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Integrating Green Infrastructure Practices into Ongoing Expansion and Management of the Chilean Electrical Transmission Network

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Abstract

The energy revolution that Chile is experiencing due to the massive incorporation of variable renewable energy to its energy matrix creates an environmental paradox. The greener our energy is getting regarding climate change, the bigger the environmental footprint due to the need to build thousands of kilometers of transmission lines. Therefore, it is an imperative to improve the environmental footprint of transmission lines.

Experiences from the United States, and the recent LIFE-Elia project implemented in the European Union prove that there is a way to manage vegetation under and surrounding transmission lines that is at the same time safer, more cost-effective and more environmentally and socially sound than the current practice of cutting and pruning trees. Such vegetation management technique has been called since the 1980s "integrative vegetation management" or "IVM", and it rests on the insight that vegetation can be a resource and not a constraint, as vegetation that will not grow to unsafe heights can be planted to crowd out tall growing trees that might endanger transmission lines.

This paper makes the case for the implementation of mandatory IMV practices in existing and new transmission lines in Chile through a three phase approach. This is not only desirable but urgent, as in the aftermath of the recent 2017 fires, vegetation management under and in the vicinity of the transmission lines in Chile has veered towards more aggressive elimination of vegetation to prevent future fires, increasing the negative environmental footprint of transmission lines. The insights of this paper not only apply to the Chilean case, but to every country that aims to incorporate renewable energy to its matrix and at the same time improve the environmental footprint of its transmission lines.

Keywords: transmission lines, environmental impact, IVM, integrative vegetation management, environmental assessment, renewable energy.

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Introduction

Currently Chile has approximately 88,000 hectares of transmission line corridors. The environmental impact of those corridors is huge, as the trees under and in the vicinity of the transmission lines are either eliminated or pruned for safety reasons, and lower vegetation and wildlife are also disturbed. The energy revolution that Chile is experiencing due to the massive incorporation of renewable energy to the energy matrix, requires the construction of thousands of kilometers of new transmission lines in the following decades. Therefore, it is imperative to improve the environmental footprint of transmission lines.

In the past decades in the United States, a new way of vegetation management called integrated vegetation management or IVM was developed. Unlike traditional transmission lines' vegetation management techniques, which involve mainly cutting and pruning undesired trees, IVM, drawing from the insights of integrated pest management, views vegetation under and in the vicinity of transmission lines not as a constraint but as a resource.[1] Vegetation that will not grow to unsafe heights is planted to crowd out tall growing trees that might endanger the lines. [2]

A pilot conducted in Europe from 2011 to 2017 that applied IVM principles to the vegetation management of 221 kilometers of transmission lines in France and Belgium, proves that IVM practices are less costly than traditional vegetation management techniques, enhance biodiversity, improve the social acceptance of transmission lines, and can help with permitting, as authorities are more willing to award those permits when they see the benefits of the new practices.

Lowering the costs associated with electricity supply and transfer, improving the environmental footprint of transmission lines, improving their social acceptability and facilitating the award of permits without sacrificing the thoroughness of the assessment or environmental protection are precisely the challenges that Chile faces today.

Therefore, we propose mandating transmission companies to implement IVM practices instead of traditional vegetation management practices. Given that the implementation of IVM not only requires capacity building within the companies and the government, but also requires site-specific scientific data, we propose a three-phase approach. Phase one includes the elaboration of Chile-specific IVM standards by a multi-stakeholder committee, and the implementation of a pilot to test and improve such standards. Phase two entails the creation of a voluntary accreditation program coupled with permitting benefits. Finally, phase three entails the issuance of regulation that mandates the use of IVM in new transmission lines, while giving incentives for the implementation of IVM in existing lines.

The case for the implementation of IVM in Chile is clear. It is a five-way win-win solution for companies, government, citizens in general, local communities and the environment.

Chile has the resources and capabilities to implement such a program without difficulty, especially given that it can draw from international experience. Therefore, it is only a matter of political will. This research has been conducted to incentivize Chile to step up to the challenge and become an example by incorporating green infrastructure practices in the development and maintenance of transmission lines.

Transmission Lines in Chile

Chile has an Extensive High Voltage Transmission System and Growing

Due to its unique geography, Chile has an extensive high voltage transmission system that reaches from the country's northern border with Peru to the Los Lagos region (also known as the tenth region, or "Region X") in the south. Note that this network does not extend deep into Patagonia, which covers roughly the southernmost one-third of the nation. In sum, across an area that is about 3,100 kilometers long and, on average, about 170 kilometers wide, Chile has approximately 32,221 kilometers of high voltage transmission lines occupying approximately 88,000 hectares.[3] This transmission system is long enough to cross Europe from north to south.

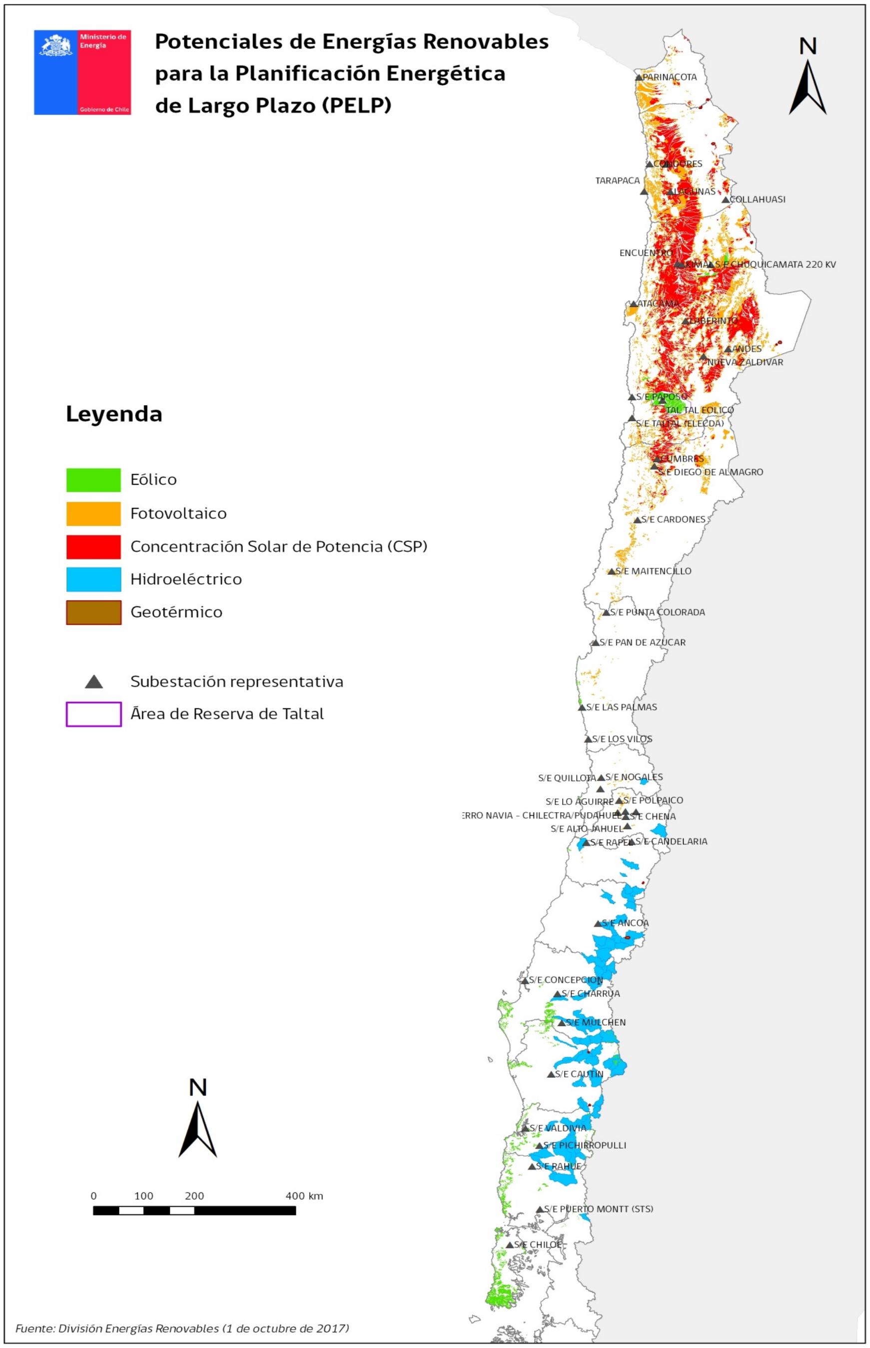
In the coming years, the Chilean transmission system will experience growth at a faster pace than in the past. This has three main causes. The first reason is the forecasted growth in demand for the entire nation, which will be concentrated in south-central regions of the country, where the majority of the Chilean population is based.

The second reason is that, to meet the forecasted growth in demand, substantial solar and wind energy capacity will be built in Chile's northern regions (Regions I, II and III). Energy produced by solar facilities in the north has to be transported to the consumption centers located in the center-south of the country.

The third reason is a regulatory one. Regulatory changes enacted in 2016 will have the effect of increasing the rate of expansion of the transmission system.

Regarding the first and second causes, during the years 2017 and 2018, the Ministry of Energy carried out the first "Long Term Energy Planning Process" ("PELP" is the Spanish acronym). The process was designed to create likely scenarios, across at least a 30-year time horizon, for the development of the energy matrix. As a result of the planning process, the Ministry came up with five equally likely scenarios for the evolution of the energy supply and demand till 2046. In all the scenarios, most of the new installed capacity comes from solar and wind technologies located in Regions I, II and III,[4] as most of the solar and wind energy potential is located in those regions (see Figure 1). Across all of these scenarios it is extremely likely that more transmission facilities will have to be built to transport energy from the north to the center and center-south of the country.

Figure 1: Renewable energy potential **(source: *PELP Final Report*, 19 Feb 2018)**[5]



English Translations -
Title: Renewable Energy Potential for the Long-Term Energy Planning Process"
Legend (from top): Wind, Photovoltaic, Potential Solar Concentration, Hydroelectric, Geothermal

Regarding the third cause, in July 2016 the new "Transmission Law" (law 20.936) came into force.[6] This law mandates the Electricity Regulator, known as the National Energy Commission ("CNE" is the Spanish acronym) to expand segments of the transmission system that previously were left to private initiative,[7] and to consider spare capacity when planning transmission lines.[8] These regulatory changes were incorporated because under the previous regulatory system private parties did not expand transmission with the required agility. New transmission lines were at full capacity the moment they started operating. These regulatory changes then, were aimed precisely at increasing the rate of transmission capacity expansion.

The incremental growth of Chile's transmission system is not going to happen sometime in the future -- it is already happening. In the first annual transmission planning process carried out by the Electricity Regulator in accordance to the Transmission Law in 2017-2018, the CNE mandated the construction of 60 transmission facilities for a total of USD 2,684 millions.[9] Among these new facilities was a 1,480 kilometers long transmission line that would extend from the north of Chile to the center.[10] This is an unprecedented plan, the largest transmission plan in terms of investment in the history of Chile's electricity sector.

In conclusion, Chile already has 88,000 hectares occupied by transmission lines and this number is expected to grow substantially, even if energy efficiency or distributed generation policies are implemented.[11] This is not a situation exclusive to Chile, as the increasing introduction of renewable energy to the energy matrix, by definition requires the expansion of the transmission system, as renewable energy is generally further removed from consumption centers than thermoelectric generation.[12]

This situation creates a paradox, as the greening of the energy matrix has significant impacts on the environment due to the increase in the construction of transmission lines; therefore, it is imperative to implement policies that can improve the environmental footprint of transmission projects. One area that can be improved on is vegetation management.

Environmental Impacts of Transmission Lines

Transmission lines usually cross many kilometers, affecting different types of land use, including forests, parks, recreation and conservation areas, agricultural lands, and developed areas (for example, residential, commercial, or industrial properties). In addition to the impacts of construction, ongoing vegetation management activities such as pruning, mowing, and the use of herbicides create impacts on these land uses.

There are no comprehensive studies identifying the environmental impacts associated with the construction and operation of overhead transmission lines in Chile.[13] However, according to international literature, the main environmental impacts of overhead transmission line construction and operation activities are on vegetation, soils, wildlife, water and on social and cultural values.

The following description of impacts comes from the paper by Ryan A. Brockbank that summarizes a 2008 Electric Power Research Institute Report on the impacts of transmission lines in the United States.[14,15]

Disturbance of forests and vegetation:

Tall trees are generally removed and eliminated from the transmission line corridor, to assure the safe and secure operation of the line. In some cases trees in the vicinity of the corridor will be removed for the same purposes.[16] Tall trees as well as lower vegetation are usually completely eliminated to build access roads and to build the support structures sites.

Therefore, vegetation is dramatically impacted. Not only the larger species are removed or heavily pruned, but lower vegetation is also affected by tree removal, as understory plant communities become exposed to sunlight and weather. Whether this exposure is beneficial or not depends on the understory species. Some of them will thrive in the light also benefiting from the reduced competition with other species; those species that require shade will be adversely impacted.

