Forest Carbon Partnership Facility (FCPF)
Carbon Fund

ER Monitoring Report (ER-MR)

ER Program Name and Country:	Emission Reduction Program of the National Strategy on Climate Change and Vegetation Resources (ENCCRV). Republic of Chile
Reporting Period covered in this report:	01-01-2018 to 04-12-2019
Number of FCPF ERs:	-5,353,046
Quantity of ERs allocated to the Uncertainty Buffer:	0
Quantity of ERs to allocated to the Reversal Buffer:	0
Quantity of ERs to allocated to the Reversal Pooled Reversal buffer:	0
Date of Submission:	29-dic-2023
Version	

Acronyms

AFOLU: Agriculture, Forestry and Other Land Use
AGCID: Agency for International Development Cooperation
ASP: Protected Wild Areas
BSP: Benefit Sharing Plan
CAPR: Rural Drinking Water Committees
CATS: Carbon Assets Tracking System
CONADI: National Indigenous Development Corporation
CONAF: National Forestry Corporation
CORECC: Regional Climate Change Committees
COSOC: CONAF Civil Society Council
MRS: Mechanisms for Complaints and Suggestions
CTICC: Interministerial Technical Committee on Climate Change
CTR-CC: Technical Coordinator of MINAGRI's Regional Technical Committee on Climate Change
DBOCC: Climate Change and Forest Departments
DCCSE: Climate Change and Ecosystem Services Department
DMECC: Climate Change and Ecosystem Monitoring Department
ENCCRV: National Strategy on Climate Change and Vegetation Resources
ERPA: Emissions Reduction Program Agreement
ERPD: Emissions Reduction Program Document
FAO: Food and Agriculture Organization
FCPF: Forest Carbon Partnership Facility
FGRM: Feedback and Grievance Redress Mechanism
FIA: Foundation for Agricultural Innovation
FMT: Fund Management Team
FREL/FRL: Forest Reference Emission Level/ Forest Reference Level
GASP: Protected Wilderness Areas Management
GBCC: Forest and Climate Change Management
GCEBX: Forest and Xerophytic Ecosystems Conservation Management
GEF MST: GEF/Sustainable Land Management Project (MST)
GEF: Environmental Evaluation and Oversight Management
GEFA: Finance and Administration Management
GEPRIF: Forest Fire Protection Management
GCF: Green Climate Fund
IFN: National Forest Inventory
INDAP: Institute for Agricultural Development
INFOR: National Forest Monitoring System
INGEI: Forest Reference Level and the National Greenhouse Gas Inventory
IPCC: Intergovernmental Panel on Climate Change
LEMU: Logging and Extraction Monitoring Unit
MGAS: Environmental and Social Management Framework
MINAGRI: Ministry of Agriculture
MINENERGIA: Ministry of Energy
MMA: Ministry of the Environment
MOFIM: Mapuche Intercultural Forestry Model
NDC: National Determined Contribution
NFMS: National Forest Monitoring System
ODEPA: Office of Agricultural Studies and Policies
OIRS: Information, Complaints and Suggestions Office
PAT: Biomass Territorial Supply Program
PMST: Sustainable Land Management Project

PTN: National Technical Proposal
PTR: Regional Technical Proposal
SAFF: Forestry Administration and Control System
SAG: Livestock Agricultural Service
SAQ: Burn Assistance System
SAT: Early Warning System
SEA: Environmental Assessment Service
SEGEGOB: Ministry General Secretariat of Government
SEIA: Environmental Impact Assessment System
SEREMI: Ministerial Regional Secretary
SESA: Strategic Environmental and Social Assessment
SIAC: Public Environmental Information System
SIDCO: Digital Information System for Operations Control
SIGEFOR: Forestry Promotion and Development Management System
SIGI: Institutional Management Information System
SIS: Safeguards Information System
SIT: Territorial Information System
SMM: Monitoring and Measurement System
SNASPE: National System of State-Protected Wilderness Areas
SNIChile: Chilean National Greenhouse Gases Inventory System
SPF: Secretariat for Forest Policy
SVS: Soil Conservation Service (USDA)
TNC: The Nature Conservancy
UACh: Universidad Austral de Chile
UAIS: Indigenous and Social Affairs Unit
UNCCD: United Nations Convention to Combat Desertification
UNFCCC: United Nations Framework Convention on Climate Change
UN-REDD: United Nation Reducing Emissions from Deforestation and forest Degradation
UPCT: Public Participation and Transparency Unit
UTRE: Specialized Regional Technical Unit

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1 IMPLEMENTATION AND OPERATION OF THE ER PROGRAM DURING THE REPORTING PERIOD

1.1 Implementation status of the ER Program and changes compared to the ER-PD

The ER Program (PRE, acronym in Spanish) of Chile corresponds to the activities developed within the framework of the implementation of the (ENCCRV, acronym in Spanish). The ENCCRV corresponds to a public policy instrument that aims to improve the condition of forest ecosystems and increase their resilience, promoting the reduction and capture of Greenhouse Gases (GEI, acronym in Spanish), along with reducing the vulnerability of human communities that rely on forests. To achieve the goal of directing and facilitating action measures were established through various technical analysis and a participative process at a national scale. Such measures are organized and reinforced through the various regular programs, plans and activities implemented by the National Forestry Corporation (CONAF, acronym in Spanish), and are supplemented in technical and financial terms with other climate initiatives with international support (FCPF, UN-REDD, GEF MST Project, Swiss Development Cooperation, Chile-México Fund). The main developments on the ER Program for the 2018 – 2019 period are presented in this chapter.

Progress on Chile´s ER Program actions and interventions

The activities developed by the ER Program in the 2018 – 2019 period encompassed actions associated to CONAF regular activities, conducted with state funding along with funds from multilateral organizations directly managed by the Corporation. For the most part, activities were focused on the implementation of pilot or demonstrative projects, capability improvement actions and environmental education at the territorial level. This follows the ENCCRV implementation approach, which prioritizes the reduction of emissions caused by forest degradation and deforestation, due to its effectiveness at reducing emissions at a lower implementation cost.

Activities implemented with a national budget

A summary of the outcomes for the ER Program activities implemented by CONAF in the reporting period is presented hereafter. These activities are associated to ENCCRV action measures and will be detailed in the safeguard's implementation report that CONAF is developing for the World Bank (BM, acronym in Spanish) and the additional background document for the Chile ERPD revision[1].

- Outcomes of deforestation reduction actions: 1,297 inspections at property level, derived from third party complaints, were conducted in the 6 regions of the accounting area during the reporting period. 438 property inspections and compliance controls were also conducted through satellite images (SAT/Logging and Extraction Monitoring Unit, LEMU). 686 inspections on firewood production sites and roadside checks were achieved in accordance with Title IV of 20,283 (D.S N°93). Finally, 11,878 hectares associated to native forest management, forestry law, extraction, felling, or work plan related to technical studies were also inspected.

- Outcomes of forest degradation reduction actions: Multiple initiatives considering improvements on firewood productive chains were conducted during the reporting period, focused on reducing market informality and therefore enabling sustainable management. Some of these actions included supporting beneficiaries (owners and farmers) in order to raise financing for the production, processing or commercialization of goods and/or services, associative business development planning, farmer certification and associativity network development (technical tours, work groups). In 2018, 688 firewood production sites were addressed with a total stock of 451,216 stere cubic meters of dry firewood, while 419 production sites with a total stock of 255,284 stere cubic meters of dry firewood were addressed in 2019. Related to another aspects of degradation, 27 community plans for forest fire prevention were developed

[1] Additional background for the Chile ER Program revision, as per recommendations from the Summary at the 15th Carbon Fund Meeting. Chile National Strategy on Climate Change and Plant Resources (2017-2025). 2018

within the framework of the Prepared Community program for forest fires, along with 51 municipal protection plans for areas at risk of forest fires. From a more technical perspective, 10 assessments were conducted for large fires during the 2018 – 2019 period. Finally, regarding the extent of capacity building for reducing risks for degradation, work was done with 5,329 beneficiaries of training sessions and inspections within the controlled burning program for forestry and agricultural waste. 295,260 beneficiaries were also trained in preventive forest management.

- Outcomes of stock enhancement actions: 146 hectares were implemented within the framework of the participative afforestation program, while the tree planting program delivered 345,000 and 65,000 native plants to beneficiaries and indigenous communities/associations, respectively. Also 1,330 native forest sustainable management plans were subsidized under Law 20,283 of Native Forest Recovery and Forest Promotion, which entails implementing actions across a total of 2,863 hectares.

- Outcomes of conservation actions: 14 concession audits were conducted in the National System of State-Protected Wilderness Areas (SNASPE, acronym in Spanish), including 4 National Parks located in 3 regions within the Accounting Area (AC, acronym in Spanish). 5 management plans under the SNASPE enhanced planning method -including actions on climate change- were also developed or updated, and a Wilderness Protected Area planning manual was developed. 40 strategies for threat management in 13 National Parks, 19 National Reserves and 4 Natural Monuments were implemented during the reporting period, along with creation, expansion and re – categorization proposals for 5 Protected Wilderness Areas (ASP, acronym in Spanish) being also generated.

- Outcomes of cross – cutting actions: 425 teachers from rural schools and the forest – urban interface were trained in systematic environmental education issues. 42 education plans for ASP conservation were also developed, and 1,617 beneficiaries were trained in urban woodland and environmental management. In a more technical aspect, 12 large – scale training activities were conducted regarding the benefits of Law 20,283, its promotion instruments, procedures (deadlines, requirements, amounts), topics regarding native forest silviculture, planning (management plans) along with commercialization and productive chains.

Activities funded by international agencies

- FPCF II/Implementation of Specialized Technical Regional Units (UTRE, acronym in Spanish): these units were established in each region of the ER Program with the aim of providing expert advice regarding the implementation of natural resource best management practices within the framework of ENCCRV action measures. UTREs were implemented in the regions within the ER Program to enhance the technical capabilities of the institution and local beneficiaries (Mainly medium and small-scale owners).

- Seven activities were established to achieve the goals defined by UTREs, namely:

1. Design and management of an intervention Model Program promoting the sustainable management of native forests (with emphasis on degradation) considering productive chains and business models associated to this resource, focusing on the increase of products and/or services supply from sustainable sources.
2. Contribute to the improvement of the Forest Extension Program implemented by CONAF in the context of climate change, desertification, land degradation and drought.
   Activities 1 and 2 are related to the development of two ENCCRV action measures: MT.4 Reforestation and Revegetation Program in prioritized areas/municipalities, and US.1 Institutional Forest Management Program focused in public and private plots.
3. Develop funding procurement technical proposals aimed towards the regional implementation of action measures in national, regional and/or municipal, public, or private instances. This activity has a cross – cutting relationship with the ENCCRV direct action measures.

4. Support the technical advice provided by CONAF to foresters and farmers to promote forest fire preventive actions. Such activities are related to three ENCCRV action measures: IF.4 Reinforcing the Prepared Communities against forest fires program; IF.3 Preventive Silviculture program focused on the rural – urban interface and IF.5 Inclusion of post fires preventive management and restoration elements in Law No. 20,283 and its provisions.
5. Design and prospect a territorial supply program (PAT, acronym in Spanish) of Biomass that guarantees the supply of standardized biomass from sustainable sources. This activity is related to action measure US.3 Reinforcement of the Wood Fuel Program and energy matrix of Chile.
6. Enhance the oversight capabilities of the institution through training in the use of early detection and monitoring systems developed under ENCCRV, with emphasis on municipalities at greater risk of Deforestation and Degradation. This activity is related to two action measures: MT.7 Reinforcement of environmental and forest oversight programs, and MT.6 Environmental education and dissemination program.
7. Review and application of social and environmental safeguards to the aforementioned activities. This activity is cross – cutting in nature, as it encompasses all ENCCRV elements and entails the use of safeguard instruments developed within the Social and Environmental Management Framework.

- GEF/Sustainable Land Management Project (PMST, acronym in Spanish): this project implements activities in the La Araucanía region of the ER Program. 44 activities were implemented during the 2018 – 2019 period in this region, mainly associated to the ENCCRV MT.6 action measure, specifically regarding environmental training and education.

- UN-REDD National Program/Support Program for the Chilean National Strategy on Climate Change and Vegetation Resources (ENCCRV): Assessment, implementation and gathering of lessons learned from operative action measures looking to establish new sustainable, replicable and scalable forest management models, including project implementation for Environmental Services – based payment projects (PSA, acronym in Spanish).

  Specifically: Continuous implementation of restoration and climate change adaptation actions in the Andean pre – mountain range. By this time, progress has been made on the restoration of 182 hectares, including a total of 25,670 individuals belonging to native tree species, along with planting 250,000 Araucaria pine nut seeds in a restoration strategy under a river basin protection approach. A 4.7-kilometer-long protective fence has been built in a complementary manner. Development of a project focusing on the recovery of pine nut ancestral gathering (sustainable) practices to improve adaptation and mitigation actions in the Quinquén indigenous community. Implementation of two PSA projects together with Rural Drinking Water Committees (CAPR, acronym in Spanish), in the Mashue and Liquiñe communities, based on the reinforcement and implementation of a compensation model for the water supply ecosystem service. Also, 27 hectares were reforested under a water stream dynamics protection and recovery approach. In parallel, 12 hectares were closed off through the construction of 3,783 meters of protective fences against herbivores.

- Advances in Carbon Accounting: Methodology and territorial scope improvements have been developed in the Forest Emissions Reference Level/Forest Reference Level (FREL/FRL), along with improvements in the National Forest Monitoring System (NFMS) and the Safeguard Information System (SIS). Details of this progress are included in Annex 4 of this report.

- Swiss Agency for Development and Cooperation (SDC)/Second contribution phase for ENCCRV development: a pilot project of ecological restoration was implemented in the La Araucanía region during 2019 during this second collaboration phase. The purpose of this initiative was the environmental

restoration of the Purén Alto River, to improve water availability and reduce erosion in small rural properties as a climate change adaptation action. The main activities conducted in the territory were the placement of erosion control modules, reforestation with native species, and innovation activities associated to rainfall accumulation, collection, and consumption.

Other technical advancements

- Advances in Safeguards: Developments have taken place during the reporting period related to the technical design for the subsequent implementation of the Safeguard Information System (SIS). This system is developed with a multiscale – local, operational, administrative, national approach to determine compliance with REDD+ safeguards within the ENCCRV implementation. On the other hand, the World Bank announced changes from the Social and Environmental Management Framework (MGAS, acronym in Spanish) to the Environmental and Social Framework which offers broad, systematic coverage of environmental and social risks with developments in transparency, non-discrimination, public participation, and accountability. Coordination with CONAF´s Information, Suggestions and Complaints Office (OIRS, acronym in Spanish) has been reinforced for the inclusion and improvement of the procedure associated to the ER Program Mechanisms for Complaints and Suggestions (MRS, acronym in Spanish). Finally, DCCSE safeguard specialists have developed and delivered a National ENCCRV Safeguards Approach Proposal, system that will address the commitments made within the ENCCRV framework. Further details regarding such developments are presented in Annex 1 of this document.

- UN REDD/Environmental Services Payment Program: Two pilot projects were developed together with Rural Drinking Water Committees (CAPR) in the Mashue, Niebla-Los Molinos and Liquiñe communities in the Los Ríos region based on the reinforcement and implementation of a compensation model for water supply ecosystemic services. Also, a project focused on the restoration of pine nut ancestral gathering practices to improve adaptation and climate change mitigation actions in the Quinquen, La Araucanía Region, indigenous community was implemented. The purpose of this project is to support bringing back ancestral pine nut sustainable management by means of planting a percentage of the seeds in nurseries, along with their subsequent use for replanting in high – priority sites.

Strategy Update to mitigate/and or minimize potential displacements

The ERPD 2016 document from Chile proposed that the most important way for ENCCRV to avoid displacements would be to implement action measures at the national level. Under this approach, the likelihood of displacements becomes significantly lower. This way remains the most relevant in the ER Program reporting period, as ENCCRV actions are effectively being implemented across all regions of Chile and not just those in the AC. Nevertheless, the ERPD mentioned possible local displacements could occur inside the AC, for which measures associated to some of the main drivers identified were proposed.

In 2018, the document "Additional background for the update of the Chilean ER Program, according to recommendations by the Chair´s Summary in the 15th Meeting of the Carbon Fund", does not refer to any changes in the strategy for mitigating and/or minimizing these possible displacements. If that is so, the strategy used to mitigate displacements inside the AC remains as such, i.e., through measures designed for some of the main causes or drivers associated to forest degradation and deforestation, which have been updated as such for the period of this report:

DD cause/driver	ERPD proposed strategy to reduce displacement risks (2016)	Strategy update for report period (2018-2019)
Unsustainable use of vegetation resources.	With the forestry management actions proposed by the ENCCRV to address this driver, a risk of emission displacement is generated due to the reduction of the potential extraction volume by forest owners under planning criteria. The strategy proposed to reduce or avoid such displacements consists in increasing sale prices under a higher valuation for sustainably sources wood. In this manner, owners can extract less wood without impacting their revenue. This is achieved through improved productive chains, moving forward in the sustainable firewood and wood certification process for obtaining better prices. On the other hand, the ENCCRV will seek to lower production costs for owners through tax reductions and improved monitoring to promote sustainable forest management.	Multiple support activities for productive chains, oversight and planning in sustainable management have been carried out within the ER Program, so this strategy remains current and active. The only component of the strategy without developments has been the tax reduction for sustainable producers.
Forest fires	With the fire prevention actions proposed by ENCCRV to address this driver, such as preventive silviculture, there is a risk of emissions displacement by promoting forest biomass extraction actions (Fire and fuel gaps). The strategy proposed to avoid and reduce such emissions entails, on one hand, detailed planning of each activity to identify the best way to remove a minimum amount of biomass with the greatest impact on fire risk reduction, and on the other, using the extracted biomass in wood – based products that fix carbon in longer terms.	Multiple training activities in fire prevention silviculture and productive linkage for owners and producers have been conducted within the framework of the ER Program and ENCCRV. Pilot experiences have also been developed, making it possible to advance in the technical validation of fire prevention silviculture and include the costs of such projects in the value table of Law No. 20,283. Given this, it can be said that this strategy is current and active for this risk.
Forest being used for livestock farming	Establishing buffer zones for livestock farming in forest areas is one of the measures proposed by the ENCCRV for addressing this driver. There is a risk of this measure generating emissions displacement, as cattle will have to be moved to other grazing areas and cause degradation. The strategy for reducing such risk is based on supporting the development of global livestock management plans, leading to a more efficient use of plains, forest grazing systems and summer grazing management.	Property planning activities have been conducted in the framework of the ER Program and ENCCRV integrating various land uses and productive activities (Livestock and forestry). UTREs have also developed such property plans for various pilot properties. On the other hand, the GEF MST project, which includes one of the AC regions, has generated pilot experiences and capabilities in management at a property scale, maximizing productive efficiency and the structured use of State promotion instruments. Given this, it may be stated that this strategy is current and active for this displacement risk, which is considered to be medium. Reinforcing such actions through training instances in other regions will be evaluated.
Agriculture and livestock expansion	In order to mitigate the potential of deforestation emissions due to this driver to transition towards forest degradation, the proposal is to promote the conservation of native forests with financial support through the incorporation of forest conservation variables in Law 18,450 on irrigation promotion and Law 20,412 on sustainability of agricultural lands. Then, farmers and livestock owners will have another sustainable source of revenue to compensate for the potential loss of their previous livelihood if changes to forest conversion promotion by means of Laws No. 18,450 and 20,412 were to deter them from expanding their agriculture lands over natural vegetation.	There have been no developments in the incorporation of forest conservation variables to Laws No. 18,450 and 20,412; therefore, this strategy is neither current nor active. The viability of achieving such regulatory adjustments during the period of the Emission Reduction Payment Agreement (ERPA) is on an evaluation process and failing this, a new strategy will be explored for this risk of displacement as it is considered low.

Effectiveness of organizational arrangements and involvement of partner agencies

CONAF possesses a governance structure at the national and regional level that has allowed it to effectively implement the ER Program and ENCCRV actions. The organizational structure of CONAF is based on a clear chain of command with well-defined instances and roles, also including agile information systems. It has allowed for the generation of governance instances along with internal functional arrangements to institutionalize and operationalize ENCCRV actions in the regions of the ER Program. As an institution spread across various territories, CONAF has a central office led by an Executive Directorate, Management, Advisory Units and Department which all contribute to the implementation of the strategy at the regional level. The Forest and Climate Change Management (GBCC, acronym in Spanish) is responsible for directing and leading the ENCCRV.

The units and departments associated with the ER Program in the reporting period are, from the central level, the Climate Change and Ecosystem Services Department (DCCSE, previously UCCSA acronym in Spanish) as the leading technical entity, the Indigenous and Social Affairs Unit (UAIS, acronym in Spanish) and the Environmental Assessment Department. Also, the Interagency Committee on Climate Change of CONAF, permanent instance with the function of coordinating all institutional actions associated to the ENCCRV, has ensured the institutionalization of both the technical activities and safeguards treatment. This structure has allowed for the development of the Strategy to be systematic, efficient and be progressively inserted in the institutional work for the scope of the proposed goals and objectives. DCCSE has also been a key instance at the central level for enabling the ENCCRV result – based payment phase. Acting as a Focal Point for REDD+, it has coordinated international cooperation associated with REDD+, also being in charge of the administrative, financial and technical aspects of projects, including the approach towards consideration and compliance with safeguards.

In addition, the CONAF Civil Society Council (COSOC, acronym in Spanish) has also participated, being a citizen participation mechanism that is advisory in nature (non - binding), whose actions are reported to and its recommendations incorporated to each of the areas of technical work, including developments in the implementation of ENCCRV. In Meeting #2 of 2019, besides from applications to the Green Climate Fund (GFC) and the FCPF Carbon Fund being informed, treatment of safeguards for project implementation in the ER Program area was also presented.

At the local level, and as a way of ensuring the effectiveness of institutional management in the implementation of ENCCRV at the regional level, there are DCCSE representation offices in all regions that are part of the ER Program. This role is fulfilled by a Coordinator of Climate Change and Ecosystem Services, who reports administratively to the Climate Change and Forest Departments (DBOCC, acronym in Spanish). These are professionals with a long-standing institutional track record, with experience in project management and community relationships. In those regions where ENCCRV pilots and/or projects have been developed, these coordinators actions have been reinforced by support professionals, who contributes towards management of projects in general and safeguard follow up, monitoring and reporting, as is the case for Regional Managers for Indigenous and Social Affairs.

Regarding the efficiency of institutional arrangements for the generation, reporting and integration of information with other State agencies, it is worth mentioning that the sources of basic information for the implementation of the ER Program Monitoring Plan, based on the National Forest Monitoring System, have been, i) Cadastre of Vegetation Resources and statistics on forest fires developed by CONAF, ii) the Continuous Forestry Inventory developed by the National Forestry Institute (INFOR, acronym in Spanish), both institutions part of the Chilean Ministry of Agriculture (MINAGRI, acronym in Spanish). Statistics on areas affected by forest fires have been permanently updated through the Digital Information System for Operations Control (SIDCO, acronym in Spanish) and reported in a yearly basis for each season in the period. Besides the aforementioned basic information, there is a set of second order information, which has to be generated within the ER Program Monitoring Plan framework, such as density plot or stock charts for estimating degradation in all AC forest types, which is being worked on through a specific agreement between CONAF and INFOR.

Regarding consistency between the Forest Reference Level and the National Greenhouse Gas Inventory (INGEI, acronym in Spanish) developed by the Ministry of the Environment (MMA, acronym in Spanish), the CONAF and

INFOR technical teams have been the technical entities in charge of building the greenhouse gases inventory for the Silviculture and Other Land Uses sectors along with ensuring the alignment between the methods applied, with the purpose of improving and maintaining the consistency of both instances. The necessary institutional arrangements to formalize the joint work between services and ministries have been made, such as the Intra – Ministry Technical Committee on Climate Change (CTICC, acronym in Spanish), instance coordinated by the Office of Agricultural Studies and Policies (ODEPA, acronym in Spanish) and composed of all MINAGRI services acting as reviewers for the ER Program and all ENCCRV initiatives, strategic and technical orientation, decision reinforcement and progress report review.

Finally, as international cooperation from different sources has continued and intensified (Section 1.1.1), CONAF has generated and enhanced an internal governance structure to manage international cooperation and strategic partnerships with implementing agencies that provide administrative and technical support, principal among them being the relationship with the Food and Agriculture Organization of the United Nations (FAO).

Financial Plan Updates

It was proposed in the ERPD Chilean document of 2016 that the ENCCRV implementation would require an estimated budget of $174 million dollars for 9 years, 30% of which would be unconditional and the remaining 70% ($121 million dollars) would be conditional on the management and obtention of external resources by CONAF. Then, in the document titled "Additional background for the update of the Chilean ER Program, according to recommendations by the Chair´s Summary in the 15th Meeting of the Carbon Fund" an update is proposed for the Initial Plan.

This update has defined the budget for a nine-year period, considering available experiences and better information about the costs of action measures, variations between region and forest types, among other aspects. Therefore, to finance all ENCCRV action measures, the new financial estimate including conditional and currently available factors amounts to $357 million dollars. This includes international bilateral and multilateral contributions, donations, and results – based payments, along with national private and government contributions. Out of all this, 23% come from international sources while the remaining 77% is national. In addition, 40% is unconditional and the remaining 60% is conditional. From the already mentioned financial sources, to meet the goals of the ENCCRV it will be critical to establish a public – private partnership work, aside from promoting regional initiatives of local funds, on which progress has been made due to the reinforcement of capabilities installed in the various regions of Chile through preparation funds.

It is important to consider that the ENCCRV non – conditional budget corresponds to state resources allocated to CONAF through the Budget Law, and that such funds have and will continue to reinforce the compliance of ENCCRV goals. Some of the actions financed through this government source during the ER program report period in order to reinforce activities associated to reducing deforestation and forest degradation have been: i) reinforcement of the firewood energy promoters program; ii) the interoperability of the platforms of the Forestry Promotion and Development Management System (SIGEFOR, acronym in Spanish) with other CONAF platforms to enhance operability; iii) the capability of on-site teams; iv) reinforcement of the Early Warning System (SAT, acronym in Spanish) for the detection of unauthorized forest felling using satellite images and drones, v) the development of a mobile app for the detection of unauthorized forest felling, and vi) a traceability system for native forest primary products. Also, the "Communities Prepared against Forest Fires" program has been strengthened, doubling its impact on 2018 along with the development of manuals and programs for the technical implementation of 7 ENCCRV direct action measures.

As part of the new financial plan, CONAF has been working with the Agency of Sustainability and Climate Change to establish similar public – private synergies and guide actions to leverage resources for actions aligned with the ENCCRV and the ER Program. These actions correspond to fire prevention, forest planning and restoration of areas affected by forest fires through compensation mechanisms that must be applied by private companies, mainly from the real estate and mining sectors. In line with this, financial instruments are being formulated together with CORFO, with such instruments being used to attract private investments for native forest management mainly for wood and energy purposes. From the business sector, an agreement has been made by forestry companies, with technical

support by CONAF, to direct efforts towards restoring native forests affected by massive forest fires in the 2017 season, encompassing two of the five AC regions. Also, financial resources provided by the Undersecretary of Agriculture have been added, along with a redirection of funds managed by the Foundation for Agricultural Innovation (FIA, acronym in Spanish) and the MMA through its Environmental Protection Fund (FPA, acronym in Spanish). In this context, companies have invested nearly $80 million dollars, which implied a 60% increase in relation to the average historical expenditure on such issues.

This new financial plan, in line with the Benefit – Sharing Plan (BSP) (See Annex 2), specifically mentions that 20% of the total founds obtained under ER Program payments ($5.2 million dollars) will be used during the implementation period of the Program, with the implementation possibly being extended beyond 2025. These resources will be used to cover and develop those actions that either provide sustainability to the system or correspond to ENCCRV facilitating action measures such as inspection, regularization of property titles of ownership, environmental education, aspects related to the communication, dissemination, and reinforcement of CONAF institutional programs, among others.

Finally, the ER Program considers that 80% ($20.8 million dollars) out of the total resources will be directed towards the population as non – monetary benefits, through technical assistance by strengthening Forestry Extension and forestry management actions where the main focus will be on lands belonging to small and medium scale forest owners, along with public lands. This dynamic applies to all payments perceived by Chile from emission reductions as established in the BSP.

1.2 Update on major drivers and lessons learned

Update on major drivers of deforestation, degradation and non – increase of forestry sinks in the Accounting Area.

The Chilean ERPD document of 2016 detailed the process of the identification, prioritization and characterization of the main drivers or causes of forest degradation, deforestation and non – increase of causal sinks for the PRE. This information was used as a basis for the proposal of the strategic actions which formed the ENCCRV action measures. For the 2018 – 2019 reporting period, no significant changes were identified in the drivers that affect native vegetation resources in the AC. Actually, the document titled “Additional background for the update of the Chilean ER Program, according to recommendations by the Chair´s Summary in the 15th Meeting of the Carbon Fund” from October 2018, does not mention any aspects regarding changes or updates on this issue.

The drivers analysis presented in the Chilean ERPD was conducted with a methodology that included the collection and systematization of information about participative processes and specialized consulting. These analyses have not been conducted again in the reporting period, therefore, the update on the status of the drivers presented below corresponds to a proposal based on updated statistical data, technical analysis of professional teams, and sectorial trends in the reporting period.

Causes or Drivers of forest degradation, deforestation and non – increase of sinks	Relevance defined in ERPD 2016	Relevance updated in the 2018-2019 reporting period	Observations/sources of information
DIRECT CAUSES[2]			
Forest fires	Very high	Very high	Remains the most important cause of degradation and deforestation in the AC, according to statistics from CONAF.
Unsustainable use of vegetation resources for production	Very high	Very high	Remains a cause of very high relevance, as there is still a significant amount of informality and unsustainable exploitation of native forests (Above 80%), mainly for firewood extraction, as its use is above 9 million cubic meters per year in the AC, according to firewood consumption data for 2018 and 2019 by INFOR.
Unsustainable use of vegetation resources for livestock	High	High	Remains a driver of high relevance, as grazing still persists in native forests for all ER Program regions in the AC. There are no systematized statistics, but it is a widely recognized reality.
Forest monoculture expansion	High	Low	The degree of relevance of this driver has decreased, as annual surfaces where native forests are replaced with forest monocultures have decreased since 2014, according to statistics on changes in land use in the CONAF Cadastre and the analysis of emissions caused by the degradation from the transformation of native forests into forest plantation, as in the REDD+ Annex for Chile in 2018.
Agriculture and livestock activity expansion	Medium	Low	The degree of relevance of this driver is decreased, as the annual surface of areas with native forests where agriculture is allowed has decreased since 2014, according to statistics on changes in land use in the CONAF Cadastre and the analysis of emissions caused by deforestation from the REDD+ Annex for Chile in 2018.
Urban and industrial activity expansion	Medium	High	The degree of relevance of this driver has increased, as even though statistics of deforestation and changes in land use have declined in general for the AC, there is an important regional trend towards the increase of property subdivisions for plots and property divisions with the aim of developing real estate projects in forest areas. There are no systematized statistics, but it is a widely recognized reality.
Industrial activity expansion	Low	Low	The degree of relevance of this driver has remained low, since the statistics of deforestation and changes in land use due to the expansion of the industry continue to be in insignificant areas of the AC. according to statistics on changes in land use in the CONAF Cadastre (REDD+ Annex for Chile in 2018).
Effects of climate change, desertification, land degradation and drought	Medium	High	The degree of relevance of this driver has increased, as it has become clear that the impacts of the Megadrought affecting a large part of Chile have intensified. Such effects have been stronger in the native forests of the regions to the north of the ER Program and associated to a Mediterranean climate (Miranda et al., 2020; Garreaud et al., 2017). Also, risk

[2] The names of the causes have been updated as per the official ENCCRV document from 2016.

Causes or Drivers of forest degradation, deforestation and non – increase of sinks	Relevance defined in ERPD 2016	Relevance updated in the 2018-2019 reporting period	Observations/sources of information
			scenarios projected in the Climate Change Risk Atlas (ARCLIM, acronym in Spanish), indicate that this scenario will be permanent in nature due to climate change, even moving towards southernmost territories. These projections, together with the raise in temperature and heat waves, will increase the likelihood of forest fires (Gonzalez et al., 2018). CONAF is planning to conduct relevant studies to determine the magnitude and repercussions of this phenomenon in the ER Program.
Plagues and diseases	Low	Medium	The degree of relevance of this driver has increased, as the risks of new pests entering Chile or existing ones propagating due to recurring climate phenomena are increasing (SAG, 2019).
Effects of contamination	Low	Low	These drivers were not described in detail in the ERPD, since they were not prioritized according to the analysis carried out by the ENCCRV and there was a significant uncertainty from the sources of information to characterize them. It is assumed that they maintain their low relevance.
Overexploitation of water	Low	Low	
Soil erosion	Low	Low	
INDIRECT CAUSES			
Public policy deficiencies for regulation	Very high	Very high	The level of relevance of this driver remains very high to medium, as even though efforts have been made to advance in the improvement and promotion of regulatory instruments for the forestry sector, a large gap still persists, and the existing instruments are neither sufficient nor adequate for meeting goals and achieving sectorial climate challenges.
Deficiency in public policies due to promotion or enforcement	Medium	Medium	The level of relevance of this driver remains high, as even though efforts have been made to advance in the improvement and promotion of regulatory instruments for the forestry sector, a large gap still persists, and the existing instruments are neither sufficient nor adequate for meeting goals and achieving sectorial climate challenges.
Poor knowledge and cultural valuation of vegetation Resources	Very high	Very high	The level of relevance of this driver remains very high relevance driver, as even though many actions focused on environmental education, awareness, and training under the ER Program and the ENCCRV have been implemented, there is an important gap represented by bad practices and unsustainable actions still occuring in native forests.
Informality in firewood markets	High	High	The level of relevance of this driver remains high, as a significant amount of informality and unsustainable exploitation of native forests for firewood extraction persists (over 80%), since its use is above 9 million cubic meters per year in the AC regions, according to firewood consumption data for 2018 and 2019 provided by INFOR.

Causes or Drivers of forest degradation, deforestation and non – increase of sinks	Relevance defined in ERPD 2016	Relevance updated in the 2018-2019 reporting period	Observations/sources of information
Rural poverty, lack of opportunities	High	High	The level of relevance of this driver remains high, as rural poverty and vulnerability still persist in AC regions.
Deficiency in public policies due to limited oversight capabilities	Medium	Medium	The level of relevance of this driver remains medium, as even though many actions focused on training, improvement of technical and technological capabilities and awareness have been present under the influence of the ER Program and the ENCCRV, there is an important gap that needs to be addressed, and CONAF oversight capabilities are limited in scope.
Low profitability, opportunity costs	Medium	Medium	The level of relevance of these drivers remains medium, since there have been no significant changes in financial returns and opportunities associated with the management of native forests.
Economic Model Deficiency for the Use of the Native Forest (NF)	Medium	Medium	
Disputes or problems due to fragmentation of property	Medium	High	The degree of relevance of this driver has increased, since there is a significant trend in the AC regions towards an increase in property plot subdivisions and divisions with the aim of developing real estate projects in wooded areas. There are no systematized statistics, but it is a widely recognized reality.
Disputes or problems due to property tenure	Low	Medium	Land tenure problems have been and continue to be a relevant issue in the AC regions, and its impact as a driver has increased, considering that most of the forest promotion programs and implementation projects within the framework of the Climate action, require forest owners to have their land tenure situation regularized. This situation leaves many potential beneficiaries out of these programs.
Deficiency of the forest institutional framework	Low	Low	It continues to be a driver of low relevance since although there are still important gaps to improve and consolidate forestry and environmental institutions in Chile, these gaps should not have a significant impact on the processes of degradation, deforestation, and the non-increase of sinks.
Lack of association for farmers	Low	Low	It continues to be a driver of low relevance since although there is still low productive associativity among forest owners, this gap should not have a significant impact on the processes of degradation, deforestation, and the non-increase of sinks.
Stigmatization of forest plantations	Low	Low	It continues to be a driver of low relevance since although the stigmatization of forest plantations has increased, this situation should not have a significant impact on the non-increase of sinks, even more so considering that the ENCCRV has restricted afforestation actions in the exclusive use of native species.
Management plans do not ensure sustainable use	Low	Low	It is assumed that the level of relevance of this driver remains low since the area managed under these plans is still small, and there has also been progress in the capacities to support and monitor the correct application of these plans. There are no systematized statistics, but it is a widely recognized reality.

2 SYSTEM FOR MEASUREMENT, MONITORING AND REPORTING EMISSIONS AND REMOVALS OCCURRING WITHIN THE MONITORING PERIOD

2.1 Forest Monitoring System

Organizational structure, responsibilities, and competencies, linking these to the diagram shown in the next section

The National Forest Monitoring System (NFMS) of Chile has been established for monitoring forests in the country and operates on existing systems supported by various supporting institutions which underpin and maintain it, which produces a functional link among its multiple building elements.

The NFMS in Chile is coordinated by CONAF, institution serving as REDD+ Focal Point to the UNFCCC (CMNUCC in Spanish) in accordance with Decision 10/CP.19. CONAF operating under the MINAGRI who gives the REDD+ Focal Point to the Climate Change and Ecosystem Services Department (DCCSE) of the Forest and Xerophytic Ecosystem Conservation Management (GCEBX, acronym in Spanish). As the REDD+ focal point, DCCSE has the responsibility of being the organization in charge of coordinating the generation and reporting of elements linked to REDD+, which includes the responsibility of coordinating the NFMS, reporting and generation for FREL/FRL and REDD+ result reports.

Inside CONAF, there are other units with the main responsibility of generating activity data. Among them, the Climate Change and Ecosystems Monitoring Department (DMECC, acronym in Spanish) of the Environmental Evaluation and Oversight Management (GEF, acronym in Spanish), has a primary role for the generation of base information for the NFMS. DMECC is responsible for implementing the mandate established in Article 4th of Law No. 20,283 of 2008 on the Restoration of Native Forest and Forest Promotion, which establishes that CONAF "Will maintain a Forest Cadastre, which is to identify and establish, at least cartographically, the forest types that exist in each region of Chile".

The Forest Cadastre, called "Cadastre of Native Forests and Vegetation Resources", is the main source of information for the development of Land – Use Change Maps, also developed by DMECC for the continuous monitoring of vegetation cover in Chile.

As the next figure shows, CONAF also includes the participation of the Forest Fire Protection Management (GEPRIF, acronym in Spanish) through the provision of information by means of the Operation Control Digital System (SIDCO, acronym in Spanish) and GEF using the Forestry Administration and Control System (SAFF, acronym in Spanish).

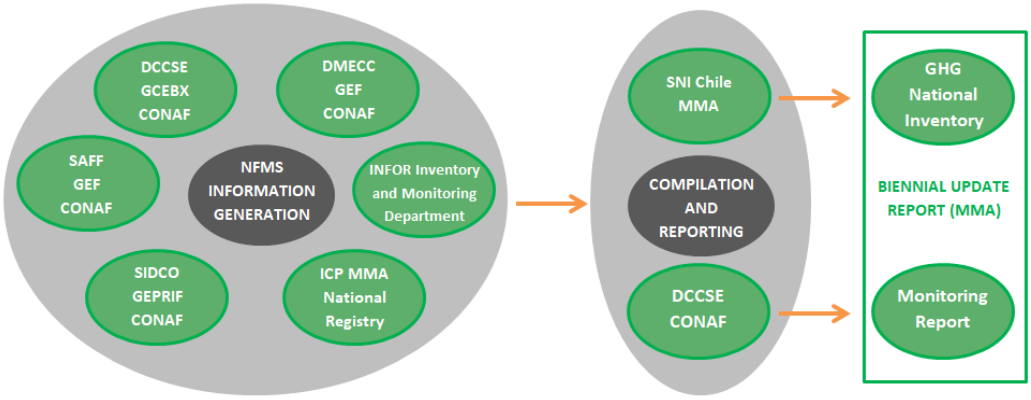


Figure 1 NFMS Organizational Structure of Chile.

Within GEPRIF, The Protection against Forest Fires Department and its Operation Control Digital Information System (SIDCO), provides annualized statistical information on the occurrence of forest fires in the entire country. On the

other hand, SAFF provides information about the implementation of forestry management plans. Finally, also within CONAF, The Protected Wilderness Areas Management is responsible for providing information on conservation areas in the National System of State-Protected Wilderness Areas SNASPE.

Together with the CONAF units, activity data for the NFMS is provided by the Forestry Institute INFOR and the Ministry of the Environment (MMA, acronym in Spanish). INFOR is established as a private law corporation, part of MINAGRI, with such institution providing public funding for the design, technological development, implementation, and execution of the National Forestry Inventory.

Information about emission factors for forest monitoring comes from the National Forestry Inventory or IFN, administered by INFOR which is also used by the Chilean National Greenhouse Gases Inventory System (SNIChile), administered by the Climate Change Office, which arises as a response to the need to inform the citizens about GHG emissions and removals in the country.

Emission factors are monitored by INFOR through inventory plots and reported annually through IFN national reports. Emission factors are applied to the NFMS by forest type and/or region, depending on the REDD+ activity evaluated.

The Ministry of the Environment is the State organ in charge of working with information provision on private conservation initiatives, for their incorporation to the accounting of areas subject to conservation. The National Registry of Protected Areas was established within the MMA, which operates as an information platform where the 9 categories are considered protected areas (Marine Park, Pristine Regions Reserve, National Park, Natural Monument, Forest Reserve, National Reserve, Marine Reserve and Multiple Use Coastal Marine Areas), aside from Private Protected Areas and Community / Private Conservation initiatives, encompassing the entire national territory.

The selection and management of GHG related data and information

The information and data selected to be incorporated to the NFMS, have been defined by Chile in the ERPD on which the subnational FREL/FRL was established. Selected information and data remain for this monitoring report, being managed by DCCSE for the monitoring and reporting.

Activity data: Land use and land use changes maps[3]

Land use data selected for the FREL/FRL were those coming from existing Native Forest Cadastres in regions of the Accounting Area. The information provided by the Cadastre is regularly updated by the Climate Change and Ecosystems Monitoring Department (DMECC) of CONAF, describing 9 Land uses and 20 Sub – uses, along with other breakdowns by altitude, cover and structure.

Nevertheless, as indicated in Annex 4, the reference level was corrected by incorporating spatially explicit use change data estimated based on reference maps for evaluation instances 2001 and 2013. Such maps are developed through the implementation of a semi – automated methodology for change detection that operates on Landsat images analyzed in Google Earth Engine by applying the land use definitions defined by Chile in the Cadastre of Native Forests.

In order to be consistent with IPCC recommendations on good practices, cadastre land uses are standardized to IPCC uses as follows:

[3] Land Use Change maps are avaible in https://drive.google.com/uc?export=download&id=1cY4zUEWYMZMyd0VUUOFgdQBA5jtrKfxn

NATIVE FOREST CADASTRE LAND SUB - USES (CONAF)	IPCC LAND USE	IPCC SUB LAND USES
City-Town-Industrial Area; Industrial Mining	Settlement	Settlement
Agricultural Land; Pasture – Crop Rotation	Croplands	Croplands
Highland Steppe; North Andean Steppe; Annual Pasture; Perennial Pasture; Central Andean Steppe; Patagonian Steppe	Grasslands	Grassland
Scrub Pasture; Scrub; Scrub with Succulents; Succulents Formation; Bush Plantation		Shrublands
Arborescent Scrub		Arborescent Shurblands
Adult Plantation; Young or Just harvested plantation; Plantation with Wild Exotic Species	Forest Lands	Plantation
Adult Native Forest; Secondary Native Forest; Secondary – Adult Native Forest; Stocky Native Forest; Mixed Forest; Native Forest - Plantation; Native Forest with Wild Exotic Species		Native Forest
Herbaceous Vegetation in Riverbanks; Herbaceous Marshland; Herbaceous and Bushy Ñadi; Peat; Wetland; Floodplain; Other Wet Areas	Wetlands	Wetlands
Sea; River; Lake-Lagoon-Reservoir-Dam		Waterbodies
Beach and Dune; Rocky Outcrop; Land above Vegetation Altitude Limit; Stream of Lava and Slag Heap; Landslide without vegetation; Salt Flats; Others without vegetation; River Box	Other land uses	Areas deprived of Vegetation
Snow; Glacier; Ice Cap		Snow and Glaciers

Table 1 Cadastre Land uses standardized to IPCC categories.

REDD+ activities and sub – activities that occur in forest remaining forests[4]

The data selected for the estimation of emissions and captures from activities that occur in forest remaining forests are those indicated in the ERPD and refer to data coming from plots in the Continuous Inventory of Forest Ecosystems or National Forest Inventory by INFOR, combined with spectral information from the Landsat series. This information integrates forest state variables on the number of trees per hectare and basal area registered in the IFN plot monitoring, with Landsat spectral data in order to estimate carbon stocks in a spatially explicit manner.

The inventory collects information on trees with Diameter at Breast Height (DBH) equal to or greater than 25 cm in the 500 m^2 plot, trees with DBH equal to or greater than 8 cm in 122 m^2 plots and trees with DBH equal to or greater than 4 cm in 12.6 m^2 plots. At the individual level, the species, DBH, bark thickness, treetop diameter and health status. More detailed information on the total height, treetop start height, stump height, etc. is obtained for a subsample on each plot.

The estimate of the variation in carbon content on forests that remain as such for FREL/FRL and monitoring report for Degradation, Restoration of Forest remaining forests and Forestry Conservation activities is estimated based on information coming from the Continuous Inventory of Forest Ecosystems and the application of remote sensing techniques on LANDSAT satellite images.

The LANDSAT earth observation program has obtained images of the terrestrial cover since 1972, through LANDSAT-1, until now, through LANDSAT – 8, being a very interesting tool for the study of temporary phenomena, as proven in a large number of publications.

Images from the various LANDSAT missions are freely and publicly available on different platforms. For the case of NFMS, access is through Google Earth Engine (GEE), from which multi – pixel mosaics are developed.

[4] CO2 maps are available in: https://drive.google.com/uc?export=download&id=1QsPkDKAS-CigPb7kDN0P8YNV-OQ2px8I

Satellite Information

The generation of activity data in land use change activities and change detection is developed based on spectral information from the Landsat data. To obtain satellite images that are representative of the beginning and end of each period, NFMS has been corrected through work with multi – pixel mosaics that require a time range for the search for cloud free images and the selection of the pixels that comprise such images. The multi – pixel mosaic is an image comprised of pixels from various images, extracted from the definition of a time range or window. The selection of each pixel seeks to define the best available information for a given area, with the priority being pixels free of clouds and shadows of such clouds.

Given the large number of clouds in the south of Chile, this time window will correspond to a range of ± 3 months for the starting date of the period and the end date of the analysis period respectively, as it corresponds to the dry season period in Chile. As an example, for the 2018 – 2019 where the starting date is January 1, 2018, the time range or window will cover between October 1, 2017, to March 31, 2018. For the end of the period until December 31, 2019, the time range for multi – pixel mosaic estimation will address from October 1, 2019, until March 31, 2020.

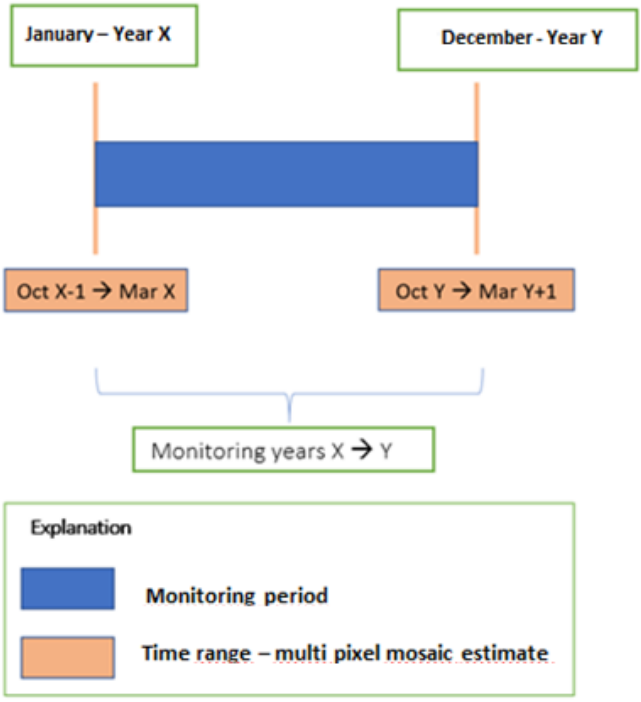


Figure 2 Example diagram for multi pixel mosaic time ranges in a monitoring period.

For pixel selection, a code is applied in GEE where median NDVI values are selected for pixels corrected to land surface. NDVI medians are selected with the purpose of not incorporating phenological states of vegetation with high photosynthetic activity or vigor, but rather selecting values that do not alter the outcome of the method application.

Information administration and Management

The management of the information that comprises the NFMS is led by the Climate Change and Ecosystem Services Department (DCCSE) of CONAF, by means of a cloud-based infrastructure. For the development of FREL/FRL, the associated information was managed through spreadsheets stored in desktop computers, backed up in external storage devices.

Currently, data management is done through cloud storage using Gmail and OneDrive platforms. A series of folders have been organized in order to favor versioned and organized information storage, to which access is granted

through various permissions to the people who participate in the estimation process. The folders are divided into base information, documents, tools, reports, and work for each of the NFMS reporting elements.

The base information provided by the DMECC and INFOR, along with the auxiliary information which feeds the monitoring, are stored in different folders that can be accessed by the working teams that generate such data. Each folder may contain different versions of the data, which is documented through files that account for the changes between versions. The versioning description is the joint responsibility of the team and the information generating team.

The data that comprise the NFMS and allow for the generation of reports are public in nature and made available to the community through links to downloadable files in the reports published by Chile. CONAF is responsible for the information as the REDD+ focal point that generates estimates and develops the reports, therefore being the owner of their intellectual property.

Processes for collecting, processing, consolidating, and reporting GHG data and information

The main processes for collecting, processing, consolidating, and reporting GHG emissions in NFMS are described below.

- Activity data generation processes

Activity data generation is also divided into land use change activities, obtained from land use change maps, and activities on forest remaining forests, these being associated to the development of carbon flow and stock maps for forest degradation.

These two elements are generated through two base official inputs, respectively: Land use type surfaces and land use change surfaces from maps of changes in land use based on the Native Forest cadastre and Carbon content and variation in forest carbon content from the Forest Inventory. Both processes begin with the development of satellite mosaics.

a) Land Use and Land use change map development

The development process for use and land use change maps has been a joint development by DCCSE and DMECC, with the purpose of defining forest related land use changes for determining REDD+ activities and sub activities.

For the 2018 – 2019 monitoring period, the process considers the development of one Land Use change Map per region based on satellite mosaics and the MIICA[5] change detection method. To achieve this objective, it was necessary to establish change thresholds that ensure the spectral values register empirical changes. Change categories to be used are those mentioned in the CONAF "Methodological protocol for the development of land use and land use change maps in Native Forests as of 2016".

The application of the MIICA methodology used multi pixel mosaics from Landsat 7 for the reference period and Landsat 8 for the monitoring period and was applied through a series of codes in programming language (Javascript, R) complemented by Google Earth Engine cloud processing, SIG programs and R software.

The following land use or land use change categories are established and represented in the land use and land use change maps, according to the minimum NFMS necessary requirements:

01. Permanent Native Forest by forest type: Corresponds to the surface reported as Native Forest in the "Map of land use and land use changes t0" which remains in the same t1 category.
02. Other permanent uses: Corresponds to the surface reported as land uses in the "Map of land use and land use changes t0" which remains in the same t1 category.
03. Deforestation: Corresponds to the Native Forest surface transformed into other land uses different from forest uses between t0 and t1 maps, specifying the final land use.

[5] The MIICA methodology is based on the combination of 2 spectral indices (dNBR, dNDVI) which, through integration rules, provide coverage of land use change, indicating the magnitude and directionality of the change.

04. Degradation: Corresponds to the Native Forest surface transformed into Forest Plantation between t0 and t1 maps, specifying the final land use.
05. Afforestation/Reforestation: Corresponds to the surface of other land uses different from forest uses transformed into Native Forest between t0 and t1 maps, specifying the initial land use.
06. Restoration: Corresponds to the forest plantation surface transformed into Native Forest between t0 and t1 maps.

Each process implemented for a specific period generates a land use change map per region which is integrated into existing land use change map layers. Such layers are called *"Trazabilidad",* as they allow for the time monitoring of use changes for all polygons inside the layer.

Land Use Change Map Validation

The land use change map development process ends with the validation of the land use and land use change maps, with the goal of validating the results obtained from higher resolution satellite images. This validation, both for the Land Use Maps and land use change maps is implemented by comparing the results achieved in maps to reference observations obtained through open-source platforms available at Open Foris: SEPAL, Open Foris Collect and its Google Earth interface, Collect Earth.

The validation process starts with the implementation of a pre – sampling to estimate the accuracy of each IPCC land sub use. Since the distribution of the population the sample is taken from is not normal, it is necessary to conduct a pre sampling with a sample size n=30, allowing to approximate the distribution to a normal one. In this way, 30 points will be randomly distributed per IPCC sub land use in every region, which will result in a total of 330 pre sampling points per region.

The polygons from the use map which are overlapped are first selected from the previously obtained pre sampling points and then entered into Google Earth in .kml format so reference data (ground truth) can be collected with support from Collect Earth surveys. Both data collection and user accuracy estimation are conducted in the same way as the sampling, through confusion matrixes.

Reference data are selected based on the information obtained in the pre sampling, through a random sampling design stratified for each IPCC land sub use in each region. This sampling type also allows to report the accuracy and surface evaluated for each category in the results, aside from adjusting a sample size for each that ensures global reliability in the evaluated areas (Olofsson et al., 2014).

Surface per IPCC land sub use information in vectorial format is necessary for the sampling design, reducing map input and processing times in the server. User accuracy parameters for each land sub use are obtained from the information obtained in the pre sampling stage, which are then entered into the platform as expected user accuracy values, considering a 0.01 standard accuracy error (Olofsson et al., 2014). The surface estimator will use these inputs to calculate the total sample size, which will then be segregated among the different classes using the following equation (Cochran, 1977):

$$n = \frac{(\sum W_i S_i)^2}{\left[S(\hat{O})\right] + (\frac{1}{N}) \sum W_i S_i^2} \approx \left(\frac{\sum W_i S_i}{S(\hat{O})}\right)^2$$

Where:

n : Sample size

N : Number of units in regions of interest (ROI)

$S(\hat{O})$: Standard error in the desired estimated accuracy

W_i : Mapped percentage of a class i area

S_i : i strata standard deviation

$$S_i \quad : \sqrt{U_i(1-U_i)}$$

In this way, once the total sample size is obtained, files are spatialized to be used in Google Earth. Also, the polygons in the land use map to be validated are selected and overlapped with sampling points, to then be entered into Google Earth in .kml format so reference data (ground truth) can be collected with support from Google Earth surveys.

Activities and sub activities related to forest remaining forests

The process is based on the methodology detailed in Bahamondez et al. (2009), which considers the number of trees per hectare and basal area monitored by the inventory as input variables. It refers to spatially explicit information which location is known, by applying an interpolation process for carbon flux and stock in the analyzed periods.

Forest Inventory plots are placed in a density plot or stock chart, based on the number of trees and basal area per hectare. The density plot considers various lines or thresholds which determine, for various forest types, their status at the time of measuring. This information identifies the state of plots, distinguishing between degraded and non-degraded plots (Bahamondez, 2009)

In the case of the methodology applied in the NFMS, the B line or threshold will allow the degradation in forest remaining forests and restoration in degraded forests to be identified. Line B represents the limit at which trees can develop large treetops and completely occupy the site capacity without excessive competition (Gingrinch, 1967). The limit for this threshold was established through field work by experts and is specific for each forest type (INFOR, 2012). Line B is considered the natural resilience threshold of a forest. Plots located below the B line or threshold are not recommended for productive work.

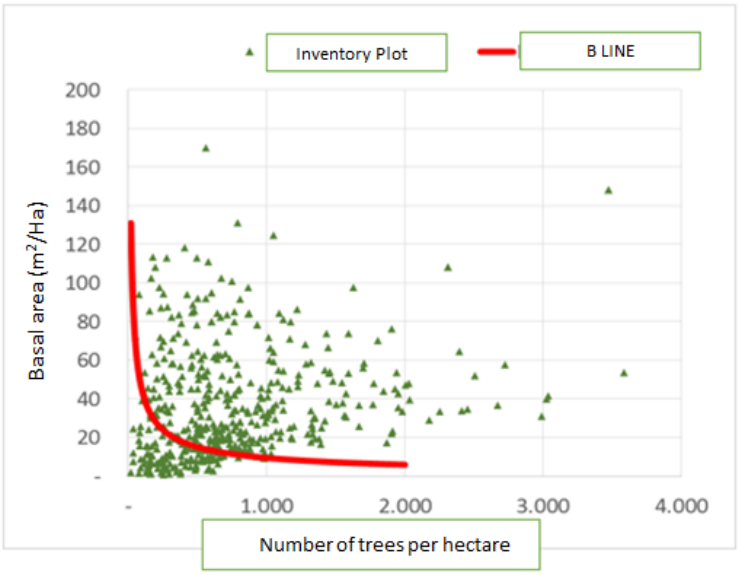


Figure 3 Density plot and B line. Based on data generated by field measurements from the National Forestry Inventory (INFOR) used in the NFMS.

The density plot is a tool which allows the description of the state of a forest in a static moment. Nevertheless, activities and sub activities to be included in emission estimates are processes developed over time. The graph records data gathered from field work which may generate estimates, but do not contain spatially explicit information encompassing the entire area of study, as they refer to specific points in inventory plots.

The movement in the population graph caused by variations in the basal area and number of trees per hectare between two measurements is analyzed to determine which plots are subjected to degradation or restoration processes.

- Plots that move towards the starting axis of the graph, going above or staying below line B, are considered degradation plots.

- Plots that move away from the starting axis of the graph, going above or staying below line B, are considered degraded forest restoration plots.

- Plots that move above line B are not considered in emissions estimates regardless of their direction, as variations are considered as natural effects and plots are within the natural resilience threshold.

Change of position in Stock Chart	Flux of CO_2	Corresponding activity
Above B in t0 and below B in t1	Emission	Degradation
Below B in t0 and below B in t1 (stock loss)	Emission	Degradation
Below B in t0 and below B in t1 (stock gain)	Absorption	Stock Enhancement
Below B in t0 and above B in t1	Absorption	Stock Enhancement
Above B in t0 and above B in t1	N/A	Not accounted

Table 2 Possible density plot changes between two periods of time.

REDD+ activities such changes are accounted in Forest types with density diagrams available and incorporated to the degradation estimation methodology are the following: Roble – Raulí – Coihue (RoRaCo in Spanish), Siempreverde, Canelo, Lenga – Hualo (RoHua), Coihue – Raulí – Tepa (CoRaTe), Coihue de Magallanes, Spinal subtype Esclerófilo and Esclerófilo.

GHG data and information consolidation and integration

The previously described inputs are integrated into geospatial relational databases associated to spreadsheets[6], which pick up and systematize information about activity data and emission factors for the inputs generated following a structure in accordance with the necessities of REDD+ activities.

DCCSE is responsible for the consolidation of information, integration, emissions and captures estimation for REDD activities, with such consolidation being implemented by the MRV Monitoring, Reporting and Verification team. The use of semi-automated software tools has the main goal of minimizing human errors, increasing result consistency and transparency through the association between these spreadsheets and a PostgreSQL database. This process also adds improvements concerning result check and update times.

The protocol for estimate integration and execution, aside from the spreadsheets summarizing estimate results divided by REDD+ activities integrating results for the updated monitoring period and FREL/FRL can be found as an annex to this document.

The data integration process operates on the PostgreSQL database server, to which the main and auxiliary NFMS information, land use change maps, carbon content map and estimate parameters are loaded. Change map vectorial coverages are used in .gdb formats, while rasters are integrated from map associated .dbf files.

Information entry to the database for estimate execution is supported by a series of geographic and topologic validation rules, data attributes and content, in order to avoid subsequent errors during estimations or errors and inconsistencies in the results. Data is repaired, corrected, and prepared for integration during these validations. Among all the processes being run, one of the most important tones is the estimation of surfaces per REDD+ activities, equivalent to activity data. As an example, the following table displays database tables for running estimations of activity surfaces:

[6] Available in https://www.enccrv.cl/erpa

Activity	Sub activity	Table name
Enhancement	Forest surface enhancement	increase_cut
		loss_increase
	Forest remaining forest enhancement	g_mov_pre_2001_2010
		g_mov_pre_2018_2019
Deforestation		deforestation_cut
Degradation	Substitution	substitution_cut
	Fires	Fire_stat
	Degradation in forest remaining forest	g_mov_pre_2001_2010
		g_mov_pre_2018_2019
Conservation		g_mov_pre_2001_2010
		g_mov_pre_2018_2019

Table 3 Databases for running activity surface estimations.

Each of these tables contains an attribute called sup_ha, which is fed by the field of the same name sub_ha from land use change map tables according to a set of conditions. For example, the SQL query for deforestation activities is as follows:

UPDATE deforestation_cut SET (sup_ha)= (SELECT sum(mh_maule_0113161719_v011_p01_20210519_mrv.shape_area/10000) AS area_ha FROM mh_maule_0113161719_v011_p01_20210519_mrv WHERE id_uso_01 = '04' AND id_sub_01='02' AND id_tifo_01='01' AND id_est_01='01' AND id_use_13='01') WHERE id_region=7 AND id_tipo_defor=1 AND id_period = 1;

This query can be translated as "Update field sup_ha of the deforestation_cut table with the value of the sum of the shape_area column divided by 10,000 of the mh_maule_0113161719_v011_p01_20210519_mrv table where as of 2001 land use was forest, the sub use was native forest, forest type was Larch, structure was adult, and that use changed to urban and industrial areas in 2013. Add the sum of the entire surface with the conditions described to the deforestation_cut table where region is Maule and id 1 (First tuple) and the period 2001 – 2013.

The process is similar for the other activity/sub activity tables, that is, the value of the surface field for the activity/sub activity tables corresponding to each tuple is updated through a set of SQL conditions on the MCUT tables.

Finally, the data uploaded to postgreSQL interacts with Excel [7]in order to run the estimation process. This connection takes place through the ODBC Open Database Connectivity connector. The data is then entered into the excel spreadsheets where result estimation is run.

Systems and processes that ensure the accuracy of the data and information

The NFMS has a series of processes established to ensure the accuracy of information, which also contribute to improving the accuracy, transparency, integrity, consistency and comparability of estimations conducted. Some of these processes have been documented, but others are still in the process of elaboration.

Land use change maps quality control

The quality control process for land use change maps has the main objective of identifying discrepancies and inconsistencies in the results obtained. Considering a semi-automated methodology where some stages are executed through programming code is applied, it is necessary to perform checks on the end product.

Quality control has been developed by DCCSE to be applied to the products delivered by the DMECC about change maps and is mainly focused on detailed map database and attribute reviews, along with layer geometry. Once

[7] Instructions are available in https://drive.google.com/uc?export=download&id=1H2OZSESnRIpiQPKMFTHRz_CFzIyKO3P2

discrepancies have been identified, they are submitted to the team responsible for their resolution, and then it must be verified if such discrepancies still remain. It is also necessary to document all methodological steps applied, in such a way that a record of continuous improvement is established.

Methodological protocol for the development of land use maps and land use change maps in Native Forests

The objective of this protocol is to describe all procedures, inputs, data sets and methodological steps needed to generate thematic cartography and statistical reports at the technical level on land use extension, distribution and coverage changes from the digital processing of satellite images, to allow for their replication and reconstruction. Some of its specific objectives are:

- Establish a methodology for the evaluation of land use and land use changes in Native Forests with biennial frequency.
- Generate use and change (directionality) coverages for Native Forest land use in the Maule, Biobío, Araucanía, Los Ríos and Los Lagos regions.

Protocol for the development of carbon stock, flux and degradation maps in forest remaining forest

The methodology for estimating forest degradation, applied by INFOR, is based on the integration of satellite information provided by CONAF and the use of information from national forest inventory plots. The use of satellite images must guarantee necessary adjustments for the application of the degradation algorithm. This process is semi-automated by using multi pixel mosaics downloaded from Google Earth Engine. The protocol establishes the requirements of spatial information, dasometric information and data processing needed for calculations.

The application of this process results in thematic maps that combine the information of parcels which information is known, then spatially intersected with state variable and spectral information data.

Uncertainty Estimation System for Change Maps

The main ways to estimate the accuracy of land use and land use change maps correspond to the comparison between the result of the sorting conducted on reference maps and observations corresponding to a sample. The factors that influence such estimation are sampling design and the size of the map accuracy and precision assessment sample. Errors related to changes in land uses and sub – uses according to Cadastre characterization are calculated by following the Guides on Good Practices for the estimation of use change accuracy described in Olofsson et al (2013). In order to use this approach, use change classes were validated using the FAO tool Collect Earth, through which the categories of a total 1,868 polygons representing a total surface of 1,832,483 hectares were validated.

Chile has a semi-automated software tool that allows to compare land use change map results to high resolution images through Collect Earth. Some of its functions and use steps are:

1. Generate a pre-sampling by change class.
2. From the results of the previously generated pre-sampling, the tool generates one sampling per class that meets the guidelines described in the Map Accuracy Reports (Maximum global error) and as in pre-sampling, this tool can be used in the Collect Earth tool where a group of expert interpreters who assess the initial and final uses of the period according to IPCC classes modified for Chile.
3. The software uses the sampling results to calculate uncertainty at the general and use change/region class level, along with details of emission and commission errors for each map.

Geographic data validation for calculating results

Results estimation is implemented from geographic data of carbon and use change maps. In order to validate such data, a process with the aim of ensuring the data meets basic conditions for spatial analysis by means of topological conditions has been developed.

Data geometry is validated in others, as it is fundamental for spatial analysis since errors detected by validation codes must be fixed before integration and calculation.

Aside from this and to reduce processing time for millions of records, an index structure for improving database performance has been developed. These indexes are applied to non-spatial values from the land use change map.

Applying a checklist to activity data

NFMS has a base process for ensuring information quality and consistency, which consists in applying checklists to the results of activity data obtained from the final integration and calculation tools. The process is applied by DCCSE, with the aim of having informed surfaces be completely consistent according to each REDD+ activity and region informed.

The verification seeks to ensure consistency between the surface reported for each activity and the official surface of each region, through two revisions:

- Total sum of REDD+ activity surfaces per region
- Consistency between the surfaces reported between two periods
- The process is applied during the integration of final calculation results and in case of finding inconsistencies, integration must be stopped, and input data reviewed.

Design and maintenance of the Forest Monitoring System

The NFMS has been designed and structured on the institutions related to Chilean forestry resources and the processes conducted by each institution, responsible for use change maps, degradation maps and forest inventory plots, and the GHG National Inventory of Chile.

Its design has a gradual approach, starting with a reference level at subnational scale and therefore its construction has been on a step-by-step basis, with the goal of advancing towards the national scale monitoring of forestry regions.

Regarding NFMS maintenance, the main activities by each institution that allow continuing the development of necessary inputs and methodologies for guaranteeing reporting on forest status in a climate change context considering continuous improvement elements are described below:

- CONAF: as part of its mandate, CONAF is responsible for implementing native forest registries through the DMEF. Also, based on international commitments on climate change, it has assumed the responsibility to develop biennial land use change national maps that contribute to ensure reporting on climate change matters and results – based payment projects. On the other hand, CONAF has made progress in the development of software tools for the development of MRV estimates and reports.

