 22        | 0.3                                   | 0.1                                   | 13.3                             | 13.7                         | 50.1                                                    | 283.2                                                           |
| 23        | 0.8                                   | 0.2                                   | 13.3                             | 14.3                         | 52.4                                                    | 283.2                                                           |

|    |       |      |      |       |       |       |
|----|-------|------|------|-------|-------|-------|
| 24 | 2.0   | 0.5  | 13.3 | 15.8  | 58.0  | 283.2 |
| 25 | 4.5   | 1.1  | 13.3 | 18.9  | 69.5  | 283.2 |
| 26 | 9.0   | 2.3  | 13.3 | 24.6  | 90.2  | 283.2 |
| 27 | 15.9  | 4.0  | 13.3 | 33.2  | 121.9 | 283.2 |
| 28 | 25.3  | 6.4  | 13.3 | 45.0  | 165.1 | 283.2 |
| 29 | 36.8  | 9.4  | 13.3 | 59.5  | 218.0 | 283.2 |
| 30 | 49.7  | 12.6 | 13.3 | 75.6  | 277.3 | 283.2 |
| 31 | 63.0  | 16.0 | 13.3 | 92.3  | 338.5 | 283.2 |
| 32 | 76.0  | 19.3 | 13.3 | 108.6 | 398.3 | 283.2 |
| 33 | 87.0  | 22.1 | 13.3 | 122.4 | 448.9 | 283.2 |
| 34 | 98.5  | 25.0 | 13.3 | 136.8 | 501.8 | 283.2 |
| 35 | 107.6 | 27.4 | 13.3 | 148.3 | 543.6 | 283.2 |
| 36 | 115.2 | 29.3 | 13.3 | 157.8 | 578.6 | 283.2 |
| 37 | 121.4 | 30.9 | 13.3 | 165.6 | 607.1 | 283.2 |
| 38 | 126.4 | 32.1 | 13.3 | 171.8 | 630.1 | 283.2 |
| 39 | 130.4 | 33.2 | 13.3 | 176.9 | 648.5 | 283.2 |
| 40 | 0.0   | 0.0  | 13.3 | 13.3  | 48.8  | 283.2 |

<sup>1</sup>Soil carbon estimates are generated using the approved CDM "Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities"

Table 3.6. Ex-ante *Eucalyptus globulus* estimates of cumulative carbon sequestered per ha on project lands.

| Stand age | Aboveground live tree biomass (tC/ha) | Belowground live tree biomass (tC/ha) | Soil carbon <sup>1</sup> (tC/ha) | Total carbon density (tC/ha) | Metric tons of CO2 (t CO2e/ha) | Adjusted long-term average GHG Benefit (t CO2e/ha) |
|-----------|---------------------------------------|---------------------------------------|----------------------------------|------------------------------|--------------------------------|----------------------------------------------------|
| 0         | 0.0                                   | 0.0                                   | 0.0                              | 0.0                          | 0.0                            | 0.0                                                |
| 1         | 1.4                                   | 0.3                                   | 0.7                              | 2.4                          | 8.7                            | 8.7                                                |
| 2         | 6.2                                   | 1.3                                   | 1.3                              | 8.9                          | 32.5                           | 32.5                                               |
| 3         | 13.8                                  | 3.0                                   | 2.0                              | 18.8                         | 68.8                           | 68.8                                               |
| 4         | 22.8                                  | 4.9                                   | 2.7                              | 30.4                         | 111.4                          | 111.4                                              |
| 5         | 31.9                                  | 6.9                                   | 3.3                              | 42.1                         | 154.4                          | 154.4                                              |
| 6         | 40.4                                  | 8.7                                   | 4.0                              | 53.1                         | 194.7                          | 180.8                                              |
| 7         | 47.8                                  | 10.3                                  | 4.7                              | 62.8                         | 230.2                          | 180.8                                              |
| 8         | 54.1                                  | 11.7                                  | 5.3                              | 71.1                         | 260.7                          | 180.8                                              |
| 9         | 59.2                                  | 12.8                                  | 6.0                              | 78.0                         | 285.9                          | 180.8                                              |
| 10        | 0.0                                   | 12.8                                  | 6.7                              | 19.4                         | 71.2                           | 180.8                                              |
| 11        | 1.4                                   | 12.8                                  | 7.3                              | 21.5                         | 78.8                           | 180.8                                              |
| 12        | 6.2                                   | 12.8                                  | 8.0                              | 27.0                         | 98.9                           | 180.8                                              |
| 13        | 13.8                                  | 12.8                                  | 8.6                              | 35.2                         | 129.2                          | 180.8                                              |
| 14        | 22.8                                  | 12.8                                  | 9.3                              | 44.9                         | 164.6                          | 180.8                                              |
| 15        | 31.9                                  | 12.8                                  | 10.0                             | 54.7                         | 200.4                          | 180.8                                              |

|    |      |      |      |      |       |       |
|----|------|------|------|------|-------|-------|
| 16 | 40.4 | 12.8 | 10.6 | 63.8 | 234.0 | 180.8 |
| 17 | 47.8 | 12.8 | 11.3 | 71.9 | 263.6 | 180.8 |
| 18 | 54.1 | 12.8 | 12.0 | 78.9 | 289.1 | 180.8 |
| 19 | 59.2 | 12.8 | 12.6 | 84.6 | 310.3 | 180.8 |
| 20 | 0.0  | 12.8 | 13.3 | 26.1 | 95.6  | 180.8 |
| 21 | 1.4  | 12.8 | 13.3 | 27.5 | 100.8 | 180.8 |
| 22 | 6.2  | 12.8 | 13.3 | 32.3 | 118.4 | 180.8 |
| 23 | 13.8 | 12.8 | 13.3 | 39.9 | 146.2 | 180.8 |
| 24 | 22.8 | 12.8 | 13.3 | 48.9 | 179.2 | 180.8 |
| 25 | 31.9 | 12.8 | 13.3 | 58.0 | 212.6 | 180.8 |
| 26 | 40.4 | 12.8 | 13.3 | 66.5 | 243.8 | 180.8 |
| 27 | 47.8 | 12.8 | 13.3 | 73.9 | 270.9 | 180.8 |
| 28 | 54.1 | 12.8 | 13.3 | 80.2 | 294.0 | 180.8 |
| 29 | 59.2 | 12.8 | 13.3 | 85.3 | 312.7 | 180.8 |
| 30 | 0.0  | 12.8 | 13.3 | 26.1 | 95.6  | 180.8 |
| 31 | 1.4  | 12.8 | 13.3 | 27.5 | 100.8 | 180.8 |
| 32 | 6.2  | 12.8 | 13.3 | 32.3 | 118.4 | 180.8 |
| 33 | 13.8 | 12.8 | 13.3 | 39.9 | 146.2 | 180.8 |
| 34 | 22.8 | 12.8 | 13.3 | 48.9 | 179.2 | 180.8 |
| 35 | 31.9 | 12.8 | 13.3 | 58.0 | 212.6 | 180.8 |
| 36 | 40.4 | 12.8 | 13.3 | 66.5 | 243.8 | 180.8 |
| 37 | 47.8 | 12.8 | 13.3 | 73.9 | 270.9 | 180.8 |
| 38 | 54.1 | 12.8 | 13.3 | 80.2 | 294.0 | 180.8 |
| 39 | 59.2 | 12.8 | 13.3 | 85.3 | 312.7 | 180.8 |
| 40 | 0.0  | 12.8 | 13.3 | 26.1 | 95.6  | 180.8 |

<sup>1</sup>Soil carbon estimates are generated using the approved CDM "Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities"

As harvesting occurs in the with-project case, the long term average GHG benefit is calculated as per VCS AFOLU guidance<sup>39</sup>.

$$LA = \frac{\sum_{t=0}^n PE_t - BE_t}{n}$$

Equation 3.6

where:

LA = The long-term average GHG benefit

<sup>39</sup> Section 4.5.5. 2012 Agriculture, Forestry and Other Land Use (AFOLU) Requirements. Version 3.3, 04 October 2012. Verified Carbon Standard, Washington, D.C.

PE = The GHG emission reductions and removals generated in the project scenario (tCO<sub>2</sub>e).  
Project scenario emission reductions and removals shall also consider project emissions of CO<sub>2</sub>, N<sub>2</sub>O, CH<sub>4</sub> and leakage.

BE = The GHG emission reductions and removals projected for the baseline scenario (tCO<sub>2</sub>e)

t = Year

n = Total number of years in the established time period

Because the project is a grouped project, and new project instances will be added over time, which will affect the long term average GHG benefit at the project level (through changing the relative composition of species and total area), the long term average GHG benefit at the project level cannot be fixed at validation, and thus the long term average GHG benefit is calculated on a per hectare per species basis. Calculation is per Equation 3.6 above to produce the LA parameter in units of t CO<sub>2</sub>e/ha for each species, with results below:

$$LA_{\text{Pinus}} = (11,328.6 \text{ tCO}_2\text{e/ha})/40 \text{ years} = 283.21 \text{ tCO}_2\text{e/ha}$$

$$LA_{\text{Eucalypts}} = (7,231.5 \text{ tCO}_2\text{e/ha})/40 \text{ years} = 180.79 \text{ tCO}_2\text{e/ha}$$

In the above calculation n is set to the project crediting period, which corresponds to two complete pine harvest cycles and four complete eucalyptus harvest cycles. BE is set to zero as there are no baseline removals in the with-project case. The sum of the GHG emission reductions and removals generated in the project scenario (PE) is calculated as the sum of the “Metric tons of CO<sub>2</sub> (t CO<sub>2</sub>e/ha)” column in Table 3.5 and 3.6. Leakage emissions are again assumed to be zero.

This calculation effectively serves as a cap on the amount of emission reductions issued. This cap has been incorporated into the ex-ante estimates in the final column of Table 3.5 and 3.6.

### 3.3 Leakage

Leakage due to displacement of agricultural activities on the initial grouped project instances have been calculated ex-ante, and will be assessed ex-post, using the approved CDM A/R Methodological Tool, “Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities in A/R CDM project activity”.