According to Brockbank, forest areas within transmission line corridors and in their vicinity will likely be substantially and permanently altered in favor of low-growing, sun-loving, early-successional plant communities. This produces an "edge effect" that alters species composition along the forest edge, and the juxtaposition of mature forest and newly created plant communities increases the likelihood of habitat fragmentation.[17] Habitat fragmentation alters the extent and/or spatial configuration of a habitat type within a landscape and can negatively affect many plant species, particularly those that require a mature forest to thrive or are rare, threatened, or endangered. The degree to which fragmentation is a negative environmental impact, or to which the creation of the 'edge effect' renders positive or negative outcomes for plant diversity along a right of way, depends upon the degree to which the surrounding landscape is already fragmented and on the specific composition of the plant communities established within the transmission corridor.[18]

In non-forest ecosystems, impacts to vegetation are less pronounced. Some shrub communities, as well as old-field vegetation can remain almost entirely intact, except on structure sites and access roads. Rangelands, grasslands and many desert plant communities can be virtually unaffected. Regardless of ecosystem type, where non-native species are introduced, invasive species increase the threat to pre-existing plant species.

Soils:

The construction of transmission lines usually requires the use of sand, gravel, or crushed rock. Applying these materials on land alters the drainage of the area where they are applied. In the case of transmission lines, this effect can be limited to the 100 square meters required for a single support (tower) structure foundation, or hundreds of hectares in the case of access roads.[19]

Soil erosion is also a major impact of vegetation removal and occurs along the transmission line corridor primarily at construction sites, as well as along the right of way. Erosion rates increase significantly when vegetation is removed, as vegetation protects soil from water and wind, and root systems bind soils to reduce runoff and erosion.[20]

Vegetation control equipment and vehicles can increase soil compaction, which in turn, can affect soil productivity. Vegetation management activities can also affect soils by altering their nutrient levels. For example, removing nitrogen-fixing plants can reduce soil nitrogen levels and impact plant productivity. Finally, herbicide use creates the potential for soil contamination, as does the risk of unintentional spill of liquid materials, such as lubricating oils or hydraulic fluids.[21]

Wildlife[22]:

Habitat fragmentation can negatively impact wildlife by reducing habitat size and connectivity, which can result in the displacement and fragmentation of wildlife populations and the disruption of rare, threatened, or endangered species of fauna. Potential impacts to wildlife resources include habitat loss, displacement, population fragmentation, reduced species abundance, and a decrease in biodiversity.

Ongoing vegetation management activities along a transmission line corridor can also adversely impact wildlife, as trees often used by wildlife for nesting, perching, hunting, shelter, and food are removed. Ground nesting birds, amphibians, and reptiles are also vulnerable to mortality from the physical disruption of soils and vegetation caused by vegetation control equipment. Furthermore, wildlife may suffer from impacts associated with herbicide use.

Water:

Transmission construction activities can adversely impact surface water (ponds, lakes, wetlands, streams, and rivers) and water quality downstream from the affected area, through soil erosion and runoff contaminated by herbicides, heavy metals, or other toxic substances. The quality of surface water can be affected by the presence of sediments, microbes, pesticides, and nutrients. Water quality is also negatively affected by the removal of shade-producing vegetation in riparian zones and subsequent increased solar radiation and temperature, as well as the inhibition of plant debris buildup that would otherwise facilitate the entry of nutrients into the water.[23]

Groundwater (wells and aquifers), when shallow, can be affected by the construction of transmission lines, as excavations can temporarily or permanently alter groundwater flows by changing existing underground channels and/or pools. This has the potential of affecting nearby groundwater pumping for domestic use.[24]

Social and cultural[25]:

Areas of cultural importance, such as prehistoric or historic sites, objects, and culturally significant infrastructure can be adversely impacted as a result of site disturbance in a transmission line corridor. Furthermore, vegetation management activities can harm plants of traditional cultural value.

The removal of tall-growing vegetation can create a sudden impact on local visual resources, that is, those features visible from areas proximate to transmission line construction. Direct and long-term impacts are likely in areas where overhead transmission lines travel across a landscape, or sites with high scenic quality or visual appeal.

Health and safety:

Transmission line construction and maintenance can also be associated with the use of potentially toxic substances including herbicides, pesticides, fungicides, fuel oils, lubricating oils and the like. Over time, the widespread use of such materials can create conditions that are hazardous to human, animal, and plant health that is otherwise valued in the area.

Transmission Line Vegetation Management in Chile

As we will see, vegetation management on transmission line corridors and surrounding areas in Chile has, generally speaking, been aimed mostly at insuring electricity service reliability. However, the extent to which vegetation is cut has been determined not only by this goal, but also by the cost of the vegetation management, environmental requirements understood mainly as decreasing the number of trees cut, and social acceptance of the lines. After the outbreak of devastating forest fires in Chile in 2017, however, a new objective has been demanded of vegetation management -- fire prevention. As we will describe, with the current vegetation management practices and regulations it seems that all goals cannot be achieved, as some must be sacrificed in favor of others. The question then is to which side the pendulum will slide, towards the elimination of most vegetation in order to achieve maximum service reliability and fire prevention, or its protection for environmental purposes and social acceptability. As we will explain, this zero-sum game can be overcome by the introduction of what is called “integrated vegetation management”.

Vegetation management in transmission corridors in Chile is mainly regulated by three government entities. The Forestry Service (“CONAF” is the Spanish acronym) and the Agricultural and Livestock Service (“SAG” is the Spanish acronym) perform an *ex ante* review (a prospective review, based on forecasted impacts), with a focus on environmental protection understood mainly –although not exclusively— as avoiding the number of trees cut and reforesting such trees in different areas. The Superintendence of Electricity and Fuels (“SEC” is the Spanish acronym) performs an *ex post* review (a review based on actual results that have occurred in the past period), with an exclusive focus on service reliability and safety.

<u>Environmental Regulation</u>

Since 1997, all high voltage transmission line projects of over 23 kV[26] must go through the environmental impact assessment system prior to their construction (“SEIA” is the Spanish acronym). The depth of the environmental assessment depends on whether the project is assessed through an abbreviated process called an Environmental Impact Declaration (or "DIA") or whether it goes through an Environmental Assessment Study (or "EIA"). If the construction and operation of a transmission line could constitute a risk for the health of the population, could have significant adverse effects over the quantity or quality of renewable resources including soil, water or air, requires the relocation of human populations, significantly alters their way of life and customs, is located near or in protected areas, resources or populations, could significantly alter the visual or touristic value of an area, or might alter sites with historical, anthropological or archeological value, it must be assessed through an EIA.[27] According to the SEIA regulation, a project has a significant adverse effect on renewable resources, and therefore will have to be assessed through an EIA, when it alters the conditions that enable the presence and development of species and ecosystems. In order to determine the aforementioned, evaluators must consider, among other indicators, the loss of capacity of the soil to sustain biodiversity due to erosion, degradation, compaction, as well as the impact on plants, algae, fungi and wildlife. There will be an emphasis on the loss of biodiversity and the impact on protected species.[28]

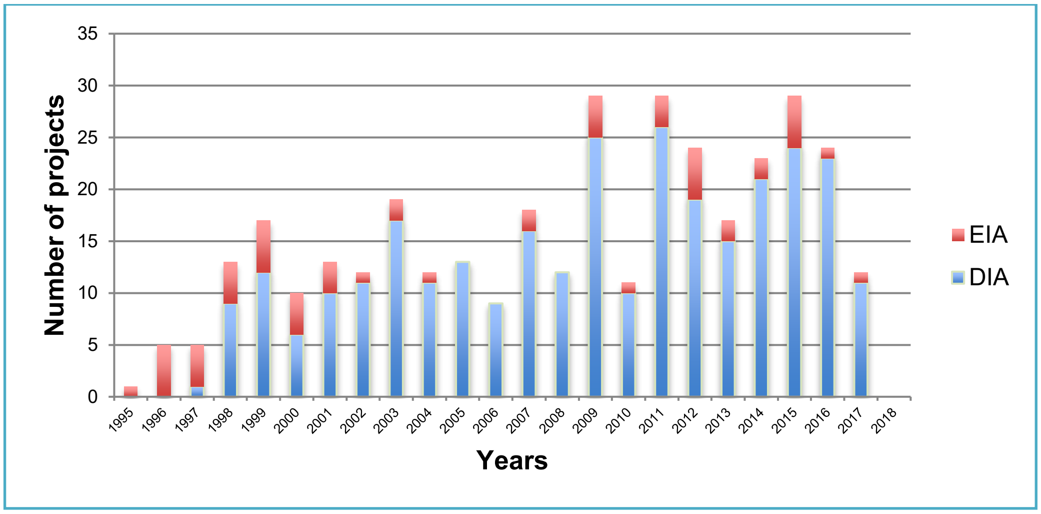
If the proposed project does not produce any of those effects, it will be assessed through a DIA. In a DIA, the developer describes and analyses the project and its forecasted or expected impact, arguing that the project does not require a full environmental impact study. Government entities in turn will analyze such impacts and corroborate – or not— the developer's assessment. Such entities can also impose conditions for the approval.

Whether a project is assessed through a DIA or a EIA is very relevant, as only in the latter the developer will have to propose measures to address the impacts of the project, and Government entities will determine if those measures are enough, and if not, require additional measures. In the former, however, the developer needs not to carry out any measures to address the impacts of the project, as those impacts are not considered of relevance.[29]

The general rule for high voltage transmission line projects in Chile is that they go through the abbreviated DIA process. From April 7th, 1995[30] to November 27, 2017, 448 transmission line projects were presented to the environmental assessment process,[31] corresponding to an estimated investment of USD 10,966 million dollars. Of those, 17% (75 projects which correspond to an estimated investment of USD 5,178 million dollars) were presented through an EIA, and 83% (373 projects which correspond to an estimated investment of 5,788 million dollars) through a DIA. Of the 448 projects, 357 were approved, 77 were rejected[32] and, at the time this information was collected, 14 were still under review.

Figure 2 shows all projects approved from 1995 to 2017 in the SEIA, distinguishing between those approved via DIA and those approved via EIA. As you can see, from 1995 till 1997 almost all projects approved where assessed through an EIA (10 out of 11). However, in recent years projects approved through an EIA are less than 10% of total projects approved.[33]

Figure 2: Projects approved within the SEIA 1995-2017 distinguishing between DIA and EIA (source: ***elaborated with data from the SEIA***)[34]



Regarding the environmental assessment, as previously mentioned, there are two main government entities in charge of evaluating the impact of transmission lines on vegetation within the SEIA: CONAF [35] and SAG. We will also briefly mention the Ministry of Environment that also has some powers regarding the protection of natural resources.

Both in a DIA and in an EIA assessment, CONAF's mandate is relatively narrow, as it is limited to the following. Generally speaking, CONAF will asses interventions on trees but only if they are part of "forests", [36] which are defined as areas of at least 5,000 square meters, with a minimum width of 40 meters, in which at least 10% of that area is comprised of trees (in arid and semiarid areas), and at least 25% in more favorable conditions.[37,38] CONAF is also tasked with the protection of vegetation that are not trees and of trees that are not part of a forest, but only in specific cases. For example, CONAF is tasked with the protection of xerophyte formations. These formations are defined as the native vegetation formed preferably by bush or succulents located in arid or semiarid areas between regions I to IV, the Metropolitan region, and the XV region, and in the interior depressions of the VII and VIII regions.[39] CONAF is also tasked with the protection of trees and bushes when they are not part of a "forest" only when they are located in areas declared as protected[40] or are protected themselves.[41]

SAG is in charge of evaluating the impacts of a transmission line on wildlife and on vegetation that is not within the purview of CONAF.[42, 43] SAG will evaluate the impact of a proposed project on wildlife,[44] with an emphasis on the loss of biodiversity and on the loss of protected species.[45] It will also evaluate impacts on soil and water, but only to determine whether the impact of the project on water will affect the fertility or drainage of the soil.[46]

In a guideline elaborated by SAG for the SEIA, SAG explains how it will conduct its assessment. It indicates that first it will asses if the proposed project generates the following environmental impacts: destruction or loss of habitat due to the total removal of the soil, vegetation or bodies of water; fragmentation of the habitat and loss of wildlife, due to, for example, electrocution in the case of transmission lines.[47] Then it will determine if the proposed project has a significant adverse effect on wildlife according to the following criteria: whether the impacted species are protected; the quantity of wildlife that will be impacted and its population density; whether the area has already been intervened, the rareness of the impacted ecosystem, its connectivity and biodiversity.[48]

The Ministry of Environment is in charge of the recovery and conservation of water resources, genetic resources, flora, fauna, habitats and ecosystems, with an emphasis on those that are fragile or degraded. It is also in charge of the protection and conservation of biodiversity.[49] We have not found guidelines indicating how the Ministry of Environment will conduct its assessment.