- INFOR, due to being responsible for the National Forestry Inventory, is responsible for continuing the measurements supported by the Chilean GHG reports, both from REDD+ and the GHG National Inventory. On the other hand, as a member of the Agriculture, Forestry and Other Land Use (AFOLU) like CONAF, INFOR remains close to the ERPA associated INGEI and REDD+ climate change commitments of Chile and maintains the commitment of executing the necessary processes for estimating degradation of the two next monitoring milestones, in accordance with the agreement.

Systems and processes that support the Forest Monitoring System, including Standard Operating Procedures and QA/QC procedures

The processes that support the FNMS are described in the next SOPS:

- **SOP01 Satellite mosaic elaboration (includes satellite image selection)**[8]

[8] SOP_01 Available in: https://drive.google.com/uc?export=download&id=1PcM3Ag1JMELuDGP04fc2X9ENQQTORpJV

This document is a guideline to select and download multi pixel satellite mosaics to monitoring land use and land use change and to evaluate forest degradation in NFMS. The document indicates the searching windows of images and pixels with the minimum required quality to be included in the mosaic elaboration.

- **SOP02 LULUCF Maps elaboration**[9]

The SOP 2 indicates the technical procedure to detect gain and losses in forest land, for the land use change monitoring, through the Multi Index Integrated Change Detection MIICA method application.

- **SOP03 Standardization and quality control protocol for land use change maps** [10]

Standards or guidelines are established and used as compliance rules to standardize formats regarding historical and use change map, which contain information and traceability by region of land use, sub – use, structure, forest type, forest subtype, change and type of change for each evaluated period.

Also, a series of methodological steps consisting in a quality control for identifying discrepancies between the various versions of the historical and use change maps is described.

- **SOP04 Uncertainty assessment on land use change maps**[11]

Correspond to standard operating procedures in writing containing detailed protocols to be followed in order to correctly attribute land uses, training procedures for interpreters/evaluators and develop a re-photointerpretation process for a series of sample units to guarantee that standard operating procedures are correctly implemented and identify areas of improvements through the use of a Platform of Uncertainty.

Visual Interpretation Classification Manual:

Written manual created as a practical, step by step tutorial meant for interpreters/evaluators that participate in uncertainty estimation processes.

- **SOP05 Forest carbon flux estimation assessment**[12]

Develops the methodological protocol for estimating carbon fluxes in forest lands that remain as such, by integrating satellite mosaics with data series from forest inventory plots. These data are combined to determine the degradation or increase of carbon stock in permanent forest.

- **SOP06 Field operation manual**[13]

This manual details the procedures and methods to be used in the field data collection for the inventory of the resources comprised in the native forest ecosystems of the country. It includes the chapters that deal with the data and information referring to the field brigades and the conglomerates, the plots and the trees, including the variables that characterize the development environment from an ecosystem perspective. As such, it aims to rescue data and information from the different components of forest ecosystems.

- **SOP07 Forest fire polygons**[14]

This document establishes the procedure for the elaboration of forest fire polygons, operational, post and final fire, as an input for the evaluation of the damage caused by these at the level of plant formations, populated centers and strategic infrastructure.

Role of communities in the forest monitoring system

[9] SOP_02 Availabe in: https://drive.google.com/uc?export=download&id=1PcloDfhFkTW8JdkqCeaZT8JEOW_SH8zc
[10] SOP_03 Availabe in: https://drive.google.com/uc?export=download&id=1Peu1EpgAXI4fFTbx0Wgo-T0zSaRgV5T4
[11] SOP_04 Availabe in: https://drive.google.com/uc?export=download&id=1PnAO7UTpGX_T7ohj2FPJfNDAzJV4t5BO
[12] SOP_05 Available in: https://drive.google.com/uc?export=download&id=1Pjtafn2coZk6H8GW8mhjKC2rcIZKlhq5
[13] SOP_06 Available in: https://drive.google.com/uc?export=download&id=1Pnc-wEZxWLpOM1Mvxx6iJBs5IK6yg-In
[14] SOP_07 Available in: https://drive.google.com/uc?export=download&id=1PnvRJObzKh0CfL00iOQZftYxEL9C4OOG

The role of communities in the NFMS is connected to a series of activities previously presented during the 2016 report, which has extended until today in this regard. In such a context, communities actively participate in the system in terms of complaints, first of all, on fire related issues, where territorial committees led by GEPRIF, and its Forest Fire Prevention Department have been established. In this point, the previous report mentioned that the use of fire as a tool in agriculture and silviculture activities is regulated by Decree No. 276 of MINAGRI, enacted in 1980. This decree regulates and establishes norms on technical and administrative procedures for fire use, mainly for agriculture or silviculture harvest residues disposal. When this decree was issued, general context was that close to 45% of all forest fires in Chile were generated using fire for disposing of forestry and agriculture residues without adequate planning or control measures. Nevertheless, the current situation reveals that only 6% of fires are caused due to agricultural and/or forest burning.

It is worth mentioning, regarding the application of Decree No.276, that it is conducted under the following procedures in case a member of the community needs to use fire for a specific agricultural, silviculture or forest activity as detailed below:

1) go to CONAF or the police and give advance notice of the date and place where fire will be used, describing planning and control measures established to prevent or fight against any possible fires that may happen.

2) proceed in accordance with a burning schedule pre-established by CONAF and broken down by counties, with a fire use timeline under suitable conditions for keeping fires under control.

3) adopt guidelines on the adequate use of fire as a tool for developing agricultural and forest lands, including topics such as controlled burning techniques and environmental considerations for keeping fire under control.

CONAF´s online platform, the Burn Assistance System (SAQ, acronym in Spanish) certainly facilitates procedures and processes when members of the community need to use fire, where the user conducting the controlled burning can obtain a voucher for his burn notification without having to visit a CONAF office in person. In this regard, CONAF has provided capacity building and trained communities so their users can use the system effectively and independently through the national territory.

On the other hand, and on this same point about controlled burning notifications, members of the community can also actively participate in complaint procedures that lead to fire use oversight, a situation made possible by the close cooperation between CONAF and the national police (Carabineros de Chile). In this context, initiatives such as these encourage the communities to actively participate in protecting their lands by establishing the already mentioned forest oversight committees, which for example have been developed in Maule, Biobío and La Araucanía regions.

In parallel, illegal logging is another aspect related to the role of communities in NFMS. For this purpose, CONAF also has a mechanism for receiving citizen complaints either via postal mail or e-mail when there is information of any acts where a violation of the Forest Law of Chile has taken place. For this, CONAF is in charge of verifying the truthfulness of the information being provided through the complaint, following a site inspection process as final verification and also setting in motion the various legal actions that are required to be filed against the alleged offender. Afterwards, CONAF sends a document to the complainant´s address to notify him/her about the outcome of the complaint and the law enforcement conducted by CONAF, informing the complainant if there was a breach of the existing forest legislation and any legal measures adopted by CONAF if required.

Use of and consistency with standard technical procedures in the country and the National Forest Monitoring System.

The approach for the measuring, monitoring, and reporting established for emission and capture accounting is completely consistent with the procedures established by Chile for the National Forest Monitoring System, which has been developed and implemented in accordance with the technical requirements established by the UNFCCC and the Carbon Fund. It has also been subject to a technical evaluation by the Green Climate Fund panel of experts during 2019, for the results – based payment phase. The NFMS is part of the ENCCRV SMM, which besides forest monitoring is also designed to monitor neutral land degradation elements, safeguards and co – benefits.

The SMM of the ENCCRV has the information collection processes and systems that act as a basis for the NFMS. These correspond to land use change maps based on a Native Forest Cadastre for land use change activity data, the National Forest Inventory for the estimation of forest degradation, the National Wood Fuel and Carbon Inventory and the Forestry Administration and Control System (SAFF) and the Territorial Information System (SIT). These systems allow the gathering, visualization, query, and maintenance of information related to land use in Chile.

The measuring, reporting and verification approach for the ER Program is formed by the integration and interoperability of the previously mentioned existing systems as explained in previous chapters, therefore the relationship between them is direct and consistency assured. Also, the implemented technical corrections that were detailed at the start of Annex 4 are cross – cutting for the processes that comprise the SMM and NFMS, being useful for their implementation in existing systems as part of their improvements.

2.2 Measurement, monitoring and reporting approach

The approach applied by the country is based on the preparation of land use / land use change maps, from which the stable and changing forest areas are defined for both the reference period and the period of follow-up. The first step in the process is the preparation of the land use change map and the second is the preparation of the carbon stock map, for monitoring degradation. These are the most important points in the process. Then the information on forest fires is included, to end with the monitoring of emission factors.

Line Diagram

A line diagram outlining the important monitoring points, parameters monitored and the integration process according to the two areas of result estimation is shown below. In addition, specific diagrams according to REDD + activity are presented in the text. The next figure shows in a summarized way, the sources of information for the generation of emissions and absorption estimations.

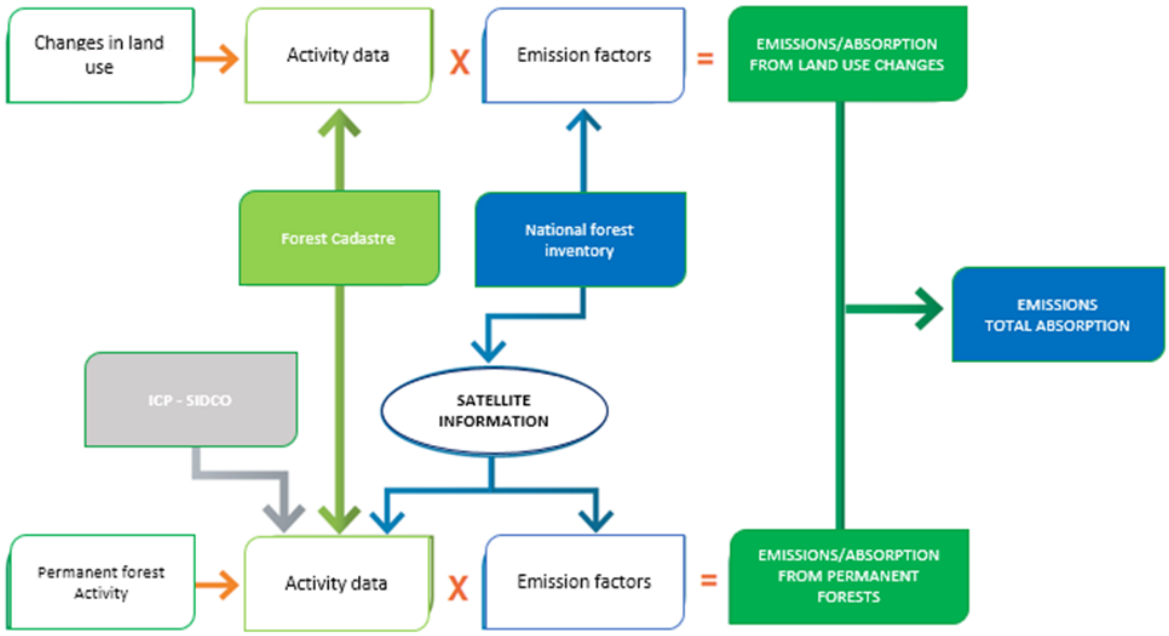


Figure 4 Sources of information for the generation of forest carbon emissions and absorption estimations.

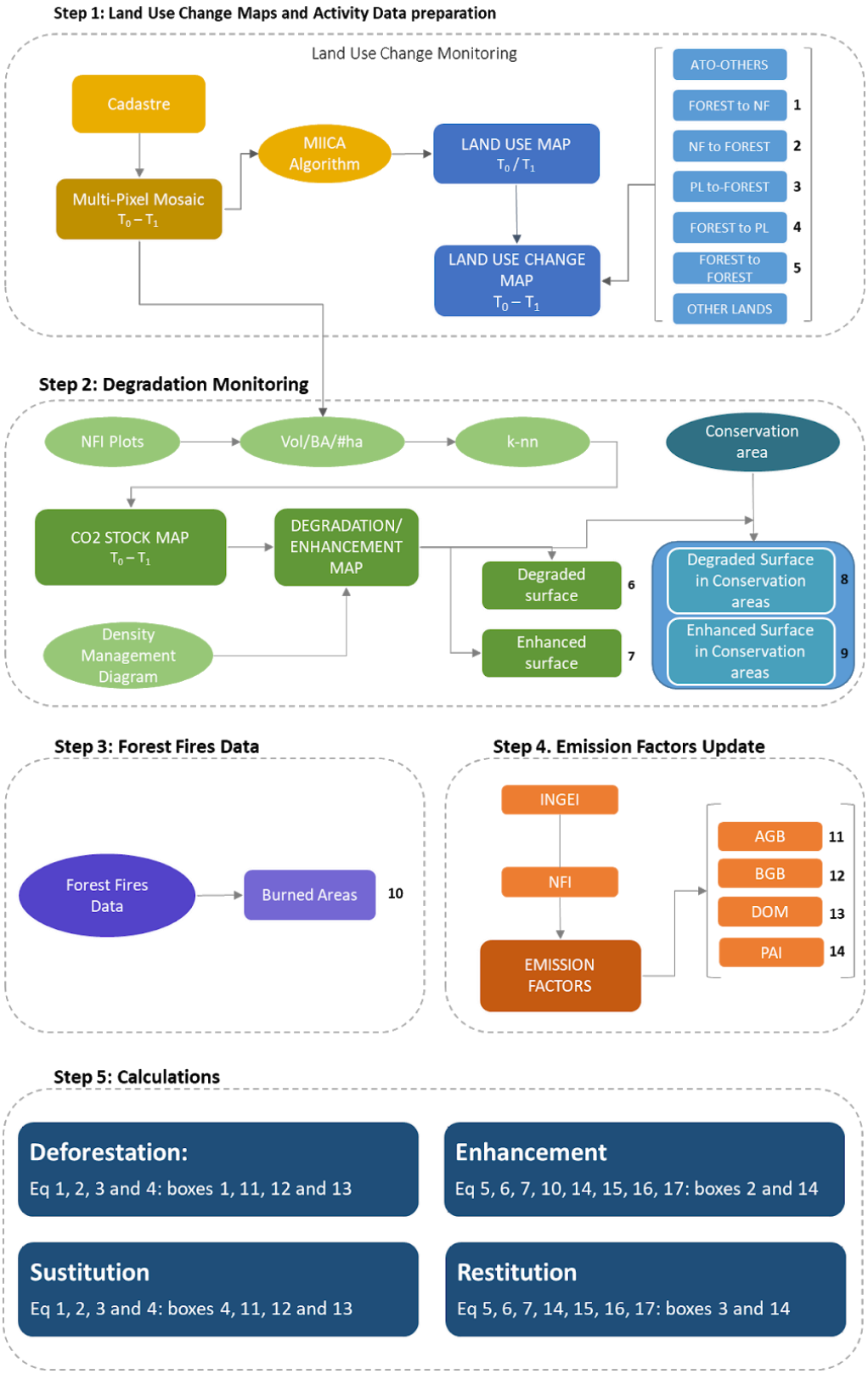


Figure 5 Methodological diagram of the Measurement and Monitoring process.

Calculation

Captures and emissions are estimated in the NFMS by applying the IPCC 2006 equations, in accordance with the methodology applied by INGEI. The equations applied are the same ones presented in the ERPD, both for the reference period and the result monitoring. They are detailed below, by REDD+ activity:

Deforestation

The methodology for calculating deforestation is based on the IPCC 2006 equations for forest lands converted into other lands, which are also used in the INGEI for calculating emissions from forests converted into other land uses. Above ground biomass, below ground biomass and DOM reservoirs are included.

Equation 1. Estimation of Deforestation

$$FREL_{Def} = \frac{\sum_t^n \Delta C_{B_{t,Def}}}{p} * \frac{44}{12}$$

Where:

- Def = annual average carbon stock losses in forest lands converted into non – forest during the reference and monitoring period, in tonnes CO_2e $year^{-1}$.
- $\mathrm{CBt,\ Def}$ = carbon stock change in forest lands converted into non – forest in year *t* of the reference and monitoring period, in tonnes C.
- *p* = years of the reference and monitoring period.
- $44/12$ = factor for converting carbon into equivalent carbon dioxide, tonnes CO_2e ton C^{-1}.

Tier 3 of the IPCC methodology is used in estimations of emissions from deforestation, as carbon stocks in land uses before and after conversion are specific to Chile, with conversion areas being broken down by original land cover type (Sidman et al., 2015).

As recommended in IPCC (2006), Equation 2.15 is used to calculate annual carbon stock changes in wooded lands converted into other land use categories (in the case of deforestation, any forest area converted into non – forest)

Equation 2 [Eq. 2.15 of IPCC (2006)]

$$\Delta C_{B_{t,Def}} = \Delta C_{G_t} + \Delta C_{CONVERSION_t} - \Delta C_{L_t}$$

Where:

- $\Delta C_{B_{t,Def}}$ = annual carbon stock change in forest lands converted into non – forest in year *t* under deforestation activity (Def), in tonnes C.
- ΔC_{G_t} = annual increase in carbon stocks due to growth in forest lands converted into non – forest in year t, tonnes C.
- $\Delta C_{CONVERSION_t}$ = initial change in biomass carbon stocks in forest lands converted into non – forest in year *t*, in tonnes C.
- ΔC_{L_t} = annual loss of biomass carbon stocks due to wood harvesting, firewood extraction and disturbances in forest lands converted into non – forest in year *t*, in tonnes C.

In this equation, changes in carbon stocks from gains and losses due to any activity other than conversion (ΔC_G and ΔC_L) to net gains and losses directly due to conversion ($\Delta C_{CONVERSION}$; in case of deforestation, as it generally results in a negative value due to the loss in forest carbon stocks) to calculate total changes in carbon stocks.

The NFMS of Chile includes ΔC_G, which represents carbon captures for non – forest uses after conversion (agricultural, urban, others). This variable will be given a value of zero, as it does not impact the deforestation loss analysis.

Equation 3 [Eq. 2.16 of IPCC (2006)]

$$\Delta C_{CONVERSION_t} = \sum_i \left\{ \left(B_{AFTER_i} - B_{BEFORE_i} \right) * \Delta A_{TO_{OTHERS_{i,t}}} \right\} * CF$$

Where:

- $\Delta C_{CONVERSION}$ = initial change in biomass carbon stocks in forest lands converted into non – forest, in tonnes C year^{-1}.
- B_{AFTER_i} = existence of biomass in non – forest land use type i after conversion, in dry biomass tonnes per hectare.
- B_{BEFORE_i} = existence of biomass in forest type before conversion, in dry biomass tonnes per hectare.
- $\Delta A_{TO_{OTHERS_{i,t}}}$ = forest type *i* area converted into non – forest in year *t*, in ha.
- CF = carbon fraction of dry biomass, in tonnes of carbon by tons of dry biomass. 0.47 is the default value as per IPCC AFOLU guidelines 2006, Table 4.3.

In the case of deforestation, these two equations can be represented with two essential inputs ($\Delta A_{TO_OTHERS_i}$), frequently called activity data (AD) and the amount of carbon stocks emitted due to conversion (B_{AFTER_i} - B_{BEFORE_i}), frequently called emission factors (EF). Parameters B_{AFTER_i} and B_{BEFORE_i} only include above and below ground biomass, so DOM is included by adding parameter ΔC_{DOM} calculated according to the following equation:

Equation 4 [Eq. 2.23 of IPCC (2006)]

$$\Delta C_{DOM_t} = \frac{(C_n - C_o) * A_{on_t}}{T_{on}}$$

Where:

- ΔC_{DOM_t} = DOM carbon stock change in year *t*, tonnes C.
- C_n = dead wood and DOM carbon stocks in non – forest land use after conversion, ton C year^{-1}.
- C_o = dead wood and DOM carbon stocks in forest before conversion into non - forest, ton C year^{-1}.
- A_{on_t} = area converted from forest into non – forest in year *t*, hectares.
- T_{on} = time period for the forest into non – forest transition.

In this equation A_{on} corresponds to activity data, or $A_{TO_{OTHERS_i}}$, according to the parameter of previously described in Equation 3. In order to simplify accounting, DOM emissions will be counted in the year of conversion (meaning T_{on} is supposed to have a value of 1).

The process for calculating emissions from deforestation is summarized in the following diagram:

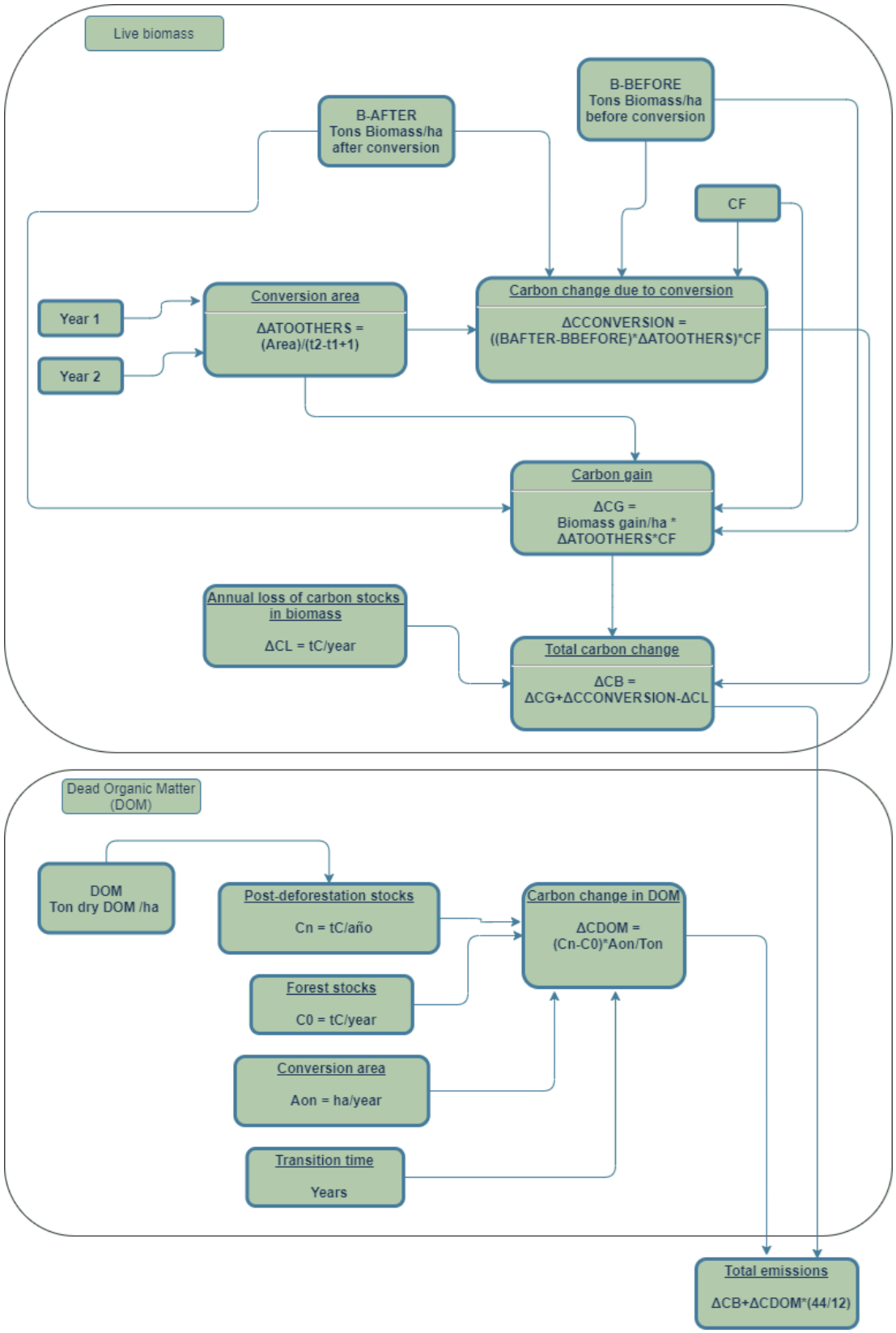


Figure 6 Step by step diagram for estimating emissions from deforestation.

Degradation from substitution

The equation used for estimating deforestation is applied to estimate degradation in native forests converted into plantations, as it is assumed that for a plantation to be established, all carbon content in the preceding native forest must be reduced to zero. Equation 1 is used to calculate the reference and monitoring period in CO_2e. Step-by-step diagram summarizing the process is presented below:

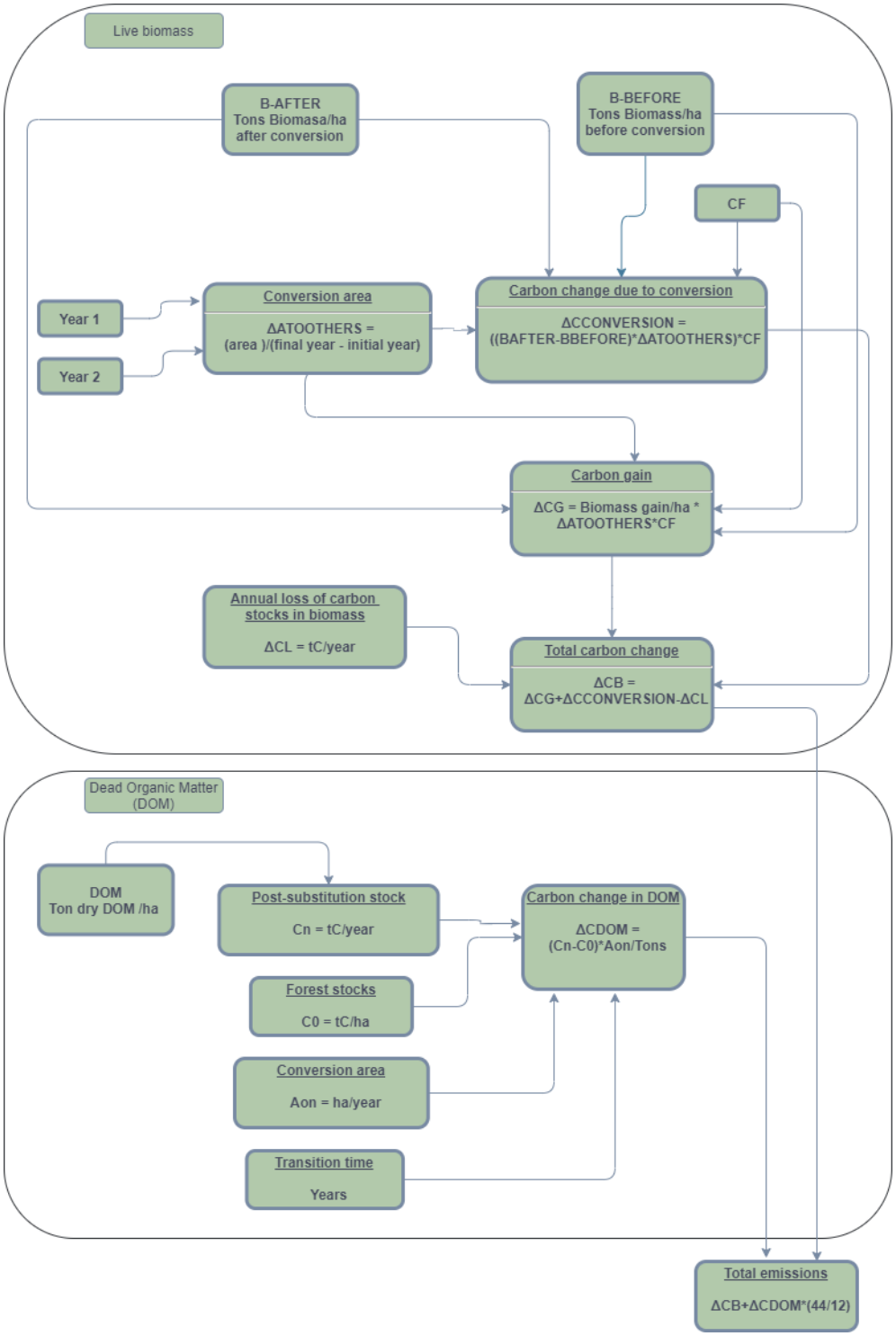


Figure 7 Step by step diagram for estimating emissions from Substitution.

Forest area Restitution and carbon stock Enhancement

As in the other calculated activities, the methodology for enhancements in other lands converted into forests is consistent with the methodology used in INGEI which is based on equations 2.9, 2.10 and 2.15 of IPCC (2006).

The general equation corresponding to Tiers 2 and 3 of IPCC (2006) is 2.15, used for calculating annual changes in carbon stocks in above and below ground biomass (the only reservoirs included in enhancement estimations) and lands converted into other land uses (In this case, non – forest into forest):

Equation 5 [Eq. 2.15 of IPCC (2006)]

$$\Delta C_{B_{t,ANFF}} = \Delta C_{G_t} + \Delta C_{CONVERSION_t} - \Delta C_{L_t}$$

Where:

- $\Delta C_{B_{t,\,ANFF}}$ = carbon stock enhancements in year *t*, from non – forest lands converted into forests during the reference period, under the stock enhancement activity (A), in tonnes C.
- ΔC_{G_t} = carbon stock enhancement due to growth in non – forest lands converted into forest year *t*, in tonnes C.
- $\Delta C_{CONVERSION_t}$= initial carbon stock change in non – forest lands converted into forests in year *t*, in ton C.
- ΔC_{L_t} = annual carbon stock decrease due to wood harvesting, firewood extraction and disturbances in non – forest lands converted into forest in year *t*, in ton C.

The estimations for enhancements assume ΔCL to be zero, due to the lack of sufficient data to quantify losses in non – forest areas converted into forest. Equation 2.16 of IPCC (2006) is used for the parameter$\Delta C_{CONVERSION_t}$:

Equation 6 [Eq. 2.16 of IPCC (2006)]

$$\Delta C_{CONVERSION_t} = \sum_i \left\{ \left(B_{AFTER_i} - B_{BEFORE_i} \right) * \Delta \mathrm{A}_{\mathrm{TO}_{\mathrm{OTHERS}_{i,t}}} \right\} * CF$$

Where:

- $\Delta C_{CONVERSION_t}$ = initial carbon change in non – forest lands converted into forest in year *t*, ton C.
- B_{AFTER_i} = biomass stocks in forest type i immediately after conversion, ton m.s. ha^{-1}.
- B_{BEFORE_i}= biomass stocks in land type i before conversion, ton d.m. ha^{-1}.
- $\Delta A_{TO_{OTHERS_{i,t}}}$= non – forest land use surface converted into forest in year *t*, ha.
- CF = carbon fraction in dry matter, ton C (ton m.s.)$^{-1}$ 0.47 is the default value as per IPCC AFOLU guidelines 2006, Table 4.3.

For parameter ΔCG (enhancement due to forest growth), INGEI uses IPCC 2006 Equation 2.9 for a Tier 2 – 3 calculation. Nevertheless, INGEI only uses it for lands converted into forest in the year of conversion.

Equation 2.9 of IPCC (2006) calculates annual carbon enhancements. But Equation 6 [(Eq. 2.16 of IPCC (2006)] does not consider captures converted in previous years that keep accumulating in strata "i". So it is necessary to modify equation 2.9 of IPCC (2006) as follows to achieve a correct accounting:

Equation 7 [adapted from Eq. 2.9 of IPCC (2006)]

$$\Delta C_{G_t} = \sum_i \sum_x \left(A_{i,x} * G_{TOTAL_i} * CF \right)$$

Where:

- ΔC_{G_t}= carbon stock enhancement in year *t*, due to growth in non – forest lands converted into forest type *i* during the reference period, in ton C.
- $A_{i,x}$= Area converted into forest *i* in year *x* of the reference period, in ha.
- G_{TOTAL_i}= annual average biomass growth in non – forest lands converted into forest type *i*, ton d. m. ha^{-1} $year^{-1}$.
- *CF* = dry matter carbon fraction, ton C (ton d.m.)$^{-1}$ · 0.47 is the default value as per IPCC AFOLU guidelines 2006, Table 4.3.

Equation 7 considers that for calculating ΔC_{G_t} in year *t*, it is necessary to add captures from areas converted in each year *x* before year *t* in the reference and monitoring period, to captures from areas converted in year *t*. In case a forest reaches adulthood and stops capturing CO_2 from the atmosphere, it should be removed from enhancement accounting. Nevertheless, this is not supposed to happen during the reference and monitoring period.

The following diagram represents step by step the calculation of removals due to increases from non-forest to forest and restitution (plantation to native forest). In the lower part, the number of years considered in the reference period is represented (13 in total), indicating that forests grow cumulatively from year 1 to year 13.

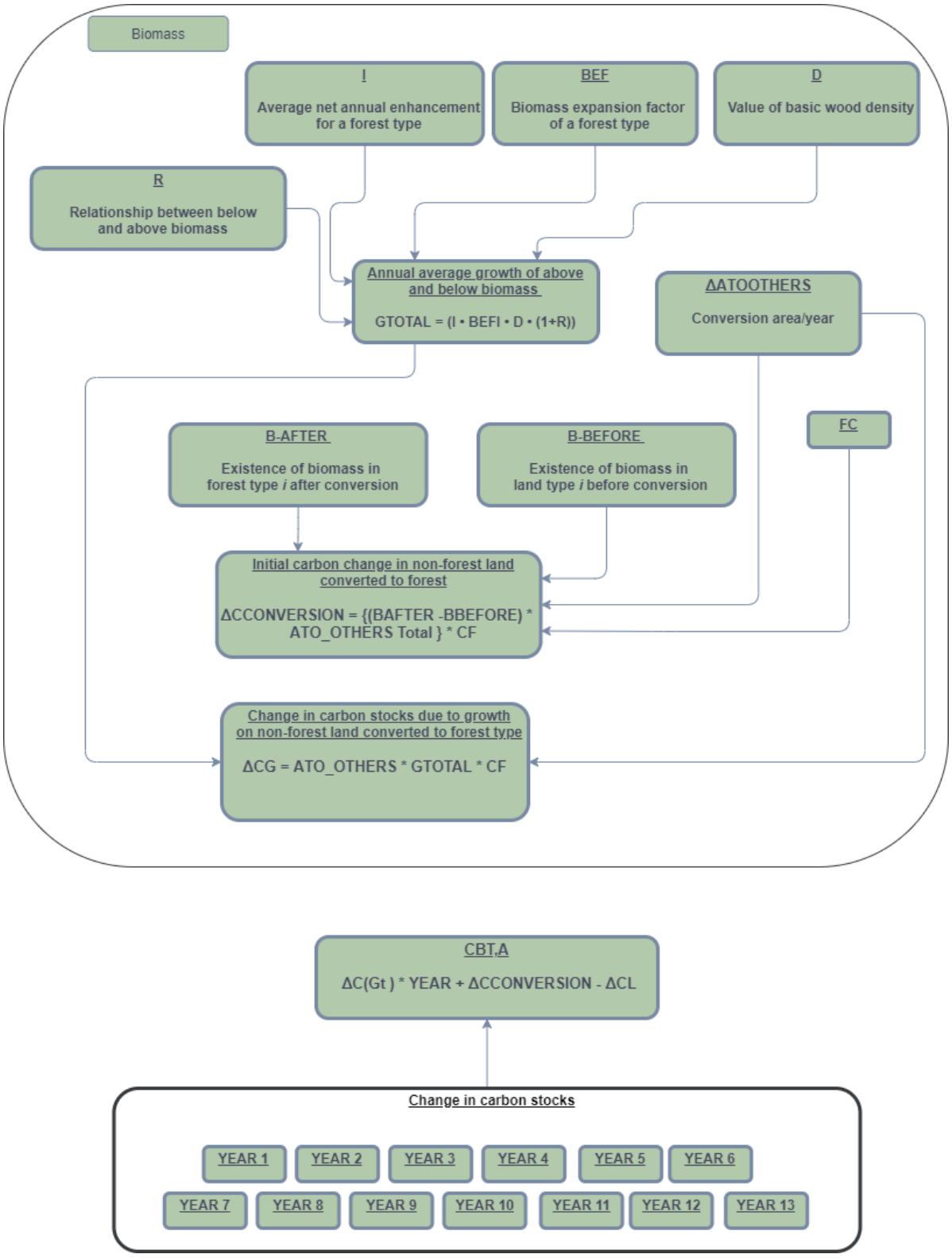


Figure 8 Step by step diagram for estimating removal from Enhancement.

Forest Remaining Forest

Degradation

Equation 2.8(a) of IPCC (2006) is used to estimate changes in carbon stocks in forest lands that remain as such due to degradation:

Equation 8 [Eq. 2.8 of IPCC (2006)]

$$\Delta C_{B_{t,DegFF}} = \frac{(C_{t_2} - C_{t_1})}{(t_2 - t_1)}$$

Where:

- $\Delta C_{B_{t,Deg}}$ = annual carbon stock change in forest lands that remain as such considering total area under degradation activity (*DegFF*), ton C.
- C_{t_2}= total forest carbon in year t_2, ton C.
- C_{t_1}= total forest carbon in year t_1, ton C.

The equation is applied for the reference level accounting described in Bahamondez *et al.* (2009)[15]. This methodology accounts for carbon stocks at different points in time, where the difference in carbon stocks in forest lands is considered degradation in case of losses. On the other hand, INGEI uses a loss – gain method, Equation 2.7 of IPCC (2006) instead of the stock difference method found in IPCC 2006 equation 2.8, where tabular data from INFOR is integrated to estimate volume extracted through selective logging, INFOR and MINENERGIA firewood statistics, and CONAF tabular data for the surface of fires in native forest and forest plantations. According to national experts, firewood extraction data are not very robust or representative of degradation in a comprehensive manner. The methodology used in NFMS allows to achieve Approach 3 results, spatially explicit data, and is based on robust and independent sources of information.

IPCC equation 2.8(b) is used to calculate carbon stocks in the initial and final moments of the reference period (C_1 and C_2 in Equation 8):

Equation 9 [Eq. 2.8 of IPCC (2006)]

$$C_t = A_{Deg} * EF * CF$$

Where:

- $C_{t,i}$= total forest carbon in year *t*, ton C.
- A_{Deg}= degradation area in forest that remains as such, ha.
- EF= carbon stocks in forest that remains as such, ton biomass ha^{-1}.
- CF= carbon fraction, *t* carbon *t* biomass^{-1}. 0.47 is the default value as per IPCC AFOLU guidelines 2006, Table 4.3.

Stock Enhancement in Forest remaining forest

[15] Bahamóndez, C., Martin, M., Muller-Using, S., Rojas, Y., Vergara, G., 2009. Case Studies in Measuring and Assessing Forest Degradation: An Operational Approach to Forest Degradation. (Forest Resources Assessment Working Paper). Forestry Department, Food and Agriculture Organization of the United Nations

IPCC (2006) equation 2.8 was used to calculate annual stock enhancements:

Equation 10 [Eq. 2.8 of IPCC (2006)]

$$\Delta C_{B_{t,AFF}} = \frac{(C_{t_2} - C_{t_1})}{(t_2 - t_1)}$$

Where:

- $\Delta C_{B_{t,AFF}}$ = annual carbon stock change in forest lands that remain as such, considering total area under stock enhancement activity (*DegFF*), ton C year^{-1}.
- C_{t_2}= total forest carbon in year t_2, ton C.
- C_{t_1}= total forest carbon in year t_1, ton C.

Carbon contents in year t_1 (2001) and t_2 (2010) were obtained from the results of applying the methodology that allows to identify areas that were below threshold or line B at the start of the reference and monitoring period.

Forest Conservation

As explained in previous sections, emissions and removals for Forest Conservation is estimated by adding emissions from forest degradation in forest remaining forest and absorptions from the restoration of degraded forests in forest areas under formal conservation processes.

Equation 11 [Eq. 2.8(a) of IPCC (2006)]

$$\Delta C_{B_{t,ConFF}} = \Delta C_{B_{t,AFF}} - \Delta C_{B_{t,DegFF}}$$

Where:

- $\Delta C_{B_{t,C}}$= carbon stock annual change in forest lands subject to formal conservation processes in year t, in ton C.
- $\Delta C_{B_{t,AFF}}$= annual changes in carbon stocks due to recovery of degraded forests in areas subject to formal conservation processes, in ton C year^{-1}.
- $\Delta C_{B_{t,DegFF}}$= annual changes in carbon stocks due to forest degradation in forest lands subject to formal conservation processes, in ton C year^{-1}.

In the following diagram the summary of steps for estimating emissions and captures in forest remaining forest is presented, both for increases, degradation and conservation. As can be seen, the conservation areas correspond to a part of the forest remaining forest that is under protection. It is defined by the geographic limit that delimits the area.

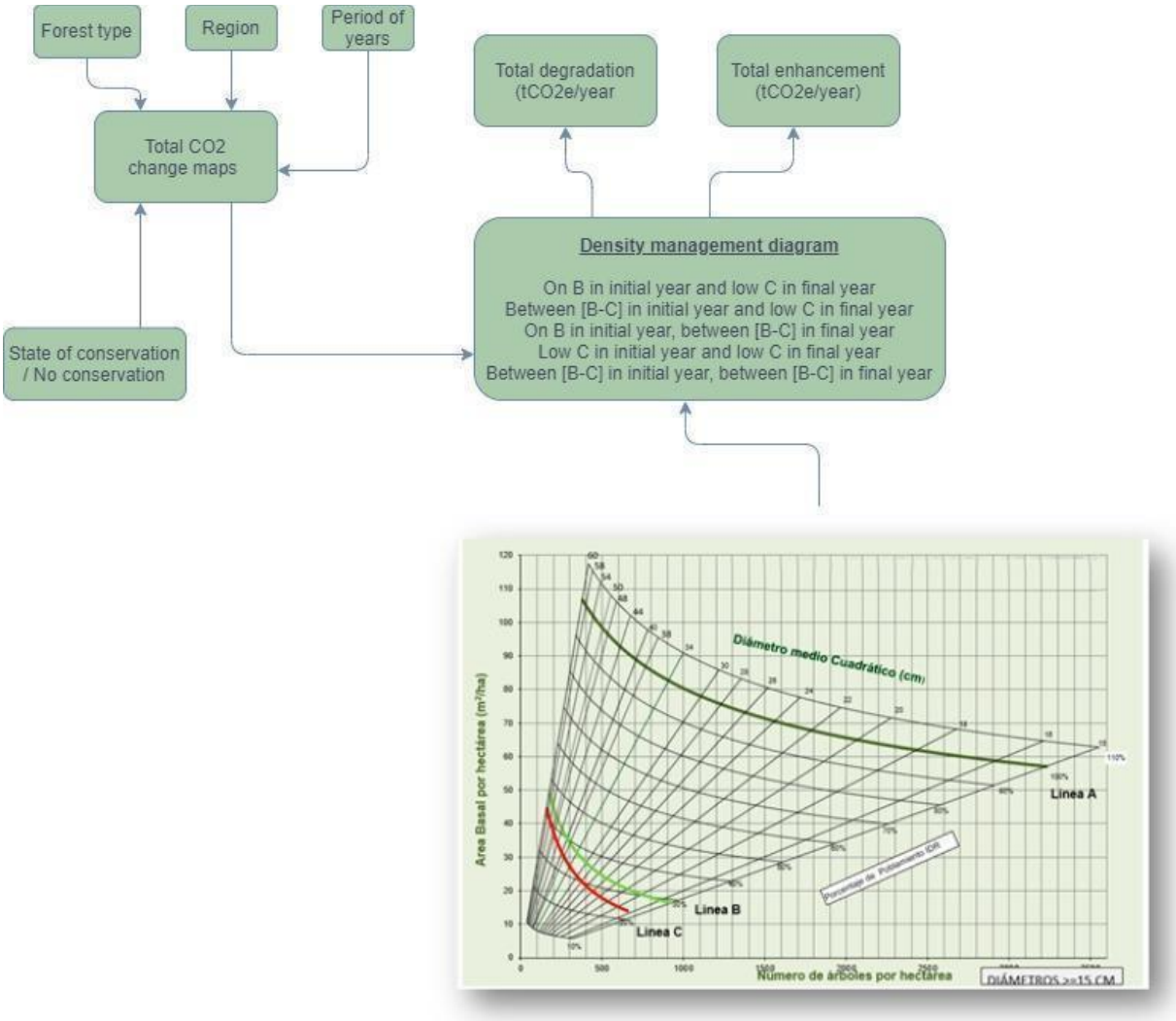


Figure 9 Step by step diagram for estimating emissions and removals from forest remaining forest.

Non -CO_2 emissions from Forest Fires

The methodology by Bahamondez et al. (2009) estimates CO_2 emissions in forest remaining forests. Therefore, Equation 2.27 of IPCC (2006) is used to calculate non – CO_2 emissions from forest fires:

Equation 12 [Eq. 2.27 of IPCC (2006)]

$$L_{fire} = A * M_B * C_f * G_{ef} * 10^{-3}$$

Where:

- L_{fire} = amount of greenhouse gas emissions caused by fire, ton of each GHG gas year^{-1}
- A = burned surface, ha year^{-1}
- M_B= fuel mass available for combustion, ton ha^{-1}.
- C_f= combustion factor, no dimension. The value applied is 0.45 according to IPCC 2006.

- G_{ef} = emission factor, g kg^{-1} of burned dry matter. Emission factors used for the equation are 4.7 for CH_4 and 0.26 for N_2O.

Equation 13 is used to convert L_{fire} into CO_2e, for Equation 12:

Equation 13

$$GEI_{fire} = L_{fire} * CF$$

Where:

- CF = conversion factor of non no-CO_2 gas into CO_2e, ton gas no-CO_2 ton CO_2e^{-1}. CF value is 25 for CH_4 and 298 for N_2O, according to IPCC 2006.

Figure 10 Step by step diagram for estimating emissions from forest fires.

Emission Factors

Deforestation

Carbon stocks before deforestation (B_{BEFORE})

Forest carbon stocks before deforestation were obtained from the information base of the INGEI of Chile. These numbers are derived from the national forest inventory in order to reach a Tier 3 living Above ground biomass estimation. Estimations are stratified by forest type to obtain carbon contents before deforestation. Information of changes in land use was updated to include forest type data.

Above and below ground biomasses (B_{BEFORE} in Equation 3 and 6) along with DOM (Co in Equation 4) are obtained from the GHG national inventory. Under deforestation accounting, harvested wood products (HWP) carbon stocks are supposed to be zero, due to the lack of reliable sources of data for distinguishing between HWP due to deforestation and HWP due to degradation.

Carbon stocks after deforestation (B_{AFTERi})

INGEI uses IPCC (2006) default values for B_{AFTERi}, but these values are supposed to be the non – forest land use growth that really corresponds to ΔCG. For FREL estimations, carbon stocks directly after deforestation in deforested lands will be assumed to be zero.

Changes in carbon stocks other than deforestation events (ΔCG and ΔCL)

Post – deforestation carbon stocks (ΔCG) are determined in one of two ways:

- Values taken from a literature review of non – forest carbon stocks, ideally studies conducted in Chile (such as Gayoso 2006). If these studies are not available, data from other regional studies (Temperate South America under similar management regimes) can be used. This is the preferred method, representing a Tier 2 approach.
- When these values are not available, IPCC (2006) default values can be used. This is the method being currently used by the INGEI but represents a Tier 1 method.

Losses due to wood harvesting, firewood extraction and disturbances (ΔCL) are supposed to be zero in deforestation areas, using the same assumption as INGEI

Degradation from Substitution

Carbon stock estimations derived from National Inventory plots and other carbon stock studies in other land uses are utilized for the emission factors in changes from native forest into plantation. Biomass stock estimations in plantations are assumed to be zero (0), as stocks in the native forest are supposed to have been reduced to zero before the establishment of the plantation.

Forest Surface Enhancement and Restitution

The value of B_{AFTER_i} in Equation 7 is supposed to be zero for agricultural lands and urban – industrial areas, as carbon stocks in non – forest land use converted into forest have been removed before forests are established. For natural land uses, mainly grasslands and scrubs, $B_{AFTER_i}$is supposed to be equal to B_{BEFORE_i}, as no clearing or cleaning processes are supposed to take place in those lands before the forest is established, but rather are naturally converted into forest without losing initial carbon stocks. Carbon stocks in $B_{BEFORE_i}$are equivalent to carbon stocks in non – forest land use. National or regional scientific reports such as Gayoso (2006) which have estimated carbon stocks in non – forest land uses are used for these stocks.

In Equation 7, G_{TOTAL_i}, average annual biomass growth per hectare for each forest type is calculated through Equation 14 (modified from Equation 2.10 in IPCC 2006).

Equation 14 [adapted from Eq. 2.10 of IPCC (2006)]

$$G_{TOTAL} = \Sigma_i (I_{Vi} \cdot BCEF_i \cdot (1+R_i))$$

Where:

- G_{TOTAL} = Average annual above and below ground biomass growth, ton d. m. ha^{-1} $year^{-1}$.
- I = Annual average net increase for one forest type, m^3 ha^{-1} $year^{-1}$.
- $BCEF_I$ = Biomass expansion and conversion factor for the conversion of annual net volume increase into Above ground biomass growth for one forest type, tons of aerial growth (m^3 of annual average increase)$^{-1}$.
- R = Relation between above and below ground biomass for one forest type in ton m.s of below ground biomass (ton m.s. of Above ground biomass)[1].

Annual average net increase values, I, are gathered in the INGEI data set, based on data from national forest inventory, which estimates values for the following forest types: Alerce, Ciprés de las Guaitecas, Araucaria, Ciprés de la Cordillera, Lenga, Coihue de Magallanes, Roble Hualo, Roble-Raulí-Coihue, Coihue-Raulí-Tepa, Esclerófilo and Siempreverde. Equation 15 is used for calculating $BCEF_i$:

Equation 15

$$BCEF_I = BEF_I \cdot D_i$$

Where:

- BEF_I= Biomass expansion factor for one forest type. This factor expands total above ground biomass value to offset the non – marketable components of the increase, no dimension
- D = Basic wood density value, ton $m^{-3.}$ The value applied for D is 0.496166.

The biomass expansion factor, BEF_I, and wood basic density value, D, come from the INGEI data set, having a BEF_I value for native forests, not classified by forest type, by Gayoso et al (2002). Likewise, there is only one wood density value for native species, without INGEI defining the original source, which is used for ensuring consistency with the INGEI.

The relation between above and below ground biomass in native forests, R, was estimated by Gayoso et al (2002) and is found in the INGEI data set. The value applied for R is 0.2869.

Forest remaining forest

Emission factors for degradation in forests remaining forests, carbon content enhancement from restoration of degraded forests, and forest conservation all use the same methodology.

The emission factors come from the national forest inventory, which is the basis for the methodology. The methodology determines a basal area for each forest hectare in t_1 and t_2. The total volume of each hectare is calculated based on this data:

Equation 16

$$Vol = KAB^{\beta}$$

Where:

- Vol= Volume of trees in forest, cubic meters ha^{-1}.
- AB= Basal area square meters ha^{-1}.

- K= Constant, value of 2.9141.
- β = Constant, value of 1.2478.

To convert volume into CO_2 for its use in equation:

Equation 17

$$EF = Vol * D * BEF$$

Where:

- EF = carbon stocks in forests that remain as such, ton biomass ha^{-1}.
- Vol = Volume of trees in forest, cubic meters ha^{-1}.
- D = average forest density, tons $meters^{-3}$.
- *BEF* = biomass expansion and conversion factor for the conversion of annual net volume increase (bark included) into above ground biomass growth for one forest type, above ground biomass growth in tons (m^3 of average annual increase)$^{-10}$.

CALCULATION OF ANNUAL EMISSION HISTORICAL AVERAGE DURING THE REFERENCE PERIOD

Forest Degradation

There are two sub activities under the degradation activity, according to the definitions:

1. Degradation in forest remaining forest.
2. Degradation from Substitution.

Various methodologies are used for each sub – activity type as previously described and justified, to calculate FREL, adding different methodologies and reference periods in ton CO_{2e}, using the following equation:

Equation 18

$$FREL_{Deg} = \frac{(\sum_t^n \ \Delta C_{B_{t,DegFF}} + \sum_t^n \ \Delta C_{B_{t,DegFNF}}) * \frac{44}{12} + \sum_t^n \ GEI_{fire}}{p}$$

Where:

- $FREL_{Deg}$ = carbon stock annual average losses due to forest degradation during the reference period, in ton C $year^{-1}$.
- $\Delta C_{B_{t,DegFF}}$ = carbon stock change in forest lands that remain as such in year *t* of the reference period, in ton C.
- $\Delta C_{B_{t,DegFNF}}$ = carbon stock change in forest lands converted into arborescent scrub or plantations in year *t* of the reference period, in ton C.
- GEI_{fire}= Amount of non-CO_2 gas emissions from forest fires, ton $CO_{2}e$.
- *p* = years of the reference period.
- $\frac{44}{12}$ = factor for converting carbon into equivalent carbon dioxide, ton $CO_{2}e$ ton C^{-1}.

Forest Carbon Stock Enhancement

Captures associated to areas that change from non – forest into forest, along with captures from forest areas that remain as such are accounted under the stock enhancement category.

1. Forest surface restitution and enhancement.
2. Restoration of degraded forests

Likewise, FREL activity data regarding forest carbon stock enhancements is estimated using differentiated methodologies for forests that remain as such and the identification of non – forest areas converted into forests, just as in the degradation FREL.

Equation 19

$$FRL_A = \frac{(\sum_t^n \ \Delta C_{B_{t,ANFF}} + \sum_t^n \ \Delta C_{B_{t,AFF}}) * \frac{44}{12}}{p}$$

Where:

- FRL_A = annual average carbon stock increase during the reference period, in ton CO_2e $year^{-1}$.
- $\Delta C_{B_{t,ANFF}}$ = carbon stock change in year t, from non – forest lands converted into forest during the reference period, under the stock enhancement activity (*A*), in ton C.
- $\Delta C_{B_{t,AFF}}$ = annual carbon stock change in forest areas that remain as forest, considering total area, in ton C $year^{-1}$.
- p = years of the reference period.

3 DATA AND PARAMETERS

The parameters applied to the estimates of emissions and removals in the NFMS are summarized below:

Parameter	Acronym	Units	Value	Source	Sub activity
Biomass expansion factor	BEF	No units	1.75	INGEI, 2020	Deforestation Substitution Stock Enhancement
Wood base density value	D	t d.m. m^{-3}	0.496166	INGEI, 2020	Deforestation Substitution Stock Enhancement
Relationship between above and below ground biomass	R	No units	0.2869	INGEI, 2020	Deforestation Substitution Stock Enhancement
Yearly decrease in carbon contents due to wood harvesting, firewood extraction and disruption in non-forest lands converted into forest	ΔCL Aum	t C $year^{-1}$	0	Assumption	Deforestation Substitution Stock Enhancement
Post – conversion biomass	BAFTER	t biomass ha^{-1}	0	Assumption	Deforestation Substitution Stock Enhancement
Post – deforestation stocks	Cn	t C ha^{-1}	0	Assumption	Deforestation Substitution Stock Enhancement
Yearly loss of carbon stocks in biomass due to disruptions in forest lands converted to non-forests in year -t.	ΔCL	t C $year^{-1}$	0	Assumption	Deforestation Substitution Stock Enhancement

Table 4 Parameters applied to emissions and removals estimations in the NFMS.

The parameters used for the calculations of emissions and reversals, segregated by land use and sub-use, according to the REDD+ activities are summarized in the following table:

Land use	Sub-use	t dry AGB/ha	t dry BGB/ha	Source
		REDD Activities Deforestation, Enhancement Substitution		
Settlements	-	2	0	INGEI, 2020
Cropland	-	10	2	INGEI, 2020
Grassland and Shrubland	Grassland	4.73	8.13	Gayoso et al. (2006)
	Scrub - Grassland	9.04	14.99	Gayoso et al. (2006)
	Scrub	9.04	14.99	Gayoso et al. (2006)
	Arborescent Scrub	21.78	35.25	Gayoso et al. (2006)
	Scrub with Succulent plants	9.04	14.99	Gayoso et al. (2006)
	Succulent Plant Formation	4.73	8.13	Assumption, equal to grassland
	Shrubs Plantation	9.04	14.99	Gayoso et al. (2006)
Forest land	Plantation	0	0	National panel of experts
Wetlands	Managed bodies (reservoirs)	0	0	Assumption
	Unmanaged bodies (natural rivers, lakes)	0	0	Assumption
Other land	Areas without vegetation (bare soil, rock)	0	0	Assumption
	Perennial snow and glacier areas	0	0	Assumption
	Unrecognized Areas	N/U	N/U	-

Table 5 Parameters by REDD activity, land use, and land sub – use.

3.1 Fixed Data and Parameters

Parameter:	Biomass expansion factor (BEF) for the native forest
Description:	This factor expands the total volume of above ground biomass to compensate for non-marketable aspects of the enhancement.
Data unit:	Dimensionless parameter
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	The Biomass expansion factor comes from information collected in the country from the study of Gayoso et al. (2002) and used in INGEI (2020). This value is for native species and has a national spatial level.
Value applied:	1.75
QA/QC procedures applied	These are reference national values obtained from Gayoso et al. (2002) and INGEI (2020) as was mentioned before.
Uncertainty associated with this parameter:	Error calculation based on statistical data from the Biomass Inventory and Carbon Accounting of the Universidad Austral de Chile (UACh). Error: 18%
Any comment:	

Parameter:	Basic density value of the wood (D)
Description:	Calculated using basic density data collected from native species growing in Chile.
Data unit:	t d.m. m^{-3}
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	A bibliographic review of basic densities of the forest species in Chile was carried out and there were no modifications for the value exposed from Gayoso et al. (2002) and INGEI (2020).
Value applied:	0.496166
QA/QC procedures applied	These are reference national values obtained from Gayoso et al. (2002) and INGEI (2020) as was mentioned before.
Uncertainty associated with this parameter:	Calculation was performed using basic density data collected from native species growing in Chile. Error: 5.6%
Any comment:	

Parameter:	Root-to-shoot ratios of native forest (R factor)
Description:	Relationship between below ground and above ground biomass
Data unit:	t d.m. m^{-3}
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	R factor comes from information collected in the country (Gayoso et al., 2002; INGEI, 2020). This value is within the range of values indicated in the 2006 IPCC Guidelines for temperate forests (between 0.20 and 0.46, according to Table 4.4; Chapter 4; Volume 4) and within the values available worldwide, which provide R factors that range between 0.09 and 0.33. This value is for native species and has a national spatial level.
Value applied:	0.2869
QA/QC procedures applied	These are reference national values obtained from Gayoso et al. (2002) and INGEI (2020) as was mentioned before. QA / QC applied in documentation process "Estimación de valores de fracción de carbono, relación tallo raíz" ("Estimation of carbon fraction values, stem-root relation").
Uncertainty associated with this parameter:	Error calculation based on statistical data from the Biomass Inventory and Carbon Accountancy of the Universidad Austral de Chile (UACh). Error: 9.4%
Any comment:	

Parameter:	Above and below ground biomass of other uses
Description:	Above and below ground biomass of Urban and Industrial Areas, agricultural land, grassland, scrub, arborescent scrub, shrub planting, succulent scrub, succulent formations, plantations, wetlands, areas deprived of vegetation, eternal snows and glaciers, waterbodies and unrecognized areas
Data unit:	Tons of dry biomass ha^{-1} (t d.m. ha^{-1})
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	● Urban and Industrial Areas (INGEI, 2020) ● Agricultural land (INGEI, 2020) ● Grassland (Gayoso et al., 2006) ● Grassland - Scrub (Gayoso et al., 2006) ● Scrub (Gayoso et al., 2006) ● Arborescent scrub (Gayoso et al., 2006) ● Scrub with succulent (Gayoso et al., 2006) ● Succulent formations (assumption of grassland values (Gayoso et al., 2006)) ● Shrub planting (Gayoso et al., 2006) ● Plantation (Expert national panel) ● Wetlands (assumption) ● Areas deprived of vegetation (assumption) ● Eternal snows and glaciers (assumption) ● Waterbodies (assumption) ● Unrecognized areas (assumption) These are reference national values obtained from Gayoso et al. (2006), INGEI (2020), an expert national panel and assumption as mentioned before.

Value applied:

Use / sub use	t dry above ground biomass ha^{-1}	t dry below ground biomass ha^{-1}
Urban and Industrial Areas	2	0
Agricultural land	10	2
Grassland	4.73	8.13
Grassland - Scrub	9.04	14.99
Scrub	9.04	14.99
Arborescent scrub	21.78	35.25
Scrub with succulent	9.04	14.99
Succulent formations	4.73	8.13
Shrub planting	9.04	14.99
Plantation	0	0
Wetlands	0	0
Areas deprived of vegetation	0	0
Eternal snows and glaciers	0	0
Waterbodies	0	0
Unrecognized areas	0	0

QA/QC procedures applied

These are reference national values obtained from Gayoso et al. (2006), INGEI (2020), an expert national panel and assumption as mentioned before.

Uncertainty associated with this parameter:

Data from INGEI (2020) and Gayoso et al., (2006).

Use / sub use	Error % in above ground biomass
Urban and Industrial Areas	95%
Agricultural land	75%
Grassland	27.7%
Grassland – Scrub	34.6%
Scrub	34.6%
Arborescent scrub	22.4%
Scrub with succulent	34.6%
Succulent formations	27.7%
Shrub planting	34.6%

Uncertainty for below ground biomass (BGB) of Non-Forest lands is based on propagation error estimate following IPCC approach 1 of Matorral-Arborescente AGB error (22.42%) and Root shoot ratio -R Factor error (48.27%) estimated by Gayoso et al. (2002), resulting in total uncertainty of 53.2%.

Any comment:

Parameter:	Above and below ground biomass of native forest.
Description:	Above and below ground biomass of native forest. The native forest is classified by different forest type and structure. Each forest type has its own biomass value in some cases, depending on data availability.
Data unit:	Tons of dry biomass ha^{-1} (t d.m. ha^{-1}).
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	Native forest data are national data and published in INGEI (2020). The mixed forest is calculated as a weighted average value of the forest types present in the region and according to the forest type surface present for the activity of deforestation of the period. For missing biomass values of the forest types and some of the structures a weighted average value was calculated in the region and according to the forest type surface present at the final year in the reference level (2013). The AGB and BGB parameters are estimated from the IFN plots. The estimate of the variation in carbon content on forests that remain as such for FREL/FRL and monitoring report for Degradation, Restoration of Forest remaining forests and Forestry Conservation activities is estimated based on information coming from the Continuous Inventory of Forest Ecosystems and the application of remote sensing techniques on LANDSAT satellite images.
Value applied:	

Forest type	Structure	AGB (t d.m. ha^{-1})	BGB (t d.m. ha^{-1})
Alerce	Adult	339.1	97.3
Alerce	Young	203.6	58.4
Alerce	Adult/Young	203.6	58.4
Alerce	Stunted	339.1	97.3
Ciprés de las Guaitecas	Adult	198.0	56.8
Ciprés de las Guaitecas	Young	198.0	56.8
Ciprés de las Guaitecas	Adult/Young	198.0	56.8
Ciprés de las Guaitecas	Stunted	198.0	56.8
Araucaria	Adult	421.4	120.9
Araucaria	Young	219.1	62.9
Araucaria	Adult/Young	219.1	62.9
Araucaria	Stunted	421.4	120.9
Ciprés de la Cordillera	Adult	124.0	35.6
Ciprés de la Cordillera	Young	124.0	35.6
Ciprés de la Cordillera	Adult/Young	124.0	35.6
Ciprés de la Cordillera	Stunted	124.0	35.6
Lenga	Adult	198.5	56.9
Lenga	Young	237.2	68.1
Lenga	Adult/Young	237.2	68.1
Lenga	Stunted	198.5	56.9
Coihue de Magallanes	Adult	129.1	37.1
Coihue de Magallanes	Young	129.1	37.1
Coihue de Magallanes	Adult/Young	129.1	37.1
Coihue de Magallanes	Stunted	129.1	37.1
Roble - Hualo	Adult	114.9	33.0
Roble - Hualo	Young	114.9	33.0

	Roble - Hualo	Adult/Young	114.9	33.0
	Roble - Hualo	Stunted	114.9	33.0
	Roble - Raulí - Coihue	Adult	178.6	51.2
	Roble - Raulí - Coihue	Young	152.8	43.8
	Roble - Raulí - Coihue	Adult/Young	152.8	43.8
	Roble - Raulí - Coihue	Stunted	178.6	51.2
	Coihue - Raulí - Tepa	Adult	377.0	108.2
	Coihue - Raulí - Tepa	Young	377.0	108.2
	Coihue - Raulí - Tepa	Adult/Young	377.0	108.2
	Coihue - Raulí - Tepa	Stunted	377.0	108.2
	Esclerófilo	Adult	18.6	5.3
	Esclerófilo	Young	18.6	5.3
	Esclerófilo	Adult/Young	18.6	5.3
	Esclerófilo	Stunted	18.6	5.3
	Siempreverde	Adult	361.6	103.8
	Siempreverde	Young	127.3	36.5
	Siempreverde	Adult/Young	127.3	36.5
	Siempreverde	Stunted	361.6	103.8
QA/QC procedures applied	SOP_06_Field Operation Manual			
Uncertainty associated with this parameter:	Uncertainty for Below Ground Biomass BGB is based on propagation error estimate following IPCC approach 1 of Above Ground Biomass-AGB error (18.85%) and Root shoot ratio -R Factor error (9.4%) estimated by Gayoso et al. (2002), resulting in total uncertainty of 44.2%. For the forest types with a limited number of sampling plots, AGB uncertainty propagation with Monte Carlo analysis uses the following information: i. DBH measurement error (0.2%), calculation based on Continuous Forest Inventory data of INFOR; ii. Volume estimation error (0.07%), calculation based on Continuous Forest Inventory data of INFOR, iii. Biomass Expansion Factor (BEF) error (18.0%), BEF comes from information collected in the country from the study of Gayoso et al. (2002) and used in INGEI (2020). This value is for native species and has a national spatial level. Error calculation is based on statistical data from the Biomass Inventory and Carbon Accountancy of the Universidad Austral de Chile (UACh); and iv. Wood Density (5.6%) calculated using basic density data collected from native species growing in Chile. Finally, these uncertainties are combined following IPCC approach 1 (error propagation), resulting in total uncertainty of 18.85%			
Any comment:				

Parameter:	Dead organic matter of native forest (DOM).
Description:	The native forest is classified by different forest types and structures. Each forest type has its own dead organic matter value in some cases, depending on data availability. The mixed forest is calculated as a weighted average value of the forest types present in the region and according to the forest surface present for the activity of deforestation of the period. For the missing DOM value of the forest types and some of the structures, a weighted average value was calculated in the region and according to the forest type surface present at the final year in the reference level (2013).
Data unit:	Tons of carbon in dead organic matter ha^{-1} ($tC\ ha^{-1}$).
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	Forest native data are national data and published in INGEI (2020).