As previously mentioned, leakage attributable to the project activity is not likely to occur since there is no displacement of agricultural production from within the project boundary and there are no displaced households within the project boundary. Prior to the project, project lands were abandoned pasture.

#### 3.3.1 Leakage equation

This tool uses the following equation to calculate leakage

$$LK_{Agric, t^*} = \frac{44}{12} * \frac{f}{T_{cred}} * \Delta Cd_{t^*}$$

Equation 3.7

where,

$LK_{Agric, t^*}$  = Leakage due to displacement of agricultural activities in year  $t^*$ ; t CO2-e

$f$  = Fraction of land covered by forest (according to the national definition of forest) in the administrative region containing the A/R CDM project activity; dimensionless

$T_{cred}$  = Number of years contained in the first crediting period; dimensionless

$\Delta Cd_t$  = The total change in carbon stocks (for all selected carbon pools) since the start of the project activity to year  $t$  multiplied by the fraction of project area subject to pre-project agricultural activities that are displaced during year  $t$ ; t C

$$\Delta Cd_t = \Delta C_{t=t_{ver}} * D_{t^*}$$

Equation 3.8

$\Delta C_{t=t_{ver}}$  = Sum of annual changes in carbon stock in all selected carbon pools since the start of the A/R CDM project activity to the year of verification  $t_{ver}$ ; t C

$D_{t^*}$  = Fraction of the total area of A/R CDM project activity subject to displacement of agricultural activities in year  $t^*$ ; dimensionless

$t = 1, 2, 3, \dots t^*$  years elapsed since the start of the A/R CDM project activity

44/12 = Ratio of molecular weight of CO2 to carbon; t CO2-e t C<sup>-1</sup>

### 3.3.2 Terms in leakage equation

Ex-ante calculation of total leakage due to displacement of agricultural activities over the life of project applies the following parameters:

$f = 0.202$ ; consistent with tool procedure, weighted average fraction of land covered by forest Region V, VI, VII, and VIII, RM<sup>40</sup>.

As per the tool, "the region shall be the smallest territorial administrative division/s encompassing all areas of land included in the A/R CDM project activity for which data on forest cover are publicly available".

$T_{cred} = 40$ ;

Term  $\Delta C_t$  is derived for all verification years. Section 3.4 further details carbon stock change ex-ante estimates.

Term  $D_t$  is derived for all verification years in which displacement is possible. None of the project area has been, nor will be (in the case of future project instances added as part of the grouped project) subject to pre-project agricultural activities. This is ensured as all project lands receive a CONAF subsidy, which

<sup>40</sup> Instituto Nacional de Estadísticas (INE). 2007. Censo Agropecuario 2007.

[http://www.ine.cl/canales/chile\\_estadistico/censos\\_agropecuarios/censo\\_agropecuario\\_07\\_comunas.php](http://www.ine.cl/canales/chile_estadistico/censos_agropecuarios/censo_agropecuario_07_comunas.php)  
Accessed: 17 July 2012

specifically prohibits conversion of productive agricultural land. As part of the application process to receive the plantation establishment subsidy, CONAF approves all forest management plans to ensure the plans are in line with Chilean Law No.: 701 which preserve existing forests and subsidize the conversion of non-forest land to forest land. The law stipulates that lands to be planted have a preferential aptitude towards forests and have degraded soils. Further, lands that are used for intensive agriculture, orchards or ranching are excluded from the possibility of receiving the subsidy, hence  $Adt=0$  and therefore  $D_t = 0$ .

Prior to the project, the land use of the project area was abandoned pasture; hence, there is no expected displacement of agricultural production from within the project boundary.

### 3.3.3 Ex-ante leakage calculation

Annual ex-ante leakage estimates are detailed in Table 3.7 below. Total leakage due to displacement of agricultural activities is estimated as 0 t CO<sub>2</sub>-e through year 40 of the crediting period.

Table 3.7. Annual leakage estimate (t CO<sub>2</sub>) for the initial project instances.

| Year of verification | Conversion factor (tC to t CO <sub>2</sub> ) | Forest cover, f | Crediting period (yr, Tcred) | Dt (fraction of project area subject to displacement) | Delta Ct (t C) | Annual estimate of leakage (t CO <sub>2</sub> ) |
|----------------------|----------------------------------------------|-----------------|------------------------------|-------------------------------------------------------|----------------|-------------------------------------------------|
| 2003                 | 3.67                                         | 0.202           | 40                           | 0.00                                                  | 0              | 0                                               |
| 2004                 | 3.67                                         | 0.202           | 40                           | 0.00                                                  | 762            | 0                                               |
| 2005                 | 3.67                                         | 0.202           | 40                           | 0.00                                                  | 3,867          | 0                                               |
| 2006                 | 3.67                                         | 0.202           | 40                           | 0.00                                                  | 9,933          | 0                                               |
| 2007                 | 3.67                                         | 0.202           | 40                           | 0.00                                                  | 19,142         | 0                                               |
| 2008                 | 3.67                                         | 0.202           | 40                           | 0.00                                                  | 31,824         | 0                                               |
| 2009                 | 3.67                                         | 0.202           | 40                           | 0.00                                                  | 47,826         | 0                                               |
| 2010                 | 3.67                                         | 0.202           | 40                           | 0.00                                                  | 65,655         | 0                                               |
| 2011                 | 3.67                                         | 0.202           | 40                           | 0.00                                                  | 84,587         | 0                                               |
| 2012                 | 3.67                                         | 0.202           | 40                           | 0.00                                                  | 107,387        | 0                                               |
| 2013                 | 3.67                                         | 0.202           | 40                           | 0.00                                                  | 132,346        | 0                                               |
| 2014                 | 3.67                                         | 0.202           | 40                           | 0.00                                                  | 153,716        | 0                                               |
| 2015                 | 3.67                                         | 0.202           | 40                           | 0.00                                                  | 165,865        | 0                                               |
| 2016                 | 3.67                                         | 0.202           | 40                           | 0.00                                                  | 172,844        | 0                                               |
| 2017                 | 3.67                                         | 0.202           | 40                           | 0.00                                                  | 180,489        | 0                                               |
| 2018                 | 3.67                                         | 0.202           | 40                           | 0.00                                                  | 189,471        | 0                                               |
| 2019                 | 3.67                                         | 0.202           | 40                           | 0.00                                                  | 199,499        | 0                                               |
| 2020                 | 3.67                                         | 0.202           | 40                           | 0.00                                                  | 204,410        | 0                                               |
| 2021                 | 3.67                                         | 0.202           | 40                           | 0.00                                                  | 204,410        | 0                                               |
| 2022                 | 3.67                                         | 0.202           | 40                           | 0.00                                                  | 204,410        | 0                                               |
| 2023                 | 3.67                                         | 0.202           | 40                           | 0.00                                                  | 204,410        | 0                                               |
| 2024                 | 3.67                                         | 0.202           | 40                           | 0.00                                                  | 204,410        | 0                                               |
| 2025                 | 3.67                                         | 0.202           | 40                           | 0.00                                                  | 204,410        | 0                                               |
| 2026                 | 3.67                                         | 0.202           | 40                           | 0.00                                                  | 204,410        | 0                                               |
| 2027                 | 3.67                                         | 0.202           | 40                           | 0.00                                                  | 204,410        | 0                                               |
| 2028                 | 3.67                                         | 0.202           | 40                           | 0.00                                                  | 204,410        | 0                                               |
| 2029                 | 3.67                                         | 0.202           | 40                           | 0.00                                                  | 204,410        | 0                                               |

|      |      |       |    |      |         |   |
|------|------|-------|----|------|---------|---|
| 2030 | 3.67 | 0.202 | 40 | 0.00 | 204,410 | 0 |
| 2031 | 3.67 | 0.202 | 40 | 0.00 | 204,410 | 0 |
| 2032 | 3.67 | 0.202 | 40 | 0.00 | 204,410 | 0 |
| 2033 | 3.67 | 0.202 | 40 | 0.00 | 204,410 | 0 |
| 2034 | 3.67 | 0.202 | 40 | 0.00 | 204,410 | 0 |
| 2035 | 3.67 | 0.202 | 40 | 0.00 | 204,410 | 0 |
| 2036 | 3.67 | 0.202 | 40 | 0.00 | 204,410 | 0 |
| 2037 | 3.67 | 0.202 | 40 | 0.00 | 204,410 | 0 |
| 2038 | 3.67 | 0.202 | 40 | 0.00 | 204,410 | 0 |
| 2039 | 3.67 | 0.202 | 40 | 0.00 | 204,410 | 0 |
| 2040 | 3.67 | 0.202 | 40 | 0.00 | 204,410 | 0 |
| 2041 | 3.67 | 0.202 | 40 | 0.00 | 204,410 | 0 |
| 2042 | 3.67 | 0.202 | 40 | 0.00 | 204,410 | 0 |
| 2043 | 3.67 | 0.202 | 40 | 0.00 | 204,410 | 0 |

### 3.4 Summary of GHG Emission Reductions and Removals

Emission reductions are calculated (see Equation 3.9) by subtracting the baseline carbon stocks (in this case zero) and leakage from the with-project emission reductions (for both the ex-ante and ex-post case), and then subtracting out the non-permanence risk buffer (see Appendix A for risk buffer determination).

$$ER = \Delta C_{\text{ACTUAL}} - \Delta C_{\text{BSL}} - LK - \text{Buffer}_{\text{VCS}} \quad \text{Equation 3.9}$$

|                              |                                                                                     |
|------------------------------|-------------------------------------------------------------------------------------|
| ER                           | Emission reductions (net anthropogenic GHG removals by sinks); t CO <sub>2</sub> -e |
| $\Delta C_{\text{ACTUAL}}$   | With-project Actual net GHG removals by sinks; t CO <sub>2</sub> -e                 |
| $\Delta C_{\text{BSL}}$      | Baseline net GHG removals by sinks; t CO <sub>2</sub> -e                            |
| LK                           | Total GHG emissions due to leakage; t CO <sub>2</sub> -e                            |
| $\text{Buffer}_{\text{VCS}}$ | VCS buffer credits; t CO <sub>2</sub> -e                                            |

Over the 40 year crediting period the initial grouped project instances are expected to generate 674,554 t CO<sub>2</sub>-e net emissions reductions (Table 3.8).

