Project co-financed by the European Regional Development Fund

# Forest Bioenergy in the Protected Mediterranean Areas

## Impact assessment of the increase biomass use in the short, medium and long term in the protected areas

**Workpackage 3 - Testing**

**Activity A.3.5. - Threats and benefits of increase the biomass use in the protected areas**

**Deliverable D.3.5.1. – Impact assessment of increase biomass use in the short, medium and long term in the protected areas**

**Partner in charge: PP2 – Enviland Ltd**

**March 2018**

# Deliverable 3.5.1

## Impact assessment of increase biomass use in the short, medium and long term in the protected areas

**Responsible Partner:**

PP2 – Enviland Ltd

**Contributing Partners:**

LP: Sicily Region - Regional Department for the Rural and Territorial Development

PP1: Municipality of Petralia Sottana

PP3: Slovenian Forestry Institute

PP4: Regional Development Agency Green Karst Ltd

PP5 - The Forestry Municipalities Association of Comunitat Valenciana

PP6 – Valencia Official Chamber of Commerce, Industry, Services and Shipping

PP7 - Zadar County

PP8 - Public institution Nature Park Velebit

March 2018

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|---|---|
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| Deliverable: | D. 3.5.1 Impact assessment of increase biomass use in the short, medium and long term in the protected areas |
| Summary: | Methodology for risks and benefits assessment of impacts derived from the biomass production. Description and evaluation of a set of indicators for the assessment of the impacts for different temporal scenarios: short, medium and long. |
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# 1 EXECUTIVE SUMMARY

Main objectives and expected results of the activity

ForBioEnergy is an innovative project focussed on the sustainable development of rural areas using the forest biomass of protected areas as driving force.

Most of the forest areas are included in the protected areas so they represent a significant opportunity for the production of sustainable energy from biomass.

However, current regulatory restrictions as well as the lack of appropriate action plans impede and slow down the forest biomass exploitation.

The goal of the project is to foster bio-energy production in protected areas providing transnational solutions for reducing barriers that hinder the development of the sector and designing models in order to exploit the full potential of biomass while preserving the biodiversity of natural and seminatural environments.

A key element of this preservation effort is the impact assessment of increased biomass use in the short, medium and long term.

The aim of this activity is the definition of a methodology for the assessment of risks and benefits arising from the extraction of biomass on the environmental (biotic and abiotic) and socio-economic components.

Involved partners

| Country | Participating partners per pilot area | |
|---|---|---|
| **Italy** | LP | Sicily Region |
| | PP1 | Municipality of Petralia Sottana |
| | PP2 | EnviLand Ltd |
| **Slovenia** | PP3 | Slovenian Forestry Institute |
| | PP4 | Regional Development Agency Green Karst Ltd. |
| **Spain** | PP5 | The Forestry Municipalities Association of Comunitat Valenciana |
| **Croatia** | PP7 | Zadar County |
| | PP8 | Public institution Nature Park Velebit |

Deliverable

| Title of the deliverable | Target value | Type of deliverable | Description |
|---|---|---|---|
| 3.5.1 Impact assessment of increase biomass use in the short, medium and long term in the protected areas | 1 Unit produced | Method | Methodology for risks and benefits assessment of impacts derived from the biomass production.<br>Description and evaluation of a set of indicators for the assessment of the impacts for different temporal scenarios: short, medium and long. |

Content of this report

This report indicates the methods to be used in impacts assessment of increased biomass use in the short, medium and long term in the protected areas.

The **Chapter 2** is divided into two sections:

Section 2.1 describes the assessment methodologies aimed at evaluating the impacts of forest biomass extraction on plant communities.

Section 2.2 describes the assessment methodologies aimed at evaluating the impacts of forest biomass extraction on animal communities.

The **Chapter 3** describes the impact assessment methods regarding abiotic components.

The **Chapter 4** describes the impact assessment methods on the socio-economic components and ecosystem services.

The **Chapter 5 and the respective Annexes** describe the peculiarities of the different study areas involved in the ForBioEnergy project and specific applications of the methods described in Chapter 2, 3 and 4 to the different study areas, taking in account the different biota occurring in each area.

The **Chapter 6** contains final remarks and recommendations.

## 2 IMPACT ASSESSMENT ON BIOTIC COMPONENTS

The first methodological step in the assessment process is to identify the threats to the biological communities associated with forest operations and biomass extraction.

All activities included in the ForBioEnergy project are designed to be compliant with conservation and management measures included in the relevant Management Plans.

Management Plans are territorial planning instruments whose main goal is to safeguard habitat structure and functionality and long-term species conservation, taking also into account social and economic factors characterizing the area. In particular, Natura 2000 Management Plans are designed with the explicit purpose of maintaining, improving or recovering a satisfactory state of nature conservation. Moreover, Management Plans of Natura 2000 Sites safeguard the efficiency of Natura 2000 Network.

Under no circumstances ForBioEnergy project activities can override Management Plans measures.

Since different taxa and communities have different sensitivity and resiliency, threats will be assessed separately depending on the type of ecosystem the operations will take place in.

Threats and potential impacts have been analysed in two different scenarios:

habitats (both priority and non priority, according to the Directive 92/43/EEC);

forest categories not included in the "Habitats Directive”: autochthonous/ allochthonous broadleaved reforestation, autochthonous/allochthonous coniferous reforestation, tree plantations for wood production.

The following matrices summarize threats and potential impacts on priority and non priority habitats and forest categories not included in the "Habitats Directive”. Magnitude of impact and reversibility of impact are indicated for each combination of threat and forestry operation according to the methods below detailed.

Two illustrative matrices on the vulnerability of two different forest habitat types are reported below. The first one shows the magnitude of impacts and the estimated resilience time for an ideal forest habitat type interested by forestry activities and included as a priority habitat in the Habitat Directive (Council Directive 92/43/EEC). The second one illustrates the same parameters for a tree plantation for wood production. A set of suitable indicators to monitor the actual magnitude of impact and the forest patch resilience is also included for each possible threat.

Because of the complexity of most stressor-response relationships, it is practically impossible to exhaustively characterize all the variables of a studied system; accordingly, a set of selected representative measurements, or indicators, should be chosen. These should be selected in order to reflect the most critical components of the studied systems and, ideally, the system as a whole. Such measurements and indicators should be included in monitoring programs to estimate trends, stressor source and the magnitude of stressing effects, thus leading to the singling out of thresholds for the implementation of management or restoration measures (Fisher et al., 2001). An environmental indicator is derived from a single variable which reflects some environmental attributes. It can be therefore defined as a “simple sign” that conveys a “complex message” resulting from numerous factors acting synergically, in a synthetic and useful fashion (Jackson et al., 2000). The implementation of proper indicators ensures that a monitoring program actually address the key variables associated with the most significant environmental impacts, also taking into account time and resources limitations. In the light of this, the methodology described and implemented in the frame of the project was realized according to the following rationale: after the identification of the forestry activities potentially compatible with the Natura2000 management plans, a panel of experts in the fields of animal communities, flora and vegetation, abiotic components, and socio-economic status singled out the possible threats and benefits deriving from them. Once these possible beneficial or noxious impacts have been identified, a set of sound and synthetic indicators was selected.

In each matrix, the forestry activities are reported on the first lines, the possible impacts on the first column, and the selected indicator(s) on the last one, according to the scheme reported below:

| | Silvicultural and harvesting practices (high forest and coppice) | | | | | | | | | | | | Post harvesting management | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Thinning/Shelterwood cutting/Salvage cutting | | | | | Crown pruning | | Clear cutting | | | | | | |
| | Felling and Arrangement | Storing (Winch) | Storing (Raceways) | Yarding (Raceways) | Yarding (Tractor) | Cutting | Yarding | Felling and Arrangement | Storing (Winch) | Storing (Raceways) | Yarding (Raceways) | Yarding (Tractor) | Chipping | |
| Possible impact 1 | | | | | | | | | | | | | | Indicator(s) 1 |
| Possible impact 2 | | | | | | | | | | | | | | Indicator(s) 2 |

Forestry activities (i.e., silvicultural and harvesting practices, post harvesting management) assessed in matrix are commonly applied in Sicilian forests. However, the matrix must be considered “open”, i.e. it is can be adapted to characteristics of forest stands and/or to local practices and legislation. A summary description of forest activities included in matrix is given in the glossary.

Presented assessment matrices analyse raw impacts without taking into account the possible implementation of mitigation measures. Even though forestry procedures are already designed to minimize their impacts, the use of specific mitigation measures might further reduce their direct impact, or improve the impact reversibility.

All the matrices produced in the frame of the ForBioEnergy project are explicitly referring to the possible impacts of the forestry interventions directly linked with biomass extraction. The possible impacts of the rest of the production chain linked with the use of the extracted biomass are not evaluated.

In each study area, a matrix should be compiled for each forest habitat type (sensu "Habitats Directive") present in the study area, plus and furthers matrix for each forest categories not included in the "Habitats Directive”. When different forest habitat types are assumed to suffer the same impact magnitude and show the same resilience time, for all the forestry activities, they can be lumped in a single matrix, given that the codes indicating the Forest Habitat types sensu "Habitats Directive" are explicitly mentioned in its heading.

The matrices include indicators for each threat/impact, which are discussed in the following paragraphs.

The potential impact associated with each operation with regard to each threat is assessed according to two factors:

- magnitude of impact
- reversibility of impact

The magnitude of the impact is an estimation of the damage that a given operation will cause to the habitat with regard to the threat considered.

The reversibility of impact is an estimation of the amount of time the community and the habitat will need to return to its previous state after impact takes place. It depends on impact type, impact magnitude and community's resilience.

## 2.1 Plant communities

The potential impacts on plant biodiversity caused by woodland biomass exploitation must be evaluated by assessing the alterations occurring in composition and structure of local plant communities.

However, forestry operations might also have beneficial effects on local biodiversity, for example through the removal of non native species, the improvement of tree stands, the opening of clearings (which might increase microclimatic and habitat diversity), etc.

The magnitude of impact is an estimation of the damage that an operation will cause to the habitat with regard to the threat considered (Table 2.1).