Value applied:

Forest type	Structure	AGB ($tC\ ha^{-1}$)
Alerce	Adult	121.4
Alerce	Young	121.4
Alerce	Adult/Young	121.4
Alerce	Stunted	121.4
Ciprés de las Guaitecas	Adult	62.11
Ciprés de las Guaitecas	Young	62.11
Ciprés de las Guaitecas	Adult/Young	62.11
Ciprés de las Guaitecas	Stunted	62.11
Araucaria	Adult	133.4
Araucaria	Young	133.4
Araucaria	Adult/Young	133.4
Araucaria	Stunted	133.4
Ciprés de la Cordillera	Adult	62.11
Ciprés de la Cordillera	Young	62.11
Ciprés de la Cordillera	Adult/Young	62.11
Ciprés de la Cordillera	Stunted	62.11
Lenga	Adult	43.4
Lenga	Young	43.4
Lenga	Adult/Young	43.4
Lenga	Stunted	43.4
Coihue de Magallanes	Adult	140.1
Coihue de Magallanes	Young	140.1
Coihue de Magallanes	Adult/Young	140.1
Coihue de Magallanes	Stunted	140.1
Roble - Hualo	Adult	62.11
Roble - Hualo	Young	62.11
Roble - Hualo	Adult/Young	62.11
Roble - Hualo	Stunted	62.11
Roble - Raulí - Coihue	Adult	52.9
Roble - Raulí - Coihue	Young	52.9
Roble - Raulí - Coihue	Adult/Young	52.9
Roble - Raulí - Coihue	Stunted	52.9

	Coihue - Raulí - Tepa	Adult	74.4
	Coihue - Raulí - Tepa	Young	74.4
	Coihue - Raulí - Tepa	Adult/Young	74.4
	Coihue - Raulí - Tepa	Stunted	74.4
	Esclerófilo	Adult	16.7
	Esclerófilo	Young	16.7
	Esclerófilo	Adult/Young	16.7
	Esclerófilo	Stunted	16.7
	Siempreverde	Adult	64.8
	Siempreverde	Young	64.8
	Siempreverde	Adult/Young	64.8
	Siempreverde	Stunted	64.8
QA/QC procedures applied	SOP_06_Field Operation Manual		
Uncertainty associated with this parameter:	Error estimated from permanent plots of the INFOR Continuous Forest Inventory Error: 28.4%		
Any comment:			

Parameter:	Periodic annual increment (PAI) according to forest type		
Description:	Periodic annual increment (PAI) according to forest type and structure. Each forest type has its own biomass value in some cases, depend on data availability. For missing PAI value of the forest types and some of the structures a weighted average value was calculated in the region and according to the forest type surface present at the final year in the reference level (2013).		
Data unit:	Cubic meter per hectare and year (m^3 ha^{-1} $year^{-1}$)		
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	Forest native data are national data and published in INGEI (2020)		
Value applied:	**Forest type**	**Structure**	**PAI (m^3 ha^{-1} $year^{-1}$)**
	Alerce	Mature	0.5
	Alerce	Young	0.5
	Alerce	Mature/Young	0.5
	Alerce	Stunted	0.5
	Ciprés de las Guaitecas	Mature	3.9
	Ciprés de las Guaitecas	Young	3.9
	Ciprés de las Guaitecas	Mature/Young	3.9
	Ciprés de las Guaitecas	Stunted	3.9
	Araucaria	Mature	4.6
	Araucaria	Young	4.6

	Araucaria	Mature/Young	4.6
	Araucaria	Stunted	4.6
	Ciprés de la Cordillera	Mature	5
	Ciprés de la Cordillera	Young	2.7
	Ciprés de la Cordillera	Mature/Young	2.7
	Ciprés de la Cordillera	Stunted	5
	Lenga	Mature	5.8
	Lenga	Young	3.9
	Lenga	Mature/Young	3.9
	Lenga	Stunted	5.8
	Coihue de Magallanes	Mature	2.6
	Coihue de Magallanes	Young	3.7
	Coihue de Magallanes	Mature/Young	3.7
	Coihue de Magallanes	Stunted	2.6
	Roble - Hualo	Mature	5.1
	Roble - Hualo	Young	3.5
	Roble - Hualo	Mature/Young	3.5
	Roble - Hualo	Stunted	5.1
	Roble - Raulí - Coihue	Mature	6.6
	Roble - Raulí - Coihue	Young	4.1
	Roble - Raulí - Coihue	Mature/Young	4.1
	Roble - Raulí - Coihue	Stunted	6.6
	Coihue - Raulí - Tepa	Mature	5.8
	Coihue - Raulí - Tepa	Young	4.9
	Coihue - Raulí - Tepa	Mature/Young	4.9
	Coihue - Raulí - Tepa	Stunted	5.8
	Esclerófilo	Mature	1.5
	Esclerófilo	Young	1.6
	Esclerófilo	Mature/Young	1.6
	Esclerófilo	Stunted	1.5
	Siempreverde	Mature	6
	Siempreverde	Young	4.1
	Siempreverde	Mature/Young	4.1
	Siempreverde	Stunted	6
QA/QC procedures applied	SOP_06_Field Operation Manual		
Uncertainty associated with this parameter:	SOP_06 Field Operations Manual was implemented during fieldwork to estimate PAI in the National Forest Inventory, for some forest types were possible to adjust a Probability Distribution Function (PDF). For the forest types with a limited number of sampling plots, uncertainty propagation with Monte Carlo analysis uses the calculation of the measurement uncertainty for PAI based on the 95% CI of the removal rate by forest type, calculated with Continuous Forest Inventory data of INFOR. ● PAI Araucaria Adulto, PAI Lenga Adulto, PAI Lenga Renoval, PAI Roble - Hualo Adulto, PAI Roble - Raulí - Coihue Adulto, PAI Roble - Raulí - Coihue Renoval, PAI Coihue - Raulí - Tepa Adulto, PAI Coihue - Raulí - Tepa		

	Renoval, PAI Esclerófilo Adulto, PAI Siempreverde Adulto, PAI Siempreverde Renoval= adjust a Probability Distribution Function (PDF) ● PAI Alerce Adulto = 58.47% (The higher uncertainty of the errors estimated for PAI is assumed due to a lack of data.) ● PAI Ciprés de las Guaitecas Adulto = 58.47% (The higher uncertainty of the errors estimated for IPA is assumed due to a lack of data.) ● PAI Ciprés de la Cordillera Adulto =15.83% (Error estimated from permanent plots of the INFOR Continuous Forest Inventory) ● PAI Ciprés de la Cordillera Renoval = 9.97% (Error estimated from permanent plots of the INFOR Continuous Forest Inventory) ● PAI Coihue de Magallanes Adulto = 13.42% (Error estimated from permanent plots of the INFOR Continuous Forest Inventory) ● PAI Coihue de Magallanes Renoval = 7.68% (Error estimated from permanent plots of the INFOR Continuous Forest Inventory) ● PAI Roble - Hualo Renoval = 54.47% (The higher uncertainty of the errors estimated for PAI is assumed due to a lack of data) ● PAI Esclerófilo Renoval = 21.31% (Error estimated from permanent plots of the INFOR Continuous Forest Inventory)
Any comment:	

Parameter:	Combustion factor
Description:	Emission factor for degradation due to forest fires
Data unit:	Non-dimensional
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	Intergovernmental Panel on Climate Change (IPCC). 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 4, Chapter 2, Table 2.6 International - Extra tropical forest
Value applied:	0.45
QA/QC procedures applied	
Uncertainty associated with this parameter:	Error estimated using the standard deviation and median default emission factor of the IPCC 2006. Error: 36%
Any comment:	

Parameter:	CH_4 emission factor
Description:	Emission factor for degradation due to forest fires
Data unit:	g kg^{-1} of burned dry material
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	Intergovernmental Panel on Climate Change (IPCC). 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 4, Chapter 2, Table 2.5 International - Extra tropical forest
Value applied:	4.7
QA/QC procedures applied	
Uncertainty associated with this parameter:	Error estimated using the standard deviation and median default emission factor of the IPCC 2006. Error: 29.0%
Any comment:	

Parameter:	N_2O emission factor
Description:	Emission factor for degradation due to forest fires
Data unit:	g kg^{-1} of burned dry material
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	Intergovernmental Panel on Climate Change (IPCC). 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 4, Chapter 2, Table 2.5 International - Extra tropical forest
Value applied:	0.26
QA/QC procedures applied	
Uncertainty associated with this parameter:	Error estimated using the standard deviation and median default emission factor of the IPCC 2006. Error: 43.8%
Any comment:	

3.2 Monitored data and parameters

a) Deforestation FREL/FRL

<table>
<tr><td>Parameter:</td><td>$\Delta A_{TO_OTHERSi,t}$ = Areas of different Forest Types(i) converted to another category of land use during the 2001 – 2013 period.</td></tr>
<tr><td>Description:</td><td>Chile has eleven different Native Forest Types in the PRE area.</td></tr>
<tr><td>Data unit:</td><td>Total hectares (ha/year) of the 2001-2013 period.</td></tr>
<tr><td>Value monitored during this Monitoring / Reporting Period:</td><td>
<table>
<tr><th>Forest Type</th><th>Area</th></tr>
<tr><td>Alerce</td><td>119.3</td></tr>
<tr><td>Araucaria</td><td>337.3</td></tr>
<tr><td>Ciprés de la Cordillera</td><td>35.4</td></tr>
<tr><td>Ciprés de las Guaitecas</td><td>9.2</td></tr>
<tr><td>Coihue - Raulí - Tepa</td><td>653.3</td></tr>
<tr><td>Coihue de Magallanes</td><td>143.9</td></tr>
<tr><td>Esclerófilo</td><td>407.2</td></tr>
<tr><td>Lenga</td><td>2,519.3</td></tr>
<tr><td>Roble - Hualo</td><td>104.4</td></tr>
<tr><td>Roble - Raulí - Coihue</td><td>1,714.6</td></tr>
<tr><td>Siempreverde</td><td>1,873.9</td></tr>
<tr><td>Without Forest Type</td><td>144.6</td></tr>
<tr><td>Total (ha)</td><td>8,062.4</td></tr>
</table>
</td></tr>
<tr><td>Source of data and description of measurement/calculation methods and procedures applied:</td><td>Matrices of change in land use taken from Land Use Change Maps. Multipixel mosaics are used for the detection of changes in land use, focused in polygons of native forest. From the mosaic, the MIICA method is applied for the identification of spectral gains and losses, which through different techniques of post-processing allow identifying areas of forest losses and gains. The application of method establishes a series of requirements for the tiles, related to the removal of clouds, cloud shadows and artifacts. In addition, the map of use and change of use is linked to the information that comes from the Native Forest Cadastres of CONAF, therefore, the map of Land Use Change is the result of the application of the MIICA method, and the Cadastre of Native Forest. The Land Use Change Map is presented as a product through a coverage geographical area called "Traceability", which has as a characteristic the monitoring periods available for a certain region, which allows giving monitoring of historical land uses for each polygon.
The final product is regional, characterized by stunted, mature, young mature, mixed and young forests converted into areas with no vegetation, urban and industrial areas, waterbodies, areas where succulents, wetlands, schrubland, perennial snow and glaciers, grasslands and farmland have formed.</td></tr>
<tr><td>QA/QC procedures applied:</td><td>For the generation of deforestation activity data and as part of the QA / QC process, the different procedures implemented are documented in SOPs that allow the estimates to be standardized over time.
SOP_01: Selection of REDD+ satellite mosaics
SOP_02: Elaboration of LULUCF maps</td></tr>
<tr><td>Uncertainty for this parameter:</td><td>The uncertainty of land-use change maps is estimated by comparing the results of the land-use change category on the map and the reference observations corresponding to a sample of visually interpreted points. The errors related to land-use change are calculated following the Good Practice Guidelines for estimating the precision of change of use described in Olofsson et al. (2013).</td></tr>
</table>

	Error = Maule 111.3%, Ñuble 72.3%, Biobío 109.6%, Araucanía 191.6%, Los Ríos 96.6%, Los Lagos 89.1%
Any comment:	Link: https://drive.google.com/uc?export=download&id=1JxwUMTfyIiozhMcPsWmwrEEPwadfUsSh

b) Degradation – forest remaining forest FREL/FRL

Parameter:	A_{DegFF} = Area of degradation of forests remaining forests monitored during 2001 - 2010 period, in areas not affected by browning (NBA).
Description:	We have 6 regions for the PRE area, Maule, Ñuble, Biobio, La Araucanía, Los Ríos and Los Lagos. The Biobio Region was divided in two Region. The province of Ñuble, which was part of Biobio Region, is a new Region. The surface of the total area remains equal. The surface area was described by degradation of native forest that remains as such.
Data unit:	Total hectares (ha/year) of the 2001-2010 period.
Value monitored during this Monitoring / Reporting Period:	**Region** / **Area** Maule 73,201 Ñuble 29,480 Biobío 50,825 La Araucanía 57,880 Los Ríos 29,709 Los Lagos 116,395 **Total** 357,490
Source of data and description of measurement/calculation methods and procedures applied:	The data comes from INFOR's National Forest Inventory (IFN) plots, combined with spectral information from the Landsat series. This information integrates the variables of the state of the forests on the number of trees per hectare, basal area and volumes recorded by the monitoring of IFN plots, with the spectral data from Landsat to estimate carbon stocks in a spatially explicit way.
QA/QC procedures applied:	Since one input for AD on degradation are the Land Use Change Maps in order to define areas of forest remaining forest, same QA/QC procedures and SOP are used during the process. Additional procedures are applied, and proper SOP were developed. SOP_05_ Method for estimating in forest remaining forests the carbon variation. SOP_06: Field Operations Manual
Uncertainty for this parameter:	Degradation mapping accuracy estimated by INFOR. Error: 32.8%
Any comment:	Link: https://drive.google.com/uc?export=download&id=1KXI4CfOKLRrtxPVXfqk5ejz2dV6Cda61

c) Degradation - Substitution activity FREL/FRL

Parameter:	A_{DegNFF} = Surface of degradation areas resulting from the conversion of forests into plantations during the 2001-2013 period.
Description:	The total of areas by forest type that was degradation to plantation were registered
Data unit:	Total hectares (ha/year) of the period 2001-2013
Value monitored during this Monitoring / Reporting Period:	

Forest Type	Area
Alerce	0.6
Araucaria	8.1
Ciprés de la Cordillera	15.2
Ciprés de las Guaitecas	0.8
Coihue - Raulí - Tepa	335.3
Coihue de Magallanes	2.5
Esclerófilo	1,423.8
Lenga	186
Roble - Hualo	523.1
Roble - Raulí - Coihue	2,881.3
Siempreverde	1,376.2
Without Forest Type	1,577.6
Total (ha)	8,330.4

Source of data and description of measurement/calculation methods and procedures applied:	To estimate degradation of native forests converted to plantations, the equation used to estimate deforestation is applied, since it is assumed that, to establish a plantation, all the carbon content present in the preceding native forest must be reduced to zero.
QA/QC procedures applied:	For the generation of degradation by substitution activity data and as part of the QA / QC process, the different procedures implemented are documented through a series of protocols or SOPs that allow the estimates to be standardized over time. SOP_01: Selection of REDD+ satellite mosaics SOP_02: Elaboration of LULUCF maps
Uncertainty for this parameter:	The uncertainty of land-use change maps is estimated by comparing the results of the land-use change category on the map and the reference observations corresponding to a sample of visually interpreted points. The errors related to land-use change are calculated following the Good Practice Guidelines for estimating the precision of change of use described in Olofsson et al. (2013). Error = Maule 191.8%, Ñuble 139.9%, Biobío 134.9%, Araucanía 113.4%, Los Ríos 138.6%, Los Lagos 100.0%
Any comment:	Link: https://drive.google.com/uc?export=download&id=1KBPzMuEUIVy0HZF9NupEoBCRjqAhKonn

d) Degradation – Forest fire activity FREL/FRL

Parameter:	A = Area burned between 2001-2010 in the ERP Regions.
Description:	The surface of burned areas was recorded to estimate the degradation of the native forest.
Data unit:	Total hectares (ha) of the 2001-2010 period.
Value monitored during this Monitoring / Reporting Period:	

Region/Year	Maule	Biobío	La Araucanía	Los Lagos	Los Ríos	Ñuble
2001	25	69	64	9	1	20
2002	147	7,443	18,765	2,552	904	117
2003	504	30	226	27	3	129
2004	171	197	268	91	175	15
2005	140	118	72	47	19	278
2006	62	57	73	207	7	90
2007	9	747	39	52	5	199
2008	344	144	307	4,234	119	87
2009	3,999	898	726	598	271	59
2010	432	581	42	1	1	399
Total period	5,834	10,285	20,581	7,819	1,504	1,392

Source of data and description of measurement/calculation methods and procedures applied:	The Forest Fire Protection Department and its Digital Information System for Operations Control provides annualized statistical information on the occurrence of forest fires for the entire country, which in recent years it has been improved by adding the spatial location of fires.
QA/QC procedures applied:	SOP_05_ Method for estimating in forest remaining forests the carbon variation.
Uncertainty for this parameter:	Area burned uncertainty estimated by INGEI (2020) Error: 15%
Any comment:	Link: https://drive.google.com/uc?export=download&id=1KP-BsYfRCbE49HZXydsGlyge0FJMRnXd

e) Enhancement activity – No forest to native forest FREL/FRL

Parameter:	$\Delta A_{TOOTHERSi,\ t}$ = Area of used non-forest land converted into forest during the reference level
Description:	The areas that correspond to non-forest lands were quantified in hectares to later estimate the carbon capture balances of these changes in land use. In this data forest plantations with exotic species are included as non-forest land.
Data unit:	Total hectares (ha/year) of the period 2001-2013
Value monitored during thisMonitoring / Reporting Period:	**Forest Type** / **Area** Alerce 23 Araucaria 103 Ciprés de la Cordillera 125 Ciprés de las Guaitecas 21 Coihue - Raulí - Tepa 202 Coihue de Magallanes 13 Esclerófilo 4,863 Lenga 320 Roble - Hualo 490 Roble - Raulí - Coihue 3,585 Siempreverde 1,417 Without Forest Type 2,360 **Total (ha)** **13,522**
Source of data and description of measurement/calculation methods and procedures applied:	A semi-automated technique is applied to detect changes using satellite images. The Multi-index method or MIICA (Jin et al., 2013) detects changes in land use for the period under study. The MIICA methodology is based on the combination of 2 spectral indices (dNBR, dNDVI) which, through integration rules, provide coverage of land use change, indicating the magnitude and directionality of the change. (Profit and loss). The MIICA methodology used images from the Landsat 8 sensor and was applied through a series of codes in programming language (Javascript, R) complemented with Google Earth Engine cloud processing, in GIS programs and R software, with the objective of obtaining an efficient land use change map.
QA/QC procedures applied:	For the generation of enhancement (non-forest to forest) activity data and as part of the QA / QC process, the different procedures implemented are documented through a series of protocols or SOPs that allow the estimates to be standardized over time. SOP_01: Selection of REDD+ satellite mosaics SOP_02: Elaboration of LULUCF maps,
Uncertainty for this parameter:	The uncertainty of land-use change maps is estimated by comparing the results of the land-use change category on the map and the reference observations corresponding to a sample of visually interpreted points. The errors related to land-use change are calculated following the Good Practice Guidelines for estimating the precision of change of use described in Olofsson et al. (2013). Error = Maule 80%, Ñuble 50.5%, Biobío 136.5%, Araucanía 192.2%, Los Ríos 65.1%, Los Lagos 138.5%
Any comment:	Link: https://drive.google.com/uc?export=download&id=1KIXPHr_Tg0YvpLkwNhx2MTJlAIdegb1U

f) Enhancement activity – forest remains forest in non-conservation areas FREL/FRL

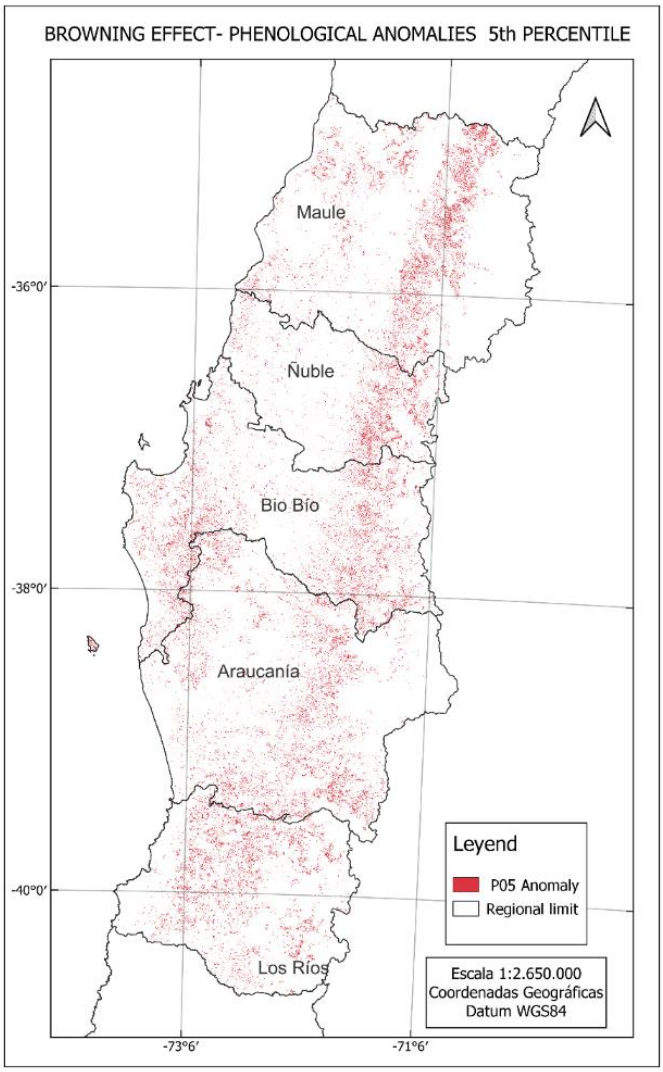
Parameter:	A_{EnhFF} = Areas of non-conservation native forest that remains forest during the 2001– 2010 period for the Sixth Region of the ERP, in areas not affected by browning (NBA).
Description:	The areas that in 2001-2010 are forest in non-conservation area and remain as such, the hectares were estimated.
Data unit:	Total hectares (ha/year) of the 2001-2010 period.
Value monitored during this Monitoring / Reporting Period:	<table><tr><th>Region</th><th>Area</th></tr><tr><td>Maule</td><td>88,778</td></tr><tr><td>Ñuble</td><td>33,323</td></tr><tr><td>Biobío</td><td>65,805</td></tr><tr><td>La Araucanía</td><td>87,901</td></tr><tr><td>Los Ríos</td><td>47,402</td></tr><tr><td>Los Lagos</td><td>139,986</td></tr><tr><td>**Total (ha)**</td><td>**463,195**</td></tr></table>
Source of data and description of measurement/calculation methods and procedures applied:	The data comes from INFOR's National Forest Inventory (IFN) plots, combined with spectral information from the Landsat series. This information integrates the variables of the state of the forests on the number of trees per hectare and basal area recorded by the monitoring of IFN plots, with the spectral data from Landsat to estimate carbon stocks in a spatially explicit way.
QA/QC procedures applied:	Since one input for AD on enhancement in areas of forest that remain as forest are the Land Use Change Maps in order to define areas of forest remaining forest, same QA/QC procedures and SOP are used during the process. Additional procedures are applied, and proper SOP were developed. SOP_05: Method for estimating in forest remaining forests the carbon variation. SOP_06: Field Operations Manual Inventory
Uncertainty for this parameter:	Degradation mapping accuracy estimated by INFOR. Error: 32.8%
Any comment:	Link: https://drive.google.com/uc?export=download&id=1KXI4CfOKLRrtxPVXfqk5ejz2dV6Cda61

g) Conservation activity FREL/FRL

<table>
<tr><td>Parameter:</td><td>$\Delta A_{TO_OTHERSi,t}$ = Areas of conservation native forest that remains as such during the 2001-2010 period in the Six Region of the ERP, in areas not affected by browning (NBA).</td></tr>
<tr><td>Description:</td><td>The areas that in 2001 to 2010 are forest in conservation area and remain as such</td></tr>
<tr><td>Data unit:</td><td>Total hectares (ha) of the period 2001-2010</td></tr>
<tr><td>Value monitored during this Monitoring / Reporting Period:</td><td><table><tr><th>Region</th><th>Area</th></tr><tr><td>Maule</td><td>3,315</td></tr><tr><td>Ñuble</td><td>8,882</td></tr><tr><td>Biobío</td><td>15,509</td></tr><tr><td>La Araucanía</td><td>27,794</td></tr><tr><td>Los Ríos</td><td>26,371</td></tr><tr><td>Los Lagos</td><td>88,396</td></tr><tr><td>Total (ha)</td><td>170,267</td></tr></table></td></tr>
<tr><td>Source of data and description of measurement/calculation methods and procedures applied:</td><td>The data comes from INFOR's National Forest Inventory (IFN) plots, combined with spectral information from the Landsat series. This information integrates the variables of the state of the forests on the number of trees per hectare and basal area recorded by the monitoring of IFN plots, with the spectral data from Landsat to estimate carbon stocks in a spatially explicit way.</td></tr>
<tr><td>QA/QC procedures applied:</td><td>Since one input for AD on enhancement in areas of forest that remain as forest are the Land Use Change Maps in order to define areas of forest remaining forest, same QA/QC procedures and SOP are used during the process. Additional procedures are applied, and proper SOP were developed.
SOP_05: Method for estimating in forest remaining forests the carbon variation.
SOP_06: Field Operations Manual</td></tr>
<tr><td>Uncertainty for this parameter:</td><td>Degradation mapping accuracy estimated by INFOR.
Error: 32.8%</td></tr>
<tr><td>Any comment:</td><td>Link:
https://drive.google.com/uc?export=download&id=1Kg4eLQfzjG3Gr3cuMfELi0aXbkBDsNgZ</td></tr>
</table>

h) Emissions and removals from browning affected forest area FREL/FRL

<table>
<tr><td>Parameter:</td><td>Browning = Areas of native forest that remains as such affected by browning during the 2001– 2010 period in the six Region of the ERP.</td></tr>
<tr><td>Description:</td><td>The areas that in 2001 to 2010 are forests affected by browning in forest areas that remain as such.</td></tr>
<tr><td>Data unit:</td><td>Total hectares (ha) of the 2001-2010 period.</td></tr>
<tr><td>Value monitored during this Monitoring / Reporting Period:</td><td>
<table>
<tr><th>Region</th><th>Degradation (Ha)</th><th>Enhancement (Ha)</th><th>Conservation (Ha)</th></tr>
<tr><td>Maule</td><td>24,394</td><td>31,978</td><td>976</td></tr>
<tr><td>Ñuble</td><td>7,157</td><td>8,850</td><td>1,342</td></tr>
<tr><td>Biobío</td><td>10,009</td><td>14,065</td><td>2,666</td></tr>
<tr><td>La Araucanía</td><td>7,725</td><td>11,916</td><td>776</td></tr>
<tr><td>Los Ríos</td><td>3,323</td><td>6,640</td><td>299</td></tr>
<tr><td>Los Lagos</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>Total (ha)</td><td>52,609</td><td>73,449</td><td>6,059</td></tr>
</table>
</td></tr>
<tr><td>Source of data and description of measurement/calculation methods and procedures applied:</td><td>As could be seen in certain tables by activity data described above, emissions accounting in forest remaining forest was carried out in areas not affected by browning (NBA) excluding the areas affected by browning (BA). This occurs due to areas affected by browning are considered as a non-anthropogenic emission source because the carbon fluxes that occurs on these areas are not related to human activities as the deforestation activity. It is a non-anthropogenic source because it is generated by the decreases in precipitation falls, and water availability. The areas affected by browning correspond to those areas of forest that remain as forests that present phenological anomalies because of the impact of the megadrought. These anomalies were detected in the integral productivity of native forest in the ERP implementation area and are under the 5th percentile data productivity anomaly (GAC,2023). The phenological anomaly results in the desiccation of the crowns, loss of foliage and even the mortality of individuals.
Down below is a map with the areas of the 5th percentile anomalies distribution. These areas were used in each monitoring report to exclude the emission related to the non-anthropogenic emissions in each period. They correspond to areas of native forest between the regions of Maule and La Araucanía, together with the area of the RORACO forest type extended to the region of Los Ríos. It is worth clarifying that the browning effect emission are excluded in both the degradation, increase and conservation activities in forest remaining forest. However, the forest stratum affected by browning is not excluded from the ERP implementation and monitoring area, and its treatment is maintained continuously at the same level of scope as those areas outside this stratum.
The raster layer of phenological anomalies could be found in the following link: https://drive.google.com/uc?export=download&id=15Yvf4zyMfiTu4HvBRyN9VgUZyt-Rv8Qk</td></tr>
</table>

	
QA/QC procedures applied:	SOP_05_Forest Carbon Flux estimation assessment SOP_06_Field Operation Manual
Uncertainty for this parameter:	Degradation mapping accuracy estimated by INFOR. Error: 32.8%
Any comment:	The same anomalies raster layer was used to segregate the browning areas in the NREF and Reporting Periods this allows that non-anthropogenic and anthropogenic emissions and removals are kept separate. The segregation considers report all the carbon fluxes which occur in those areas (gain, loss and neutral) from each period and excluding them from the account.
Any comment:	

i) Deforestation activity MR1

Parameter:	$\Delta A_{TO_OTHERS i,t}$ = Areas of different Forest Types (i) converted to another category of land use during the 2018 – 2019 period.
Description:	Chile has 11 different Native Forest Type in the PRE area.
Data unit:	Total hectares (ha) of the 2018-2019 period.
Value monitored during this Monitoring / Reporting Period:	

Forest Type	Area
Alerce	48
Araucaria	107
Ciprés de la Cordillera	191
Ciprés de las Guaitecas	6
Coihue - Raulí - Tepa	1,461
Coihue de Magallanes	104
Esclerófilo	1,848
Lenga	1,404
Roble - Hualo	134
Roble - Raulí - Coihue	5,702
Siempreverde	5,667
Without Forest Type	1,583
Total	**18,255**

Source of data and description of measurement/calculation methods and procedures applied:	Matrixes of change in land use taken from land-use change maps. Regional, characterized by stunted, mature, young mature, mixed and young forests converted into areas with no vegetation, urban and industrial areas, waterbodies, areas where succulents, wetlands, scrubland, perennial snow and glaciers, grasslands and farmland have formed.
QA/QC procedures applied:	SOP_02_LULUCF Maps Elaboration QAQC_02_Review and rectification of LULUCF maps ERPA SOP_03_ Standardization and quality control protocol for land use change maps QAQC_03_ Standardization and Quality control for land use change maps_ERPA
Uncertainty for this parameter:	The uncertainty of land-use change maps is estimated by comparing the results of the land-use change category on the map and the reference observations corresponding to a sample of visually interpreted points. The errors related to land-use change are calculated following the Good Practice Guidelines for estimating the precision of change of use described in Olofsson et al. (2013) and the estimator of the total area using the separate ratio estimator (formulas from sec. 6.10 of W.G. Cochran, Sampling Techniques, 3rd Edition, 1977) Error = Maule 74%, Ñuble 66%, Biobío 85%, Araucanía 155%, Los Ríos 113%, Los Lagos 78%.
Any comment:	Link: https://drive.google.com/uc?export=download&id=1JxwUMTfyIiozhMcPsWmwrEEPwadfUsSh

j) Degradation – forest remaining forest MR1

<table>
<tr><td>Parameter:</td><td>A_{DegFF} = Area of degradation of forests that remain as forests monitored during the 2018 - 2019 period.</td></tr>
<tr><td>Description:</td><td>The area was described by degradation of native forest that remains as such, in areas not affected by browning (NBA).</td></tr>
<tr><td>Data unit:</td><td>Total hectares (ha) of the 2018-2019 period.</td></tr>
<tr><td>Value monitored during this Monitoring / Reporting Period:</td><td>
<table>
<tr><th>Region</th><th>Area</th></tr>
<tr><td>Maule</td><td>66,869</td></tr>
<tr><td>Ñuble</td><td>22,583</td></tr>
<tr><td>Biobío</td><td>34,262</td></tr>
<tr><td>La Araucanía</td><td>47,666</td></tr>
<tr><td>Los Ríos</td><td>29,142</td></tr>
<tr><td>Los Lagos</td><td>90,428</td></tr>
<tr><td>Total</td><td>290,950</td></tr>
</table>
</td></tr>
<tr><td>Source of data and description of measurement/calculation methods and procedures applied:</td><td>The data comes from INFOR's National Forest Inventory (IFN) plots, combined with spectral information from the Landsat series. This information integrates the variables of the state of the forests on the number of trees per hectare, basal area and volumes recorded by the monitoring of IFN plots, with the spectral data from Landsat to estimate carbon stocks in a spatially explicit way.
The estimate of the variation in carbon content on forests that remain as such for FREL/FRL and monitoring report for Degradation, Restoration of Forest remaining forests and Forestry Conservation activities is estimated based on information coming from the Continuous Inventory of Forest Ecosystems and the application of remote sensing techniques on LANDSAT satellite images.</td></tr>
<tr><td>QA/QC procedures applied:</td><td>SOP_05_Forest Carbon Flux estimation assessment
QAQC_05_Forest Carbon Flux estimation assessment_ERPA
SOP_06_Field Operation Manual</td></tr>
<tr><td>Uncertainty for this parameter:</td><td>Degradation mapping accuracy estimated by INFOR.
Error: 32.8%</td></tr>
<tr><td>Any comment:</td><td>Link:
https://drive.google.com/uc?export=download&id=1KXI4CfOKLRrtxPVXfqk5ejz2dV6Cda61</td></tr>
</table>

k) Degradation - Substitution activity MR1

<table>
<tr><td>Parameter:</td><td>A_{DegNFF} = Surface of degradation areas resulting from the conversion of forests into plantations during the 2018 – 2019 period.</td></tr>
<tr><td>Description:</td><td>The total of areas by forest type that was degraded to plantation were registered.</td></tr>
<tr><td>Data unit:</td><td>Total hectares (ha) of the 2018-2019 period.</td></tr>
<tr><td>Value monitored during this Monitoring / Reporting Period:</td><td>
<table>
<tr><th>Forest Type</th><th>Area</th></tr>
<tr><td>Alerce</td><td>0</td></tr>
<tr><td>Araucaria</td><td>1</td></tr>
<tr><td>Ciprés de la Cordillera</td><td>43</td></tr>
<tr><td>Ciprés de las Guaitecas</td><td>0</td></tr>
<tr><td>Coihue - Raulí - Tepa</td><td>130</td></tr>
<tr><td>Coihue de Magallanes</td><td>0</td></tr>
<tr><td>Esclerófilo</td><td>1,254</td></tr>
<tr><td>Lenga</td><td>57</td></tr>
<tr><td>Roble - Hualo</td><td>168</td></tr>
<tr><td>Roble - Raulí - Coihue</td><td>5,656</td></tr>
<tr><td>Siempreverde</td><td>1,164</td></tr>
<tr><td>Without Forest Type</td><td>5,903</td></tr>
<tr><td>Total</td><td>14,377</td></tr>
</table>
</td></tr>
<tr><td>Source of data and description of measurement/calculation methods and procedures applied:</td><td>To estimate degradation of native forests converted to plantations, the equation used to estimate deforestation is applied, since it is assumed that, to establish a plantation, all the carbon content present in the preceding native forest must be reduced to zero.</td></tr>
<tr><td>QA/QC procedures applied:</td><td>SOP_02_LULUCF Maps Elaboration
QAQC_02_Review and rectification of LULUCF maps ERPA
SOP_03 Standardization and quality control protocol for land use change maps
QAQC_03_ Standarization and Quality control for land use change maps_ERPA</td></tr>
<tr><td>Uncertainty for this parameter:</td><td>The uncertainty of land-use change maps is estimated by comparing the results of the land-use change category on the map and the reference observations corresponding to a sample of visually interpreted points. The errors related to land-use change are calculated following the Good Practice Guidelines for estimating the precision of change of use described in Olofsson et al. (2013) and the estimator of the total area using the separate ratio estimator (formulas from sec. 6.10 of W.G. Cochran, Sampling Techniques, 3rd Edition, 1977).
Error = Maule 96%, Ñuble 109%, Biobío 73%, Araucanía 106%, Los Ríos 48%, Los Lagos 100.0%</td></tr>
<tr><td>Any comment:</td><td>Link:
https://drive.google.com/uc?export=download&id=1KBPzMuEUIVy0HZF9NupEoBCRjqAhKonn</td></tr>
</table>

l) Degradation – Forest fire activity MR1

Parameter:	A = Area burned between 2018 and 2019 in the ERP Regions.
Description:	The surface of burned areas was recorded to estimate the degradation of the native forest.
Data unit:	Total hectares (ha) of the 2018-2019 period.
Value monitored during this Monitoring / Reporting Period:	

Region	2018's area	2019's area
Maule	600	1,759
Ñuble	66	404
Biobío	148	235
La Araucanía	502	3,005
Los Ríos	61	222
Los Lagos	95	638
Total (ha)	**1,472**	**6,262**

Source of data and description of measurement/calculation methods and procedures applied:	The Forest Fire Protection Department and its Digital Information System for Operations Control (SIDCO), provides annualized statistical information on the occurrence of forest fires for the entire country, which in recent years has been improved by adding the spatial location of fires.
QA/QC procedures applied:	SOP_07_ForestFire_Polygons
Uncertainty for this parameter:	Area burned uncertainty estimated by INGEI (2020) Error: 15%
Any comment:	Link: https://drive.google.com/uc?export=download&id=1KP-BsYfRCbE49HZXydsGlyge0FJMRnXd

m) Enhancement activity – No forest to native forest MR1

Parameter:	$\Delta A_{TOOTHERSi,\ t}$ = Non-forest land use area converted to forest during the credit period.
Description:	The areas that correspond to non-forest lands were quantified in hectares to later estimate the carbon capture balances of these land changes use. In this data forest plantations with exotic species are included as non-forest land.
Data unit:	Total hectares (ha) of the 2018-2019 period.
Value monitored during this Monitoring / Reporting Period:	

Forest Type	Area
Alerce	0
Araucaria	178
Ciprés de la Cordillera	42
Ciprés de las Guaitecas	0
Coihue - Raulí - Tepa	171
Coihue de Magallanes	0
Esclerófilo	1,171
Lenga	1,947
Roble - Hualo	5
Roble - Raulí - Coihue	6,921
Siempreverde	2,252
Without Forest Type	3

	Total (ha)	**12,690**
Source of data and description of measurement/calculation methods and procedures applied:	A semi-automated technique is applied to detect changes using satellite images. The Multi-index method or MIICA (Jin et al., 2013) detects land use changes for the period under study. The MIICA methodology is based on the combination of 2 spectral indexes (dNBR, dNDVI) which, through integration rules, provide coverage of land use change, indicating the magnitude and directionality of the change. (Gain and loss). The MIICA methodology used images from the Landsat 8 sensor and was applied through a series of co des in programming language (JavaScript, R) complemented with Google Earth Engine cloud processing, in GIS programs and R software, with the objective of obtaining an efficient land use change map.	
QA/QC procedures applied:	SOP_02_LULUCF Maps Elaboration SOP_03 Standardization and quality control protocol for land use change maps QAQC_02_Review and rectification of LULUCF maps ERPA QAQC_03_ Standardization and Quality control for land use change maps_ERPA	
Uncertainty for this parameter:	The uncertainty of land-use change maps is estimated by comparing the results of the land-use change category on the map and the reference observations corresponding to a sample of visually interpreted points. The errors related to land-use change are calculated following the Good Practice Guidelines for estimating the precision of change of use described in Olofsson et al. (2013) and the estimator of the total area using the separate ratio estimator (formulas from sec. 6.10 of W.G. Cochran, Sampling Techniques, 3rd Edition, 1977) Error = Maule 142%, Ñuble 156%, Biobío 122%, Araucanía 129%, Los Ríos 116%, Los Lagos 70%.	
Any comment:	Link: https://drive.google.com/uc?export=download&id=1KIXPHr_Tg0YvpLkwNhx2MTJlAIdegb1U	

n) Enhancement activity – forest remains forest in non-conservation areas MR1

Parameter:	A_{EnhFF} = Areas of non-conservation native forest that remains forest during the 2018 – 2019 period for the six Region of the ERP.
Description:	The number of hectares of forest that remains as forest during the period 2018 - 2019 was estimated, in non-conservation areas considering that they are not within an area affected by browning (NBA).
Data unit:	Total hectares (ha) of the 2018-2019 period.
Value monitored during this Monitoring / Reporting Period:	

Region	**Area**
Maule	44,426
Ñuble	16,549
Biobío	32,686
La Araucanía	43,622
Los Ríos	29,025
Los Lagos	96,157
Total (ha)	**262,465**

Source of data and description of measurement/calculation methods and procedures applied:	The data comes from INFOR's NFI plots, combined with spectral information from Landsat series. This information integrates the variables of the state of the forests on the number of trees per hectare and basal area recorded by the monitoring plots, with the spectral data from Landsat to estimate carbon stocks in a spatially explicit way.
QA/QC procedures applied:	SOP_05_Forest Carbon Flux estimation assessment SOP_06_Field Operation Manual
Uncertainty for this parameter:	Degradation mapping accuracy estimated by INFOR. Error: 32.8%
Any comment:	Link: https://drive.google.com/uc?export=download&id=1KXI4CfOKLRrtxPVXfqk5ejz2dV6Cda61

o) Conservation activity MR1

Parameter:	$\Delta A_{TO_OTHERSi,t}$ = areas of conservation of native forest that remains as such during the 2018 – 2019 period in the six Region of the ERP.
Description:	The areas that in 2018 to 2019 are forest in conservation area and remain as such.
Data unit:	Total hectares (ha) of the 2018-2019 period.
Value monitored during this Monitoring / Reporting Period:	**Region** / **Area** Maule: 2,495 Ñuble: 6,327 Biobío: 10,148 La Araucanía: 20,657 Los Ríos: 27,247 Los Lagos: 83,597 **Total (ha): 150,471**
Source of data and description of measurement/calculation methods and procedures applied:	The data comes from NFI plots, combined with spectral information from the Landsat series. This information integrates the variables of the state of the forests on the number of trees per hectare and basal area recorded by the monitoring of IFN plots, with spectral data from Landsat to estimate carbon stocks in a spatially explicit way.
QA/QC procedures applied:	SOP_05_Forest Carbon Flux estimation assessment SOP_06_Field Operation Manual
Uncertainty for this parameter:	Degradation mapping accuracy estimated by INFOR. Error: 32.8%
Any comment:	Link: https://drive.google.com/uc?export=download&id=1Kg4eLQfzjG3Gr3cuMfELi0aXbkBDsNgZ

p) Emissions and removals from browning affected forest area MR1

Parameter:	Browning = Areas of native forest that remains as such affected by browning during the 2018 – 2019 period in the six Region of the ERP.
Description:	The areas that in 2018 to 2019 are forests affected by browning in forest areas that remain as such.
Data unit:	Total hectares (ha) of the 2018-2019 period.
Value monitored during this Monitoring / Reporting Period:	

Region	Degradation (Ha)	Enhancement (Ha)	Conservation (Ha)
Maule	25,168	15,297	734
Ñuble	5,979	4,314	1,069
Biobío	7,997	7,696	1,872
La Araucanía	6,340	5,018	460
Los Ríos	2,545	2,674	205
Los Lagos	0	0	0
Total (ha)	**48,029**	**34,999**	**4,340**

Source of data and description of measurement/calculation methods and procedures applied:	For the first monitoring period, the same methodology applied in the NREF was carried out regarding the segregation of non-anthropogenic emission through the exclusion of the areas affected by browning (BA) in forest remaining forest. These areas are considered as a non-anthropogenic emission source because the carbon fluxes that occurs on these areas are not related to human activities as the deforestation activity and it is generated by the decreases in precipitation falls, and water availability. The areas affected by browning correspond to those areas of forest that remain as forests that present phenological anomalies because of the impact of the megadrought. These anomalies were detected in the integral productivity of native forest in the ERP implementation area and are under the 5th percentile data productivity anomaly (GAC,2023). The phenological anomaly results in the desiccation of the crowns, loss of foliage and even the mortality of individuals. The same anomalies raster layer was used to segregate the browning areas in the NREF and Reporting Periods this allows that non-anthropogenic and anthropogenic emissions and removals are kept separate. The segregation considers report all the carbon fluxes which occur in those areas (gain, loss and neutral) from each period and excluding them from the account.
QA/QC procedures applied:	SOP_05_Forest Carbon Flux estimation assessment SOP_06_Field Operation Manual
Uncertainty for this parameter:	Degradation mapping accuracy estimated by INFOR. Error: 32.8%
Any comment:	Regarding to the provisions will be established towards monitoring browning area recovery, the areas will continue to be monitored as part of the PRE's accounting area in accordance with the established methodology and monitoring plan. These areas are not being excluded and it is expected that, if they remain as forest, the recovery or loss of the stock can be detected, or that emissions can be detected in the event that they are deforested, which will be reported in the third monitoring event to guarantee the account of emissions resulting from any land use changes and any other anthropogenic activities in the areas affected by browning. Notwithstanding the above, it is not feasible to propose that these areas can recover their initial condition prior to the disturbance, since even if restoration or recovery actions are carried out, there is no certainty of the result they may have in reversing the effect of water deficit and stress.

	Link: https://drive.google.com/uc?export=download&id=1KXI4CfOKLRrtxPVXfqk5ejz2dV6Cda61

q) Periodic annual increment (PAI) for mixed forest NREF and MR1

Parameter:	Periodic annual increment (PAI) for mixed forest
Description:	The mixed forest is calculated as a weighted average value of the forest types present in the region and according to the forest surface present for the activity of enhancement of the period (from no forest to native forest).
Data unit:	Cubic meter per hectare and year (m^3 ha^{-1} $year^{-1}$)
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	Forest native data are national data and published in INGEI (2020)
Value applied:	

Region	PAI NREF (m^3 ha^{-1} $year^{-1}$)	PAI MR1 (m^3 ha^{-1} $year^{-1}$)
Maule	2.1	4.2
Ñuble	2.8	2.4
Biobío	3.7	4
Araucanía	4.2	4.1
Los Ríos	4.1	4.2
Los Lagos	4.2	4.9

QA/QC procedures applied	SOP_06_Field Operation Manual
Uncertainty associated with this parameter:	SOP_06 Field Operations Manual was implemented during fieldwork to estimate PAI in the National Forest Inventory, for some forest types were possible to adjust a Probability Distribution Function (PDF). For the forest types with a limited number of sampling plots, uncertainty propagation with Monte Carlo analysis uses the calculation of the measurement uncertainty for PAI based on the 95% CI of the removal rate by forest type, calculated with Continuous Forest Inventory data of INFOR. ● PAI Mixed Forest = 28.7% (Average of PAI error for all forest types given lack of data.)
Any comment:	

4 QUANTIFICATION OF EMISSION REDUCTIONS

4.1 ER Program Reference level for the Monitoring / Reporting Period covered in this report

The Letter No. 119/2020 was sent in order to notify the application of technical improvements to the NFMS, to ensure consistency in the implementation of technical corrections to the data and methods used to establish the reference level included in the Emission Reduction Program. The technical corrections implemented are covered by paragraph 3 of the Guideline on the application of the Methodological Framework Number 2 – Technical corrections, and specifically related to literal "a" emission factor replacement, and literal "c" corrections to historical activity data. Also, methodological findings and new improvement opportunities were detected during the correction application process. The following bullet points, includes the corrections applied to the FREL detailed in Annex 4:

Update of Emission Factors (FE, acronym in Spanish)

- Replacing the use of regional EFs with EF by Forest Type from National Forest Inventory data
- Improvement of EFs used in estimating degradation emissions
- Inclusion of spatially explicit data for the historical reference period
- Consideration on arborescent scrubs
- Degradation estimation algorithm improvements
- Improvements to the land use change detection method
- Accuracy of the identification of reservoirs per REDD+ activity
- Carbon fraction value adjustment: Carbon factor is corrected from 0.5 to 0.47 to be consistent with IPCC 2006 guidelines.
- Integration Process
- Uncertainty has been estimated through the Monte Carlo method in order to meet indicators 6.1, 7.1 and 7.2.

Year of Monitoring/ Reporting period *t*	Average annual historical emissions from deforestation over the Reference Period (tCO_{2-e}/yr)	If applicable, average annual historical emissions from forest degradation over the Reference Period (tCO_{2-e}/yr)	If applicable, average annual historical removals by sinks over the Reference Period (tCO_{2-e}/yr)	Adjustment, if applicable (tCO_{2-e}/yr)	Reference level (tCO_{2-e}/yr)
2001	5,140,727	11,914,436	-10,740,394	NA	6,314,770
2002	5,140,727	11,914,436	-10,740,394	NA	6,314,770
2003	5,140,727	11,914,436	-10,740,394	NA	6,314,770
2004	5,140,727	11,914,436	-10,740,394	NA	6,314,770
2005	5,140,727	11,914,436	-10,740,394	NA	6,314,770
2006	5,140,727	11,914,436	-10,740,394	NA	6,314,770
2007	5,140,727	11,914,436	-10,740,394	NA	6,314,770
2008	5,140,727	11,914,436	-10,740,394	NA	6,314,770
2009	5,140,727	11,914,436	-10,740,394	NA	6,314,770
2010	5,140,727	11,914,436	-10,740,394	NA	6,314,770
2011	5,140,727	11,914,436	-10,740,394	NA	6,314,770
2012	5,140,727	11,914,436	-10,740,394	NA	6,314,770
2013	5,140,727	11,914,436	-10,740,394	NA	6,314,770
Total	**66,829,454**	**154,887,668**	**-139,625,118**	**0**	**82,092,006**

4.2 Estimation of emissions by sources and removals by sinks included in the ER Program's scope

Year of Monitoring/Reporting Period	Emissions from deforestation (tCO_{2-e}/yr)	If applicable, emissions from forest degradation (tCO_{2-e}/yr)*	If applicable, removals by sinks (tCO_{2-e}/yr)	Net emissions and removals (tCO_{2-e}/yr)
2018	4,857,817	37,952,461	-33,716,188	9,094,089
2019	4,857,817	37,952,461	-33,716,188	9,094,089
Total	9,715,634	75,904,921	-67,432,376	18,188,179

4.3 Calculation of emission reductions

Total Reference Level emissions during the Monitoring Period (tCO_2-e)	12,629,539
Net emissions and removals under the ER Program during the Monitoring Period (tCO_2-e)	18,188,179
Emission Reductions during the Monitoring Period (tCO_2-e)	-5,558,639
Length of the Reporting period / Length of the Monitoring Period (# days/# days)	703/730 (0.963014)
Emission Reductions during the Reporting Period (tCO_2-e)[16]	-5,353,046

[16] Spreadsheets are available in https://drive.google.com/uc?export=download&id=1cE37yHovlWp4EtXmijxh7T4FdyAvp-AX

5 UNCERTAINTY OF THE ESTIMATE OF EMISSION REDUCTIONS

The country allocated Emission Reductions attributed to the reporting pro-rata period to the number of days of the Reporting Period. Chile applied a pro-rata factor of 0.963014. The ER global uncertainty was estimated with and without the pro-rata factor. The application of the pro-rata factor resulted in a reduction by 2.8% in the ER uncertainty. The quantification of the uncertainty estimates of Emission Reductions and the sensitivity analysis included in this section have been calculated applying the pro-rata values.

5.1 Identification, assessment and addressing sources of uncertainty

In the table below, the country identified and discussed a list of the main sources of uncertainty and if its contribution to the total uncertainty of Emission Reductions is high or low, and whether they are systematic or random. In addition, the table includes the measures implemented to address these sources of uncertainty as part of the Monitoring Cycle.

Since a sampling approach is not used for Activity Data and emission factors are estimated from a model-based estimator, the uncertainty estimate of reduced emissions has deviated from the Guidelines on uncertainty ERs.

Sources of uncertainty	Systematic and/or random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
Activity Data					
Measurement	Systematic and random	Land-use and land-use change areas: The Activity Data for deforestation, substitution, restitution, area increase of native forest, and permanent forest lands come from Land-use changes maps. A Protocol have been prepared to facilitate the replication of the mapping steps from the digital processing of satellite images. All procedures required to prepare land-use and land-use change maps are described in the Methodological Protocol for the land-use and land-use change mapping in Native Forest (SOP 02). This protocol includes inputs, data sets, and the methodological steps necessary to generate thematic cartography and statistical reports at the national level on the extension, distribution, and land-use change. The land-use change detection maps are prepared with the Multi-Index Integrated Change Analysis methodology (MIICA - Jin et al., 2013), both for the reference and reporting periods. The application of the MIICA methodology uses the Landsat 7 multipixel mosaics for the reference period and Landsat 8 for the monitoring period. Land-use change control polygons (ground truth) are taken proportionally to each of the regions' surface to establish the spectral thresholds of the zones of change and the evaluated index for each IPCC land-use category. Next, the polygons are verified visually on the time series of high-resolution images provided by the Google Earth software. Finally, land-use allocation of the loss vector layer is done applying a supervised classification method to the multi-pixel mosaic. Additionally, temporal tracking of land-use changes is done by integrating the polygons of areas of change resulting from each monitoring period into the existing layers of change maps. The topological conditions, data geometry, databases, and map attributes are reviewed in detail. Then, any discrepancies or inconsistencies are sent to the	Low	Yes: SOP_01_Satellite mosaic elaboration and QAQC_01_Mosaics elaboration metadata_ERPA https://drive.google.com/uc?export=download&id=1PcM3Ag1JMELuDGP04fc2X9ENQQTORpJV SOP_02_LULUCF Maps Elaboration and QAQC_02_Review and rectification of LULUCF maps ERPA https://drive.google.com/uc?export=download&id=1PcloDfhFkTW8JdkqCeaZT8JEOW_SH8zc QAQC_03_ Standardization and Quality control for land use change maps_ERPA	NO

Sources of uncertainty	Systematic and/or random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
		responsible team for resolution (SOP 03). After the solution, the inconsistency is double checked. The result of the activity data measurement is reviewed to ensure consistency, according to the sum of REDD+ activities areas and the surface region. This process is applied during the integration of final calculation results, and in case of finding inconsistencies, the integration must stop, and the input data must be verified. Finally, Uncertainties associated with AD are due to the production process of land use maps. The uncertainties of the AD for deforestation, substitution, restitution, area increase of native forest, and permanent forest activities are associated with the errors of the satellite image processing during the preparation of land-use change maps. The uncertainty of land-use change maps[17] is estimated by comparing the results of the land-use change category on the map and the reference observations corresponding to a sample of visually interpreted points. Factors influencing the estimation of uncertainty are the sampling design and the sample size used to assess the precision and accuracy of the maps. The errors related to land-use change are calculated following the Good Practice Guidelines for estimating the precision of change of use described in Olofsson et al. (2013). This approach is applied with the FAO Collect Earth tool. With this tool, the land-use change categories from 8,717 polygons, representing a total area of 241,120 ha, for the monitoring period, were assessed. The sample size of the accuracy assessment of the land-use change maps is calculated considering the user's precision parameters for each land use or category of change. These parameters are obtained from a pre-sampling. The sample size is calculated assuming a standard error of the precision of 0.01 using the equation of Cochran (1977). The evaluation points are selected with a stratified random sampling design for each IPCC sub-use in each region.		https://drive.google.com/uc?export=download&id=1Peu1EpgAXl4fFTbx0Wgo-T0zSaRgV5T4	
Measurement	Systematic and random	Permanent forest degradation and carbon enhancement: The Activity Data for degradation and carbon enhancement in permanent forest lands comes from satellite imaging and NFI biomass information integration. A Protocol has been prepared to facilitate replicating the mapping process from the digital processing of satellite images and NFI biomass information (SOP 05). All procedures are described in the Protocol to prepare carbon flux, stock, and degradation mapping in the permanent forest. This protocol includes methods	High	Yes, for a and b sources: SOP_05: Forest Carbon Flux estimation assessment and QAQC_05_Forest Carbon Flux estimation assessment_ERPA	NO

[17] Available in https://drive.google.com/uc?export=download&id=1NWZOu8I1JxXF2SBzEyCpjt24dRLTXj4o

Sources of uncertainty	Systematic and/or random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
		description, spatial and dasometric information, and satellite data processing required to estimate activity data for degradation and carbon enhancement. The sources of error for estimating carbon degradation and enhancement activity data on permanent forest lands are: Uncertainty associated with the forest density charts used to determine the direction of carbon flux (neutral, loss or gain) for each pixel. This uncertainty has been estimated in 32.8%. Uncertainty associated with integrating the multi-pixel mosaic satellite data with the dasometric variables. This uncertainty has been estimated by calculating the Standard Error of Estimation of the volume function k-nn. This uncertainty has been estimated in 57%.		https://drive.google.com/uc?export=download&id=1Pjtafn2coZk6H8GW8mhjKC2rcIZKlhq5 SOP_06: SOP06 Field Operation Manual https://drive.google.com/uc?export=download&id=1Pnc-wEZxWLpOM1Mvxx6iJBs5IK6yg-ln	
Representativeness	Systematic	Land-use and land-use change areas: Multi-pixel mosaics are prepared with a temporal range with cloud-free pixels to obtain representative satellite images of the beginning and end of each period. The multi-pixel mosaic is an image composed of pixels of different images extracted from the definition of a range or time window. The selection of each pixel seeks to define the best information available in a specific area, prioritizing above all that they are pixels free of cloud and cloud shadows. Given the high cloud cover present in southern Chile, a ± 3 months window is used for the start and end date of the analyzed period. For example, considering the period 2018 - 2019, the start date is January 1, 2018, the range or time window will correspond from October 1, 2017, to March 31, 2018; the multipixel mosaic time window for the end of period (December 31, 2019) is from October 1, 2019, to March 31, 2020.	Low	Yes: SOP_01_Satellite mosaic elaboration and QAQC_01_Mosaics elaboration metadata_ERPA https://drive.google.com/uc?export=download&id=1PcM3Ag1JMELuDGP04fc2X9ENQQTORpJV	NO
Sampling	NA	Land-use and land-use change areas: This source of uncertainty is not applicable. It is not required to use a sampling technique to estimate ADs for carbon deforestation, substitution, restitution, area increase of native forest, and permanent forest lands. The AD estimation is made with a total pixel count of the carbon content map for each land-use change category.	NA	NA	NA
	NA	Permanent forest degradation and carbon enhancement: This source of uncertainty is not applicable. It is not required to use a sampling technique to estimate ADs for carbon degradation and enhancement. The AD estimation is made with a total pixel count of the carbon content map for each flow category (biomass gain or loss).	NA	NA	NA

Sources of uncertainty	Systematic and/or random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
Extrapolation	NA	This source of uncertainty is not applicable. Extrapolation is not applied to estimate REDD+ activities, the sample-based estimation area method is not used. All REDD+ activities are calculated from spatially explicit information.	NA	NA	NA
Approach 3	NA	This source of uncertainty is not applicable. Activity data were estimated conducting tracking of lands or IPCC Approach 3 for reference and monitoring periods.	NA	NA	NA
Emission Factor					

Sources of uncertainty	Systematic and/or random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
DBH measurement H measurement Plot delineation Wood density estimation Biomass allometric model	Systematic and Random	Aerial Biomass The measurement uncertainty for aerial biomass estimate depends on the land-use carbon density data source: Aerial biomass of native and mixed forest: SOP_06 Field Operations Manual was implemented during fieldwork for the estimation of AGB in the National Forest Inventory. For some forest types were possible to adjust a Probability Distribution Function (PDF). For the forest types with a limited number of sampling plots, uncertainty propagation with Monte Carlo analysis uses the following information: DBH measurement error (0.2%). Calculation based on Continuous Forest Inventory data of INFOR. Volume estimation error (0.07%). Calculation based on Continuous Forest Inventory data of INFOR. Biomass Expansion Factor (BEF) error (18.0%). BEF comes from information collected in the country from the study of Gayoso et al. (2002) and used in INGEI (2020). This value is for native species and has a national spatial level. Error calculation is based on statistical data from the Biomass Inventory and Carbon Accountancy of the Universidad Austral de Chile (UACh). Wood Density (5.6%). Calculated using basic density data collected from native species growing in Chile. A bibliographic review of basic densities of the forest species in Chile was carried out and there were no modifications for the value exposed form Gayoso et al. (2002) and INGEI (2020). Finally, these uncertainties are combined following IPCC approach 1 (propagation of error), resulting in total uncertainty of 18.85%. Aerial biomass of non-forest uses: Monte Carlo analysis uses error estimation published in INGEI (2020) and Gayoso (2006) and Expert judgment estimates (IPCC, 2006). The error of carbon density for wetlands, water bodies, and other non-vegetations uses was assumed cero due to a lack of data. Annual Periodic Increment (IPA Spanish acronym): SOP_06 Field Operations Manual was implemented during fieldwork to estimate IPA in the National Forest Inventory, for some forest types were possible to adjust a Probability Distribution Function (PDF). For the forest types with a limited number of sampling plots, uncertainty propagation with Monte Carlo analysis uses the calculation of the measurement uncertainty for IPA based on the 95% CI of the removal rate by forest type, calculated with Continuous Forest Inventory data of INFOR.	Low	Yes, for a: SOP_06: Field Operation Manual https://drive.google.com/uc?export=download&id=1Pnc-wEZxWLpOM1Mvxx6iJBs5IK6yg-In	Yes

Sources of uncertainty	Systematic and/or random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
Sampling	Random	The Continuous Inventory of Forestry Ecosystems, henceforth referred to as the Continuous Inventory, managed by INFOR, and has been operational since 2000. The Continuous Inventory was designed under a statistical bi-stage design in three circular sample plot clusters in an area equivalent to 500m2 distributed in a systematic area of 5x7km. The sampling units have been systematically distributed over the national territory from the Maule to the Magallanes region.	Low	Yes: QA / QC applied in SOP06 https://drive.google.com/uc?export=download&id=1Pnc-wEZxWLpOM1Mvxx6iJBs5IK6yg-In	Yes
Other parameters (e.g. Carbon Fraction, root-to-shoot ratios)	Systematic and Random	Root-to-shoot ratio (R factor-40% error): R factor comes from information collected in the country (Gayoso et al., 2002; INGEI, 2020). This value is within the range indicated in the 2006 IPCC Guidelines for temperate forests (between 0.20 and 0.46, according to Table 4.4; Chapter 4; Volume 4) and within of the values available worldwide, which provide R factors that range between 0.09 and 0.33. This value is for native species and has a national spatial level. Error calculation based on statistical data from the Biomass Inventory and Carbon Accountancy of the Universidad Austral de Chile (UACh). Finally, aerial biomass and R factor uncertainties are combined following IPCC approach 1 (propagation of error), resulting in total uncertainty of 44.2%.	Low	NA	Yes
Representativeness	NA	This source of uncertainty is not applicable. Chile generates estimates of carbon densities per forest type, and non-forest land uses. Different forest types and structures classify the native forest. Each forest type has its biomass value depending on data availability. Also, non-forest lands include the following uses: Urban and Industrial Areas, agricultural land, grassland, scrub, arborescent scrub, shrub planting, succulent scrub, succulent formations, plantations, wetlands, areas deprived of vegetation, eternal snows and glaciers, waterbodies and unrecognized areas.	NA	NA	NA
Integration					
Model	Systematic	Calculation tools have been prepared to estimate Emission Reductions, including the FREL and Monitoring Period for REDD activity. In these tools, you can review the formulas used to estimate ERs. The country prepared these tools to ensure the same calculation methods are applied for all monitoring events and avoid errors during the processing and data preparation.	Low	NA	No
Integration	Systematic	The Emission factors were calculated for each region and forest type according to AGB sampling plots' location to assure the comparability between transition classes of the Activity Data and those of the Emission Factors. This source of uncertainty is considered in the sampling error of the AGB inventory.	Low	Yes: SOP_06_Field Operation Manual https://drive.google.com/uc?export=download&id=1Pnc-	No

Sources of uncertainty	Systematic and/or random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
				wEZxWLpOM1Mvxx6iJBs5IK6yg-In	

5.2 Uncertainty of the estimate of Emission Reductions

Parameters and assumptions used in the Monte Carlo method

The following table shows the parameters and assumptions used in the Monte Carlo Analysis[18] to estimate the uncertainty of the Emission Reduction for the Monitoring Period. The parameter where the type of Probability Distribution Function (PDF) is fitted indicates the p-value of the adjustment obtained for the distribution function and its parameters.