If the description of the assessments carried out by CONAF, SAG and the Ministry of Environment seems confusing as it is sometimes too narrow, and sometimes they seem to overlap, is because it is. On 2016, the Government created a commission to evaluate the SEIA from its inception, and to propose measures for its improvement (the "2016 SEIA Commission").[50] The 2016 SEIA Commission recognized that the laws that mandate government entities to carry out assessments within the SEIA are old and outdated, creating uncertainty as to the extent and boundaries of the assessment that each government entity should perform.[51] The 2106 SEIA Commission also recognized that in many cases the assessment carried out by government entities exceeds the scope of their legal mandate or lacks adequate technical base.[52] Finally, the Commission indicated that in its opinion, it is unclear whether the impacts of projects on biodiversity can be assessed within the SEIA as it stands today,[53] therefore it suggested to explicitly indicate in the law that biodiversity must be protected and evaluated within the SEIA.[54] This is relevant, as in many cases government entities such as CONAF have explicitly asked developers to evaluate the impact of a project on biodiversity.[55]

Once the assessment of the impact is done, in the case of EIA developers must propose measures to mitigate or compensate the impact. We carried out an analysis of transmission line projects that were assessed through an EIA and approved from 2010 onwards in the regions with most vegetation in Chile.[56] From that analysis, we conclude that the measures usually required by CONAF with regards to impacts on vegetation or are proposed by the developers and accepted by CONAF, on top of the legal requirement of presenting a management plan for the reforestation of certain areas, are the following: in areas of native forest, only trees will be cut (leaving smaller vegetation in place), and among those, tree species will be cut only if the distance between the cable of the transmission line and the canopy of trees is less than a certain number of meters.[57] If the species are below that threshold they will not be cut.[58] In non-native forests, in some cases[59] only the canopy of tree species will be cut to allow for a safety distance.[60] Protected species will be dug out and replanted in nearby areas.[61] In order to avoid ground erosion, the tree stumps will be left in the transmission line corridor;[62] the use of fire is prohibited to clean the area under the line[63], and the developer is mandated to spread in the right of way the organic material left over from the removal of vegetation.[64] Compensation measures include growing and planting eliminated species in sites with similar conditions.[65]

According to SAG's guidelines, some of the mitigation measures recommended are the following: to maintain the vegetation under transmission lines by only controlling its height in order to mitigate habitat fragmentation; install anti-collision appliances in the cables as well as implement safety distances between them in order to avoid collision and electrocution of birds;[66] implement what SAG calls "controlled disturbance", which aims to allow small wildlife to voluntarily move to nearby sites. For these purposes, animal shelters (rocks, shrubs, etc.) must be manually removed and transported to nearby sites.[67] Finally, project developers may capture and relocate wildlife, in which case they will need a permit from SAG.[68,69] Some of the compensation measures in the case of a loss of habitat that is relevant due to its biodiversity, are the recovery of degraded areas and protection of areas equivalent to the one impacted.[70]

After a review of the laws, regulations, and guidelines issued by government entities and of environmental assessments conducted on transmission lines, we can conclude the following:

(i) There is uncertainty regarding the scope of the assessment that government entities must carry out, as they tend to overlap. Also, although CONAF, SAG and the Ministry of Environment not only assess the impact of a project on individual species but also on habitat, ecosystems and biodiversity, it is unclear if they are legally authorized to carry out such assessment, as the 2016 SEIA Commission pointed out with regards to biodiversity.

(ii) Generally speaking, transmission line developers do not completely eliminate the vegetation under transmission lines, in line with international practice, as described in section 2 above. In the case of trees, they are pruned to maintain them at safe heights when possible, if not, they will be cut.[71] Vegetation other than trees is generally maintained when possible (i.e. it is eliminated in the area where towers are built and on access roads).

(iii) The measures established within the SEIA usually aim to mitigate or compensate the impacts produced by the construction of the line, whereas the impacts of transmission line maintenance are barely mentioned.[72,73] In fact, neither CONAF nor SAG have guidelines for vegetation management under and surrounding transmission lines.

(iii) Finally, the mitigation and compensation measures approved within the SEIA are very limited, as they only aim to decrease the impact on vegetation or wildlife of the project, but do not aim to enhance biodiversity or even improve environmental indicators within the impacted site. Mitigation measures usually only involve limiting the elimination of trees by pruning or cutting the canopies. Exceptionally, in the case of protected species, it can involve planting those species on site, when they are impacted by the construction of the line.[74] Compensation measures generally involve planting the same species in another site with similar characteristics and enhancing the habitat in those areas for displaced fauna.[75] With notable exceptions,[76] we have not found measures that require planting new individuals or species within the transmission line corridor to mitigate the impact on biodiversity, habitats or ecosystems or to enhance them. Our conclusion is consistent with the findings of the 2016 SEIA Commission, that indicated that government entities put more emphasis on reviewing the quality of the information presented by developers to describe the current status of the environment (base line), and on the methodologies used in accruing such information, and not enough emphasis on evaluating the impacts of the projects, and on evaluating the measures proposed to address them, as well as not enough emphasis on follow up plans.[77]

<u>Electricity Regulation</u>

According to the law, transmission operators must maintain their facilities in order to provide reliable service at a set standard of quality.[78] They must also maintain their facilities in good condition in order to avoid danger to people or things.[79]

Regarding vegetation management, regulations give some guidelines. The regulation, however, is not comprehensive. Moreover, the main regulation regarding vegetation management, Technical Norm Nº 5 ("NSEG 5") is from 1955 and has not been updated since 1971.[80] Therefore, the only type of vegetation management techniques that it mentions are cutting, pruning and removing vegetation. The NSEG 5 does not however require the complete elimination of vegetation under and surrounding lines.

The rules established by the electricity regulation are as follows. Regarding the management of trees, the Electricity Services General Law ("LGSE") and its regulation ("RLGSE") require that distribution and transmission companies avoid cutting trees when constructing their lines.[81] NSEG 5, however, establishes a mandatory safety distance within which trees must be cut. In the case of lines of more than 25 kV, for example, the distance from the cables to nearby trees must be equal to the height of the surrounding trees, and at least, of 5 meters.[82] Beyond that safety distance, NSEG provides a general guideline indicating that companies must also cut or prune trees that are outside their right of way if they are a danger to the lines.[83] Within the right of way NSEG 5 allows for the existence of trees under the lines, as long their height does not surpass 4 meters.[84]

Companies must have maintenance programs, in which they will include cutting or pruning trees that could affect the safety of the lines. In those maintenance programs they must use techniques that help preserve the trees.[85]

Regarding vegetation other than trees, NSEG 5 establishes that companies may eliminate the vegetation nearby if it might contribute to or accelerate a forest fire.[86]

In conclusion, the general rule is that electricity regulation does not require transmission operators to eliminate all vegetation under and in the proximity of transmission lines, in fact it declares that trees and vegetation must be preserved if they do not endanger the line. Regarding trees, the general rule is that companies must cut trees within a determined safety distance. Companies must also cut trees outside the right of way if they pose a danger to the line. Under the line trees of no more than 4 meters of height are accepted. Vegetation other than trees must be eliminated if it could contribute to a fire or pose a threat in case of one.

The SEC, as a general rule, neither reviews the maintenance programs nor supervises their implementation. It usually intervenes when the company cannot perform the maintenance due to the opposition of the owner of the land,[87] when the public reports companies in violation of relevant regulations, or when the electricity service is interrupted, in which case it investigates and can fine companies as well as establish action plans for those companies.[88]

A Fork in the Road: The 2017 Fires

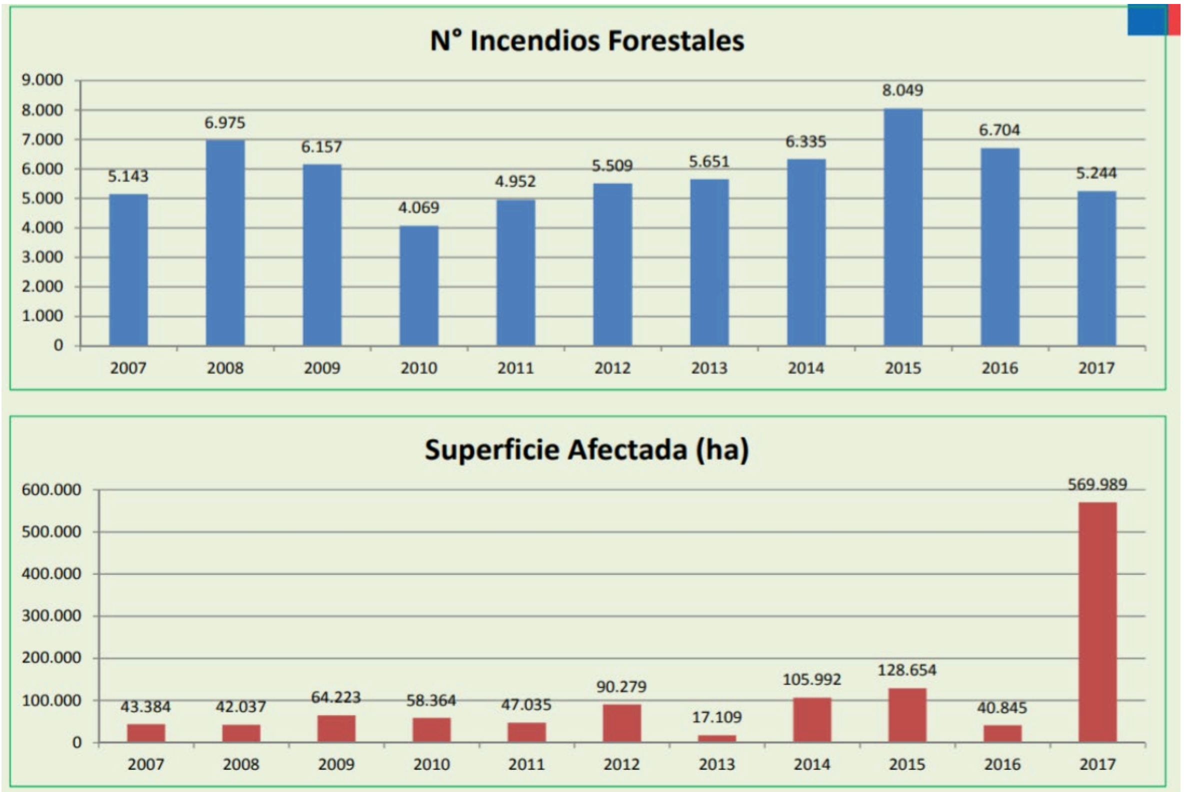
Up until 2017, the main issues regarding vegetation management were the difficulty companies had to enter private properties to conduct maintenance activities on their rights of way and within the safety area, and the interruption of service as a consequence of trees touching or falling on the lines.

This changed with the disastrous 2017 fires. During the fire season, electricity related fires became a major concern, making the issue of vegetation management under and near transmission lines a topic of national importance.

During January and February 2017, Chile had fires of unusual severity. The fires burned for 41 days straight and consumed approximately 518,174 hectares across seven regions.[89] About 93% of these fires burned hectares occupied mainly by vegetation. Of the 518,174 hectares burnt, 55% consisted of forestry plantations, 20% of native forest, 18% of prairies and bushes, and 7% of agricultural land.[90] The fires affected 22 ecosystems, 3 of which are considered in "critical danger", and 3 "in danger" according to the International Union for Conservation of Nature (IUCN) classification.[91]

Even though, as Figure 3 shows, the number of fires in 2017 was not particularly unusual, the number of hectares affected was.

Figure 3: Number of fires per year and hectares affected by fires per year



English Translations -
Titles (from top): Number of Forest Fires, Area Affected

CONAF, Statistics of occurrence and damage of forest fires associated to electric situations, 2nd Technical workshop CNE, September 7, 2017.

According to CONAF, three conditions contributed to the severity of these fires. First, record high temperatures. For example, on January 26 and 27, 2017, the city of Chillán had a maximum of 41,5ºC, the highest in the last 71 years. A second condition that contributed to the fires was a severe drought that had affected the respective regions since 2009. Third, affected dead vegetation had moisture content of less than 5%, which is considered critical.[92]

The electricity sector paid particular attention to the 2017 fires when a public prosecutor charged the managers of an electricity company as responsible for five fires, given that electrical lines had allegedly caused the fires. Specifically, the fires allegedly started due to the contact of trees with the transmission lines, causing heavy objects to fall from the line to the ground, which in turn led to the ignition of grass that acted as combustion material in spreading forest fires.[93] Two of the managers were put in prison during the investigation. This case made national news.[94]

In response to this situation, in August 2017 the Ministry of Energy mandated the National Energy Commission to create a task force that would identify regulatory impediments to the prevention and mitigation of fires caused by the interaction of electricity infrastructure and vegetation. The task force met a number of times but did not produce any specific results.

One immediate consequence of the 2017 fires on vegetation management however, was a shift of the SEC towards supervising and demanding the elimination of all vegetation under and around the lines, given that such vegetation could create a fire hazard. For example, on July 19, 2017 the SEC fined an electricity company because it found, among other things, dry grass under the lines; the SEC indicated that these conditions were in contravention of the company's obligation to maintain the lines.[95] In this case, the Distribution and Transmission Companies' trade association complained, indicating "it is illogical to think that the mere existence of grass, or dry grass [under the transmission line] would be contrary to the law".[96] The company appealed the fine, and in this case the SEC decided to decrease the fine, indicating that the mere presence of vegetation, specifically, dry grass in the safety area would not be taken into account for the issuance of the fine.[97]

In another case, the SEC of the VIII region mandated that an electricity company cut and eliminate all combustible material under its transmission line that could endanger the line in case of a fire. The SEC cited as reasons for the order the disastrous fires of 2017 and the increase in temperature during spring and summer. The company went to court to have the order annulled. The court dismissed the suit.[98]

Although this evidence is anecdotal, one can see that after a catastrophic event such as the 2017 fires, authorities, and as a consequence, companies have the incentive to move towards removing all vegetation from transmission corridors. Therefore, the pendulum, if nothing is done, might slide towards the elimination of most vegetation under and surrounding transmission lines, resulting in additional negative environmental impact.

One thing that can be done to avoid such slide is to design policies that incentivize or mandate the use of integrative vegetation management practices. This because, as we will explain, such practices can aim to achieve different policy goals, being one of them fire prevention.