Table 2.1 Magnitude scale of impact

| Magnitude | Impact | Description |
|---|---|---|
| | None | The operation will cause no relevant impact or may be beneficial to plant community structure or functionality, with regard to the threat considered. |
| I | Low | The operation will cause limited impact to plant community structure or functionality, with regard to the threat considered. |
| II | Medium | The operation will cause significant impact to plant community structure or functionality, with regard to the threat considered. |
| III | High | The operation will cause extreme impact to plant community structure or functionality, with regard to the threat considered.<br>In this case operation should not be performed. |

The reversibility of impact is an estimation of the amount of time the plant community will need to return to its previous state after impact takes place (Table 2.2). It depends on impact type, impact magnitude and community's resilience, which is its capacity to absorb or withstand disturbance and other stressors such that it maintains its structure and functions (Holling 1973, Walker et al. 2004).

Table 2.2 Reversibility scale of impact

| Colour | Reversibility | Description |
|---|---|---|
| (green) | Short term | Plant community structure or functionality will be unaffected or recover in a short amount of time. |
| (yellow) | Medium term | Plant community structure or functionality will recover over a period of time measured in years. |
| (orange) | Long term | Plant community structure or functionality will recover over a period of time measured in decades. |
| (red) | Irreversibile | Impact is irreversible and plant community will not recover. Operation should not be performed. |

With regard to the introduction of synanthropic or alien species, the reversibility will not be estimated, due to the extreme complexity of the issue.

The following matrices (Tables 2.3 & 2.4) summarize threats and potential impacts on the plant communities. These matrices have to be filled in for each forest habitat type (sensu "Habitats Directive") and for each forest categories not included in the "Habitats Directive" , for each study areas.

The matrices include indicators for each threat/impact, which are discussed in the following paragraphs.

Table 2.3 Potential impacts on habitats (according to Directive 92/43/EEC).

| **Natura 2000 Habitat Code:** | *(Indicate the habitat code or codes of the considered habitats*)* * When different forest habitat types are assumed to suffer the same impact magnitude and show the same resilience time, for all the forestry activities, they can be lumped in a single matrix. | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Action** | **Silvicultural and harvesting practices (high forest and coppices)** | | | | | | | | | | | | **Post harvesting management** | |
| **Threat** | Thinning/Shelterwood cutting/Salvage cutting | | | | | Crown pruning | | Clear cutting | | | | | | **INDICATOR(S)** |
| | Felling and Arrangement | Storing (Winch) | Storing (Raceways) | Yarding (Raceways) | Yarding (Tractor) | Cutting | Yarding | Felling and Arrangement | Storing (Winch) | Storing (Raceways) | Yarding (Raceways) | Yarding (Tractor) | Chipping | |
| direct removal of natural vegetation | | | | | | | | | | | | | | vegetation sampling life-form spectrum/ diversity indices |
| alteration of floristic composition | | | | | | | | | | | | | | |
| reduction of protected and endemic species population | | | | | | | | | | | | | | presence of protected and endemic species |
| introduction of synanthropic species | | | | | | | | | | | | | | presence of synanthropic species |
| introduction of alien species | | | | | | | | | | | | | | presence of alien species |
| reduction of natural regeneration | | | | | | | | | | | | | | presence of natural regeneration |
| damage to natural regeneration | | | | | | | | | | | | | | presence of damages to natural regeneration |

Table 2.4 Potential impacts on forest categories not included in the "Habitats Directive".

| **Forest categories not included in the "Habitats Directive"** | ***(Indicate the forest categories not included in the "Habitats Directive")*** *autochthonous/ allochthonous broadleaved reforestation, autochthonous/ allochthonous coniferous reforestation, tree plantations for wood production* | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Action** | **Silvicultural and harvesting practices (high forest and coppices)** | | | | | | | | | | | | **Post harvesting management** | |
| | Thinning/ Shelterwood cutting/Salvage cutting | | | | | Crown pruning | | Clear cutting | | | | | | |
| **Threat** | Felling and Arrangement | Storing (Winch) | Storing (Raceways) | Yarding (Raceways) | Yarding (Tractor) | Cutting | Yarding | Felling and Arrangement | Storing (Winch) | Storing (Raceways) | Yarding (Raceways) | Yarding (Tractor) | Chipping | **INDICATOR(S)** |
| direct removal of natural vegetation | | | | | | | | | | | | | | vegetation sampling life-form spectrum/ diversity indices |
| alteration of floristic composition | | | | | | | | | | | | | | |
| reduction of protected and endemic species population | | | | | | | | | | | | | | presence of protected and endemic species |
| introduction of synanthropic species | | | | | | | | | | | | | | presence of synanthropic species |
| introduction of alien species | | | | | | | | | | | | | | presence of alien species |
| reduction of natural regeneration | | | | | | | | | | | | | | presence of natural regeneration |
| damage to natural regeneration | | | | | | | | | | | | | | presence of damages to natural regeneration |

### 2.1.1 Selected indicators for the impacts assessment on plant communities

The assessment of impacts on plant communities caused by increased biomass use in the protected areas will be carried out using eight different indicators, as shown in the table 2.5.

Table 2.5 List of the selected indicators for the impacts assessment on plant communities

| INDICATOR | Sampling unit | Data source | Before operations | During operations | After operations (short term) | After operations (medium term) | After operations (long term) |
|---|---|---|---|---|---|---|---|

| INDICATOR | Sampling unit | Data source | Before operations | During operations | After operations (short term) | After operations (medium term) | After operations (long term) |
|---|---|---|---|---|---|---|---|
| **Vegetation sampling/ diversity indices** | 2 plots per site (400 m$^2$ each) | Field survey | 1 year (2 surveys / year) | 2 surveys / year | 1st year (2 surveys / year) | 2nd year (2 surveys / year) | 3rd and 4th year (2 surveys / year) |
| **Presence of protected species** | 2 plots per site (400 m$^2$ each) | Field survey | 1 year (2 surveys / year) | 2 surveys / year | 1st year (2 surveys / year) | 2nd year (2 surveys / year) | 3rd and 4th year (2 surveys / year) |
| **Presence of endemic species** | 2 plots per site (400 m$^2$ each) | Field survey | 1 year (2 surveys / year) | 2 surveys / year | 1st year (2 surveys / year) | 2nd year (2 surveys / year) | 3rd and 4th year (2 surveys / year) |
| **Presence of synanthropic species** | 2 plots per site (400 m$^2$ each) | Field survey | 1 year (2 surveys / year) | 2 surveys / year | 1st year (2 surveys / year) | 2nd year (2 surveys / year) | 3rd and 4th year (2 surveys / year) |
| **Presence of alien species** | 2 plots per site (400 m$^2$ each) | Field survey | 1 year (2 surveys / year) | 2 surveys / year | 1st year (2 surveys / year) | 2nd year (2 surveys / year) | 3rd and 4th year (2 surveys / year) |
| **Life form spectrum** | 2 plots per site (400 m$^2$ each) | Field survey | 1 year (2 surveys / year) | 2 surveys / year | 1st year (2 surveys / year) | 2nd year (2 surveys / year) | 3rd and 4th year (2 surveys / year) |
| **Presence of natural regeneration** | 2 plots per site (400 m$^2$ each) | Field survey | 1 year (2 surveys / year) | 2 surveys / year | 1st year (2 surveys / year) | 2nd year (2 surveys / year) | 3rd and 4th year (2 surveys / year) |
| **Damages to natural regeneration** | 2 plots per site (400 m$^2$ each) | Field survey | 1 year (2 surveys / year) | 2 surveys / year | 1st year (2 surveys / year) | 2nd year (2 surveys / year) | 3rd and 4th year (2 surveys / year) |

The main indicator is vegetation sampling, accepted as the standard sampling method to collect base information essential for habitat monitoring (ISPRA, 2016). Vegetation plots also allow acquiring a wide range of derived information that will be used as additional indicators (presence of protected, endemic, synathropic and alien species, life form spectrum).

Since forest operations are a key element of the project, the presence of natural regeneration and damages to natural regeneration will be also be used as indicators.

The chosen indicators have the merit of being accepted as standard and acknowledged as effective by the scientific community. Added to that, they have other significant desirable characteristics, because they are:

- Sensitive to anthropogenic impacts and able to measure changes caused specifically by humans;
- Dynamic and responsive to ongoing changes;
- Able to address positive and negative changes;
- Spatially relevant across the required geographical scale.

A minimum of three sampling sites having homogeneous environmental characteristics (climate, soil, altitude, exposure and slope) will be selected according to standard methods (Elzinga et al., 1998) and marked using a GPS receiver.

In addition, sampling will be carried out in a control site not subject to biomass exploitation and with similar environmental characteristics, marked using a GPS receiver.

A first reference sampling campaign will be carried out before any forest operations take place to have baseline data for comparison.

All sampling campaigns will be carried out two times a year, according to plants phenology and preferably during Spring and Autumn seasons.

The following paragraphs describe each of the indicators, data collection and analysis procedures.

#### *2.1.1.1 Vegetation sampling*

Vegetation, like any biological system, is not static but a dynamic entity. Plant communities can change their floristic composition and structure in a relatively short amount of time, in relation to changes of abiotic and biotic environmental factors.

The result of this process, defined ecological succession, is the temporal sequence of different plant communities that succeed one another at a given site. Secondary succession is the sequential changes in vegetation that occur after a disturbance, such as human alterations. These changes can be reliably detected analysing floristic composition.

Phytosociology is a branch of vegetation science that analyses current plant assemblages (communities), delimiting and characterizing vegetation types based on the complete floristic (species) composition.

Phytosociological relevés will be carried out according to the standard methods (Braun-Blanquet 1951, Barbour 1987).

The data of a single plot consist of header and species data.

Header data comprise plot identification, information on methodology (date, data collector, plot size), geographic localization (name of the locality and geographic coordinates), environmental data determined on the plot (altitude, slope, aspect, soil parameters) and structural data (vegetation layers coverage and height).

Species data comprises a complete census of plant taxa (species and infraspecific taxa, further called species) found on the plot and their attributes.

All visible living vascular plants are recorded and every species is assigned to one or more layers (tree, shrub, herb).

Each observation of a species in a layer is assigned a cover value, estimated by the data collector, recorded according to the B-B scale, modified by Pignatti (1953).