[18] Available in: https://drive.google.com/uc?export=download&id=1r5elDCbpA2-dJ_L5lbz9N4pVup8LLOSL

Parameter included in the model	Parameter values	Error sources quantified in the model	Probability distribution function	Assumptions
Activity Data				
Non-Forest land - Forest Maule Reference Period (ha/yr)	7,012.55	10.9%	Normal	Activity Data uncertainty used in Monte Carlo Analysis was calculated using the confidence limits of the sampling-based land-use change estimation areas for the reference and monitoring periods.
Non-Forest land - Forest Ñuble Reference Period (ha/yr)	1,144.04	10.9%	Normal	
Non-Forest land - Forest Biobio Reference Period (ha/yr)	2,156.59	8.84%	Normal	
Non-Forest land - Forest Araucanía Reference Period(ha/yr))	2,948.47	7.9%	Normal	
Non-Forest land - Forest Los Ríos Reference Period (ha/yr)	1,545.03	9.4%	Normal	
Non-Forest land - Forest Los Lagos Reference Period (ha/yr)	1,004.49	11.0%	Normal	
Non-Forest land - Forest Maule Monitoring Period (ha/yr)	89,761.96	10.9%	Normal	
Non-Forest land - Forest Ñuble Monitoring Period (ha/yr)	14,078.26	10.9%	Normal	
Non-Forest land - Forest Biobio Monitoring Period (ha/yr)	27,556.16	10.9%	Normal	
Non-Forest land - Forest Araucanía Monitoring Period (ha/yr))	38,629.67	7.9%	Normal	
Non-Forest land - Forest Los Ríos Monitoring Period (ha/yr)	22,527.47	9.4%	Normal	
Non-Forest land - Forest Los Lagos Monitoring Period (ha/yr)	14,671.02	11.0%	Normal	
Forest land – Non-Forest Maule Reference Period (ha/yr)	828	11.1%	Normal	
Forest land – Non-Forest Ñuble Reference Period (ha/yr)	453	11.1%	Normal	
Forest land – Non-Forest Biobio Reference Period (ha/yr)	1,296	3.4%	Normal	
Forest land – Non-Forest Araucanía Reference Period(ha/yr))	1,537	9.9%	Normal	
Forest land – Non-Forest Los Ríos Reference Period (ha/yr)	1,529	8.0%	Normal	
Forest land – Non-Forest Los Lagos Reference Period (ha/yr)	3,530	23.4%	Normal	
Forest land – Non-Forest Maule Monitoring Period (ha/yr)	1,045	11.1%	Normal	
Forest land – Non-Forest Ñuble Monitoring Period (ha/yr)	883	11.1%	Normal	
Forest land – Non-Forest Biobio Monitoring Period (ha/yr)	800	3.4%	Normal	
Forest land – Non-Forest Araucanía Monitoring Period (ha/yr))	2,236	9.9%	Normal	
Forest land – Non-Forest Los Ríos Monitoring Period (ha/yr)	1,650	8.0%	Normal	
Forest land – Non-Forest Los Lagos Monitoring Period (ha/yr)	3,887	23.4%	Normal	
Aum No Conserv Bajo C en 2001, entre [B-C] en 2010 RP (ha/yr)	54,672	42%	Normal	Degradation mapping accuracy estimated by INFOR.
Aum No Conserv Entre [B-C] en 2001 y sobre B en 2010 RP (ha/yr)	271,368	42%	Normal	
Aum No Conserv Bajo C en 2001 y sobre B en 2010 RP (ha/yr)	167,695	42%	Normal	

Parameter included in the model	Parameter values	Error sources quantified in the model	Probability distribution function	Assumptions
Aum No Conserv Bajo C en 2001 y bajo C en 2010 RP (ha/yr)	59,742	42%	Normal	
Aum No Conserv Entre [B-C] en 2001, entre [B-C] en 2010 RP (ha/yr)	38,912	42%	Normal	
Aum No Conserv Bajo C en 2018, entre [B-C] en 2019 MP (ha/yr)	32,693	42%	Normal	
Aum No Conserv Entre [B-C] en 2018 y sobre B en 2019 MP (ha/yr)	165,530	42%	Normal	
Aum No Conserv Bajo C en 2018 y sobre B en 2019 MP (ha/yr)	66,823	42%	Normal	
Aum No Conserv Bajo C en 2018 y bajo C en 2019 MP (ha/yr)	50,746	42%	Normal	
Aum No Conserv Entre [B-C] en 2018, entre [B-C] en 2019 MP (ha/yr)	34,948	42%	Normal	
Deg No Conserv Sobre B en 2001 y bajo C en 2010 RP (ha/yr)	121,830	42%	Normal	
Deg No Conserv Entre [B-C] en 2001 y bajo C en 2010 RP (ha/yr)	45,625	42%	Normal	
Deg No Conserv Sobre B en 2001, Entre [B-C] en 2010 RP (ha/yr)	224,752	42%	Normal	
Deg No Conserv Bajo C en 2001 y bajo C en 2010 RP (ha/yr)	53,030	42%	Normal	
Deg No Conserv Entre [B-C] en 2001, entre [B-C] en 2010 RP (ha/yr)	37,029	42%	Normal	
Deg No Conserv Sobre B en 2018 y bajo C en 2019 MP (ha/yr)	90,596	42%	Normal	
Deg No Conserv Entre [B-C] en 2018 y bajo C en 2019 MP (ha/yr)	40,882	42%	Normal	
Deg No Conserv Sobre B en 2018, Entre [B-C] en 2019 MP (ha/yr)	180,634	42%	Normal	
Deg No Conserv Bajo C en 2018 y bajo C en 2019 MP (ha/yr)	51,665	42%	Normal	
Deg No Conserv Entre [B-C] en 2018, entre [B-C] en 2019 MP (ha/yr)	35,732	42%	Normal	
Aum Conserv Bajo C en 2001, entre [B-C] en 2010 RP (ha/yr)	10,541	42%	Normal	
Aum Conserv Entre [B-C] en 2001 y sobre B en 2010 RP (ha/yr)	53,982	42%	Normal	
Aum Conserv Bajo C en 2001 y sobre B en 2010 RP (ha/yr)	28,729	42%	Normal	
Aum Conserv Bajo C en 2001 y bajo C en 2010 RP (ha/yr)	10,265	42%	Normal	
Aum Conserv Entre [B-C] en 2001, entre [B-C] en 2010 RP (ha/yr)	8,272	42%	Normal	
Aum Conserv Bajo C en 2018, entre [B-C] en 2019 MP (ha/yr)	10,569	42%	Normal	
Aum Conserv Entre [B-C] en 2018 y sobre B en 2019 MP (ha/yr)	55,782	42%	Normal	
Aum Conserv Bajo C en 2018 y sobre B en 2019 MP (ha/yr)	25,667	42%	Normal	
Aum Conserv Bajo C en 2018 y bajo C en 2019 MP (ha/yr)	11,739	42%	Normal	
Aum Conserv Entre [B-C] en 2018, entre [B-C] en 2019 MP (ha/yr)	10,167	42%	Normal	
Deg Conserv Sobre B en 2001 y bajo C en 2010 MP (ha/yr)	26,389	42%	Normal	

Parameter included in the model	Parameter values	Error sources quantified in the model	Probability distribution function	Assumptions
Deg Conserv Entre [B-C] en 2001 y bajo C en 2010 MP (ha/yr)	9,675	42%	Normal	
Deg Conserv Sobre B en 2001, Entre [B-C] en 2010 MP (ha/yr)	51,707	42%	Normal	
Deg Conserv Bajo C en 2001 y bajo C en 2010 MP (ha/yr)	9,548	42%	Normal	
Deg Conserv Entre [B-C] en 2001, entre [B-C] en 2010 MP (ha/yr)	7,888	42%	Normal	
Deg Conserv Sobre B en 2018 y bajo C en 2019 RP (ha/yr)	20,322	42%	Normal	
Deg Conserv Entre [B-C] en 2018 y bajo C en 2019 RP (ha/yr)	11,232	42%	Normal	
Deg Conserv Sobre B en 2018, Entre [B-C] en 2019 RP (ha/yr)	50,988	42%	Normal	
Deg Conserv Bajo C en 2018 y bajo C en 2019 RP (ha/yr)	12,424	42%	Normal	
Deg Conserv Entre [B-C] en 2018, entre [B-C] en 2019 RP (ha/yr)	10,308	42%	Normal	
Forest land - Forest Plantation Maule RP (ha/yr)	2,004	11.1%	Normal	Activity Data uncertainty used in Monte Carlo Analysis was calculated using the confidence limits of the sampling-based land-use change estimation areas for the reference and monitoring periods.
Forest land - Forest Plantation Ñuble RP (ha/yr)	778	11.1%	Normal	
Forest land - Forest Plantation Bío-Bío RP (ha/yr)	1,590	3.4%	Normal	
Forest land - Forest Plantation La Araucanía RP (ha/yr)	2,772	9.9%	Normal	
Forest land - Forest Plantation Los Ríos RP (ha/yr)	944	8.0%	Normal	
Forest land - Forest Plantation Los Lagos RP (ha/yr)	664	23.4%	Normal	
Forest land - Forest Plantation Maule MP (ha/yr)	817	11.1%	Normal	
Forest land - Forest Plantation Ñuble MP (ha/yr)	392	11.1%	Normal	
Forest land - Forest Plantation Bío-Bío MP (ha/yr)	2,229	3.4%	Normal	
Forest land - Forest Plantation La Araucanía MP (ha/yr)	3,428	9.9%	Normal	
Forest land - Forest Plantation Los Ríos MP (ha/yr)	1,446	8.0%	Normal	
Forest land - Forest Plantation Los Lagos MP (ha/yr)	157	23.4%	Normal	
Forest fires area Maule RP (ha/yr)	583.4	15%	Normal	INGEI, 2020
Forest fires area Ñuble RP (ha/yr)	139.2	15%	Normal	
Forest fires area Biobio RP (ha/yr)	1,028.5	15%	Normal	
Forest fires area Araucanía RP (ha/yr)	2,058.1	15%	Normal	
Forest fires area Los Ríos RP (ha/yr)	150.4	15%	Normal	
Forest fires area Los Lagos RP (ha/yr)	781.9	15%	Normal	
Forest fires area Maule MP (ha/yr)	1,179.3	15%	Normal	

Parameter included in the model	Parameter values	Error sources quantified in the model	Probability distribution function	Assumptions
Forest fires area Ñuble MP (ha/yr)	235.0	15%	Normal	
Forest fires area Biobio MP (ha/yr)	191.2	15%	Normal	
Forest fires area Araucanía MP (ha/yr)	1,753.7	15%	Normal	
Forest fires area Los Ríos MP (ha/yr)	141.5	15%	Normal	
Forest fires area Los Lagos MP (ha/yr)	366.5	15%	Normal	
Carbon content of Non-Forest Lands				
AGB Áreas Urbanas e Industriales	2.00	95%	Normal	(INGEI, 2020)
AGB Terrenos Agrícolas	10.00	75%	Normal	(INGEI, 2020)
AGB Praderas y Matorrales Praderas	4.73	27.7%	Normal	(Gayoso, 2006)
AGB Praderas y Matorrales Matorral-Pradera	9.04	34.6%	Normal	
AGB Praderas y Matorrales Matorral Arborescente	21.78	22.4%	Normal	
Carbon content of Native Forest				
BGB Terrenos Agrícolas	2.00	53.2%	Normal	Uncertainty for BGB of Non-Forest lands is based on propagation error estimate following IPCC approach 1 of Matorrals-Arborescente AGB error (22.42%) and Root shoot ratio -R Factor error (48.27%) estimated by Goyoso et al. (2002), resulting in total uncertainty of 53.2%.
BGB Praderas y Matorrales Praderas	8.13	53.2%	Normal	
BGB Praderas y Matorrales Matorral-Pradera	14.99	53.2%	Normal	
BGB Praderas y Matorrales Matorral Arborescente	35.25	53.2%	Normal	
AGB Alerce Adulto (t dry biomass/ha)	339.109	18.85%	Normal	For the forest types with a limited number of sampling plots, uncertainty propagation with Monte Carlo analysis uses the following information: i. DBH measurement error (0.2%), calculation based on Continuous Forest Inventory data of INFOR; ii. Volume
AGB Alerce Renoval (t dry biomass/ha)	203.590	18.85%	Normal	
AGB Ciprés de las Guaitecas Adulto (t dry biomass/ha)	221.848	18.85%	Normal	
AGB Araucaria Adulto (t dry biomass/ha)	β: 222.628; k: 1.886	PDF	Gama 2; P:0.998; n: 16	
AGB Araucaria Renoval (t dry biomass/ha)	219.131	18.85%	Normal	
AGB Ciprés de la Cordillera Adulto (t dry biomass/ha)	97.116	18.85%	Normal	
AGB Ciprés de la Cordillera Renoval (t dry biomass/ha)	124.019	18.85%	Normal	
AGB Lenga Adulto (t dry biomass/ha)	μ: 207.038; s: 84.017	PDF	Logistic; P:0.958; n:10	

Parameter included in the model	Parameter values	Error sources quantified in the model	Probability distribution function	Assumptions
AGB Lenga Renoval (t dry biomass/ha)	α: 0.431; β:0.439	PDF	Beta4; P:0.776; n:8	estimation error (0.07%), calculation based on Continuous Forest Inventory data of INFOR, iii. Biomass Expansion Factor (BEF) error (18.0%), BEF comes from information collected in the country from the study of Gayoso et al. (2002) and used in INGEI (2018). This value is for native species and has a national spatial level. Error calculation is based on statistical data from the Biomass Inventory and Carbon Accountancy of the Universidad Austral de Chile (UACh); and iv. Wood Density (5.6%) calculated using basic density data collected from native species growing in Chile. Finally, these uncertainties are combined following IPCC approach 1 (propagation of error), resulting in total uncertainty of 18.85%
AGB Coihue de Magallanes Adulto (t dry biomass/ha)	129.148	18.85%	Normal	
AGB Roble - Hualo Adulto (t dry biomass/ha)	β: 17.695; k: 5.884	PDF	Gamma (2); P:0.808; n: 17	
AGB Roble - Raulí - Coihue Adulto (t dry biomass/ha)	λ: 0.006	PDF	Exponential; P:0.850; n: 65;	
AGB Roble - Raulí - Coihue Renoval (t dry biomass/ha)	λ: 0.006	PDF	Exponential; P:0.709; n: 71	
AGB Coihue - Raulí - Tepa Adulto (t dry biomass/ha)	β: 1.162; γ:414.153	PDF	Weibull (2); P: 0.831; n: 57	
AGB Coihue - Raulí - Tepa Renoval (t dry biomass/ha)	β: 117.880; k: 1.720	PDF	Gamma (2); P:0.989; n: 12	
AGB Esclerófilo Adulto (t dry biomass/ha)	β: 0.721; γ:12.840	PDF	Weibull (2); P: 0.858; n: 33	
AGB Siempreverde Adulto (t dry biomass/ha)	μ: 5.765; σ: 0.646	PDF	Log-normal; P: 0.194; n: 49	
AGB Siempreverde Renoval (t dry biomass/ha)	β: 1.584; γ:139.543	PDF	Weibull (2); P: 0.673; n: 25	
AGB Araucanía Mixed Forest Monitoring Period (t dry biomass/ha)	161.13	18.85%	Normal	
AGB Los Ríos Mixed Forest Monitoring Period (t dry biomass/ha)	165.98	18.85%	Normal	
AGB Los Lagos Mixed Forest Monitoring Period (t dry biomass/ha)	207.13	18.85%	Normal	
AGB Ñuble Mixed Forest Monitoring Period (t dry biomass/ha)	57.48	18.85%	Normal	
AGB Maule Mixed Forest Monitoring Period (t dry biomass/ha)	43.46	18.85%	Normal	
AGB Biobio Mixed Forest Monitoring Period (t dry biomass/ha)	131.77	18.85%	Normal	
AGB Maule Mixed Forest Reference Period (t dry biomass/ha)	58.85	18.85%	Normal	
AGB Biobio Mixed Forest Reference Period (t dry biomass/ha)	210.75	18.85%	Normal	
AGB Araucanía Mixed Forest Reference Period (t dry biomass/ha)	246.71	18.85%	Normal	
AGB Los Ríos Mixed Forest Reference Period (t dry biomass/ha)	194.05	18.85%	Normal	
AGB Los Lagos Mixed Forest Reference Period (t dry biomass/ha)	221.64	18.85%	Normal	
AGB Ñuble Mixed Forest Reference Period (t dry biomass/ha)	58.85	18.85%	Normal	
BGB Araucanía Mixed Forest Monitoring Period (t dry biomass/ha)	46.23	44.2%	Normal	Uncertainty for Below Ground Biomass BGB is based on propagation error estimate following IPCC approach 1 of Above Ground Biomass-AGB error (18.85%) and Root shoot ratio -R
BGB Los Ríos Mixed Forest Monitoring Period (t dry biomass/ha)	47.62	44.2%	Normal	
BGB Los Lagos Mixed Forest Monitoring Period (t dry biomass/ha)	59.42	44.2%	Normal	
BGB Ñuble Mixed Forest Monitoring Period (t dry biomass/ha)	16.49	44.2%	Normal	
BGB Maule Mixed Forest Monitoring Period (t dry biomass/ha)	16.89	44.2%	Normal	
BGB Biobio Mixed Forest Monitoring Period (t dry biomass/ha)	60.46	44.2%	Normal	

Parameter included in the model	Parameter values	Error sources quantified in the model	Probability distribution function	Assumptions
BGB Maule Mixed Forest Reference Period (t dry biomass/ha)	70.78	44.2%	Normal	Factor error (40.0%) estimated by Goyoso et al. (2002), resulting in total uncertainty of 44.2%.
BGB Biobio Mixed Forest Reference Period (t dry biomass/ha)	55.67	44.2%	Normal	
BGB Araucanía Mixed Forest Reference Period (t dry biomass/ha)	63.59	44.2%	Normal	
BGB Los Ríos Mixed Forest Reference Period (t dry biomass/ha)	47.21	44.2%	Normal	
BGB Los Lagos Mixed Forest Reference Period (t dry biomass/ha)	12.47	44.2%	Normal	
BGB Ñuble Mixed Forest Reference Period (t dry biomass/ha)	37.80	44.2%	Normal	
Dead matter Araucanía Mixed Forest MP (t dry biomass/ha)	57.42	28.4%	Normal	Error estimated from permanent plots of the INFOR Continuous Forest Inventory
Dead matter Los Ríos Mixed Forest MP (t dry biomass/ha)	57.52	28.4%	Normal	
Dead matter Los Lagos Mixed Forest MP (t dry biomass/ha)	62.39	28.4%	Normal	
Dead matter Ñuble Mixed Forest MP (t dry biomass/ha)	27.19	28.4%	Normal	
Dead matter Maule Mixed Forest MP (t dry biomass/ha)	19.90	28.4%	Normal	
Dead matter Biobio Mixed Forest MP (t dry biomass/ha)	54.10	28.4%	Normal	
Dead matter Maule Mixed Forest RP (t dry biomass/ha)	72.30	28.4%	Normal	
Dead matter Biobio Mixed Forest RP (t dry biomass/ha)	52.91	28.4%	Normal	
Dead matter Araucanía Mixed Forest RP (t dry biomass/ha)	61.16	28.4%	Normal	
Dead matter Los Ríos Mixed Forest RP (t dry biomass/ha)	47.61	28.4%	Normal	
Dead matter Los Lagos Mixed Forest RP (t dry biomass/ha)	18.92	28.4%	Normal	
Dead matter Ñuble Mixed Forest RP (t dry biomass/ha)	45.49	28.4%	Normal	
Annual Periodic Increase of Native Forest				
IPA Araucanía Mixed Forest Monitoring Period (t dry biomass/ha)	4.13	28.7%	Normal	Average of IPA error for all forest types given lack of data.
IPA Los Ríos Mixed Forest Monitoring Period (t dry biomass/ha)	4.18	28.7%	Normal	
IPA Los Lagos Mixed Forest Monitoring Period (t dry biomass/ha)	4.81	28.7%	Normal	
IPA Ñuble Mixed Forest Monitoring Period (t dry biomass/ha)	2.82	28.7%	Normal	
IPA Maule Mixed Forest Monitoring Period (t dry biomass/ha)	2.02	28.7%	Normal	
IPA Biobio Mixed Forest Monitoring Period (t dry biomass/ha)	3.55	28.7%	Normal	
IPA Maule Mixed Forest Reference Period (t dry biomass/ha)	4.20	28.7%	Normal	
IPA Biobio Mixed Forest Reference Period (t dry biomass/ha)	4.14	28.7%	Normal	
IPA Araucanía Mixed Forest Reference Period (t dry biomass/ha)	4.06	28.7%	Normal	
IPA Los Ríos Mixed Forest Reference Period (t dry biomass/ha)	2.21	28.7%	Normal	

Parameter included in the model	Parameter values	Error sources quantified in the model	Probability distribution function	Assumptions
IPA Los Lagos Mixed Forest Reference Period (t dry biomass/ha)	3.70	28.7%	Normal	
IPA Ñuble Mixed Forest Reference Period (t dry biomass/ha)	4.03	28.7%	Normal	
IPA Alerce Adulto (m3/ha/yr)	0.5	58.47%	Normal	The higher uncertainty of the errors estimated for IPA is assumed due to a lack of data.
IPA Ciprés de las Guaitecas Adulto (m3/ha/yr)	3.9	58.47%	Normal	
IPA Araucaria Adulto (m3/ha/yr)	μ: 4.882; σ: 2.516	PDF	Normal; P:0.923; n: 16	
IPA Ciprés de la Cordillera Adulto (m3/ha/yr)	5.0	15.83%	Normal	Error estimated from permanent plots of the INFOR Continuous Forest Inventory
IPA Ciprés de la Cordillera Renoval (m3/ha/yr)	2.7	9.97%	Normal	
IPA Lenga Adulto (m3/ha/yr)	k: 5; γ:0.921	PDF	Erlang; P:0.986; n:10	
IPA Lenga Renoval (m3/ha/yr)	μ: 2.995; β:2.054	PDF	Fisher-Tippett (2); P:0.907; n:8	
IPA Coihue de Magallanes Adulto (m3/ha/yr)	2.6	13.42%	Normal	Error estimated from permanent plots of the INFOR Continuous Forest Inventory
IPA Coihue de Magallanes Renoval (m3/ha/yr)	3.7	7.68%	Normal	
IPA Roble - Hualo Adulto (m3/ha/yr)	μ: 1.534; σ: 0.507	PDF	Log Normal; P:0.873; n: 17	
IPA Roble - Hualo Renoval (m3/ha/yr)	3.5	54.47%	Normal	The higher uncertainty of the errors estimated for IPA is assumed due to a lack of data.
IPA Roble - Raulí - Coihue Adulto (m3/ha/yr)	μ: 1.335; σ: 1.106	PDF	Log Normal; P:0.257; n: 65;	
IPA Roble - Raulí - Coihue Renoval (m3/ha/yr)	β: 1.777; γ:4.664	PDF	Weibull (2); P:0.760; n: 71	
IPA Coihue - Raulí - Tepa Adulto (m3/ha/yr)	β: 1.403; γ:6.264	PDF	Weibull (2); P: 0.789; n: 57	
IPA Coihue - Raulí - Tepa Renoval (m3/ha/yr)	μ: 4.364; s: 1.558	PDF	Logistic; P:0.825; n: 12	
IPA Esclerófilo Adulto (m3/ha/yr)	β: 0.667; γ:0/875	PDF	Weibull (2); P: 0.512; n: 33	
IPA Esclerófilo Renoval (m3/ha/yr)	1.6	21.31%	Normal	Error estimated from permanent plots of the INFOR Continuous Forest Inventory
IPA Siempreverde Adulto (m3/ha/yr)	α: 13.411; β:29.589	PDF	Beta4; P: 0.940; n: 49	

Parameter included in the model	Parameter values	Error sources quantified in the model	Probability distribution function	Assumptions
IPA Siempreverde Renoval (m3/ha/yr)	μ: 4.664; s:0/893	PDF	Logistic; P: 0.994; n: 25	
Degradation and Enhancement in permanent forest				
Carbon stock change in permanent forest	Values depending on density diagram change and forest type	57%	Normal	Error estimation based on the standard error of the k-nn algorithm volume estimation.
Carbon content of forest lands (forest fires)				
AGB Maule (t dry biomass/ha/yr)	80.35	18.85%	Normal	This uncertainty is estimated following IPCC approach 1 (propagation of error), resulting in total uncertainty of 18.85%.
AGB Biobio (t dry biomass/ha/yr)	149.88	18.85%	Normal	
AGB Araucanía (t dry biomass/ha/yr)	252.33	18.85%	Normal	
AGB Los Ríos (t dry biomass/ha/yr)	310.35	18.85%	Normal	
AGB Los Lagos (t dry biomass/ha/yr)	230.41	18.85%	Normal	
AGB Ñuble (t dry biomass/ha/yr)	149.88	18.85%	Normal	
BGB Maule (t dry biomass/ha/yr)	23.05	44.2%	Normal	Uncertainty for Below Ground Biomass BGB is based on propagation error estimate following IPCC approach 1 of Above Ground Biomass-AGB error (18.85%) and Root shoot ratio -R Factor error (40.0%) estimated by Goyoso et al. (2002), resulting in total uncertainty of 44.2%.
BGB Biobio (t dry biomass/ha/yr)	43.00	44.2%	Normal	
BGB Araucanía (t dry biomass/ha/yr)	72.39	44.2%	Normal	
BGB Los Ríos (t dry biomass/ha/yr)	89.04	44.2%	Normal	
BGB Los Lagos (t dry biomass/ha/yr)	66.10	44.2%	Normal	
BGB Ñuble (t dry biomass/ha/yr)	43.00	44.2%	Normal	
Dead matter Maule (t dry biomass/ha)	52.60	28.4%	Normal	Error estimated from permanent plots of the INFOR Continuous Forest Inventory
Dead matter Biobio (t dry biomass/ha)	122.10	28.4%	Normal	
Dead matter Araucanía (t dry biomass/ha)	165.50	28.4%	Normal	
Dead matter Los Ríos (t dry biomass/ha)	146.90	28.4%	Normal	
Dead matter Los Lagos (t dry biomass/ha)	157.00	28.4%	Normal	
Dead matter Ñuble (t dry biomass/ha)	122.10	28.4%	Normal	
Other Factors				

Parameter included in the model	Parameter values	Error sources quantified in the model	Probability distribution function	Assumptions
Combustion factor	0.45	36.0%	Normal	IPCC, 2006
Emission Factor CH4	4.7	29.0%	Normal	
Emission Factor N2O	0.26	43.8%	Normal	

Quantification of the uncertainty of the estimate of Emission Reductions

		Reporting Period	Crediting Period
		Total Emission Reductions*	**Total Emission Reductions***
A	**Median**	-4,280,711	-4,280,711
B	**Upper bound 90% CI** (Percentile 0.95)	10,644,325	10,644,325
C	**Lower bound 90% CI** (Percentile 0.05)	-19,639,331	-19,639,331
D	**Half Width Confidence Interval at 90% (B – C)/ 2**	15,141,828	15,141,828
E	**Relative margin (D / A)**	353.7%	353.7%
F	**Uncertainty discount**	15%	15%

5.3 Sensitivity analysis and identification of areas of improvement of MRV system

The following table and figure show the results for the sensitivity analysis of Emission Reductions (ERs) uncertainty. ERs estimate in forest remaining forest (conserved and non-conserved) contributes the 54.3% of total ERs uncertainty. The main contribution is coming from ERs' uncertainty in the non-conserved permanent forest (42.5%).

The sources of error for estimating forest degradation and carbon enhancement on permanent forest lands are:

i. Uncertainty associated with the forest density charts used to determine the direction of carbon flux (neutral, loss or gain) for each pixel (32.8%)
ii. Uncertainty associated with integrating the multi-pixel mosaic satellite data with the dasometric variables. This uncertainty has been estimated by calculating the Standard Error of Estimation of the volume function k-nn (57%).

Table 7 shows the results of sensitivity analysis for Emission Reductions uncertainty in non-conserved permanent forest. Both activity data and emission factors contributed equally to the uncertainty (50/50). The same uncertainty for AD and EF was used for all regions, therefore the difference in the uncertainty contribution between regions responds to the magnitude of ERs.

Further analysis of the Methodology used to estimate emissions and removals in permanent forest are required to determine the improvement actions on the MRV system to reduce Emission Reduction uncertainty.

REDD Activity	Component	Uncertainty Contribution
Carbon enhancement	Removals in forest remaining as forest	23.9%
	Removals in lands converted to forest	66.5%
	Total removals	**90.4%**
Conservation	Removals in forest remaining as forest	2.5%
	Emissions in forest remaining as forest	80.6%
	Conservation Total	**83.1%**
	Deforestation Total	**2.0%**
Degradation	Emissions in forest remaining as forest	23.3%
	Emissions from forests converted to plantations.	3.7%
	Forest fires	1.8%
	Degradation Total	**28.8 %**
	Grand Total	**204.4%**

Table 6 Results for the sensitivity analysis of ERs' global uncertainty.

Region	Absolut contribution		Total
	Activity data	Emission Factor	
Biobío	7%	8%	14%
Ñuble	10%	7%	16%
La Araucanía	7%	14%	21%
Los Ríos	5%	6%	11%
Los Lagos	9%	7%	16%
Maule	11%	11%	22%
Grand Total	**48%**	**52%**	**100%**

Table 7 Results of sensitivity analysis for Emission Reductions uncertainty in non-conserved permanent forest.

6 TRANSFER OF TITLE TO ERS

6.1 Ability to transfer title

The 2016 ERPD document defined that the Chilean ER Program will define a Benefit Sharing Plan, which is based on the basic principle that the distribution of benefits associated to result – based payment is conditional on a previous transfer of carbon rights (Annex 2). Nevertheles, no Contract ERs have been generated during this monitoring period so that no Contract ERs will be transferred to the FC.

Under this principle, CONAF, as the REDD+ focal point in Chile, carried out a legal study* with external specialists. These analyzes have made it possible to demonstrate Chilean capabilities for the transfer of titles on emission reductions (ER) caused by the implementation of ENCCRV actions, considering criterion 36 of the Methodological Framework of the Forest Carbon Partnership Facility (FCPF) Carbon Fund.

In the first place, this study determined that in the case of Chile, the ENCCRV contains a series of diverse actions affecting public, private or both public/private lands, without being possible to specifically determine the ER sources. This is explained by the fact that the FREL/FRL of Chile and its monitoring milestones estimate the volumes of carbon emission and removal due to deforestation, forest degradation, stock enhancements and forest conservation on a regional scale. This makes it impossible to identify whether specific smaller scale actions could be considered incremental. Because of this, ERs cannot be attributed to a spatially explicit area or individual owners.

In the case of activities associated with sequestration, although it is possible to identify with greater spatial accuracy the areas where such activities are being carried out, it is not technically feasible to isolate those that allow reaching the FREL estimated volume from which they should be considered. In accordance with these technical aspects of carbon accounting, the current methodology does not allow an individual owner to claim or demonstrate that they have rights to capture or reduction of emissions on a regional scale that implies additionality, therefore, the same applies to possible properties. Following this understanding, the fact that the reductions occur as a result of a better performance of forests located in public lands, areas protected by the State or private lands is not relevant for the transfer of ERs.

From a regulatory point of view, Chile does not have a specific framework to determine the transfer or ownership of ERs. However, of transferring ERs is based on different legal norms and other mechanisms that give effect to criterion 36 of the FPCF Carbon Fund Methodological Framework. In that case, the ability of the ER Program of Chile to transfer ER titles to the Carbon Fund is demonstrated through the following three mechanisms:

1) Regulatory Framework

The government of Chile ratified the CMNUCC and the Paris Agreement, converting its Nationally Determined Contribution (NDC) commitments into obligations and on the other hand, the appointment of CONAF as REDD+ focal point was made official[19]. Both decisions lead to the validation of a special title for transferring RE to the World Bank within the FCPF framework, which is aligned with the system the UNFCCC and the Paris Agreement have developed to obtain emission reduction-based payments for REDD+.

The foregoing is consistent with the internal legal system, since according to CONAF Statutes Article 3, this organization has the exclusive purpose of "Contributing to the conservation, improvement, management and use of the protected forest resources and areas of wildlife of the country", also including among its functions the possibility of creating agreements and contracts with different organizations to achieve this purpose.

2) Additional agreements with possible title holders on use and land ownership rights

The previously mentioned legal study determined that ownership of lands where GHG capture capacity enhancements are produced is not relevant for determining a possible ER title transfer, as there is no ownership on said reduction but rather an obligation being complied with. In fact, individuals can own a specific land, but not the emission reductions produced by said land (or vegetation resources inside it) because this reduction is a national

[19] Letter No. 99, of February 19, 2014, Issued by the Ministers of Agriculture and Foreign Affairs

asset for public use. Nevertheless, owners are able to transfer the right to transact that emission reduction in other instances such as the voluntary carbon market, or a local offset market, representing a real risk of double counting in the AC of the ER Program.

To avoid this risk, there are mechanisms for promoting compliance with emission reduction obligations that owners can choose to obtain benefits associated to land ownership. One of such agreements is the signing of Additional Agreements between land/resource ownership title holders and CONAF, which make express provisions for prohibiting those who adhere to such agreement of signing other similar instruments with public or private entities. And explicitly authorize CONAF to transfer ERs generated in such lands as a consequence of projects implemented there. Currently, no additional agreements have been signed in the ER program area.

CONAF is empowered to formalize such agreements, which is mentioned in the previously mentioned Article 3 of its statutes, more specifically in its literal which states: "Implement all kinds of actions and enter into all kinds of conventions or contracts aimed at the obtention or related to such purposes, with individuals or legal entities, national or foreign, under public or private law, even with its own partners". In line with this, there is no doubt the emission reduction objective is aligned with the objectives of CONAF, which is therefore empowered to enter into agreements and contracts with individuals for such purposes.

3) Benefit – Sharing Plan (BSP)

Besides the regulatory framework and agreements, the third FCPF mechanism for justifying ER transfers is referring to the BSP. This is even more important than the two previous mechanisms, as it recognized that public policy outcomes are not necessarily prone to private appropriation.

CONAF has developed a BSP for the ENCCRV and ER Program under transparency, participation, and fairness standards according to criteria 29, 30, 31, 32 and 33 of the FCPF Methodological Framework, a process described in Annex 2 of this report.

This BSP has a harmonious relationship with the previously mentioned regulatory framework and additional agreements; it also ensures and promotes an adequate benefit sharing which meets the principles of environmental law and UNFCCC agreements, particularly in terms of poverty eradication and respect for the human rights of vulnerable groups, article 3 and the preamble of the Paris Agreement.

To ensure this outcome and reduce possible conflicts, CONAF designed the BSP through a series of participative processes with gender and interculturality approaches, in accordance with the vision of communities within the territory. The foregoing to assure a fair, equitable and transparent distribution of resources considering the distribution of non-monetary benefits, which will be mainly focused on small and medium forest owners. In that same line, any measures taken such as collaboration agreements with large private conservation areas, will be important. Such agreements must include, on one hand, the transfer of rights to transact past and future ERs, committing result – based payment benefits, and on the other, collaboration agreements so that these private actors continue the emission reducing activities. At the present, no one of these agreements have been signed.

In conclusion, the BSP meets the requirements of the methodological framework and serves as a basis to validate that CONAF can transfer ERs according to the requirements.

Therefore, considering the three described mechanisms, the legal analysis determined that according to the FCPF Carbon Fund Methodological Framework, the document "Note on the Ability of Program Entity to Transfer Title to Emission Reductions (ERs) Forest Carbon Partnership Facility, Carbon Fund" and the existing legal framework, CONAF is empowered to transfer ERs, as stated in Official Letter No. 74/2019, March 1st, 2019, submitted to the FCPF by CONAF. However, for this reporting period, the Program Entity has not been aware of any title contest in which interested parties in the RE Program area have challenged the capacity of the Program Entity.

6.2 Implementation and operation of Program and Projects Data Management System

The design of the data management system for the ER Program and its respective projects was presented in the 2016 ERPD document, according to the requirements of the FCPF Methodological Framework. This is a fundamental part of the Monitoring Plan and suggests as objectives: provide transparent data and information, which are consistent over time and suitable for measuring, reporting and allowing the verification of emissions by the considered sources, absorptions and sinks.

Then, the document "Additional Information for the ER Program Update, per recommendations issued in the Chair´s Summary in the 15th Meeting of the Carbon Fund" from 2018 updates the Monitoring Plan and describes the progress made in its implementation, including time planning for monitoring milestone implementation, systems and methodologies to be used and institutional arrangements involved. The objectives of the NFMS Monitoring and Measurement System (SMM, acronym in Spanish) were also updated, defining the following:

- Optimize generation processes and ensure the implementation of monitoring events for primary elements (Land use and Land use change maps) for the estimation of emissions and absorptions linked to REDD+.
- Generate interoperability protocols for the integration of information at various spatial scales, time scales, differentiated file formats and purposes, including information of Co-benefits and Safeguard Follow-up.
- Automate report generation processes and increase report transparency.
- Have a visualization and consultation platform, in order to facilitate the dissemination of results, that responds both to the verification criteria in international instances as well as to institutional necessities and citizen demands for information.

The Data Management System, the development of the ENCCRV information platform was updated including semi-automated information integration tools. Also contain a geospatial content manager with a web mapper viewer and a forest carbon calculator for the executed land/property projects in regions of Chile. From here, two key tools are developed to monitor ENCCRV projects, the property monitoring system and the safeguards information system.

This computer applications were based on open programming languages to ensure and guarantee the durability of these components, with an interoperability that applies to other systems developed under CONAF and associated with the ENCCRV at the institutional level, such as the Uncertainty Evaluation System (Sistema de Evaluación de Incertidumbre, in Spanish), the Land Prioritization System (Sistema de Priorización de Territorios, in Spanish) and the Co-Benefits System (Sistema de Co-Beneficios, in Spanish). These systems are integrated into a unique digital platform, available in plataforma.enccrv.cl.

The Chilean ER Program Monitoring Plan is part of the ENCCRV Measuring and Monitoring System (SMM, acronym in Spanish), which began its implementation and operation during 2019, developing the Information Platform based on alphanumeric and spatial databases.

The development of this platform considered the following specific activities:

- Protocol elaboration for the standardization of spatial information and alphanumeric information generated in the ENCCRV framework.
- Standardization of the existing information and quality control of the information under development.
- Development of database architecture and model
- Development of report generation tools
- Development of web mapping viewer and geospatial content manager
- Definition of the official registration system of the ER Program
- Maintenance, adjustments, improvements, and new functionalities of the platform
- Performance evaluation (tests) during the trial period
- Technology transfer and training of pertinent/applicable CONAF personnel to carry out an internal execution of the platform

This robust platform has made possible an adequate storage and visualization of the generated information. The platform has been able to improve reconstruction tasks and data integration, elaborating reports, indicators and

perform calculations at different scales for multiple needs. This is in accordance with and responds to compliance with international requirements and responses, and also to specific requests from institutional executives instances or public consultation.

The ENCCRV Platform constitutes a centralized system of REDD+ projects executed within the framework of the ENCCRV, which is fed by the territorial implementation teams of REDD+ projects of CONAF. The system currently supports REDD+ projects executed by CONAF and does not yet consider the use of private projects, because CONAF does not have the power to mandate the use of the system by other developers.

As long as this data management system remains limited to CONAF projects, to registry REDD project executed by another entities a procedure is carried out that considers a review of the international registration systems for reduced emissions transactions or carbon credits, with the aim of keeping this information controlled and so that it can be excluded, in the event that a payment is generated. This information is made available to the general public through the ENCCRV site, in the Redd+ information tracking system, accessible in 2.4 of https://www.enccrv.cl/medicion-y-monitoreo. The details of this information are presented in 6.4.

6.3 Implementation and operation of ER transaction registry

As previously mentioned (6.2), the ENCCRV SMM defined the basic development of a Reduced Emission Transaction Registration System as one of its objectives. This tool responds to the FCPF Methodological Framework for those countries that aim to reach a result – based payment agreement with the Carbon Fund. It also responds to Articles 5 and 6 of the Paris Agreement on REDD+ through market-based approaches and other agreements, which makes it possible for different countries to exchange reduced emissions caused by the implementation of REDD+, in order to achieve the goals established in their NDCs and avoid double counting.

The ERPD considered developing a ENCCRV Reduced Emission Transaction Registration System, which should be a national and centralized system which guaranteed that the reduced emissions generated within the ENCCRV framework could be adequately emitted, serialized, transferred, removed, or canceled. In addition, it should also offer clear connections to different sources of information contained in the platforms used within the SMM framework. Its main function would be to avoid the duplicate transaction of reduced emissions, and act as the main tool for the control of REDD+ emission reduction transaction reporting and accounting in Chile.

The design of this registration system began in 2018, is already created and described in more detail in the ENCCRV SMM. It was developed under a system with IHS Markit adapted to the REDD+ activities quantified by CONAF.

Nevertheless, the World Bank designed the Carbon Assets Tracking System (CATS), a central platform to support operations under the FCPF CF and BioCF ISFL which is free and has flexible enough operating rules to be easily adapted to other World Bank platforms and future scenarios. Given this, Chile issued a formal letter to define the CATS platform as the official reduced emission transaction registration system of the ER Program and ENCCRV.

The use of CATS to register ER transactions generated in the accounting area of the PRE, has not yet begun its practical operation, therefore the country has not implemented a transaction registration system. However, in order to avoid double counting, Chile executes a verification procedure for International ER Registrations to identify REDD+ projects that are executed in the country. International registrations are reviewed every two months, and the information that is collected gives rise to a data sheet where the information of the projects is entered, including the owner, the volume of transfer of ER, the year of generation, along with other background. This information is publicly available on the ENCCRV website, SMM section https://www.enccrv.cl/medicion-y-monitoreo.

In addition to the above, it must be taken into consideration that recently in 2023 [20], the compensation regulation was approved and published in Chile, which regulates the operation of the Emissions Compensation System, which will allow offsetting emissions affected by the tax. This system considers the development and implementation of

[20] Available in https://www.bcn.cl/leychile/navegar/imprimir?idNorma=1196414&idVersion=2023-09-29

all the necessary infrastructure to offset local pollutants and other GHGs, including nature-based solutions projects, so greater interest is expected in the development of projects from private developers.

6.4 ERs transferred to other entities or other schemes

The ENCCRV ER Program corresponds to the first subnational program of result – based payments associated with REDD+ in Chile. The reductions associated to the Emission Reduction Payment Agreement signed by Chile are insured in accordance with the estimates made in the FREL. This has encouraged Chile to develop a financing package for result – based payments mainly associated with the Green Climate Fund, which despite not considering transfers, would not affect compliance with the ER Program. Thus, work has been done to improve the registration and monitoring systems to avoid double counting or payments that can generate legal or other disputes in the implementation territory, so that this and other future initiatives can be implemented correctly.

Currently, there are six REDD+ projects linked to the voluntary market implemented by VCS in Chile [21]. **According to its own records, no credits due to emission reductions have been claimed during the 2018-2019 reporting period which significantly reduces potential inconveniences**. These are:

- Valdivian Coastal Reserve Project, Los Ríos region. Project led by The Nature Conservancy (TNC), corresponding to a project in the planned degradation and deforestation REDD subcategory, generating around 58,154 VCUs per year.
- California Valley degraded land reforestation project, Los Lagos region. The initiative is led by the Agrícola y Forestal SNP Limitada Company, being an ARR project estimated to generate 1,193 VCUs per year
- Caelus project: under validation process, with 111 estimated annual emission reductions. The project is based on GHG emission reductions and removals generated by improving forest management practices to increase the carbon stock on land by extending the rotation age of a forest before harvesting.
- Bosques Cautín S.A. proyect: under validation process, with 124,951 estimated annual emissions reductions. The project is a forest developer operating in Chile, that has traditionally operate a silvicultural model for commercial timber, and is expanding its business model to dedicate different areas of forest plantations to carbon sinks.
- Proventus project: under validation process, with 2,301 estimated annual emissions reductions. The project is based on changing the use of low productivity land to sustainable forest production systems, which will increase the forest cover and promote remnant natural forest improvement generating a landscape of biological corridors that bring about financial, social and environmental services.
- Reforestation in degradation land, in Biobío region: project in their first steps of development. With 16,864 estimated annual emissions reductions. Is a reforestation project with local land owners and considers advanced propagation technology, mycorrhizal inoculation, to help restore and convert degraded grassland into productive forests in several regions of Chile.

In addition, they do not have a record of information of geographical boundaries with public reach. Based on the above, the areas of these projects could not be excluded from the PRE analysis.

CONAF has not defined procedures and agreements to sell or assign ERs of the ER Program area to other entities under a different GHG program or standard. Indeed, these projects could trade ER for the period 2018-2019. In order to avoid double counting, CONAF considers the exclusion of the areas reported in as participants of a voluntary carbon market standard, thus avoiding considering ERs from areas committed to other buyers. In particular, for this period it was not possible to collect the geographical areas, however, transactions with other standards were not recorded either. For future reports, it is expected to have the information to exclude project areas and discount ER in case they are registered.

[21] See section 2.4 in: https://www.enccrv.cl/medicion-y-monitoreo

7 REVERSALS

Regarding the strategy that the ER Program has proposed to prevent and minimize the potential for reversals, the ERPD document proposed several measures. Given that the program has not yet been implemented, many of these actions do not present concrete progress, but other measures associated with the permanent activity of CONAF do have progress for the period of this report, which are summarized below.

In relation to the risk associated with the lack of broad and sustained support from key stakeholders, progress has been made in analyzing the risk of land conflicts before designing and executing ENCCRV projects in the territories, establishing protocols and procedures for this within the Environmental and Social Management Framework (MGAS). In addition, the ENCCRV has continued to be developed with expanded participatory processes, ensuring that their opinions and needs are included in the design of different key components of the ER Program, such as the BSP.

Regarding the risk associated with the lack of institutional capacity and/or ineffective vertical/cross-sector coordination, an important inter and intra-institutional coordination has been maintained, carrying out multiple induction, training and dissemination activities on political and technical issues of the REDD + approach and on the ENCCRV.

Regarding the risk associated with the lack of long-term effectiveness in confronting underlying factors, progress has been made in improvements to the current forest policy and regulations, including improvements to the Native Forest Law, and the design of a new forest law that promote the recovery of areas burned by forest fires and promote reforestation with new generation plantations that take into account the country's climate scenarios and goals. Progress has also been made in governance, strengthening the issue of Climate Change at the institutional level through specific programs (wood energy, forestry extension, community forestry, others) and the strengthening of capacities in CONAF's technical structures.

Finally, the advances associated with reducing the risk of natural disturbances and disasters have focused on strengthening the efforts to prevent and combat forest fires in CONAF, including different institutional programs for education and preparation of communities for these events, as well as of improvements in infrastructures, equipment, capacities and technologies for the prediction and combat of fire. Important progress has also been made in the monitoring and evaluation of fires, relevant inputs for restorative processes in affected areas.

Regarding the reversal management mechanism, Chile proposed using the Carbon Fund Buffer to store the credits associated with the risk of uncertainty and reversals. Specifically for reversals, it was proposed to use the reversal risk assessment tool that requires a specific amount to put in the buffer for each risk factor. These factors and an update of them are presented in more detail in section 7.3.

7.1 Occurrence of major events or changes in ER Program circumstances that might have led to the Reversals during the Reporting Period compared to the previous Reporting Period(s)

During the monitoring period, anomalous and extreme events that occurred in the PRE accounting area could be potentially associated with the results that were presented in this report. These events were namely the 2017 firestorm and the Megadrought that has impacted over the Mediterranean and temperate forests of Chile for more than a decade, triggering a browning trend in these forest masses and resulting in a diminished photosyntetic capacity of this area. Both events occurred before the monitoring period, however they may have played a role as drivers/cause towards emission increase, especially those derived from forest degradation. The megadrought and the warming trends of summer temperatures are two current climatological features that are not directly-antropogenic caused, but it requires further analysis to prove if these phenomena are influencing/impacting at least 25% of the accounting area of the program.

In this regard, the country developed a study on the Browning effect in the Mediterranean and temperate forests of Chile to determine and quantify the affected forest ratio and the degradation-derived emissions ratio caused by the megadrought.

The mega-drought event was reported to the Trustee in 2023, while the 2017 firestorm was reported in the ERPA update document in 2018.

- **Forest Fires**

Reversal risks identified in the 2016 ERPD have not experienced significant changes. Nevertheless, due to the magnitude and dynamics of the event known as Mega Forest Fire which impacted Chile in the summer of 2017, the potential of forests to acting as sinks is estimated to have been affected. Around 500,000 hectares were burnt during this event, of which an important surface corresponded to pastures, scrubs, and forest plantations, excluded by both the ER Program and the FREL/FRL. The impact on the AC Native Forest was 38,000 hectares, being the Maule region the most affected with 28,000 ha, then 10,000 ha in the Biobío region and finally 570 ha in the Araucanía region. Of the 81 million tons of gross CO_2 equivalent emissions estimated for the entire event, 7.45 million tons CO_2 were associated with the native forest of the CA. This information, along with other details associated to the analysis of the aforementioned event, can be found in the document "Additional information for the update of the Emission Reduction Program of Chile, as per recommendations by the Chair´s Summary in the 15th Meeting of the Carbon Fund" from 2018 (here).

Although direct emissions generated by these forest fires are not considered in the period of this report (2018-2019), CONAF has identified that this mega event increased emissions from Degradation in this period, given the losses of sink capabilities in the affected forests.

Fires in Chile are caused by anthropic actions and correspond to one of the main drivers of ecosystem degradation in the world. As such, it was identified as one of the drivers of forest degradation in the ERPD. Fire seasons in Chile are frequent events that occur during the summer season; also, high temperature, low humidity and drought conditions can turn these frequent events into exceptional, barely controllable events.

In order to check the sensitivity of the degradation methodology for the detection of degraded areas affected by forest fires in the reporting period (2018 – 2019), CONAF developed a preliminary study about degradation data, using forest fire occurrence spatialized coverages. A simple experiment was carried out, where the data of forest carbon losses due to forest fires during the season was compared against estimated values in areas with no fires during that year.

This analysis was conducted for the Maule (7), Ñuble (16), Biobío (8), La Araucanía (9), and Los Lagos (10) regions. The next graph uses a Boxplot to display carbon values means and distributions for these three treatments and by administrative region. The table after that shows the distribution of total CO2 values by region and treatment.

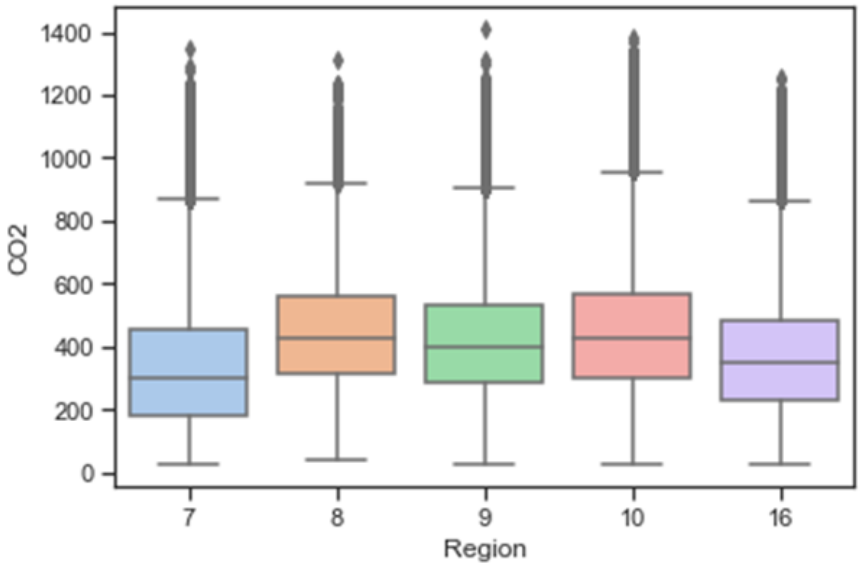


Figure 11 CO2 captures during 2019, disaggregated at the regional level.

Region	Tto	N	mean	std	min	25%	50%	75%	max
7	1	2,202	309.8	203.5	46.0	153.0	234.5	434.0	1042.0
	2	84,345	351.9	192.7	29.0	198.0	319.0	474.0	1216.0
	3	246,423	333.1	194.1	26.0	175.0	292.0	450.0	1346.0
8	1	24	367.5	188.2	95.0	224.3	327.0	535.0	714.0
	2	5,464	455.6	176.8	64.0	328.0	431.0	567.0	1215.0
	3	31,580	446.1	184.3	37.0	314.0	423.5	556.0	1311.0
9	1	1,845	302.1	184.6	57.0	170.0	247.0	391.0	1091.0
	2	63,180	407.8	184.0	37.0	269.0	383.0	518.0	1310.0
	3	255,322	423.4	182.7	23.0	288.0	402.0	534.0	1413.0
10	1	196	255.4	104.6	72.0	213.5	242.0	270.8	892.0
	2	18,365	433.2	184.2	41.0	288.0	408.0	543.0	1342.0
	3	95,808	452.9	189.9	25.0	306.0	432.0	569.0	1382.0
16	1	15	267.1	175.2	62.0	157.0	247.0	329.5	653.0
	2	4,340	362.5	191.5	31.0	220.0	337.0	477.0	1145.0
	3	66,911	372.6	187.0	24.0	232.0	347.0	486.0	1258.0

Table 8 Distribution of CO2 values by region and treatment in 2019.

The differences between burned areas and those without fires were analyzed by isolating data at the regional level and allocating a similar amount of data for each treatment. This was carried out by randomly selecting the data from treatments 2 (areas located 10 km away from the fire) and 3 (areas located 30 km away from the fire) as these areas are larger than their burned counterparts (Table 9, each pixel corresponds to 1 hectare, therefore, region 7 of treatment 1 has 2,202 ha and treatment 2 84,345 ha2). These sample sizes of the various treatments were used to identify the statistical differences that may exist between areas 1, 2 and 3.

The collected data considers large sampling sizes except for the Ñuble and Biobío regions, which were joined to correct the effect of low amounts of data for burned areas in these regions compared to other categories. Despite these sampling sizes, the data do not meet the normality assumptions, and normality is not achieved by looking for

a transformation that allows to meet such assumptions either. Because of this, non – parametric variance analyses were conducted using the Kruskal Wallis method and subsequent comparisons in order to know the differences between groups, applying the Holm-Bonferroni method and the Bonferroni sequential method, less conservative than the original Bonferroni test.

Regarding the general findings from this exercise, it was found that there are significant differences between estimations from burned areas in the various ERP regions for 2018-2019, in regard to those areas located at various distances away from the fires. Therefore, there are differences in the degradation detecting capability of the methodology applied for estimating native forest degradation as a REDD+ activity, it being sensitive to the clear impacts on forest areas after a forest fire.

While fire seasons in Chile are frequent events that occur during the summer season, fire events in January and February 2017 were extreme under high temperatures, low humidity and drought conditions that caused an exceptional event known as a firestorm.

The firestorm affected 518,000 hectares, out of which 93% corresponded to vegetation formations with the Maule region being the most affected, having 54% of its total surface burned, followed by the Biobío region with 19.2%. A total of 89,347 native forest hectares were affected among the native forest vegetation formations, equivalent to 17.24% of the total burned area. The most affected forest type is Sclerophyll, with 72,064.1 ha.

A simple exercise where the surface affected by the firestorm was intersected with pixels from the degradation map, being able to isolate burned pixels, was conducted in order to assess the areas affected by this firestorm.

Among the main findings, areas under degradation in the 2018 – 2019 period affected by the 2017 Firestorm are not too representative in relation to the total degraded surface of the period, only representing 1.3%. This is because areas burned in 2017 were mostly forests of planted exotic species, which are included in the degradation analysis that only considers native forests, which were not as impacted. Also, one of the most impacted regions is that of O´Higgins, which is not in the accounting area. This translated into emissions estimated from these areas being minimal in relation to the total emissions of the period, therefore, the effects of the firestorm phenomenon do not have a major influence in the degradation results for the monitoring period. In addition to this, there is on – site evidence of the post fire restoration process as of 2020 (3 years later) which makes it important to evaluate the state of this forest condition before confirming the dismissal of the areas burned by the 2017 mega fire.

- **Drought**

The important increase in degradation during the period is linked with the impact of drought and climate change on the state of vegetation, which has been scientifically proven by analyzing the impact of the decrease in rainfall on browning signs representing loss of vigor, especially in sclerophyll forests. In addition, this fosters environmental conditions for forest fires to occur and propagate, which is one of the main causes of forest degradation identified.

Chile has experienced over a decade of drought nationwide. The precipitation deficit since 2010 is 30% (CR2, 2015). The center-south of the country, that is, the north of the CA, are those that have experienced the most significant variations (ARCLIM). Although the native forest has adapted to short drought periods, the duration of the current scenario is causing a significant increase in the native forest deterioration. (CR2, 2020; Miranda et al., 2020; Garreaud et al., 2017), along with an increase in the forest fire regime. In particular, some species and forest types in the CA have displayed a higher sensitivity to precipitations and climate variables, being more affected (Venegas-González et al., 2018; Urrutia, R. & Rojas, Y., 2020).

This scenario is capable of impact the implementation and results of the Chilean ER Program, especially in the CA northern regions. While there are scientific studies that have addressed some specific aspects of the drought, CONAF has undertaken to study its impacts on the ER Program. These analyses will be aimed towards:

i) Determine the CA native forest surface being affected.
ii) Assess the magnitude of these impacts on the native forest.
iii) Estimate their effects over time.
iv) Establish a correlation between these trends with emissions and captures from the native forest, both for the ER Program and the National REDD+ Strategy.

Recent studies (Miranda et al, 2020)[22], have addressed the impact of the 2010 – 2017 mega drought on the forests of central Chile, indicating its significant impact of the productivity of Mediterranean forests. In addition, a preliminary study conducted by the Forest Institute regarding degradation outcomes analyzed the 2000 – 2020 time series, seeking to identify drought events and their relationship with forests under browning conditions. As a result, the effect on browning in sclerophyll forests is made evident, which coincides with drought events in the evaluated period. The next graph displays the annual browning surface calculated based on Landsat ETM+ and OLI satellite material, for the Maule region and the north area of the Biobío (Just before the Ñuble – Biobío division) considering NDVI ranges of <0.45 and >0.2. The following figure is a synoptic depiction of the NDVI behavior for a stand in a sclerophyll forest, as an example.

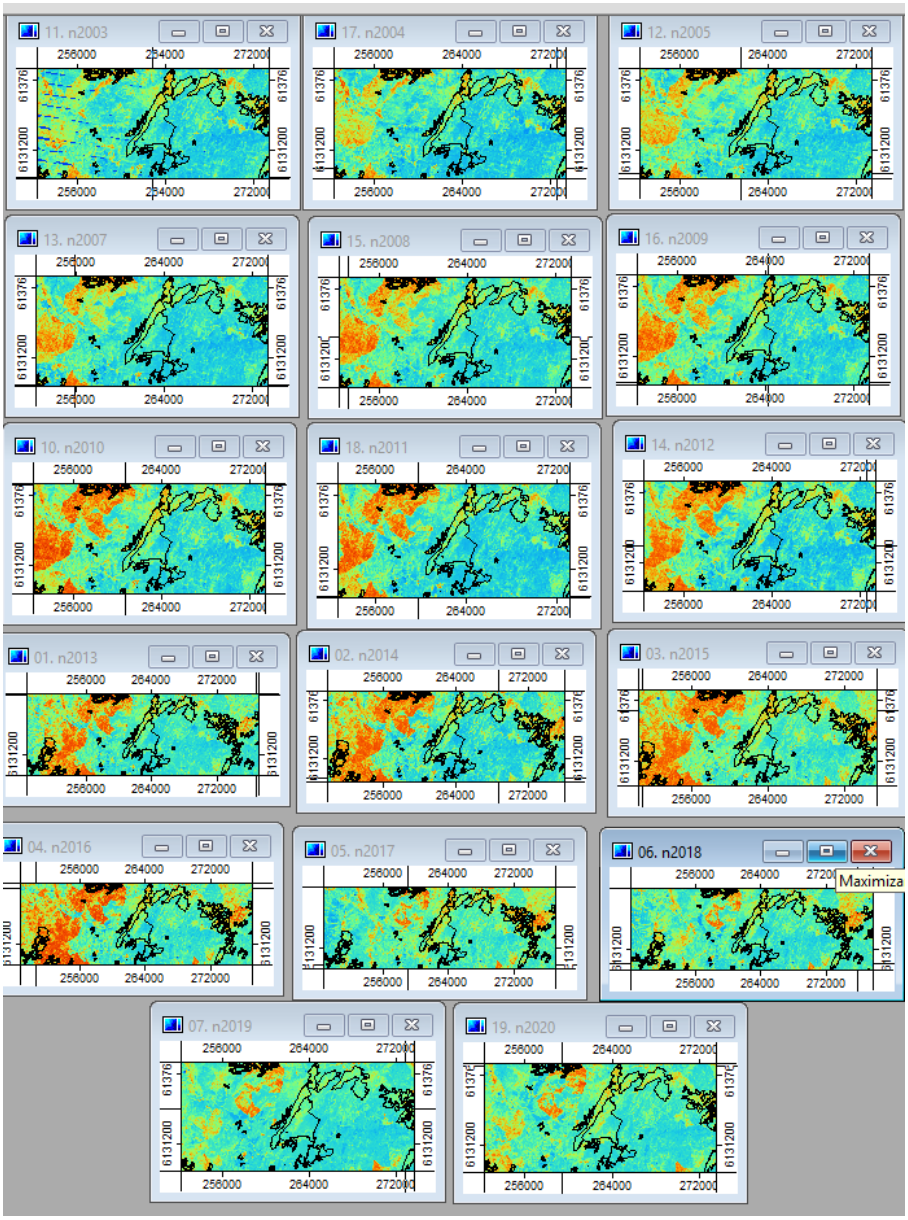


Figure 12 Synoptic view of NDVI behavior in sclerophyll forests (example).

[22] Forest browning trends in response to drought in a highly threatened Mediterranean landscape of South America, Ecological Indicators (journal homepage: www.elsevier.com/locate/ecolind).

This information was used to count the sclerophyll forest surface with signs of browning, based on the native forest registry for these regions. The occurrence of drought events in the period was added, corresponding to 2007, 2010 – 11, 2016 and 2019 – 20. As a result, the following graph summarizes the annual browning surface, highlighting the years with drought events in pink.

It is possible to conclude that, while browning is evident in the results, it would not be a new event only specific for the period associated to the mega drought, but would rather be associated to a cycle of recurring drought weather events in the last two decades, which is related to climate change. Then, the peaks showing the largest browning effect in the graph coincide with historical drought events reported in Chile and are possibly related to El Niño/La Niña phenomena. It is also worth noting the frequency of these events has increased from 6 to 7 years at 2 to 3 year rates, although their magnitude is greater with regard to the base year (2000), possibly indicating a resilience effect of this forest type.

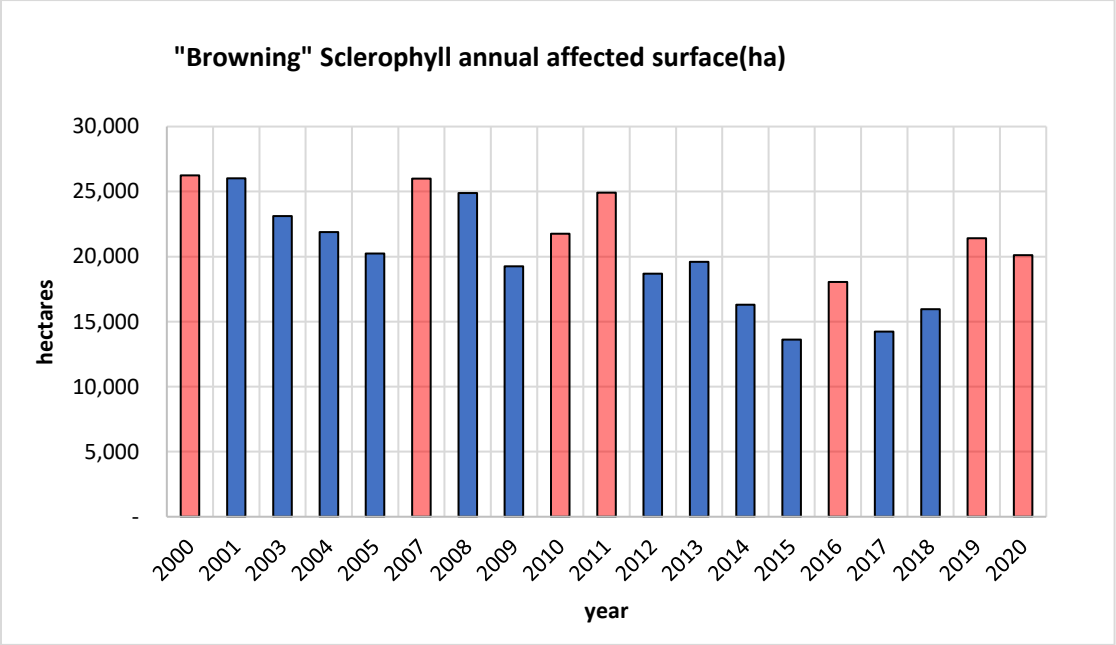


Figure 13 Annual yellowing evolution in Sclerophyll forests of the Maule region.

As demonstrated on a preliminary basis, there is evidence of a browning effect on sclerophyll forests, exacerbated by the mega drought. Nevertheless, more information is required for this to be determined. This requires more in – depth studies in order to determine the magnitude of these effects on the various forest types or some species, at different latitudes where the impacts of the effects of mega drought are also different.

To be able to specify the impact, it is required to expand the time period being evaluated including a period before the year 2000 which would allow to analyze spectral responses of forests in scenarios with no drought events, therefore knowing how plant formations respond to a lower water availability.

Literature also indicates that, along with the decline in rainfall and temperature increase, slope exposure could be an important factor in the loss of vegetation vigor, so it would be another variable worth evaluating. Definitely, once impacts have been detected on a preliminary basis, it is necessary to spatialize their occurrence in native forests, determining their effect in terms of captures and emissions.

In 2022 the GAC consulting develops a methodology to determine the effect of the megadrought in the forest remaining forest. The Chilean experts (GAC-UC) identified areas, by forest type, where vegetation anomalies in the primary productivity variable were frequent between 2001 and 2021. These areas under the impact of the megadrought are the areas affected by browning and correspond to those areas of forest that remain as forests that present phenological anomalies. So, in this study, browning was understood as an abrupt drop in the productivity of trees whose consequences translate into decreased growth or in? mortality. The study area was the accountability forestland remaining forestland (FRF) area of the ERP.

7.2 Quantification of Reversals during the Reporting Period

Not applicable, as it corresponds to the first 2018-2019 period, so there have been no previous transfers to the Carbon Fund.

A.	**ER Program Reference level for this Reporting Period (tCO_2-e)**	*from section 5*		
B.	**ER Program Reference level for all previous Reporting Periods in the ERPA (tCO2-e).**	*from previous ER Monitoring Reports*		+
C.	**Cumulative Reference Level Emissions for all Reporting Periods [A + B]**			
D.	**Estimation of emissions by sources and removals by sinks for this Reporting Period (tCO_2-e)**	*from section 4.2*		
E.	**Estimation of emissions by sources and removals by sinks for all previous Reporting Periods in the ERPA (tCO_2-e)**	*from previous ER Monitoring Reports*		
F.	**Cumulative emissions by sources and removals by sinks including the current reporting period (as an aggregate accumulated since beginning of the ERPA) [D + E]**			–
G.	**Cumulative quantity of Total ERs estimated including the current reporting period (as an aggregate of ERs accumulated since beginning of the ERPA) [C – F]**			
H.	**Cumulative quantity of Total ERs estimated for prior reporting periods (as an aggregate of ERs accumulated since beginning of the ERPA)**	*from previous ER Monitoring Reports*		–
I.	**[G – H], negative number indicates Reversals**			
If I. above is negative and reversals have occurred complete the following:				
J.	**Amount of ERs that have been previously transferred to the Carbon Fund, as Contract ERs and Additional ERs**			
H.	**Quantity of Buffer ERs to be canceled from the Reversal Buffer account [J / H × (H – G)]**			

7.3 Reversal risk assessment

Risk Factor	Risk indicators	Default Reversal Risk Set-Aside Percentage	Discount	Resulting reversal risk set-aside percentage
Default risk	*Minimum quantity set in the ERPD*	**10%**	*N/A*	*10%*
Lack of broad and sustained stakeholder support	This risk was defined as Medium in the ERPD, considering that there are land tenure conflicts in Chile, uncertainty in the appropriation of benefit rights, and risks of an inappropriate inclusion of the different actors in the ER Program. In the period of this report, there has been progress in the country in improving these aspects, however, there are still relevant gaps that keep the risk level at medium. The main indicators of progress are: ● Existence of a participatory and inclusion processes in the ER Program formulation and their implementation, focused on small owners and indigenous communities. ● Permanent operation of platforms for channeling citizen demands, such as the GRM. ● Maintain validation and communication channels with formal participation instances in CONAF and MINAGRI, e.g. COSOC of CONAF. ● Adequate functioning and representativeness of Regional REDD+ Groups. ● Efficient and transparent BSP operation. ● Operation of the Safeguard Information System and other monitoring instances. ● Dissemination of the ER Program integrated into CONAF institutional management at the national and regional level (Forest dissemination and extension programs)	**10%**	**Medium risk, 5% deducted**	**5%**
Lack of institutional capacities and/or ineffective vertical/cross sectorial coordination	This risk was defined as Low in the ERPD, considering the knowledge and skills gaps existing in the institutions involved and the lack of coordination between them. In the period covered by this report, Chile has taken measures to ensure an ever-greater articulation and strengthening of government institutions involved in the issue of climate change with the ER Program and the ENCCRV, with formal entities such as the Intraministerial Technical Committee of Climate Change (CTICC, acronym in Spanish). These advances keep the risk level low. The main indicators of progress are:	**10%**	**Low risk, 10% deducted**	**0%**

	● Reinforcement of the CONAF institutional capabilities (DCCSE, other departments and regional offices) for ER Program management. ● Improvement of the institutional conditions, management, and logistics to the proper working of REDD+ Regional Groups. ● Signing of required agreements among land-use sector's institutions for an adequate implementation of the Program in the AC. ● Ensure integration and coordination of both CONAF extension programs and MINAGRI promotion instruments in the ER Program regions. ● Maintain and expand the participation – when needed - of other institutional coordination instances linked to climate change and land management at the regional level (e.g. Intra-ministry Technical Committee on Climate Change, CTICC). ● Ensure additional funding required for the institutional operation of the ER Program.			
Lack of long term effectiveness in addressing underlying drivers	This risk was defined as Medium in the ERPD, considering the deficiencies and limited scope of forest laws and their promotion instruments, which did not adequately address the causes and agents of deforestation and degradation. Risks of ineffectiveness in governance and the lack of continued funding to implement the ENCCRV action measures were also considered. In the period of this report, there has been progress in the country in improving these aspects, however, there are still relevant gaps that keep the risk level at medium. The main indicators of progress are: ● Institutional commitment to address both ENCCRV and PRE implementation. Approval of the ENCCRV by the Council of Ministers for Sustainability, submitting the ENCCRV at the UNFCCC. ● Integration of ENCCRV into the environmental and climate policies of Chile for REDD+ compliance. Climate Change Adaptation Plan in the Agroforestry Sector, National Climate Change Action Plan 2017-2022, NDC of Chile (2020 update). ● Funding for ENCCRV and ER Program institutional management at the national and regional level, along with leveraging of additional funds for their implementation in the territory (UN-REDD, GCF). ● Search for new long-term funding schemes .	**5%**	**Medium – low risk, 2% deducted**	**3%**

	● Alignment of ENCCRV and ER Program action measures with actions defined under national forest legislation (Law 20,283 and Decree 259)			
Exposure and vulnerability to natural disturbances	This risk was defined as Medium in the ERPD, considering that although there is a permanent risk of earthquakes, volcanic eruptions and droughts in the AA, most of these disasters do not cause extensive damage to the forests and their temporary recurrence it is low. .As evidenced in 7.1, droughts increased their recurrence in the AA, so the level of this risk should increase to a high risk. On the other hand, forest fires cause a lot of impact, degradation and emissions, but in Chile these events are classified as 100% of anthropogenic origin, therefore, they are not considered natural disturbances. It is then considered that this factor should increase its risk to a high level, in the period of this report. The main indicators of progress are: ● High risk of natural disasters, as the state and capture and store carbon capability of the AA native forest, may be affected directly. (Mega droughts, volcanic eruptions). Although forest fires cause a greater degradation, they are classified as 100% anthropogenic. Nevertheless, due to the effects of climate change (temperature increase, precipitation decline), forest fires could increase in the future. This would amplify the negative effects of mega droughts in the northern CA regions. ● Increase and refocus programs to reduce the occurrence, magnitude and intensity of forest fires and strengthen institutional capabilities to conserving and restoring the native forests most vulnerable to droughts.	**5%**	**High risk, 0% deducted**	**5%**
		Total reversal risk set-aside percentage		**23%**
		Total reversal risk set-aside percentage from ER-PD or previous monitoring report (whichever is more recent)		**23%**

In accordance with the indications for evaluating the risk of reversals established in the Buffer Guidelines[23], the total risk of reversals calculated for Chile is 23%. However, during September and October 2023, through discussions held with the Carbon Fund donors where Chile presented an adjustment to the emissions accounting methodology, it was proposed to apply the maximum risk of possible reversals established in the Buffer Guideline.