Integrative Vegetation Management

According to Brockbank, "Integrated Vegetation Management (IVM) is a strategy designed to minimize tall-growing vegetation by establishing stable, low-growing plant communities on overhead transmission rights of way through utilization of complementary control methods that maximize public health and safety, cost effectiveness, and protection of the environment (EPRI 2002). A relatively stable, low-growing plant community on the utility right of way is the desired goal. Such a community can be attractive and useful for humans, provide a diverse array of habitat for wildlife, and can be inexpensive to maintain using vegetation management methods that have relatively minor environmental impacts".[99]

According to Nowak,[100] this practice started in the United States in the 1980s by applying vegetation management treatments consistent with the principles and practices of Integrated

Pest Management ("IPM"), where tall growing trees are viewed as the pests.[101] The key steps of IVM consistent with IPM are the following "1) gaining science-based understanding of the pest and ecosystem dynamics; 2) setting management objectives and tolerance levels based on institutional requirement and broad stakeholder input; 3) compiling a broad array of treatment options that are combined in various ways to produce desired plant communities, including biological, chemical, manual, mechanical, cultural and physical methods, and applying them in concert on a site specific basis to foster prevention if possible, and control of the pest problem with an emphasis on biological control; and 4) monitoring the system to determine when treatments are both necessary and how effective they are in achieving the desired plant communities and meeting objectives."[102]

IVM as a discipline started to be codified in the 1990s. It emerged as a system in the 2000s, through the issuance of the ANSI A300[103] standards and the issuance of management best practice guidelines of the International Society of Arboriculture.[104]

One of the goals of IVM is to ensure service reliability and the safety of transmission lines by controlling and limiting the growth of tall growing tree species. According to Kooser *et al,* "early evidence of the ability of IVM to develop a stable community of compatible species arose in the 1970's (Bramble and Byrnes 1976[105])"[106]. Kooser and co-authors also cite studies performed by Bramble and Byrnes 1983,[107] Haggie et al. in 2008,[108] and Nesmith et al. in 2008[109] as evidence of the effectiveness of IVM in creating stable communities of low species that discouraged the growth and development of tall trees.

Also, a recent study by Kooser *et al* that analyzed 14 years of data of IVM by the New York Power Authority ("NYPA"), concluded that IVM has "greatly reduced the density of non-compatible species across the entire system" as well as reduced the mean heights of non-compatible species.[110] They leave it as an open question, however, whether NYPA has created a stable community.[111]

These, of course, are not the only benefits of IVM; other documented benefits "include improved cost effectiveness, (…), aesthetic appeal, as well as decreased fire risk, and wildlife habitat enhancement for some species".[112]

With regards to wildlife habitat enhancement, studies have demonstrated that early successional habitats created and maintained through IVM, increase the use of the right of way by a variety of species and have improved food and cover for wildlife.[113] Also, early successional habitats benefit threatened and endangered species.[114] As a consequence of this, in 2012 the Vermont Electric Power Company identified the need to create best management practices for the protection of threatened and endangered species within the right of way.[115] Finally, a research project conducted from 2012 to 2015 along the American River Parkway in a right of way jointly managed by PG&E, the Sacramento Municipal Utility District and Sacramento County Parks, demonstrated that IVM treated sites increased pollinator (bees) occurrence.[116]

The LIFE-Elia Project

A recent case of a successful use of IVM principles can be found in the LIFE-Elia project.

The main objective of the LIFE-Elia project was to transform the routes occupied by high voltage transmission lines into ecological corridors. Its premise was that keeping transmission line's routes devoid of vegetation, even though important for safety reasons, was costly and created a "no man's land" which no one could benefit from. The LIFE-Elia project aimed to transform transmission line routes in order for those areas to play a part in restoring an ecological network, without additional maintenance costs.[117]

The pilot, that started in September 2011 and concluded in December 2017, intervened over a total of 221 kilometers of high voltage lines in France and Belgium.[118] All the work was led by a team of 7 people and had a total funding of approximately USD 3.5 million.[119] It is important to note, that this work was carried out in collaboration with Elia, a transmission system operator in Belgium, and RTE a transmission system operator in France, which provided access, information and financing for the development of this project.

Although the project only intervened 221 kilometers, it was designed as a pilot that could be implemented by most if not all European Transmission System Operators.[120] In fact, one of the main drivers of the project is the obligation of member states to comply with two apparently contradictory mandates:[121] the mandate in the Renewable Energy Directive[122] according to which by 2020, 20% of the energy must come from renewable energy sources, including the development of transmission projects to achieve greater regional interconnectivity;[123] and the mandate to create and maintain Natura 2000 sites, which are a group of semi-natural sites within the European Union that have high heritage value due to the exceptional flora and fauna they contain.[124] The Natura 200 sites are selected to ensure the long-term survival of species and habitats protected under the Birds and Habitat Directive.[125] The impact of the implementation of a LIFE-Elia like program throughout the European Union would be unprecedented, as there are approximately 300,000 high voltage transmission lines in the 27 member states.

According to the information provided by the Life-Elia team, the pilot was extremely successful, as it proved to be more cost effective than traditional vegetation management practices and had significant positive environmental and social externalities.

The following description of activities and impacts comes from the information and brochures put together by the LIFE-Elia team.[126]

<u>Seven Interventions</u>

The LIFE-Elia project chose to carry out 7 ecological restoration actions, that it classified in 4 groups: Group 1 "Structured edges," consisted of the plantation and restoration of forest edges and orchards; Group 2 "Open land management," consisted of the enhancement of bovine, equine or ovine pastures, mowing and sowing of flower meadows; Group 3 "Natural habitats," comprised the restoration of moors, peat lands and lowland hay meadows; and Group 4 "Ponds and invasive species," consisted of digging ponds and fighting against invasive species.[127]

The interventions, that were designed to combine electricity safety, biodiversity and attractiveness for local communities, draw from the same insights as integrative vegetation management, and therefore view vegetation as an ally and not a constraint.[128]

Plantation and Restoration of Forest Edges and Orchards

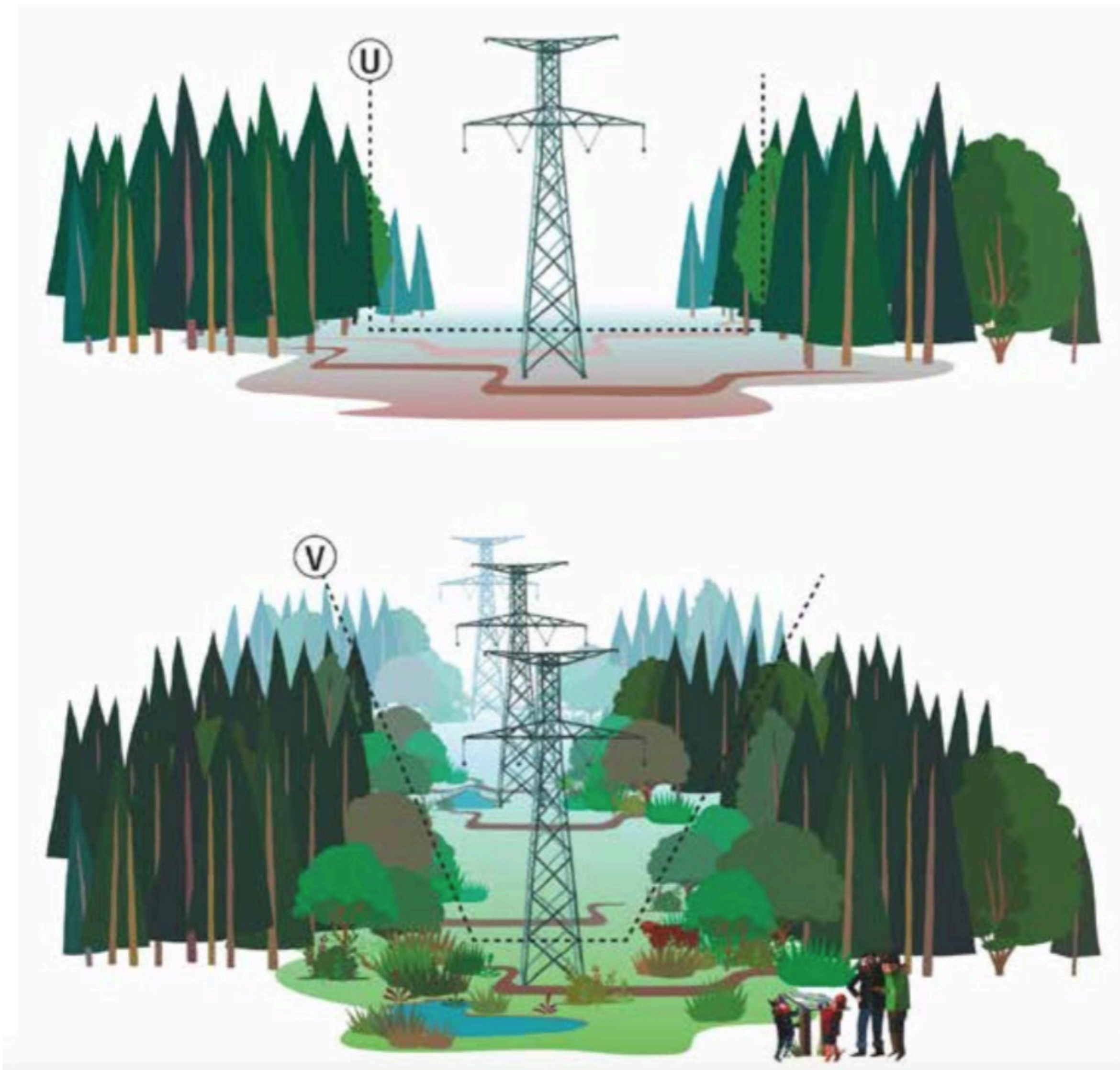
This intervention, aims to replace rotary slashing, which according to the LIFE-Elia team is commonly used to maintain high voltage transmission corridors in forests. This technique involves grinding thick vegetation, usually through a powerful tractor equipped with a device to shred/chip the vegetation before it becomes too high. This work is repeated every three years on average.[129]

According to the LIFE-Elia team, the downside of this method from the safety and cost standpoint is that after milling, the land is left bare, an therefore seed from neighboring trees is allowed to germinate, as the area has a high level of exposure to light and there is no competition from other vegetation due to the slashing. Also, since the slashing usually only affects the upper part of the plant, the stump grows vigorous sprouts that can grow as trees.[130] Other downsides are the destruction of flora and fauna, the negative visual impact, the compaction of soil due to the regular passage of heavy machinery, enrichment of soil due to the decomposition of shredded material that contributes to the lack of variety in flora, and the multiplication of invasive species by unintentional dissemination.[131]

According to the LIFE-Elia team, an alternative to rotary slashing in forest areas is the creation of a forest edge. A forest edge is a transition zone between a “closed” environment, such as forests, and an “open” environment like meadows or crops. The edge is called “tiered” when it is composed of vegetation of different heights.[132] The forest edges are created through the plantation of species that will not grow to unsafe heights, can resist grazing by animals, enhance biodiversity and are local, as they acclimate better.[133]

Another alternative to rotary slashing is planting orchards. The logic behind planting orchards is equal to that of forest edges, as orchards also reduce the possibility of undesirable species from growing. According to the LIFE-Elia Team in Europe, they also have a conservation value, as wild fruit trees have almost disappeared in some regions.[134]

Figure 4: Traditional transmission line corridors (forming a "U" shaped corridor) as compared to corridors with forest edges (leaving free space in the middle that allows the operator access (closer to a "V" shaped corridor)



Brochure 4[135]

The benefits of the forest edge and planting orchards intervention from the safety standpoint is that it reduces the possibility of growth of undesirable trees species, as the species chosen will suppress the problematic species.[136] In terms of cost, the LIFE-Elia team found that introducing and maintaining forest edges is cheaper than periodically performing rotary milling.[137] In terms of maintenance, the first three years of forest edging require replanting plants in empty areas and removing plants that hinder the growth of the selected species. In the long term, however, maintenance only requires selective cutting of species that can become problematic.[138]

In terms of cost, the LIFE-Elia team and Elia calculated, that the forest edges strategy reaches its break-even point after 3 years in the case of restoration of forest edges, and after 9 years in the case of creation or planting of forest edges. After 30 years, forest edge management has a cumulative cost of 1.9 to 2.1 times less than the traditional management done via rotary slashing.