The method assumes that the data collector has a good knowledge of local flora.

Based on the information gathered it is possible to proceed to vegetation classification (IAVS, 2017).

Data collected before operations will be used as a term of comparison (diachronic analysis). Moreover, data collected in the sampling sites will be compared to data collected in the control site.

<table>
<tr><th>Indicator name</th><th colspan="3">Vegetation sampling</th></tr>
<tr><td colspan="4">Application</td></tr>
<tr><td colspan="2">Potential impact/threat<br>direct removal of natural vegetation<br>alteration of floristic composition</td><td>Sector of bioenergy chain<br>Forest harvesting</td><td>Action<br>All</td></tr>
<tr><td colspan="4">Indicator description<br>When changes to abiotic and biotic environmental factors occur, plant communities' composition and structure may be altered. These variations can be reliably detected analysing floristic composition. A widely accepted vegetation sampling method makes use of phytosociological relevés, carried out according to the standard techniques (Braun-Blanquet 1951, Barbour 1987).</td></tr>
<tr><td colspan="4">Data sources and retrieval methods<br>Field surveys will be performed in each plot. Complete header and species data will be recorded. Header data comprise plot identification, information on methodology (date, data collector, plot size), geographic localization (name of the locality and geographic coordinates), environmental data determined on the plot (altitude, slope, aspect, soil parameters) and structural data (vegetation layers coverage and height).<br>Species data comprises a complete census of plant taxa (species and infraspecific taxa, further called species) found on the plot and their attributes. All visible living vascular plants are recorded and every species is assigned to one or more layers (tree, shrub, herb).<br>Each observation of a species in a layer is assigned a cover value, estimated by the data collector, recorded according to the B-B scale, modified by Pignatti (1953):<br>+ = insignificant species;<br>r = rare species;<br>1= cover between 1 and 20%;<br>2= cover between 20 and 40%;<br>3= cover between 40 and 60%;<br>4 = cover between 60 and 80%;<br>5 = cover between 80 and 100%;<br>Based on the information gathered it is possible to proceed to vegetation classification<br>(IAVS, 2017).</td></tr>
<tr><td>Sampling unit</td><td colspan="3">2 plots per site (400 m$^2$ each)</td></tr>
<tr><td rowspan="2">Monitoring timeframe</td><td>Short</td><td>Medium</td><td>Long</td></tr>
<tr><td>2 surveys / year</td><td>2 surveys / year</td><td>2 surveys / year</td></tr>
<tr><td>Links with other indicators</td><td colspan="3">Collected data will be also used to evaluate the presence of protected, endemic, synanthropic and alien species. Collected data will be also used to elaborate the life form spectrum.</td></tr>
<tr><td colspan="4">References<br>Braun-Blanquet J., 1951. Pflanzensoziologie. Grundzüge der vegetationnskunde. Springer-Verlag, Wien.<br>IAVS (International Association for Vegetation Science), 2017. Vegetation Classifcation Methods."</td></tr>
</table>

| Indicator name | Vegetation sampling |
|---|---|
| https://sites.google.com/site/vegclassmethods/(accessed September 19, 2017)<br>Pignatti S., 1953. Introduzione allo studio fitosociologico della pianura veneta orientale con particolare riguardo alla vegetazione litoranea - Arch. Bot. 28 (4): 265-329; 29 (1): 1-25, 65-98, 129-174. | |

### *2.1.1.2 Diversity indices*

Biodiversity is one of the primary interests in the impact assessment of increased biomass use in protected areas, hence it is important to quantify species diversity of ecological communities and how it may be affected. The task is complex: in addition to issues of statistical sampling, the rather arbitrary nature of delineating an ecological community and the difficulty of positively identifying all of the species present, species diversity itself has two separate components: the number of species present (species richness), and their relative abundances (termed dominance or evenness).

A diversity index is a mathematical measure of species diversity in a given community, based on the species richness (the number of species present) and species abundance (the number of individuals per species).

Many different measures (or indices) of biodiversity have been developed (see Magurran, 2004).

Two of the most used indices are the Shannon-Wiener and Simpson's index, which will be calculated using data obtained from vegetation sampling.

The Shannon-Wiener index takes into account both species richness and abundance, using a logarithmic scale. This index comes from the theory of information. The value varies from 0 (when there is only one species) and lnS. The Shannon index increases as both the richness and the evenness of the community increase. Typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4.

Simpson's index is based on the probability of any two individuals drawn at random from an infinitely large community belonging to the same species. It is a measure of dominance where common species have a lot of weight in respect to the rare species. The value oscillates between 0 (when there is only one specie) and 1-1/S.

An additional index that can grant useful information on the communities is the uniformity index of Pielou, which measures the uniformity or the balance of an ecosystem, expressed as the diversity observed regarding the diversity which could be obtained in a community with the same number of species but with maximum diversity. It oscillates between 0 and 1. Therefore, the application of these indices allows to obtain data about the species richness, as well as the uniformity (Ferriol Molina, M.; Merle Farinós, HB. (2012).

| Indicator name | Diversity indices | | |
|---|---|---|---|
| **Application** | | | |
| **Potential impact/threat**<br>direct removal of natural vegetation<br>alteration of floristic composition | | **Sector of bioenergy chain**<br>Forest harvesting | **Action**<br>All |
| **Indicator description**<br>When changes to abiotic and biotic environmental factors occur, plant communities' composition may be altered. These variations can be detected using diversity indices. | | | |

**Data sources and retrieval methods**

In each plot, from the complete census of plant taxa obtained from vegetation plots, diversity indices will be calculated.

"Pi" is the proportion of the species. This value is the number of individuals of the species "i" in respect to the total individuals of the "S" species of a community (instead of using the number of individuals, coverage or abundance/dominance can be used to calculate "pi").

Shannon-Wiener Index (Equation 1).

$$\overline{H} = -\sum_{i=1}^{s} p_i \ln p_i$$

Equation 1: Shannon-Wiener Index

Simpson's Index (Equation 2).

$$\lambda = 1 - \sum_{i=1}^{S} p_i^2$$

Equation 2: Simpon's Index

Uniformity index of Pielou (Equation 3).

$$\overline{e} = \frac{\overline{H}}{\ln S}$$

Equation 3. Uniformity Index of Pielou

| Sampling unit | 2 plots per site (400 $m^2$ each) | | |
|---|---|---|---|
| **Monitoring timeframe** | **Short** | **Medium** | **Long** |
| | 2 surveys / year | 2 surveys / year | 2 surveys / year |
| **Links with other indicators** | Data obtained from vegetation sampling. | | |

**References**

Magurran, A.E. 2004. Meausuring Biological Diversity. Blackwell.

Ferriol Molina, Maria and Merle Farinós, Hugo. UPV. 2012. Los componentes alfa, beta y gamma de la biodiversidad. Aplicación al estudio de comunidades vegetales.

### *2.1.1.3 Presence of protected species*

It is mandatory that impact assessment of increased biomass use in protected areas targets protected species, whose conservation is one of the core objectives. The indicator will take into account species included in the "EU Habitat Directive" (Council Directive 92/43/EEC), annexes II, IV, V, species included in the Standard Data Form (including important species), within SCIs or in their proximity, and species otherwise identified as protected.

For each study-area, a list of the potentially occurring protected species should be obtained through a literature review, paying particular attention to local and national checklists, floras and atlases. In each plot, from the complete census of plant taxa obtained from vegetation plots, the number of protected species present will be counted and the percentage of total number of species will be calculated.

The number and percentage of protected species recorded before operations will be used as a term of comparison (diachronic analysis).

Moreover, number and percentage of protected species recorded in the sampling sites will be compared to data recorded in the control site. This approach allows to detect indicator changes or trends (diachronic analysis), whether these are associated with biomass use or not (control site), and to design corrective actions.

<table>
<tr><th>Indicator name</th><th colspan="3">Presence of protected species</th></tr>
<tr><td colspan="4">Application</td></tr>
<tr><td>Potential impact/threat<br>reduction of protected and endemic species population</td><td colspan="2">Sector of bioenergy chain<br>Forest harvesting</td><td>Action<br>All</td></tr>
<tr><td colspan="4">Indicator description<br>Impact assessment in protected areas must target protected species, whose conservation is one of the core objectives.<br>The indicator will take into account species included in the “EU Habitat Directive” (Council Directive 92/43/EEC), annexes II, IV, V, species included in the Standard Data Form (including important species), within SCIs or in their proximity, and species otherwise identified as protected.<br>For each study-area, a list of the potentially occurring protected species should be obtained through a literature review, paying particular attention to local and national checklists, floras and atlases.</td></tr>
<tr><td colspan="4">Data sources and retrieval methods<br>In each plot, from the complete census of plant taxa obtained from vegetation plots, the number of protected species present will be counted and the percentage of total number of species will be calculated.</td></tr>
<tr><td>Sampling unit</td><td colspan="3">2 plots per site (400 m$^2$ each)</td></tr>
<tr><td rowspan="2">Monitoring timeframe</td><td>Short</td><td>Medium</td><td>Long</td></tr>
<tr><td>2 surveys / year</td><td>2 surveys / year</td><td>2 surveys / year</td></tr>
<tr><td>Links with other indicators</td><td colspan="3">Data obtained from vegetation sampling</td></tr>
<tr><td colspan="4">References</td></tr>
</table>

### *2.1.1.4 Presence of endemic species*

Endemic species are native species that are confined to a certain region or having a comparatively restricted distribution. Because of this, threats to endemics carry more risk of extinction than for broadly distributed species.

Furthermore, according to the book Climate Change and Biodiversity (Lovejoy & Hannah, 2005), when an endemic plant species becomes extinct, between 10 and 30 endemic animal species risk extinction as well.

Thus, endemic species are a focus for biological diversity conservation, especially in biodiversity hotspots where exceptional concentrations of endemic species are undergoing exceptional loss of habitat.

Impact assessment of increased biomass use on endemics is therefore of key importance in protected areas.

For each study-area, a list of the potentially occurring endemic species should be obtained through a literature review, paying particular attention to local and national checklists, floras and atlases.