In this way, applying a completely conservative criterion and given the methodological adjustment in which the occurrence of non-anthropogenic disturbances is assessed, it was decided to apply 40% as the total risk of reversals.

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https://www.forestcarbonpartnership.org/system/files/documents/fcpf_buffer_guidelines_may_2022_version_3.1.pdf

8 EMISSION REDUCTIONS AVAILABLE FOR TRANSFER TO THE CARBON FUND

No emission reductions have been generated to be transferred to the Carbon Fund in the 2018 – 2019 monitoring period. As indicated in Chapter 4, Chile increased its emissions by -5,353,046 ton CO2eq for the two years monitored during this period, in not browning affected areas.

Among the REDD+ activities being reported, forest degradation reaches above 38 million tonnes of CO2eq during the period, representing a significant increase regarding the reference period. Deforestation is reduced by around 6% regarding the baseline.

A.	**Emission Reductions during the Reporting period (tCO_2-e)**	from section 4.3	-5,353,046
B.	**If applicable, number of Emission Reductions from reducing forest degradation that have been estimated using proxy-based estimation approaches (use zero if not applicable)**		0
C.	**Number of Emission Reductions estimated using measurement approaches (A-B)**		-5,353,046
D.	**Percentage of ERs (A) for which the ability to transfer Title to ERs is clear or uncontested**	from section 6.1	100%
E.	**ERs sold, assigned, or otherwise used by any other entity for sale, public relations, compliance or any other purpose including ERs accounted separately under other GHG accounting schemes or ERs that have been set-aside to meet Reversal management requirements under the GHG accounting schemes**	From section 6.4	0
F.	**Total ERs (B+C)*D-E**		-5,353,046
G.	**Conservativeness Factor to reflect the level of uncertainty from non-proxy based approaches associated with the estimation of ERs during the Crediting period**	from section 5.2	15%
H.	**Quantity of ERs to be allocated to the Uncertainty Reversal Buffer (0.15*B/A*F) +(G*C/A*F)**		0
I.	**Total reversal risk set-aside percentage applied to the ER program**	From section 7.3	40%
J.	**Quantity of ERs to allocated to the Reversal Buffer (F-H)*(I-5%)**		0
K.	**Quantity of ERs to allocated to the Pooled Reversal Buffer (F-H)*5%**		0
L.	**Number of FCPF ERs (F-H-J-K).**		-5,353,046

ANNEX 1: INFORMATION ON THE IMPLEMENTATION OF THE SAFEGUARDS PLANS

ANNEX 2: INFORMATION ON THE IMPLEMENTATION OF THE BENEFIT-SHARING PLAN

ANNEX 3: INFORMATION ON THE GENERATION AND/OR ENHANCEMENT OF PRIORITY NON-CARBON BENEFITS

ANNEX 4: CARBON ACCOUNTING – ADDENDUM TO THE ERPD

Technical corrections

The technical corrections detailed in this Annex have been applied in the FCPF framework, therefore, this reference level has differences regarding the FREL/FRL valid before the UNFCCC. Nevertheless, the national monitoring system has planned for the consignment of updated reference levels before the Convention, considering these technical corrections as a base and expanding the regions containing forests in Chile. In this way, Chile will present a new FREL/FRL in 2023 whose validation process is expected to finish in the second semester.

On March 24, 2020, the FCPF was informed, by means of Official Letter No. 119/2020 about the application of technical improvements to the National Forest Monitoring System of Chile, in order to guarantee consistency on the implementation of technical corrections to the methods and data used for establishing the reference level included in the Emission Reduction Program.
The technical corrections implemented are considered in paragraph 3 of the Guidelines on the application of Methodological Framework No. 2 – Technical corrections. Corrections are specifically related to literal "a" replacement of emission factors, and literal "c" corrections to historical activity data. Also, new methodological findings and improvement opportunities were found during the correction application process.

The improvements mentioned in said letter were as such:

- Emission Factors Update (EF) an inconsistency in the value of Dead Organic Matter (DOM) used in the 1990 – 2010 GHG inventory was corrected. This correction ensures consistency with the 1990 – 2013 GHG inventory, which uses EFs from the first Forest Inventory cycle, where this issue has been fixed.
- Regional EFs replaced with EFs by Forest Type from forest inventory data; Activity Data (AD) must also be adjusted in order to have spatially explicit information by forest type.
- Improvements to EFs used in the estimation of degradation emissions, replacing EFs belonging to the model for one forest cover type (Roble-Raulí-Coihue, RORACO), with data modelled for at least eight additional forest cover types.
- Inclusion of spatially explicit activity data for the historical period used for FREL/FRL estimations (2001 – 2013), replacing the interpolation data being currently used.

Summary of technical corrections

As mentioned in the previous section, four points have been incorporated into and informed to the FCPF to be considered in the FREL/FRL update. Also, new improvement opportunities were detected as part of the complete reference level estimation process during the implementation process for said technical corrections. Among them, some parameters were updated to achieve more consistency with more recent GHG reports in Chile, and unintended errors identified during the process were also corrected.

- Emission Factors (EF) Update

An inconsistency in the value of the Dead Organic Matter (DOM) used in the 1990 – 2010 GHG inventory was detected after the FREL/FRL consignment. This correction was updated in the Chilean updated INGEI reports, also applying the corrected value to the reference line and ensuring consistency with the 1990 – 2018 GHG inventory.

DOM values are estimated from the Forest Inventory (IFN). Chile considered regional values in the FREL/FRL, but DOM estimated for the following forest types has been applied to make such values consistent with the EF update. DOM data are estimated for the forest types Alerce, Araucaria, Lenga, Coihue de Magallanes, Roble-Raulí-Coihue, Coihue-Raulí-Tepa, Esclerófilo, Siempreverde. The remaining forest types: Ciprés de las Guaitecas, Ciprés de la Cordillera and Roble-Hualo do not have any estimated data, so approximations based on other forest types have been applied for them.

- Regional EFs replaced with EFs by Forest Type from the national forest inventory data

The reference level applied regional values for emission factors; nevertheless, Chile has biomass content estimates (above and root) for most forest types in native forests, also having biomass estimates in secondary forests for some forest types. All forest types have information about periodic annual increments (PAI) in volume, used to estimate absorption in areas with carbon content increases.

- Improvements in EFs used in the estimation of degradation emissions

The reference level estimation considered the use of degradation thresholds belonging to the model of one forest cover type (RORACO) for estimating degradation. Chile has made progress in this area and today it has modelled data for the following forest types: Siempreverde with Canelo Forest subtype, Lenga, Roble-Hualo (RoHua), Coihué-Raulí-Tepa (CoRaTe), Coihue de Magallanes, Esclerófilo with Espinal forest subtype and Esclerófilo.
These degradation thresholds are represented through density management diagrams (DMD), which have been integrated and used for the development of a new CO2 stock and flux map, the main input for estimating degradation.

- Inclusion of spatially explicit data for the historic reference period

Emissions in the 2001 – 2013 reference period for land use changes and 2001 – 2010 for forest remaining forests were estimated through interpolated activity data, as Chile did not have land use map data for the initial and final years in all the regions of the accounting area. Other improvements have been incorporated into the process by implementing this correction, starting with the use of multi – pixel mosaics from Landsat images for the initial and final years (2001, 2010 and 2013), as the main input for the development of the previously mentioned maps. In this way, activity data for changes in land use and degradation estimation are calculated based on multipixels with specific dates for the relevant year. With the correction phase, it is possible consider that each reference period includes the entire initial and final years in its analysis, therefore 13- and 10-year values are used as the divisor in order to obtain annualized rates for activities generating changes in land use and activities that occur in forests that remain as such, respectively.

- Considerations on arborescent scrubs

The reference level consigned in 2016 considered that land uses classified as arborescent scrubs in the native forest cadastre may constitute forests in accordance with the definition of other wooded lands. As a legal definition of forest was established according to Law 20,283 starting in 2008, it was possible to apply this definition to the updates to the native forest cadastre. In this way, those surfaces classified as arborescent scrubs will not constitute forests in accordance with the legal definition. With this, arborescent scrubs are considered as such and therefore not counted in the native forest surface for reference level updates.

- Improvements in the degradation estimation algorithm

For the specific case of degradation estimations, improvements were made to the algorithm, specifically increasing the K value from 5 to 7 by implementing the nearest k – neighbors' model (k – NN).

- Improvements in the changes in land use detection method

For the development of spatially explicit activity data, it is worth mentioning the application of the Multi – Index Integrated Change Analysis (MIICA) methodology (Jin et al. 2013), which was already used for the development of the REDD+ Technical Result Annex submitted to the UNFCCC.

- Accuracy of reservoir identification per REDD+ activity

Inconsistencies in reservoirs estimated by REDD activity and those informed in the FREL/FRL were found during the reference line update process. For example, dead organic matter is estimated in the Deforestation, Substitution and Fire activities and not all activities as previously declared.

- Carbon fraction value adjustment

Carbon factor is corrected from 0.5 to 0.47 to be consistent with 2006 IPCC Guidelines.

- Integration process

The integration of results for emissions and captures for the current reference level of Chile was conducted through simple Excel spreadsheets separated by REDD+ activity. By implementing corrections, with the purpose of increasing the transparency and replicability of such results, these spreadsheets were updated to use semi – automated tools based on PostgreSQL, odbc and database type resources, which allow to handle larger quantities of information without impacting the performance of work system. In this way, it is possible to follow up on new calculations by integrating results from the reference level and monitoring periods into a single tool per REDD+ activity.

- Uncertainty estimation

On the other hand, uncertainty has been estimated through the Monte Carlo Method in order to comply with indicators 6.1, 7.1 and 7.2.

- Emissions estimation by forest degradation

The estimation of emissions and captures in forest remaining forest areas affected by mega drought and climate change has been identified appling a segregation of pixels where vegetation phenologic anomalies have been cuantified. A detailed study carries on by chilean experts teams identified areas by forest type where the vegetation anomalies were frequently between 2001 and 2021, defining anomalies threshold for exclusion areas. These areas of phenological anomalies were the basis for excluding non-anthropogenic emissions in the NREF.

The presentation of this reference level, updated together with the results of the estimations for the monitoring period, will be made publicly available on the ENCCRV website once the validation process has been completed. This, in order to favor the transparency of the process and disseminate the results of the NFMS.

Start Date of the Crediting Period

The proposed date to start the crediting period is January 1st, 2018. This date is after the date on which the first PRE activities began to be executed in 2016-2017. In addition, this date largely excludes the event of mega fires or firestorms that affected more than 580 thousand hectares, whose emissions of anthropic origin could not have been reduced by the PRE. On the other hand, the date is after January 1, 2016, it is not within the reference period either, and it meets the requirements for the application of safeguards, carbon accounting and avoiding double accounting.

7 CARBON POOLS, SOURCES AND SINKS

7.1 Description of Sources and Sinks selected

The reference level of Chile considers emissions from forest degradation and deforestation and captures or removals from stock enhancements in forest remaining forests and lands transformed from non – forest to forest, along with forest conservation activities. Captures and emissions from sustainable forest management activities are not estimated, as Chile does not have the spatial information needed to geographically separate these areas.

Sources/Sinks	Included?	Justification/Explanation
Emissions from deforestation	Yes	Emissions from deforestation are considered in Chile´s ER Program, although they are not the most significant source of emissions.
Emissions from forest degradation	Yes	Emissions from degradation in native forests that remain as such and emissions from native forests converted into exotic plantations are included. The emissions from exotic plantations as such,are not included in Chile´s ER Program (Cano and Sartori, 2015). Emissions from forest fires are also included in forest degradation, as those do not constitute changes in land use.
Absorptions from forest carbon stock enhancements	Yes	Absorptions from native forests that remain as such and other lands converted into forests are included, including restoration of forest plantations.
Emissions and absorptions from forest carbon stock conservation	Yes	All carbon stock emissions and absorptions are estimated in conservation areas, whether public or private, for this activity. Carbon fluxes in these areas are usually caused by forest grow, wood legal and illegal extraction, selective logging, firewood extraction, forest fires, overgrazing, natural regeneration or anthropogenic plantation/enrichment.
Emissions and absorptions from sustainable forest management	No	Sustainable forest management activities as defined by Cano and Sartori (2015) must include all carbon fluxes in native forests that are subject to the formal management process. Under these considerations, Cano and Sartori cite the three different CONAF approved and reviewed management plans: i) native forest management plan, ii) native forest organization management plan, and iii) forest management plan for small areas. CONAF currently has a system that reviews, approves and registers such plans called Forestry Administration and Control System (SAFF, acronym in Spanish) and while this system details the activities implemented in the various management plans (for example selective logging in the basal area, enrichment of plantations with exotic species, etc.) and provides the total areas on which these activities must be conducted, it does not locate them spatially within the Chilean territory. Since this area cannot be geographically separated, carbon fluxes generated by management actions will be within the degradation baseline or carbon stock enhancements in forests that remain as such, as long as efforts to geographically locate management plans are not implemented.
Non-anthropogenic emissions	Yes	Areas affected by browning effect is considered as a non-anthropogenic emission source because the carbon fluxes that occurs on these areas are not related to human activities as the deforestation activity. It is a non-anthropogenic source because it is generated by the decreases in precipitation falls, and water availability. Regarding the phenological anomalies analysis, the analysis carried out considered that the anomalies percentiles from 5 & 10 could be included in the source, but for conservative effects, just the forest remaining forest cover under the percentile 5 in included in the segregation areas proposal. They correspond to areas of native forest between the regions of Maule and La Araucanía, together with the area of the RORACO forest type extended to the region of Los Ríos.

To clarify, the areas affected by browning correspond to those areas of forest that remain as forests that present phenological anomalies because of the impact of the megadrought. These anomalies were detected in the integral productivity of native forest in the ERP implementation area and are under the 5th percentile data productivity anomaly. The phenological anomaly results in the desiccation of the crowns, loss of foliage and even the mortality of individuals. These areas are under the impact of the megadrought, so the emissions and removals that come from them have been segregated from the accounting system, to facilitate their monitoring.
However, the forest stratum affected by browning is not excluded from the ERP implementation and monitoring area, but its treatment is maintained continuously and at the same level of scope as those areas outside this stratum.

7.2 Description of carbon pools and greenhouse gases selected

Regarding carbon pools included for reference level estimations, technical corrections are applied with the purpose of defining which pools are considerations related to REDD+ activities and sub activities, aside from including below ground biomass reservoirs in activities taking place in forests that remain as such.
Above and below ground biomass is estimated for all REDD+ activities and sub activities, except degradation from forest fires where below ground biomass is not considered. Necromass or dead organic matter is included just for deforestation and degradation from substitution. It is not included in enhancement activities, as there is no information available regarding DOM accumulation rate in areas converted into forest lands. It is not included in forest remaining forest activities either, as in that case selective logging is applied and those deposits are not extracted.

As indicated in the ERPD, soil organic carbon is excluded based on the fact that land carbon stock largely depends on local conditions (climate, soil type and management factor related). As a result, the more general default values are not realistic. Besides, Chile does not have official geo – referenced information that allows to estimate the relationship between land and activities. In order to solidify this decision, an estimation of emissions caused by the deforestation of the previously mentioned reservoir was conducted using a Tier 1 based methodology, which determined emissions from this source to be 128,005 equivalent CO2 tons/year, on the 1,653,819 equivalent CO2 tons/year from living Biomass and DOM emissions from Deforestation, representing 7.7% of the total.

Considering that Chile is one of the countries participating in the Carbon Fund, the exclusion of this group is additionally justified regarding compliance with Criterion 4, indicator 4.1.i of the FCPF Methodological Framework. In addition, this decision is explained by indicator 4.2.ii “The excluded reservoir underestimates emission reductions”. The following tables, explain the carbon pools and GHG selection, and a summary considering REDD+ activities reported by the country.

Carbon Pools	Selected?	Justification/Explanation
Above and below ground biomass	Yes	Above and below ground biomass is included in all REDD+ activities (Except for emissions associated to forest fires, which do not consider below ground biomass) in the Chilean ER Program.
Dead Organic Matter	Yes	Included in deforestation and degradation from substitution and fires. Not included in conservation or enhancement of forest carbon stocks, as the DOM accumulation rate in forest converted lands is unknown. It is included neither in degradation and enhancement estimations in forest remaining forests, nor forest conservation.
Soil organic carbon	No	Specifically, the decision to exclude this sink is based on the values being largely dependent on local conditions (climate, land type and management factor related). Default values are not realistic as a result. On the other hand, Chile does not have geo – referenced official information that allows a relationship between lands and activities.

GHG	Selected?	Justification/Explanation
CO_2	Yes	CO_2 is accounted in all REDD+ activities included in the Chilean ER Program.
CH_4	Yes	Methane gas is released from the burning of organic matter. Therefore, CH_4 emissions from forest fires are accounted in degradation.
N_2O	Yes	Nitrous oxide is released from the burning of organic matter. Therefore, N_2O emissions from forest fires are accounted in degradation.

REDD+ Activity	Sub-activity	Tier	Carbon Pools	GHG
Deforestation	N/A	3	Above ground biomass	CO_2
		2	Below ground biomass	
		3	Dead Organic Matter	
Forest Degradation	Forest remaining forest Degradation	3	Above ground biomass	CO_2
		2	Below ground biomass	
	Substitution	3	Above ground biomass	CO_2
		2	Below ground biomass	
		3	Dead Organic Matter	
	Forest Fires	3	Above ground biomass	CH_4 - N_2O
		3	Dead Organic Matter	
Carbon Stock Conservation	N/A	3	Above ground biomass	CO_2
Stock Enhancement	Degraded Forest Restoration	3	Above ground biomass	
		2	Below ground biomass	
	Restoration	3	Above ground biomass	
		2	Below ground biomass	

8 REFERENCE LEVEL

The FREL/FRL of Chile describes absorptions and emissions generated in Temperate Native Forests during the reference period for the Deforestation, Degradation, Forest Conservation and Carbon Stock Enhancement activities based on the concepts shown in Figure 34 which are described below.

For this update, according to the guidelines established by the FCPF, REDD+ activities and sub activities along with their definitions adopted by Chile, the reference period and definition are maintained. An important change though is the consideration on arborescent scrubs, which may be separated as since 2008 Law 20,283 establishes a legal concept for the definition of forests, which is applied to native forest Cadastre updates since then. In this way, the arborescent scrub land use type, which was originally considered native forest, can be separated.

As explained before the NFMS does not consider the estimation of emissions or captures from Forest Sustainable Management activities and therefore FREL/FRL has not been calculated, as official data that allow for the spatial delimitation of the surface subject to this condition is not yet available as of today. On the other hand, and if the information were to be available, incorporating a new REDD+ activity to accounting is not a correction allowed by the Carbon Fund.

8.1 Reference Period

The reference period used for the estimation of the national FREL/FRL of Chile was determined by the availability of the information needed for its development, along with the various methodologies applied for estimating emissions and absorptions from various activities and sub - activities. As indicated, the update reference period is the same applied in the ERPD development.

Considering the circumstances established in the previous paragraph, two differentiated reference periods are established, one for activities or sub activities related to changes in land uses or sub – uses and another for activities or sub activities taking place in forest remaining forests.

i. Changes in land use or sub use

Activities and sub activities related to changes in land use or sub use include:

- Deforestation: Native forest transformed into non – forest, other land uses.
- Substitution: Native forest transformed into forest plantation, corresponding to Degradation activities.
- Carbon stock enhancements due to forest converted into other land uses: other land uses transformed into native forest lands, corresponding to carbon stock enhancement activities. Includes the restoration, conversion of lands forested with exotic plantations into forest lands with native forest.

The Cadastre and Evaluation of Vegetation Resources of Chile, which is updated at different times for each region, was the source of activity data for activities and sub activities related to changes in land use or sub use. Said input has a more recent coverage, dated 2013, for most regions and coverages for different years in previous periods, so interpolations were made in the original NR version in order to adjust all regions to a historic period between 2001 and 2013. Forest cover change maps have been developed to update the reference level in the selected periods, which avoids the use of any extrapolation or interpolation technique.

ii. Forest remaining forest

The activities and sub activities that occur in forest remaining forests are:

- Degradation in forest remaining forests: emissions in forests that remain as such, caused by degradation including forest fires, wood and non – timber product extraction, and others.
- Carbon stock enhancements from degraded forest restorations: enhancement in carbon stock from degraded forest restoration corresponds to forest carbon stock enhancement activities.
- Forest conservation: net emission flux in forest remaining forests including degradation and absorptions from the restoration of degraded forests, in formal conservation areas.

The methodology generates carbon content maps for the years with ground measurements from the Continuous Forest Inventory. Registered plots are extrapolated to the entire forest remaining forest using the K – nn method. The first measurement cycle of the Continuous Forest Inventory corresponds to the 2001 – 2010, with measurements for the years mentioned. Extrapolation was applied to satellite images corresponding to those years, therefore the reference period for these activities and sub activities is that of 2001 – 2010.

8.2 Forest definition used in the construction of the Reference Level

Law 20,283 on restoration of Native Forests and Forestry Development defines **Forests** as "*Site inhabited by plant formations dominated by trees and which occupies a surface of at least 5.000 square meters with a minimum width of 40 meters, treetop cover above 10% of said total surface in arid and semi-arid conditions, and 25% in more favorable conditions*".

Law 20,283 also establishes a definition of **Native Forests**: *"Forest formed by native species of natural generation, natural regeneration, or plantation under canopy with the same species existing in the original distribution area, with accidental presence of randomly distributed exotic species*".

Law 20,283 does not establish any definition for Forest Plantations. According to FAO (2015)[24] **Forest Plantations or Planted Forests are**: "*Forests mainly comprised of trees established by deliberate plantation and/or seeding"*, taking into account that: "*1) For the most part, means planted or seeded trees are expected to constitute over 50% of mass in mature stage; 2) Includes regrowth of originally planted or seeded trees; 3) Includes rubber, cork oak and Christmas tree plantations 4) Excludes trees of naturally regenerated introduced species*". In the same document, FAO describes **Exotic Forest Plantations as**, "*Forest Plantations comprised of more than 50% exotic species in its adult development stage"*.

The combination of these definitions would be able to fully cover the national reality including Native Forests and Plantations, containing a subcategory for Exotic Species Forest Plantations and Native Species Forest Plantations. Currently, practically all Forest Plantations in Chile are single – species plantations with exotic species and a logging – productive objective, with little representation in number and sizes of Native Forest Plantations[25]. One of the few recorded instances of forest plantations with native species are the Tamarugo forest plantations, located in the Tarapacá and Antofagasta regions[26].

In this regard, this document will consider, in a practical manner and based on available data up to date (Historic reference), the total Forest Plantations recorded up to the last Cadastre update as a uniform set, as single – species plantations with exotic species and a logging – productive objective represent practically the entire national reality.

Nevertheless, this stratification is recorded to unequivocally identify it in subsequent monitoring milestones, in terms of contributions to carbon capture with their respective spatial representation, in the face of future interventions based on potential ENCCRV strategic options. According to this, the significant increase and establishment of the surface and number of Native Forest Plantations, along with those with objectives and processes aimed towards Climate Change mitigation and adaptation, fighting against desertification, and preserving

[24] http://www.conaf.cl/cms/editorweb/transparencia/potestades/Ley-20283_bn.pdf
http://www.fao.org/docrep/017/ap862e/ap862e00.pdf

[25] According to the Continuous Inventory by INFOR (2014) 2.7% of plantations correspond to other species, where both exotic and native species are included. Source: INFOR
http://mapaforestal.infor.cl/phocadownload/Informe_Inventario_Continuo_2014.pdf

[26] The Continuous Forest Inventory of INFOR does not collect information of the regions to the north of the Coquimbo Region, also, due to the differences in methodologies and the frequency of information, there are variations between data from this source and data from the Cadastre. This information comes from the monitoring and update of the 2015 Cadastre in the Antofagasta Region. Source: CONAF.

Biological Diversity could be included, even more so as it is one of goals stated by Chile in its Nationally Determined Contribution (NDC) regarding the afforestation of 200,000 hectares, which will be mainly carried out with native species.

All lands defined as Native Forest by the current Chilean legislation will be considered as forests under the context of REDD+, which governs the estimation of the Reference Level:

Comments:

1. Those lands defined as Native Forest or Mixed Forest by the Cadastre will be considered as forest under the operability concept of this document.
2. In line with the environmental goals the ENCCRV seeks to promote, the reference level will not consider carbon fluxes generated in areas considered by the Cadastre as Forest Plantations, which are associated to planted forests of exotic species with an industrial logging objective, in its accounting.
3. To comply with the concept of completeness, carbon fluxes in forest plantations will continue to be reported in the INGEI. New forest plantations will be included in future estimates, in the event that such plantations are meant for preserving permanent cover and consistent with the objectives established in the NDC.

The definition applied in the FREL/FRL of Chile´s Native Forest varies regarding the definition applied in INGEI for Forest Lands which integrate both Native Forests and Forest Plantation, which based on the previously redacted description was taken into consideration to comply with the REDD+ safeguards agreed in the Cancun CoP 16[27], described in Annex I, specifically points 2.e[28] and 2.a[29].

In this regard, it is fundamental to follow the ENCCRV objective, which seeks to support the restoration and protection of Native Forests and xerophytic formations, along with enhancing the appearance of plant formations in lands likely to be planted as mitigation and adaptation measures against the effects of climate change, and the fight against desertification. This is expected to be achieved through the design and implementation of a state mechanism that facilitates the access of communities and forest owners, xerophytic formations and lands likely to be planted, to the benefits associated to the environmental services of these ecosystem, also complying with the international commitments entered into by Chile regarding climate change and fighting against desertification.

In this way, and as can be concluded from the "ENCCRV Participation and Formulation Workshops" [30], there is a general approach among the various stakeholders in the territory towards promotion and development to increase the sustainably managed native forest surface, along with surfaces covered by this resource over industrial exotic plantations, as the latter are assumed to be overseen by companies that obtain profits on their own.

8.3 Average annual historical emissions over the Reference Period

Description of method used for calculating the average annual historical emissions over the Reference Period

The reference level of Chile was calculated through the estimation of the historic average for the reference periods indicated in the previous section. It refers to the absorption and emission average for the 10 or 13-year period, which allows to average intertemporal variability and assess the achievement of REDD+ measures relative to this historic period.

[27] http://unfccc.int/resource/docs/2010/cop16/spa/07a01s.pdf

[28] "The compatibility of measures with the conservation of natural forests and biological diversity, ensuring that the measures indicated in paragraph 70 of this decision are not used for the conversion of natural forests, but rather to incentivize the protection and conservation of said forests and services derived from those ecosystems, to foster other environmental and social benefits."

[29] "The complementarity or compatibility of these measures with the objectives of national forest programs, along with international conventions and agreements on the matter"

[30] http://www.conaf.cl/cms/editorweb/ENCCRV/PLAN-SALVAGUARDAS-ENCCRV.pdf

The estimation of the historic mean has been executed based on the guidelines provided by the Intergovernmental Panel on Climate Change IPCC of 2006, where the equations indicated below have been taken from, along with default values for some parameters without specific data at the national level.

IPCC Guidelines for GHG inventories present different approaches and levels for representing various degrees of complexity used in the methodology. REDD+ activities included in FREL use information derived from a IPCC Approach 3, that is, geographically explicit data. Degrees used are often a mix of 2 and 3, since the necessary information that allows to meet specific Level 3 requirements is not available.

According to the activity and sub activity structure, FREL/FRL has been constructed and developed from two different methodologies, one for activities that imply a change in land use or sub use, where the gains and losses method is applied, and another for activities that occur in forest remaining forests, where the stock change method is applied. This configuration remains just as the one described in the ERPD.

i. Activities and sub activities related to changes in land use or sub use

- Deforestation

The methodology for calculating the deforestation FREL of Chile is based on the equations from IPCC 2006[31] for forest lands converted into other lands, which are also used in the INGEI for calculating emissions in forests converted to other land uses. Reservoirs of above ground biomass, below ground biomass and DOM are included. The following equation is used to calculate FREL in tonnes of equivalent CO_2:

$$FREL_{Def} = \frac{\sum_t^n \Delta C_{B_{t,Def}}}{p} * \frac{44}{12}$$

Equation 20 Deforestation reference level

Where:

$FREL_{Def}$ = average annual carbon stock losses in forest lands converted into non – forests during the reference period, in tonnes CO_2e $year^{-1}$.
$\Delta C_{B_{t,Def}}$ = changes in carbon stock for forest lands converted into non – forests during year t of the reference period, in tonnes C. Reservoirs included are mentioned below.
p = years of the reference period.
$\frac{44}{12}$ = factor to convert carbon into equivalent carbon dioxide, ton CO_2e ton C^{-1}.

IPCC methodology Tier 3 is used in estimations of emissions from deforestation, as carbon stocks in land use pre and post conversion are specific to Chile, with conversion areas broken down by cover type of the original land (Sidman et al., 2015).

As recommended in IPCC (2006), Equation 2.15 is used to calculate annual changes of carbon stocks in wooded lands converted to other land use categories (In the case of deforestation, any forest area converted into non – forest):

[31] Intergovernmental Panel on Climate Change (IPCC) (2006). Guidelines for National Greenhouse Gas Inventories, Volume 4: Agriculture, Forestry and Other Land Use

$$\Delta C_{B_{t,Def}} = \Delta C_{G_t} + \Delta C_{CONVERSION_t} - \Delta C_{L_t}$$

Equation 21 (Ec. 2.15 IPCC, 2006)

Where:

$\Delta C_{B_{t,Def}}$ = annual changes to carbon stocks in forest lands converted into non – forest in year *t* under deforestation (Def) activities, in ton C.
ΔC_{G_t} = annual increases in carbon stocks due to growth in forest lands converted to non – forest in year t, ton C.
$\Delta C_{CONVERSION_t}$ = initial change in carbon stocks in biomass of forest lands converted to non – forest in year t, ton C.
ΔC_{L_t} **=** annual carbon stock losses in biomass due to firewood extraction, wood harvesting and other disturbances in forest areas converted into non – forest in year t, ton C.

In this equation, changes in carbon stocks from gains and losses due to any activity other than conversion (ΔCG and ΔCL) are added to net gains or losses directly caused by conversion (ΔCCONVERSION; in the case of deforestation, generally results in a negative value due to forest carbon stock losses) in order to calculate total changes in carbon stocks.

ΔCG is included for the deforestation FREL of Chile, representing carbon captures in non-forest uses after conversion (agricultural, urban, others). This variable will be given a value of zero, as it has no influence on the analysis of losses caused by deforestation.

Equation 22 (Equation 2.16 of IPCC, 2006) calculates parameter ΔCONVERSION for it to be included in Equation 21:

$$\Delta C_{CONVERSION_t} = \sum_i \left\{ \left(B_{AFTER_i} - B_{BEFORE_i} \right) * \Delta \mathrm{A}_{\mathrm{TO}_{\mathrm{OTHERS}_{i,t}}} \right\} * CF$$

Equation 22 (Ec. 2.16 IPCC, 2006)

Where:

$\Delta C_{CONVERSION}$ = initial change in biomass carbon stocks in forest lands converted into non - forest, in ton C year^{-1}.
B_{AFTER_i} = biomass stock per non – forest land use type *i* after conversion, in tons of dry biomass per hectare.
B_{BEFORE_i} = biomass stock per forest land use before conversion, in tons of dry biomass per hectare.
$\Delta A_{TO_{OTHERS_{i,t}}}$ **=** *i* forest type area converted into non – forest in year t, in ha.
CF = carbon fraction in dry biomass, in tonnes of carbon per tonnes of dry biomass.

In the case of deforestation, these equations can be represented with two essential inputs, forest area converted into other uses ($\Delta A_{T0_OTHERSi}$), frequently called activity data (AD), and the amount of carbon stocks issued due to conversion (B_{AFTERi} - $B_{BEFOREi}$), frequently called emission factors (EF). Parameters B_{AFTERi} y $B_{BEFOREi}$ only include above and below ground biomass, so DOM is included by adding parameter ΔC_{DOM} calculated according to Equation 23:

$$\Delta C_{DOM_t} = \frac{(C_n - C_o) * A_{on_t}}{T_{on}}$$

Equation 23 (Ec. 2.23 IPCC, 2006)

Where:

ΔC_{DOM_t} = changes in carbon stocks in DOM for year t, ton C.

C_n = carbon stocks in forest DOM and dead wood in non – forest land use after conversion, ton C year^{-1}.
C_o = carbon stocks in forest DOM and dead wood before conversion into non – forest, ton C year^{-1}.
A_{on_t} = forest area converted into non – forest in year t, hectares.
T_{on} = period of time for the forest into non – forest transition.

In this equation, Aon corresponds to activity data or $\Delta A_{TOOTHERSi,t}$, according to the parameter in equation 3 described above. In order to simplify accounting, DOM emissions will be accounted in the year of conversion (where Ton is assumed to have a value of 1).

- Degradation from substitution

The equation used for estimating deforestation is used to estimate degradation of native forests converted into plantation, as it is assumed that the entire carbon content in the preceding native forest must be reduced to zero to establish a plantation. Equation 1 is used to calculate FREL in equivalent CO2.

- Forest Surface Enhancement and Restoration

As in other activities, FREL methodology for enhancements in other lands converted into forests is consistent with the methodology used in INGEI, which is based on equations 2.9, 2.10, and 2.15 of the IPCC (2006).

The general equation corresponding to Tier 2 and 3 is 2.15 of IPCC (2006), used to calculate annual changes of biomass stocks in above and below ground biomass (The only reservoirs included in enhancement estimations) and lands converted into other land uses (In this case, from non – forest to forest):

$$\Delta C_{B_{t,ANFF}} = \Delta C_{G_t} + \Delta C_{CONVERSION_t} - \Delta C_{L_t}$$

Equation 24 (Ec. 2.15, IPCC 2006)

Where:

$\Delta C_{B_{t,ANFF}}$ = changes in carbon stocks in year t, from non – forest lands converted into forests during the reference period, under the stock enhancement activity (A), in ton C.
ΔC_{G_t} = carbon stock increase due to growth of non – forest lands converted into forest in year t, in ton C.
$\Delta C_{CONVERSION_t}$= initial change in carbon stock in non – forest lands converted into forest in year t, in ton C.
ΔC_{L_t} = annual decrease in carbon stocks due to wood harvesting, firewood extraction and disruptions in non – forest lands converted into forest in year t, ton C.

In the FREL for enhancements, ΔCL assumed to be zero, due to the lack of sufficient data to quantify losses in non – forest areas converted into forests. Equation 2.16 of IPCC (2006) is used for parameter ΔCONVERSION:

$$\Delta C_{CONVERSION_t} = \sum_i \left\{ \left(B_{AFTER_i} - B_{BEFORE_i} \right) * \Delta A_{\mathrm{TO_{OTHERS}}_{i,t}} \right\} * CF$$

Equation 25 (Ec. 2.16 (IPCC 2006)

Where:

$\Delta C_{CONVERSION_t}$ = initial carbon changes in non – forest lands converted into forest in year t, ton C
B_{AFTER_i} = biomass stocks in forest type i immediately after conversion, ton m.s ha^{-1}
B_{BEFORE_i}= biomass stocks in land type i before conversion, ton d.m. ha^{-1}

$\Delta A_{TO_{OTHERS_{i,t}}}$= use surface in non – forest land converted into forest in year t, ha
CF = carbon fraction in dry matter, ton C (ton m.s.)$^{-1}$

For parameter ΔCG (increase due to forest growth), INGEI uses IPCC 2006 Equation 2.9 in a Tier 2 – 3 calculation. Nevertheless, INGEI only uses it for forest – converted lands in the conversion year. In the FREL for enhancements, converted areas are accounted for the entire period, in this way enhancements continue to accumulate accounted under the stock enhancement activity and do not move to the category of forests that remain as such in INGEI.

IPCC (2006) Equation 2.9 calculates annual carbon increases. But Equation 26 does not consider captures that continue to accumulate in strata "i" converted for previous years. So equation 2.9 of IPCC (2006) must be modified in the following way to achieve a correct accounting:

$$\Delta C_{G_t} = \sum_i \sum_x \left(A_{i,x} * G_{TOTAL_i} * CF\right)$$

Equation 26 (Adapted from Equation 2.9 IPCC, 2006)

Where:

$\Delta C_{G\ i,t}$= increase in carbon stocks for year *t*, due to growth in non – forest lands converted into *i* forest type during the reference period, in ton C.
$A_{i,x}$= Area converted into forest *i* for year *k* of the reference period, ha.
G_{TOTAL_i}= annual biomass growth average in non – forest lands converted into forest type *i*, ton d. m. ha^{-1} year^{-1}.
CF = carbon fraction in dry matter, ton C (ton d.m.)$^{-1}$.

Equation 26 considers that in order to calculate Δ_{CGi}, *t* in year *t*, it is necessary to add captures from areas converted in each year x before year t of the reference period, along with captures from areas converted in year t. In the event that a forest reaches adulthood and finishes capturing CO2 from the atmosphere, it should be removed from enhancement accounting. Nevertheless, this is not supposed to occur during the reference period.

ii. Activities in forest remaining forest

- Degradation in Forest remaining forest

IPCC (2006) Equation 2.8 is used to estimate changes in carbon stocks for forest lands that remain as such due to degradation:

$$\Delta C_{B_{t,DegFF}} = \frac{(C_{t_2} - C_{t_1})}{(t_2 - t_1)}$$

Equation 27 ([IPCC 2006] Ec. 2.8)

Where:

$\Delta C_{B_{t,Deg}}$ = annual changes in carbon stocks for forest lands that remain as such, considering total area under degradation activity (*DegFF*), ton C.
C_{t_2}= total forest carbon in year t_2, ton C.
C_{t_1}= total forest carbon in year t_1, ton C.

For the accounting of the reference level described in Bahamondez *et al.* (2009)[32]. This methodology counts carbon stocks at different points in time, where differences in carbon stocks in forest lands are considered degradation in case of losses. On their part, INGEI uses a gain – loss method, Equation 2.7 of the IPCC (2006) instead of the stock difference method in equation 2.8 of IPCC 2006, where INFOR tabular data is integrated to estimate volume extracted through selective logging, INFOR and MINENERGIA firewood statistics, and CONAF tabular data for native forest and forest plantation fire surface area. According to national experts, data on firewood extraction isn´t very robust and representative of degradation in a comprehensive manner. The methodology used in FREL allows to reach Approach 3 outcomes, spatially explicit data, and is based on robust, independent sources of information.

IPCC equation 2.8 is used to calculate carbon stocks at the initial and final moments of the reference period (C1 and C2 in Equation 28):

$$C_t = A_{Deg} * EF * CF$$

Equation 28 (IPCC, 2006 Ec. 2.8)

Where:

$C_{t,i}$= total forest carbon in year t, ton C
A_{Deg}= degradation area in forest that remains as such, ha
EF= carbon stocks in forest that remains as such, biomass ton ha^{-1}
CF= carbon fraction, t carbon t biomass^{-1}

- Degraded Forest Restoration

The methodology described in the forest remaining forest degradation areas was used. IPCC (2006) equation 2.8 was used to calculate enhancements in annual stocks:

$$\Delta C_{B_{t,AFF}} = \frac{(C_{t_2} - C_{t_1})}{(t_2 - t_1)}$$

Equation 29 (Ec. 2.8, IPCC 2006)

Where:

$\Delta C_{B_{t,AFF}}$ = annual changes in carbon stocks in forest lands that remain as such, considering total area under stock enhancement activity (*DegFF*), ton C year^{-1}.
C_{t_2}= total forest carbon in year t_2, ton C.
C_{t_1}= total forest carbon in year t_1, ton C.

Carbon contents in t1 (2001) and t2 (2010) were obtained from the results of applying the methodology that allows the identification of areas that are below the threshold of line B at the start of the reference period.

- Forest Conservation

[32] Bahamóndez, C., Martin, M., Muller-Using, S., Rojas, Y., Vergara, G., 2009. Case Studies in Measuring and Assessing Forest Degradation: An Operational Approach to Forest Degradation. (Forest Resources Assessment Working Paper). Forestry Department, Food and Agriculture Organization of the United Nations

As explained in previous chapters, Reference Level for Forest Conservation is estimated by adding emissions from forest degradation in forest remaining forests and absorptions from restoration of degraded forests in forest areas under formal conservation processes.

$$\Delta C_{B_{t,ConFF}} = \Delta C_{B_{t,AFF}} - \Delta C_{B_{t,DegFF}}$$

Equation 30 (Ec. 2.8 IPCC, 2006)

Where:

$\Delta C_{B_{t,C}}$= annual changes in carbon stocks in forest lands subject to formal conservation processes in year *t*, ton C.
$\Delta C_{B_{t,AFF}}$= annual changes in carbon stocks due to recovery of degraded forests in areas subject to formal conservation processes, in ton C year^{-1}.
$\Delta C_{B_{t,DegFF}}$= annual changes in carbon stocks due to forest degradation in forest lands subject to formal conservation processes, in ton C year^{-1}.

- Non – CO2 emissions from Forest Fires

Bahamondez´ methodology estimates CO_2 emissions, so IPCC (2006) Equation 2.27 is used to calculate non – CO_2 emissions from forest fires:

$$L_{fire} = A * M_B * C_f * G_{ef} * 10^{-3}$$

Equation 31 (Ec. 2.27 IPCC, 2006)

Where:

L_{fire} = amount of greenhouse gas emissions caused by fire, ton of each GHG gas year^{-1}.
A = burnt surface, ha year^{-1}.
M_B= available fuel mass for combustion, ton ha^{-1}.
C_f= combustion factor, no magnitude.
G_{ef} = emission factor, g kg^{-1} of burnt dry matter.

Equation 32 is used to convert Lfire to CO_{2e} which is necessary for Equation 12:

$$GEI_{fire} = L_{fire} * CF$$

Equation 32

Where:

CF = non-CO_2 into CO_2e conversion factor, ton gas non-CO_2 ton CO_2e^{-1}.

Activity data and emission factors used for calculating the average annual historical emissions over the Reference Period

Activity data

The activity data presented below are available at:

https://drive.google.com/drive/folders/1AJn9zkAonOGkwrbPH531oIwPWkfzQxdN?usp=drive_link

a) Deforestation

Parameter:	$\Delta A_{TO_OTHERSi,t}$ = Areas of different Forest Types(i) converted to another category of land use during the 2001 – 2013 period.
Description:	Chile has eleven different Native Forest Types in the PRE area.
Data unit:	Total hectares (ha/year) of the 2001-2013 period.
Value monitored during this Monitoring / Reporting Period:	**Forest Type** / **Area** Alerce 119.3 Araucaria 337.3 Ciprés de la Cordillera 35.4 Ciprés de las Guaitecas 9.2 Coihue - Raulí - Tepa 653.3 Coihue de Magallanes 143.9 Esclerófilo 407.2 Lenga 2,519.3 Roble - Hualo 104.4 Roble - Raulí - Coihue 1,714.6 Siempreverde 1,873.9 Without Forest Type 144.6 **Total (ha)** 8,062.4
Source of data and description of measurement/calculation methods and procedures applied:	Matrices of change in land use taken from Land Use Change Maps. Multipixel mosaics are used for the detection of changes in land use, focused in polygons of native forest. From the mosaic, the MIICA method is applied for the identification of spectral gains and losses, which through different techniques of post-processing allow identifying areas of forest losses and gains. The application of method establishes a series of requirements for the tiles, related to the removal of clouds, cloud shadows and artifacts. In addition, the map of use and change of use is linked to the information that comes from the Native Forest Cadastres of CONAF, therefore, the map of Land Use Change is the result of the application of the MIICA method, and the Cadastre of Native Forest. The Land Use Change Map is presented as a product through a coverage geographical area called "Traceability", which has as a characteristic the monitoring periods available for a certain region, which allows giving monitoring of historical land uses for each polygon. The final product is regional, characterized by stunted, mature, young mature, mixed and young forests converted into areas with no vegetation, urban and industrial areas, waterbodies, areas where succulents, wetlands, scrubland, perennial snow and glaciers, grasslands and farmland have formed.
QA/QC procedures applied:	For the generation of deforestation activity data and as part of the QA / QC process, the different procedures implemented are documented in SOPs that allow the estimates to be standardized over time. SOP_01: Selection of REDD+ satellite mosaics SOP_02: Elaboration of LULUCF maps

Uncertainty for this parameter:	The uncertainty of land-use change maps is estimated by comparing the results of the land-use change category on the map and the reference observations corresponding to a sample of visually interpreted points. The errors related to land-use change are calculated following the Good Practice Guidelines for estimating the precision of change of use described in Olofsson et al. (2013). Error = Maule 111.3%, Ñuble 72.3%, Biobío 109.6%, Araucanía 191.6%, Los Ríos 96.6%, Los Lagos 89.1%
Any comment:	Link: https://drive.google.com/uc?export=download&id=1JxwUMTfyIiozhMcPsWmwrEEPwadfUsSh

b) Degradation – forest remaining forest

Parameter:	A_{DegFF} = Area of degradation of forests remaining forests monitored during 2001 - 2010 period, in areas not affected by browning (NBA).
Description:	We have 6 regions for the PRE area, Maule, Ñuble, Biobio, La Araucanía, Los Ríos and Los Lagos. The Biobio Region was divided in two Region. The province of Ñuble, which was part of Biobio Region, is a new Region. The surface of the total area remains equal. The surface area was described by degradation of native forest that remains as such.
Data unit:	Total hectares (ha/year) of the 2001-2010 period.
Value monitored during this Monitoring / Reporting Period:	**Region** / **Area** Maule 73,201 Ñuble 29,480 Biobío 50,825 La Araucanía 57,880 Los Ríos 29,709 Los Lagos 116,395 **Total** 357,490
Source of data and description of measurement/calculation methods and procedures applied:	The data comes from INFOR's National Forest Inventory (IFN) plots, combined with spectral information from the Landsat series. This information integrates the variables of the state of the forests on the number of trees per hectare, basal area and volumes recorded by the monitoring of IFN plots, with the spectral data from Landsat to estimate carbon stocks in a spatially explicit way.
QA/QC procedures applied:	Since one input for AD on degradation are the Land Use Change Maps in order to define areas of forest remaining forest, same QA/QC procedures and SOP are used during the process. Additional procedures are applied, and proper SOP were developed. SOP_05_ Method for estimating in forest remaining forests the carbon variation. SOP_06: Field Operations Manual
Uncertainty for this parameter:	Degradation mapping accuracy estimated by INFOR. Error: 32.8%
Any comment:	Link: https://drive.google.com/uc?export=download&id=1KXI4CfOKLRrtxPVXfqk5ejz2dV6Cda61

c) Degradation - Substitution activity

<table>
<tr><td>Parameter:</td><td>A_{DegNFF} = Surface of degradation areas resulting from the conversion of forests into plantations during the 2001-2013 period.</td></tr>
<tr><td>Description:</td><td>The total of areas by forest type that was degradation to plantation were registered</td></tr>
<tr><td>Data unit:</td><td>Total hectares (ha/year) of the period 2001-2013</td></tr>
<tr><td>Value monitored during this Monitoring / Reporting Period:</td><td>
<table>
<tr><th>Forest Type</th><th>Area</th></tr>
<tr><td>Alerce</td><td>0.6</td></tr>
<tr><td>Araucaria</td><td>8.1</td></tr>
<tr><td>Ciprés de la Cordillera</td><td>15.2</td></tr>
<tr><td>Ciprés de las Guaitecas</td><td>0.8</td></tr>
<tr><td>Coihue - Raulí - Tepa</td><td>335.3</td></tr>
<tr><td>Coihue de Magallanes</td><td>2.5</td></tr>
<tr><td>Esclerófilo</td><td>1,423.8</td></tr>
<tr><td>Lenga</td><td>186</td></tr>
<tr><td>Roble - Hualo</td><td>523.1</td></tr>
<tr><td>Roble - Raulí - Coihue</td><td>2,881.3</td></tr>
<tr><td>Siempreverde</td><td>1,376.2</td></tr>
<tr><td>Without Forest Type</td><td>1,577.6</td></tr>
<tr><td>Total (ha)</td><td>8,330.4</td></tr>
</table>
</td></tr>
<tr><td>Source of data and description of measurement/calculation methods and procedures applied:</td><td>To estimate degradation of native forests converted to plantations, the equation used to estimate deforestation is applied, since it is assumed that, to establish a plantation, all the carbon content present in the preceding native forest must be reduced to zero.</td></tr>
<tr><td>QA/QC procedures applied:</td><td>For the generation of degradation by substitution activity data and as part of the QA / QC process, the different procedures implemented are documented through a series of protocols or SOPs that allow the estimates to be standardized over time.
SOP_01: Selection of REDD+ satellite mosaics
SOP_02: Elaboration of LULUCF maps</td></tr>
<tr><td>Uncertainty for this parameter:</td><td>The uncertainty of land-use change maps is estimated by comparing the results of the land-use change category on the map and the reference observations corresponding to a sample of visually interpreted points. The errors related to land-use change are calculated following the Good Practice Guidelines for estimating the precision of change of use described in Olofsson et al. (2013).
Error = Maule 191.8%, Ñuble 139.9%, Biobío 134.9%, Araucanía 113.4%, Los Ríos 138.6%, Los Lagos 100.0%</td></tr>
<tr><td>Any comment:</td><td>Link:
https://drive.google.com/uc?export=download&id=1KBPzMuEUIVy0HZF9NupEoBCRjqAhKonn</td></tr>
</table>

d) Degradation – Forest fire activity

Parameter:	A = Area burned between 2001-2010 in the ERP Regions.
Description:	The surface of burned areas was recorded to estimate the degradation of the native forest.
Data unit:	Total hectares (ha) of the 2001-2010 period.
Value monitored during this Monitoring / Reporting Period:	

Region/Year	Maule	Biobío	La Araucanía	Los Lagos	Los Ríos	Ñuble
2001	25	69	64	9	1	20
2002	147	7,443	18,765	2,552	904	117
2003	504	30	226	27	3	129
2004	171	197	268	91	175	15
2005	140	118	72	47	19	278
2006	62	57	73	207	7	90
2007	9	747	39	52	5	199
2008	344	144	307	4,234	119	87
2009	3,999	898	726	598	271	59
2010	432	581	42	1	1	399
Total period	5,834	10,285	20,581	7,819	1,504	1,392

Source of data and description of measurement/calculation methods and procedures applied:	The Forest Fire Protection Department and its Digital Information System for Operations Control provides annualized statistical information on the occurrence of forest fires for the entire country, which in recent years it has been improved by adding the spatial location of fires.
QA/QC procedures applied:	SOP_05_ Method for estimating in forest remaining forests the carbon variation.
Uncertainty for this parameter:	Area burned uncertainty estimated by INGEI (2020) Error: 15%
Any comment:	Link: https://drive.google.com/uc?export=download&id=1KP-BsYfRCbE49HZXydsGlyge0FJMRnXd

e) Enhancement activity – No forest to native forest

Parameter:	$\Delta A_{TOOTHERSi,\ t}$ = Area of used non-forest land converted into forest during the reference level
Description:	The areas that correspond to non-forest lands were quantified in hectares to later estimate the carbon capture balances of these changes in land use. In this data forest plantations with exotic species are included as non-forest land.
Data unit:	Total hectares (ha/year) of the period 2001-2013
Value monitored during thisMonitoring / Reporting Period:	

Forest Type	Area
Alerce	23
Araucaria	103
Ciprés de la Cordillera	125
Ciprés de las Guaitecas	21
Coihue - Raulí - Tepa	202
Coihue de Magallanes	13
Esclerófilo	4,863
Lenga	320
Roble - Hualo	490
Roble - Raulí - Coihue	3,585
Siempreverde	1,417
Without Forest Type	2,360
Total (ha)	**13,522**

Source of data and description of measurement/calculation methods and procedures applied:	A semi-automated technique is applied to detect changes using satellite images. The Multi-index method or MIICA (Jin et al., 2013) detects changes in land use for the period under study. The MIICA methodology is based on the combination of 2 spectral indices (dNBR, dNDVI) which, through integration rules, provide coverage of land use change, indicating the magnitude and directionality of the change. (Profit and loss). The MIICA methodology used images from the Landsat 8 sensor and was applied through a series of codes in programming language (Javascript, R) complemented with Google Earth Engine cloud processing, in GIS programs and R software, with the objective of obtaining an efficient land use change map.
QA/QC procedures applied:	For the generation of enhancement (non-forest to forest) activity data and as part of the QA / QC process, the different procedures implemented are documented through a series of protocols or SOPs that allow the estimates to be standardized over time. SOP_01: Selection of REDD+ satellite mosaics SOP_02: Elaboration of LULUCF maps,
Uncertainty for this parameter:	The uncertainty of land-use change maps is estimated by comparing the results of the land-use change category on the map and the reference observations corresponding to a sample of visually interpreted points. The errors related to land-use change are calculated following the Good Practice Guidelines for estimating the precision of change of use described in Olofsson et al. (2013). Error = Maule 80%, Ñuble 50.5%, Biobío 136.5%, Araucanía 192.2%, Los Ríos 65.1%, Los Lagos 138.5%
Any comment:	Link: https://drive.google.com/uc?export=download&id=1KIXPHr_Tg0YvpLkwNhx2MTJlAIdegb1U

f) Enhancement activity – forest remains forest in non-conservation areas

Parameter:	A_{EnhFF} = Areas of non-conservation native forest that remains forest during the 2001– 2010 period for the Sixth Region of the ERP, in areas not affected by browning (NBA).
Description:	The areas that in 2001-2010 are forest in non-conservation area and remain as such, the hectares were estimated.
Data unit:	Total hectares (ha/year) of the 2001-2010 period.
Value monitored during this Monitoring / Reporting Period:	<table><tr><th>Region</th><th>Area</th></tr><tr><td>Maule</td><td>88,778</td></tr><tr><td>Ñuble</td><td>33,323</td></tr><tr><td>Biobío</td><td>65,805</td></tr><tr><td>La Araucanía</td><td>87,901</td></tr><tr><td>Los Ríos</td><td>47,402</td></tr><tr><td>Los Lagos</td><td>139,986</td></tr><tr><td>**Total (ha)**</td><td>**463,195**</td></tr></table>
Source of data and description of measurement/calculation methods and procedures applied:	The data comes from INFOR's National Forest Inventory (IFN) plots, combined with spectral information from the Landsat series. This information integrates the variables of the state of the forests on the number of trees per hectare and basal area recorded by the monitoring of IFN plots, with the spectral data from Landsat to estimate carbon stocks in a spatially explicit way.

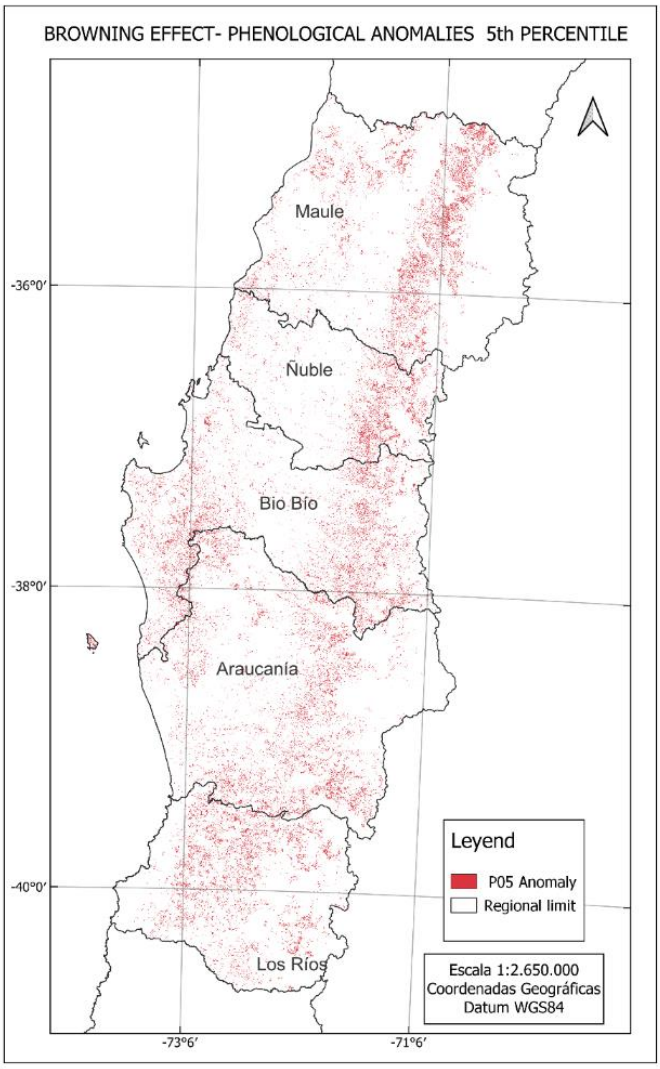
QA/QC procedures applied:	Since one input for AD on enhancement in areas of forest that remain as forest are the Land Use Change Maps in order to define areas of forest remaining forest, same QA/QC procedures and SOP are used during the process. Additional procedures are applied, and proper SOP were developed. SOP_05: Method for estimating in forest remaining forests the carbon variation. SOP_06: Field Operations Manual Inventory
Uncertainty for this parameter:	Degradation mapping accuracy estimated by INFOR. Error: 32.8%
Any comment:	Link: https://drive.google.com/uc?export=download&id=1KXI4CfOKLRrtxPVXfqk5ejz2dV6Cda61

g) Conservation activity

Parameter:	$\Delta A_{TO_OTHERSi,t}$ = Areas of conservation native forest that remains as such during the 2001-2010 period in the Six Region of the ERP, in areas not affected by browning (NBA).
Description:	The areas that in 2001 to 2010 are forest in conservation area and remain as such
Data unit:	Total hectares (ha) of the period 2001-2010
Value monitored during this Monitoring / Reporting Period:	<table><tr><th>Region</th><th>Area</th></tr><tr><td>Maule</td><td>3,315</td></tr><tr><td>Ñuble</td><td>8,882</td></tr><tr><td>Biobío</td><td>15,509</td></tr><tr><td>La Araucanía</td><td>27,794</td></tr><tr><td>Los Ríos</td><td>26,371</td></tr><tr><td>Los Lagos</td><td>88,396</td></tr><tr><td>**Total (ha)**</td><td>**170,267**</td></tr></table>
Source of data and description of measurement/calculation methods and procedures applied:	The data comes from INFOR's National Forest Inventory (IFN) plots, combined with spectral information from the Landsat series. This information integrates the variables of the state of the forests on the number of trees per hectare and basal area recorded by the monitoring of IFN plots, with the spectral data from Landsat to estimate carbon stocks in a spatially explicit way.
QA/QC procedures applied:	Since one input for AD on enhancement in areas of forest that remain as forest are the Land Use Change Maps in order to define areas of forest remaining forest, same QA/QC procedures and SOP are used during the process. Additional procedures are applied, and proper SOP were developed. SOP_05: Method for estimating in forest remaining forests the carbon variation. SOP_06: Field Operations Manual
Uncertainty for this parameter:	Degradation mapping accuracy estimated by INFOR. Error: 32.8%
Any comment:	Link: https://drive.google.com/uc?export=download&id=1Kg4eLQfzjG3Gr3cuMfELi0aXbkBDsNgZ

h) Emissions and removals from browning affected forest area

<table>
<tr><td>Parameter:</td><td>Browning = Areas of native forest that remains as such affected by browning during the 2001– 2010 period in the six Region of the ERP.</td></tr>
<tr><td>Description:</td><td>The areas that in 2001 to 2010 are forests affected by browning in forest areas that remain as such.</td></tr>
<tr><td>Data unit:</td><td>Total hectares (ha) of the 2001-2010 period.</td></tr>
<tr><td>Value monitored during this Monitoring / Reporting Period:</td><td>
<table>
<tr><th>Region</th><th>Degradation (Ha)</th><th>Enhancement (Ha)</th><th>Conservation (Ha)</th></tr>
<tr><td>Maule</td><td>24,394</td><td>31,978</td><td>976</td></tr>
<tr><td>Ñuble</td><td>7,157</td><td>8,850</td><td>1,342</td></tr>
<tr><td>Biobío</td><td>10,009</td><td>14,065</td><td>2,666</td></tr>
<tr><td>La Araucanía</td><td>7,725</td><td>11,916</td><td>776</td></tr>
<tr><td>Los Ríos</td><td>3,323</td><td>6,640</td><td>299</td></tr>
<tr><td>Los Lagos</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>Total (ha)</td><td>52,609</td><td>73,449</td><td>6,059</td></tr>
</table>
</td></tr>
<tr><td>Source of data and description of measurement/calculation methods and procedures applied:</td><td>As could be seen in certain tables by activity data described above, emissions accounting in forest remaining forest was carried out in areas not affected by browning (NBA) excluding the areas affected by browning (BA). This occurs due to areas affected by browning are considered as a non-anthropogenic emission source because the carbon fluxes that occurs on these areas are not related to human activities as the deforestation activity. It is a non-anthropogenic source because it is generated by the decreases in precipitation falls, and water availability. The areas affected by browning correspond to those areas of forest that remain as forests that present phenological anomalies because of the impact of the megadrought. These anomalies were detected in the integral productivity of native forest in the ERP implementation area and are under the 5th percentile data productivity anomaly (GAC,2023). The phenological anomaly results in the desiccation of the crowns, loss of foliage and even the mortality of individuals.
Down below is a map with the areas of the 5th percentile anomalies distribution. These areas were used in each monitoring report to exclude the emission related to the non-anthropogenic emissions in each period. They correspond to areas of native forest between the regions of Maule and La Araucanía, together with the area of the</td></tr>
</table>

	RORACO forest type extended to the region of Los Ríos.  It is worth clarifying that the browning effect emission are excluded in both the degradation, increase and conservation activities in forest remaining forest. However, the forest stratum affected by browning is not excluded from the ERP implementation and monitoring area, and its treatment is maintained continuously at the same level of scope as those areas outside this stratum. The raster layer of phenological anomalies could be found in the following link: https://drive.google.com/uc?export=download&id=15Yvf4zyMfiTu4HvBRyN9VgUZyt-Rv8Qk
QA/QC procedures applied:	SOP_05_Forest Carbon Flux estimation assessment SOP_06_Field Operation Manual
Uncertainty for this parameter:	Degradation mapping accuracy estimated by INFOR. Error: 32.8%
Any comment:	The same anomalies raster layer was used to segregate the browning areas in the NREF and Reporting Periods this allows that non-anthropogenic and anthropogenic emissions and removals are kept separate. The segregation considers report all the carbon fluxes which occur in those areas (gain, loss and neutral) from each period and excluding them from the account.

Emission factors

i. Changes in land use or sub use

Deforestation

Carbon stocks before deforestation (B_{BEFORE})

Forest carbon stocks before deforestation were obtained from the information databases of the Chilean INGEI. These numbers are derived from the INFOR Continuous Forest Inventory to achieve an estimation of Tier 3 living above ground biomass. Estimations are stratified by forest type to obtain carbon contents before deforestation. The information of changes in land use was updated to include forest type data.

Above and below ground biomass (B_{BEFORE} in equations 4 and 8), and DOM (Co in Equation 5) are obtained from the GHG national inventory. Under deforestation accounting, carbon stocks of Harvested Wood Products (HWP) is supposed to be zero, due to the lack of reliable data sources for distinguishing between HWP from deforestation and HWP due to degradation.

Carbon stocks after deforestation (B_{AFTERi})

The INGEI uses IPCC (2006) default values for B_{AFTERi}, but these values are supposed to be from non-forest land use growth that actually corresponds to Δ_{CG}. For FREL estimations, carbon stocks directly after deforestation are assumed to be zero.

Changes in carbon stocks other than deforestation events (Δ_{CG} and Δ_{CL})

Post – deforestation carbon stocks (Δ_{CG}) are determined in one of two ways:

- Values taken from a literature review of non – forest carbon stocks, preferably studies conducted within Chile (Such as Gayoso 2006). If such studies are not available, data from other regional studies can be used (Temperate South America with similar management systems). This is the preferred method, representing a Tier 2 or 3 approach.

- When these values are not available, IPCC (2006) default values can be used. This is the method currently used by the INGEI but represents a Tier 1 method.

Losses due to wood harvesting, firewood extraction and disturbances (Δ_{CL}) are supposed to be zero in deforestation areas, using the same INGEI assumption.

Degradation from Substitution

For emission factors due to changes from native forest to plantation, estimations of carbon stocks derived from plots in the Continuous Forest Inventory and other carbon stock studies for other land uses are used. Biomass stock in plantation estimation is assumed to be zero (0) as stocks in native forest before plantations are established are assumed to go down to zero.

Forest Surface Enhancement and Restoration

In equation 6, the value of B_{AFTERi} is supposed to be zero for agricultural lands and industrial/urban areas, since carbon stocks from land use in non – forest converted into forest have been eliminated before the establishment of forests. For natural land uses, mainly meadows and scrubs, B_{AFTER} is supposed to be equal to B_{BEFORE}, since clearing or cleaning processes are not supposed to take place in those lands before the establishment of forests, but rather naturally

become forests without losing initial carbon stocks. Carbon stocks from $B_{BEFOREi}$ to carbon stocks for non – forest land use. Scientific regional or national reports such as Gayoso (2006) which have estimated carbon stocks in non – forest land uses are utilized for these stocks.