Table 3.8. Ex-ante estimate of net emission reductions for the initial grouped project instances.

| Year | Annual estimates of carbon sequestration (t CO <sub>2</sub> ) | Annual baseline carbon stocks (t CO <sub>2</sub> ) | Nonpermanence Risk deduction (t CO <sub>2</sub> ) | Annual leakage (t CO <sub>2</sub> ) | Annual estimates of net emission reductions (t CO <sub>2</sub> ) | Cumulative estimates of net emission reductions (t CO <sub>2</sub> ) |
|------|---------------------------------------------------------------|----------------------------------------------------|---------------------------------------------------|-------------------------------------|------------------------------------------------------------------|----------------------------------------------------------------------|
| 2003 | 0                                                             | 0                                                  | 0                                                 | 0                                   | 0                                                                | 0                                                                    |
| 2004 | 2,795                                                         | 0                                                  | 279                                               | 0                                   | 2,515                                                            | 2,515                                                                |
| 2005 | 11,386                                                        | 0                                                  | 1,139                                             | 0                                   | 10,247                                                           | 12,763                                                               |
| 2006 | 22,239                                                        | 0                                                  | 2,224                                             | 0                                   | 20,015                                                           | 32,778                                                               |
| 2007 | 33,768                                                        | 0                                                  | 3,377                                             | 0                                   | 30,391                                                           | 63,169                                                               |
| 2008 | 46,501                                                        | 0                                                  | 4,650                                             | 0                                   | 41,851                                                           | 105,020                                                              |
| 2009 | 58,673                                                        | 0                                                  | 5,867                                             | 0                                   | 52,806                                                           | 157,826                                                              |

|      |        |   |       |   |        |         |
|------|--------|---|-------|---|--------|---------|
| 2010 | 65,372 | 0 | 6,537 | 0 | 58,835 | 216,661 |
| 2011 | 69,418 | 0 | 6,942 | 0 | 62,476 | 279,137 |
| 2012 | 83,600 | 0 | 8,360 | 0 | 75,240 | 354,376 |
| 2013 | 91,517 | 0 | 9,152 | 0 | 82,366 | 436,742 |
| 2014 | 78,357 | 0 | 7,836 | 0 | 70,521 | 507,263 |
| 2015 | 44,546 | 0 | 4,455 | 0 | 40,092 | 547,355 |
| 2016 | 25,590 | 0 | 2,559 | 0 | 23,031 | 570,386 |
| 2017 | 28,032 | 0 | 2,803 | 0 | 25,229 | 595,615 |
| 2018 | 32,934 | 0 | 3,293 | 0 | 29,641 | 625,255 |
| 2019 | 36,767 | 0 | 3,677 | 0 | 33,090 | 658,345 |
| 2020 | 18,009 | 0 | 1,801 | 0 | 16,208 | 674,554 |
| 2021 | 0      | 0 | 0     | 0 | 0      | 674,554 |
| 2022 | 0      | 0 | 0     | 0 | 0      | 674,554 |
| 2023 | 0      | 0 | 0     | 0 | 0      | 674,554 |
| 2024 | 0      | 0 | 0     | 0 | 0      | 674,554 |
| 2025 | 0      | 0 | 0     | 0 | 0      | 674,554 |
| 2026 | 0      | 0 | 0     | 0 | 0      | 674,554 |
| 2027 | 0      | 0 | 0     | 0 | 0      | 674,554 |
| 2028 | 0      | 0 | 0     | 0 | 0      | 674,554 |
| 2029 | 0      | 0 | 0     | 0 | 0      | 674,554 |
| 2030 | 0      | 0 | 0     | 0 | 0      | 674,554 |
| 2031 | 0      | 0 | 0     | 0 | 0      | 674,554 |
| 2032 | 0      | 0 | 0     | 0 | 0      | 674,554 |
| 2033 | 0      | 0 | 0     | 0 | 0      | 674,554 |
| 2034 | 0      | 0 | 0     | 0 | 0      | 674,554 |
| 2035 | 0      | 0 | 0     | 0 | 0      | 674,554 |
| 2036 | 0      | 0 | 0     | 0 | 0      | 674,554 |
| 2037 | 0      | 0 | 0     | 0 | 0      | 674,554 |
| 2038 | 0      | 0 | 0     | 0 | 0      | 674,554 |
| 2039 | 0      | 0 | 0     | 0 | 0      | 674,554 |
| 2040 | 0      | 0 | 0     | 0 | 0      | 674,554 |
| 2041 | 0      | 0 | 0     | 0 | 0      | 674,554 |
| 2042 | 0      | 0 | 0     | 0 | 0      | 674,554 |
| 2043 | 0      | 0 | 0     | 0 | 0      | 674,554 |

The number of VCUs at time  $t_2$  (the date of verification) is estimated using Equation 3.10.

$$\text{VCUs} = \text{ER}_{t_2} - \text{ER}_{t_1}$$

Equation 3.10

VCUs Number of Verified Carbon Units

$\text{ER}_{t_2}$  Emission reductions (net anthropogenic GHG removals by sinks) for time  $t_2$ ; t CO<sub>2</sub> - e

$\text{ER}_{t_1}$  Emission reductions (net anthropogenic GHG removals by sinks) for time  $t_1$  (the previous verification); t CO<sub>2</sub> - e

Note that  $\text{ER}_{t_1} = 0$  for the first verification.

## 4.0 MONITORING

This grouped project will use the Clean Development Mechanism (CDM) approved consolidated afforestation and reforestation baseline and monitoring methodology “AR-ACM0003 Afforestation and reforestation of lands except wetlands (Version 1.0)”. See Section 2.1 and 2.2 for explanation of methodological choice.

The project monitoring plan conforms with monitoring requirements of methodology AR-ACM0003 and follows general principles of carbon accounting provided in Chapter 4 (AFOLU; Agriculture, Forestry and Other Land-use) of the IPCC 2006 Guidelines for National Greenhouse Gas Inventories and IPCC Good Practice Guidance (IPCC GPG 2006), specifically Chapter 4.3 Guidance for Projects.

Over the life of the project, carbon stock and stock change estimates will be derived from direct measurements on permanent plots and thus satisfy the IPCC Tier 3 highest level of accuracy criteria. Soil carbon is accounted for using the approved CDM “Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities”, as permitted by CDM Methodology AR-ACM0003, Version 1.0.

In conformance with IPCC guidance, the monitoring plan is designed to quantify and control for uncertainty in estimates by employing sufficient sampling intensity and unbiased allocation of measurement plots to produce estimates with a known level of confidence.

Per IPCC 2006GL guidance, the monitoring plan includes a Quality Assurance/Quality Control (QA/QC) plan to control for errors in measurement and data analysis. Application of the QA/QC plan will provide documentation and consistency in data archiving to permit efficient third-party auditing and evaluation against measurement and quantification standards over the life of monitoring.

Mikro-Tek is responsible for all monitoring aspects including planning, fieldwork, reporting, and data archiving.

### 4.1 Data and Parameters Available at Validation

The following data and parameters will be available prior to or calculated during the course of preparing verification reports.

Table 4.1. Key data /parameters used for monitoring project activity.

| Parameter | Data                                                                                                                              | Data unit | Measured, calculated, default, other | Measurement frequency (if measured) | Source of data |
|-----------|-----------------------------------------------------------------------------------------------------------------------------------|-----------|--------------------------------------|-------------------------------------|----------------|
| A         | Total area of A/R VCS project activity                                                                                            | Ha        | Measured                             | Once, at beginning of project       | GIS            |
| Ai        | (a) Area of tree biomass stratum i;<br>(b) Area of SOC stratum i of the land meeting the applicability conditions of the SOC tool | Ha        | Measured                             | Once, at beginning of project       | GIS            |

|                     |                                                                                                                                                                                                                                                                                                                 |                                       |            |                              |                                                                                                                                    |
|---------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|------------|------------------------------|------------------------------------------------------------------------------------------------------------------------------------|
| $a_{pi}$            | Total area of sample plots in tree biomass stratum $i$                                                                                                                                                                                                                                                          | Ha                                    | Calculated |                              |                                                                                                                                    |
| $CF_j$              | Carbon fraction of biomass for tree species $j$                                                                                                                                                                                                                                                                 | $0.5 \text{ t C t}^{-1} \text{ d.m.}$ | Default    |                              | CDM Tool "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities"; Version 3.0" |
| $LK_{Agric,t}$      | Leakage due to the displacement of agricultural activities in year $t$                                                                                                                                                                                                                                          | $\text{t CO}_2\text{-e}$              | Calculated |                              |                                                                                                                                    |
| $D_t$               | Fraction of the total area of A/R VCS project activity subject to displacement of agricultural activities in year $t$                                                                                                                                                                                           | dimensionless                         | Measured   | Once at beginning of project | landowner                                                                                                                          |
| $Ad_t$              | Area subject to pre-project agricultural activities that are displaced during year $t$ since the start of the A/R project activity                                                                                                                                                                              | ha                                    | Measured   | Once at beginning of project | landowner                                                                                                                          |
| $\Delta Cd_t$       | Annual change in carbon stock in all selected carbon pools for year $t$                                                                                                                                                                                                                                         | $\text{t C yr}^{-1}$                  | Calculated |                              | Inventory results                                                                                                                  |
| $\Delta C_{t=tver}$ | Sum of annual changes in carbon stock in all selected carbon pools since the start of the A/R VCS project activity to the year of verification $t_{ver}$                                                                                                                                                        | $\text{t C}$                          | Calculated |                              | Inventory results                                                                                                                  |
| $\Delta Cd_{t^*}$   | Sum of annual changes in carbon stock in all selected carbon pools since the start of the A/R VCS project activity to the year of verification $t_{ver}$ attributable to the area subject to pre-project agricultural activities that are displaced during year $t$ since the start of the A/R project activity | $\text{t C}$                          | Calculated |                              |                                                                                                                                    |
| $f$                 | Fraction of land covered by forest (according to the national definition of forest) in the region containing the A/R VCS project activity                                                                                                                                                                       | dimensionless                         | Measured   | Once at beginning of project |                                                                                                                                    |
| $bm_{Eucalyptus}$   | total aboveground biomass for trees, $bm = \text{Exp}(2.3177 + 0.1303 * \text{dbh})$ , where $n=107$ , $r^2=96.29$                                                                                                                                                                                              | kg                                    | Calculated |                              | Gayoso 2008a; Gayoso et al., 2002                                                                                                  |