In each plot, from the complete census of plant taxa obtained from vegetation plots, the number of endemic species present will be counted and the percentage will be calculated.

The number and percentage of endemic species recorded before operations will be used as a term of comparison (diachronic analysis).

Moreover, number and percentage of endemic species recorded in the sampling sites will be compared to data recorded in the control site.

This approach allows to detect indicator changes or trends (diachronic analysis), whether these are associated with biomass use or not (control site), and to design corrective actions.

<table>
<tr><th>Indicator name</th><th colspan="3">Presence of endemic species</th></tr>
<tr><td colspan="4">Application</td></tr>
<tr><td colspan="2">Potential impact/threat<br>reduction of protected and endemic species population</td><td>Sector of bioenergy chain<br>Forest harvesting</td><td>Action<br>All</td></tr>
<tr><td colspan="4">Indicator description<br>Endemic species are native species that are confined to a certain region or having a comparatively restricted distribution. Because of this, threats to endemics carry more risk of extinction than for broadly distributed species. Endemic species are a focus for biological diversity conservation and assessment of potential impacts on endemics is therefore of key importance in protected areas.<br>For each study-area, a list of the potentially occurring endemic species should be obtained through a literature review, paying particular attention to local and national checklists, floras and atlases.</td></tr>
<tr><td colspan="4">Data sources and retrieval methods<br>In each plot, from the complete census of plant taxa obtained from vegetation plots, the number of endemic species present will be counted and the percentage of total number of species will be calculated.</td></tr>
<tr><td>Sampling unit</td><td colspan="3">2 plots per site (400 m$^2$ each)</td></tr>
<tr><td rowspan="2">Monitoring timeframe</td><td>Short</td><td>Medium</td><td>Long</td></tr>
<tr><td>2 surveys / year</td><td>2 surveys / year</td><td>2 surveys / year</td></tr>
<tr><td>Links with other indicators</td><td colspan="3">Data obtained from vegetation sampling</td></tr>
<tr><td colspan="4">References<br>Lovejoy T. E., HannaH, L. J., 2005. Climate Change and Biodiversity. Yale University Press. pp 418.</td></tr>
</table>

### *2.1.1.5 Presence of synanthropic species*

Synanthropic and ruderal plants benefit from the somewhat artificial habitats that humans create. When an environment is affected by human activities, a potential side effect is the penetration of synanthropic species into the ecosystem, with a consequent synanthropization of flora and vegetation and a potential biodiversity loss.

Synanthropic species are therefore a very good indicator of possible impacts of increased biomass use in protected areas.

A preliminary step necessary to allow measurement of this indicator is the identification of synanthropic or ruderal species, achieved through literature review.

In each plot, from the complete census of plant taxa obtained from vegetation plots, the number of synanthropic species present will be counted and the percentage of total number of species will be calculated.

The number and percentage of synanthropic species recorded before operations will be used as a term of comparison.

Moreover, number and percentage of synanthropic species recorded in the sampling sites will be compared to data recorded in the control site.

This approach allows to detect indicator changes or trends (diachronic analysis), whether these are associated with biomass use or not (control site), and to design corrective actions.

| Indicator name | Presence of synanthropic species | | |
|---|---|---|---|
| **Application** | | | |
| **Potential impact/threat**<br>introduction of synanthropic species | | **Sector of bioenergy chain**<br>Forest harvesting | **Action**<br>All |
| **Indicator description**<br>Synanthropic and ruderal plants benefit from the somewhat artificial habitats that humans create. The synanthropization of flora and vegetation caused by human activities may result in biodiversity loss.<br>Synanthropic species are therefore a very good indicator of possible impacts of increased biomass use in protected areas.<br>A preliminary step necessary to allow measurement of this indicator is the identification of synanthropic or ruderal species, achieved through literature review. | | | |
| **Data sources and retrieval methods**<br>In each plot, from the complete census of plant taxa obtained from vegetation plots, the number of synanthropic species present will be counted and the percentage of total number of species will be calculated. | | | |
| **Sampling unit** | 2 plots per site (400 $m^2$ each) | | |
| **Monitoring timeframe** | **Short** | **Medium** | **Long** |
| | 2 surveys / year | 2 surveys / year | 2 surveys / year |
| **Links with other indicators** | Data obtained from vegetation sampling | | |

| Indicator name | Presence of synanthropic species |
|---|---|
| **References** | |

### *2.1.1.6 Presence of alien species*

Alien species are species that are introduced outside their natural past or present distribution area and succeed in surviving and subsequently reproducing. Alien species are defined invasive when their introduction and/or spread threaten biological diversity, as acknowledged by the European Commission and stated in the CBD Guiding Principles (CBD Decision COP VI/23).

Since biodiversity conservation is a key goal of a protected area, it is mandatory to monitor the potential spread of alien species, which might be facilitated by the activities associated with biomass exploitation.

In each plot, from the complete census of plant taxa obtained from vegetation plots, the number of alien species present will be counted and the percentage of total number of species will be calculated.

The number and percentage of alien species recorded before operations will be used as a term of comparison.

Moreover, number and percentage of alien species recorded in the sampling sites will be compared to data recorded in the control site.

This approach allows to detect indicator changes or trends (diachronic analysis), whether these are associated with biomass use or not (control site), and to design corrective actions.

<table>
<tr><th>Indicator name</th><th colspan="3">Presence of alien species</th></tr>
<tr><td colspan="4" align="center">Application</td></tr>
<tr><td>Potential impact/threat<br>introduction of alien species</td><td colspan="2">Sector of bioenergy chain<br>Forest harvesting</td><td>Action<br>All</td></tr>
<tr><td colspan="4">Indicator description<br>Alien species are species that are introduced outside their natural past or present distribution area and succeed in surviving and subsequently reproducing. Their introduction and/or spread threaten biological diversity (CBD Decision COP VI/23).<br>Since biodiversity conservation is a key goal of a protected area, it is mandatory to monitor the potential spread of alien species, which might be a result of human activities.</td></tr>
<tr><td colspan="4">Data sources and retrieval methods<br>In each plot, from the complete census of plant taxa obtained from vegetation plots, the number of alien species present will be counted and the percentage of total number of species will be calculated.</td></tr>
<tr><td>Sampling unit</td><td colspan="3">2 plots per site (400 m² each)</td></tr>
<tr><td rowspan="2">Monitoring timeframe</td><td align="center">Short</td><td align="center">Medium</td><td align="center">Long</td></tr>
<tr><td align="center">2 surveys / year</td><td align="center">2 surveys / year</td><td align="center">2 surveys / year</td></tr>
<tr><td>Links with other indicators</td><td colspan="3">Data obtained from vegetation sampling</td></tr>
<tr><td colspan="4">References<br>"Communication From The Commission To The Council, The European Parliament, The European Economic And Social Committee And The Committee Of The Regions Towards An EU Strategy On Invasive Species"<br>(retrieved September 19, 2017)</td></tr>
</table>

### *2.1.1.7 Life form spectrum*

Life forms (Raunkiaer, 1934) classify plants according to the place where the growth point is located during the less favourable seasons, provided the plant maintains the capability to survive.

The locations of shoot apical meristems within a vegetation unit, hence the representation of the life form classes among the species that are present in that vegetation unit, characterize the prevailing environmental conditions affecting that plant community.

Different environmental conditions may select against some life form classes more than others.

The floristic life form spectrum is obtained by counting relative numbers of plant species per life form occurring within the plot, each expressed as a percentage of the total.

The life form spectrum calculated before operations will be used as a term of comparison.

Moreover, life form spectra obtained in the sampling sites will be compared to that of the control site.

This approach allows to detect indicator changes or trends (diachronic analysis), whether these are associated with biomass use or not (control site), and to design corrective actions.

<table>
<tr><th>Indicator name</th><th colspan="3">Life form spectrum</th></tr>
<tr><td colspan="4">Application</td></tr>
<tr><td>Potential impact/threat<br>direct removal of natural vegetation<br>alteration of floristic composition</td><td>Sector of bioenergy chain<br>Forest harvesting</td><td colspan="2">Action<br>All</td></tr>
<tr><td colspan="4">Indicator description<br>Life forms (Raunkiaer, 1934) classify plants according to the position of shoot apical meristems during the less favourable seasons.<br>The representation of the life form classes among the species that are present in a vegetation unit characterize the prevailing environmental conditions affecting that plant community, as different environmental conditions may select against some life form classes more than others.</td></tr>
<tr><td colspan="4">Data sources and retrieval methods<br>In each plot, from the complete census of plant taxa obtained from vegetation plots, The floristic life form spectrum is obtained by counting relative numbers of plant species per life form occurring, expressed as a percentage of the total.<br>The main life forms are:<br>• Phanerophytes - Shoot apical meristems are borne more than 25 cm above the soil surface<br>• Chamaephyte - Shoot apical meristems are borne less than 25 cm above the soil<br>• Hemicryptophytes - Shoot apical meristems are borne at or near soil level<br>• Geophyte - Shoot apical meristems are borne below the soil level<br>• Hydrophyte - The shoot system is entirely underwater<br>• Epiphytes - depending on other plants for their support<br>• Therophytes - Shoot apical meristems persist during unfavorable climatic conditions only</td></tr>
<tr><td>Sampling unit</td><td colspan="3">2 plots per site (400 $m^2$ each)</td></tr>
<tr><td rowspan="2">Monitoring timeframe</td><td>Short</td><td>Medium</td><td>Long</td></tr>
<tr><td>2 surveys / year</td><td>2 surveys / year</td><td>2 surveys / year</td></tr>
<tr><td>Links with other indicators</td><td colspan="3">Data obtained from vegetation sampling</td></tr>
</table>

| Indicator name | Life form spectrum |
|---|---|
| **References**<br>Raunkiaer C., 1934. The Lifeforms of plants and Statistical Plant Geography. Oxford University Press, Oxford. pp 632. | |

### *2.1.1.8 Presence of natural regeneration*

An efficient indicator of the impact of increased biomass use is the amount of natural regeneration of tree species.

The estimation will be carried out on two sampling areas per site, 400 $m^2$ each, marked using a GPS receiver, where the presence of natural regeneration (number of individuals) will be recorded, divided per tree species.