In equation 7, G_{TOTAL}, average biomass annual growth per hectare for each forest type is calculated through Equation 33 (Modified from Equation 2.10 in IPCC 2006)

$$G_{TOTAL} = \Sigma_i (I_{Vi} \cdot BCEF_i \cdot (1+R_i))$$

Equation 33 (Ec. 2.10 IPCC, 2006)

Where:

G_{TOTAL} = below ground and above ground biomass average annual growth, ton d. m. ha^{-1} $year^{-1}$
I_i = average annual net increase for one forest type, m^3 ha^{-1} $year^{-1}$
$BCEF_I$ = biomass expansion and conversion factor for conversion from annual net volume increase (Including bark) to above ground biomass growth for one forest type, aerial bark growth tonnes (m^3 of average annual increase)$^{-1}$
R = relation between above and below ground biomass for one forest type in ton m.s of below ground biomass (ton m.s. of above ground biomass)$^{-1}$.

Annual net average increase values, I, are gathered in the INGEI data set based on data from the INFOR forest inventory, which estimates values for the following forest types: Alerce, Ciprés de las Guaitecas, Araucaria, Ciprés de la Cordillera, Lenga, Coihue de Magallanes, Roble Hualo, Roble-Raulí-Coihue, Coihue-Raulí-Tepa, Esclerófilo, and Siempreverde. Equation 34 is used to calculate BCEFI:

$$BCEF_I = BEF_I \cdot D_i$$

Equation 34

Where:

BEF_I= Expansion factor for the biomass of one forest type. This factor expands the total above ground biomass volume to compensate for the non – marketable components of the increase, no scale
D = basic wood density value, ton m^{-3}

The biomass expansion factor, BEF_I, and basic wood density value, D, come from the INGEI data set, having a BEF_I value for native forests, non – broken down per forest type, by Gayoso et al (2002).

The relation between above and below ground biomass for native forests, R, was estimated by Gayoso et al (2002) and can be found in the INGEI data set.

ii. Forest remaining forest

Emission factors for degradation in forests that remain as such, carbon content enhancements from degraded forest restoration and forest conversion all use the same methodology.

Emission factors come from the INFOR continuous forest inventory, which is the base for the methodology.

$$Vol = KAB^{\beta}$$

Equation 35

Where:

Vol= Volume of trees in forest, cubic meters ha^{-1}.
AB= Basal Area square meters ha^{-1}.
K= constant, value of 2.9141.
β = constant, value 1.2478.

For converting volume to CO_2 for its use in the equation:

$$EF = Vol * D * BEF$$

Equation 36

Where:

EF = carbon stocks in forest that remains as such, ton biomass ha^{-1}
Vol= volume of trees in forest, cubic meters ha^{-1}
D= average forest density, tonnes meters^{-3}
BEF= biomass conversion and expansion factor for the conversion of annual volume net increase (Including bark) to above ground biomass growth for one forest type, aerial bark tonnes growth (m^3 of average annual increase

Emission factors

Parameter:	Root-to-shoot ratios of native forest (R factor)
Description:	Relationship between below ground and above ground biomass
Data unit:	t d.m. m^{-3}
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	R factor comes from information collected in the country (Gayoso et al., 2002; INGEI, 2020). This value is within the range of values indicated in the 2006 IPCC Guidelines for temperate forests (between 0.20 and 0.46, according to Table 4.4; Chapter 4; Volume 4) and within the values available worldwide, which provide R factors that range between 0.09 and 0.33. This value is for native species and has a national spatial level.
Value applied:	0.2869
QA/QC procedures applied	These are reference national values obtained from Gayoso et al. (2002) and INGEI (2020) as was mentioned before. QA / QC applied in documentation process "Estimación de valores de fracción de carbono, relación tallo raíz" ("Estimation of carbon fraction values, stem-root relation").
Uncertainty associated with this parameter:	Error calculation based on statistical data from the Biomass Inventory and Carbon Accountancy of the Universidad Austral de Chile (UACh). Error: 9.4%
Any comment:	

a) Deforestation activity

Parameter:	Biomass expansion factor (BEF) for the native forest
Description:	This factor expands the total volume of above ground biomass to compensate for non-marketable aspects of the increase.
Data unit:	Non-dimensional
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	The Biomass expansion factor becomes from information collected in the country from the study of Gayoso et al. (2002) and used in INGEI (2020). This value is for native species and has a national spatial level.
Value applied:	1.75
QA/QC procedures applied	This are reference national values obtained from Gayoso et al. (2002) and INGEI (2020) as was mentioned before.
Uncertainty associated with this parameter:	Error calculation based on statistical data from the Biomass Inventory and Carbon Accounting of the Universidad Austral de Chile (UACh). Error: 18%
Any comment:	
Parameter:	Basic wood density value (D)
Description:	Calculated using basic density data collected from native species growing in Chile.
Data unit:	t d.m. m^{-3}
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	A bibliographic review of basic densities of forest species in Chile was carried out and there were no modifications for the value exposed in Gayoso et al. (2002) and INGEI (2020).
Value applied:	0.496166
QA/QC procedures applied	These are reference national values obtained from Gayoso et al. (2002) and INGEI (2020) as mentioned before.
Uncertainty associated with this parameter:	It was calculated using basic density data collected from native and exotic species growing in Chile. Error: 5.6%
Any comment:	

<table>
<tr><td>Parameter:</td><td>Above and below ground biomass of other uses</td></tr>
<tr><td>Description:</td><td>Above and below ground biomass of Urban and Industrial Areas, agricultural land, grassland, scrub, arborescent scrub, shrub planting, succulent scrub, succulent formations, plantations, wetlands, areas deprived of vegetation, eternal snows and glaciers, waterbodies and unrecognized areas</td></tr>
<tr><td>Data unit:</td><td>Tons of dry biomass ha^{-1} (t d.m. ha^{-1})</td></tr>
<tr><td>Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):</td><td>

Urban and Industrial Areas (INGEI, 2020)
Agricultural land (INGEI, 2020)
Grassland (Gayoso et al., 2006)
Grassland - Scrub (Gayoso et al., 2006)
Scrub (Gayoso et al., 2006)
Arborescent scrub (Gayoso et al., 2006)
Scrub with succulent (Gayoso et al., 2006)
Succulent formations (assumption of grassland values (Gayoso et al., 2006))
Shrub planting (Gayoso et al., 2006)
Plantation (Expert national panel)
Wetlands (assumption)
Areas deprived of vegetation (assumption)
Eternal snows and glaciers (assumption)
Waterbodies (assumption)
Unrecognized areas (assumption)

These are reference national values obtained from Gayoso et al. (2006), INGEI (2020), an expert national panel and assumption as mentioned before.
</td></tr>
<tr><td>Value applied:</td><td>
<table>
<tr><th>Use / sub use</th><th>t dry above ground biomass ha^{-1}</th><th>t dry below ground biomass ha^{-1}</th></tr>
<tr><td>Urban and Industrial Areas</td><td>2</td><td>0</td></tr>
<tr><td>Agricultural land</td><td>10</td><td>2</td></tr>
<tr><td>Grassland</td><td>4.73</td><td>8.13</td></tr>
<tr><td>Grassland - Scrub</td><td>9.04</td><td>14.99</td></tr>
<tr><td>Scrub</td><td>9.04</td><td>14.99</td></tr>
<tr><td>Arborescent scrub</td><td>21.78</td><td>35.25</td></tr>
<tr><td>Scrub with succulent</td><td>9.04</td><td>14.99</td></tr>
<tr><td>Succulent formations</td><td>4.73</td><td>8.13</td></tr>
<tr><td>Shrub planting</td><td>9.04</td><td>14.99</td></tr>
<tr><td>Plantation</td><td>0</td><td>0</td></tr>
<tr><td>Wetlands</td><td>0</td><td>0</td></tr>
<tr><td>Areas deprived of vegetation</td><td>0</td><td>0</td></tr>
<tr><td>Eternal snows and glaciers</td><td>0</td><td>0</td></tr>
<tr><td>Waterbodies</td><td>0</td><td>0</td></tr>
<tr><td>Unrecognized areas</td><td>0</td><td>0</td></tr>
</table>
</td></tr>
<tr><td>QA/QC procedures applied</td><td>These are reference national values obtained from Gayoso et al. (2006), INGEI (2020), an expert national panel and assumption as mentioned before.</td></tr>
</table>

<table>
<tr><td>Uncertainty associated with this parameter:</td><td>Data from INGEI (2020) and Gayoso et al., (2006).

<table><tr><th>Use / sub use</th><th>Error % in above ground biomass</th></tr><tr><td>Urban and Industrial Areas</td><td>95%</td></tr><tr><td>Agricultural land</td><td>75%</td></tr><tr><td>Grassland</td><td>27.7%</td></tr><tr><td>Grassland – Scrub</td><td>34.6%</td></tr><tr><td>Scrub</td><td>34.6%</td></tr><tr><td>Arborescent scrub</td><td>22.4%</td></tr><tr><td>Scrub with succulent</td><td>34.6%</td></tr><tr><td>Succulent formations</td><td>27.7%</td></tr><tr><td>Shrub planting</td><td>34.6%</td></tr></table>
Uncertainty for below ground biomass (BGB) of Non-Forest lands is based on propagation error estimate following IPCC approach 1 of Matorral-Arborescente AGB error (22.42%) and Root shoot ratio -R Factor error (48.27%) estimated by Gayoso et al. (2002), resulting in total uncertainty of 53.2%.</td></tr>
<tr><td>Any comment:</td><td></td></tr>
</table>

Parameter:	Above and below ground biomass of native forest
Description:	Above and below ground biomass of native forest. The native forest is classified by different forest type and structure. Each forest type has its own biomass value in some cases, depending on data availability.
Data unit:	Tons of dry biomass ha^{-1} (t d.m. ha^{-1})
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	Native forest data are national data and published in INGEI (2020) The mixed forest is calculated as a weighted average value of the forest types present in the region and according to the forest type surface present for the deforestation activity of the period. For missing biomass value of the forest types and some of the structures a weighted average value was calculated in the region and according to the forest type surface present at the final year in the reference level (2013).
Value applied:	

Forest type	Structure	AGB (t d.m. ha^{-1})	BGB (t d.m. ha^{-1})
Alerce	Mature	339.1	97.3
Alerce	Young	203.6	58.4
Alerce	Mature/Young	203.6	58.4
Alerce	Stunted	339.1	97.3
Ciprés de las Guaitecas	Mature	198.0	56.8
Ciprés de las Guaitecas	Young	198.0	56.8
Ciprés de las Guaitecas	Mature/Young	198.0	56.8
Ciprés de las Guaitecas	Stunted	198.0	56.8
Araucaria	Mature	421.4	120.9
Araucaria	Young	219.1	62.9
Araucaria	Mature/Young	219.1	62.9
Araucaria	Stunted	421.4	120.9
Ciprés de la Cordillera	Mature	124.0	35.6
Ciprés de la Cordillera	Young	124.0	35.6
Ciprés de la Cordillera	Mature/Young	124.0	35.6
Ciprés de la Cordillera	Stunted	124.0	.35.6
Lenga	Mature	198.5	56.9
Lenga	Young	237.2	68.1
Lenga	Mature/Young	237.2	68.1
Lenga	Stunted	198.5	56.9
Coihue de Magallanes	Mature	129.1	37.1
Coihue de Magallanes	Young	129.1	37.1
Coihue de Magallanes	Mature/Young	129.1	37.1
Coihue de Magallanes	Stunted	129.1	37.1
Roble - Hualo	Mature	114.9	33.0
Roble - Hualo	Young	114.9	33.0
Roble - Hualo	Mature/Young	114.9	33.0
Roble - Hualo	Stunted	114.9	33.0
Roble - Raulí - Coihue	Mature	178.6	51.2
Roble - Raulí - Coihue	Young	152.8	43.8
Roble - Raulí - Coihue	Mature/Young	152.8	43.8
Roble - Raulí - Coihue	Stunted	178.6	51.2
Coihue - Raulí - Tepa	Mature	377.0	108.2

	Coihue - Raulí - Tepa	Young	377.0	108.2
	Coihue - Raulí - Tepa	Mature/Young	377.0	108.2
	Coihue - Raulí - Tepa	Stunted	377.0	108.2
	Esclerófilo	Mature	18.6	5.3
	Esclerófilo	Young	18.6	5.3
	Esclerófilo	Mature/Young	18.6	5.3
	Esclerófilo	Stunted	18.6	5.3
	Siempreverde	Mature	361.6	103.8
	Siempreverde	Young	127.3	36.5
	Siempreverde	Mature/Young	127.3	36.5
	Siempreverde	Stunted	361.6	103.8
QA/QC procedures applied	The SOP_06: Field Operations Manual describes in detail the entire process of gather information in the field for the Forest Ecosystem Inventory.			
Uncertainty associated with this parameter:	For the Forest types with field sampling plots available to assess, the PDF values where directly used in the Montecarlo Method (see section 12.2 Quantification of uncertainty in Reference Level Setting, for detail). For the forest types with a limited number of sampling plots, uncertainty propagation with Monte Carlo analysis uses the following information: i. DBH measurement error (0.2%), calculation based on Continuous Forest Inventory data of INFOR; ii. Volume estimation error (0.07%), calculation based on Continuous Forest Inventory data of INFOR, iii. Biomass Expansion Factor (BEF) error (18.0%), BEF comes from information collected in the country from the study of Gayoso et al. (2002) and used in INGEI (2020). This value is for native species and has a national spatial level. Error calculation is based on statistical data from the Biomass Inventory and Carbon Accountancy of the Universidad Austral de Chile (UACh); and iv. Wood Density (5.6%) calculated using basic density data collected from native species growing in Chile. Finally, these uncertainties are combined following IPCC approach 1 (propagation of error), resulting in total uncertainty of 18.85% Uncertainty for Below Ground Biomass BGB is based on propagation error estimate following IPCC approach 1 of Above Ground Biomass-AGB error (18.85%) and Root shoot ratio -R Factor error (40.0%) estimated by Gayoso et al. (2002), resulting in total uncertainty of 44.2%.			
Any comment:				

Parameter:	Dead organic matter of native forest (DOM)
Description:	The native forest is classified by different forest type and structure. Each forest type has its own dead organic matter value in some cases, depending on data availability. The mixed forest is calculated as a weighted average value of the forest types present in the region and according to the forest surface present for the activity of deforestation of the period. For missing DOM value of the forest types and some of the structures was calculate a weighted average value in the region and according to the forest type surface present at the final year in the reference level (2013).
Data unit:	Tons of carbon in dead organic matter ha^{-1} ($tC\ ha^{-1}$)
Source of data or description of the method for developing the	Forest native data are national data and published in INGEI (2020)

data including the spatial level of the data (local, regional, national, international):	

Value applied:

Forest type	Structure	AGB (tC ha^{-1})
Alerce	Mature	121.4
Alerce	Young	121.4
Alerce	Mature/Young	121.4
Alerce	Stunted	121.4
Ciprés de las Guaitecas	Mature	62.11
Ciprés de las Guaitecas	Young	62.11
Ciprés de las Guaitecas	Mature/Young	62.11
Ciprés de las Guaitecas	Stunted	62.11
Araucaria	Mature	133.4
Araucaria	Young	133.4
Araucaria	Mature/Young	133.4
Araucaria	Stunted	133.4
Ciprés de la Cordillera	Mature	62.11
Ciprés de la Cordillera	Young	62.11
Ciprés de la Cordillera	Mature/Young	62.11
Ciprés de la Cordillera	Stunted	62.11
Lenga	Mature	43.4
Lenga	Young	43.4
Lenga	Mature/Young	43.4
Lenga	Stunted	43.4
Coihue de Magallanes	Mature	140.1
Coihue de Magallanes	Young	140.1
Coihue de Magallanes	Mature/Young	140.1
Coihue de Magallanes	Stunted	140.1
Roble - Hualo	Mature	62.11
Roble - Hualo	Young	62.11
Roble - Hualo	Mature/Young	62.11
Roble - Hualo	Stunted	62.11
Roble - Raulí - Coihue	Mature	52.9
Roble - Raulí - Coihue	Young	52.9
Roble - Raulí - Coihue	Mature/Young	52.9
Roble - Raulí - Coihue	Stunted	52.9
Coihue - Raulí - Tepa	Mature	74.4
Coihue - Raulí - Tepa	Young	74.4
Coihue - Raulí - Tepa	Mature/Young	74.4
Coihue - Raulí - Tepa	Stunted	74.4
Esclerófilo	Mature	16.7
Esclerófilo	Young	16.7
Esclerófilo	Mature/Young	16.7
Esclerófilo	Stunted	16.7
Siempreverde	Mature	64.8

	Siempreverde	Young	64.8
	Siempreverde	Mature/Young	64.8
	Siempreverde	Stunted	64.8
QA/QC procedures applied	The SOP_06: Field Operations Manual describes in detail the entire process of gather information in the field for the Forest Ecosystem Inventory.		
Uncertainty associated with this parameter:	Error estimated from permanent plots of the INFOR Continuous Forest Inventory Error 28.4%		
Any comment:			

b) Degradation activity

Parameter:	Combustion factor
Description:	Emission factor for degradation due to forest fires
Data unit:	Non-dimensional
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	Intergovernmental Panel on Climate Change (IPCC). 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 4, Chapter 2, Table 2.6 International - Extra tropical forest
Value applied:	0.45
QA/QC procedures applied	
Uncertainty associated with this parameter:	Error estimated using the standard deviation and median default emission factor of the IPCC 2006. Error: 36%
Any comment:	

Parameter:	CH_4 emission factor
Description:	Emission factor for degradation due to forest fires
Data unit:	g kg^{-1} of burned dry material
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	Intergovernmental Panel on Climate Change (IPCC). 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 4, Chapter 2, Table 2.5 International - Extra tropical forest
Value applied:	4.7
QA/QC procedures applied	
Uncertainty associated with this parameter:	Error estimated using the standard deviation and median default emission factor of the IPCC 2006. Error: 29.0%
Any comment:	

Parameter:	N_2O emission factor
Description:	Emission factor for degradation due to forest fires
Data unit:	g kg^{-1} of burned dry material
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	Intergovernmental Panel on Climate Change (IPCC). 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 4, Chapter 2, Table 2.5 International - Extra tropical forest
Value applied:	0.26
QA/QC procedures applied	
Uncertainty associated with this parameter:	Error estimated using the standard deviation and median default emission factor of the IPCC 2006. Error: 43.8%
Any comment:	

c) Enhancement activity

Parameter:	Periodic annual increment (PAI) according to forest type
Description:	Periodic annual increment (PAI) according to forest type and structure. Each forest type has its own biomass value in some cases, depending on data availability For the missing PAI value of the forest types and some of the structures, a weighted average value was calculated in the region and according to the forest type surface present at the final year in the reference level (2013).
Data unit:	Cubic meter per hectare and year (m^3 ha^{-1} $year^{-1}$)
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	Native forest data are national data and published in INGEI (2020)
Value applied:	

Forest type	Structure	PAI (m^3 ha^{-1} $year^{-1}$)
Alerce	Mature	0.5
Alerce	Young	0.5
Alerce	Mature/Young	0.5
Alerce	Stunted	0.5
Ciprés de las Guaitecas	Mature	3.9
Ciprés de las Guaitecas	Young	3.9
Ciprés de las Guaitecas	Mature/Young	3.9
Ciprés de las Guaitecas	Stunted	3.9
Araucaria	Mature	4.6
Araucaria	Young	4.6
Araucaria	Mature/Young	4.6
Araucaria	Stunted	4.6
Ciprés de la Cordillera	Mature	5
Ciprés de la Cordillera	Young	2.7

	Ciprés de la Cordillera	Mature/Young	2.7
	Ciprés de la Cordillera	Stunted	5
	Lenga	Mature	5.8
	Lenga	Young	3.9
	Lenga	Mature/Young	3.9
	Lenga	Stunted	5.8
	Coihue de Magallanes	Mature	2.6
	Coihue de Magallanes	Young	3.7
	Coihue de Magallanes	Mature/Young	3.7
	Coihue de Magallanes	Stunted	2.6
	Roble - Hualo	Mature	5.1
	Roble - Hualo	Young	3.5
	Roble - Hualo	Mature/Young	3.5
	Roble - Hualo	Stunted	5.1
	Roble - Raulí - Coihue	Mature	6.6
	Roble - Raulí - Coihue	Young	4.1
	Roble - Raulí - Coihue	Mature/Young	4.1
	Roble - Raulí - Coihue	Stunted	6.6
	Coihue - Raulí - Tepa	Mature	5.8
	Coihue - Raulí - Tepa	Young	4.9
	Coihue - Raulí - Tepa	Mature/Young	4.9
	Coihue - Raulí - Tepa	Stunted	5.8
	Esclerófilo	Mature	1.5
	Esclerófilo	Young	1.6
	Esclerófilo	Mature/Young	1.6
	Esclerófilo	Stunted	1.5
	Siempreverde	Mature	6
	Siempreverde	Young	4.1
	Siempreverde	Mature/Young	4.1
	Siempreverde	Stunted	6
QA/QC procedures applied	The SOP_06: Field Operations Manual describes in detail the entire process of gather information in the field for the Forest Ecosystem Inventory.		
Uncertainty associated with this parameter:	Forest types with field plots available, PDF were assessed and used directly in the Montecarlo Method (see section 12.2 Quantification of uncertainty in Reference Level Setting, for detail). Error 28.7%		
Any comment:			

<table>
<tr><td>Parameter:</td><td>Periodic annual increment (PAI) for mixed forest</td></tr>
<tr><td>Description:</td><td>The mixed forest is calculated as a weighted average value of the forest types present in the region and according to the forest surface present for the activity of enhancement of the period (from no forest to native forest).</td></tr>
<tr><td>Data unit:</td><td>Cubic meter per hectare and year (m^3 ha^{-1} $year^{-1}$)</td></tr>
<tr><td>Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):</td><td>Forest native data are national data and published in INGEI (2020)</td></tr>
<tr><td>Value applied:</td><td>
<table>
<tr><th>Region</th><th>PAI NREF (m^3 ha^{-1} $year^{-1}$)</th></tr>
<tr><td>Maule</td><td>2.1</td></tr>
<tr><td>Ñuble</td><td>2.8</td></tr>
<tr><td>Biobío</td><td>3.7</td></tr>
<tr><td>Araucanía</td><td>4.2</td></tr>
<tr><td>Los Ríos</td><td>4.1</td></tr>
<tr><td>Los Lagos</td><td>4.2</td></tr>
</table>
</td></tr>
<tr><td>QA/QC procedures applied</td><td>SOP_06_Field Operation Manual</td></tr>
<tr><td>Uncertainty associated with this parameter:</td><td>SOP_06 Field Operations Manual was implemented during fieldwork to estimate PAI in the National Forest Inventory, for some forest types were possible to adjust a Probability Distribution Function (PDF). For the forest types with a limited number of sampling plots, uncertainty propagation with Monte Carlo analysis uses the calculation of the measurement uncertainty for PAI based on the 95% CI of the removal rate by forest type, calculated with Continuous Forest Inventory data of INFOR.
● PAI Mixed Forest = 28.7% (Average of PAI error for all forest types given lack of data.)</td></tr>
<tr><td>Any comment:</td><td></td></tr>
</table>

8.4 Estimated Reference Level

ER Program Reference level, considering only the areas of permanent forest not affected by browning.

Year of Monitoring/Reporting period *t*	Average annual historical emissions from deforestation over the Reference Period (tCO_{2-e}/yr)	If applicable, average annual historical emissions from forest degradation over the Reference Period (tCO_{2-e}/yr)	If applicable, average annual historical removals by sinks over the Reference Period (tCO_{2-e}/yr)	Adjustment, if applicable (tCO_{2-e}/yr)	Reference level (tCO_{2-e}/yr)
2001	5,140,727	11,914,436	-10,740,394	NA	6,314,770
2002	5,140,727	11,914,436	-10,740,394	NA	6,314,770
2003	5,140,727	11,914,436	-10,740,394	NA	6,314,770
2004	5,140,727	11,914,436	-10,740,394	NA	6,314,770
2005	5,140,727	11,914,436	-10,740,394	NA	6,314,770
2006	5,140,727	11,914,436	-10,740,394	NA	6,314,770
2007	5,140,727	11,914,436	-10,740,394	NA	6,314,770
2008	5,140,727	11,914,436	-10,740,394	NA	6,314,770
2009	5,140,727	11,914,436	-10,740,394	NA	6,314,770
2010	5,140,727	11,914,436	-10,740,394	NA	6,314,770
2011	5,140,727	11,914,436	-10,740,394	NA	6,314,770
2012	5,140,727	11,914,436	-10,740,394	NA	6,314,770
2013	5,140,727	11,914,436	-10,740,394	NA	6,314,770
Total	66,829,454	-154,887,668	-139,625,118	0	**82,092,006**

Calculation of the average annual historical emissions over the Reference Period

The spreadsheets that support this information are available at: https://www.enccrv.cl/erpa

8.5 Upward or downward adjustments to the average annual historical emissions over the Reference Period (if applicable)

Explanation and justification of proposed upward or downward adjustment to the average annual historical emissions over the Reference Period

The entity has not considered applying an adjustment rate (%) to the historical emissions average over the reference period.

Quantification of the proposed upward or downward adjustment to the average annual historical emissions over the Reference Period

The entity has not considered applying an adjustment rate (%) to the historical emissions average over the reference period. However, the consultancy on the Browning Project that is expected to carry out this year, could collect enough evidence and results to recommend the application of an adjustment rate or factor to the emissions produced over the relevant period.

8.6 Relation between the Reference Level, the development of a FREL/FRL for the UNFCCC and the country's existing or emerging greenhouse gas inventory

The updated reference level has been presented in this Annex, to be subject to the validation and review process by the Fund evaluation team. With this, Chile has the intent to submit the updated reference level to the UNFCCC in 2022, which will also be expanded to forest regions not addressed in the ER Program and therefore neither the

current FREL/FRL. In this way, Chile expects to have an updated and expanded to a national scale reference level by the end of 2022, with validation from the FCPF and the UNFCCC.

The FREL/FRL submitted for the native forest of Chile remains highly consistent with the national INGEI. Nevertheless, it is important to consider the various intrinsic differences that exist between a reference level and a GHG inventory.

In Chile, the Ministry of Agriculture is the institution responsible for the Agriculture, Forestry and Land Use sector for the INGEI, and CONAF and INFOR are responsible for the specific calculations of the Land Use and Changes in Land Use sector, both institutions with responsibilities in the development of the Chilean forest FREL/FRL.

Carbon flux accounting is considered in forest plantations of exotic species included in the INGEI and not in the reference level as part of such intrinsic differences. On the other hand, degradation activities and stock enhancements in forest remaining forests would be integrated in the calculation of emissions and absorptions generated in forest lands that remain as such in the INGEI. On the other hand, deforestation activity and stock enhancements from non – forest to forest uses would be associated to changes in land use from forest use to Other Uses and from Other Uses to Forest, respectively.

Deforestation

The GHG Inventory considers the following categories for deforestation emissions: forest lands converted into farmlands, forest lands converted into pastures, forest lands converted into settlements and forest lands converted into other lands (Including areas deprived of vegetation, snows and glaciers, waterbodies and non – recognized areas). All final land use classes resulting from deforestation are specified in the FREL estimation.

Information from use change maps developed based on the Cadastre for activity data generation is used for the GHG Inventory and FREL/FRL. While both previously considered information from the Cadastre, Chile developed the method based on multi pixel mosaics and MIICA for the development of change maps. In this way, the product of semi-automated change maps for changes in land uses can be utilized in both reports.

Biomass stocks in land use before conversion consider the same information in both reports, applying stock values per forest type according to their structure. Post – deforestation biomass content in both INGEI and FREL considers IPCC default values in some non – forest land use classes. Also, the reference level uses specific values for Chile from Gayoso (2006) for scrubs, arborescent scrubs, grasslands and succulent formations to have more emission factors that are specific for Chile.

Regarding the estimation of changes in carbon stocks other than deforestation events, both INGEI and FREL consider losses due to wood harvesting, firewood extraction and disturbances to be zero in deforestation areas.

The GHG inventory in Chile considers commercial wood harvesting activities for native and exotic species, wood harvesting, and fires within forest lands that remain as such. Such activities can be homologated to degradation in forest remaining forests in the NFMS. In order to count forest degradation, INGEI uses a gain – loss method based on IPCC (2006) Equation 2.7; nevertheless, the FREL/FRL uses the stock difference method based on IPCC (2006) Equation 2.8.

INGEI uses tabular data from INFOR for forest removals, and statistics from INFOR and the Ministry of Energy for firewood along with surface of fires in native forest and forest plantations tables from CONAF to count emissions from forest. The same accounting as that of the INGEI of Chile is used for non – CO_2 GHG from forest fire combustions.

Firewood extraction data are highly complex, as most extractions are informal making it more difficult to estimate the accuracy and reliability of this information. Due to this a different methodology, considered to be more robust, is used for the degradation reference level accounting.

The fact that INGEI counts carbon enhancements in forest plantations, while the FREL assumes carbon stocks in plantations to be zero for the native forests converted into forest plantations activity, is another reason that explains the difference between annual emissions.

Accounting for the enhancement in carbon stocks varies between what is applied in the Gas Inventory and FREL, nevertheless, both consider lands converted into forest lands and biomass expansion in forests that remain as such to be enhancements. The FREL/FRL also accounts for the transition lands category.

The differences in results for removal estimations are mainly because the FREL does not account for enhancements from forest plantations, aside from differences in the methodology applied for enhancements in forests that remains as such. The FREL/FRL only includes biomass enhancements in native forests.

The NGHGI uses IPCC 2006 Equation 2.9 for Tier 2 – 3 calculations in enhancements from forest growth. Nevertheless, INGEI only uses it for lands converted into forests in the conversion year. Afterwards, these lands move to the in-transition category, where their enhancements are accounted.

The stock enhancement FREL continues counting absorptions coming from areas converted into forests during the reference period, for the entire period. For example, an area converted into forest in the first year of the reference period continues increasing its carbon stock in the second, third, and subsequent years in the reference period. Second year enhancements coming from areas planted/seeded in the first year are counted in the second year, along with increases from areas seeded/restored in the second year. In this way, enhancements continue to accumulate, always counted under the stock enhancement activity.

For NGHGI, the estimation of activity data for enhancements in non – forest areas converted into forests and forests that remain as such comes from use change maps, likewise for the enhancement FREL. The annual average net increase values used as Absorption Factor are the same ones used in the INGEI, based on INFOR data. There are values for the following forest types: Alerce, Ciprés de las Guaitecas, Araucaria, Ciprés de la Cordillera, Lenga, Coihue de Magallanes, Roble Hualo, Roble-Raulí-Coihue, Coihue-Raulí-Tepa, Esclerófilo, and Siempreverde.

Likewise, the biomass expansion factor and basic wood density value from NGHGI are used as values for calculating the conversion factor and biomass expansion for the conversion of the annual net volume increase (Bark included) into above ground biomass growth for one forest type.

9 APPROACH FOR MEASUREMENT, MONITORING AND REPORTING

The national forest monitoring system must provide data and information that are transparent, consistent over time and suitable for measuring, reporting and allowing emission verification from sources and absorptions from sinks considered in the ER Program of Chile.

The MRV system is methodologically consistent with the FREL/FRL, considering the same sinks and sources, deposits and gases, to guarantee the comparability of estimations between the historical reference period and the performance period.

The monitoring frequency and subsequent data generation is homogeneous for each MRV event. Activity data, or surface subject to anthropogenic actions delimiting each REDD+ activity is calculated through information from coverage and changes in coverage maps developed through the methodologies described in the FREL; monitoring can take place on a biennial basis in accordance with the requirements of the Methodological Framework. Annual data from CONAF historical forest fire statistics are used to account for the surfaces affected by forest fires, the same source of information that feeds into the INGEI and was used on the development of the FREL/FRL.

The ERPD of Chile considered a Monitoring Plan based on three MRV monitoring events for the years 2017, 2019 and 2023, along with the corresponding reports for the years 2018, 2020, 2022 and 2024. Nevertheless, the ERPA of Chile was signed on December 2019 considering the administrative regions from Maule to Los Lagos and the 4 REDD+ activities reported in the FREL/FRL for the 2018-2023 period.

The agreement pledges the transaction of 5.2 MtCO2e in two differentiated trenches A and B distributed in three monitoring milestones as per the following table, where the first monitoring milestone corresponds to a Fund approved retroactive period. In this way, the second monitoring milestone shall represent the greatest effort Chile must make to reduce 2.5 M – tonnes of equivalent CO2.

Monitoring Milestone	Years	Report *	Trench A ER ($TonCO_2eq$)	Trench B ER ($TonCO_2eq$)	Total ER ($TonCO_2eq$)
1	2018-2019	2021	75,000	1,425,000	1,500,000
2	2020-2021	2023	125,000	2,375,000	2,500,000
3	2022-2023	2025	60,000	1,140,000	1,200,000
Total			260,000	4,940,000	5,200,000

Table 9 ER Distribution by period and section. *April of that period

On the other hand, there are ER amounts reserved and pledged in the Payment Agreement, which are associated to mitigating the risk of data Reversals and Uncertainty. These reserves come from percentages related to the total reversal risk estimation (21%), and a factor related to the uncertainty of total estimations (8%).

Monitoring Milestone	Buffer TA TonCO2eq	Buffer TB TonCO2eq	Total Buffer TonCO2eq	Total ER TonCO2eq
1	20,490	389,310	409,800	1,909,800
2	34,150	648,850	683,000	3,183,000
3	16,392	311,448	327,840	1,527,840
Total	71,032	1,349,608	1,420,640	6,620,640

Table 10 Total ER reserves by period and sections.

The makeup and details of each milestone are detailed below.

Monitoring milestone time planning

Carbon accounting in the area of the Emission Reduction Program consists of three main stages:

1. Reference Period: Historical stage where average emissions are estimated then projected as a future Reference Level. The Reference Level of Chile considers the 2001 – 2010 period for activities that occur in forest remaining forests and 2001 – 2013 for activities that generate changes in land use and have been reported by the country in 2016.

2. Exclusion Period: Intermediate stage between the end of the Reference Period and the beginning of the implementation of the Emission Reduction Program. Emissions and/or absorptions produced during this stage are estimated and excluded from the results of the program. Corresponds to the period between years 2014 and 2017 for use change activities and 2011 – 2017 for activities that occur in forest remaining forests.

3. Monitoring Period: Implementation stage of the Emission Reduction Program, divided into two periods; the regular and retroactive periods as detailed in Figure 32 between 2018 and 2025. Emission reductions and/or absorption enhancements regarding the current Reference Level of the country are estimated in both stages, with results obtained based on flux measurements between each Monitoring event with regards to the base year.

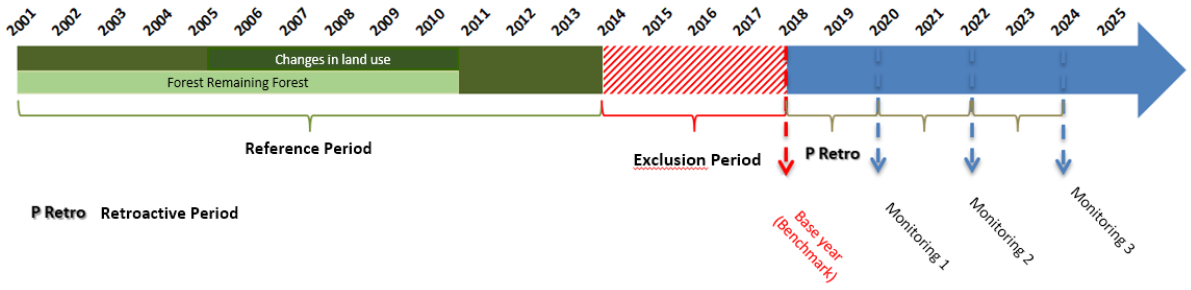


Figure 14 Emission Reduction Program Timeline.

✓ Monitoring 1: Considers the use of Cadastre update data generated through spectral analysis during the 2017/2018 dry seasons as the beginning and 2019/2020 dry season data for the end of the period, which together with information from the Forest Inventory will allow to estimate Emission Reductions associated to calendar years 2018 and 2019.

✓ Monitoring 2: Considers the use of Cadastre update data generated through spectral analysis during the 2019/2020 dry seasons as the beginning and 2021/2022 dry season data for the end of the period, which together with information from the Forest Inventory will allow to estimate Emission Reductions associated to calendar years 2020 and 2021.

✓ Monitoring 3: Considers the use of Cadastre update data generated through spectral analysis during the 2021/2022 dry seasons as the beginning and 2023/2024 dry season data for the end of the period, which together with information from the Forest Inventory will allow to estimate Emission Reductions associated to calendar years 2022 and 2023.

Activity summary

i. Imaging

Corresponds to the development of digital multi pixel mosaics for obtaining activity data on changes in land use and stable land uses. It is necessary to generate two multi pixel mosaics, initial and final years, to develop the monitoring report of a given period. For example, the initial year mosaic for the 2018 – 2019 retroactive period covers the dry season window from October 2017 to March 2018, while the time window for the final year is from October 2019 to March 2020.

A requirement for the mosaics is for them to be formed by pixels free of clouds and shadows so change detection analysis methodologies can be applied, which is why the time window must consider dry season months in Chile, between October and March, especially in the southern regions of the country.

ii. Development of in Land Use Changes Maps

The map of changes in land use is one of the main inputs for result estimation, and its development requires the application of specific change detection methodologies. During its development, it is necessary to test and validate methodologies for defining which land uses change and which uses remain stable, a process which includes attributing and verifying changes through the analysis of high-resolution images.

A database called “Traceability”, which contains the definition of REDD+ activities for polygons in the Native Forest Cadastre, is obtained from this task. This database is used to determine which surface changes its use and the direction of such changes, along with the forest surface that remains as such, on which the Forest Institute then applies the forest degradation methodology.

iii. Accuracy/error evaluation

Accuracy evaluation encompasses the estimation of the accuracy of land use change maps in ER Program regions, which must be evaluated by a third party by applying the Oloffson (2013 and 2014) methodology. This information is integrated into other sources of error that allow calculating the final uncertainty of each report.

iv. Public Conservation Areas

It addresses the collection and systematization of official information about existing conservation areas (Old and new) in the regions of the ER Program, especially spatial representation of updated boundaries of properties/conservation areas in mapped format. The Ministry of National Assets of Chile, institution in charge of surveying and updating information about state owned property boundaries, is responsible for generating and publishing this information.

Once the geographic information layers are available, the necessary geoprocessing must be conducted to add this information as attributes to changes in land use and forest degradation (forest remaining forest) data sets.

Private Conservation Areas

Private Conservation Initiatives incorporated as attributes to activity data correspond to private owned property surfaces under conservation regimes. This information is managed by the Ministry of the Environment, which is in charge of generating spatial information for the property limits in these areas, then processed with activity data to be added to data sets as attributes.

v. Carbon Maps

The development of carbon maps corresponds to the forest degradation methodology conducted by the Forest Institute. It consists in processing multi pixel mosaics with stand state variables by forest type, in order to aggregate information at the pixel level regarding position in the stock chart, carbon content in the period and flux compared to the previous period. This stage includes the analysis of results in forest remaining forests regarding the reference level and uncertainty estimation.

vi. Fire statistics

Addresses the integration of fire statistical information, which is generated by CONAF and delivered in July every year. These data are used to estimate degradation emissions in forests due to fires, calculating methane and nitrous oxide emissions.

vii. ER calculation and information integration

Estimations of carbon emissions/absorptions into the atmosphere calculations can be conducted once systematized and updated activity data information is available for the entire study area, which covers the use of the traceability database, emission factors and the application of a degradation methodology. Both result calculation and integration are organized in Excel spreadsheets named “Tools”, spreadsheets where IPCC equations are entered to obtain result estimations, according to the determined scale and scope.

viii. Report Development

The last stage for reporting monitoring milestone results covers the development of the document which compiles and systematizes results, providing information regarding work methods, information sources and considerations for obtaining results. Includes the full uncertainty calculation chapter.

Activity integration and planning

The activities described above are organized over time according to Table 27

RESPONSIBLE INSTITUTION	UNIT	ACTIVITY	Year 1												Year 2											
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
			O	N	D	E	F	M	A	M	J	JL	A	S	O	N	D	E	F	M	A	M	J	JL	A	S	O	N	D
LAND USE CHANGE MAP DEVELOPMENT																										
CONAF	DMEF	Satellite Imaging																								
CONAF	GASP	Public Conservation Areas																								
MMA		Private Conservation Areas																								
CONAF	DMEF	Processing																								
CONAF	3ro	Uncertainty Evaluation																								
CARBON STOCK MAPS																										
INFOR	CC INFOR	Carbon Stock Maps																								
REPORT DEVELOPMENT																										
CONAF	GEPRIF	Forest Fires Data																								
CONAF	UCCSA/MRV	Calculation and Integration																								

Table 11 Activity Gantt Chart

The activities described and organized in the previous Gantt chart are highlighted as shown in Figure 33, highlighting the dependence between obtaining satellite data and developing maps of changes in land use; the same satellite data and definition of forest remaining forest areas for the development of Forest Carbon Maps.

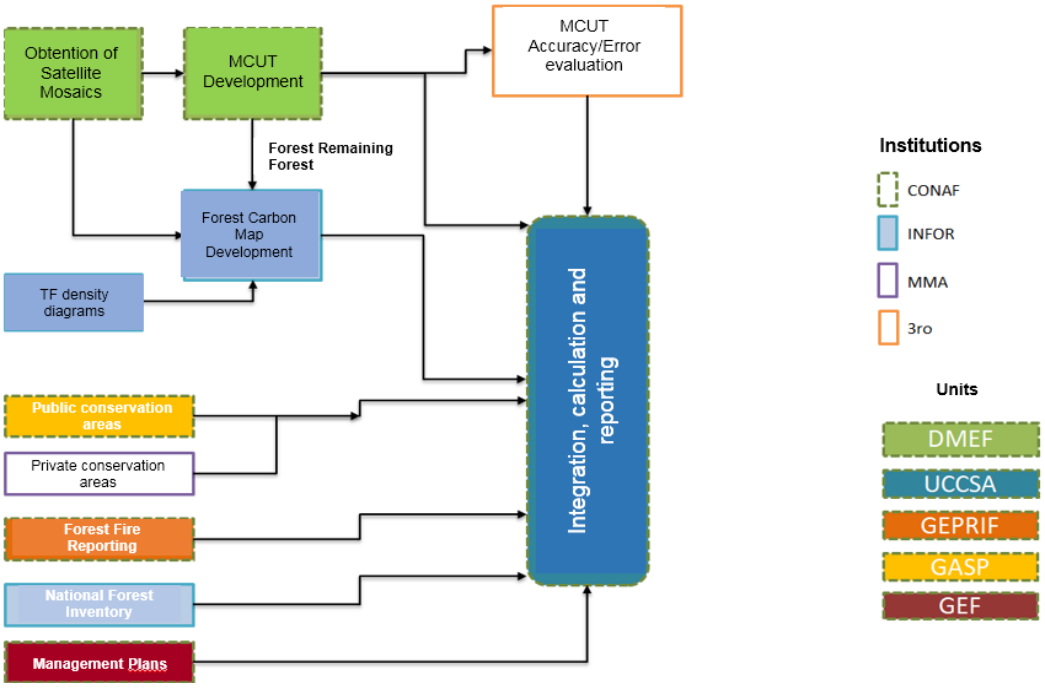


Figure 15 REDD+ reporting process general flow.

Buffer Reserves

As mentioned in the buffer guidelines of the program, there are 3 equivalent CO_2 allowances to be used as buffer reserves:

1. Uncertainty Buffer: Reserve associated to the uncertainty from ER estimations, which allow to manage risks from overestimated emission reductions during previously reported periods;
2. Reversal Buffer: Reserve that allows to offer guarantees in the face of potential reversals;
3. Grouped Buffer.: Reserve that allows to offer guarantees in the face of potential large scale reversals that exceed the amount of buffer ERs that are set aside in the reversal buffer account

Each of these percentages is calculated according to FCPF guidelines and reported in tonCO_2 for each transaction, in separate accounts, by reserve type and trenches.

9.1 Measurement, monitoring and reporting approach for estimating emissions occurring under the ER Program within the Accounting Area

The approach applied by the country is based on the preparation of land use / land use change maps, from which the stable and changing forest areas are defined for both the reference period and the period of follow-up. The first step in the process is the preparation of the land use change map and the second is the preparation of the carbon stock map, for monitoring degradation. These are the most important points in the process. Then the information on forest fires is included, to end with the monitoring of emission factors.

Line Diagram

A line diagram outlining the important monitoring points, parameters monitored and the integration process according to the two areas of result estimation is shown below. In addition, specific diagrams according to REDD + activity are presented in the text. The next figure shows in a summarized way, the sources of information for the generation of emissions and absorption estimations.

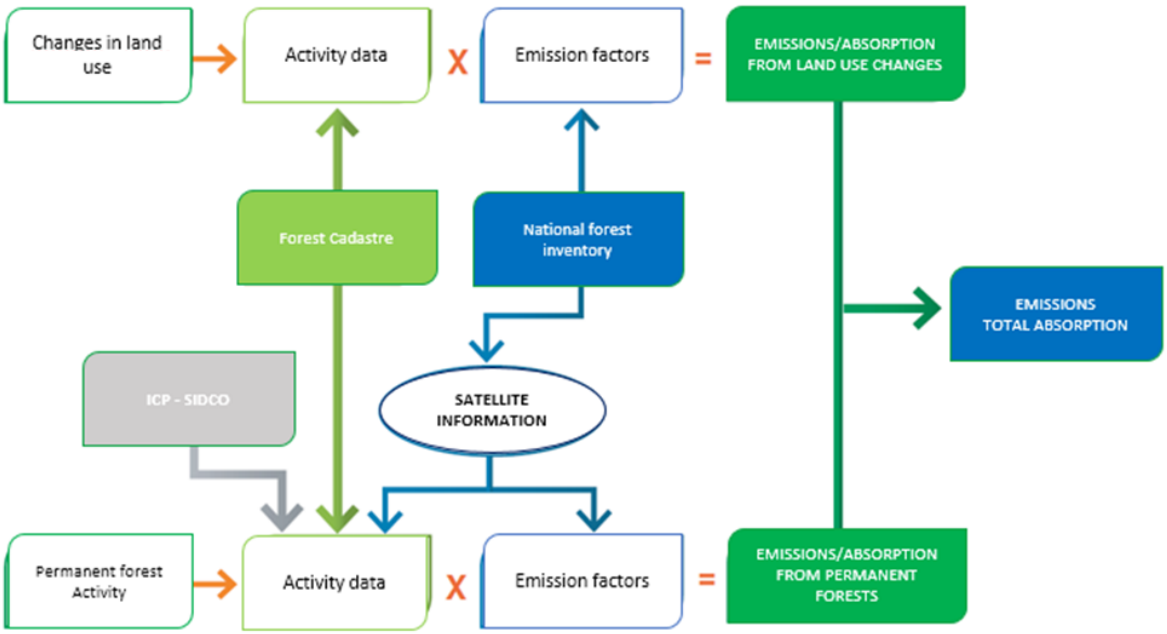


Figure 16 Sources of information for the generation of forest carbon emissions and absorption estimations.

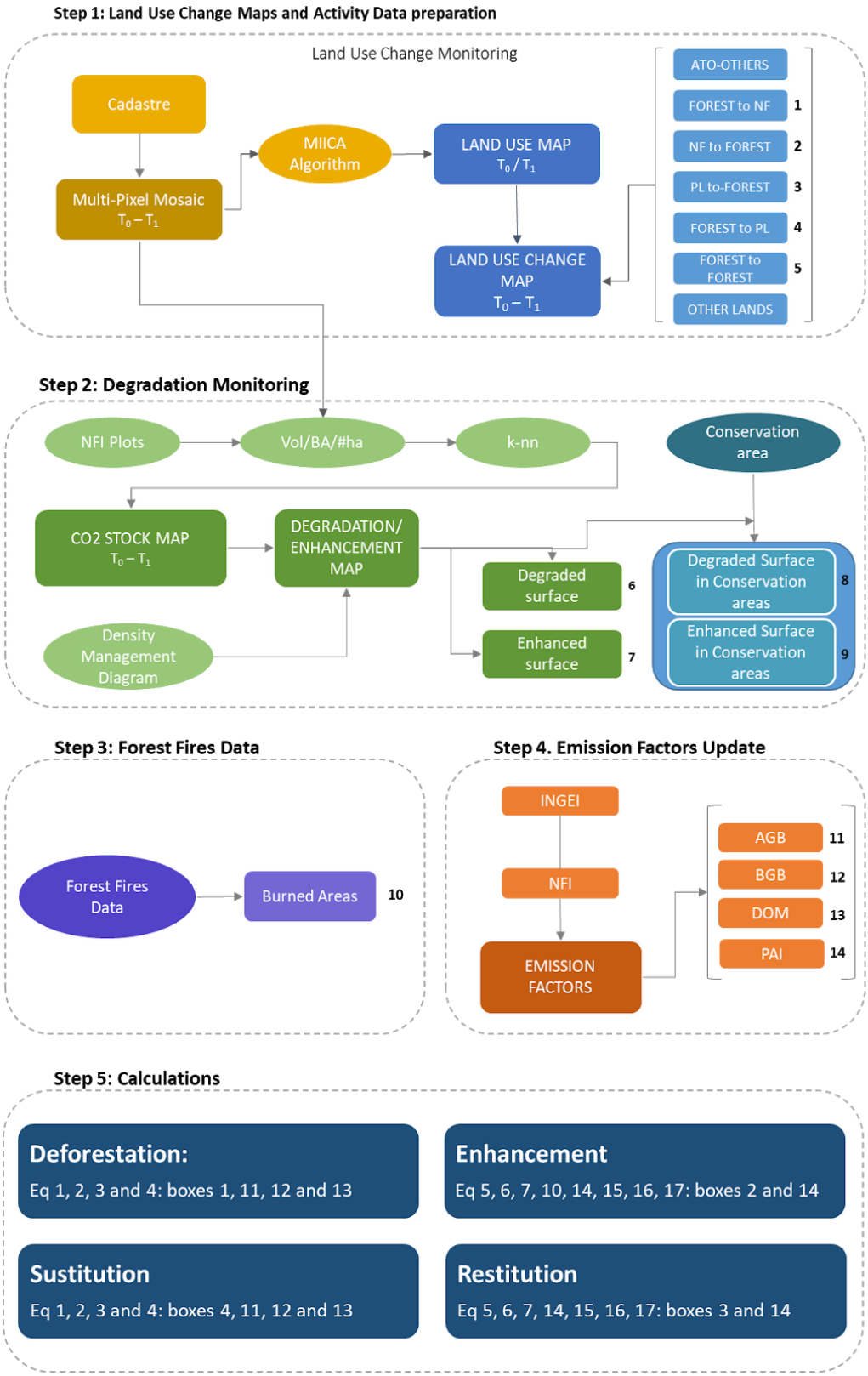


Figure 17 Methodological diagram of the Measurement and Monitoring process

Calculation Steps

Captures and emissions are estimated in the NFMS by applying the IPCC 2006 equations, in accordance with the methodology applied by INGEI. The equations applied are the same ones presented in the ERPD, both for the reference period and the result monitoring. They are detailed below, by REDD+ activity:

Deforestation

The methodology for calculating deforestation is based on the IPCC 2006 equations for forest lands converted into other lands, which are also used in the INGEI for calculating emissions from forests converted into other land uses. Above ground biomass, below ground biomass and DOM reservoirs are included.

Equation 37. Estimation of Deforestation

$$FREL_{Def} = \frac{\sum_t^n \Delta C_{B_{t,Def}}}{p} * \frac{44}{12}$$

Where:

- Def = annual average carbon stock losses in forest lands converted into non – forest during the reference and monitoring period, in ton CO_2e $year^{-1}$
- $\mathrm{CBt,\ Def}$ = carbon stock change in forest lands converted into non – forest in year t of the reference and monitoring period, in ton C
- *p* = years of the reference and monitoring period
- $44/12$ = factor for converting carbon into equivalent carbon dioxide, ton CO_2e ton C^{-1}

Tier 3 of the IPCC methodology is used in estimations of emissions from deforestation, as carbon stocks in land uses before and after conversion are specific to Chile, with conversion areas being broken down by original land cover type (Sidman et al., 2015).

As recommended in IPCC (2006), Equation 2.15 is used to calculate annual carbon stock changes in wooded lands converted into other land use categories (in the case of deforestation, any forest area converted into non – forest)

Equation 38 [Eq. 2.15 of IPCC (2006)]

$$\Delta C_{B_{t,Def}} = \Delta C_{G_t} + \Delta C_{CONVERSION_t} - \Delta C_{L_t}$$

Where:

- $\Delta C_{B_{t,Def}}$ = annual carbon stock change in forest lands converted into non – forest in year t under deforestation activity (Def), in ton C
- ΔC_{G_t} = annual enhancement in carbon stocks due to growth in forest lands converted into non – forest in year t, ton C
- $\Delta C_{CONVERSION_t}$ = initial change in biomass carbon stocks in forest lands converted into non – forest in year t, in ton C
- ΔC_{L_t} = annual loss of biomass carbon stocks due to wood harvesting, firewood extraction and disturbances in forest lands converted into non – forest in year t, in ton C

In this equation, changes in carbon stocks from gains and losses due to any activity other than conversion (ΔC_G and ΔC_L) to net gains and losses directly due to conversion ($\Delta C_{CONVERSION}$; in case of deforestation, as it generally results in a negative value due to the loss in forest carbon stocks) to calculate total changes in carbon stocks.

The NFMS of Chile includes ΔC_G, which represents carbon captures for non – forest uses after conversion (agricultural, urban, others). This variable will be given a value of zero, as it does not impact the deforestation loss analysis.

Equation 39 [Eq. 2.16 of IPCC (2006)]

$$\Delta C_{CONVERSION_t} = \sum_{i}^{n} \left\{ \left(B_{AFTER_i} - B_{BEFORE_i} \right) * \Delta A_{TO_{OTHERS_{i,t}}} \right\} * CF$$

Where:

- $\Delta C_{CONVERSION}$ = initial change in biomass carbon stocks in forest lands converted into non – forest, in ton C year^{-1}.
- B_{AFTER_i} = existence of biomass in non – forest land use type i after conversion, in dry biomass tons per hectare.
- B_{BEFORE_i} = existence of biomass in forest type before conversion, in dry biomass tons per hectare.
- $\Delta A_{TO_{OTHERS_{i,t}}}$ = forest type *i* area converted into non – forest in year t, in ha.
- CF = carbon fraction in dry biomass, in tons of carbon by tons of dry biomass. 0.47 is the default value as per IPCC AFOLU guidelines 2006, Table 4.3.

In the case of deforestation, these two equations can be represented with two essential inputs ($\Delta A_{TO_OTHERS_i}$), frequently called activity data (AD) and the amount of carbon stocks emitted due to conversion (B_{AFTER_i} - B_{BEFORE_i}), frequently called emission factors (EF). Parameters B_{AFTER_i} and B_{BEFORE_i} only include above and below ground biomass, so DOM is included by adding parameter ΔC_{DOM} calculated according to the following equation:

Equation 40 [Eq. 2.23 of IPCC (2006)]

$$\Delta C_{DOM_t} = \frac{(C_n - C_o) \times A_{on_t}}{T_{on}}$$

Where:

- ΔC_{DOM_t} = DOM carbon stock change in year t, ton C.
- C_n = dead wood and DOM carbon stocks in non – forest land use after conversion, ton C year^{-1}.
- C_o = dead wood and DOM carbon stocks in forest before conversion into non - forest, ton C year^{-1}.
- A_{on_t} = area converted from forest into non – forest in year t, hectares.
- T_{on} = time period for the forest into non – forest transition.

In this equation A_{on} corresponds to activity data, or $A_{TO_{OTHERS_i}}$, according to the parameter of previously described Equation 3. In order to simplify accounting, DOM emissions will be counted in the year of conversion (meaning T_{on} is supposed to have a value of 1).

The process for calculating emissions from deforestation is summarized in the following diagram:

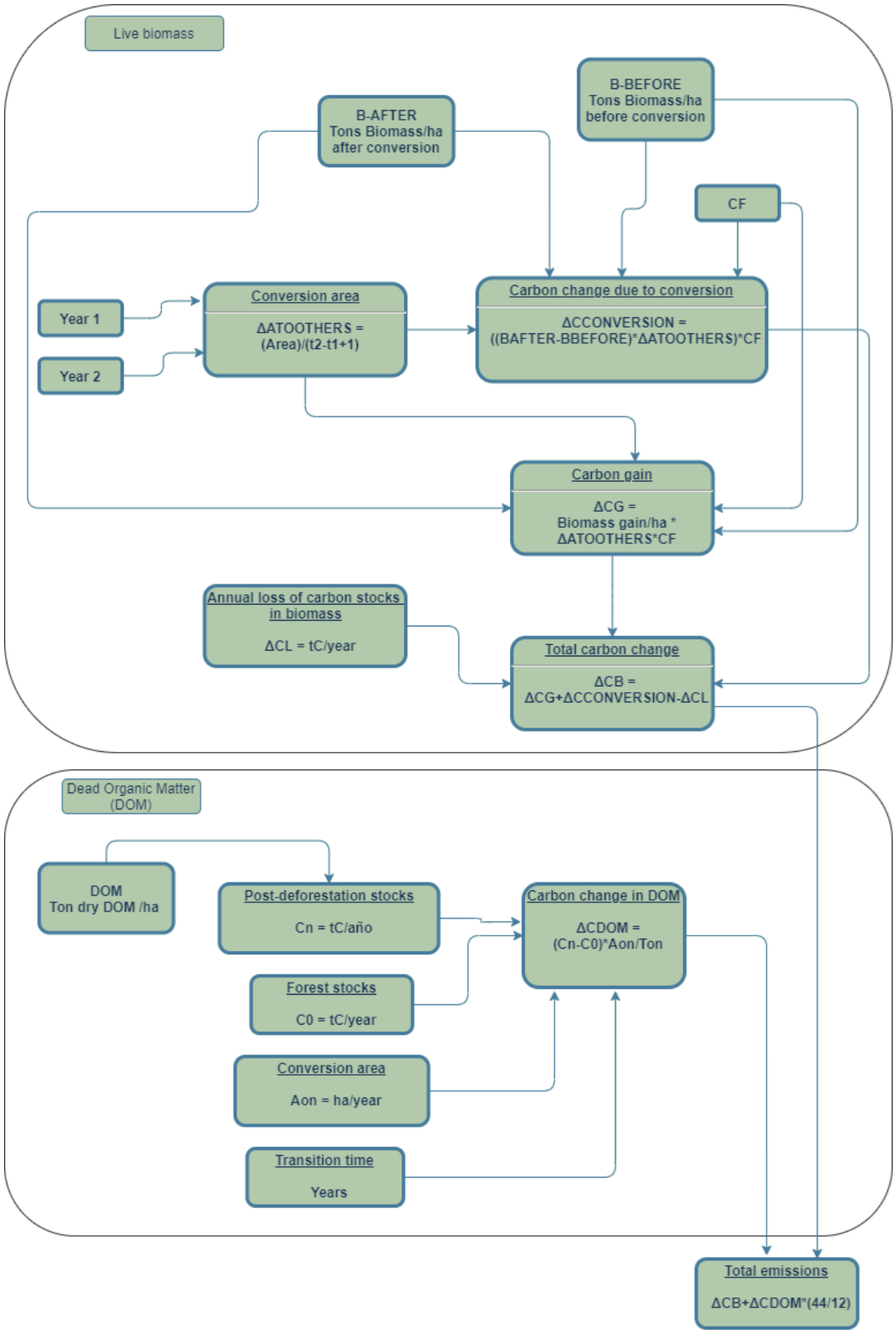


Figure 18 Step-by-step diagram for estimating emissions from deforestation.

Degradation from substitution

The equation used for estimating deforestation is applied to estimate degradation in native forests converted into plantations, as it is assumed that for a plantation to be established, all carbon content in the preceding native forest must be reduced to zero. Equation 1 is used to calculate the reference and monitoring period in CO_2e. Step-by-step diagram summarizing the process is presented below:

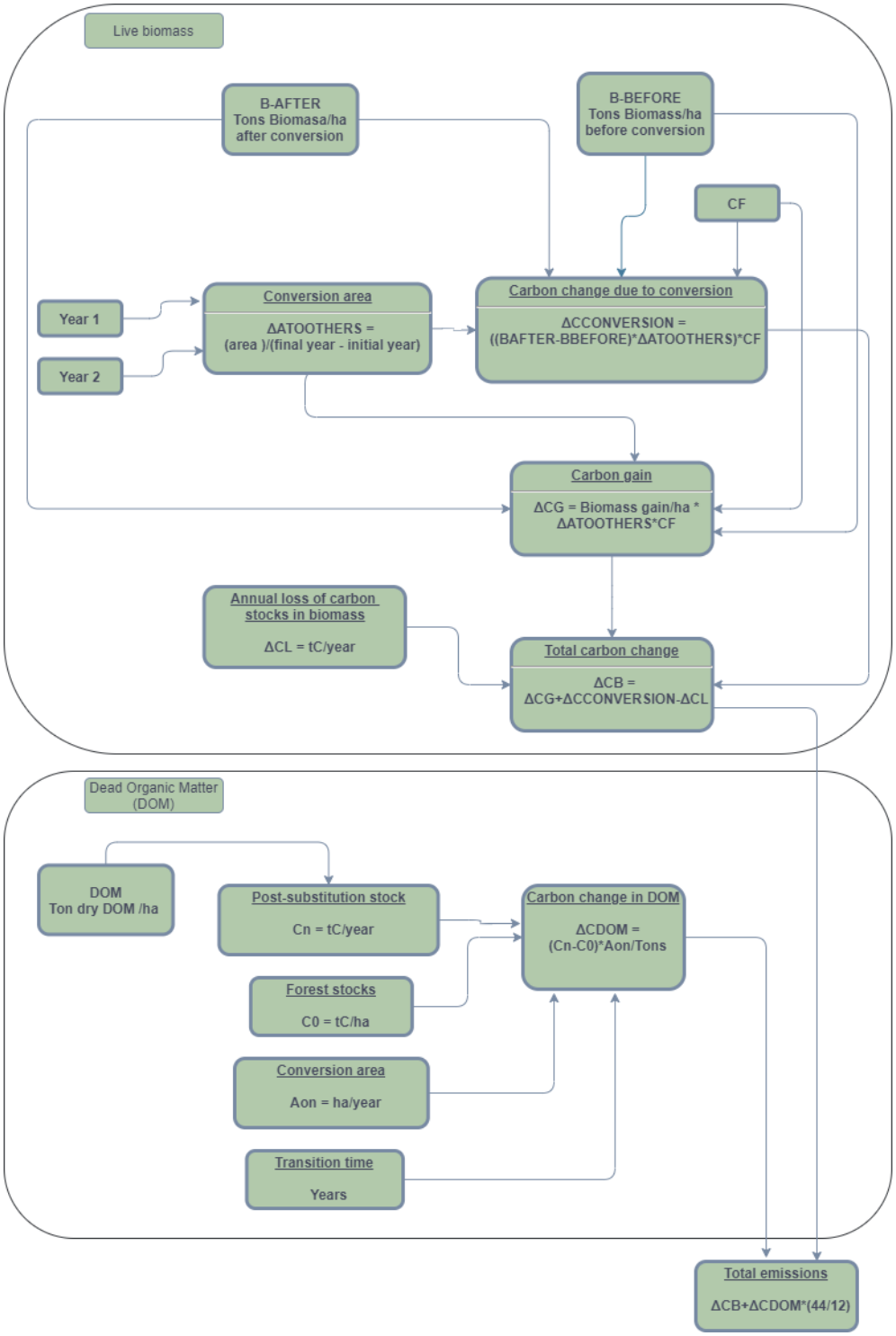


Figure 19 Step-by-step diagram for estimating emissions from Substitution.

Forest area Restitution and carbon stock Enhancement

As in the other calculated activities, the methodology for enhancements in other lands converted into forests is consistent with the methodology used in INGEI which is based on equations 2.9, 2.10 and 2.15 of IPCC (2006).

The general equation corresponding to Tiers 2 and 3 of IPCC (2006) is 2.15, used for calculating annual changes in carbon stocks in above and below ground biomass (the only reservoirs included in enhancement estimations) and lands converted into other land uses (In this case, non – forest into forest):

Equation 41 [Eq. 2.15 of IPCC (2006)]

$$\Delta C_{B_{t,\,ANFF}} = \Delta C_{G_t} + \Delta C_{CONVERSION_t} - \Delta C_{L_t}$$

Where:

- $\Delta C_{B_{t,\,ANFF}}$ = carbon stock enhancements in year t, from non – forest lands converted into forests during the reference period, under the stock enhancement activity (A), in ton C.
- ΔC_{G_t} = carbon stock enhancement due to growth in non – forest lands converted into forest year t, in ton C.
- $\Delta C_{CONVERSION_t}$= initial carbon stock change in non – forest lands converted into forests in year t, in ton C.
- ΔC_{L_t} = annual carbon stock decrease due to wood harvesting, firewood extraction and disturbances in non – forest lands converted into forest in year t, in ton C.

The estimations for enhancements assumes ΔCL to be zero, due to the lack of sufficient data to quantify losses in non – forest areas converted into forest. Equation 2.16 of IPCC (2006) is used for the parameter $\Delta C_{CONVERSION_t}$:

Equation 42 [Eq. 2.16 of IPCC (2006)]

$$\Delta C_{CONVERSION_t} = \sum_{i}^{n} \left\{ \left(B_{AFTER_i} - B_{BEFORE_i} \right) * \Delta A_{TO_{OTHERS_{i,t}}} \right\} * CF$$

Where:

- $\Delta C_{CONVERSION_t}$ = initial carbon change in non – forest lands converted into forest in year t, ton C.
- B_{AFTER_i} = biomass stocks in forest type i immediately after conversion, ton m.s. ha^{-1}.
- B_{BEFORE_i}= biomass stocks in land type i before conversion, ton d.m. ha^{-1}.
- $\Delta A_{TO_{OTHERS_{i,t}}}$= non – forest land use surface converted into forest in year t, ha.
- CF = carbon fraction in dry matter, ton C (ton m.s.)$^{-1}$ 0.47 is the default value as per IPCC AFOLU guidelines 2006, Table 4.3.

For parameter ΔCG (enhancement due to forest growth), INGEI uses IPCC 2006 Equation 2.9 for a Tier 2 – 3 calculation. Nevertheless, INGEI only uses it for lands converted into forest in the year of conversion.

Equation 2.9 of IPCC (2006) calculates annual carbon enhancements. But Equation 6 [(Eq. 2.16 of IPCC (2006)] does not consider captures converted in previous years that keep accumulating in strata "i". So it is necessary to modify equation 2.9 of IPCC (2006) in the following manner to achieve a correct accounting:

Equation 43 [adapted from Eq. 2.9 of IPCC (2006)]

$$\Delta C_{G_t} = \sum_{i}^{n} \sum_{x}^{m} \left(A_{i,x} * G_{TOTAL_i} * CF \right)$$

Where:

- ΔC_{G_t}= carbon stock enhancement in year t, due to growth in non – forest lands converted into forest type i during the reference period, in ton C.
- $A_{i,x}$= Area converted into forest i in year x of the reference period, ha.
- G_{TOTAL_i}= annual average biomass growth in non – forest lands converted into forest type *i*, ton d. m. ha^{-1} $year^{-1}$.
- *CF* = dry matter carbon fraction, ton C (ton d.m.)$^{-1}$ · 0.47 is the default value as per IPCC AFOLU guidelines 2006, Table 4.3.

Equation 7 considers that for calculating ΔC_{G_t} in year t, it is necessary to add captures from areas converted in each year x before year t in the reference and monitoring period, to captures from areas converted in year t. In case a forest reaches adulthood and stops capturing CO_2 from the atmosphere, it should be removed from enhancement accounting. Nevertheless, this is not supposed to happen during the reference and monitoring period.