|                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                       |               |            |  |                                   |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|---------------|------------|--|-----------------------------------|
| bm <sub>Pinus</sub>                                                                                                                                                                                                                                                                                                                                                                                                   | total aboveground biomass for trees, $bm = -5.0506 + 0.8173*(dbh^2)$ , where $n = 58$ , $r^2 = 97.65$ | kg            | Calculated |  | Gayoso 2008b; Gayoso et al., 2002 |
| R <sub>Eucalyptus</sub>                                                                                                                                                                                                                                                                                                                                                                                               | root to shoot ratio for <i>Eucalyptus globulus</i> = 0.2159                                           | dimensionless | Default    |  | Gayoso 2008a                      |
| R <sub>Pinus</sub>                                                                                                                                                                                                                                                                                                                                                                                                    | root to shoot ratio for <i>Pinus radiata</i> = 0.2543                                                 | dimensionless | Default    |  | Gayoso 2008b                      |
| CDM Executive Board. 2009. Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities in A/R CDM project activity - Version 1. EB51. UNFCCC, Bonn, Germany.                                                                                                                                                                                                      |                                                                                                       |               |            |  |                                   |
| CDM Executive Board. 2012. AR-ACM0003 Afforestation and reforestation of lands except wetlands - Version 1.0. UNFCCC, Bonn, Germany.                                                                                                                                                                                                                                                                                  |                                                                                                       |               |            |  |                                   |
| Gayoso, J. 2008a. Eucalyptus sp. Resultados Proyecto FONDEF D98i1076 "Medición y Monitoreo de la Captura de Carbono en Ecosistemas Forestales y Promoción en el Mercado Mundial del Carbono". Bosque PROCarbono, Universidad Austral de Chile. <a href="http://www.uach.cl/procarbono/pdf/fichas/ficha_eucalyptus_sp.pdf">http://www.uach.cl/procarbono/pdf/fichas/ficha_eucalyptus_sp.pdf</a> Accessed 21 July 2011. |                                                                                                       |               |            |  |                                   |
| Gayoso, J.; Guerra, J.; Alarcón, D. 2002. Contenido de carbono y funciones de biomasa en especies nativas y exóticas. Proyecto FONDEF D98i1076 Medición de la capacidad de captura de carbono en bosques de Chile y promoción en el mercado mundial. 157 p.                                                                                                                                                           |                                                                                                       |               |            |  |                                   |
| Gayoso, J. 2008b. Pinus radiata. Resultados Proyecto FONDEF D98i1076 "Medición y Monitoreo de la Captura de Carbono en Ecosistemas Forestales y Promoción en el Mercado Mundial del Carbono". Bosque PROCarbono, Universidad Austral de Chile. <a href="http://www.uach.cl/procarbono/pdf/fichas/ficha_pinus_radiata.pdf">http://www.uach.cl/procarbono/pdf/fichas/ficha_pinus_radiata.pdf</a> Accessed 21 July 2011. |                                                                                                       |               |            |  |                                   |

## 4.2 Data and Parameters Monitored

The following data and parameters will be monitored prior to each verification.

Table 4.2 List of data to be monitored.

| Parameter       | Data                                                                                                                              | Data unit | Measured, calculated, default, other | Measurement frequency (if measured)    | Source of data    |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------|-----------|--------------------------------------|----------------------------------------|-------------------|
| dbh             | Diameter at breast height of tree                                                                                                 | cm        | Measured                             | Every 5 years after first verification | Directly measured |
| Ai              | (a) Area of tree biomass stratum i;<br>(b) Area of SOC stratum i of the land meeting the applicability conditions of the SOC tool | Ha        | Measured                             | Once, at beginning of project          | GIS               |
| a <sub>pi</sub> | Total area of sample plots in tree biomass stratum i                                                                              | Ha        | Calculated                           | Every 5 years after first verification | GIS               |

## 4.3 Description of the Monitoring Plan

### 4.3.1 Monitoring approach

#### 4.3.1.1 Precision target

The monitoring plan is designed to produce biomass stock estimates with a precision level of +/-10% of the mean with 90% confidence at the first measurement, with precision expected to improve over time as the stands mature and become more homogeneous. In the event that monitoring of biomass yields a precision of the estimates exceeding  $\pm 10\%$  of the mean at a 90% confidence level, as required by the methodology, an appropriate confidence deduction will be applied as suggested by VCS<sup>41</sup>.

#### 4.3.1.2 Carbon pools

Project monitoring will measure and quantify carbon stocks in terrestrial carbon pools including aboveground biomass and belowground biomass. Soil carbon stocks will not be monitored; change in soil carbon stocks will be determined using the approved CDM "Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities".

#### 4.3.1.3 Definition and delineation of strata

For the purpose of estimation of biomass, stratification is not required. However, stratification of the project area into relatively homogeneous units can either increase the precision of biomass estimation without increasing the cost unduly or reduce the cost without reducing the precision of biomass estimation because of the lower variance within each homogeneous unit.

The project area will be stratified in the ex-ante and ex-post case by planting year and species.

The ex post stratification shall be updated for the following reasons:

- a) Unexpected disturbances occurring during the crediting period (e.g. due to fire, pests or disease outbreaks) that have differing impacts on various parts of an originally homogeneous stratum;
- b) Forest management activities (cleaning, planting, thinning, harvesting, re-planting) that are implemented in a way that affects the existing stratification.

For the purpose of calculation of changes in SOC, the project area will be stratified by soil type and planting year.

#### 4.3.1.4 Sampling design

The project will employ stratified random sampling using permanent 10-meter radius circular (fixed area) plots for live aboveground biomass. Sample size will be determined prior to the monitoring date on the basis of field data.

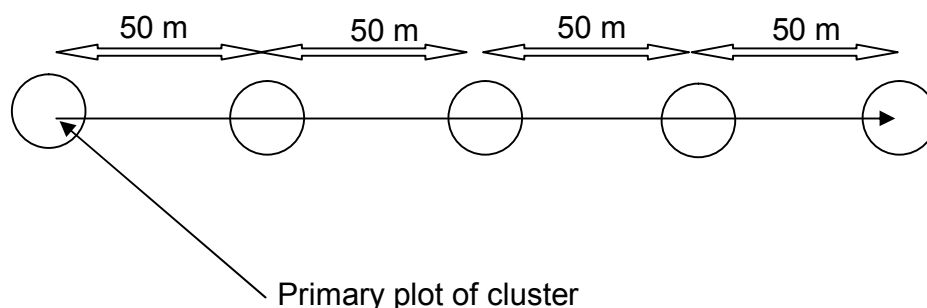
Cluster sampling will be employed to improve precision. Each cluster sample will be composed of a string of five ten-meter radius plots, with the first plot permanently monumented (Figure 4.1). The secondary plots will be un-marked temporary plots expanding the sample unit to a cluster. Sample units will be allocated at random within strata using ArcGIS. GPS coordinates correspond with the center point of the primary plot. The direction of the string cluster is random and will be assigned prior to arriving at the sampling plot.

Both live biomass and soil will be verified every five years after its initial verification. Soil carbon will be estimated, as stipulated above in section 4.3.1.2.

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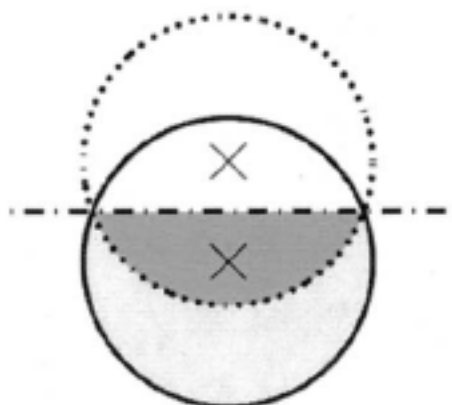
<sup>41</sup> VCS. 2012 VCS Standard. Version 3.3, 04 October 2012. Verified Carbon Standard, Washington, D.C.

Figure 4.1. Diagram of cluster monitoring plot design with the permanently monumented plot as the initial plot in the cluster.



It is expected that issues of boundary overlap will be encountered at some clusters/plots in the field. Plots that overlap the project boundary will be corrected using the mirage method<sup>42, 43</sup> (Figure 4.2). The solid-lined circle is the actual plot border. The portion of the circle above the horizontal line is outside of the forest strata being sampled. After sampling all the trees within the sampling circle within the forest strata (e.g. below the line), the trees within the grey shaded area will then be registered twice on the data sheet to account for the same area which is above the horizontal line and outside the plot.