Figure 5

	Comparison of the costs of the LIFE activities (planting and restoration of edge) with those of standard management		with a weighted average cost of capital of 5%
Activities	**Break-even point**	**Comparison after 30 years**	**Comparison after 30 years**
Planted forest edges	9 years	1.9 times less costly	1.4 times less costly
Restored forest edges	3 years	2.1 times less costly	1.8 times less costly

Brochure 04[139]

Figure 6

Brochure 002/10[140]

Forest edges also have forest management benefits. For example, when tiered, they act as a shield from the wind reducing the risk of uprooted trees. Forest edges also allow planting fruit bearing species that require light, providing alternative species for wood production.[141]

Forest edges are favorable to forest biodiversity as they play an important role allowing animal and plant populations to grow and spread thanks to the diversity of conditions they create.[142] Finally, they help integrate the high voltage lines into the landscape.[143]

Grazing and Mowing

According to the LIFE-Elia team, grazing and mowing serve as also an alternative to rotary slashing. Grazing involves confining herbivorous animals, such as cows, horses, sheep or goats, in the high-voltage transmission lines corridors so they graze the vegetation, turning the vegetation into more grassy vegetation due to the repeated passage of the animals.[144] This technique requires fencing the transmission line corridor. Management by mowing consists in allowing a local partner e.g. a local farmer, to mow the grassy vegetation, such as hay, each year.[145]

The LIFE-Elia team has found that for the success of either of these techniques, the following conditions must be met: (i) it is necessary to have local management conducted by local partners, mainly farmers; (ii) the area must be large enough to ensure some profitability for the local manager (around 1 hectare);[146] (iii) the sites must be easy to access, allowing the operation of farm machinery; and (iv) it must be relatively close to populated areas, in order for the manager to inspect the site periodically.[147]

Whenever a local partner is required an agreement is signed. The agreement specifies the provisional and free nature of the occupation, on one hand, and the management requirements, on the other.[148]

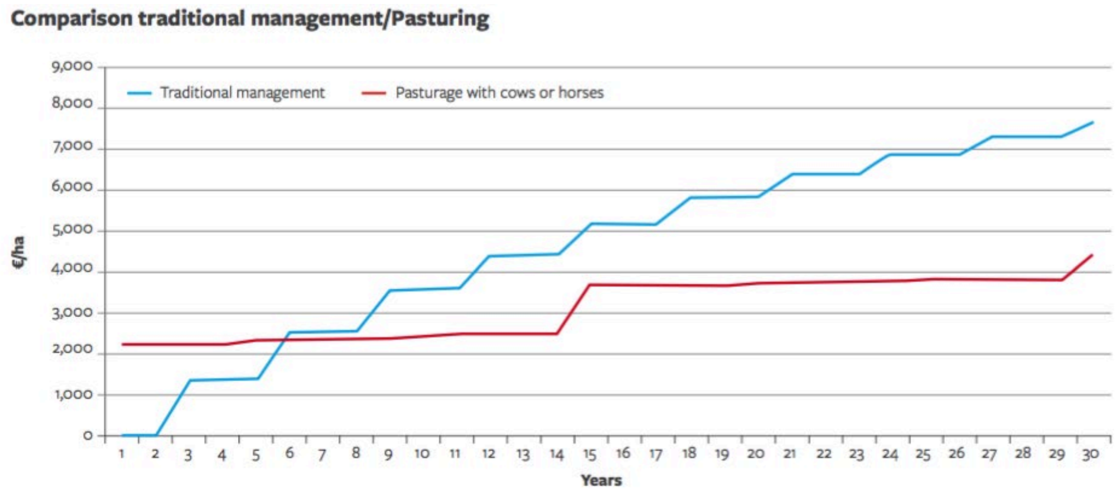
The LIFE-Elia team and Elia calculated that management by grazing and mowing is also less costly than rotary milling or slashing. Even considering the highest cost scenario for grazing, which would be the case in which the fence must be replaced after 15 years, the results show that the break-even point is reached after 6 years and after 30 years, grazing and mowing have a cumulative cost of 2 times to 4.9 times less than traditional management by rotary slashing and manual felling.[149]

Figure 7

	Comparison of the costs of the LIFE activities (grazing and mowing) with those of standard management		With a weighted average cost of capital of 5%
Activities	**Break-even point**	**Comparison after 30 years**	**Comparison after 30 years**
Grazing	6 years	2 times less costly	1.8 times less costly
Grazing in difficult area	5 years	4.7 times less costly	3.9 times less costly
Mowing	6 years	4.9 times less costly	2.5 times less costly

Brochure 03[150]

Figure 8



Brochure 02/10[151]

Figure 9

Brochure 02/10[152]

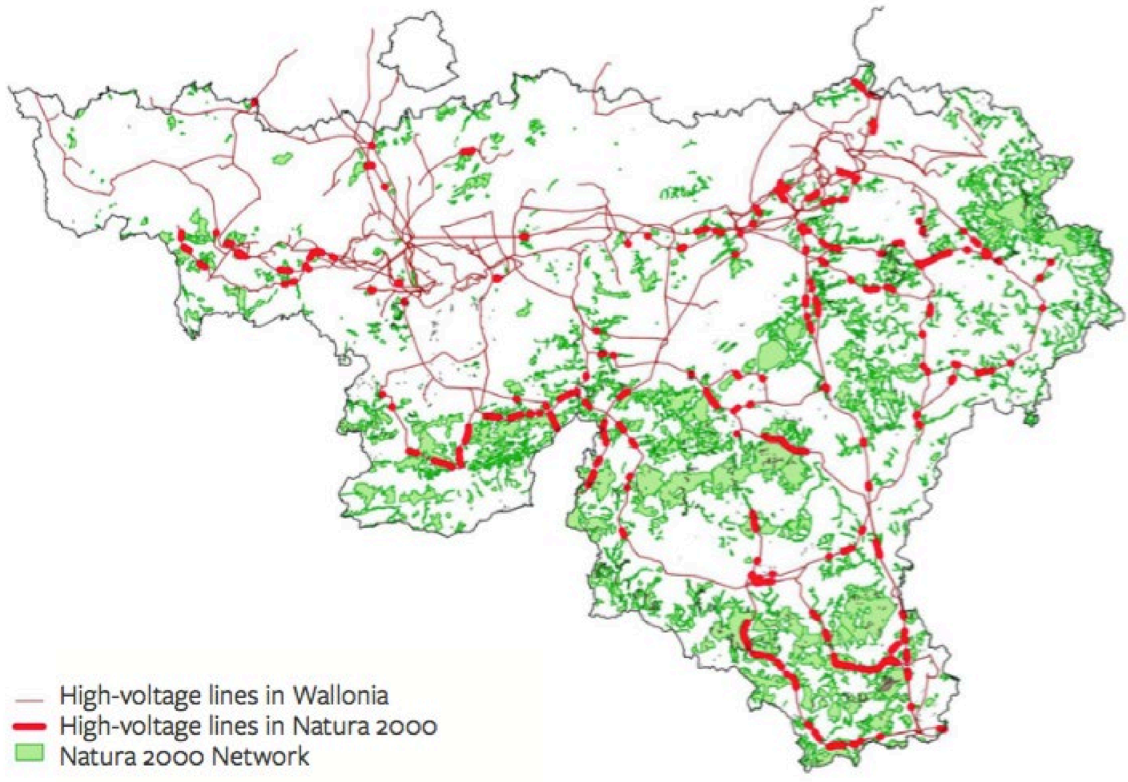
Grazing and mowing also have biodiversity benefits. Since these techniques are gentler than rotary slashing, plants and animal species find a stable living environment. Also, in the context of forests, these open spaces provide light to the lowest plant strata diversifying forest habitats. Low grassy areas also attract wild fauna as they offer a food supply partially absent from forests environments.[153]

Restoration of Natural Habitats

Another intervention performed by the LIFE-Elia team is the restoration of natural habitats. A natural habitat is a homogenous space from the point of view of ecological conditions (especially soil and climate) and its vegetation that hosts a certain fauna with species having all or part of their various vital activities in this space.[154]

The main natural habitats covered by the LIFE-Elia project are peat lands, moors, chalky grasslands and lean meadows, which are classified as "of community interest" by the European Commission, therefore, must be protected and restored. Also, the Natura 2000 network encompasses a large number of these natural habitats.

Figure 10: High voltage lines and Natura 2000 network



Source: Booklet 6[155]

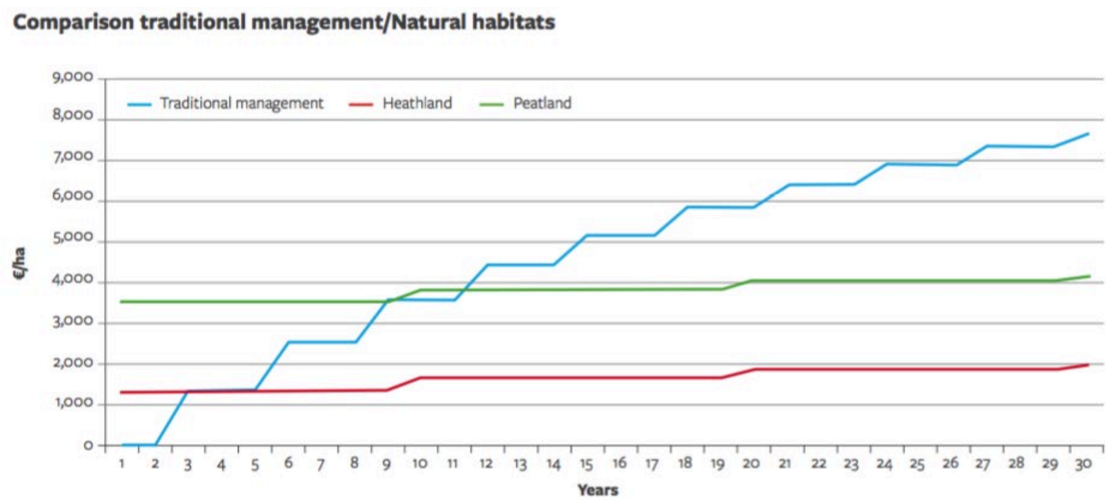
Peat lands are wetlands that have productive vegetation that accumulates. Since they are saturated with stagnant or barely moving water, peat lands are poor in oxygen. Asphyxiation of the soil severely limits the development of woody species and favors species of small dimensions.[156] Moors can develop on dry to very moist environment. The dominant vegetation are shrubs, bushes and dwarf bushes.[157] Chalky grasslands are grassed formations on dry soils located on soils that are not favorable for agriculture.[158] Lean meadows are plant formations, which host a wide variety of tall grasses and flowering plants, some of which are protected.[159]

As is evident from their description, all these natural habitats are ideal from a transmission line safety standpoint, as all the vegetation is very low.

According to their calculations, the restoration actions carried out by the LIFE-Elia project were more cost effective than the traditional vegetation management actions carried out by the transmission operators, with the obvious added benefits for biodiversity.

The break-even point, that is, the point where the LIFE-Elia intervention becomes less costly than the traditional management activities is after 3 years for heathlands and 12 years for peat lands. After 30 years, the cumulative cost of the natural habitats restoration intervention is 3.9 times lower for heathlands and 1.8 lower for peat lands than the costs of traditional management.[160]

Figure 11



Brochure 02/10[161]

Ponds and Invasive Species

Another intervention performed by the LIFE-Elia team was the construction of ponds. Although their advantage with regards to vegetation management is limited for the transmission line operator, their creation strengthens one of the main components of an ecological network –connectivity— as many animal and plant species use the ponds as springboards for moving, feeding and reproduction;[162] therefore, their environmental benefits are evident.

The ponds dug up in the context of the LIFE-Elia program are semi-natural, as they are man-made, but an effort was done to give them the same characteristics as natural ponds, i.e. no sheeting in the pond bed, irregular contours of the banks and no species introduced.[163]

Finally, the LIFE-Elia carried out actions to eliminate invasive species, as according to the IUCN, the propagation of invasive species is considered to be the third-largest cause of loss of biodiversity in the world.[164] This intervention also does not have benefits with regards to vegetation management, but it has important environmental benefits.

Because the interventions related to pond digging and with the elimination of invasive species do not have clear benefits regarding vegetation management, they were not included in the cost benefit analysis.[165]

A Positive Cost-Benefit Analysis and More Social Acceptability

As we have indicated, the LIFE-Elia team and Elia have calculated and forecasted that forest edges and orchards, grazing and mowing, and restorations of natural habitats are more cost-effective than the traditional management techniques currently used by Elia, such as rotary milling or slashing, manual felling[166], pollarding[167] or pruning lateral branches.

The LIFE-Elia actions become cheaper than traditional management practices in 3 to 12 years depending on the actions, and after 30 years these actions become 2.4 to 3.9 cheaper than traditional management practices.[168]

It is important to note that the cost-benefit analysis performed in the context of the LIFE-Elia project compared only invoiced costs of materials and external assistance i.e. subcontractors, to carry out the traditional vegetation management practices carried out by Elia versus the cost of external assistance to carry out the LIFE-Elia interventions,[169] using as a unit of comparison Euros per hectare of corridor per year. This analysis did not include the costs associated with the staff that worked in this project, both from Elia and LIFE-Elia as it would be a less accurate calculation, nor it included non-monetary benefits such as increased local acceptance, aesthetic appeal and environmental benefits.[170] Moreover, this analysis is very conservative as it considers that all the costs are borne by the transmission operator, when in reality, some of those costs could be borne by local actors as they conduct the maintenance activities for their own benefit e.g. grazing in corridors.[171]

The results of the cost-benefit analysis are as follows. The “return on investment column” shows for each action, after how many years the action becomes profitable, that is, how long it takes for the costs of the action to become lower than the costs of traditional management. The “after 30 years” column compares the relationship of the costs for each LIFE-Elia action with the costs of traditional management without a weighted average cost of capital (WACC) of 5%, and then with a WACC of 5%.

Figure 12

	Comparison traditional management/LIFE method		With WACC = 5%
Actions	Return on investment	After 30 years	After 30 years
Planted edges	9 years	1.9 times cheaper	1.4 times cheaper
Restored edges	3 years	2.1 times cheaper	1.8 times cheaper
Pasturage	6 years	2 times cheaper	1.8 times cheaper
Pasturage in hard conditions	5 years	4.7 times cheaper	3.9 times cheaper
Mowing	6 years	4.9 times cheaper	2.5 times cheaper
Natural habitats (heathlands)	3 years	5.3 times cheaper	3.9 times cheaper
Natural habitats (peatlands)	9 years	3 times cheaper	1.8 times cheaper

Source: Brochure 02/10[172]

Every one of the actions carried out by the LIFE-Elia project is more cost-effective than those performed up to that date by Elia and most transmission operators.