The following diagram represents step by step the calculation of removals due to increases from non-forest to forest and restitution (plantation to native forest). In the lower part, the number of years considered in the reference period is represented (13 in total), indicating that forests grow cumulatively from year 1 to year 13.

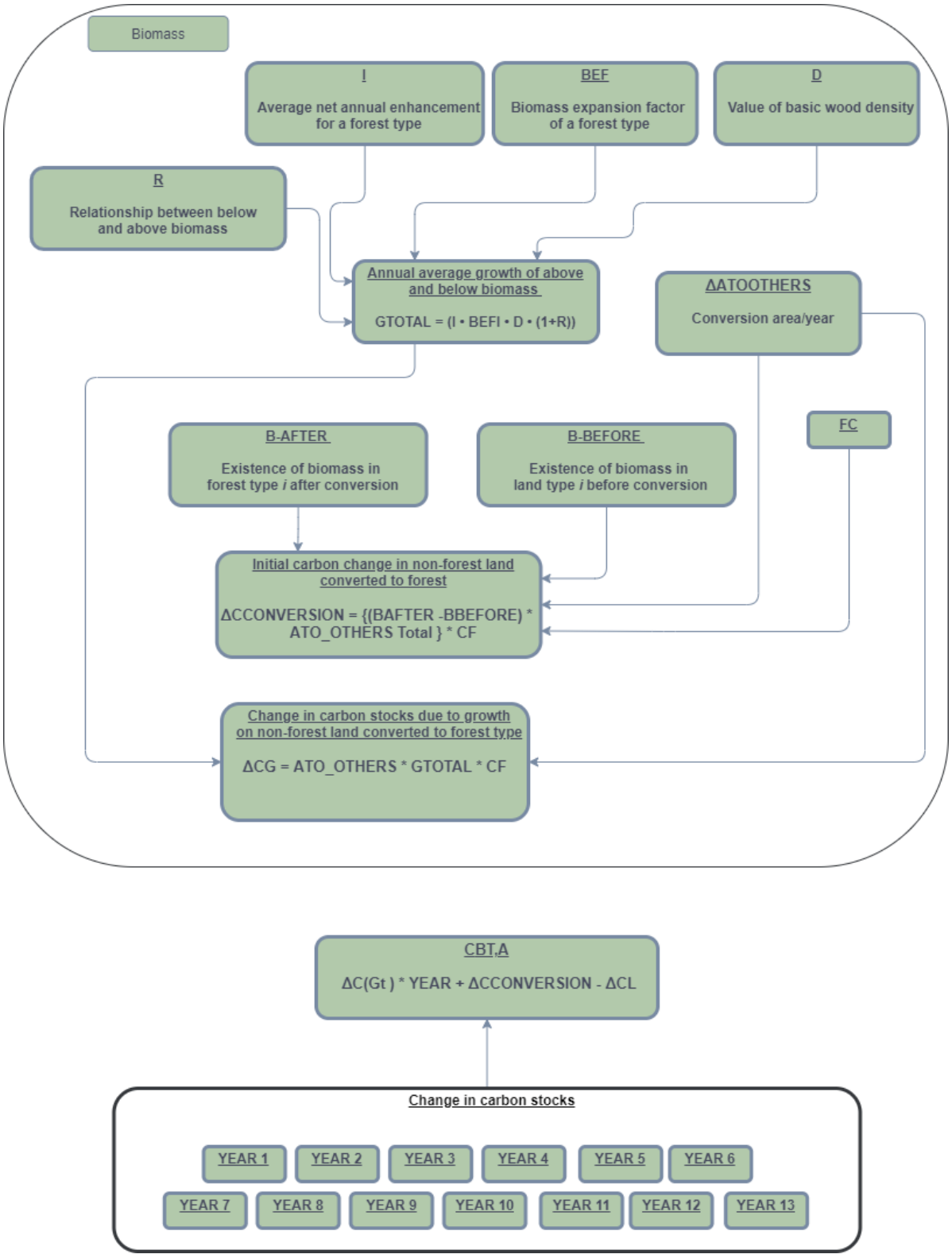


Figure 20 Step-by-step diagram for estimating removal from Enhancement.

Forest Remaining Forest
Degradation

Equation 2.8 of IPCC (2006) is used to estimate changes in carbon stocks in forest lands that remain as such due to degradation:

Equation 44 [Eq. 2.8 of IPCC (2006)]

$$\Delta C_{B_{t,DegFF}} = \frac{(C_{t_2} - C_{t_1})}{(t_2 - t_1)}$$

Where:

- $\Delta C_{B_{t,Deg}}$ = annual carbon stock change in forest lands that remain as such considering total area under degradation activity (*DegFF*), ton C.
- C_{t_2}= total forest carbon in year t_2, ton C.
- C_{t_1}= total forest carbon in year t_1, ton C.

The equation is applied for the reference level accounting described in Bahamondez *et al.* (2009)[33]. This methodology accounts for carbon stocks at different points in time, where the difference in carbon stocks in forest lands is considered degradation in case of losses. On the other hand, INGEI uses a loss – gain method, Equation 2.7 of IPCC (2006) instead of the stock difference method found in IPCC 2006 equation 2.8, where tabular data from INFOR is integrated to estimate volume extracted through selective logging, INFOR and MINENERGIA firewood statistics, and CONAF tabular data for the surface of fires in native forest and forest plantations. According to national experts, firewood extraction data are not very robust or representative of degradation in a comprehensive manner. The methodology used in NFMS allows to achieve Approach 3 results, spatially explicit data, and is based on robust and independent sources of information.

IPCC equation 2.8 is used to calculate carbon stocks in the initial and final moments of the reference period (C_1 and C_2 in Equation 8):

Equation 45 [Eq. 2.8 of IPCC (2006)]

$$C_t = A_{Deg} * EF * CF$$

Where:

- $C_{t,i}$= total forest carbon in year t, ton C.
- A_{Deg}= degradation area in forest that remains as such, ha.
- EF= carbon stocks in forest that remains as such, ton biomass ha^{-1}.
- CF= carbon fraction, t carbon t $biomass^{-1}$. 0.47 is the default value as per IPCC AFOLU guidelines 2006, Table 4.3.

[33] Bahamóndez, C., Martin, M., Muller-Using, S., Rojas, Y., Vergara, G., 2009. Case Studies in Measuring and Assessing Forest Degradation: An Operational Approach to Forest Degradation. (Forest Resources Assessment Working Paper). Forestry Department, Food and Agriculture Organization of the United Nations

Stock Enhancement in Forest remaining forest

IPCC (2006) equation 2.8 was used to calculate annual stock enhancements:

Equation 46 [Eq. 2.8 of IPCC (2006)]

$$\Delta C_{B_{t,AFF}} = \frac{(C_{t_2} - C_{t_1})}{(t_2 - t_1)}$$

Where:

- $\Delta C_{B_{t,AFF}}$ = annual carbon stock change in forest lands that remain as such, considering total area under stock enhancement activity (*DegFF*), ton C year^{-1}.
- C_{t_2}= total forest carbon in year t_2, ton C.
- C_{t_1}= total forest carbon in year t_1, ton C.

Carbon contents in year t_1 (2001) and t_2 (2010) were obtained from the results of applying the methodology that allows to identify areas that were below threshold or line B at the start of the reference and monitoring period.

Forest Conservation

As explained in previous sections, emissions and removals for Forest Conservation is estimated by adding emissions from forest degradation in forest remaining forest and absorptions from the restoration of degraded forests in forest areas under formal conservation processes.

Equation 47

$$\Delta C_{B_{t,ConFF}} = \Delta C_{B_{t,AFF}} - \Delta C_{B_{t,DegFF}}$$

Where:

- $\Delta C_{B_{t,C}}$= carbon stock annual change in forest lands subject to formal conservation processes in year t, in ton C
- $\Delta C_{B_{t,AFF}}$= annual changes in carbon stocks due to recovery of degraded forests in areas subject to formal conservation processes, in ton C year^{-1}.
- $\Delta C_{B_{t,DegFF}}$= annual changes in carbon stocks due to forest degradation in forest lands subject to formal conservation processes, in ton C year^{-1}.

In the following diagram the summary of steps for estimating emissions and captures in forest remaining forest is presented, both for increases, degradation and conservation. As can be seen, the conservation areas correspond to a part of the forest remaining forest that is under protection. It is defined by the geographic limit that delimits the area.

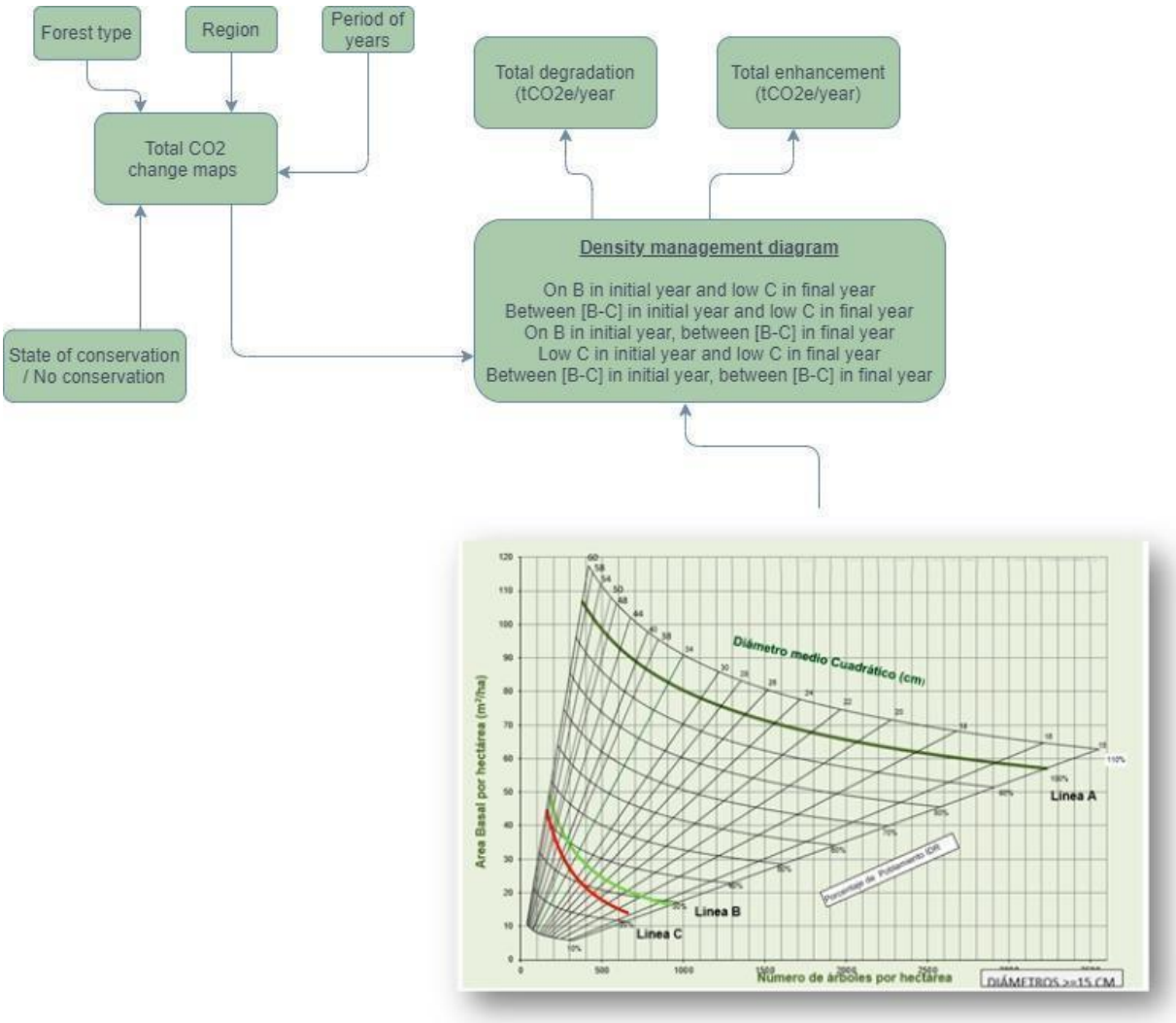


Figure 21 Step by step diagram for estimating emissions and removals from forest remaining forest.

Non -CO_2 emissions from Forest Fires

The methodology by Bahamondez et al. (2009) estimates CO_2 emissions in forest remaining forests. Therefore, Equation 2.27 of IPCC (2006) is used to calculate non – CO_2 emissions from forest fires:

Equation 48 [Eq. 2.27 of IPCC (2006)]

$$L_{fire} = A * M_B * C_f * G_{ef} * 10^{-3}$$

Where:

- L_{fire} = amount of greenhouse gas emissions caused by fire, ton of each GHG gas year^{-1}
- A = burned surface, ha year^{-1}
- M_B= fuel mass available for combustion, ton ha^{-1}.
- C_f= combustion factor, no dimension. The value applied is 0.45 according to IPCC 2006.
- G_{ef} = emission factor, g kg^{-1} of burned dry matter. Emission factors used for the equation is 4.7 for CH_4 and 0.26 for N_2O.

Equation 14 is used to convert L_{fire} into CO_2e which is necessary for Equation 13:

Equation 49

$$GEI_{fire} = L_{fire} * CF$$

Where:

- CF = conversion factor of non no-CO_2 gas into CO_2e, ton gas no-CO_2 ton CO_2e^{-1}. CF value is 25 for CH_4 and 298 for N_2O, according to IPCC 2006.

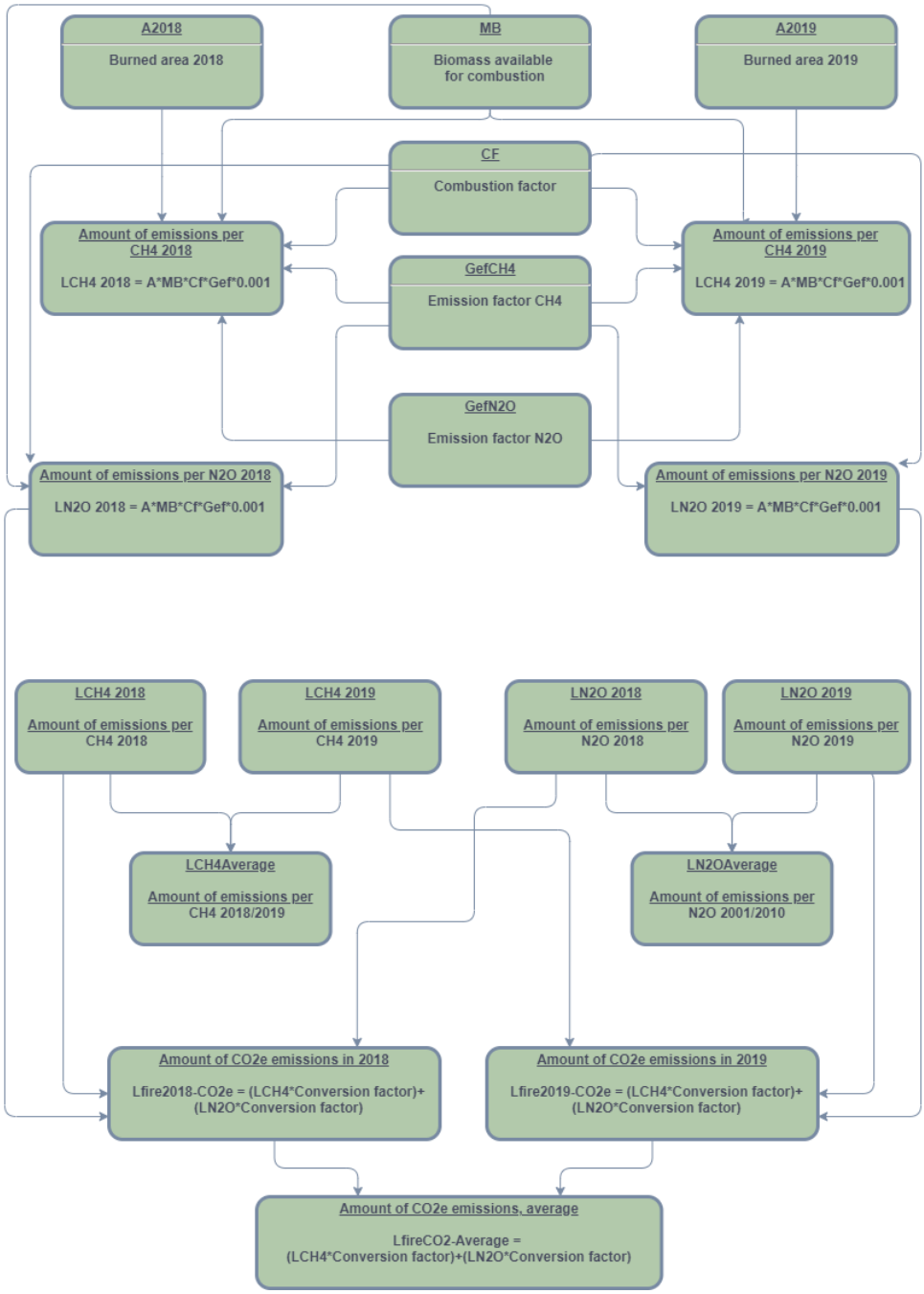


Figure 22 Step by step diagram for estimating emissions from forest fires.

Emission Factors

Deforestation

Carbon stocks before deforestation (BBEFORE)

Forest carbon stocks before deforestation were obtained from the information base of the INGEI of Chile. These numbers are derived from the national forest inventory in order to reach a Tier 3 living Above ground biomass estimation. Estimations are stratified by forest type to obtain carbon contents before deforestation. Information of changes in land use was updated to include forest type data.

Above and below ground biomass (BBEFORE in Equation 3 and 6) along with DOM (Co in Equation 4) are obtained from the GHG national inventory. Under deforestation accounting, harvested wood products (HWP) carbon stocks are supposed to be zero, due to the lack of reliable sources of data for distinguishing between HWP due to deforestation and HWP due to degradation.

Carbon stocks after deforestation (BAFTERi)

INGEI uses IPCC (2006) default values for BAFTERi, but these values are supposed to be the non – forest land use growth that really corresponds to ΔCG. For FREL estimations, carbon stocks directly after deforestation in deforested lands will be assumed to be zero.

Changes in carbon stocks other than deforestation events (ΔCG and ΔCL)

Post – deforestation carbon stocks (ΔCG) are determined in one of two ways:

- Values taken from a literature review of non – forest carbon stocks, ideally studies conducted in Chile (such as Gayoso 2006). If these studies are not available, data from other regional studies (Temperate South America under similar management regimes) can be used. This is the preferred method, representing a Tier 2 or 3 approach.
- When these values are not available, IPCC (2006) default values can be used. This is the method being currently used by the INGEI but represents a Tier 1 method.

Losses due to wood harvesting, firewood extraction and disturbances (ΔCL) are supposed to be zero in deforestation areas, using the same assumption as INGEI

Degradation from Substitution

Carbon stock estimations derived from National Inventory plots and other carbon stock studies in other land uses are utilized for the emission factors in changes from native forest into plantation. Biomass stock estimations in plantations are assumed to be zero (0), as stocks in the native forest are supposed to have been reduced to zero before the establishment of the plantation.

Forest Surface Enhancement and Restitution

The value of B_{AFTER_i} in Equation 7 is supposed to be zero for agricultural lands and urban – industrial areas, as carbon stocks in non – forest land use converted into forest have been removed before forests are established. For natural land uses, mainly grasslands and scrubs, $B_{AFTER_i}$is supposed to be equal to B_{BEFORE_i}, as no clearing or cleaning processes are supposed to take place in those lands before the forest is established, but rather are naturally converted into forest without losing initial carbon stocks. Carbon stocks in $B_{BEFORE_i}$are equivalent to carbon stocks in non – forest land use. National or regional scientific reports such as Gayoso (2006) which have estimated carbon stocks in non – forest land uses are used for these stocks.

In Equation 7, G_{TOTAL_i}, average annual biomass growth per hectare for each forest type is calculated through Equation 14 (modified from Equation 2.10 in IPCC 2006).

Equation 50 [adapted from Eq. 2.10 of IPCC (2006)]

$$G_{TOTAL} = \sum_i \left(I_{vi} * BCEF_i * (1 + R_i)\right)$$

Where:

- G_{TOTAL} = average annual above and below ground biomass growth, ton d. m. ha^{-1} $year^{-1}$.
- I = annual average net increase for one forest type, m^3 ha^{-1} $year^{-1}$.
- $BCEF_I$ = biomass expansion and conversion factor for the conversion of annual net volume increase into Above ground biomass growth for one forest type, tons of aerial growth (m^3 of annual average increase)$^{-1}$.
- R = relation between above and below ground biomass for one forest type in ton m.s of below ground biomass (ton m.s. of Above ground biomass)[1].

Annual average net increase values, I, are gathered in the INGEI data set, based on data from national forest inventory, which estimates values for the following forest types: Alerce, Ciprés de las Guaitecas, Araucaria, Ciprés de la Cordillera, Lenga, Coihue de Magallanes, Roble Hualo, Roble-Raulí-Coihue, Coihue-Raulí-Tepa, Esclerófilo and Siempreverde. Equation 15 is used for calculating $BCEF_i$:

Equation 51

$$BCEF_i = BEF_i * D_i$$

Where:

- BEF_I= Biomass expansion factor for one forest type. This factor expands total above ground biomass value to offset the non – marketable components of the increase, no dimension.
- D = basic wood density value, ton m^{-3}. The value applied for D is 0.496166.

The biomass expansion factor, BEF_I, and wood basic density value, D, come from the INGEI data set, having a BEF_I value for native forests, not classified by forest type, by Gayoso et al (2002). Likewise, there is only one wood density value for native species, without INGEI defining the original source, which is used for ensuring consistency with the INGEI. The relation between above and below ground biomass in native forests, R, was estimated by Gayoso et al (2002) and is found in the INGEI data set. The value applied for R is 0.2869.

Forest remaining forest

Emission factors for degradation in forests remaining forests, carbon content enhancement from restoration of degraded forests, and forest conservation all use the same methodology.

The emission factors come from the national forest inventory, which is the basis for the methodology. The methodology determines a basal areafor each forest hectare in t_1 and t_2. The total volume of each hectare is calculated based on this data:

Equation 52

$$Vol = KAB^{\beta}$$

Where:

- Vol= Volume of trees in forest, cubic meters ha^{-1}.
- AB= Basal area square meters ha^{-1}.
- K= constant, value of 2,9141.

- β = constant, value of 1,2478.

To convert volume into CO_2 for its use in equation:

Equation 53

$$EF = Vol * D * BEF$$

Where:

- EF = carbon stocks in forests that remain as such, ton biomass ha^{-1}.
- Vol = Volume of trees in forest, cubic meters ha^{-1}.
- D = average forest density, tons $meters^{-3}$.
- *BEF* = biomass expansion and conversion factor for the conversion of annual net volume increase (bark included) into above ground biomass growth for one forest type, above ground biomass growth in tons (m^3 of average annual increase)$^{-10}$.

CALCULATION OF ANNUAL EMISSION HISTORICAL AVERAGE DURING THE REFERENCE PERIOD

Forest Degradation

There are two sub activities under the degradation activity, according to the definitions:

3. Degradation in forest remaining forest.
4. Degradation from Substitution.

Various methodologies are used for each sub – activity type as previously described and justified, to calculate FREL, adding different methodologies and reference periods in ton CO_{2e}, using the following equation:

Equation 54

$$FREL_{Deg} = \frac{(\sum_t^n \ \Delta C_{B_{t,DegFF}} + \sum_t^n \ \Delta C_{B_{t,DegFNF}}) * \frac{44}{12} + \sum_t^n \ GEI_{fire}}{p}$$

Where:

- $FREL_{Deg}$ = carbon stock annual average losses due to forest degradation during the reference period, in ton C $year^{-1}$.
- $\Delta C_{B_{t,DegFF}}$ = carbon stock change in forest lands that remain as such in year t of the reference period, in ton C.
- $\Delta C_{B_{t,DegFNF}}$ = carbon stock change in forest lands converted into arborescent scrub or plantations in year t of the reference period, in ton C.
- GEI_{fire}= Amount of non-CO_2 gas emissions from forest fires, ton CO_{2e}.
- *p* = years of the reference period.
- $\frac{44}{12}$ = factor for converting carbon into equivalent carbon dioxide, ton CO_{2e} ton C^{-1}.

Forest Carbon Stock Enhancement

Captures associated to areas that change from non – forest into forest, along with captures from forest areas that remain as such are accounted under the stock enhancement category.

3. Forest surface restitution and enhancement.
4. Restoration of degraded forests

Likewise, FREL activity data regarding forest carbon stock enhancements is estimated using differentiated methodologies for forests that remain as such and the identification of non – forest areas converted into forests, just as in the degradation FREL.

Equation 55

$$FRL_A = \frac{(\sum_t^n \ \Delta C_{B_{t,ANFF}} + \sum_t^n \ \Delta C_{B_{t,AFF}}) * \frac{44}{12}}{p}$$

Where:

- FRL_A = annual average carbon stock increase during the reference period, in ton CO_2e $year^{-1}$.
- $\Delta C_{B_{t,ANFF}}$ = carbon stock change in year t, from non – forest lands converted into forest during the reference period, under the stock enhancement activity (*A*), in ton C.
- $\Delta C_{B_{t,AFF}}$ = annual carbon stock change in forest areas that remain as forest, considering total area, in ton C $year^{-1}$.
- *p* = years of the reference period.

Parameters to be monitored

***a) Deforestation* activity**

Parameter:	$\Delta A_{TO_OTHERSi,t}$ = Areas of different Forest Types (i) converted to another category of land use during the 2018 – 2019 period.
Description:	Chile has eleven different Native Forest Types in the PRE area.
Data unit:	Total hectares (ha) of the 2018-2019 period.
Value monitored during this Monitoring / Reporting Period:	

Forest Type	Area
Alerce	48
Araucaria	107
Ciprés de la Cordillera	191
Ciprés de las Guaitecas	6
Coihue - Raulí - Tepa	1,461
Coihue de Magallanes	104
Esclerófilo	1,848
Lenga	1,404
Roble - Hualo	134
Roble - Raulí - Coihue	5,702
Siempreverde	5,667
Without Forest Type	1,583
Total (ha)	**18,255**

Source of data and description of measurement/calculation methods and procedures applied:	Matrixes of change in land use taken from Land-use change maps. Regional, characterized by stunted, mature, young mature, mixed and young forests converted into areas with no vegetation, urban and industrial areas, waterbodies, areas where succulents, wetlands, scrubland, perennial snow and glaciers, grasslands and farmland have formed.
QA/QC procedures applied:	SOP_02_LULUCF Maps Elaboration QAQC_02_Review and rectification of LULUCF maps ERPA SOP_03_ Standardization and quality control protocol for land use change maps QAQC_03_Standardization and Quality control for land use change maps_ERPA
Uncertainty for this parameter:	The uncertainty of land-use change maps is estimated by comparing the results of the land-use change category on the map and the reference observations corresponding to a sample of visually interpreted points. The errors related to land-use change are calculated following the Good Practice Guidelines for estimating the precision of change of use described in Olofsson et al. (2013) and the estimator of the total area using the separate ratio estimator (formulas from sec. 6.10 of W.G. Cochran, Sampling Techniques, 3rd Edition, 1977) Error = Maule 111.3%, Ñuble 72.3%, Biobío 109.6%, Araucanía 191.6%, Los Ríos 96.6%, Los Lagos 89.1%
Any comment:	

b) Degradation – native forest that remains as such

Parameter:	A_{DegFF} = Area of degradation of forests that remain as forests monitored during the 2018 - 2019 period.
Description:	The area was described by degradation of native forest that remains as such, in areas not affected by browning (NBA).
Data unit:	Total hectares (ha) of the 2018-2019 period.
Value monitored during this Monitoring / Reporting Period:	**Region** / **Area** Maule 66,869 Ñuble 22,583 Biobío 34,262 La Araucanía 47,666 Los Ríos 29,142 Los Lagos 90,428 **Total** **290,950**
Source of data and description of measurement/calculation methods and procedures applied:	The data comes from INFOR's National Forest Inventory (IFN) plots, combined with spectral information from the Landsat series. This information integrates the variables of the state of the forests on the number of trees per hectare, basal area and volumes recorded by the monitoring of IFN plots, with the spectral data from Landsat to estimate carbon stocks in a spatially explicit way. The estimate of the variation in carbon content on forests that remain as such for FREL/FRL and monitoring report for Degradation, Restoration of Forest remaining forests and Forestry Conservation activities are estimated based on information coming from the Continuous Inventory of Forest Ecosystems and the application of remote sensing techniques on LANDSAT satellite images.
QA/QC procedures applied:	SOP_05: Method for estimating carbon variations in forest remaining forests. QAQC_05_Forest Carbon Flux estimation assessment_ERPA SOP_06_Field Operation Manual
Uncertainty for this parameter:	Degradation mapping accuracy estimated by INFOR. Error: 32.8%
Any comment:	

c) Degradation - Substitution activity

Parameter:	A_{DegNFF} = Surface of degradation areas resulting from the conversion of forests into plantations during the 2018 – 2019 period.
Description:	The total of areas by forest type that was degraded to plantation were registered
Data unit:	Total hectares (ha) of the 2018 – 2019 period.
Value monitored during this Monitoring / Reporting Period:	
Source of data and description of measurement/calculation methods and procedures applied:	To estimate degradation of native forests converted to plantations, the equation used to estimate deforestation is applied, since it is assumed that, to establish a plantation, all the carbon content present in the preceding native forest must be reduced to zero.
QA/QC procedures applied:	SOP_02_LULUCF Maps Elaboration QAQC_02_Review and rectification of LULUCF maps ERPA SOP_03 Standardization and quality control protocol for land use change maps QAQC_03_ Standardization and Quality control for land use change maps_ERPA
Uncertainty for this parameter:	The uncertainty of land-use change maps is estimated by comparing the results of the land-use change category on the map and the reference observations corresponding to a sample of visually interpreted points. The errors related to land-use change are calculated following the Good Practice Guidelines for estimating the precision of change of use described in Olofsson et al. (2013) and the estimator of the total area using the separate ratio estimator (formulas from sec. 6.10 of W.G. Cochran, Sampling Techniques, 3rd Edition, 1977). Error = Maule 191.8%, Ñuble 139.9%, Biobío 134.9%, Araucanía 113.4%, Los Ríos 138.6%, Los Lagos 100.0%.
Any comment:	

Forest Type	Area
Alerce	0
Araucaria	1
Ciprés de la Cordillera	43
Ciprés de las Guaitecas	0
Coihue - Raulí - Tepa	130
Coihue de Magallanes	0
Esclerófilo	1,254
Lenga	57
Roble - Hualo	168
Roble - Raulí - Coihue	5,656
Siempreverde	1,164
Without Forest Type	5,903
Total (ha)	**14,377**

d) Degradation – Forest fire activity

Parameter:	A = Area burned between 2018 and 2019 in the ERP Regions.
Description:	The surface of burned areas was recorded to estimate the degradation of the native forest.
Data unit:	Total hectares (ha) of the 2018-2019 period.
Value monitored during this Monitoring / Reporting Period:	

Region/year	2018's area	2019's area
Maule	599	1,759
Biobío	148	235
Araucanía	502	3,005
Los Lagos	95	638
Los Ríos	61	222
Ñuble	66	404
Total (ha)	**1,472**	**6,262**

Source of data and description of measurement/calculation methods and procedures applied:	The Forest Fire Protection Department and its Digital Information System for Operations Control (SIDCO), provides annualized statistical information on the occurrence of forest fires for the entire country, which in recent years has been improved by adding the spatial location of fires.
QA/QC procedures applied:	SOP_07_ForestFire_Polygons
Uncertainty for this parameter:	Area burned uncertainty estimated by INGEI (2020) Error: 15%
Any comment:	

e) Enhancement activity – No forest to native forest

Parameter:	$\Delta A_{TOOTHERS i,\ t}$ = Non-forest land use area converted to forest during the credit period
Description:	The areas that correspond to non-forest lands were quantified in hectares to later estimate the carbon capture balances of these land changes use. In this data forest plantations with exotic species are included as non-forest land.
Data unit:	Total hectares (ha) of the 2018-2019 period.
Value monitored during this Monitoring / Reporting Period:	

Forest Type	Area
Alerce	0
Araucaria	178
Ciprés de la Cordillera	42
Ciprés de las Guaitecas	0
Coihue - Raulí - Tepa	171
Coihue de Magallanes	0
Esclerófilo	1,171
Lenga	1,947
Roble - Hualo	5
Roble - Raulí - Coihue	6,921
Siempreverde	2,252

	Without Forest Type	3
	Total (ha)	**12,690**
Source of data and description of measurement/calculation methods and procedures applied:	A semi-automated technique is applied to detect changes using satellite images. The Multi-index method or MIICA (Jin et al., 2013) detects land use changes for the period under study. The MIICA methodology is based on the combination of 2 spectral indexes (dNBR, dNDVI) which, through integration rules, provide coverage of land use change, indicating the magnitude and directionality of the change. (Gain and loss). The MIICA methodology used images from the Landsat 8 sensor and was applied through a series of codes in programming language (JavaScript, R) complemented with Google Earth Engine cloud processing, in GIS programs and R software, with the objective of obtaining an efficient land use change map.	
QA/QC procedures applied:	SOP_02_LULUCF Maps Elaboration SOP_03 Standardization and quality control protocol for land use change maps QAQC_02_Review and rectification of LULUCF maps ERPA QAQC_03_ Standardization and Quality control for land use change maps_ERPA	
Uncertainty for this parameter:	The uncertainty of land-use change maps is estimated by comparing the results of the land-use change category on the map and the reference observations corresponding to a sample of visually interpreted points. The errors related to land-use change are calculated following the Good Practice Guidelines for estimating the precision of change of use described in Olofsson et al. (2013) and the estimator of the total area using the separate ratio estimator (formulas from sec. 6.10 of W.G. Cochran, Sampling Techniques, 3rd Edition, 1977). Error = Maule 80%, Ñuble 50.5%, Biobío 136.5%, Araucanía 192.2%, Los Ríos 65.1%, Los Lagos 138.5%	
Any comment:		

f) Enhancement activity – forest remains forest in non-conservation areas

Parameter:	A_{EnhFF} = Areas of non-conservation native forest that remains forest during the 2018– 2019 period for the six Region of the ERP
Description:	The number of hectares of forest that remains as forest during the period 2018 - 2019 was estimated, in non-conservation areas considering that they are not within an area affected by browning (NBA).
Data unit:	Total hectares (ha) of the 2018-2019 period.
Value monitored during this Monitoring / Reporting Period:	**Region** / **Area** Maule 44,426 Ñuble 16,549 Biobío 32,686 La Araucanía 43,622 Los Ríos 29,025 Los Lagos 96,157 **Total 262,465**
Source of data and description of measurement/calculation methods and procedures applied:	The data comes from INFOR's National Forest Inventory (IFN) plots, combined with spectral information from the Landsat series. This information integrates the variables of the state of the forests on the number of trees per hectare and basal area recorded by the monitoring of IFN plots, with the spectral data from Landsat to estimate carbon stocks in a spatially explicit way.
QA/QC procedures applied:	SOP_05_Forest Carbon Flux estimation assessment SOP_06_Field Operation Manual
Uncertainty for this parameter:	Degradation mapping accuracy estimated by INFOR. Error: 32.8*%*
Any comment:	

g) Conservation activity

Parameter:	$\Delta A_{TO_OTHERSi,t}$ = areas of conservation of native forest that remains as such during the 2018 – 20109 period in the six Region of the ERP.
Description:	Forest areas not affected by browning (NBA) within conservation areas that between 2018 and 2019 remain as forest.
Data unit:	Total hectares (ha) of the 2018-2019 period.
Value monitored during this Monitoring / Reporting Period:	Region / Area Maule 2,495 Ñuble 6,327 Biobío 10,148 La Araucanía 20,657 Los Ríos 27,247 Los Lagos 83,597 Total 150,471

Source of data and description of measurement/calculation methods and procedures applied:	The data comes from INFOR's National Forest Inventory (IFN) plots, combined with spectral information from the Landsat series. This information integrates the variables of the state of the forests on the number of trees per hectare and basal area recorded by the monitoring of IFN plots, with the spectral data from Landsat to estimate carbon stocks in a spatially explicit way.
QA/QC procedures applied:	SOP_05_Forest Carbon Flux estimation assessment SOP_06_Field Operation Manual
Uncertainty for this parameter:	Degradation mapping accuracy estimated by INFOR. Error: 32.8%
Any comment:	

9.2 Organizational structure for measurement, monitoring and reporting

Organizational structure, responsibilities and competencies, linking these to the diagram shown in the next section

The National Forest Monitoring System (NFMS) of Chile has been established for monitoring forests in the country and operates on existing systems supported by various supporting institutions which underpin and maintain it. It is characterized by being supported by existing systems, processes and supplying data that must be completely transparent and consistent over time, which produces a functional link among its multiple building elements.

The NFMS in Chile is coordinated by CONAF, institution serving as REDD+ Focal Point to the UNFCCC (CMNUCC in Spanish) in accordance with Decision 10/CP.19. CONAF operating under the MINAGRI who gives the REDD+ Focal Point to the Climate Change and Ecosystem Services Department (DCCSE) of the Forest and Climate Change Management (GBCC, acronym in Spanish). As the REDD+ focal point, DCCSE has the responsibility of being the organization in charge of coordinating the generation and reporting of elements linked to REDD+, which includes the responsibility of coordinating the NFMS, reporting and generation for FREL/FRL and REDD+ result reports.

Inside CONAF, there are other units with the main responsibility of generating activity data. Among them, Climate Change and Ecosystem Monitoring Department (DMECC, acronym in Spanish) of the Environmental Evaluation and Oversight Management (GEF, acronym in Spanish), has a primary role for the generation of base information for the NFMS. DMECC is responsible for implementing the mandate established in Article 4th of Law No. 20,283 of 2008 on the Restoration of Native Forest and Forest Promotion, which establishes that CONAF "Will maintain a Forest Cadastre, which is to identify and establish, at least cartographically, the forest types that exist in each region of Chile, their status and those areas that have ecosystems with presence of native forests of special interest for conservation or preservation according to the criteria established in the regulation of this law. The Forest Cadastre must be updated at least every ten years and its information will be public in nature".

The Forest Cadastre, called "Cadastre of Native Forests and Vegetation Resources", is the main source of information for the development of Land – Use Change Maps, also developed by DMECC for the continuous monitoring of vegetation cover in Chile. This input feeds directly into the data of REDD+ activities and the methodology for developing use change biennial maps, to be able to comply with national reporting.

As the next figure shows, CONAF also includes the participation of the Forest Fire Protection Management (GEPRIF, acronym in Spanish) through the provision of information by means of the Operation Control Digital System (SIDCO, acronym in Spanish) and GEF using the Forestry Administration and Control System (SAFF, acronym in Spanish).

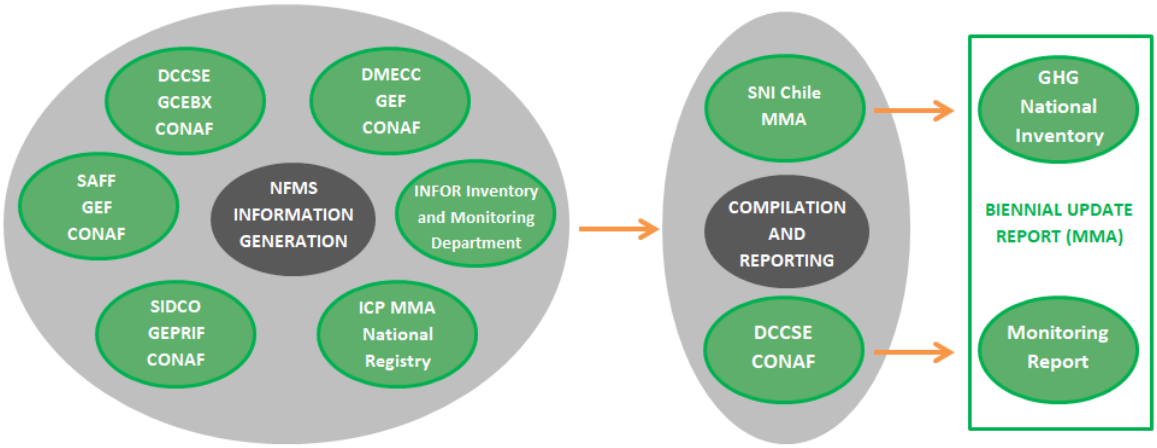


Figure 23 Organizational Structure of Chile.

Within GEPRIF, The Protection against Forest Fires Department and its Operation Control Digital Information System (SIDCO), provides annualized statistical information on the occurrence of forest fires in the entire country, with said information improving in the last few years by adding the spatial location of fires. On the other hand, SAFF provides information about the implementation of forestry management plans implemented with support by CONAF in Chilean forests. Finally, also within CONAF, The Protected Wilderness Areas Management is responsible for providing information on conservation areas in the National System of Wilderness Protection Areas or SNASPE.

Together with the CONAF units, activity data for the NFMS is provided by the Forestry Institute INFOR and the Ministry of the Environment. INFOR is established as a private law corporation, part of MINAGRI, with such institution providing public funding for the design, technological development, implementation, and execution of the National Forestry Inventory. In particular, the Forestry Ecosystems Monitoring and Inventory Department of INFOR is in charge of permanently supplying data collected both on-site and remotely, such as information that makes it possible to observe the evolution of forestry ecosystems regarding their integrity through monitoring under the pressure – state – response (PSR) scheme. From this information, information is generated about the emission factors of native forests, and the methodology to estimate forest degradation is applied.

The Ministry of the Environment is the State organ in charge of working with information provision on private conservation initiatives, for their incorporation to the accounting of areas subject to conservation. The National Registry of Protected Areas was established within the MMA, which operates as an information platform where the 9 categories are considered protected areas (Marine Park, Pristine Regions Reserve, National Park, Natural Monument, Forest Reserve, National Reserve, Marine Reserve and Multiple Use Coastal Marine Areas), aside from Private Protected Areas and Community / Private Conservation initiatives, encompassing the entire national territory.

Information about emission factors for forest monitoring comes from the National Forestry Inventory or IFN, administered by INFOR which is also used by the Chilean National Greenhouse Gases Inventory System (SNIChile), administered by the Climate Change Office, which arises as a response to the need to inform the citizens about GHG emissions and removals in the country.

Emission factors are monitored by INFOR through inventory plots and reported annually through IFN national reports. Emission factors are applied to the NFMS by forest type and/or region, depending on the REDD+ activity evaluated.

The NFMS is responsible for generating information for the Monitoring, Reporting and Verification (MRV) System for the most part, but also the Safeguard Information System (SIS) and the Co benefits System. Also, the most direct NFMS association is established with the MRV system through the presentation, generation, and verification of FREL / FRL and technical annexes of REDD+ results.

NFMS reporting, as previously mentioned, is a direct responsibility of DCCSE as a REDD+ focal point. Based on the agreement of Decision 11 / CP.19 of 2013 in Warsaw, DCCSE takes responsibility for calculating forest related emissions and removals based on the newest guidelines and orientations of the Intergovernmental Panel on Climate Change (IPCC), supported, and driven by the CoP, forest related GEI emissions and removals reporting and verification, ensuring that data and information are transparent and coherent over time. REDD+ reporting is coherent and consistent with SNIChile.

While as of nowprogress has been made on the development of formal agreements that are binding within the NFMS framework, CONAF and INFOR develop joint activities in the framework of cooperative, voluntary work. In addition, MINAGRI institutionalized an inter – ministry structure that allows for the adequate organization of actions in the areas of climate change mitigation and adaptation, which was made official on the 4th of December 2017 through Exceptional Decree No. 360 of MINAGRI, that "Creates the Intra – ministry Technical Committee on Climate Change (CTICC)". CTICC is chaired by the National Director of the Office of Agriculture Studies and Policies (ODEPA, acronym in Spanish), which integrates, besides CONAF and INFOR, the Undersecretary of Agriculture, Agricultural and Livestock Service (SAG, acronym in Spanish), Institute of Agricultural Development (INDAP), National Irrigation Center (CNR, acronym in Spanish), Institute of Agricultural Development (INIA, acronym in Spanish), National Resources Information Center (CIREN, acronym in Spanish), and the Foundation for Communications, Training and Culture of Agriculture (FUCOA, acronym in Spanish), among others. The objectives of the CTICC include, according to Article 2 literal iv. "Favor and foster the generation of information and support systems for ministerial decisions that are adopted…", to support monitoring and evaluation of climate change policies and the promotion of instruments to generate structural and organization improvements on matters of climate change, which allows for the provision of explicit support for institutional organization and structuring, for purposes such as the Measuring and Monitoring System (SMM, acronym in Spanish) of the ENCCRV.

The selection and management of GHG related data and information

The information and data selected to be incorporated to the NFMS, have been defined by Chile in the ERPD on which the subnational FREL/FRL was established. Selected information and data remain for this monitoring report, being managed by DCCSE for the monitoring and reporting of captures and emissions.

Land use and land use changes analysis

Land use data selected for the FREL/FRL were those coming from existing Native Forest Cadastres in regions of the Accounting Area. The information provided by the Cadastre is regularly updated by the Forest Ecosystems Monitoring Department of CONAF, describing 9 Land uses and 20 Sub – uses, along with other breakdowns by altitude, cover and structure.

Nevertheless, as indicated in Annex 4, the level of reference was corrected by incorporating spatially explicit use change data estimated based on reference maps for evaluation instances 2001 and 2013. Such maps are developed through the implementation of a semi – automated methodology for change detection that operates on Landsat images analyzed in Google Earth Engine by applying the land use definitions defined by Chile in the Cadastre of Native Forests.

Forest National Inventory

The data selected for the estimation of emissions and captures from activities that occur in forest remaining forests are those indicated in the ERPD and refer to data coming from plots in the Continuous Inventory of Forest Ecosystems or National Forest Inventory by INFOR, combined with spectral information from the Landsat series. This information integrates forest state variables on the number of trees per hectare and basal area registered in the IFN plot monitoring, with Landsat spectral data to estimate carbon stocks in a spatially explicit manner.

The IFN is designed under a two stage statistical design concept, in clusters of three concentric circular plots of an area equivalent to 500m^2, distributed in a 5x7 km systematic grid. The inventory is based on the generation of a first measurement cycle for permanent sampling plots covering 9.38 million hectares of native forest between the Coquimbo and Magallanes regions, completed in the 2001 – 2010 period, together with a second yearly basis measurement cycle under the partial replacement system with support from growth projections.

The inventory collects information on trees with Diameter at Breast Height (DBH) equal to or greater than 25 cm in the 500 m^2 plot, trees with DBH equal to or greater than 8 cm in 122 m^2 plots and trees with DBH equal to or greater than 4 cm in 12.6 m^2 plots. At the individual level, the species, DBH, bark thickness, treetop diameter and health status. More detailed information on the total height, treetop start height, stump height, etc. is obtained for a subsample on each plot.

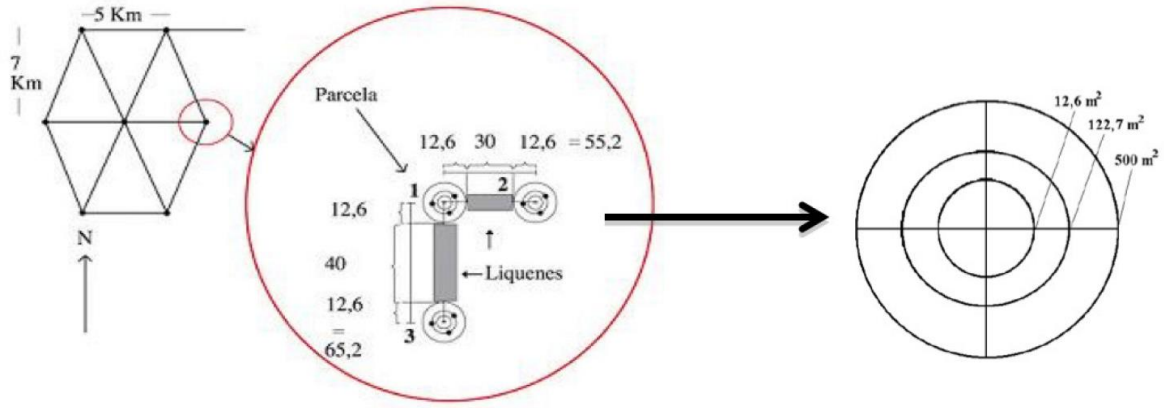


Figure 24 Continuous Inventory plot design.

Sub plots 1 m^2 wide are established at the plot level with the purpose of measuring all existing vegetation along with regeneration, woody debris, dead trees, etc. General descriptions are developed, reflecting observations for each cluster in each of the 3 established plots on the degree of anthropic intervention, the presence of civil works, degradation, and evolutionary state.

The estimate of the variation in carbon content on forests that remain as such for FREL/FRL and monitoring report for Degradation, Restoration of Forest remaining forests and Forestry Conservation activities is estimated based on information coming from the Continuous Inventory of Forest Ecosystems and the application of remote sensing techniques on LANDSAT satellite images.The LANDSAT earth observation program has obtained images of the terrestrial cover since 1972, through LANDSAT-1, until now, through LANDSAT – 8, being a very interesting tool for the study of temporary phenomena, as proven in many publications.

Images from the various LANDSAT missions are freely and publicly available on different platforms. For the case of NFMS, access is through Google Earth Engine (GEE), from which multi – pixel mosaics are developed.

Satellite Information

The generation of activity data in land use change activities and change detection is developed based on spectral information from the Landsat series which characteristics, resolution, revisit, and other aspects are known and can be found in the literature.

To obtain satellite images that are representative of the beginning and end of each period, NFMS has been corrected through work with multi – pixel mosaics that require a time range for the search for cloud free images and the selection of the pixels that comprise such images. The multi – pixel mosaic is an image comprised of pixels from various images, extracted from the definition of a time range or window. The selection of each pixel seeks to define the best available information for a given area, with the priority being pixels free of clouds and shadows of such clouds.

Given the large number of clouds in the south of Chile, this time window will correspond to a range of ± 3 months for the starting date of the period and the end date of the analysis period respectively, as it corresponds to the dry season period in Chile. As an example, for the 2018 – 2019 where the starting date is January 1, 2018, the time range

or window will cover between October 1, 2017, to March 31, 2018. For the end of the period until December 31, 2019, the time range for multi – pixel mosaic estimation will address from October 1, 2019, until March 31, 2020.

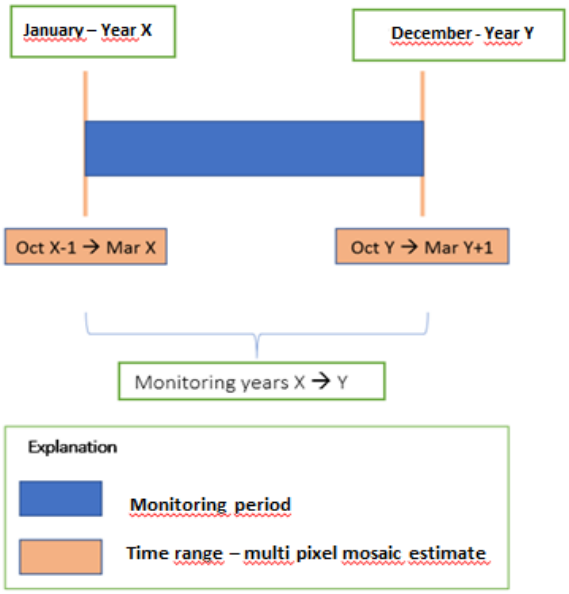


Figure 25 Example diagram for multi pixel mosaic time ranges in a monitoring period.

For pixel selection, a code is applied in GEE where median NDVI values are selected for pixels corrected to land surface. NDVI medians are selected with the purpose of not incorporating phenological states of vegetation with high photosynthetic activity or vigor, but rather selecting values that do not alter the outcome of the method application.

Information administration and Management

The management of the information that comprises the NFMS is led by the Ecosystem Services and Climate Change Department (DCCSE) of CONAF, by means of a cloud-based infrastructure. For the development of FREL/FRL, the associated information was managed through spreadsheets stored in desktop computers, backed up in external storage devices.

Currently, data management is done through cloud storage using Gmail and OneDrive platforms. A series of folders have been organized in order to favor versioned and organized information storage, to which access is granted through various permissions to the people who participate in the estimation process. The folders are divided into base information, documents, tools, reports, and work for each of the NFMS reporting elements.

The base information provided by the DMEF and INFOR, along with the auxiliary information which feeds the monitoring, are stored in different folders that can be accessed by the working teams that generate such data. Each folder may contain different versions of the data, which is documented through files that account for the changes between versions. The versioning description is the joint responsibility of the DCCSE team and the information generating team.

The data that comprise the NFMS and allow for the generation of reports are public in nature and made available to the community through links to downloadable files in the reports published by Chile. CONAF is responsible for the information as the REDD+ focal point that generates estimates and develops the reports, therefore being the owner of their intellectual property.

CONAF has developed an information management platform associated to ENCCRV, which has incorporated a series of tools that facilitate the monitoring and follow up of activities implemented within the REDD+ framework. The

emission estimation system, which seeks to semi automate such processes, is one of the IT modules being developed. The DCCSE team has made progress migrating from the use of basic Excel tools to estimate computer programming by using PostgreSQL, GDAL and ODBC. The end goal is to have a Django based online platform which allows for the automatic operation of estimates, promoting the transparency, consistency, replicability, and reporting of information.

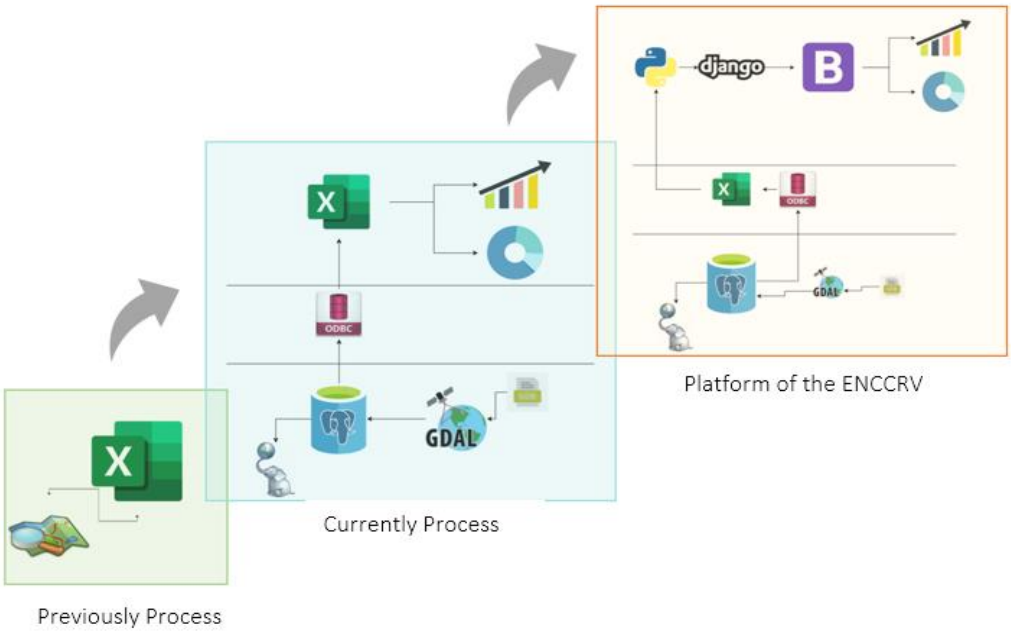


Figure 26 Evolution of NFMS support systems.

Processes for collecting, processing, consolidating, and reporting GHG data and information

The main processes for collecting, processing, consolidating, and reporting GHG emissions in NFMS are described below.

- Activity data generation processes

Activity data generation is also divided into land use change activities, obtained from use change maps, and activities on forest remaining forests, these being associated to the development of carbon flow and stock maps for forest degradation.

These two elements are generated through two base official inputs, respectively: Land use type surfaces and land use change surfaces from maps of changes in land use based on the Native Forest cadastre and Carbon content and variation in forest carbon content from the Forest Inventory. Both processes begin with the development of satellite mosaics.

b) Land Use and Land use change map development

The development process for use and change maps has been a joint development by DCCSE and DMECC, with the purpose of defining forest related land use changes for determining REDD+ activities and sub activities. DMECC is responsible for the implementation of this process, as the unit responsible for monitoring land use changes, and the frequency of its implementation is directly related to NFMS reporting processes.

For the 2018 – 2019 monitoring period, the process considers the development of one Use Map per region for 2018 and one for 2019 based on satellite mosaics and the MIICA change detection method. Land use rasterized coverage is generated in this stage by applying the Multi – Index Integrated Change Analysis (MIICA) (Jin et al., 2013) on previously obtained multi pixel mosaics for T0 (2001) and T1 (2013). To achieve this objective, it was necessary to

establish change thresholds that ensure the spectral values register empirical changes. Change categories to be used are those mentioned in the CONAF “Methodological protocol for the development of land use and land use change maps in Native Forests as of 2016”.

The change detection method is based on the combination of 2 spectral indexes (dNBR, dNDVI), which use integration rules to deliver land use change coverage, indicating the magnitude and direction of such changes (gains and losses).

The application of the MIICA methodology used multi pixel mosaics 5 and 7 for the reference period and Landsat 8 for the monitoring period and was applied through a series of codes in programming language (Javascript, R) complemented by Google Earth Engine cloud processing, SIG programs and R software.

For the specific case of Chile, it was necessary to adapt the MIICA code mainly focusing on determining empirical threshold to determine coverage changes (gains and losses) in IPCC sub uses containing vegetation of interest, that is, Native Forest, Arborescent Scrub, Scrub and Pastures. Aside from this consideration, only the dNDVI and dNBR spectral indexes will be used in accordance with the Methodological Protocol (CONAF 2016).

In order to generate statistics to establish spectral thresholds between change zones and their relationship with the indexes being evaluated, change control polygons (Ground Truth) proportional to the surface of each region are taken, then evaluated and stratified by the IPCC sub used mentioned in the previous section. These polygons are visually verified with support from the high-resolution images time series provided by Google Earth.

The resulting pixels will be transformed into points, with the purpose of using each of them to extract the values of dNDVI and dNBR indexes. In this manner, the distribution, variability and spectral convergence of data in places where verified changes occur will be established through descriptive statistics, determining spectral gain and loss thresholds.

For the generation of cut – off thresholds, a field called “TC” (change type, acronym in Spanish) is assigned to points coming from ground truth polygons, with the detected changes identified in this field, that is, if it corresponds to a spectral gain or loss. Having identified values by change type, and having such values represented in the histogram, the graph will be adjusted by standard deviation, shortening the ends of the histogram so they end up having a volume close to 75% of the data (See next figure) finally adjusting the values representing a change range for a specific macro – region.

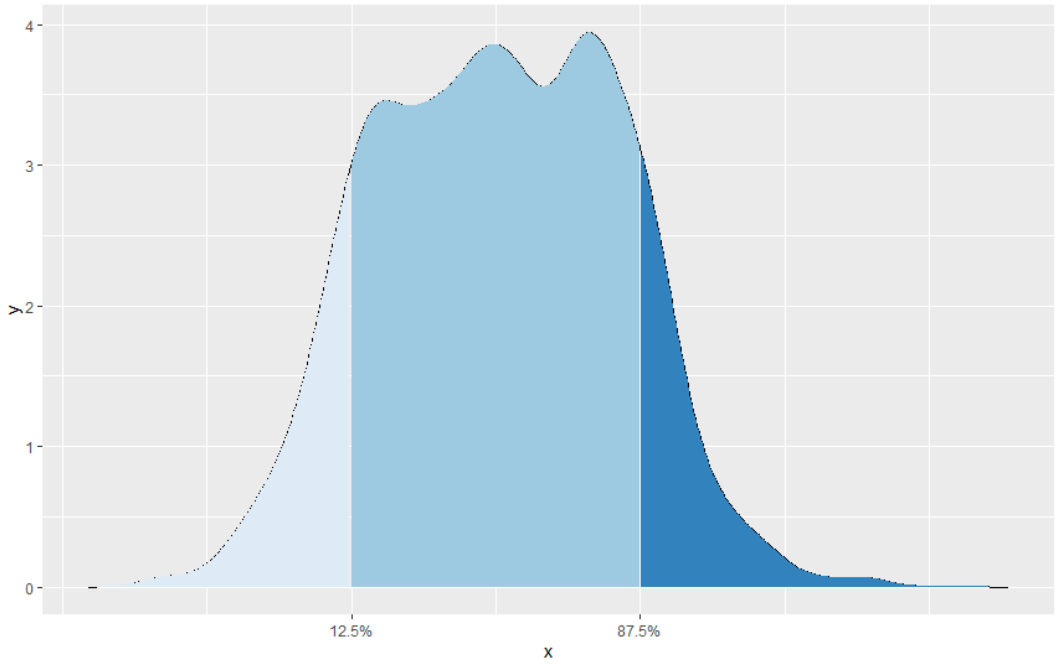


Figure 27 dNBR spectral gains histogram.

The following permanent change or land use categories are established and represented in the land use and land use change maps, according to the minimum NFMS necessary requirements:

07. Permanent Native Forest by forest type: Corresponds to the surface reported as Native Forest in the "Map of land use and land use changes t0" which remains in the same t1 category.
08. Other permanent uses: Corresponds to the surface reported as land uses in the "Map of land use and land use changes t0" which remains in the same t1 category.
09. Deforestation: Corresponds to the Native Forest surface transformed into other land uses different from forest uses between t0 and t1 maps, specifying the final land use.
10. Degradation: Corresponds to the Native Forest surface transformed into Forest Plantation between t0 and t1 maps, specifying the final land use.
11. Afforestation/Reforestation: Corresponds to the surface of other land uses different from forest uses transformed into Native Forest between t0 and t1 maps, specifying the initial land use.
12. Restoration: Corresponds to the forest plantation surface transformed into Native Forest between t0 and t1 maps.

The methodological process can be summarized in the stages described below, each with its different intermediate products and sub processes obtained after applying the land use change detection methodology.
The general stages are as follows:

- Gain – loss analysis in native forests: The main objective of this stage is to obtain native forest gain – loss raster coverages through the application of the MIICA multi – index method (adapted) among the mosaics obtained in the previous process.
  An algorithm for obtaining gains and losses in Native Forests applying NDVI, NBR and dNBR indexes is developed and applied from the results of the threshold assessment.

- Land use allocation: The land use allocation to the loss vector coverage generated in the previous stage occurs in this stage of the process, in order to attribute use changes (Native Forest use change direction). Once the process has been conducted, an intersection that results in a use and use change coverage will

also be conducted, with such coverage being used in the validation process for the categorization supervised in the previous stage.

- Land use change map generation: The technical report of the methodological protocol for the development of Native Forest land use and land use change maps can be reviewed for a detailed description of the entire process.

The following information can be obtained for the periods being analyzed from land use change maps, with spatial references allowing for spatial localization

- Forest remaining forest area, referring to the forest surface that remains as such between the initial Cadastre and its various updates.
- Deforestation area, referring to the permanent transformation of forest areas into other land uses.
- Substitution or native forest into forest plantation transformation area.
- Restoration or forest plantation into native forest transformation area.
- Forest surface enhancement area, referring for the surface of land uses other than forests, transformed into native forest
- Other land uses.

Each process implemented for a specific period generates a land use change map per region which is integrated into existing land use change map layers. Such layers are called *"Trazabilidad",* as they allow for the time monitoring of use changes for all polygons inside the layer.

The land use change map development process ends with the validation of the lan use and land use change maps, with the goal of validating the results obtained from higher resolution satellite images. This validation, both for the Land Use Maps and land use change maps is implemented by comparing the results achieved in maps to reference observations obtained through open-source platforms available at Open Foris: SEPAL, Open Foris Collect and its Google Earth interface, Collect Earth.

The Open Foris service consists in an open-source system which allows the visualization and interpretation of satellite images, developed by SERVIR (NASA joint program together with technical regional organizations from all over the world and the FAO) as a tool to be used in projects requiring land coverage and/or use baseline data. Its system for earth observation, access to data, processing and analysis for earth monitoring (SEPAL) allows to quickly and efficiently access and process satellite data through a set of applications for such purposes among which there are the online interface for the statistical software RStudio, used for the spatial selection of validation points in the pre – sampling stage and a Stratified Surface Estimator that allows sample size selection and validation point spatialization in the sampling process. On the other hand, Collect promotes coherence in the location, interpretation and labelling of reference data plots (ground truth) for their use in the organization, monitoring and in this case, validation of ground coverage and/or changes in use through the development of surveys that are then applied through their Google Earth interface Collect Earth, allowing to use satellite images to evaluate the actual degree of success or failure of adjusted registries and MIIICA modeling in Land Use Change Maps, replacing on – site visits and their associated costs.

The validation process starts with the implementation of a pre – sampling to estimate the accuracy of each IPCC land sub use. Since the distribution of the population the sample is taken from is not normal, it is necessary to conduct a pre sampling with a sample size n=30, allowing to approximate the distribution to a normal one. In this way, 30 points will be randomly distributed per IPCC sub land use in every region, which will result in a total of 330 pre sampling points per region.

The polygons from the use map which are overlapped are first selected from the previously obtained pre sampling points, then entered into Google Earth in .kml format so reference data (ground truth) can be collected with support from Collect Earth surveys. Both data collection and user accuracy estimation are conducted in the same way as the sampling, through confusion matrixes.

Reference data are selected based on the information obtained in the pre sampling, through a random sampling design stratified for each IPCC land sub use in each region. This sampling type also allows to report the accuracy and surface evaluated for each category in the results, aside from adjusting a sample size for each that ensures global reliability in the evaluated areas (Olofsson et al., 2014).

Surface per IPCC land sub use information in vectorial format is necessary for the sampling design, reducing map input and processing times in the server. User accuracy parameters for each land sub use are obtained from the information obtained in the pre sampling stage, which are then entered into the platform as expected user accuracy values, considering a 0.01 standard accuracy error (Olofsson et al., 2014). The surface estimator will use these inputs to calculate the total sample size, which will then be segregated among the different classes using the following equation (Cochran, 1977):

$$n = \frac{(\sum W_i S_i)^2}{[S(\hat{O})] + (\frac{1}{N}) \sum W_i S_i^2} \approx \left(\frac{\sum W_i S_i}{S(\hat{O})} \right)^2$$

Where:

n : sample size

N : number of units in regions of interest (ROI)

$S(\hat{O})$: standard error in the desired estimated accuracy

W_i : mapped percentage of a class i area

S_i : i strata standard deviation

$$S_i \quad : \sqrt{U_i(1 - U_i)}$$

In this way, once the total sample size is obtained, files are spatialized to be used in Google Earth. Also, the polygons in the land use map to be validated are selected and overlapped with sampling points, to then be entered into Google Earth in .kml format so reference data (ground truth) can be collected with support from Google Earth surveys.

Activities and sub activities related to forest remaining forests

The process for estimating activities and sub activities that occur in forest remaining forests has been developed by INFOR, with the purpose of quantifying degradation and restoration in forests that remain as such. It is based on the use of National Forest Inventory plot information combined with the multi pixel mosaics developed by CONAF.

The process is based on the methodology detailed in Bahamondez et al. (2009), which considers the number of trees per hectare and basal area monitored by the inventory as input variables. It refers to spatially explicit information which location is known, by applying an interpolation process for carbon flux and stock in the analyzed periods.