Figure 4.2. Diagram of mirage method (Avery and Burkhardt, 1994)

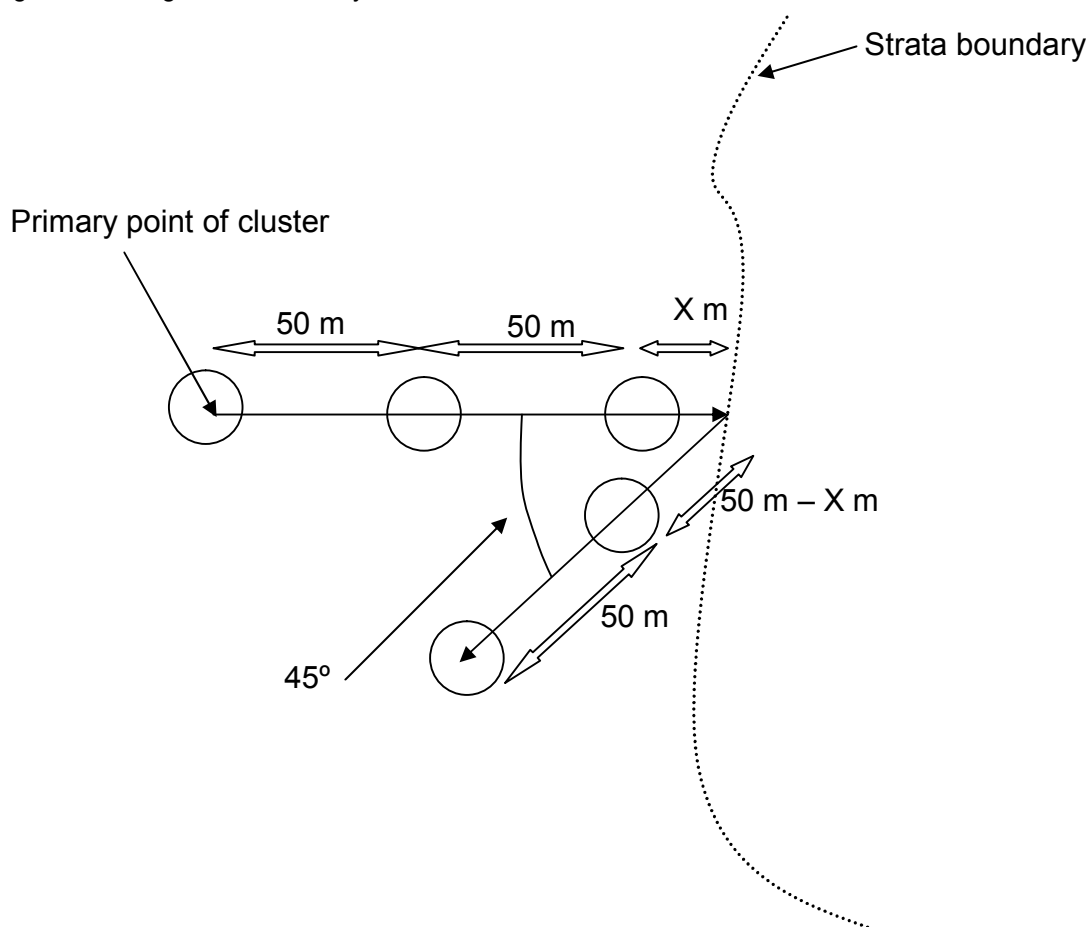


Where the 50 meter lines of transit from the direction of the primary plot center crosses the strata boundary prior to terminating, lines will be deflected from the boundary back into the project area using a "ricochet" method to complete the 50 m, where the line of transit will ricochet back into the project area to the right of the original bearing at a 45 degree angle.

<sup>42</sup>Avery, T.E. and H.E. Burkhardt. 1994. Forest Measurements. Fourth Edition. McGraw Hill, Boston, Massachusetts, USA. 408 pp.

<sup>43</sup>Ducey, M.J., J.H. Gove, and H.T. Valentine. 2004. A Walkthrough Solution to the Boundary Overlap Problem. Forest Science, 50: 427-435.

Figure 4.3. Diagram of boundary reflection method.



#### 4.3.2 Field measurement protocols

Direct field measurements of aboveground biomass will follow standard forest inventory best practices outlined in Avery and Burkhart (1994). As allowed under methodology AR-ACM0003, deadwood, litter and soil organic carbon will not be measured and monitored.

##### 4.3.2.1 Establishment of measurement plots

Once the plot center location is reached, the plot will be marked by hammering a 1 cm diameter metal rebar into the ground. The metal rebar should be approximately 1.5 m in length. An aluminum tag, labeled with a unique monitoring plot identification name, should be attached to each primary plot center.

Coordinates of all secondary sample plots will be recorded with a GPS.

##### 4.3.2.2 Layout of measurement plots

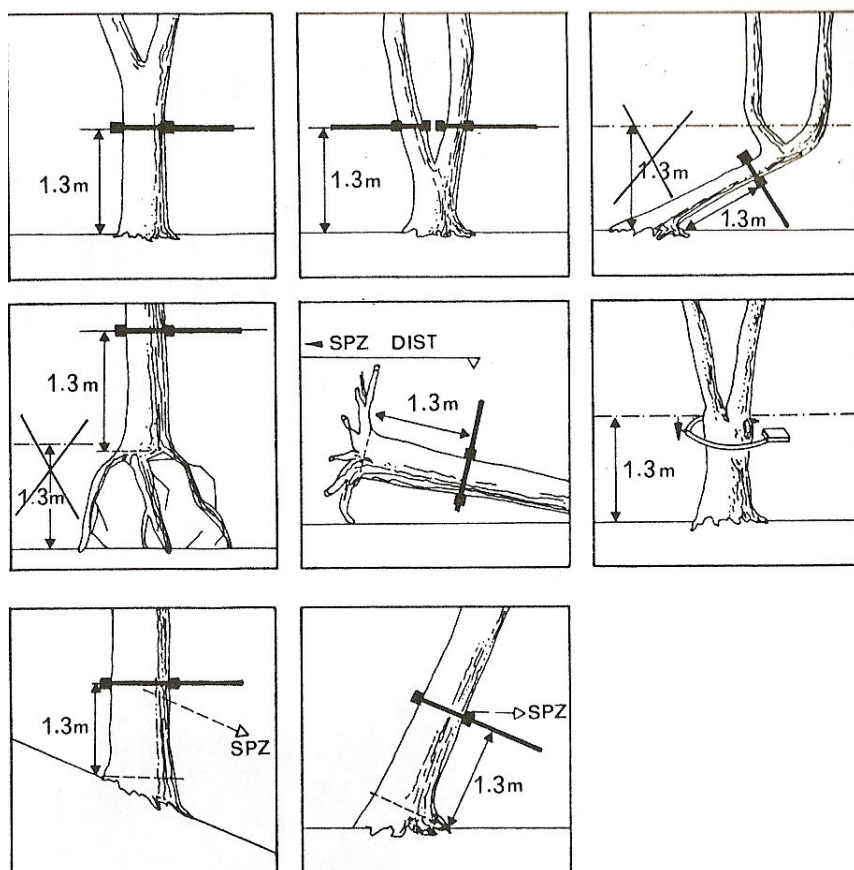
The slope (in %) of each monitoring plot (both permanent and temporary plots) should be taken with a clinometer and recorded. The slope will be recorded so the plot radii in the direction of the slope can later be adjusted to calculate the equivalent horizontal area.

#### 4.3.2.3 Measurement of live trees

Within each sampling plot all planted stems (e.g., *Pinus radiata*, *Eucalyptus globulus*, etc.) > 5 cm dbh will be measured. Native woody species, including trees and shrubs if present, are not included in the project and hence will not be measured. Diameter of trees will be measured at breast height (1.3 m above ground level, see Figure 4.4).

To avoid either missed trees or double recording, the point of initiation of measurement will be noted, and measurement should proceed in a consistent clockwise or counter-clockwise fashion.

Figure 4.4. Point of measurement of diameter at breast height (from Pancel<sup>44</sup>, 1993).



#### 4.3.2.4 Measuring distance

If sonic measuring equipment, such as Haglof DMEs, is to be used in the field (to check plot radii and borderline trees) they will be calibrated before each use and allowed 10+ minutes prior to use to equilibrate the unit to ambient conditions.

<sup>44</sup> Pancel, L., ed. 1993. Tropical forestry handbook. Berlin, Germany, Springer-Verlag. Volume 1, 738 pp.

#### 4.3.3 Data analysis for aboveground and belowground biomass

Field measurements will be used to estimate biomass stocks in live aboveground and belowground trees. Aboveground live tree biomass will be estimated from dbh applying allometric equations found in Gayoso (2008a)<sup>45</sup> for *Eucalyptus globulus* and Gayoso (2008b)<sup>46</sup> for *Pinus radiata*. The appropriateness<sup>47</sup> of these allometric equations is demonstrated by the fact that each equation was derived from a data set of at least 30 sample trees, and the value of coefficient of determination (R<sup>2</sup>) obtained was not less than 0.85, as noted in Table 4.1. Root to shoot ratios for calculating belowground biomass are found in Gayoso (2008a)<sup>48</sup> for *Eucalyptus globulus* ( $R_{\text{Eucalyptus}} = 0.2159$ ) and Gayoso (2008b)<sup>49</sup> for *Pinus radiata* ( $R_{\text{Pinus}} = 0.2543$ ).

#### 4.3.4 Leakage monitoring

Leakage will be calculated ex-post using the approved CDM A/R Methodological Tool, “Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities in A/R CDM project activity.” Leakage calculations and parameters are detailed in Section 3.3.

#### 4.3.5 Quality control and data archiving

Implementation of the monitoring plan will apply QA/QC procedures as outlined here to minimize errors in measurement and data analysis, and to provide documentation and consistency in data archiving. The plan will cover procedures for: (1) collecting reliable field measurements, (2) documenting data entry and analysis techniques and (3) data maintenance and archiving.

The grouped project maintains an electronic database of GIS coverages detailing parcel boundaries, and will record and archive raw field measurements and analyses to permit independent review of source data over the life of the project.

##### 4.3.5.1 Field measurements

Field crews will be fully trained in all aspects of the field data collection and adhere to field measurement protocols. Field crew leaders will be responsible for ensuring that field protocols are followed to ensure accurate and consistent measurement. Pilot sample plots shall be measured before the initiation of formal

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<sup>45</sup>Gayoso, J. 2008a. *Eucalyptus* sp. Resultados Proyecto FONDEF D98i1076 “Medición y Monitoreo de la Captura de Carbono en Ecosistemas Forestales y Promoción en el Mercado Mundial del Carbono”. Bosque PROCarbono, Universidad Austral de Chile.

[http://www.uach.cl/procarbono/pdf/fichas/ficha\\_eucalyptus\\_sp.pdf](http://www.uach.cl/procarbono/pdf/fichas/ficha_eucalyptus_sp.pdf) Accessed 21 July 2011.

<sup>46</sup> Gayoso, J. 2008b. *Pinus radiata*. Resultados Proyecto FONDEF D98i1076 “Medición y Monitoreo de la Captura de Carbono en Ecosistemas Forestales y Promoción en el Mercado Mundial del Carbono”. Bosque PROCarbono, Universidad Austral de Chile.