Each plot has an area of 400 $m^2$, hence 800 $m^2$ in total. The number of individuals counted in the plots multiplied by 12,5 gives an estimation of the number of individuals per hectare.

| Indicator name | Presence of natural regeneration | | |
|---|---|---|---|
| **Application** | | | |
| **Potential impact/threat**<br>reduction of natural regeneration | **Sector of bioenergy chain**<br>Forest harvesting | | **Action**<br>All |
| **Indicator description**<br>An efficient indicator of the impact of increased biomass use is the amount of natural regeneration of tree species. The indicator provides an estimation per hectare of natural regeneration density (n/ha) in site, divided per tree species. | | | |
| **Data sources and retrieval methods**<br>The estimation will be carried out on two sampling areas per site, 400 $m^2$ each, marked using a GPS receiver, where the presence of natural regeneration (number of individuals) will be recorded, divided per tree species.<br>*Each plot has an approximate area of 400 $m^2$, hence 800 $m^2$ in total. The number of individuals counted in the plots multiplied by 12,5 gives an estimation of the number of individuals per hectare.* | | | |
| **Sampling unit** | 2 plots per site (400 $m^2$ each) | | |
| **Monitoring timeframe** | **Short** | **Medium** | **Long** |
| | 2 surveys / year | 2 surveys / year | 2 surveys / year |
| **Links with other indicators** | | | |
| **References** | | | |

### *2.1.1.9 Presence of damages to natural regeneration*

To assess the impact of forest operations on young trees, the most vulnerable, the presence of damages to natural regeneration will be used as an indicator.

The use of working systems with a low degree of mechanization in the different phases of work should prevent significant impacts on the natural regeneration and on the remaining trees.

Within 2 sampling plots per site (400 m$^2$ each), marked using a GPS receiver, the regeneration of tree species with presence of damages will be recorded as a percentage.

| Indicator name | Presence of natural regeneration | | |
|---|---|---|---|
| **Application** | | | |
| **Potential impact/threat**<br>reduction of natural regeneration | **Sector of bioenergy chain**<br>Forest harvesting | **Action**<br>All | |
| **Indicator description**<br>To assess the impact of forest operations on young trees, the most vulnerable, the presence of damages to natural regeneration will be used as an indicator. | | | |
| **Data sources and retrieval methods**<br>Within 2 sampling plots per site (400 m$^2$ each), marked using a GPS receiver, the regeneration of tree species with presence of damages will be recorded as a percentage. | | | |
| **Sampling unit** | 2 plots per site (400 m$^2$ each) | | |
| **Monitoring timeframe** | **Short** | **Medium** | **Long** |
| | 2 surveys / year | 2 surveys / year | 2 surveys / year |
| **Links with other indicators** | | | |
| **References** | | | |

## 2.2 Animal communities

The possible detrimental effects (=impacts) on biodiversity due of the removal of biomass from woodland areas must be monitored through the assessment of the possible changes occurring in the *composition* and *structure* of the local animal communities. However, forestry interventions might also have positive effects (=opportunities) on local biological diversity through the opening of clearings (and the consequent increase in microclimatic and habitat diversity), and due to the “intermediate disturbance” and “edge” effects (e.g. Verschuyl et al., 2011). Accordingly, in order to carry out a sound assessment of the impacts and opportunities linked with biomass extraction in woodland\forest ecosystems, it is necessary to select a pool of “*target taxa*”, which are informative and representative of the actual positive and\or detrimental changes possibly taking places in the whole local biocoenoses.

Those taxa strictly linked to forest ecosystems are ideal candidates for monitoring the impacts of the forestry activities. Conversely, the monitoring of taxa characterised by broader ecological niches and\or including species with different ecological *preferenda* allows to study the species turnover, and the possible local increase (or loss) of biological diversity linked with the biomass removal. A simultaneous monitoring of both taxon types is thus pivotal to get a clear picture of the actual effects of forestry activities.

The simultaneous implementation of dedicated monitoring of the forest-specialists xylobiont (*sensu* Contarini & Strocchi, 2009) and, when present, saproxylic (*sensu* Speight 1989) coleopterans, and of the ground beetles and the breeding and wintering birds (both are species-rich taxa including species with broadly different ecological *preferenda*) represents an effective and feasible approach to the impact assessment of biomass removal in forests, as these groups behave as valid surrogates for the total biodiversity of the area.

Obviously, the presence in the study areas of taxa included in local or international red-lists or directives must also be considered, and the statuses of these taxa (If present) must be monitored according to the existing national or sovranational legislations, which usually require the application of standardised sampling and monitoring techniques (e.g. see Campanaro et al., 2011; Jurc, 2012; Stoch & Genovesi, 2016; Carpaneto et al., 2017 for the saproxylic beetles). A baseline inventory of the target taxa occurring in the study-areas before the actual beginning of the forestry activities is essential to be able to single out and document their possible diachronic changes linked with the forestry activities themselves. Accordingly, in each study-area the monitoring programme should include at least a one-year-long monitoring activity *prior* to the beginning of the actual biomass extraction, followed by the carrying out of the monitoring for the entire duration of the forestry activities.

Furthermore, the actual carrying out of the forestry activities might implicate some casualties due to the passage of heavy vehicles and\or the cutting of the plant itself. Accordingly, throughout the carrying out of the activities, the possible presence of casualties must be monitored through the monitoring of carcasses.

The magnitude of the impact is an estimation of the damage that a given operation will cause to the animal communities with regard to the threat considered. It is indicated with roman numerals according to the table 2.6.

Table 2.6 Magnitude scale of impact

| Magnitude | Impact | Description |
|---|---|---|
| | None | The operation will cause no relevant impact or may be beneficial to animal community structure or composition, with regard to the threat considered |
| I | Low | The operation will cause limited impact to animal community structure or composition, with regard to the threat considered |
| II | Medium | The operation will cause significant impact to animal community structure or composition, with regard to the threat considered |
| III | High | The operation will cause extreme impact to animal community structure or composition, with regard to the threat considered.. |

The reversibility of impact is an estimation of the amount of time the community will need to return to its previous state after impact takes place. It depends on impact type, impact magnitude and community’s resilience. The reversibility of impact is colour coded according to the following colour scale:

Table 2.7 Reversibility scale of impact

| Colour | Reversibility | Description |
|---|---|---|
| | Short term | Animal community structure or composition will be unaffected or recover in a short amount of time.. |
| | Medium term | Animal community structure or composition will recover over a period of time measured in years.. |
| | Long term | Animal community structure or composition will recover over a period of time measured in decades |
| | Irreversible | Animal community structure or composition recover will take an extremely long time. Operation should preferably not be performed. |

The following matrices (Table 2.8 & 2.9) summarize threats and potential impacts on the animal communities present in the habitats (according to Directive 92/43/EEC) and in the other forest categories not included in the "Habitats” Directive. These matrices have to be filled in for each forest habitat type (sensu "Habitats Directive") and for each forest categories not included in the "Habitats Directive" , for each study areas.

The matrices include indicators for each threat/impact, which are discussed in the following paragraphs.

Table 2.8 Potential impacts on the animal communities present in the habitats (according to Directive 92/43/EEC).

| **Natura 2000 Habitat Code:** | *(Indicate the habitat code or codes of the considered habitats*)* * When different forest habitat types are assumed to suffer the same impact magnitude and show the same resilience time, for all the forestry activities, they can be lumped in a single matrix. | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Action** | **Silvicultural and harvesting practices (high forest and coppice)** | | | | | | | | | | | | **Post harvesting management** | |
| | Thinning/Shelterwood cutting/Salvage cutting | | | | | Crown pruning | | Clear cutting | | | | | | |
| **Threat** | Felling and Arrangement | Storing (Winch) | Storing (Raceways) | Yarding (Raceways) | Yarding (Tractor) | Cutting | Yarding | Felling and Arrangement | Storing (Winch) | Storing (Raceways) | Yarding (Raceways) | Yarding (Tractor) | Chipping | **INDICATOR(S)** |
| Noise | | | | | | | | | | | | | | Birds (Non-Strigiformes) |
| Soil compaction | | | | | | | | | | | | | | Ground-active beetles |
| Decrease of habitat suitability | | | | | | | | | | | | | | Xylobiont and Saproxylic beetles; Birds (Strigiformes) |
| Decrease of the availability of trophic resources | | | | | | | | | | | | | | Xylobiont beetles; Birds (non-Strigiformes) |
| Casualties | | | | | | | | | | | | | | Monitoring of carcasses |

Table 2.9 Potential impacts on the animal communities present in the forest categories not included in the Habitats

| **Forest categories not included in the "Habitats Directive"** | ***(Indicate the forest categories not included in the "Habitats Directive)*** *autochthonous/ allochthonous broadleaved reforestation, autochthonous/ allochthonous coniferous reforestation, tree plantations for wood production* | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Action** | **Silvicultural and harvesting practices (high forest and coppice)** | | | | | | | | | | | | **Post harvesting management** | |
| | Thinning/Shelterwood cutting/Salvage cutting | | | | | Crown pruning | | Clear cutting | | | | | | |
| **Threat** | Felling and Arrangement | Storing (Winch) | Storing (Raceways) | Yarding (Raceways) | Yarding (Tractor) | Cutting | Yarding | Felling and Arrangement | Storing (Winch) | Storing (Raceways) | Yarding (Raceways) | Yarding (Tractor) | Chipping | **INDICATOR(S)** |
| Noise | | | | | | | | | | | | | | Birds (Non-Strigiformes) |
| Soil compaction | | | | | | | | | | | | | | Ground-active beetles |
| Decrease of habitat suitability | | | | | | | | | | | | | | Xylobiont and Saproxylic beetles; Birds (Strigiformes) |
| Decrease of the availability of trophic resources | | | | | | | | | | | | | | Xylobiont beetles; Birds (non-Strigiformes) |
| Casualties | | | | | | | | | | | | | | Monitoring of carcasses |

### 2.2.1 Selected Indicators for the impacts assessment on animal communities

The assessment of impacts on animal communities caused by increased biomass use in the protected areas will be carried out using six different indicators, as shown in the tables 2.10 & 2.11.