Moreover, the LIFE-Elia project interventions have additional benefits that have nothing to do with lower costs. These actions enhance biodiversity. In terms of social or community benefits, the LIFE-Elia interventions help better integrate transmission lines to the landscape, increasing the level of acceptance from the public. They also create benefits and even financial resources for actors other than transmission operators, as they allow for the integration of local actors in the management of the vegetation under the line, such as local farmers. It also has reputational benefits as it shows a company committed with nature conservation. The LIFE-Elia team also noticed a positive effect when obtaining permits from authorities, as authorities saw Elia as a partner in promoting biodiversity and not as an organization that destroys biodiversity.[173]

The Future of Transmission Development and Vegetation Management in Chile

As the LIFE-Elia project and other integrative vegetation management cases show, IVM can be financially less costly than traditional vegetation management practices. This is extremely relevant for Chile, as electricity customers pay for all maintenance costs through a set tariff.[174] Therefore, lowering transmission line maintenance costs would imply lowering electricity bills, which is one of the goals set in the current Energy Policy.[175]

Implementing IVM practices in Chile would also decrease the environmental impact of transmission lines, and even improve the biodiversity of certain areas. Moreover, vegetation under and in the vicinity of transmission lines could be used to resist the spread of fire in fire prone areas.[176]

Implementing IVM practices in Chile could also help improve the social acceptability of transmission lines. This is a very important challenge for Chile. Today transmission lines have very low social acceptability. This is evidenced, for example, by the fact that it is a common occurrence for property owners to deny transmission operators access to their property to carry out maintenance activities, as they view them as detrimental.[177] This is also evident from the number of cases before the courts against the construction of new transmission lines.

Finally, implementing IVM practices in Chile could facilitate the awarding of permits by the authorities, as transmission lines would enhance biodiversity and not destroy it. This is not a minor issue, as transmission lines are in many cases delayed due to, in part, a delay in awarding permits. For example, the third segment of the Cardones-Polpaico line, a 743 kilometers line of crucial importance for the electricity system, has not yet been commissioned, as CONAF has not awarded the company the required permits.[178] As of August 2018, the third segment of the Cardones-Polpaico Line had a 7-month delay, costing the electricity system and its users millions of dollars.

Therefore, there is a very strong case for the implementation of IVM practices in transmission lines in Chile. Given that IVM requires scientific based information and very different methods depending on the specific environment surrounding transmission lines, it is not possible to simply mandate that companies apply IVM on their lines. Especially since electricity customers would pay for all over spending due to lack of knowledge of the required techniques.

Considering this as well as international best practices, is that we suggest a three-phase approach for the mandatory implementation of IVM in Chile.

Phase 1. This phase would consist of two activities. The first one is the creation of a multi-stakeholder committee to issue Chile specific IVM standards. The second is the elaboration of a pilot project, to test and improve the standards.

In the United States during the 2000s, IVM was codified into the ANSI A300 part 7 standard, increasing the understanding and commitment to IVM.[179]

The ANSI A300 standards are voluntary industry consensus standards developed by the Tree Care Industry Association ("TCI"), a trade association of tree care firms and affiliated companies.[180] The TCI meets regularly to write new and review existing ANSI 300 standards. The committee includes industry representatives, utility, municipal and federal sectors and other interested organizations.[181]

As the LIFE-Elia project shows, a pilot demonstrating the benefits of IVM is essential to get stakeholder buy in. For example, after seeing the benefits of the LIFE-Elia project, Elia – the transmission operator— decided to expand it to the rest of Belgium.[182]

In the case of Chile, as it was the case of Europe, such a pilot would require a private-public partnership. We recommend working on existing lines, instead of applying IVM to new lines that have yet to be constructed. We recommend this because new lines are always very controversial and trying to implement IVM for the first time as well as trying to get the line commissioned on time could prove very difficult. It could also obscure the results, as it might not show the social and environmental benefits of implementing IVM based interventions, given that the area where the transmission line corridor will be located has yet to be intervened.

Phase 2. This phase consists of the creation of a voluntary certification program coupled with permitting benefits for accredited companies. This will incentivize companies to develop their capabilities in IVM, at the same time as providing more experience, allowing for incremental improvements in the set standards.

The accreditation committee should be comprised of at least private transmission companies, government authorities (mainly the Ministry of Energy, the CNE, SEC, CONAF, the Superintendency of Environment, the Ministry of Agriculture, SAG, the Ministry of Environment and the Environmental Assessment Service), and representatives of civil society such as environmental NGOs.

In the United States, the Right of Way ("ROW") Stewardship Council is an accreditation entity. It was established in December 2012, and it includes representatives from environmental NGO's, government regulators, academia, the public, electric industry organizations, transmission asset managers, suppliers, contractors and consultants. The ROW Stewardship Council accreditation program was fully launched in March 2014.[183]

As of 2018, seven utilities are accredited: The New York Power Authority ("NYPA"), Pacific Gas and Electric Company ("PG&E"), Vermont Electric Company ("VELCO"), Bonneville Power Administration ("BPA"), Sacramento Municipal Utility District ("SMUD"), Arizona Public Service ("APS"), and AltaLink.[184]

Phase 3 consists in the implementation of regulations mandating the use of IVM in new transmission lines. This should be accompanied by incentives for companies to apply IVM also in existing transmission lines.

Conclusions

Chile's energy revolution, which implies having an energy matrix made up of at least 70% renewable energy by 2050,[185] and making the most of its renewable energy potential, that in the II region alone is estimated at 1,652 GW[186] –equivalent to the United States current installed capacity—[187] will have a relevant environmental footprint, given the need to build thousands of kilometers of additional transmission lines. This is not a problem of Chile alone. In order to curve climate change, many countries have pledged to promote the inclusion of renewable energy such as wind and solar to their energy matrix, and thus will have to strengthen or expand their transmission systems which have relevant negative impacts on the environment. Such impacts include those on vegetation, wildlife, soil and water, as well as social and cultural impacts, such as displacing other land uses (e.g. residential or for conservation purposes), and negatively impacting a landscape's aesthetic value. As a consequence of such impacts, the construction of transmission lines and their operation is facing strong and increasing opposition from local communities the world over.

The European Commission, acknowledging the paradox created by the incorporation of clean renewable energy to the matrix, partnered with Walloon, a state in Belgium, Elia, a transmission operator in Belgium, and RTE, a transmission operator in France, to conduct a 6 year pilot in which the traditional way of vegetation management under and surrounding transmission lines was replaced by seven alternative management interventions that decrease the environmental footprint of transmission lines, as they enhance biodiversity. The LIFE-Elia project replaced the vegetation management techniques applied by Elia – cutting and pruning trees that could reach unsafe heights— in 200 kilometers of transmission lines that run mainly through forests. The interventions consisted of planting and restoring forest edges, planting orchards, allowing for grazing and mowing, restoring natural habitats, creating ponds and eliminating invasive species within transmission lines' corridors. These interventions were selected as they were safe from the electricity point of view, improve the environmental footprint of transmission lines, and improve the level of acceptance by local community, by either improving the environmental footprint and aesthetic value of transmission lines or providing an economic benefit to the local community that is allowed to use the corridor for grazing and mowing. The LIFE-Elia project interventions proved not only to have these benefits, but according to a conservative assessment, they are more cost-effective than the techniques that Elia currently applies. As a consequence, both Elia and RTE have committed to continue with the interventions and expand them to other parts of their network.[188]

The LIFE-Elia project is not the only one of its kind. In fact, it draws from the insights of integrated vegetation management or IVM, a technique that has been applied since the 1980s in the United States. This technique of vegetation management consists in planting low growing species that will crowd out and discourage the growth of tall trees, instead of cutting and pruning trees, therefore, decreasing the environmental footprint of transmission lines, and enhancing biodiversity. This technique is currently applied by the following transmission line operators and companies in the United States: The New York Power Authority, Pacific Gas and Electric Company, Vermont Electric Company, Bonneville Power Administration, Sacramento Municipal Utility District, Arizona Public Service and AltaLink.

The LIFE-Elia project as well as the transmission line operators and companies that apply IVM are proof that there is a better way to manage vegetation under and surrounding transmission lines. A way that is better from every angle. It can be safer, cheaper, and more environmentally and socially sound.

The positive impact of its implementation in Chile would be enormous. Chile already has 88,000 hectares of transmission line corridors and will build thousands of kilometers of additional transmission lines. The vegetation management techniques applied as of today in the country are similar to those applied by Elia. With regards to trees, the only vegetation management technique that is applied is to cut them altogether or prune them to prevent them from reaching unsafe heights. Regarding low growing vegetation, until now transmission companies have tried to avoid eliminating it, as it does not constitute a risk because of its height. After the 2017 devastating fires, however, we have seen the authorities mandate eliminating all vegetation in fire prone areas. A measure that if generally applied could increase the negative environmental footprint of transmission lines.

This paper makes a case for the elaboration of policies that mandate the implementation of IVM practices to existing and new transmission lines in Chile, as international examples have already proved its benefits, which could include planting fire resilient or retardant vegetation.

Drawing from international experience and given that IVM requires capacity building, we have recommended a three-phase approach. The first phase consists in the creation of a multi-stakeholder committee to elaborate voluntary IVM standards for Chile, and the elaboration of a pilot to test and improve those standards. A second phase, consists in the creation of a voluntary accreditation system that would be coupled with permitting benefits, and the third phase consists of mandating the use of IVM for new transmission lines and creating incentives for its use in existing lines.

On top of the benefits already mentioned, the implementation of IVM in Chile could be part of the solution of a Chile-specific challenge. As a Government convened Commission declared in 2016, the environmental assessment of projects in Chile needs to be improved. With the current regulation, there is uncertainty regarding what specifically should be assessed within the SEIA, and the 2016 SEIA Commission is of the opinion that, although biodiversity should be protected by the SEIA, as the law stands today it is not. There is lack of clarity regarding the scope of the environmental assessment that each government entity must carry out, which can lead to overlapping and/or sub-optimal assessment. Also, the Commission identified that in many cases the assessments of government entities lack a solid technical base. Finally, according to the 2016 SEIA Commission, in the environmental assessment there is not enough focus on compensation and mitigation measures, with the consequent detriment to the environment.

The three-phase implementation of IVM in Chile can address these challenges by allowing for capacity building within government entities and companies. This policy can also include biodiversity as one of the measurable goals of IVM implementation. It can help clarify the role of each government entity, at least with regards to IVM implementation, and IVM could be a new mitigation/compensation measure to include to the current toolkit of compensation and mitigation measures for transmission lines.

Chile's electricity regulation has been a model in the region. It is time to aim for Chile to become a model for the protection of the environment as it continues its energy revolution.

[1] LIFE-Elia project, Brochure 04, "Electrical Transmission, Management of vegetation in forest corridors. Forest Edges and Orchards under high-voltage lines" ("Brochure 04"), p. 2. See *http://www.life-*

elia.eu/_dbfiles/lacentrale_files/1200/1267/LIFE%20Elia-RTE_Forest%20edges%20and%20orchards_EN_WEB.pdf

[2] Nowak, Christopher A., "What is Integrated Vegetation Management, this IVM –Now, Today and into the Future?", Environmental Concerns in Rights-of-Way Management, 10th International Symposium, Jean Doucet (editor), 2014 Utility Arborist Association ("What is IVM?"), pp. 282 and 288.

[3] Calculated based on data obtained from the Chilean National Energy Coordinator ("CEN" is the Spanish acronym) on January 10, 2018. This information considers transmission lines from 23 kV to 500 kV.

[4] That is the case for all scenarios with the exception of scenario C, where the new wind installed capacity is distributed among the regions in the north, center and south of the country. Ministry of Energy, Long Term Energy Planning Process, Final Report, February 19, 2018, ("PELP Report"), p. 74 to 83.

[5] PELP Report, p. 39

[6] Law 20.936 that establishes a new electrical transmission system and creates an entity that independently coordinates the National Electrical System, published in the Official Gazette on July 20, 2016.

[7] The National Energy Commission is now tasked with planning and bidding out the construction of the so-called zonal transmission lines. This tasks were left to private initiative before law 20.936.

[8] Chapter II: "Of energy planning and transmission" of Law 20,936. Articles 83 to 99.

[9] Final Technical Report of the Annual Transmission Expansion Plan 2017 approved by Exempt Resolution 163 of the CNE, February 27, 2018 ("2017 Expansion Plan"), p. 21.

[10] 2017 Expansion Plan, p. 35. As authorized by the regulation, private parties (i.e. a mining company) disputed the need for the aforementioned line before the Panel of Experts, an electricity tribunal. In August 10, 2018 through ruling 7-2018, the Panel of Experts decided to exclude the disputed line from the 2017 Expansion Plan. This does not necessarily mean that the line will no be built, it only means that it will not be constructed mandated by the 2017 Expansion Plan. The regulator can include this line or one with similar characteristics in future expansion plans.

[11] In fact, the PELP Report took into account the implementation of energy efficiency policies when estimating future electricity demand (pp. 70-72), as well as the introduction of more distributed generation (pp. 22-24).

[12] As an example, a solar power plant is, in average, 10 kilometers away from the main transmission system, a wind farm 30 kilometers away, and a run of the river power plant, 50 kilometers away. A coal power plant is 20 kilometers away, a diesel power plant only 3 kilometers and an LNG power plant 15 kilometers away. Energy Scenarios Chile 2030: Visions and key issues for the electricity matrix. ("Energy Scenarios 2030")

[13] Studies analyzing some of its impacts have been conducted, e.g. Guide for the environmental assessment of Wind Projects and Transmission Lines on birds and bats, Ministry of Energy, Agriculture and Livestock Service, 2015. See http://www.sag.gob.cl/ambitos-de-accion/sistema-de-evaluacion-de-impacto-ambiental-seia/141/publicaciones. Last visited July 20, 2018.