[http://www.uach.cl/procarbono/pdf/fichas/ficha\\_pinus\\_radiata.pdf](http://www.uach.cl/procarbono/pdf/fichas/ficha_pinus_radiata.pdf) Accessed 21 July 2011.

<sup>47</sup> See the CDM tool “Demonstrating appropriateness of allometric equations for estimation of aboveground tree biomass in A/R CDM project activities” for details.

<sup>48</sup>Gayoso, J. 2008a. *Eucalyptus* sp. Resultados Proyecto FONDEF D98i1076 “Medición y Monitoreo de la Captura de Carbono en Ecosistemas Forestales y Promoción en el Mercado Mundial del Carbono”. Bosque PROCarbono, Universidad Austral de Chile.

[http://www.uach.cl/procarbono/pdf/fichas/ficha\\_eucalyptus\\_sp.pdf](http://www.uach.cl/procarbono/pdf/fichas/ficha_eucalyptus_sp.pdf) Accessed 21 July 2011.

<sup>49</sup> Gayoso, J. 2008b. *Pinus radiata*. Resultados Proyecto FONDEF D98i1076 “Medición y Monitoreo de la Captura de Carbono en Ecosistemas Forestales y Promoción en el Mercado Mundial del Carbono”. Bosque PROCarbono, Universidad Austral de Chile.

[http://www.uach.cl/procarbono/pdf/fichas/ficha\\_pinus\\_radiata.pdf](http://www.uach.cl/procarbono/pdf/fichas/ficha_pinus_radiata.pdf) Accessed 21 July 2011.

measurements to appraise field crews and identify and correct any errors in field measurements. During measurement, a consistency check of an opportunistic sample of plots shall be re-measured to determine measurement error. Re-measurement for this purpose shall be done by different field personnel. These internal check cruises will serve to quantify measurement error and allow for the identification and correction of any field measurement issues arising during implementation of the monitoring plan.

All equipment used in the course of field measurements will be calibrated according to the equipment's specifications or national/international standards.

#### 4.3.5.2 Data entry

Data will be recorded on field sheets and then transcribed to electronic media. To minimize errors in data entry, where they are not the same, personnel involved in data analysis will consult with personnel involved in measurement to clarify any anomalous values or ambiguities in transcription.

#### 4.3.5.3 Data archiving

Because of the long-term objective of the monitoring plan, data archiving is essential. Field measurement data will be recorded on field sheets, which shall be duplicated and archived. Field data will be entered in an electronic database; data entry shall work with photocopies, not originals, to avoid loss of data. Each new grouped project instance will be given a unique identifier and incorporated into the overall project accounting tracking system. The project maintains an electronic database of GIS coverages detailing parcel boundaries and monitoring plot locations (once established), and maps archived in both digital and hard copy form. Original field monitoring data sheets, GIS data layers, reports of analyses and supporting spreadsheets will be stored in both hard copy and digital form at the Mikro-Tek Office in Timmins, Ontario for at least 2 years beyond the project crediting period. Copies of all raw data, reports of analysis and supporting spreadsheets will be stored in a dedicated long-term electronic archive. Given the extended timeframe and the pace of production of updated versions of software and new hardware for storing data, electronic files will be updated periodically or converted to a format accessible to future software applications. Adherence to these procedures will also ensure smooth transitions and maintain “institutional memory” in the event of changes in personnel responsible for the monitoring plan.

## 5.0 ENVIRONMENTAL IMPACT

No environmental impact assessment was required prior to project implementation. Further, each site has a forestry plan approved by Corporación Nacional Forestal (CONAF) and is in compliance with applicable laws, see Section 1.11.

In March 2003, the Chilean Environmental Agency (CONAMA) commissioned a “National Strategy Study for the CDM in Chile”<sup>50</sup> which provided principals to guide CDM LULUCF activities in the forestry sector. Mikro-Tek has incorporated the environmental criteria outlined in that report. Specifically that the project improves eroded and deteriorated soils; protects waterways and their sources; and uses forest species common in Chile that were known not to present any negative environmental impacts.

Further the project incorporated mycorrhizal inoculation technology, which has been shown to provide additional environmental benefits including:

- enhanced survival and growth of plants on eroded and nutrient-poor sites;
- optimized productivity of land aided by improved water and nutrient-use efficiency;
- improved biological health of the soil, including improved organic content, soil structure, porosity and water holding capacity;
- enhancement of the plants’ resistance to various environmental stresses such as heat and drought; and
- an increase in the forest’s ability to adapt to climate change, and better withstand extreme weather events.

No negative impacts have been envisioned for the project activity, reforestation of degraded lands.

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<sup>50</sup> Comisión Nacional del Medio Ambiente. 2003. “National Strategy Study for the CDM in Chile” Sanhueza, Eduardo, Moldonado, Pedro, and Neuenschwander, Aquiles, <http://www.gtz.de/de/dokumente/en-climate-chile-national-strategy-study-cdm-summary.pdf>, published by Deutsche Gesellschaft für Technische Zusammenarbeit,

## 6.0 STAKEHOLDER COMMENTS

The following stakeholder consultations were undertaken by Mikro-Tek prior to the start and during the course of the Reforesting Degraded Lands in Chile through the use of Mycorrhizal Inoculation project.

In 1999, to examine the feasibility of carbon sequestration projects in Chile, Mikro-Tek established a demonstration project in collaboration with Instituto Forestal (INFOR), a Chilean Forest Research Institute. Working with local individuals, forestry companies and organizations, local species and strains of mycorrhizae were collected, screened, tested and produced under a technology transfer agreement. Approximately one million seedlings were produced in local nurseries and planted in field trials to demonstrate the effect of mycorrhizal inoculation on the survival and growth of three tree species chosen by the Chilean authorities, including: Radiata pine, eucalyptus and Quillay (*Quillaja saponaria*).

In 2002, Mikro-Tek further conducted a Feasibility Study in which two members of Mikro-Tek, along with their Chilean agent, met with various potential stakeholders. The interviews fell into three categories: Chilean country CDM and Forestry authorities; Large-Scale Forestry Companies; and Small-Scale Forestry Groups. A total of 30 individuals were interviewed. All were provided with a report<sup>51</sup> on first year field performance of the demonstration seedlings and provided with an overview of the potential of applying this technology to reforestation projects. During the course of these 30 meetings, feedback, including comments and concerns, was invited and responses were given. Everyone seemed generally interested to learn more about the potential of participating in a reforestation project, and their concerns and questions could be summarized in three categories:

1. Technology Issues: concerns regarding barriers to incorporating technology in forestry projects: cost, availability, timing, shipping, application methods, training required, effects, indigenous vs. foreign mycorrhizal species, inoculation of cuttings vs. seedlings or genetically improved stock; how does the technology impact on normal handling of crops for the forestry company; will there be any effect on the properties of wood such as density, fiber etc.
2. Project Eligibility: questions regarding afforestation vs. reforestation, land reclamation, small-scale development projects, agroforestry etc; Can CDM projects be undertaken by a Chilean forestry company on their landholdings in other countries such as Argentina?
3. Kyoto Rules: who sets the rules; how would changing rules be addressed; potential need to aggregate small projects and how; how would credits be received, sold and distributed, at what intervals and how transferred to final investors; Reporting required from forestry partners, frequency and format; discussion of terms like additionality and permanence; methods for modeling carbon sequestration; how to ensure that foreign companies are not buying credits in Chile so that they can pollute more at home, etc.

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<sup>51</sup> Kean, M., M. Wood, & A. Unda. 2002. Demostración del Aumento en Almacenaje de Carbono en Plantaciones Forestales Chilenas mediante la inoculación con Micorrizas. Resultados del Primer Año de Plantación – junio 2002. Mikro-Tek, Inc.

Based on these interviews, and the success of the demonstration field trials, it was decided to proceed with a reforestation project working with small and medium sized landowners in Chile to use mycorrhizal inoculated Radiata pine and eucalyptus species to reforest degraded lands.

Since 2003, participating land owners and interested parties have been periodically contacted by phone, email, and personal meetings. In this way, partners have been kept abreast of changes to the project, as well as being provided printed updates on the field results from the demonstration plots established in 2001. Mikro-Tek's agent in Chile has been available for answering questions on a regular basis, and personnel from Canada have visited once each year to meet with local stakeholders and to collect updated information as required.

In December 2007, an extended stakeholder review process was conducted with a cross section of both the rural and urban population in the project region. A printed copy of Mikro-Tek's concept paper "Mycorrhizal Inoculation of CDM Afforestation Projects in Chile" was provided to give an overview of the project and Mikro-Tek's use of mycorrhizal inoculation technology in reforestation of marginal land. This document explained how these projects would sequester carbon from the atmosphere and generate carbon credits and would provide additional income for small and medium-scale landowners. The interviewer met personally with the respondents and explained the project in more detail, answered questions, and provided a written questionnaire that was filled out at the meeting, or in some cases, returned to the interviewer at a later date. There were no additional concerns expressed by any of the respondents, and many stated that they saw this as an opportunity for local landowners to improve the productivity and value of unproductive lands. Respondents were provided with contact information for future comments and/or questions about the project.

## APPENDICES

### APPENDIX A. NON-PERMANENCE RISK REPORT

The risk analysis has been conducted in accordance with the VCS AFOLU Non-Permanence Risk Tool version 3.2, dated 4 October 2012. This tool assesses a project's internal risk, external risk, natural risk and mitigation measures which help to reduce risk. The risk ratings and supporting evidence are detailed in Section 1, 2, and 3, below, and apply specifically to the initial project instances. Letters in the risk factor column correspond to the risk factor explained in the VCS Risk Tool.