Table 2.10 - Synopsis of the monitoring activities (animal communities)

| Target taxon | Method | Number of traps\ point count sites\ broadcasting stations | Timing and frequency of the activity |
|---|---|---|---|
| Xylobiont beetles | Suspended baited traps | See text | Every second week from May to August |
| Ground-active beetles | Pitfall traps on the ground | See text | Every second week from May to August; monthly from September to April |
| Saproxylic beetles (strictly protected species only) | As described in the literature (see text) | Refer to the relevant references | Refer to the relevant references |
| Non-Strigiformes birds (both breeding and wintering species) | Echantillonnages Fréquentiel Progressif (E.F.P.) | 10 sampling points (=point count sites) for each study-area | Two times in spring (May and June) and two times in winter (December and January) |
| Strigiformes | Call playbacks | See text | Twice, during the breeding period of each species possibly present in the study area. |
| Monitoring of carcasses | Visual inspection of the areas where the forestry activities are carried out | Not applicable | Every second day throughout the carrying out of the activities |

Table 2.11 List of the indicators for the impacts assessment on animal communities

| INDICATOR | Sampling unit | Data source | Before operations | During operations | After operations (short term) | After operations (medium term) | After operations (long term) |
|---|---|---|---|---|---|---|---|
| **Xylobiont beetles** | Suspended baited trap | Field survey | 1 year (every second week from May to August) | Every second week from May to August | 1st year (every second week from May to August) | 2nd year (every second week from May to August) | 3rd to 4th years (every second week from May to August) |
| **Ground-active beetles** | Pitfall traps | Field survey | 1 year (every second week from May to August; monthly from September to April) | Every second week from May to August; monthly from September to April) | 1st year (every second week from May to August; monthly from September to April) | 2nd year (every second week from May to August; monthly from September to April) | 3rd to 4th years (every second week from May to August; monthly from September to April) |
| **Saproxylic beetles** | See text | Field survey | See text | See text | See text | See text | See text |
| **Non-Strigiformes birds** | 10 Sampling points for each area | Field survey | 1 year (Two times in spring and two times in winter) | Two times in spring and two times in winter | 1st year (Two times in spring and two times in winter) | 2nd year (Two times in spring and two times in winter) | 3rd to 5th years (Two times in spring and two times in winter) |
| **Strigiformes** | Call playback | Field survey | 1 year (two surveys during the breeding season of each species) | Two surveys during the breeding season of each species | 1st year (surveys during the breeding season of each species) | 2nd year (surveys during the breeding season of each species) | 3rd to 5th years (surveys during the breeding season of each species) |
| **Monitoring of** | Transect | Field survey | NO | See text | NO | NO | NO |

| INDICATOR | Sampling unit | Data source | Before operations | During operations | After operations (short term) | After operations (medium term) | After operations (long term) |
|---|---|---|---|---|---|---|---|
| **carcasses** | | | | | | | |

### 2.2.1.1 *Xylobiont, saproxylic and ground beetles*

Xylobiont, i.e. those coleopterans living on trees, and saproxylic beetles, i.e. those coleopterans largely depending on old trees and dead wood, are mostly belonging to the families Cerambycidae, Elateridae and Cetoniidae. They are forest-specialists, and their diversity and abundance are known to be significantly influenced by the composition, age, and management of the forest stands, with higher diversity values observed in old, mixed, unmanaged forests (Audisio et al., 2014). Accordingly, this group is one of those which are more likely negatively affected by forestry interventions (Nieto & Alexander, 2010).

Furthermore, several saproxylic coleopteran species are considered “priority species” in the EU (Council Directive 92/43/EEC) and\or are included in European and national red-lists (e.g. Nieto & Alexander, 2010; Audisio et al., 2014) and, when their presence is known for a study area, their status must be carefully monitored following the available standard official guidelines (e.g. see Stoch & Genovesi, 2016; Carpaneto et al., 2017, and references therein).

Apart from these cases, when no evidence of the presence of strictly-protected saproxylic coleopteran species is available (which is likely the case when the biomass extraction is carried out in reforested areas and\or in heavily disturbed forest patches), the protocol for the monitoring of xylobiont beetles described below must be implemented. This is based on the use of baited funnel traps suspended from tree branches. The use of these traps is aimed at getting a representative (even if not exhaustive) picture of the xylobiont coleopteran fauna inhabiting the study area. In order to optimise the sampling efforts, samplings must be implemented in the months comprised between May and August. Furthermore, in order to make the monitoring effective, it is of utmost importance that the number and arrangement of the implemented traps is kept constant throughout the carrying out of the monitoring, both *ante*- and *in- and* post- o*peram* activities .

Ground-active coleopterans (mostly belonging to the families Carabidae, Scarabeidae, Curculionidae and Staphylinidae, but representative of several other families are routinely observed) are extremely diversified, with taxa characterised by different ecological *preferenda* and different responses to land-use changes and human-induced disturbance. Accordingly, if the forestry activities have a significant impact on the ecosystem, we expect to observe a species turnover with a shift in dominance from typical forest-dwellers to more euryecious taxa. Ground-active beetles are routinely studied through the use of pitfall traps.

If, in spite of the absence of available data about their presence in the study area, priority or endangered saproxylic coleopteran species fell in the traps mentioned above, these sampling methodologies should be abandoned in order not to damage their local populations; the monitoring activities will then focus on these strictly-protected species only, following the standard procedures mentioned above (see Campanaro et al., 2011; Jurc, 2012; Stoch & Genovesi, 2016; Carpaneto et al., 2017).

(i) Suspended baited traps

These traps are constituted by one or more stacked funnels with a container attached to the bottom-most funnel; these are mostly known as “funnel traps” or “modified bottle traps”, and can be easily built or purchased from different commercial providers (e.g. Galko et al., 2016). Black funnels and collecting containers are often used in order to make the trap looking similar to a trunk, and thus possibly more effective in attracting xylobiont and saproxylic beetles. These traps must be suspended from tree branches (close to the tree trunk, at a height of 1.5 – 7 m), and baited with water, beer and molasses or with a mixture of red wine, vinegar and sugar. The insects attracted by the baits reach the funnels and slide down to the collection bottle. The effectiveness of these traps is high, so that they should be checked no less than every second week, or once a week when necessary due to the high amount of captures. Collected specimens must be moved to an adequately-labelled bottle, and sent to coleopteran taxonomists for their identification to species or subspecies level. The number of traps to be settled and their arrangement (in line or in a grid) depend on the study area type and characteristics, so that their arrangement has to be chosen by a specialist on a case-by-case basis. The position of each trap must be geo-referenced with a GPS.

(ii) Pitfall traps located on the ground

Pitfall traps located on the ground provide a consistent method for accurately assessing ground-active insect assemblages through time. The pitfall traps should be made following the standardized design described by the guidelines of Brown & Matthews (2016), and 100 ml of a suitable transparent, nontoxic killing preservative such as propylene glycol should be used. The pitfall traps will be kept active throughout the year (compatibly with the local weather conditions and area accessibility), and the traps should be checked every second week in the months comprised between May and August, and monthly from September to April, for the collection of samples and the replacement of the preservative. Collected specimens must be moved to an adequately-labelled bottle, and sent to coleopteran taxonomists for their identification to species or subspecies level. Also in this case, the number of traps to be settled and their arrangement (in line or in a grid) depend on the study area type and characteristics, so that their arrangement has to be chosen by a specialist on a case-by-case basis. However, at least a linear transect of 100 metres, with 5 pitfall traps located at least at 15 m of distance one from the other must be implemented in each study area. The position of each trap must be geo-referenced with a GPS.

<table>
<tr><th>Indicator name</th><th colspan="5">Xylobiont and Saproxylic beetles</th></tr>
<tr><td colspan="6">Application</td></tr>
<tr><td colspan="3">Potential impact/threat<br>Reduction of species richness and species densities</td><td colspan="3">Sector of bioenergy chain<br>Biomass extraction</td></tr>
<tr><td colspan="6">Indicator definition<br>Xylobiont and saproxylic beetles are largely depending on old trees and dead wood, and one of the invertebrate taxa which are more likely negatively affected by forestry interventions (Nieto & Alexander, 2010).<br>Xylobiont beetles can be sampled through the use of baited funnel traps suspended from tree branches.<br>Several saproxylic coleopteran species are considered “priority species” in the EU (Council Directive 92/43/EEC) and\or are included in European and national red-lists (e.g. Nieto & Alexander, 2010; Audisio et al., 2014). Standard official guidelines are available for the strictly protected species (see text).</td></tr>
<tr><td colspan="6">Data sources and retrieval methods<br>Suspended baited traps (SBT) are constituted by one or more stacked funnels with a container attached to the bottom-most funnel; these can be easily built or purchased from different commercial providers (e.g. Galko et al., 2016).<br>SBT must be suspended from tree branches close to the tree trunk, at a height of 1.5 – 7 m, and baited with water, beer and molasses or with a mixture of red wine, vinegar and sugar. The insects attracted by the baits reach the funnels and slide down to the collection bottle.<br>The effectiveness of these traps is high, so that they should be checked no less than every second week, or once a week when necessary due to the high amount of captures. Collected specimens must be moved to an adequately-labelled bottle, and sent to coleopteran taxonomists for their identification to species or subspecies level.<br>The number of traps to be settled and their arrangement depend on the study area type and characteristics, so that their arrangement has to be chosen by a specialist on a case-by-case basis.<br>The position of each trap must be geo-referenced with a GPS.<br><br>Sampling timeframe<br>Samplings must be implemented between May and August.</td></tr>
<tr><td rowspan="2">Monitoring timeframe</td><td>Before operations</td><td>During operations</td><td>After operations (short-term)</td><td>After operations (medium-term)</td><td>After operations (long-term)</td></tr>
<tr><td>1 year (every second week from May to August)</td><td>every second week from May to August</td><td>$1^{st}$ year (every second week from May to August)</td><td>$2^{nd}$ year (every second week from May to August)</td><td>$3^{rd}$ to $4^{th}$ years (every second week from May to August)</td></tr>
</table>

**References**

Audisio, P., Baviera, C., Carpaneto, G.M., Biscaccianti, A.B., Battistoni, A., Teofili, C., Rondinini, C., 2014. Lista Rossa IUCN dei Coleotteri saproxilici Italiani. Comitato Italiano IUCN e Ministero dellAmbiente e della Tutela del Territorio e del Mare, Roma.