[14] Ryan A. Brockbank, "Environmental Effects of Underground and Overhead Transmission Line Construction and Maintenance", published in the Environmental Concerns in Rights-of-Way Management, 11th International Symposium, 2014, ("Environmental Effects") pp. 37-70. According to its author, the paper updates and summarizes the 2008 Electric Power Research Institute (EPRI) Report Nº 1015597, where the environmental effects of current underground and overhead transmission line construction and maintenance activities in the United States were comparatively assessed.

[15] According to its author, the paper does not address health issues associated with overhead and underground transmission lines such as electro-magnetic fields, nor does it address effects on air resources, Brockbank, R. Environmental Effects, p. 39.

[16] "Trees allowed to grow close to the conductors can induce flashover from the line through the air to the tree, resulting in a line to ground fault that can trip the line out of service or cause a sustained outage. Multiple line outages sometimes referred to as cascading line outages, can result in a widespread system blackout", Brockbank, R. Environmental Effects, p. 42.

[17] Brockbank, R. Environmental Effects, p. 66.

[18] Brockbank, R. Environmental Effects, p. 44.

[19] Brockbank, R. Environmental Effects, p. 47.

[20] Brockbank, R. Environmental Effects, p. 47.

[21] Brockbank, R. Environmental Effects, p. 47.

[22] Brockbank, R. Environmental Effects, p. 46.

[23] Brockbank, R. Environmental Effects, p. 47.

[24] Brockbank, R. Environmental Effects, p. 48.

[25] Brockbank, R. Environmental Effects, pp. 48, 49.
[26] Article 10 of Law 19,300 that sets the general bases of the environment, published in the Official Gazette on march 9, 1994 ("Law 19,300) and article 3 b) of the Regulation of the Environmental Assessment System, approved by Decree Nº40, of October 2012, of the Ministry of Environment, published in the Official Gazette on August 12, 2013 (the "SEIA Regulation").
[27] Article 11 of Law 19,300.
[28] Article 6 of the SEIA Regulation.
[29] Environmental Assessment Service, "Guide about Adverse Effects on Renewable Natural Resources", 2015, p. 15, available at http://www.sea.gob.cl/sites/default/files/imce/archivos/2016/02/08/guia_recursos_naturales.pdf, last visited on August 20th, 2018 ("Guide on Adverse Effects").
[30] Prior to Law 19,300, a provisional regulatory framework of the SEIA was created. This framework consisted in a presidential instruction that regulated a voluntary environmental impact assessment system. This voluntary environmental assessment system operated from September 1993 to the beginning of April of 1997. Del Fávero, G. y R. Katz,"La Evaluación Ambiental Estratégica (EAE) y su aplicación a políticas, programas y planes", *Estudios Públicos,* 64, 1996. p.254. See *https://www.cepchile.cl/cep/site/artic/20160304/asocfile/20160304093215/07_favero.pdf*. Therefore, at that time developers where not obligated to go through an environmental assessment process, but it was voluntary. It became mandatory on April 1997 when the Regulation of the Environmental Impact Assessment System was published (Approved by Decree 30/1997 of the Ministry General Secretariat of the Presidency).
[31] See *http://seia.sea.gob.cl/busqueda/buscarProyecto.php*. Search criteria: (1) Both types (DIA and EIA), (2) Date of presentation: November 1st 1992 – November 27th 2017, Type of project: High voltage electric transmission lines.
[32] This includes projects that were rejected, withdrawn by its developer, not assessed or not admitted for assessment.
[33] This is the case of years 2014, 2016 and 2017. The only exception is year 2015 where projects approved via EIA were 17% of the total.
[34] See http://seia.sea.gob.cl/busqueda/buscarProyecto.php.
[35] See Supreme Decree Nº 1546, 2009, of the Ministry of Justice, DL 2565, of 1979 of the Ministry of Agriculture, and Law 20,283 about the recovery of the native forest and promotion of plantations.
[36] Permits granted by CONAF regulated on articles 148, 149, 150, 152 of the SEIA Regulation are required when trees that are part of a forest (native or located in areas with forest land use aptitude) are affected. Guide on Adverse Effects, p. 16.
[37] Law 20,283, article 2 number 2.
[38] If the plantation of trees has originated such forest, then the developer must obtain the permit called PAS 149 (article 149 of the SEIA Regulation). If the forest is comprised by native species, then the developer must obtain the permit called PAS 148 (article 148 of the SEIA Regulation).
[39] In the case of these vegetation, the alteration of these species will require a management plan (Article 151 of the SEIA Regulation).
[40] Article 153, SEIA Regulation.
[41] Guide on Adverse Effects, p. 16.
[42] The Agricultural and Livestock Service is tasked with the protection and conservation of the renewable natural resources that affect the agricultural production of the country. In order to do that it must apply and supervise the fulfillment of the laws and regulations regarding hunting, land, flora of agricultural use and fauna, and take measures to protect agricultural land and water, to avoid erosion and improve its productivity. Articles 2, 3 letters k and l of Law 18,755 that establishes the norms for the Agricultural and Livestock Service, published in the Official Gazette on January 7, 1989.
[43] Guide for the environmental assessment of vegetation and wild flora, G-PR-GA-002, SAG, see at http://www.sag.gob.cl/ambitos-de-accion/sistema-de-evaluacion-de-impacto-ambiental-seia/141/publicaciones, last visited July, 23, 2018.
[44] The capture of protected wildlife is forbidden. However, SAG may give permission for its capture. Articles 3 and 9 of Law 4,601, as amended by Law 19,473 regarding Hunting, published in the Official Gazette on September 27, 1996.
[45] Article 6 of the SEIA Regulation.
[46] Guide on Adverse Effects, p. 16.

[47] Guide for the environmental Assessment of the wildlife component, D-PR-GA-01, version 1, SAG. See at http://www.sag.gob.cl/ambitos-de-accion/sistema-de-evaluacion-de-impacto-ambiental-seia/141/publicaciones, last visited July, 29, 2018.

[48] Id.

[49] Guide on Adverse Effects, p. 16

[50] The Commission was created through Supreme Decree Nº 20 of April 10, 2015, of the Ministry of Environment.

[51] Presidential Commission for the assessment of the SEIA, Final Report, Ministry of Environment, 2016, ("Final Report 2016 Commission"). p. 108.

[52] Final Report 2016 Commission, p. 116.

[53] Final Report 2016 Commission, p. 100.

[54] Final Report 2016 Commission, p. 224.

[55] In some cases CONAF has asked developers to asses the impact the transmission line is expected to produce due to the fragmentation of the habitat, or loss of biodiversity. E.g. Line Charrúa-Ancoa, Of. Ord. CONAF Nº377-EA/2013.

[56] In order to select the environmental assessments to be reviewed, we chose those we estimated were likely to have a higher impact on vegetation. According to that criterion, we eliminated those that were located in the north of Chile (XV, I, II and III regions). Then we selected those that were likely to have a higher level of scrutiny (therefore we selected those that went through an EIA, as opposed to a DIA, and that were authorized from 2010 onwards. Also, on 2010 there was a major institutional and legal reform that created the system that we have today, see Law 20,417). That left a total of 11 facilities: (1) Line Lo Aguirre-Cerro Navia 2x220 kV, a line of 16,5 kilometers in the Metropolitan Region, authorized by the Environmental Assessment Resolution Nº 165/2017, ("Line Lo Aguirre-Cerro Navia"), (2) Expansion Plan LT 2x500 kV Cardones Polpaico, a line of 753 kilometers in the III, IV, Metropolitan region and V regions, authorized by the Environmental Assessment Resolution Nº 1608/2017, ("Line Cardones-Polpaico"); (3) New Line Charrúa-Ancoa first cable, a 500 kV line of 196,5 kilometers in the VII and VIII regions, authorized by the Environmental Assessment Resolution Nº 84/2015, ("Line Charrúa-Ancoa"), (4) Line 2x220 kV Ciruelos-Pichirripulli, a line of 71 kilometers in the XIV region, authorized by the Environmental Assessment Resolution Nº 25/2015 ("Line Ciruelos-Pichirripulli"), (5) Complements and rectification of the path of Line Ancoa-Alto Jahuel 2x500 kV first cable, authorized by the Environmental Assessment Resolution Nº 0087/2014, ("Rectification Line Ancoa-Alto Jahuel"); (6) Line Los Hierros-Canal Melado and substation, a 110 kV line of 18 kilometers in the VII Region, authorized by the Environmental Assessment Resolution Nº 151/2011, ("Line Los Hierros-Canal Melado"); (8) Line Ancoa-Alto Jahuel 2x 500 kV, a line of 255 kilometers in the Metropolitan region, VI and VII regions, authorized by the Environmental Assessment Resolution Nº 50/2012, ("Line Ancoa-Alto Jahuel"); (9) Line of entry to Alto Jahuel 2x500 kV, a line of 11,3 kilometers in the Metropolitan Region, authorized by the Environmental Assessment Resolution Nº 454/2011, ("Line of Entry Alto Jahuel"); (10) Line Condores-S/E Ancoa, a line of 86,7 kilometers in the VII Region, authorized by the Environmental Assessment Resolution Nº 52/2012, ("Line Condores-S/E Ancoa"); and (11) Linea S/E Maitenes-S/E Alfalfal, a line of 17,1 kilometers in the Metropolitan Region, authorized by the Environmental Assessment Resolution Nº 443/2010, ("Line S/E Maitenes-S/E Alfalfal").

[57] See Rectification Line Ancoa-Alto Jahuel.

[58] See Line Charrúa-Ancoa Line. Similar actions include mandating the developer to conduct a study to determine what was the minimum cutting necessary in order to comply with electricity laws, suggesting the use of existing paths or roads for the construction of lines to decrease the impact on vegetation. It also indicated that any vegetation that had a distance of more than 4 meters to the conductors of the line would not be cut. Also, the authority required the developer to georeference the existence of certain tree species in order to avoid its cutting, and to change the location of the future towers if necessary. Exempt Resolution Nº174 / 2009 that environmentally qualifies the project "Charrúa-Lagunillas 2x220 kV Electric Transmission Line", July 6th 2009. ("Charrúa-Lagunillas Electric Transmission Line").

[59] In some cases, trees are eliminated completely. See Rectification Line Ancoa-Alto Jahuel.

[60] See Line Cardones-Polpaico.

[61] See Line Cardones-Polpaico.

[62] Id. Also see Line Los Hierros-Canal Melado.

[63] See Line of Entry Alto Jahuel.

[64] See Exempt Resolution Nº138/2016 that environmentally qualifies the project "Bureo-Mulchén Electric Transmission Line", April 5th 2016. ("Bureo-Mulchén Electric Transmission Line"). Also see Line Ancoa-Alto Jahuel.
[65] See Line Cardones-Polpaico.
[66] See Line Cardones-Polpaico.
[67] See Line Cardones-Polpaico.
[68] Id. Also, article 146 of the SEIA Regulation, also known as PAS 146.
[69] See Line Cardones-Polpaico.
[70] Id.
[71] See Line Charrúa-Ancoa that allows trees under the line. Also see Line Condores-S/E Ancoa, and Line S/E Maitenes-S/E Alfalfal.
[72] See Line Charrúa-Ancoa.
[73] See Line Cardones-Polpaico.
[74] See Line Charrúa-Ancoa, also see Line Los Hierros-Canal Melado.
[75] See Line Charrúa-Ancoa.
[76] See Line Ciruelos-Pichirripulli, where one of the mitigation measures consists in the creation of biological corridors within the right of way and in nearby sites.
[77] Final Report 2016 Commission, p. 103.
[78] Article 72-2 of the LGSE regulates the compensations that transmission companies must pay when there are outages.
[79] Article 139 of the LGSE.
[80] Decree 4.188/1955 of the Ministry of Interior, "Reglamento de Instalaciones Eléctricas de corrientes fuertes" ("NSEG 5") See https://www.leychile.cl/Navegar?idNorma=1038346.
[81] Article 222 of the LGSE, and article 217 of the RLGSE.
[82] Article 111.3 establishes that in lines located in rural areas, of a voltage between 1 kV and 25 kV, the distance between the cables of the lines and the trees must be of at least 5 meters, unless the height of the trees requires a larger distance. Article 111.4 establishes that in lines of a voltage of over 25 kV, the distance between the cables of the lines and trees must be equal to the height of the trees, and at least of 5 meters. NSEG 5.
[83] Article 111.1. NSEG 5. Also, Oficio Circular Nº 2999, of March 3rd, 2015, of the SEC, Case Nº (Rol) 748-2013 of the Appeals Court of Valparaiso, Case (Rol) Nº 2436-2016 of the Appeals Court of Santiago.
[84] Article 111.5 NSEG 5.
[85] Article 218 RGLSE.
[86] Article 111.6. NSEG 5.
[87] Oficio Circular Nº 2154, of April 21, 2004 of the SEC that "Issues instructions regarding the use of public force", Oficio Circular Nº 2824, of March 28th, 2013 of the SEC that "Issues instructions regarding cutting and pruning trees in the vicinity of electrical lines of public service". Oficio Circular Nº 2999, of March 3rd, 2015 of the SEC that "Issues new instructions about the maintenance of facilities, cutting and pruning of trees in the vicinity of electricity lines that have a concession" and Oficio Circular Nº 26035, of December 15th, 2017 of SEC that "Issues new instructions regarding the maintenance of facilities, cutting and pruning of trees in the vicinity of electrical lines".
[88] Oficio Ordinario Nº 01916, February 3rd, 2017.
[89] CONAF, "Report: Analysis of the forest fires affectation and severity that occurred in January and February 2018 and affects on land and natural ecosystems from Coquimbo and Araucanía, Chile", April 2017, See: http://www.conaf.cl/tormenta_de_fuego-2017/INFORME-AFECTACION-Y_SEVERIDAD-DE-INCENDIOS-FORESTALES-VERANO-2017-SOBRE-ECOSISTEMAS-VEGETACIONALES-CONAF.pdf, last viewed on June 29, 2018 ("CONAF Fire Report"), p. 5.
[90] Id., p. 8.
[91] Id., p. 21.
[92] CONAF Statistics of occurrence and damage of forest fires associated to electric situations, 2nd Technical workshop CNE, September 7, 2017.
[93] Formalization hearing, Case RIT 5-2017, Juzgado de Garantía of Peralillo, April 18, 2017.
[94] Bio-Bio Radio, "The harsh sentence that executives of CGE risk due to formalization due to forest fires", April 13, 2017, See https://www.biobiochile.cl/noticias/biobiochile/videos/2017/04/13/la-dura-condena-que-arriesgan-los-ejecutivos-de-cge-formalizados-por-incendios-forestales.shtml, last seen June 20, 2018.