#### A1.0 INTERNAL RISKS

| Project Management |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |             |
|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| Risk Factor        | Risk Factor and/or Mitigation Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Risk Rating |
| a)                 | Species planted, including <i>Pinus radiata</i> and <i>Eucalyptus globulus</i> , are non-native but are commonly planted in Chile and have been for >50 years and thus their suitability to the agro-ecological zone of the project is proven.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 0           |
| b)                 | There is no ongoing enforcement needed to prevent encroachment by outside actors on any part of the project area. Encroachment by outside actors is not anticipated as the planted areas are in a sparsely populated region and property lines are well marked and respected. Access into many of the project areas is by mountain road, which is steep in sections and sometimes contains water crossings in the rainy season, thus restricting access to 4-wheel drive vehicles.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 0           |
| c)                 | <p>The management team responsible for the day-to-day project management includes Mark Kean, Marilyn Wood, and Alfredo Unda, each with significant experience in their respective fields.</p> <p>Mark Kean founded Mikro-Tek in 1990 and has since led Mikro-Tek in its development of commercial mycorrhizal strains, its application of this biotechnology in both domestic and foreign markets, and use of the technology as an integral part of forest carbon projects. Mark has over ten years experience managing reforestation projects which incorporate the use of mycorrhizal inoculation in Chile.</p> <p>Marilyn Wood has over 20 years experience in small business management. She is responsible for maintenance of Mikro-Tek's strategic organizational plans, accounting and management information systems; development and execution of marketing efforts including licensing and distribution agreements in foreign markets; and, international and domestic project management.</p> <p>Alfredo Unda has been working with Mikro-Tek on projects in Chile since 1998. Alfredo is a Santiago based forester who has an extensive background in environmental consulting, natural resource management, and FSC auditing. Alfredo's primary role is as a project manager for Mikro-Tek's carbon sequestration projects and also acts as a liaison between Mikro-Tek and Chilean forestry partners.</p> | 0           |
| d)                 | Although Mikro-Tek's headquarters are in Timmins, ON, Canada, a branch office has been established in Chile with a local project manager. The branch office is located                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 0           |

|                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |           |
|---------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
|                                                                                                               | in Santiago, approximately 200 km to the north of the project areas, and is run by a Chilean forester. The forest management team is local, and visits the project sites to monitor progress several times a year.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |           |
| e)                                                                                                            | <p>The management team has experience in AFOLU project design and implementation. Mark Kean of Mikro-Tek has developed a forest carbon project under the CDM, and has been working in the forest carbon arena for over 5 years with experiences including managing the project design, implementation, and financing.</p> <p>The project proponents work alongside and have access to experts in carbon accounting and reporting (i.e., TerraCarbon) who have significant experience in all aspects of AFOLU project design and implementation, carbon accounting and reporting under the VCS Program. TerraCarbon has successfully validated and verified numerous projects under the VCS, including validation and verification of the VCS ARR project "Reforestation Across the Lower Mississippi Valley"</p> | -2        |
| f)                                                                                                            | Not applicable.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 0         |
| <b>Total Project Management (PM) [as applicable, (a + b + c + d + e + f)]</b><br>Total may be less than zero. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>-2</b> |

| Financial Viability                                                                                                              |                                                                                                                                                  |             |
|----------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| Risk Factor                                                                                                                      | Risk Factor and/or Mitigation Description                                                                                                        | Risk Rating |
| a, b, c, d)                                                                                                                      | The project cash flow breakeven point (in 2013) is 4 years or less from the current risk assessment, as documented in the project database.      | 0           |
| e, f, g, h,)                                                                                                                     | Project has secured all necessary funding to cover cash out for plantation establishment, provided by Micro-Tek and loans administered by CONAF. | 0           |
| i)                                                                                                                               | Not applicable.                                                                                                                                  | 0           |
| <b>Total Financial Viability (FV) [as applicable, ((a, b, c or d) + (e, f, g or h) + i)]</b><br>Total may not be less than zero. |                                                                                                                                                  | <b>0</b>    |

| Opportunity Cost  |                                                                                                                                                                                                                                                                                                                                                                                                                               |             |
|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| Risk Factor       | Risk Factor and/or Mitigation Description                                                                                                                                                                                                                                                                                                                                                                                     | Risk Rating |
| a, b, c, d, e, f) | <p>The dry climate and degradation of the soil pose a significant ecological barrier. The only credible alternative land use scenario, as identified and substantiated in the additionality analysis, is abandoned pasture, with an equivalent NPV of zero. Hence, NPV from the project activity is expected to be at least 50% more profitable than the most profitable than the credible alternative land use activity.</p> | -4          |
| g)                | Not applicable.                                                                                                                                                                                                                                                                                                                                                                                                               | 0           |

|                                                                                                                      |                                                                                                                                                                                                                                                  |          |
|----------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| h, i)                                                                                                                | Project is protected by legally binding commitment (i.e., CONAF approved forest management plan with commitment to replant after each harvest) to continue management practices that protect the credited carbon stocks over at least 100 years. | -8       |
| <b>Total Opportunity Cost (OC) [as applicable, (a, b, c, d, e or f) + (g or h)]</b><br>Total may not be less than 0. |                                                                                                                                                                                                                                                  | <b>0</b> |

| Project Longevity                                                |                                                                                                                                                                                                                                                                                                                                                                  |          |
|------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| a, b)                                                            | While the project crediting period is 40 years, on each project parcel there is a legal requirement under CONAF Forest Law 701 to replant and allow re-growth of harvested areas, hence maintaining the areas as forest. As there is a legally binding agreement that covers at least a 100 year period from the project start date, a score of zero is applied. | 0        |
| <b>Total Project Longevity (PL)</b><br>May not be less than zero |                                                                                                                                                                                                                                                                                                                                                                  | <b>0</b> |

| Internal Risk                                                                      |          |
|------------------------------------------------------------------------------------|----------|
| <b>Total Internal Risk (PM + FV + OC + PL)</b><br>Total may not be less than zero. | <b>0</b> |

## A2.0 EXTERNAL RISKS

| Land Ownership and Resource Access/Use Rights |                                                                                                                                                                                                                                                                                                         |             |
|-----------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| Risk Factor                                   | Risk Factor and/or Mitigation Description                                                                                                                                                                                                                                                               | Risk Rating |
| a)                                            | Not applicable.                                                                                                                                                                                                                                                                                         | 0           |
| b)                                            | The project area is under clear private title to the land owners and subject to a legally-binding Business Collaboration Agreement. Mikro-Tek is assigned the carbon rights as mentioned in Section 1.12 of the PD.                                                                                     | 2           |
| c)                                            | No dispute over land ownership or land tenure exists for any part of the project area.                                                                                                                                                                                                                  | 0           |
| d)                                            | No dispute over access/use rights exist for any part of the project area.                                                                                                                                                                                                                               | 0           |
| e)                                            | Not applicable.                                                                                                                                                                                                                                                                                         | 0           |
| f)                                            | Project area is protected by legally binding commitment to continue management practices that protect carbon stocks over the length of the project crediting period. For each project parcel there is a legal requirement under CONAF Forest Law 701 to replant and allow re-growth of harvested areas. | -2          |

|                                                                                                               |                 |          |
|---------------------------------------------------------------------------------------------------------------|-----------------|----------|
| g)                                                                                                            | Not applicable. | 0        |
| <b>Total Land Tenure (LT) [as applicable, ((a or b) + c + d + e + f)]</b><br>Total may not be less than zero. |                 | <b>0</b> |

| Community Engagement                                                                               |                                                                                                                                                                                                                                                             |             |
|----------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| Risk Factor                                                                                        | Risk Factor and/or Mitigation Description                                                                                                                                                                                                                   | Risk Rating |
| a, b)                                                                                              | Community engagement risk has been assessed as zero because no people live or lived within the project area and the population within 20 km of the project area is not reliant on the project area for food, fodder, fuel, medicine, or building materials. | 0           |
| c)                                                                                                 | Not applicable.                                                                                                                                                                                                                                             | 0           |
| <b>Total Community Engagement (CE) [where applicable, (a+b+c)]</b><br>Total may be less than zero. |                                                                                                                                                                                                                                                             | <b>0</b>    |

| Political Risk                                                                                          |                                                                                                                                                                                                    |             |
|---------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| Risk Factor                                                                                             | Risk Factor and/or Mitigation Description                                                                                                                                                          | Risk Rating |
| a, b, c, d, e)                                                                                          | Chile's governance score (1.16) is 0.82 or higher. Calculation of the governance score is documented in the project database.                                                                      | 0           |
| f)                                                                                                      | The country has an established Designated National Authority, Comisión Nacional del Medio Ambiente (CONAMA), under the CDM and has at least one registered CDM Afforestation/Reforestation project | -2          |
| <b>Total Political (PC) [as applicable ((a, b, c, d or e) + f)]</b><br>Total may not be less than zero. |                                                                                                                                                                                                    | <b>0</b>    |

Table A1. Calculation of Chile's average governance score.

| Governance Indicator                    | 2007 | 2008 | 2009 | 2010 | 2011 |
|-----------------------------------------|------|------|------|------|------|
| Voice and Accountability                | 1.07 | 0.99 | 0.98 | 1.06 | 1.06 |
| Political Stability/Absence of Violence | 0.38 | 0.41 | 0.56 | 0.63 | 0.56 |
| Government Effectiveness                | 1.27 | 1.18 | 1.15 | 1.18 | 1.17 |
| Regulatory Quality                      | 1.48 | 1.54 | 1.5  | 1.47 | 1.54 |
| Rule of Law                             | 1.24 | 1.29 | 1.24 | 1.29 | 1.37 |
| Control of Corruption                   | 1.34 | 1.34 | 1.38 | 1.5  | 1.57 |
| Overall Mean                            | 1.16 |      |      |      |      |

| External Risk                             |          |
|-------------------------------------------|----------|
| <b>Total External Risk (LT + CE + PC)</b> | <b>0</b> |

Total may not be less than zero.