Galko J., C. Nikolov, A. Kunca, J. Vakula, A. Gubka, M. Zúbrik, S. Rell & B. Konôpka, 2016. Effectiveness of pheromone traps for the European spruce bark beetle: a comparative study of four commercial products and two new models. Lesn. Cas. For. J. 62: 207–215.

Nieto A. & K.N.A. Alexander, 2010. European Red List of Saproxylic Beetles. Luxembourg: Publications Office of the

| Indicator name | Xylobiont and Saproxylic beetles |
|---|---|
| European Union. | |

| Indicator name | Ground-active beetles | | | | |
|---|---|---|---|---|---|
| **Application** | | | | | |
| **Potential impact/threat**<br>Reduction of species richness and species densities | | | **Sector of bioenergy chain**<br>Biomass extraction | | |
| **Indicator definition**<br>Ground-active coleopterans are extremely diversified, with taxa characterised by different ecological *preferenda* and responding differently to land-use changes and human-induced disturbance. Accordingly, if the forestry activities have a significant impact on the ecosystem, a sharp species turnover with a shift in dominance from typical forest-dwellers to more euryecious taxa is expected.<br>Ground-active beetles are routinely studied through the use of pitfall traps. | | | | | |
| **Data sources and retrieval methods**<br>The pitfall traps should be made following the standardized design described by the guidelines of Brown & Matthews (2016), and 100 ml of a suitable transparent, nontoxic killing preservative such as propylene glycol must be used.<br>The number of traps to be settled and their arrangement (in line or in a grid) depend on the study area type and characteristics, so that their arrangement has to be chosen by a specialist on a case-by-case basis.<br>The position of each trap must be geo-referenced with a GPS.<br><br>Sampling timeframe<br>The pitfall traps will be kept active throughout the year, and checked every second week between May and August, and monthly from September to April. | | | | | |
| **Monitoring timeframe** | **Before operations** | **During operations** | **After operations (short-term)** | **After operations (medium-term)** | **After operations (long-term)** |
| | 1 year (every second week from May to August; monthly from September to April) | every second week from May to August; monthly from September to April | 1st year (every second week from May to August; monthly from September to April) | 2nd year (every second week from May to August; monthly from September to April) | 3rd to 4th years (every second week from May to August; monthly from September to April) |
| **References**<br>Brown G.R. & I.M. Matthews, 2016. A review of extensive variation in the design of pitfall traps and a proposal for a standard pitfall trap design for monitoring ground-active arthropod biodiversity. Ecology and Evolution, 6: 3953-3964. | | | | | |

### *2.2.1.2 Breeding and wintering birds*

The class Aves (=birds) includes about 10.000 species worldwide, with representatives colonizing any and every available habitat on Earth, from the driest deserts, to the highest mountain peaks and the pelagic oceanic realm. In the Mediterranean area, about 700 non-accidental, breeding bird species are reported to occur. Some species are characterised by widespread distribution areas and noteworthy ecological plasticity, so that they are poor ecological and biogeographical indicators; conversely, other taxa are strictly specialised to well-defined ecological conditions, so that their presence (or absence) in a given area is highly informative about its environmental characteristics and conditions. Furthermore, birds' high dispersal abilities allow them to quickly react to any environmental change possibly occurring, and thus to rapidly (re)colonise newly-available suitable areas or swiftly abandon a habitat patch which is not optimal any more for their presence.

Common forest bird species in the Mediterranean area include mostly representatives of the orders Passeriformes (passerines), Strigiformes (owls s.l.) and Piciformes (woodpeckers s.l.). The nocturnal behaviour of the Strigiformes makes it necessary to carry out specific surveys for them, so that the "Monitoring of breeding and wintering birds" must be carried out following two distinct sampling procedures for (i) Strigiformes and (ii) non-Strigiformes taxa.

(i) Strigiformes

An effective approach to the monitoring of Strigiformes is based on the use of "call playbacks", its assumption being that wild birds respond to the playback of recorded calls. Call playback surveys should be carried out by experienced ornithologists and are conducted by broadcasting species-specific vocalizations at sampling stations which should be separated along a transect such that duplication of called areas is minimized. An explicit authorization from the local government might be locally needed to use "call playbacks".

For each study-area, a list of the potentially-occurring Strigiformes should be obtained through a literature review, paying particular attention to local and national checklists and atlases. Once the list is compiled, recordings of the different vocalizations of each potentially occurring species must be retrieved. In the light of the possible existence of local variations in the species calls, recordings coming from geographically-close regions to the study area are to be preferred, when available. To broadcast the "calls", a portable player with speakers is needed. Players should be played at a loud volume but without distortion; ideally, the player should have a volume output of about 80-110 decibel at 1 metre from the speaker (Hardy & Morrison, 2000).

Monitoring should be carried out from stationary positions (=sampling stations) two times during the breeding period of each species, from half-a-hour after the sunset, until half-a-hour before the sunrise. Strigiformes are reported to call more in conditions of bright light availability (e.g. Penteriani et al. 2010), so that nights with bright moonlight should be preferred for the sampling. Conversely, it is important not to conduct the sampling surveys during strong winds and\or heavy rain, or when the sky is completely overcast, since these factors diminish the ability of the data collectors to hear the possible responses and will also diminish the calling rates of Strigiformes, thus hampering the results of the survey.

Once the data collector reached a sampling station, a 6-minutes block must take place to give the birds time to settle. Then, the first species call will be played for 20 seconds, followed by two minutes of passive listening. This procedure must be repeated three times for each species. If no response is elicited after broadcasting the series of three call recordings, further five minutes should be waited before moving on with broadcasting the call of the second species, and so forth, until the calls of all the potentially-present species have been broadcasted. The responses of the birds, when present, can be either behavioural or vocal, and both responses should be registered by the data-collector, since they are both evidences of the presence of the species in the study area. All the “presence” and “not detected” outcomes of the broadcasting must be reported in a form for each visited sampling station.

| Indicator name | Birds (Strigiformes) | | | | |
|---|---|---|---|---|---|
| **Application** | | | | | |
| **Potential impact/threat**<br>Reduction of species richness and species densities | | | **Sector of bioenergy chain**<br>Biomass extraction | | |
| **Indicator definition**<br>Common forest bird species in the Mediterranean area include mostly representatives of the orders Passeriformes (passerines), Strigiformes (owls s.l.) and Piciformes (woodpeckers s.l.). This box applies to the Strigiformes (owls s.l.), whose nocturnal behaviour makes it necessary to carry out specific surveys. For the non-Strigiformes birds, see the relevant box. | | | | | |
| **Data sources and retrieval methods**<br>The monitoring of Strigiformes is based on the use of call playbacks at sampling stations along a transect. For each study-area, recordings of the different vocalizations of each potentially occurring species must be retrieved, and these have to be broadcasted with a portable player. This should have a volume output of about 80-110 decibel at 1 metre from the speaker (Hardy & Morrison, 2000).<br>For each sampling station, the procedure consists in: (i) a 6-minutes block to give the birds time to settle, (ii) broadcasting the first species call for 20 seconds, followed by two minutes of passive listening, (iii) repeating step “ii” three times for each species; if no response is elicited after broadcasting the series of three call recordings, (iv) further five minutes should be waited before broadcasting the call of the second species, and so forth, until the calls of all the potentially-present species have been broadcasted. The responses of the birds, when present, can be either behavioural or vocal.<br><br>Sampling timeframe<br>Monitoring are carried out from sampling stations two times during the breeding period of each species, from half-a-hour after the sunset, until half-a-hour before the sunrise.<br>Nights with bright moonlight should be preferred for the sampling, when possible. Strong winds, heavy rain, or cloudy weather should be avoided, since these hamper the results of the survey. | | | | | |
| **Monitoring timeframe** | **Before operations** | **During operations** | **After operations (short-term)** | **After operations (medium-term)** | **After operations (long-term)** |
| | 1 year (Two surveys during the breeding season of each species) | Two surveys during the breeding season of each species | 1st year (Two surveys during the breeding season of each species) | 2nd year (Two surveys during the breeding season of each species) | 3rd to 5th years (Two surveys during the breeding season of each species) |
| **References**<br>Hardy, P.C., and M.L. Morrison. 2000. Factors affecting the detection of elf owls and western screech owls. Wildl. Soc. Bull. 28(2):333-342. | | | | | |

(ii) Non-Strigiformes taxa

The methodology known as "Echantillonnages Fréquentiel Progressif (E.F.P.)", described by Blondel (1975) and Blondel et al. (1981), is known to be an effective technique to get sound data on the presence and frequency of birds occurring in a given area, since the mean bird richness yielded by this method is thought to be a reliable index of the actual bird total abundance in the communities. When repeated at regular intervals, the E.F.P. allows to track changes in bird populations and to undertake an assessment of the impacts of the forestry activities on the nature conservation value of the study-area.

The method consists in carrying out of point-counts by expert ornithologists. In each point-count-site, the data collector must stop at predefined spots (= point-count-sites), allow the birds time to settle (2-5 minutes is usually enough), and then record all the birds contacted (i.e. seen or heard) in a 15 minutes time span, no matter about the distance at which the contacted birds are actually occurring. Any contacted bird species must be registered in a form. Since this method is based on the species frequency, only information about the presence of a species in a given point-count-site must be included, and no information on the actual number of contacted specimens is needed.

Such census must be carried out in the cooler hours of the day (i.e. from dawn to 4 hours after dawn, and 3 hours before the dusk to the dusk) in 10 point-count-sites randomly distributed in each study area (assuming that the study-area is environmentally homogeneous), with the only caveat of opting for point-count-sites far enough one from the other not to be potentially interfering (i.e., the risk of censing the same bird specimen in two different point-count-sites should be negligible). To avoid double-counting of the same individual birds at different point-count-sites, a minimum distance of 200 m between counting stations is recommended.

At the end of each survey, the ratio between the number of point-count-sites where it was contacted and the total number of surveyed point-count sites (normally 10) represents the frequency with which a species is present in that given date in the study area.