[95] Exempt Resolution Nº 19576 July 19, 2017 of the SEC that "Applies fines to company CGE Distribución S.A. with regards to the charges presented via document Nº86, 2017".
[96] Letter EEAG-DJ-004/2007, August 18, 2017.
[97] SEC Exempt Resolution Nº 20830, October 16, 2017.
[98] Case Nº (Rol) 8007-2017 Concepción Court of Appeals.
[99] Brockbank, R. Environmental Effects, p. 59.
[100] Nowak, What is IVM? (2014) pp. 281-288.
[101] Nowak, What is IVM? (2014) pp. 282 and 285.
[102] Nowak, What is IVM? (2014), p. 282.
[103] American National Standards Institute 2006. ANSI A300 (Part 7)-2006 IVM, American National Standard for Tree Care Operations – Tree, Shrub, and Other Woody Plant Maintenance – Standard Practices (Integrated Vegetation Management a. Electric Utility Rights- of-Way). Washington, D.C.: American National Standards, Inc.
[104] Nowak, What is IVM (2014) pp. 284-285. Gardener, R.H. 2007. Best Management Practices: Integrated Vegetation Management. Champaign, IL: International Society of Arboriculture.
[105] Cited by Kooser, James; Gorsky, Kendra; Khitrik, Lana; Coogan, Donald; Payne, Lewis; Gwozdz, John; Breier, Paul. ROW vegetation changes over four treatment cycles, IVM controls the growth of non-compatible trees, p. 196, Environmental Concerns in Right of Way management, 11th International Symposium, 2016 ("NYPA IVM"), p. 197. The study referred to is Bramble, W.C. and W.R. Byrnes, 1976, Development of a stable, low plant cover on a utility right of way. First Symposium on Environmental Concerns in Rights of Way management, pp. 168-179.
[106] Kooser et al NYPA IVM, pp. 191-200.
[107] Cited by Kooser et al, NYPD IVM, p. 197. This study evaluated 30 years of data of the State Games Lands 33 project, in a forest area. Bramble, W.C. and W.R. Byrnes 1983. Thirty years of research on development of plant cover on an electric transmission right of way. Journal of Arboriculture 9 (3), pp. 67-74.
[108] According to Kooser et al, this is a short-term study on the east coast that showed that a stable community of compatible species could be developed and maintained, using IVM techniques, in as few as five years. NYPD IVM p. 196. Haggie, M.R., R.A. Johnstone, and H.A. Allen, Jr. 2008. Tree, Shrub and Herb Succession and Five Years of Management Following the Establishment of a New Electric Transmission Right-of-Way through a Wooded Wetland. In Proceedings of the 8th International Symposium on Environmental Concerns in Rights-of-Way Management, eds. Goodrich-Mahoney, J.W., L.P. Abrahamson, J. L. Ballard, and S. M. Tikalsky, pp. 37-41, Electric Power Research Institute, Washington, D.C.
[109] According to Kooser et al, this study showed on the west coast that stable communities of clonal-growing shrubs could form dense thickets along right of way's, discouraging the growth and development of tall trees NYPD IVM, p. 196. Nesmith, J.C.B., J.P. Shatford, and D.E. Hibbs. 2008. Stable Plant Communities in the Pacific Northwest. In Proceeding of the 8th International Symposium on Environmental Concerns in Rights-of-Way Management. (J. W. Goodrich-Mahoney, L. P. Abrahamson, J. L. Ballard, S. M. Tikalsky, Eds.). Electric Power Research Institute, Washington, D.C., pages 47-59.
[110] Kooser el al, NYPA IVM, p. 198.
[111] They conclude by saying that they "strongly suspect that while IVM efforts, and herbicide use, will decrease over time, some IVM will likely always be required to ensure that tall woody species do not threaten operation of the transmission system", Kooser et al, NYPA IVM, p. 198.
[112] Brockbank, R. Environmental Effects, p. 61.
[113] Guerrero-Murphy, Galen; Follensbee II, Tim; and Disorda, Jeff, Best management Practices (BPMs) for protection of threatened species during integrated vegetation management and operation and maintenance of Electric Transmission lines in Vermont, Environmental Concerns Right of Way Management 11th International Symposium, Jean Doucet Editor, 2016 Utility Arborist Association ("Guerrero-Murphy 2016"), p. 346 citing Bramble, W.C., and W.R. Byrnes. 1996. Integrated vegetation management of an electric utility right-of-way ecosystem, Down to Earth 51(1): 29-34 and Duncan, C. 2014. Plant and Animal Community Response to Long-term Vegetation Management Practices on Rights-of-Way. The Bramble and Byrnes Projects. Available at http://brambleandbyrnes.com/wp- content/uploads/2014/11/Plant-and-Anima l-Response-to-Long-Term-IVM-on-ROW.pdf .
[114] As seen in the Pennsylvania State Game Lands 33 research project in Central Pennsylvania, that started in 1953. The data from this project demonstrate that IVM of the ROW has provided conditions for many native bird species to thrive, species that are on the Audubon Society's conservation watch list or are in a dramatic decline throughout the eastern United States. Mahan, Carolyn G; Krause, Dave and Duncan, Celestine. Plant

and animal response to long-term vegetation management practices on Rights of Way. Environmental Concerns in Rights of Way Management 11th Symposium, Jean Doucet editor, 2016 utility arborist association, p. 202.

[115] Guerrero-Murphy 2016, p. 346-347.

[116] Wokcik, Victoria; Beesley, Peter; Brenton, Bob; Brown, Eric; Hallmark, Steven, Innovations in Right of Way management that support pollinators, ecosystem services and save energy transmission, Environmental Concerns Right of Way Management 11th International Symposium, Jean Doucet Editor, 2016 Utility Arborist Association, p. 257.

[117] See http://www.life-elia.eu/_dbfiles/lacentrale_files/600/676/LIFE%20ELIA_Folder_EN_WEB.pdf.

[118] Life-ELIA project, Brochure 02/10, Transmission of Electricity, Vegetation Management in forest corridors. A cost-benefit analysis of an alternative vegetation management. Analysis by LIFE-Elia-RTE and Elia, November 2015 ("Brochure 02/10"), p 15. See at *http://www.life-elia.eu/en/Brochure-n-1-Vegetation-mapping*. Last visited June 25, 2018.

[119] The funding was of € 3,000,000, of which 38% was funded by the European Commission, 27% by the Walloon Regional Government, 22% by Elia, a transmission system operator in Belgium, and 13% by RTE, a transmission system operator in France.

[120] See: *http://www.life-elia.eu/_dbfiles/lacentrale_files/600/676/LIFE%20ELIA_Folder_EN_WEB.pdf.*

[121] Life Elia Biodiversity under high voltage overhead lines, Brussels, December 5th, 2017, Johan Mortier at Final Conference Proceedings ("Final Conference") see at http://www.life-elia.eu/_dbfiles/lacentrale_files/1400/1411/LIFE%20Elia-RTE_Proceedings%20final%20conference%20in%20Brussels_5:12:2017_part3of3_WEB.pdf. Last visited May 30, 2018.

[122] See https://ec.europa.eu/energy/en/topics/renewable-energy/renewable-energy-directive

[123] Strengthening Europe's energy networks, Tomasz Jerzyniak, European Commission, Directorate-General for Energy networks and Regional Initiatives. See at Final Conference.

[124] Life-ELIA project, Brochure 01/10, Vegetation mapping of power corridors in forests ("Brochure 01/10"), p. 4.

[125] See http://ec.europa.eu/environment/nature/natura2000/faq_en.htm#6-0. Last visited May 30, 2018.

[126] See http://www.life-elia.eu/en/. Last visited on June 31, 2018.

[127] Brochure 02/10, p. 8.

[128] Brochure 04, p. 2.

[129] Brochure 04, p. 4.

[130] Brochure 02/10, pp. 4,5.

[131] Brochure 02/10, p. 5.

[132] Brochure 04, p. 6.

[133] Brochure 04, p. 2.

[134] Brochure 04, p. 20.

[135] Brochure 04, p. 10.

[136] Brochure 04, p. 6.

[137] Brochure 04, p. 24.

[138] Brochure 04, p. 17-18.

[139] Brochure 04, p. 25.

[140] Brochure 04, p. 25.

[141] Brochure 02/10, p. 17.

[142] Brochure 04, p. 7.

[143] Brochure 04, p. 9.

[144] Brochure 03, Electrical Transmission, Vegetation Management in forest corridors, Grazing and Mowing under high-voltage lines ("Brochure 03"), p. 6.

[145] Brochure 03, p. 7.

[146] Brochure 03, p. 9.

[147] Brochure 03, p. 5.

[148] The provisional and free nature is important to avoid falling under a farm lease system. Brochure 03, p. 16.

[149] Brochure 03, p. 20.

[150] Brochure 02/10, p. 18.

[151] Id.

[152] Brochure 02/10 p. 19.

[153] Brochure 03, p. 21.
[154] Definition by the European Fauna-Flora-Habitats Directive, cited in Booklet 06, Transmission of Electricity Management of Vegetation in Forest Corridors, Restoration of natural habitats under high voltage lines ("Booklet 06"), p. 4.
[155] Booklet 6, p. 4.
[156] Booklet 6, p. 5.
[157] Booklet 6, p. 7.
[158] Booklet 6, p. 9.
[159] Booklet 6, p. 11.
[160] Brochure 02/10 p. 19.
[161] Brochure 02/10 p. 19.
[162] Brochure 05, Electrical Transmission, Vegetation Management in forest corridors, Ponds and invasive species under high-voltage lines ("Brochure 05"), p. 2.
[163] Brochure 05, p. 5.
[164] Brochure 05, p. 4.
[165] Brochure 02/10, p. 8.
[166] This system is usually used where the machines for the rotary milling cannot go and is carried out by workers with chainsaws. Brochure 02/10, p. 7.
[167] This technique consists in cutting down the upper part of the tree 1/5 to 1/3 of the total height.
[168] Brochure 02/10, p. 22.
[169] Brochure 02/10, pp. 4-5.
[170] Brochure 02/10, p. 5.
[171] Brochure 02/10, p. 22.
[172] Brochure 02/10, p. 17.
[173] Brochure 02/10, pp. 20-21.
[174] Article 115, LGSE.
[175] The goal is for Chile to be among the three OECD countries with the lowest average cost of electricity for residential and industrial customers by 2050. Energy 2050, Energy Policy for Chile, Ministry of Energy, p. 68. Although this goal refers to the price of electricity and not transmission, recent regulatory changes, i.e. Law 20,936 that transferred the costs of transmission from generators to customers have significantly increased customer's bills, so any move towards lower prices is a goal to pursue.
[176] The California Department of Forestry and Fire Protection recommends planting certain plants that are fire resistant (have high moisture, grow closet o the ground and have low resin content) and draught tolerant. Available at: http://www.readyforwildfire.org/Fire-Safe-Landscaping/. Last visited June 17, 2018.
[177] Id. Footnote 87.
[178] Monthly progress Report Nº54, Technical audit of project New Line Cardones-Polpaico 2x500kv, 2018-7330-POW/VP, Abril 27, 2018.
[179] Nowak, What is IVM? (2014), p. 6.
[180]Available at https://www.tcia.org/TCIA/ABOUT/TCIA/About/About.aspx?hkey=428d3267-44e8-415d-8b42-f558b2e9644d. Last visited June 3, 2018.
[181] Available at http://www.tcia.org/TCIA/BUSINESS/A300_Standards/History.aspx. Last visited June 3, 2018.
[182] LIFE-Elia, Final Conference of the LIFE-Elia RTE Project, Conference proceedings, Brussels, Elia's headquarters-5/12/2017.
[183] See http://www.rowstewardship.org/about_us/history. Last visited June 27, 2018.
[184] See http://www.rowstewardship.org/accredited_utilities. Last visited June 10, 2018.
[185] Ministry of Energy, Energy 2050, 2016, p. 74. Available at http://www.energia2050.cl/es/energia-2050/descripcion-del-proceso/. Last visited July 28, 2018.
[186] Regional Energy Plan, Tarapaca Region. Available at http://www.minenergia.cl/per/region/tarapaca/. Last visited August 1, 2018.
[187] According to the CIA World Factbook, which considers data from 2015. Available at http://www.minenergia.cl/per/region/tarapaca/. Last visited August 2, 2018.
[188] See http://www.life-elia.eu/en/News/Final-conference-of-the-LIFE-Elia-RTE-project-in-Brussels. Last visited August 2, 2018.