### A3.0 NATURAL RISKS

| Fire Risk             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|-----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Evidence              | Statistics on the extent of fire in Region VI, VII, and VIII are shown in Table A1, below. An analysis of these data demonstrates that fire affects on average 1.7% of the area of plantation forest in Region VI, VII, and VIII each year. Over a 100 year period, fire is therefore likely to occur every 58.8 years <sup>52</sup> on any given parcel. Due to the geographic spread of the project instances and the fact that fires rarely affect more than 50% of biomass on site, fires are unlikely to result in greater than a 50% loss of carbon stocks in the project area and the significance has been assessed as major.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| Significance          | Major                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| Likelihood            | Every 50 to less than 100 years                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Score (LS)            | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Mitigation            | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Pest and Disease Risk |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Evidence              | Chile is largely a pest free country due in part to its natural conditions and in part to the strict pest control and surveillance program of SAG (Servicio Agrícola y Ganadero), the entity responsible for the permanent monitoring of pests in fruit and forestry plantations. Risks of pests and disease found in plantation forests in the project region are mitigated by correctly siting plantation species and close oversight and management. Further, local foresters have access to pest and disease management expertise at the local SAG office.<br><br>Data from the FAO <sup>53</sup> estimate that 1,341,000 ha of forest land were disturbed by pest and disease in Chile in the year 2000. With a total forest area of 16,121,000 ha, this implies that 8.3% of Chilean forests are affected annually. Assuming all forest is equally likely to be infected by pest and disease, this indicates a return interval of over 12 years <sup>54</sup> . Due to the geographic spread of the project instances and the fact there are no pest species that lead to full stand replacement currently in Chile, pest and disease in the project region are unlikely to affect more than 25% of the carbon stocks in the project area, hence the significance has been assessed as minor. |
| Significance          | Minor                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| Likelihood            | Every 10 to less than 25 years                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Score (LS)            | 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |

<sup>52</sup> The return interval is calculated as 100 years divided by 1.7 = 58.8 years.

<sup>53</sup> FAO. 2009. Global Review of Forest Pests and Diseases. FAO Forestry Paper 156. Food and Agricultural Organization of the United Nations, Rome

<sup>54</sup> The return interval is calculated as 100 years divided by 8.3 = 12 years.

|                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|-----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Mitigation                  | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Extreme Weather Risk</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Evidence                    | <p>Extreme weather risks affecting the project area include blowdown due to strong winds, rain induced flooding and erosion, and drought,</p> <p>A local forester who has worked in Chile's central valley for over ten years has confirmed that he does not know of any instances of blowdown affecting plantations in the planting region (I. Fazzi, pers. comm.). As such the likelihood of an extreme wind event is thought to be in the range of once in every 100 years or more which corresponds to a score of zero risk.</p> <p>While the risk of severe rain events include flooding and erosion, flooding is not an issue as the project areas are on slopes or the top of mountains and are not prone to flooding. When water is channelized due to natural topography, rain events can lead to erosion and mortality of planted trees. While the return interval of gully erosion is not known, the effect is likely to be insignificant with less than 1% of the project area being affected in a way that leads to tree mortality.</p> <p>In 2011, Núñez et al,<sup>55</sup> estimated that significant droughts have a return period of 22 years in the project region. Given that the geographic spread of the project stands and their various ages (with the knowledge that drought effects decrease with stands establishment and development), any drought is unlikely to lead to significant (&gt;50%) loss in carbon stocks and the significance level has been assessed as major.</p> <p>The highest likelihood and greatest significance (that of drought) was used to assess the risk of extreme weather.</p> <p>A mitigation measure used to lessen the influence of drought has been built into the project design whereby the susceptibility of all trees planted to drought is reduced because of the increased water uptake capacity of the mycorrhizal inoculated seedlings.</p> <p>The significance of extreme weather risk is estimated at major with a likelihood estimated as once every 25-50 years.</p> |
| Significance                | Major                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Likelihood                  | Every 10 to less than 25 years                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| Score (LS)                  | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Mitigation                  | 0.50                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Geologic Risk</b>        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Evidence                    | <p>Geologic risks in Chile include volcanoes, earthquakes, and land slides. Volcanoes in the project region and earthquakes are unlikely to result in a</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |

<sup>55</sup> Núñez, J. H.; Verbist, K.; Wallis, J. R.; Schaefer, M. G.; Morales, L.; Cornelis, W. M. 2011. Regional frequency analysis for mapping drought events in north-central Chile. Journal of Hydrology, Volume 405, Issue 3, p. 352-366.

|              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|              | significant loss to the projects carbon stocks due to their distance. The closest volcano to any project area is the Antuco Volcano which is approximately 65 km from the site MikroTek0040 in Region VIII. While landslides are arguably the most significant natural risk, planted trees are arranged along contours when on sloped ground and project proponents have avoided planting in very steep areas. Further, the project activity is likely to reduce the incidence of land slides as roots of planted trees stabilize slopes and reduce erosion. The significance of geologic risk is estimated at minor with infrequent likelihood estimate as once every 50-100 years. |
| Significance | Minor                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Likelihood   | Every 50 to less than 100 years                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Score (LS)   | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Mitigation   | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

Natural risk is quantified by assessing both the significance (i.e. the damage that the project would sustain if the event occurred, expressed as an estimated percentage of average carbon stocks in the project area that would be lost in a single event) and likelihood (i.e., the historical average number of times the event has occurred in the project area over the last 100 years) of the four primary types of natural risk, including the risk of fire, pest and disease, extreme weather, and geologic hazards. The significance of the risk of fire and extreme weather has been assessed as “Major” as none of these risks, should they occur, result in greater than a 50% loss of carbon stocks in the project area. The significance of pest and disease and geologic risk have been assessed as “Minor” as neither pest and disease, volcanic activity, earthquakes, or landslides, if they occur, would lead to a loss of greater than 25% of the carbon stocks in the project area. The significance of the above natural risks has been assessed as such due the dispersed nature of the planted fields. By planting in three regions, the occurrence of any natural risk is unlikely to affect 50% of the planted areas. Where a natural risk does occur it is unlikely to remove >50% of the carbon stocks in the project area.

It is at times difficult to quantify the likelihood of natural risks when these risks occur infrequently. By definition likelihood is the historical average number of times an event has occurred over the last 100 years. Another term often used when referring to the likelihood of natural risk is the return interval. The return interval is common in literature pertaining to fire and flooding (e.g., the 100 year flood). While the likelihood or return interval would also be useful for geologic risk, a key feature when calculating the likelihood or return interval is that an event has occurred enough times in enough places such that there is sufficient data to calculate the return interval. A review of the literature revealed little data to support a return interval for Chile for geologic risk. For this reason, we have conservatively assigned geologic risk a return interval of “Every 50 to less than 100 years”.

Table A2. Total areas of forest fires in plantations per region.

| Region      | 2001-2002 | 2002-2003 | 2003-2004 | 2004-2005 | 2005-2006 | 2006 - 2007 | 2007-2008 | 2008-2009 | 2009-2010 | 2010-2011 | Average area affected by fire per year (ha) | Area of plantation forest (ha) | Percent of plantation forest affected by fire (%) |
|-------------|-----------|-----------|-----------|-----------|-----------|-------------|-----------|-----------|-----------|-----------|---------------------------------------------|--------------------------------|---------------------------------------------------|
| Region VI   | 151       | 315       | 1,468     | 533       | 498       | 1,955       | 511       | 2,253     | 1,708     | 1,883     | 1,128                                       | 73,340                         | 1.5                                               |
| Region VII  | 941       | 769       | 708       | 531       | 199       | 217         | 812       | 3,329     | 1,990     | 6,727     | 1,622                                       | 174,252                        | 0.9                                               |
| Region VIII | 13,866    | 1,094     | 4,726     | 2,592     | 357       | 21,834      | 2,008     | 7,610     | 7,571     | 432       | 6,209                                       | 231,973                        | 2.7                                               |

Fire data is from Corporación Nacional Forestal (CONAF). 2011. Estadísticas Históricas Incendios Forestales. <http://www.conaf.cl/proteccion/seccion-estadisticas-historicas.html> Accessed 19 July 2011.

Area of plantation forest is from Instituto Nacional de Estadísticas (INE). 2007. Censo Agropecuario 2007.

[http://www.ine.cl/canales/chile\\_estadistico/censos\\_agropecuarios/censo\\_agropecuario\\_07\\_comunas.php](http://www.ine.cl/canales/chile_estadistico/censos_agropecuarios/censo_agropecuario_07_comunas.php) Accessed: 17 July 2012

| Score for each natural risk applicable to the project<br>(Determined by (LS × M)) |            |
|-----------------------------------------------------------------------------------|------------|
| Fire (F)                                                                          | 1          |
| Pest and Disease Outbreaks (PD)                                                   | 2          |
| Extreme Weather (W)                                                               | 2.5        |
| Geological Risk (G)                                                               | 1          |
| Other natural risk (ON)                                                           | 0          |
| <b>Total Natural Risk (as applicable, F + PD + W + G + ON)</b>                    | <b>6.5</b> |

#### A4.0 OVERALL NON-PERMANENCE RISK RATING AND BUFFER DETERMINATION

##### A4.1 Overall Risk Rating

The overall risk rating calculated using the VCS AFOLU Non-Permanence Risk Tool is 6.5%, as calculated below.

| Risk Category                          | Rating     |
|----------------------------------------|------------|
| a) Internal Risk                       | 0          |
| b) External Risk                       | 0          |
| c) Natural Risk                        | 6.5        |
| <b>Overall Risk Rating (a + b + c)</b> | <b>6.5</b> |

As the calculated buffer (6%) is less than the default withholding percentage (10%), the default nonpermanence risk deduction of 10% will be used.

##### A4.2 Calculation of Total VCUs

Over the 40 year life of the project, the project area is expected to sequester 749,504 tons t CO<sub>2</sub>-e leading to a buffer pool contribution of 74,950 t CO<sub>2</sub>-e and a total expected emission reduction of 674,554 t CO<sub>2</sub>-e. Annual ex-ante estimates, including deductions to be deposited in the AFOLU pooled buffer account, are detailed in Section 3.4 of the project document.

Table A2. Emissions reductions (t CO<sub>2</sub>-e) expected to be generated by the project over the crediting period.

| Aspect of emission reductions estimate                                                 | t CO <sub>2</sub> -e |
|----------------------------------------------------------------------------------------|----------------------|
| Net forest carbon sequestration (t CO <sub>2</sub> ) (With project scenario- baseline) | 749,504              |
| Buffer pool contribution                                                               | 74,950               |
| <sup>1</sup> Implementation of Project Activity                                        | 0                    |
| <sup>2</sup> Leakage                                                                   | 0                    |
| <i>Total Emission Reductions</i>                                                       | 674,554              |