Forest Inventory plots are placed in a density plot or stock chart, based on the number of trees and basal area per hectare. The density plot considers various lines or thresholds which determine, for various forest types, their status at the time of measuring. This information identifies the state of plots, distinguishing between degraded and non-degraded plots (Bahamondez, 2009)

In the case of the methodology applied in the NFMS, the B line or threshold will allow the degradation in forest remaining forests and restoration in degraded forests to be identified. Line B represent the limit at which trees can develop large treetops and completely occupy the site capacity without excessive competition (Gingrinch, 1967). The limit for this threshold was established through field work by experts and is specific for each forest type (INFOR,

2012). Line B is considered the natural resilience threshold of a forest. Plots located below the B line or thresholds are not recommended for productive work.

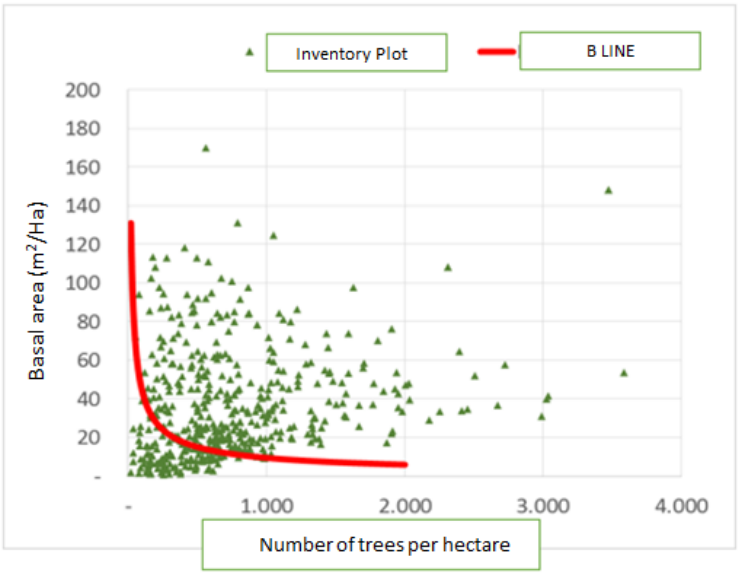


Figure 28 Density Plot and B line. Based on data generated by field measurements from the National Forestry Inventory (INFOR) used in the NFMS.

The density plot is a tool which allows the description of the state of a forest in a static moment. Nevertheless, activities and sub activities to be included in emission estimates are processes developed over time. The graph records data gathered from field work which may generate estimates, but do not contain spatially explicit information encompassing the entire area of study, as they refer to specific points in inventory plots.

The movement in the population graph caused by variations in the basal area and number of trees per hectare between two measurements is analyzed to determine which plots are subjected to degradation or restoration processes.

- Plots that move towards the starting axis of the graph, going above or staying below line B, are considered degradation plots.

- Plots that move away from the starting axis of the graph, going above or staying below line B, are considered degraded forest restoration plots.

- Plots that move above line B are not considered in emissions estimates regardless of their direction, as variations are considered asnatural effects and plots are within the natural resilience threshold.

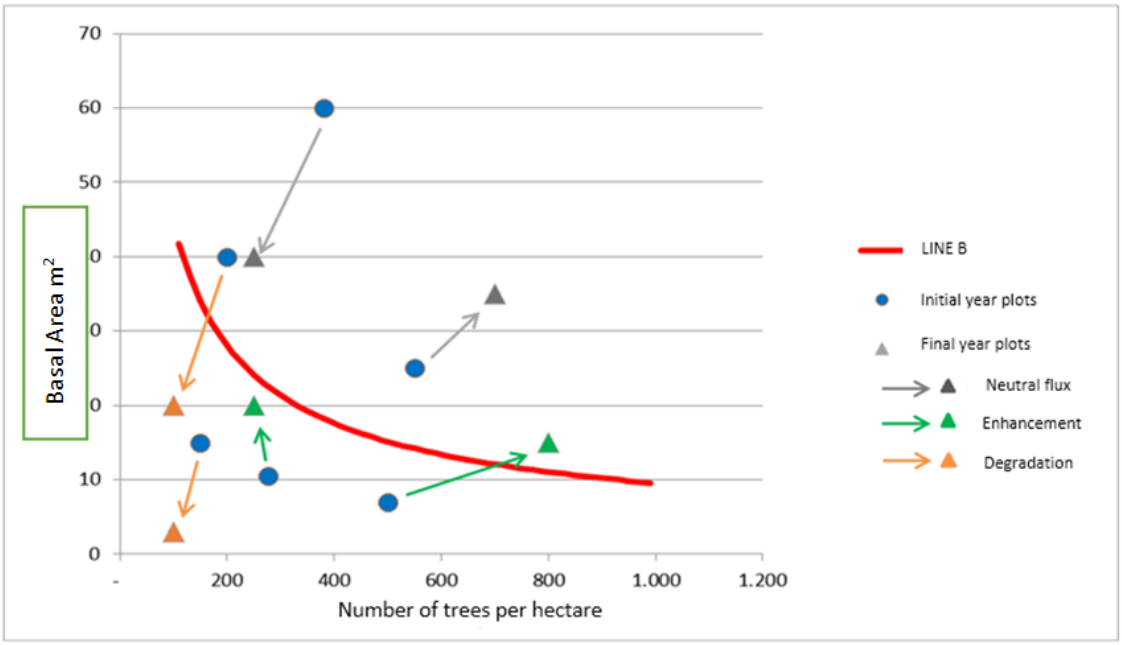


Figure 29 Example of carbon fluxes representing enhancements: (Green arrow) degradation (red arrow) and natural flux (grey arrow).

Change of position in Stock Chart	Flux of CO_2	Corresponding activity
Above B in t0 and below B in t1	Emission	Degradation
Below B in t0 and below B in t1 (stock loss)	Emission	Degradation
Below B in t0 and below B in t1 (stock gain)	Absorption	Stock Enhancement
Below B in t0 and above B in t1	Absorption	Stock Enhancement
Above B in t0 and above B in t1	N/A	Not accounted

Table 12 Possible density plot changes between two periods of time.

REDD+ activities such changes are accounted in Forest types with density diagrams available and incorporated to the degradation estimation methodology are the following: Roble – Raulí – Coihue (RoRaCo in Spanish), Siempreverde, Canelo, Lenga – Hualo (RoHua), Coihue – Raulí – Tepa (CoRaTe), Coihue de Magallanes, Spinal subtype Esclerófilo and Esclerófilo.

The application of this process starts with the integration of multi pixel mosaic satellite data into inventory plot state variables for the development of carbon content thematic maps, using the k – nearest neighbor method (k-NN) in the ER Program regions for the reference and monitoring periods. The multi pixel mosaic is then subject to a re sampling process and taken to a 1-hectare resolution, for the subsequent application of k-NN.

The content and flux estimation process are implemented on the polygons defined by the use change maps as forest remaining forest area by forest type. The forest remaining forest layer corresponding to change use maps for the period is updated for each analysis, reference or monitoring period.

K-NN is a non – parametric method that allows the interpolation of thematic surfaces of interest, in this case Volume/hectare, Basal area/hectare and Number of trees/hectares. This method considers Euclidean distance dpi,p in the space of auxiliary or explanatory variables (Landsat bands 1 to 5) as the distance between pixel p and pixel pi which contains the ground truth. Then, a certain k number of elements with ground truth showing a minimum dpi, p distance in the space of explanatory variables must be considered in such a way that:

$$d_{p_1,p},.....,d_{p_k,p},(d_{p_1,p} \le .....\le d_{p_k,p}),k \approx 5-10$$

Using these Euclidean distances, and their rearrangement in closer k neighbors, it is possible to calculate a k set of wi weightings with i=1,k: in such a way that the linear combination of such weightings provides an estimate of the stand state vector in non-observed positions (pixels where resampling = 1 hectare). Weightings are calculated as such:

$$w_{i,p} = \begin{cases} \dfrac{1}{d^2_{p_i,p}}\left[\sum_{j=1,k} 1/d^2_{p_j,p}\right]^{-1} & ,si \quad i \in \{i_1(p),.....,i_k(p)\} \\ 0 & ,si \quad i \notin \{i_1(p),.....,i_k(p)\} \end{cases}$$

Where ii(p) indicates the ground truth plots that are closer in Euclidean distances within the multidimensional space of auxiliary variables. Considering these expressions, the estimated value of the pixels not observed on site is calculated as the following linear combination:

$$y_{est} = \sum_{i=1,k} w_{i,p} y_i$$

As mentioned before the quality of the method is approximated by the value of the Mean Squared Error (RMSE) in as per the following expression:

$$\sigma_{y_{est}} = \sqrt{\frac{\sum_{i=1,k}(y_{est} - y)^2}{k}}$$

With bias according to:

$$e_{y_{est}} = \frac{\sum_{i=1,k}(y_{est} - y)}{k}$$

Standard deviation approximation is calculated as:

$$S = \sqrt{{\sigma_{yest}}^2 - {e_{yest}}^2}$$

As mentioned before, in order to execute k-NN it is necessary to have a pattern file that associates target variables (That is, Volume/hectare, Basal area/hectare and Number of trees/hectare) to their auxiliary variables (Bands 1 to 5), this file being unique for each mosaic year, and the usual format of this file is displayed in the table below:

Volume m3/ha	Basal area m2/ha	Number of trees/hectares	b1_land	b2_land	b3_land	b4_land	b5_land
211	35	1,199	105	246	148	2,189	710
185	24	1,344	185	348	219	2,558	922
45	.	.	145	300	203	1,978	772
.	.	.	306	543	346	2,793	1,133
.	.	.	133	325	194	3,275	1,015
.	.	.	239	509	341	3,531	1,521
.	.	.	83	244	133	2,663	744
.	.	.	.	240	133	1,346	443
.	.		.	316	214	2,780	869

Table 13. k-NN pattern file example.

In addition, the execution of k-NN requires an auxiliary variable file representing all the pixels to be interpolated, as exemplified in the following table.

b1_land	b2_land	b3_land	b4_land	b5_land
105	246	148	2,189	710
185	348	219	2,558	922
145	300	203	1,978	772
306	543	346	2,793	1,133
133	325	194	3,275	1,015
239	509	341	3,531	1,521
83	244	133	2,663	744
.	.	.	.	.
.	.	.	.	.

Table 14 Auxiliary variable example file.

The result of this procedure is a thematic map corresponding to a GeoTiff file for each Stand state variable, that is Volume/hectare, Basal area/hectare and Number of trees/hectares.

Once the thematic surfaces have been obtained, it is necessary to estimate the carbon flux associated to forest remaining forests for the regions in the Accounting Area, so the position of forest stand state variables must be analyzed in the context of density management diagrams (DMD) available to date. The DMD of forest types of Roble – Raulí – Coihue, Coihue – Raulí, Tepa, Siempreverde Canelo subtype, Lenga, Roble – Hualo, Esclerófilo espinal subtype, Coihue de Magallanes and Esclerófilo are used for the regions in the ER Program.

DMDs allow to identify these, through lines C and B, as threshold values determining carbon movement within the DMD and therefore determine carbon movements in the analyzed period. According to this, forest remaining forests are classified in accordance with the alternatives described in table 28 coming from the observation of stock charts and threshold values by forest type.

- *Lenga forest type*

DMD for Lenga forest type corresponds to:

Line B $G = 248.07 * N^{-0.368}$

Line C $G = 352 * N^{-0.485}$

With: G: basal area ($m^2 \cdot ha^{-1}$)

N: density ($N \cdot ha^{-1}$)

- *Siempreverde forest type, Canelo subtype*

DMD for Siempreverde Canelo subtype corresponds to:

Line B $G = 417.43 * N^{-0.51}$

Line C $G = 646.75 * N^{-0.618}$

With: G: basal area ($m^2 \cdot ha^{-1}$)

N: density ($N \cdot ha^{-1}$)

- *Roble-Raulí-Coihue forest type*

DMD for Roble-Raulí-Coihue corresponds to:

Line B $G = 974.6 * N^{-0.67}$

Line C $G = 866.31 * N^{-0.731}$

With: G: basal area ($m^2 \cdot ha^{-1}$)

N: density ($N \cdot ha^{-1}$)

- *Coihue-Raulí-Tepa forest type*

DMD for Coihue-Raulí-Tepa corresponds to:

Line B $G = 268.93 * N^{-0.424}$

Line C $G = 514.27 * N^{-0.61}$

With: G: basal area ($m^2 \cdot ha^{-1}$)

N: density ($N \cdot ha^{-1}$)

- *Roble-Hualo forest type*

DMD for Roble-Hualo corresponds to:

Line B $G = 376.41 * N^{-0.525}$

Line C $G = 1{,}029.30 * N^{-0{,}779}$

With: G: basal area ($m^2 \cdot ha^{-1}$)

N: density ($N \cdot ha^{-1}$)

- *Esclerófilo forest type with Espinal subtype*

DMD for Esclerófilo forest type with Espinal subtype

Line B $G = 30.507 * N^{-0.343}$

Line C $G = 54.894 * N^{-0.508}$

With: G: basal area ($m^2 \cdot ha^{-1}$)

N: density ($N \cdot ha^{-1}$)

- *Coihue de Magallanes forest type*

DMD for Coihue de Magallanes forest type

Line B $G = 1{,}446.8 * N^{-0.656}$

Line C $G = 4{,}506.1 * N^{-0{,}900}$

With: G: basal area ($m^2 \cdot ha^{-1}$)

N: density ($N \cdot ha^{-1}$)

- *Esclerófilo forest type*

DMD for Esclerófilo forest type.

Line B $G = 210.21 * N^{-0.405}$

Line C $G = 250.46 * N^{-0.463}$

With: G: basal area ($m^2 \cdot ha^{-1}$)

N: density ($N \cdot ha^{-1}$)

Carbon flux is determined by observing if the values associated to each pixel remain in the same position or are relocated in the density diagram regarding threshold lines for the analysis period. The amount of carbon associated to the flux comes from the expansion of Volume/hectare to equivalent CO_2, applying biomass expansion factors.

As an outcome of the process, carbon stock and flux maps are obtained with 1-hectare output resolution pixels that contain the following information in their attribute table:

- Chart: refers to the movement of the pixel in the density diagram
- CO_2 period 1: initial year stock content
- CO_2 period 2: final year stock content
- Cam CO_2: changes in CO_2 or carbon flux
- Ca_ras_erp: conservation area characterization
- TF: forest type
- Region: from El Maule to Los Lagos.

The following figure represents an example of a stock map, 2001 – 2010 period for the regions in the Accounting Area.

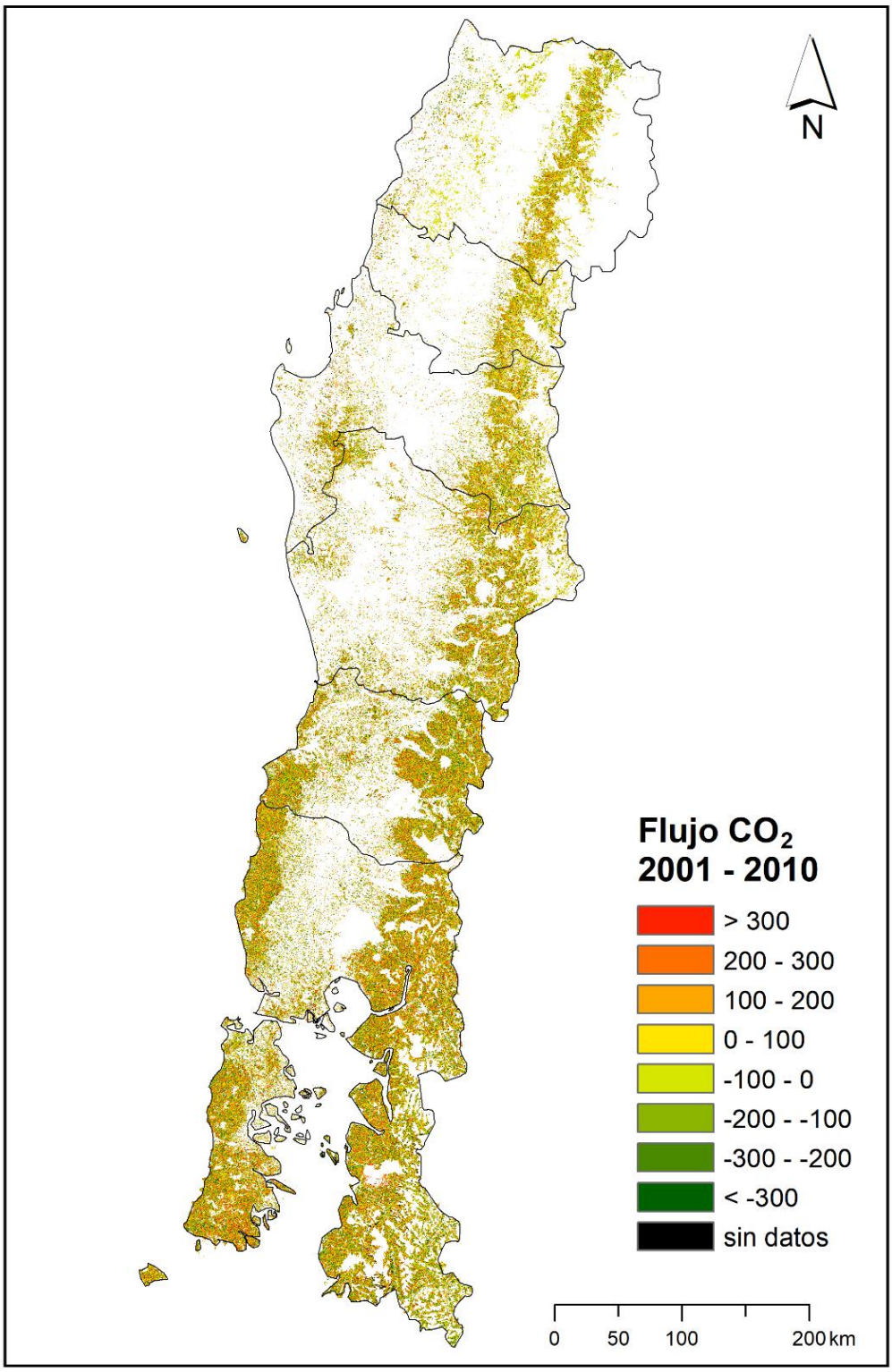


Figure 30 CO2 flux map between 2001 and 2010 in the temperate forests of Chile.

GHG data and information consolidation and integration

The previously described inputs are integrated into geospatial relational databases associated to spreadsheets, which pick up and systematize information about activity data and emission factors for the inputs generated following a structure in accordance with the necessities of REDD+ activities.

DCCSE is responsible for the consolidation of information, integration, emissions and captures estimation for REDD activities, with such consolidation being implemented by the MRV Monitoring, Reporting and Verification team. The use of semi-automated software tools has the main goal of minimizing human errors, increasing result consistency and transparency through the association between these spreadsheets and a PostgreSQL database. This process also adds improvements concerning result check and update times.

The protocol for estimate integration and execution, aside from the spreadsheets summarizing estimate results divided by REDD+ activities integrating results for the updated monitoring period and FREL/FRL can be found as an annex to this document.

The data integration process operates on the PostgreSQL database server, to which the main and auxiliary NFMS information, land use change maps, carbon content map and estimate parameters are loaded. Change map vectorial coverages are used in .gdb formats, while rasters are integrated from map associated .dbf files.

Information entry to the database for estimate execution is supported by a series of geographic and topologic validation rules, data attributes and content, in order to avoid subsequent errors during estimations or errors and inconsistencies in the results. Data is repaired, corrected, and prepared for integration during these validations. Among all the processes being run, one of the most important tones is the estimation of surfaces per REDD+ activities, equivalent to activity data. As an example, the following table displays database tables for running estimations of activity surfaces:

Activity	Sub activity	Table name
Enhancement	Forest surface enhancement	increase_cut
		loss_increase
	Forest remaining forest enhancement	g_mov_pre_2001_2010
		g_mov_pre_2018_2019
Deforestation		deforestation_cut
Degradation	Substitution	substitution_cut
	Fires	Fire_stat
	Degradation in forest remaining forest	g_mov_pre_2001_2010
		g_mov_pre_2018_2019
Conservation		g_mov_pre_2001_2010
		g_mov_pre_2018_2019

Table 15 Databases for running activity surface estimations.

Each of these tables contains an attribute called sup_ha, which is fed by the field of the same name sub_ha from land use change map tables according to a set of conditions. For example, the SQL query for deforestation activities is as follows:

UPDATE deforestation_cut SET (sup_ha)= (SELECT sum(mh_maule_0113161719_v011_p01_20210519_mrv.shape_area/10000) AS area_ha FROM mh_maule_0113161719_v011_p01_20210519_mrv WHERE id_uso_01 = '04' AND id_sub_01='02' AND id_tifo_01='01' AND id_est_01='01' AND id_use_13='01') WHERE id_region=7 AND id_tipo_defor=1 AND id_period = 1;

This query can be translated as "Update field sup_ha of the deforestation_cut table with the value of the sum of the shape_area column divided by 10,000 of the mh_maule_0113161719_v011_p01_20210519_mrv table where as of 2001 land use was forest, the sub use was native forest, forest type was Larch, structure was adult, and that use changed to urban and industrial areas in 2013. Add the sum of the entire surface with the conditions described to the deforestation_cut table where region is Maule and id 1 (First tuple) and the period 2001 – 2013.

The process is similar for the other activity/sub activity tables, that is, the value of the surface field for the activity/sub activity tables corresponding to each tuple is updated through a set of SQL conditions on the MCUT tables.

Finally, the data uploaded to postgreSQL interacts with Excel in order to run the estimation process. This connection takes place through the ODBC Open Database Connectivity connector. The data is then entered into the excel spreadsheets where result estimation is run.

Systems and processes that ensure the accuracy of the data and information

The NFMS has a series of processes established to ensure the accuracy of information, which also contribute to improving the accuracy, transparency integrity, consistency and comparability of estimations conducted. Some of these processes have been documented, but others are still in the process of elaboration.

Land use change maps quality control

The quality control process for use change maps has the main objective of identifying discrepancies and inconsistencies in the results obtained. Considering a semi-automated methodology where some stages are executed through programming code is applied, it is necessary to perform checks on the end product.

Quality control has been developed by DCCSE to be applied to the products delivered by the DMECC about change maps and is mainly focused on detailed map database and attribute reviews, along with layer geometry. Once discrepancies have been identified, they are submitted to the team responsible for their resolution, and then it must be verified if such discrepancies still remain. It is also necessary to document all methodological steps applied, in such a way that a record of continuous improvement is established.

Methodological protocol for the development of land use maps and land use change maps in Native Forests

The objective of this protocol is to describe all procedures, inputs, data sets and methodological steps needed to generate thematic cartography and statistical reports at the technical level on land use extension, distribution and coverage changes from the digital processing of satellite images, to allow for their replication and reconstruction. Some of its specific objectives are:

- Establish a methodology for the evaluation of land use and land use changes in Native Forests with biennial frequency.
- Generate use and change (directionality) coverages for Native Forest land use in the Maule, Biobío, Araucanía, Los Ríos and Los Lagos regions.

Protocol for the development of carbon stock, flux and degradation maps in forest remaining forest

The methodology for estimating forest degradation, applied by INFOR, is based on the integration of satellite information provided by CONAF and the use of information from national forest inventory plots. The use of satellite images must guarantee necessary adjustments for the application of the degradation algorithm. This process is semi-automated by using multi pixel mosaics downloaded from Google Earth Engine. The protocol establishes the requirements of spatial information, dasometric information and data processing needed for calculations.

The application of this process results in thematic maps that combine the information of parcels which information is known, then spatially intersected with state variable and spectral information data.

Uncertainty Estimation System for Change Maps

The main ways to estimate the accuracy of land use and land use change maps correspond to the comparison between the result of the sorting conducted on reference maps and observations corresponding to a sample. The factors that influence such estimation are sampling design and the size of the map accuracy and precision assessment sample. Errors related to changes in land uses and sub – uses according to Cadastre characterization are calculated by following the Guides on Good Practices for the estimation of use change accuracy described in Olofsson et al (2013). In order to use this approach, use change classes were validated using the FAO tool Collect Earth, through which the categories of a total 1,868 polygons representing a total surface of 1,832,483 hectares were validated.

Chile has a semi-automated software tool that allows to compare use change map results to high resolution images through Collect Earth. Some of its functions and use steps are:

4. Generate a pre-sampling by change class.
5. From the results of the previously generated pre-sampling, the tool generates one sampling per class that meets the guidelines described in the Map Accuracy Reports (Maximum global error) and as in pre-sampling, this tool can be used in the Collect Earth tool where a group of expert interpreters who assess the initial and final uses of the period according to IPCC classes modified for Chile.
6. The software uses the sampling results to calculate uncertainty at the general and use change/region class level, along with details of emission and commission errors for each map.

Geographic data validation for calculating results

Results estimation is implemented from geographic data of carbon and use change maps. In order to validate such data, a process with the aim of ensuring the data meets basic conditions for spatial analysis by means of topological conditions has been developed.

Data geometry is validated in others, as it is fundamental for spatial analysis since errors detected by validation codes must be fixed before integration and calculation.

Aside from this and to reduce processing time for millions of records, an index structure for improving database performance has been developed. These indexes are applied to non-spatial values from the land use change map.

Applying a checklist to activity data

NFMS has a base process for ensuring information quality and consistency, which consists in applying checklists to the results of activity data obtained from the final integration and calculation tools. The process is applied by DCCSE, with the aim of having informed surfaces be completely consistent according to each REDD+ activity and region informed.

The verification seeks to ensure consistency between the surface reported for each activity and the official surface of each region, through two revisions:

- Total sum of REDD+ activity surfaces per region
- Consistency between the surfaces reported between two periods

The process is applied during the integration of final calculation results and in case of finding inconsistencies, integration must be stopped, and input data reviewed.

Design and maintenance of the Forest Monitoring System

The NFMS has been designed and structured on the institutions related to Chilean forestry resources and the processes conducted by each institution, responsible for use change maps, degradation maps and forest inventory plots, and the GHG National Inventory of Chile.

Its design has a gradual approach, starting with a reference level at subnational scale and therefore its construction has been on a step-by-step basis, with the goal of advancing towards the national scale monitoring of forestry regions.

Regarding NFMS maintenance, the main activities by each institution that allow to continue the development of necessary inputs and methodologies for guaranteeing reporting on forest status in a climate change context considering continuous improvement elements are described below:

-CONAF: as part of its mandate, CONAF is responsible for implementing native forest registries through the DMEF. Also, based on international commitments on climate change, it has assumed the responsibility to develop biennial land use change national maps that contribute to ensure reporting on climate change matters and results – based payment projects. On the other hand, CONAF has made progress in the development of software tools for the development of MRV estimates and reports.

-INFOR, due to being responsible for the National Forestry Inventory, is responsible for continuing the measurements supported by the Chilean GHG reports, both from REDD+ and the GHG National Inventory. On the other hand, as a member of the Agriculture, Forestry and Other Land Use (AFOLU) like CONAF, INFOR remains close to the ERPA associated INGEI and REDD+ climate change commitments of Chile and maintains the commitment of executing the necessary processes for estimating degradation of the two next monitoring milestones, in accordance with the agreement.

Systems and processes that support the Forest Monitoring System, including Standard Operating Procedures and QA/QC procedures

The processes that support the FNMS are described in the next SOPS:

- **SOP01 Satellite mosaic elaboration (includes satellite image selection)**

This document is a guideline to select and download multipixel satellite mosaics to monitoring land use and land use change and to evaluate forest degradation in NFMS. The document indicates the searching windows of images and pixels with the minimum required quality to be included in the mosaic elaboration.

- **SOP02 LULUCF Maps elaboration**

The SOP 2 indicates the technical procedure to detect gain and losses in forest land, for the land use change monitoring, through the Multi Index Integrated Change Detection MIICA method application.

- **SOP03 Standardization and quality control protocol for use change maps**

Standards or guidelines are established and used as compliance rules to standardize formats regarding historical and use change map, which contain information and traceability by region of land use, sub – use, structure, forest type, forest subtype, change and type of change for each evaluated period.

Also, a series of methodological steps consisting in a quality control for identifying discrepancies between the various versions of the historical and use change maps is described.

- **SOP04 for evaluating uncertainty on land use and land use change maps**

Correspond to standard operating procedures in writing containing detailed protocols to be followed in order to correctly attribute land uses, training procedures for interpreters/evaluators and develop a re-photointerpretation process for a series of sample units to guarantee that standard operating procedures are correctly implemented and identify areas of improvements through the use of a Platform of Uncertainty.

Visual Interpretation Classification Manual:

Written manual created as a practical, step by step tutorial meant for interpreters/evaluators that participate in uncertainty estimation processes.

- **SOP05 Forest Remaining Forest Carbon Flux estimation**

Develops the methodological protocol for estimating carbon fluxes in forest lands that remain as such, by integrating satellite mosaics with data series from forest inventory plots. These data are combined to determine the degradation or increase of carbon stock in permanent forest.

- **SOP06 Field Operation Manual**

This manual details the procedures and methods to be used in the field data collection for the inventory of the resources comprised in the native forest ecosystems of the country. It includes the chapters that deal with the data and information referring to the field brigades and the conglomerates, the plots and the trees, including the variables that characterize the development environment from an ecosystem perspective. As such, it aims to rescue data and information from the different components of forest ecosystems

Role of communities in the forest monitoring system

The role of communities in the NFMS is connected to a series of activities previously introduced in the 2016 report, which has been extended until now in such regard. In this context, the communities have been actively participating in the system regarding complaints, first, on fire related issues, where territorial committees led by the Forest Fire Protection Management (GEPRIF) and its Forest Fires Prevention Department have been established. On this point, the previous report mentioned that the use of fire as a tool in agriculture and forestry activities is regulated by Decree No. 276 of the Ministry of Agriculture, enacted in 1980. This decree regulates and establishes rules on technical and administrative procedures for the use of fire, mainly for disposing of agricultural or forestry residues. When this decree was issued, the usual consensus was that close to 45% of forest fires in Chile were due to the use of fire for disposing of agricultural and forest residues without adequate planning or control measures. Nevertheless, the current situation reveals that only 6% of fires are generated due to agricultural and/or forest burning.

It is worth mentioning, regarding the application of Decree No.276, that it is conducted under the following procedures in case a member of the community needs to use fire for a specific agricultural, silviculture or forest activity as detailed below:

1) Go to CONAF or the police and give advance notice of the date and place where fire will be used, describing planning and control measures established to prevent or fight against any possible fires that may happen.

2) Proceed in accordance with a burning schedule pre-established by CONAF and broken down by counties, with a fire use timeline under suitable conditions for keeping fires under control.

3) Adopt guidelines on the adequate use of fire as a tool for developing agricultural and forest lands, including topics such as controlled burning techniques and environmental considerations for keeping fire under control.

CONAF´s online platform, the Burn Assistance System (SAQ, acronym in Spanish) certainly facilitates procedures and processes when members of the community need to use fire, where the user conducting the controlled burning can obtain a voucher for his burn notification without having to visit a CONAF office in person. In this regard, CONAF has provided capacity building and trained communities so their users can use the system effectively and independently through the national territory.

On the other hand, and on this same point about controlled burning notifications, members of the community can also actively participate in complaint procedures that lead to fire use oversight, a situation made possible by the close cooperation between CONAF and the national police (Carabineros de Chile). In this context, initiatives such as these encourage the communities to actively participate in protecting their lands by establishing forest oversight committees, which for example have been developed in theVII, VIII and IX regions.

At the same time, illegal logging is another aspect related to the role of communities in NFMS. For this purpose, CONAF also has a mechanism for receiving citizen complaints either via postal mail or e-mail when there is information of any acts where a violation of the Forest Law of Chile has taken place. For this, CONAF is responsible for verifying the truthfulness of the information being provided through the complaint, following a site inspection process as final verification and also setting in motion the various legal actions that are required to be filed against the alleged offender. Afterwards, CONAF sends a document to the complainant´s address to notify him/her about

the outcome of the complaint and the law enforcement conducted by CONAF, informing the complainant if there was a breach of the existing forest legislation and any legal measures adopted by CONAF if required.

9.3 Relation and consistency with the National Forest Monitoring System

The approach for the measuring, monitoring, and reporting established for emission and capture accounting is completely consistent with the procedures established by Chile for the National Forest Monitoring System, which has been developed and implemented in accordance with the technical requirements established by the UNFCCC and the Carbon Fund. It has also been subject to a technical evaluation by the Green Climate Fund panel of experts during 2019, for the results – based payment phase. The NFMS is part of the ENCCRV SMM, which besides forest monitoring is also designed to monitor neutral land degradation elements, safeguards and co – benefits.

The SMM of the ENCCRV has the information collection processes and systems that act as a basis for the NFMS. These correspond to land use change maps based on a Native Forest Cadastre for land use change activity data, the National Forest Inventory for the estimation of forest degradation, the National Wood Fuel and Carbon Inventory and the Forestry Administration and Control System (SAFF) and the Territorial Information System (SIT). These systems as a whole allow the gathering, visualization, query and maintenance of information related to land use in Chile. The measuring, reporting and verification approach for the ER Program is formed by the integration and interoperability of the previously mentioned existing systems as explained in previous chapters, therefore the relationship between them is direct and consistency assured. Also, the implemented technical corrections that were detailed at the start of Annex 4 are cross – cutting for the processes that comprise the SMM and NFMS, being useful for their implementation in existing systems as part of their improvements.

12 UNCERTAINTIES OF THE CALCULATION OF EMISSION REDUCTIONS

The following table identifies and discusses a list of the main sources of uncertainty and an analysis of its contribution to the uncertainty of Reference Emission Level. The table also includes the procedures implemented to address these sources of uncertainty as part of the Monitoring Cycle. The main sources of uncertainty of Forest Reference Emission Level are:

i. Land-use / land-use change maps derived from the classification of multi-pixel mosaics,

ii. Carbon flux mapping in permanent forest derived from carbon flux models and carbon density mapping,

iii. Total biomass estimate, and Annual periodic Increment estimate obtained with the National Forest Inventory.

12.1 Identification and assessment of sources of uncertainty

Sources of uncertainty	Analysis of contribution to overall uncertainty
Activity Data	
Measurement	**Land-use and land-use change areas**: The Activity Data (AD) for deforestation, substitution, restitution, area increase of native forest, and permanent forest lands come from three sources of information: i. Land use maps, ii. Land-use changes maps and iii. Cadastre Maps. A Protocol has been prepared to facilitate the replication of the mapping process from digital processing of satellite images. All procedures required to prepare land-use and land-use change maps are described in the Methodological Protocol for the land-use and land-use change mapping in Native Forest. This protocol includes the inputs, data sets, and methodological steps necessary to generate thematic cartography and statistical reports at the national level on the extension, distribution, and land-use change. The land-use change detection maps are prepared with the Multi-Index Integrated Change Analysis methodology (MIICA - Jin et al., 2013), both for the reference and reporting periods. The application of the MIICA methodology uses the multipixel mosaics Landsat 5 and 7 for the reference period and Landsat 8 for the monitoring period. Land-use change control polygons (ground truth) are taken proportionally to each of the regions' surfaces to establish the spectral thresholds of the zones of change and the evaluated index for each IPCC land-use category. Next, the polygons are verified visually on the time series of high-resolution images provided by the Google Earth software. Finally, land-use allocation of the loss vector layer is done with supervised classification of multi-pixel mosaic. Additionally, temporal tracking of land-use changes is done by integrating the polygons of areas of change resulting from each monitoring into the existing layers of change maps. Topological conditions, data geometry, databases, and map attributes are reviewed in detail. Then, any discrepancies or inconsistencies are sent to the responsible team for resolution. After the solution, the inconsistency is double checked and verified again. The result of the activity data measurement is reviewed to ensure consistency, according to the sum of REDD+ activities areas and the surface region. This process is applied during the integration of final calculation results, and in the case of finding inconsistencies, the integration must stop, and the input data reviewed. Finally, uncertainties associated with AD are due to the production process of land use maps. The uncertainties of the AD for deforestation, substitution, restitution,

Sources of uncertainty	Analysis of contribution to overall uncertainty
	increased area of native forest, and permanent forest activities are associated with the errors of the satellite image processing during the preparation of land-use change maps. The uncertainty of land-use change maps is estimated by comparing the results of the land-use change category on the map and the reference observations corresponding to a sample of visually interpreted points. Factors influencing the estimation of uncertainty are the sampling design and the sample size used to assess the precision and accuracy of the maps. The errors related to land-use change are calculated following the Good Practice Guidelines for estimating the accuracy of land-use change described in Olofsson et al. (2013). This approach is applied with the FAO Collect Earth tool. With this tool, the land-use change categories from 1,868 polygons, representing a total area of 1,832,483 ha, were assessed. The sample size of the accuracy assessment of the land-use change maps is calculated considering the user's precision parameters for each land use or category of change. These parameters are obtained from a pre-sampling. The sample size is calculated assuming a standard error of the precision of 0.01 using the equation of Cochran (1977). The evaluation points are selected with a stratified random sampling design for each IPCC sub-use in each region. **Permanent forest degradation and carbon enhancement**: The Activity Data for degradation and carbon enhancement in permanent forest lands comes from satellite imaging and NFI biomass information integration. A Protocol has been prepared to facilitate replicating the mapping process from the digital processing of satellite images and NFI biomass information. All procedures are described in the Protocol to prepare carbon flux, stock, and degradation mapping in the permanent forest. This protocol includes a methodological description, spatial and dasometric information, and satellite data processing required to estimate activity data for degradation and carbon enhancement. The sources of error for estimating carbon degradation and enhancement activity data on permanent forest lands are: a. Uncertainty associated with the forest density charts used to determine the direction of carbon flux (neutral, loss, or gain) for each pixel. This uncertainty has been estimated at 32.8%. Uncertainty associated with integrating the multi-pixel mosaic satellite data with the dasometric variables. This uncertainty has been estimated by calculating the Standard Error of Estimation of the volume function k-nn. This uncertainty has been estimated at 57%.
Representativeness	Land-use and land-use change areas: multi-pixel mosaics are prepared with a temporal range with cloud-free pixels to obtain representative satellite images of the beginning and end of each period. The multi-pixel mosaic is an image composed of pixels of different images extracted from the definition of a range or time window. The selection of each pixel seeks to define the best information available in a specific area, prioritizing above all that they are pixels free of cloud and cloud shadows. Given the high cloud cover present in southern Chile, a ± 3 months window is used for the start and end date of the analyzed period. For example, considering the period 2018 - 2019, the start date is January 1, 2018, the range or time window will correspond from October 1, 2017, to March 31, 2018; the multipixel mosaic time window for the end of period (December 31, 2019) is from October 1, 2019, to March 31, 2020.
Sampling	Land-use and land-use change areas: This source of uncertainty is not applicable. It is not required to use a sampling technique to estimate ADs for carbon deforestation, substitution, restitution, increased area of native forest, and permanent forest lands. The AD estimation is made with a total pixel count of the carbon content map for each land-use change category.

Sources of uncertainty	Analysis of contribution to overall uncertainty
Extrapolation	This source of uncertainty is not applicable. Extrapolation is not applied to estimate REDD+ activities, the sample-based estimation area method is not used. All REDD+ activities are calculated from spatially explicit information.
Approach 3	This source of uncertainty is not applicable. Activity data were estimated conducting tracking of lands or IPCC Approach 3 for reference and monitoring periods.
Emission factors	
DBH measurement H measurement Plot delineation Wood density estimation Biomass allometric model	**Aerial Biomass** The measurement uncertainty for aerial biomass estimate depends on the land-use carbon density data source: a. **Aerial biomass of native and mixed forest**: SOP_06 Field Operations Manual was implemented during fieldwork for the estimation of AGB in the National Forest Inventory. For some forest types were possible to adjust a Probability Distribution Function (PDF). For the forest types with a limited number of sampling plots, uncertainty propagation with Monte Carlo analysis uses the following information: ● DBH measurement error (0.2%). Calculation based on Continuous Forest Inventory data of INFOR. ● Volume estimation error (0.07%). Calculation based on Continuous Forest Inventory data of INFOR. ● Biomass Expansion Factor (BEF) error (18.0%). BEF comes from information collected in the country from the study of Gayoso et al. (2002) and used in INGEI (2018). This value is for native species and has a national spatial level. Error calculation is based on statistical data from the Biomass Inventory and Carbon Accountancy vary out by the Universidad Austral de Chile (UACh). ● Wood Density (5.6%). Calculated using basic density data collected from native species growing in Chile. A bibliographic review of basic densities of the forest species in Chile was carried out and there were no modifications for the value exposed form Gayoso et al. (2002) and INGEI (2018). Finally, these uncertainties are combined following IPCC approach 1 (propagation of error), resulting in total uncertainty of 18.85%. b. **Aerial biomass of non-forest uses**: Monte Carlo analysis uses error estimation published in INGEI (2020) and Gayoso (2006) and expert judgment estimates (IPCC, 2006). The error of carbon density for wetlands, water bodies, and other non-vegetations uses was assumed zero due to lack of data. **Annual Periodic Increment (IPA Spanish acronym):** SOP_06 Field Operations Manual was implemented during fieldwork to estimate IPA in the National Forest Inventory, for some forest types were possible to adjust a Probability Distribution Function (PDF). For the forest types with a limited number of sampling plots, uncertainty propagation with Monte Carlo analysis uses the calculation of the measurement uncertainty for IPA based on the 95% CI of the removal rate by forest type, calculated with Continuous Forest Inventory data of INFOR.
Sampling	The Continuous Inventory of Forestry Ecosystems or Forest National Inventory, henceforth referred to as the Continuous Inventory, is managed by INFOR, and it has been operational since 2000. The Continuous Inventory was designed under a statistical bi-stage design in three circular sample plot clusters in an area equivalent to 500m2 distributed in a systematic area of 5x7km. The sampling units have been systematically distributed over the national territory from the Maule to the Magallanes region.
Other parameters (e.g. Carbon Fraction, root-to-shoot ratios)	**Root-to-shoot ratio (R factor-40% error)**: R factor comes from information collected in the country (Gayoso et al., 2002; INGEI, 2020). This value is within the range indicated in the 2006 IPCC Guidelines for temperate forests (between 0.20 and 0.46, according to Table 4.4; Chapter 4; Volume 4) and within of the values available

Sources of uncertainty	Analysis of contribution to overall uncertainty
	worldwide, which provide R factors that range between 0.09 and 0.33. This value is for native species and has a national spatial level. Error calculation based on statistical data from the Biomass Inventory and Carbon Accountancy of the Universidad Austral de Chile (UACh). Finally, aerial biomass and R factor uncertainties are combined following IPCC approach 1 (propagation of error), resulting in total uncertainty of 44.2%.
Representativeness	This source of uncertainty is not applicable. Chile generates estimates of carbon densities per forest type, and non-forest land uses. Different forest types and structures classify the native forest. Each forest type has its biomass value depending on data availability. Also, non-forest lands include the following uses: Urban and Industrial Areas, agricultural land, grassland, scrub, arborescent scrub, shrub planting, succulent scrub, succulent formations, plantations, wetlands, areas deprived of vegetation, eternal snows and glaciers, waterbodies and unrecognized areas.
Integration	
Model	Calculation tools have been prepared to estimate Emission Reductions, including the FREL and Monitoring Period for REDD activity. In these tools, you can review the formulas used to estimate ERs. The country prepared these tools to ensure the same calculation methods are applied for all monitoring events and avoid errors during the processing and data preparation.
Integration	The Emission factors were calculated for each region and forest type according to AGB sampling plots' location to assure the comparability between transition classes of the Activity Data and those of the Emission Factors. This source of uncertainty is considered in the sampling error of the AGB inventory.

12.2 Quantification of uncertainty in Reference Level Setting

Parameters and assumptions used in the Monte Carlo method

Parameter included in the model	Parameter values	Error sources quantified in the model	Probability distribution function	Assumptions
Activity Data				
Non-Forest land - Forest Maule Reference Period (ha/yr)	7,012.55	27.98 %	Normal	Activity Data uncertainty used in Monte Carlo Analysis was calculated using the confidence limits of the sampling-based land-use change estimation areas for the reference and monitoring periods.
Non-Forest land - Forest Ñuble Reference Period (ha/yr)	1,144.04	24.05 %	Normal	
Non-Forest land - Forest Biobio Reference Period (ha/yr)	2,156.59	36.83 %	Normal	
Non-Forest land - Forest Araucanía Reference Period(ha/yr))	2,948.47	57.52 %	Normal	
Non-Forest land - Forest Los Ríos Reference Period (ha/yr)	1,545.03	34.85 %	Normal	
Non-Forest land - Forest Los Lagos Reference Period (ha/yr)	1,004.49	36.91 %	Normal	
Forest land – Non-Forest Maule Reference Period (ha/yr)	828	78.00 %	Normal	
Forest land – Non-Forest Ñuble Reference Period (ha/yr)	453	48.81 %	Normal	
Forest land – Non-Forest Biobio Reference Period (ha/yr)	1,296	58.61 %	Normal	
Forest land – Non-Forest Araucanía Reference Period(ha/yr))	1,537	50.22 %	Normal	
Forest land – Non-Forest Los Ríos Reference Period (ha/yr)	1,529	36.26 %	Normal	
Forest land – Non-Forest Los Lagos Reference Period (ha/yr)	3,530	25.25 %	Normal	
Aum No Conserv Bajo C en 2001, entre [B-C] en 2010 RP (ha/yr)	54,672	32.80 %	Normal	Degradation mapping accuracy estimated by INFOR.
Aum No Conserv Entre [B-C] en 2001 y sobre B en 2010 RP (ha/yr)	271,368	32.80 %	Normal	
Aum No Conserv Bajo C en 2001 y sobre B en 2010 RP (ha/yr)	167,695	32.80 %	Normal	
Aum No Conserv Bajo C en 2001 y bajo C en 2010 RP (ha/yr)	59,742	32.80 %	Normal	
Aum No Conserv Entre [B-C] en 2001, entre [B-C] en 2010 RP (ha/yr)	38,912	32.80 %	Normal	
Deg No Conserv Sobre B en 2001 y bajo C en 2010 RP (ha/yr)	121,830	32.80 %	Normal	
Deg No Conserv Entre [B-C] en 2001 y bajo C en 2010 RP (ha/yr)	45,625	32.80 %	Normal	
Deg No Conserv Sobre B en 2001, Entre [B-C] en 2010 RP (ha/yr)	224,752	32.80 %	Normal	
Deg No Conserv Bajo C en 2001 y bajo C en 2010 RP (ha/yr)	53,030	32.80 %	Normal	

Parameter included in the model	Parameter values	Error sources quantified in the model	Probability distribution function	Assumptions
Deg No Conserv Entre [B-C] en 2001, entre [B-C] en 2010 RP (ha/yr)	37,029	32.80 %	Normal	
Aum Conserv Bajo C en 2001, entre [B-C] en 2010 RP (ha/yr)	10,541	32.80 %	Normal	
Aum Conserv Entre [B-C] en 2001 y sobre B en 2010 RP (ha/yr)	53,982	32.80 %	Normal	
Aum Conserv Bajo C en 2001 y sobre B en 2010 RP (ha/yr)	28,729	32.80 %	Normal	
Aum Conserv Bajo C en 2001 y bajo C en 2010 RP (ha/yr)	10,265	32.80 %	Normal	
Aum Conserv Entre [B-C] en 2001, entre [B-C] en 2010 RP (ha/yr)	8,272	32.80 %	Normal	
Deg Conserv Sobre B en 2001 y bajo C en 2010 MP (ha/yr)	26,389	32.80 %	Normal	
Deg Conserv Entre [B-C] en 2001 y bajo C en 2010 MP (ha/yr)	9,675	32.80 %	Normal	
Deg Conserv Sobre B en 2001, Entre [B-C] en 2010 MP (ha/yr)	51,707	32.80 %	Normal	
Deg Conserv Bajo C en 2001 y bajo C en 2010 MP (ha/yr)	9,548	32.80 %	Normal	
Deg Conserv Entre [B-C] en 2001, entre [B-C] en 2010 MP (ha/yr)	7,888	32.80 %	Normal	
Forest land - Forest Plantation Maule RP (ha/yr)	2,004	59.02 %	Normal	Activity Data uncertainty used in Monte Carlo Analysis was calculated using the confidence limits of the sampling-based land-use change estimation areas for the reference and monitoring periods.
Forest land - Forest Plantation Ñuble RP (ha/yr)	778	37.64 %	Normal	
Forest land - Forest Plantation Bío-Bío RP (ha/yr)	1,590	62.23 %	Normal	
Forest land - Forest Plantation La Araucanía RP (ha/yr)	2,772	64.36 %	Normal	
Forest land - Forest Plantation Los Ríos RP (ha/yr)	944	77.14 %	Normal	
Forest land - Forest Plantation Los Lagos RP (ha/yr)	664	76.22 %	Normal	
Forest fires area Maule RP (ha/yr)	583.4	15%	Normal	INGEI
Forest fires area Ñuble RP (ha/yr)	139.2	15%	Normal	
Forest fires area Biobio RP (ha/yr)	1,028.5	15%	Normal	
Forest fires area Araucanía RP (ha/yr)	2,058.1	15%	Normal	
Forest fires area Los Ríos RP (ha/yr)	150.4	15%	Normal	
Forest fires area Los Lagos RP (ha/yr)	781.9	15%	Normal	
Carbon content of Non-Forest Lands				
AGB Áreas Urbanas e Industriales	2.00	95%	Normal	(INGEI, 2020)
AGB Terrenos Agrícolas	10.00	75%	Normal	(INGEI, 2020)
AGB Praderas y Matorrales Praderas	4.73	27.7%	Normal	(Gayoso, 2006)
AGB Praderas y Matorrales Matorral-Pradera	9.04	34.6%	Normal	

Parameter included in the model	Parameter values	Error sources quantified in the model	Probability distribution function	Assumptions
AGB Praderas y Matorrales Matorral Arborescente	21.78	22.4%	Normal	
Carbon content of Native Forest				
BGB Terrenos Agrícolas	2.00	53.2%	Normal	Uncertainty for BGB of Non-Forest lands is based on propagation error estimate following IPCC approach 1 of Matorrals-Arborescente AGB error (22.42%) and Root shoot ratio -R Factor error (48.27%) estimated by Gayoso et al. (2002), resulting in total uncertainty of 53.2%.
BGB Praderas y Matorrales Praderas	8.13	53.2%	Normal	
BGB Praderas y Matorrales Matorral-Pradera	14.99	53.2%	Normal	
BGB Praderas y Matorrales Matorral Arborescente	35.25	53.2%	Normal	
AGB Alerce Adulto (t dry biomass/ha)	339.109	18.85%	Normal	For the forest types with a limited number of sampling plots, uncertainty propagation with Monte Carlo analysis uses the following information: i. DBH measurement error (0.2%), calculation based on Continuous Forest Inventory data of INFOR; ii. Volume estimation error (0.07%), calculation based on Continuous Forest Inventory data of INFOR, iii. Biomass Expansion Factor (BEF) error (18.0%), BEF comes from information collected in the country from the study of Gayoso et al. (2002) and used in INGEI (2020). This value is for native species and has a national spatial level. Error calculation is based on statistical data from the Biomass Inventory and Carbon Accountancy of the Universidad Austral de Chile (UACh); and iv. Wood Density (5.6%) calculated using basic density data collected from native species growing in Chile. Finally, these uncertainties are combined following IPCC approach 1 (propagation of error),
AGB Alerce Renoval (t dry biomass/ha)	203.590	18.85%	Normal	
AGB Ciprés de las Guaitecas Adulto (t dry biomass/ha)	221.848	18.85%	Normal	
AGB Araucaria Adulto (t dry biomass/ha)	β: 222.628; k: 1.886	PDF	Gama 2; P:0.998; n: 16	
AGB Araucaria Renoval (t dry biomass/ha)	219.131	18.85%	Normal	
AGB Ciprés de la Cordillera Adulto (t dry biomass/ha)	97.116	18.85%	Normal	
AGB Ciprés de la Cordillera Renoval (t dry biomass/ha)	124.019	18.85%	Normal	
AGB Lenga Adulto (t dry biomass/ha)	μ: 207.038; s: 84.017	PDF	Logistic; P:0.958; n:10	
AGB Lenga Renoval (t dry biomass/ha)	α: 0.431; β:0.439	PDF	Beta4; P:0.776; n:8	
AGB Coihue de Magallanes Adulto (t dry biomass/ha)	129.148	18.85%	Normal	
AGB Roble - Hualo Adulto (t dry biomass/ha)	β: 17.695; k: 5.884	PDF	Gamma (2); P:0.808; n: 17	
AGB Roble - Raulí - Coihue Adulto (t dry biomass/ha)	λ: 0.006	PDF	Exponential ; P:0.850; n: 65;	
AGB Roble - Raulí - Coihue Renoval (t dry biomass/ha)	λ: 0.006	PDF	Exponential ; P:0.709; n: 71	
AGB Coihue - Raulí - Tepa Adulto (t dry biomass/ha)	β: 1.162; γ:414.153	PDF	Weibull (2); P: 0.831; n: 57	
AGB Coihue - Raulí - Tepa Renoval (t dry biomass/ha)	β: 117.880; k: 1.720	PDF	Gamma (2); P:0.989; n: 12	
AGB Esclerófilo Adulto (t dry biomass/ha)	β: 0.721; γ:12.840	PDF	Weibull (2); P: 0.858; n: 33	

Parameter included in the model	Parameter values	Error sources quantified in the model	Probability distribution function	Assumptions
AGB Siempreverde Adulto (t dry biomass/ha)	μ: 5.765; σ: 0.646	PDF	Log-normal; P: 0.194; n: 49	resulting in total uncertainty of 18.85%
AGB Siempreverde Renoval (t dry biomass/ha)	β: 1.584; γ:139.543	PDF	Weibull (2); P: 0.673; n: 25	

Parameter included in the model	Parameter values	Error sources quantified in the model	Probability distribution function	Assumptions
AGB Maule Mixed Forest Reference Period (t dry biomass/ha)	58.85	18.85%	Normal	
AGB Biobio Mixed Forest Reference Period (t dry biomass/ha)	210.75	18.85%	Normal	
AGB Araucanía Mixed Forest Reference Period (t dry biomass/ha)	246.71	18.85%	Normal	
AGB Los Ríos Mixed Forest Reference Period (t dry biomass/ha)	194.05	18.85%	Normal	
AGB Los Lagos Mixed Forest Reference Period (t dry biomass/ha)	221.64	18.85%	Normal	
AGB Ñuble Mixed Forest Reference Period (t dry biomass/ha)	58.85	18.85%	Normal	
BGB Maule Mixed Forest Reference Period (t dry biomass/ha)	70.78	44.2%	Normal	Uncertainty for Below Ground Biomass BGB is based on propagation error estimate following IPCC approach 1 of Above Ground Biomass-AGB error (18.85%) and Root shoot ratio -R Factor error (40.0%) estimated by Gayoso et al. (2002), resulting in total uncertainty of 44.2%.
BGB Biobio Mixed Forest Reference Period (t dry biomass/ha)	55.67	44.2%	Normal	
BGB Araucanía Mixed Forest Reference Period (t dry biomass/ha)	63.59	44.2%	Normal	
BGB Los Ríos Mixed Forest Reference Period (t dry biomass/ha)	47.21	44.2%	Normal	
BGB Los Lagos Mixed Forest Reference Period (t dry biomass/ha)	12.47	44.2%	Normal	
BGB Ñuble Mixed Forest Reference Period (t dry biomass/ha)	37.80	44.2%	Normal	
Dead matter Maule Mixed Forest RP (t dry biomass/ha)	72.30	28.4%	Normal	Error estimated from permanent plots of the INFOR Continuous Forest Inventory
Dead matter Biobio Mixed Forest RP (t dry biomass/ha)	52.91	28.4%	Normal	
Dead matter Araucanía Mixed Forest RP (t dry biomass/ha)	61.16	28.4%	Normal	
Dead matter Los Ríos Mixed Forest RP (t dry biomass/ha)	47.61	28.4%	Normal	
Dead matter Los Lagos Mixed Forest RP (t dry biomass/ha)	18.92	28.4%	Normal	
Dead matter Ñuble Mixed Forest RP (t dry biomass/ha)	45.49	28.4%	Normal	
Annual Periodic Increase of Native Forest				
PAI Maule Mixed Forest Reference Period (t dry biomass/ha)	4.20	28.7%	Normal	Average of PAI error for all forest types given lack of data.
PAI Biobio Mixed Forest Reference Period (t dry biomass/ha)	4.14	28.7%	Normal	
PAI Araucanía Mixed Forest Reference Period (t dry biomass/ha)	4.06	28.7%	Normal	
PAI Los Ríos Mixed Forest Reference Period (t dry biomass/ha)	2.21	28.7%	Normal	
PAI Los Lagos Mixed Forest Reference Period (t dry biomass/ha)	3.70	28.7%	Normal	
PAI Ñuble Mixed Forest Reference Period (t dry biomass/ha)	4.03	28.7%	Normal	
PAI Alerce Adulto (m3/ha/yr)	0.5	58.47%	Normal	The higher uncertainty of the errors estimated for PAI is assumed due to a lack of data.
PAI Ciprés de las Guaitecas Adulto (m3/ha/yr)	3.9	58.47%	Normal	

Parameter included in the model	Parameter values	Error sources quantified in the model	Probability distribution function	Assumptions
PAI Araucaria Adulto (m3/ha/yr)	μ: 4.882; σ: 2.516	PDF	Normal; P:0.923; n: 16	
PAI Ciprés de la Cordillera Adulto (m3/ha/yr)	5.0	15.83%	Normal	Error estimated from permanent plots of the INFOR Continuous Forest Inventory
PAI Ciprés de la Cordillera Renoval (m3/ha/yr)	2.7	9.97%	Normal	
PAI Lenga Adulto (m3/ha/yr)	k: 5; γ:0.921	PDF	Erlang; P:0.986; n:10	
PAI Lenga Renoval (m3/ha/yr)	μ: 2.995; β:2.054	PDF	Fisher-Tippett (2); P:0.907; n:8	
PAI Coihue de Magallanes Adulto (m3/ha/yr)	2.6	13.42%	Normal	Error estimated from permanent plots of the INFOR Continuous Forest Inventory
PAI Coihue de Magallanes Renoval (m3/ha/yr)	3.7	7.68%	Normal	
PAI Roble - Hualo Adulto (m3/ha/yr)	μ: 1.534; σ: 0.507	PDF	Log Normal; P:0.873; n: 17	
PAI Roble - Hualo Renoval (m3/ha/yr)	3.5	54.47%	Normal	The higher uncertainty of the errors estimated for IPA is assumed due to a lack of data.
PAI Roble - Raulí - Coihue Adulto (m3/ha/yr)	μ: 1.335; σ: 1.106	PDF	Log Normal; P:0.257; n: 65;	
PAI Roble - Raulí - Coihue Renoval (m3/ha/yr)	β: 1.777; γ:4.664	PDF	Weibull (2); P:0.760; n: 71	
PAI Coihue - Raulí - Tepa Adulto (m3/ha/yr)	β: 1.403; γ:6.264	PDF	Weibull (2); P: 0.789; n: 57	
PAI Coihue - Raulí - Tepa Renoval (m3/ha/yr)	μ: 4.364; s: 1.558	PDF	Logistic; P:0.825; n: 12	
PAI Esclerófilo Adulto (m3/ha/yr)	β: 0.667; γ:0/875	PDF	Weibull (2); P: 0.512; n: 33	
PAI Esclerófilo Renoval (m3/ha/yr)	1.6	21.31%	Normal	Error estimated from permanent plots of the INFOR Continuous Forest Inventory
PAI Siempreverde Adulto (m3/ha/yr)	α: 13.411; β:29.589	PDF	Beta4; P: 0.940; n: 49	
PAI Siempreverde Renoval (m3/ha/yr)	μ: 4.664; s:0/893	PDF	Logistic; P: 0.994; n: 25	

Parameter included in the model	Parameter values	Error sources quantified in the model	Probability distribution function	Assumptions
Degradation and Enhancement in permanent forest				
Carbon stock change in permanent forest	Values depending on density diagram change and forest type	57%	Normal	Error estimation based on the standard error of the k-nn algorithm volume estimation.
Carbon content of forest lands (forest fires)				
AGB Maule (t dry biomass/ha/yr)	80.35	18.85%	Normal	This uncertainty is estimated following IPCC approach 1 (propagation of error), resulting in total uncertainty of 18.85%.
AGB Biobio (t dry biomass/ha/yr)	149.88	18.85%	Normal	
AGB Araucanía (t dry biomass/ha/yr)	252.33	18.85%	Normal	
AGB Los Ríos (t dry biomass/ha/yr)	310.35	18.85%	Normal	
AGB Los Lagos (t dry biomass/ha/yr)	230.41	18.85%	Normal	
AGB Ñuble (t dry biomass/ha/yr)	149.88	18.85%	Normal	
BGB Maule (t dry biomass/ha/yr)	23.05	44.2%	Normal	Uncertainty for Below Ground Biomass BGB is based on propagation error estimate following IPCC approach 1 of Above Ground Biomass-AGB error (18.85%) and Root shoot ratio -R Factor error (40.0%) estimated by Gayoso et al. (2002), resulting in total uncertainty of 44.2%.
BGB Biobio (t dry biomass/ha/yr)	43.00	44.2%	Normal	
BGB Araucanía (t dry biomass/ha/yr)	72.39	44.2%	Normal	
BGB Los Ríos (t dry biomass/ha/yr)	89.04	44.2%	Normal	
BGB Los Lagos (t dry biomass/ha/yr)	66.10	44.2%	Normal	
BGB Ñuble (t dry biomass/ha/yr)	43.00	44.2%	Normal	
Dead matter Maule (t dry biomass/ha)	52.60	28.4%	Normal	Error estimated from permanent plots of the INFOR Continuous Forest Inventory
Dead matter Biobio (t dry biomass/ha)	122.10	28.4%	Normal	
Dead matter Araucanía (t dry biomass/ha)	165.50	28.4%	Normal	
Dead matter Los Ríos (t dry biomass/ha)	146.90	28.4%	Normal	
Dead matter Los Lagos (t dry biomass/ha)	157.00	28.4%	Normal	
Dead matter Ñuble (t dry biomass/ha)	122.10	28.4%	Normal	
Other Factors				
Combustion factor	0.45	36.0%	Normal	IPCC, 2006
Emission Factor CH4	4.7	29.0%	Normal	
Emission Factor N2O	0.26	43.8%	Normal	

Quantification of the uncertainty of the estimate of the Reference level

		Deforestation	Forest degradation	Enhancement of carbon stocks	Conservation
A	**Median**	4,985,269	12,087,643	-10,809,741	56,168
B	**Upper bound 90% CI** (Percentile 0.95)	7,130,706	15,386,105	-7,866,347	1,162,736
C	**Lower bound 90% CI** (Percentile 0.05)	3,287,298	9,398,309	-13,752,891	-1,068,201
D	**Half Width Confidence Interval at 90% (B – C / 2)**	1,921,704	2,993,898	2,943,272	1,115,469
E	**Relative margin (D / A)**	38.5%	24.8%	27.2%	1985.9%
F	**Uncertainty discount**	8%	4%	4%	15%

Sensitivity analysis and identification of areas of improvement of MRV system

The sensitivity analysis was carried out for the Emissions Reductions (ERs) calculations, which includes the reference level and the monitoring periods. The following table and figure show the results for the sensitivity analysis of ERs uncertainty. ERs estimate in forest remaining forest (conserved and non-conserved) contributes the 54.2% of total ERs uncertainty. The main contribution is coming from ERs' uncertainty in the non-conserved permanent forest (42.5%).

The sources of error for estimating forest degradation and carbon enhancement on permanent forest lands are i. Uncertainty associated with the forest density charts used to determine the direction of carbon flux (neutral, loss or gain) for each pixel (32.8%), and ii. Uncertainty associated with integrating the multi-pixel mosaic satellite data with the dasometric variables. This uncertainty has been estimated by calculating the Standard Error of Estimation of the volume function k-nn (57%).

Table 20 shows the results of sensitivity analysis for Emission Reductions uncertainty in non-conserved permanent forest. Both activity data and emission factors contributed equally to the uncertainty (50/50). The same uncertainty for AD and EF was used for all regions, therefore the difference in the uncertainty contribution between regions responds to the magnitude of ERs.

Further analysis of the Methodology used to estimate emissions and removals in permanent forest are required to determine the improvement actions on the MRV system to reduce Emission Reduction uncertainty.

REDD Activity	Component	Uncertainty Contribution
Carbon enhancement	Removals in forest remaining as forest	20.1%
	Removals in lands converted to forest	0.4%
	Total removals	**20.4%**
Conservation	Removals in forest remaining forest	6.2%
	Emissions in forest remaining forest	5.6%
	Conservation Total	**11.8%**
	Deforestation Total	**0.3%**
Degradation	Emissions in forest remaining forest	22.4%
	Emissions from forests converted to plantations.	1.8%
	Forest fires	0.1%
	Degradation Total	**24.3%**
	Grand Total	**56.8%**

Table 16 Results for the sensitivity analysis of ERs' global uncertainty.

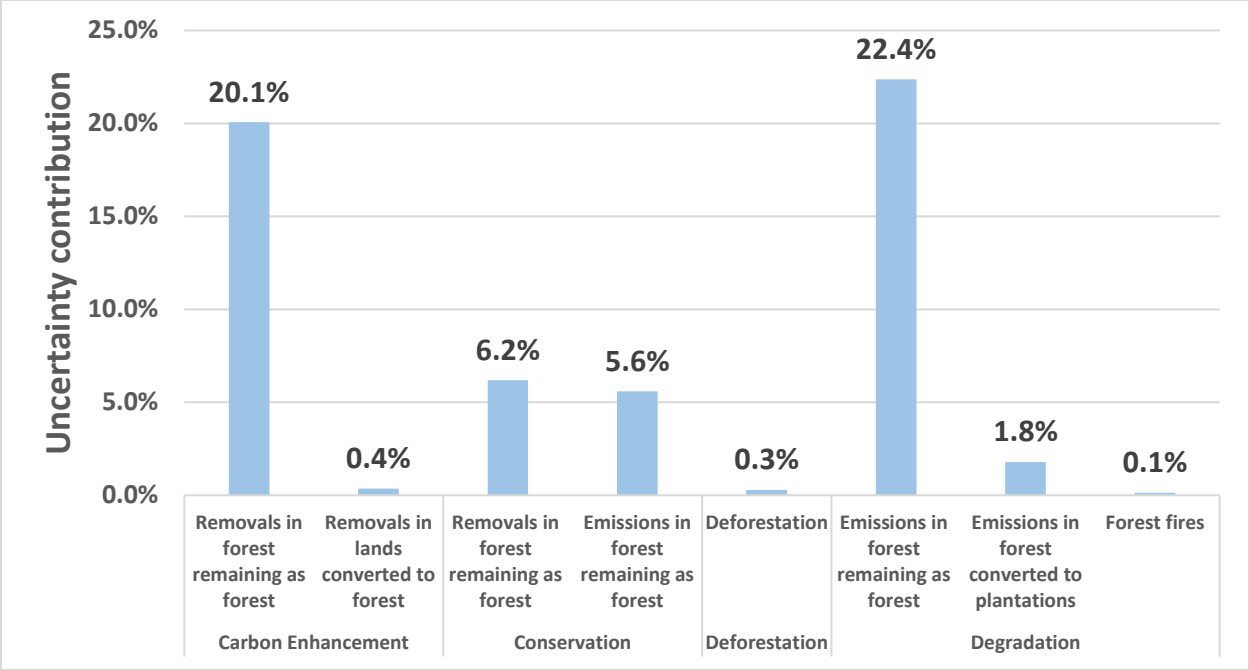


Figure 31 Results for the sensitivity analysis of ERs' global uncertainty.