Censing activities must be carried out in spring (one survey in May and one survey in June), and in winter (one survey in December and one survey in January) to account for both the breeding and wintering bird communities occurring the study area.

| Indicator name | Birds (Non-Strigiformes) |
|---|---|
| **Application** | |
| **Potential impact/threat**<br>Reduction of species richness and species densities | **Sector of bioenergy chain**<br>Biomass extraction |
| **Indicator definition**<br>Common forest bird species in the Mediterranean area include mostly representatives of the orders Passeriformes (passerines), Strigiformes (owls s.l.) and Piciformes (woodpeckers s.l.). The nocturnal behaviour of the Strigiformes makes it necessary to carry out specific surveys for them (see the relevant box). | |
| **Data sources and retrieval methods**<br>The "Echantillonnages Fréquentiel Progressif (E.F.P.)" (Blondel, 1975; Blondel et al. 1981) allows to collect data on the presence and frequency of birds occurring in a given area. The mean bird richness yielded by this method is an | |

| Indicator name | Birds (Non-Strigiformes) | | | | |
|---|---|---|---|---|---|
| index of the actual bird total abundance in the communities.<br>The method consists in carrying out of point-counts by expert ornithologists. In each point-count-site, the data collector must stop at predefined spots, allow the birds time to settle (waiting 2-5 minutes), and then record all the birds contacted (i.e. seen or heard) in a 15 minutes time span, no matter about the distance at which the contacted birds are actually occurring. Only information about the presence of a species in a given point-count-site must be included, and no information on the actual number of contacted specimens is needed.<br>E.F.P. must be carried out from dawn to 4 hours after dawn, and 3 hours before the dusk to the dusk in 10 point-count-sites randomly distributed in each study area. To avoid double-counting of the same individual birds at different point-count-sites, a minimum distance of 200 m between counting stations is recommended.<br><br>Sampling timeframe<br>Censing activities must be carried out in spring (one survey in May and one survey in June), and in winter (one survey in December and one survey in January) to account for both the breeding and wintering bird communities occurring the study area. | | | | | |
| **Monitoring timeframe** | **Before operations** | **During operations** | **After operations (short-term)** | **After operations (medium-term)** | **After operations (long-term)** |
| | 1 year (Two times in spring and two times in winter) | Two times in spring and two times in winter | 1st year (Two times in spring and two times in winter) | 2nd year (Two times in spring and two times in winter) | 3rd to 5th years (Two times in spring and two times in winter) |
| **References** | | | | | |
| Blondel J., 1975. L’analyse des peuplement d’oiseaux, éléments d’un diagnostic écologique. 1. La méthode des échantillonnages fréquentiels progressifs (E.F.P.). Terre et Vie, 29: 533-589.<br>Blondel J., Ferry C. & Frochot B., 1981. Point counts with unlimited distance. In: Estimating numbers of terrestrial birds. Ralph C.J. & Scott J.M. (Eds). Studies in Avian Biology, 6: 414-420. | | | | | |

### *2.2.1.3 Monitoring of carcasses*

The passage of heavy vehicles and\or the forestry activities themselves (e.g. cutting, chipping and so forth) might cause the accidental death of some animals. While accounting for the death of small-sized invertebrates is a gruelling and hard-to-realise activity, the casualties involving vertebrates can be easily monitored. Accordingly, the possible presence of casualties must be registered throughout the whole duration of the activities based on regular surveys. An operator expert in the identification of local vertebrates (Amphibia, Reptilia, Aves and Mammalia) and their rests must search for them every second day throughout the area interested by the activities, taking note of the spotted evidences and their precise location. Furthermore, foresters and workers involved in the activities must be interviewed once a week for gathering further information on the possible occurrence of casualties which might have been overlooked by the standard surveys. In case some animal species are particularly affected by casualties and\or some places prove to be particularly prone to the occurring of casualties, the forestry activities should be modified in order to eliminate or, at least, lessen the impact.

| Indicator name | Monitoring of carcasses |
|---|---|
| **Application** | |
| **Potential impact/threat**<br>Occurrence of casualties | **Sector of bioenergy chain**<br>Biomass extraction |

<table>
<tr><th>Indicator name</th><th colspan="5">Monitoring of carcasses</th></tr>
<tr><td colspan="6">Indicator definition<br>The passage of vehicles and\or the cutting of the plant itself might cause casualties. Accordingly, throughout the carrying out of the activities, the possible presence of animal carcasses in the study area must be monitored.</td></tr>
<tr><td colspan="6">Data sources and retrieval methods<br>An operator expert in the identification of local vertebrates (Amphibia, Reptilia, Aves and Mammalia) and their rests must search for them every second day throughout the area interested by the forestry activities, taking note of the spotted evidences and their location.<br>Foresters and workers involved in the activities must be interviewed once a week for gathering information on the possible occurrence of casualties which might have been overlooked by the standard surveys.<br>In case some animal species are particularly affected by casualties and\or some places prove to be particularly prone to the occurring of casualties, the forestry activities should be modified in order to eliminate or, at least, lessen the impact.<br><br>Sampling timeframe<br>Every second day for the visual search of carcasses.<br>Once a week for the interviews to the workers</td></tr>
<tr><td rowspan="2">Monitoring timeframe</td><td>Before operations</td><td>During operations</td><td>After operations (short-term)</td><td>After operations (medium-term)</td><td>After operations (long-term)</td></tr>
<tr><td>Not applicable</td><td>Every second day for the field surveys.<br>Once a week for the interviews</td><td>Not applicable</td><td>Not applicable</td><td>Not applicable</td></tr>
<tr><td colspan="6">References</td></tr>
</table>

| Box | Title/Name of the "Case study" |
|---|---|
| **n. 1** | ***Biodiversity and biomass production in North America*** |

**Short description and geographic localization**

*Vershuyl and colleagues (2011) summarized the available data on the relationships between forest thinning treatments and forest biodiversity in North America. The biodiversity response to forest thinning was evaluated through the assessment of a "response ratio" based on the ratio of richness, diversity, and abundance of the studied taxa (birds, mammals, reptiles, amphibians, and invertebrates) in the experimental (thinned) versus control (unthinned) areas.*

*Bird communities and small mammals consistently responded favourably to forest thinning treatments, and thinned forest stands usually also reported significantly higher biomass and abundance of invertebrates than unthinned ones, although the magnitude and timing of the response was often specific to the functional group being examined. Conversely, results dealing with reptiles and amphibian proved to be less sharp, with forest thinning having various effects on these taxa depending on their life histories.*

*Moderate or light forest thinning treatments thus proved to have positive or, at most, neutral effects on the diversity and abundance of those animal groups for which enough data are available. This positive biodiversity response was attributed to the increased structural complexity of properly-managed forest stands and to the development of a more diversified understorey vegetation linked with increased light availability below the tree canopy. On the other hand, negative responses were consistently observed for studied areas where >66% of basal area or trees per hectare were removed during thinning.*

**Additional information**

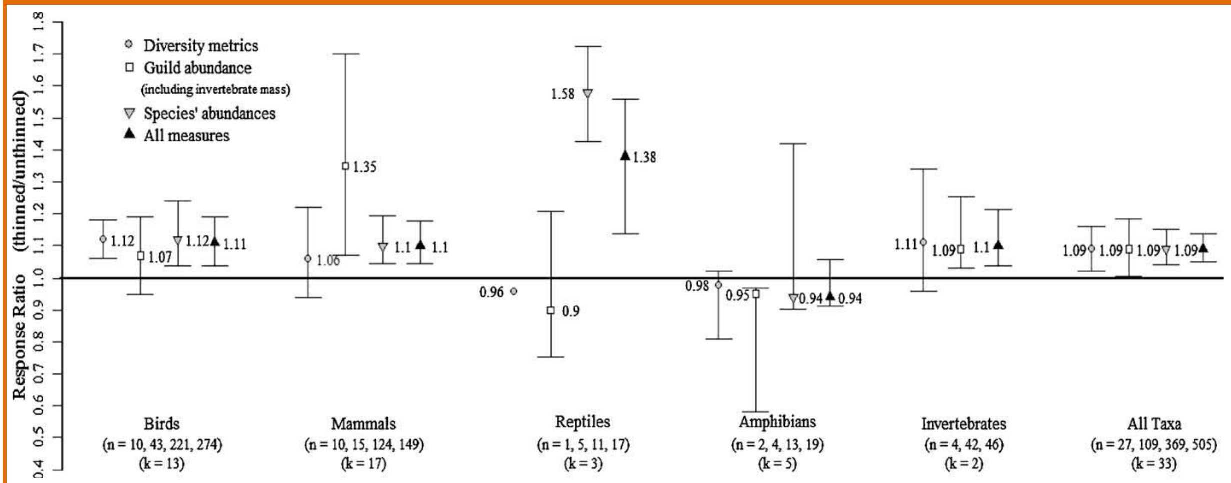


*Fig. 1. Summary effect sizes for the studied taxa. From Verschuyl et al. (2011), slightly modified.*

**Website/ Bibliographic references**

*Verschuyl J., Riffell S., Miller D. & T. Bently Wigleyd, 2011. Biodiversity response to intensive biomass production from forest thinning in North American forests – A meta-analysis. Forest Ecology and Management, 261: 221–232. "A method to assess the economic impacts of forest biomass use on ecosystem services in a National Park", Biomass and Bioenergy, Vol. 98, No. 1, pp. 252-263.*

**Contact details**

| Box | Title/Name of the "Case study" |
|---|---|
| n. 2 | ***Bird diversity and forest management in Sicily (Italy)*** |

**Short description and geographic localization**

*La Mantia and colleagues (2014) investigated the relationships between bird diversity, implemented silvicultural approaches, and relevant environmental features of different forest stands spread throughout the island. The study was carried out in 15 study areas representatives of 9 different forest types subject to different silvicultural managements, and the bird diversity was evaluated following the methodology "EFP" ("Echantillonnages Fréquentiel Progressif"), leading to the overall census of 51 different bird species, with species richness ranging from 0 to 23 species in the different study areas.*

*The analysis of collected data showed that bird species richness is mostly influenced by local bioclimate, maximum tree diameter, and nutritive value of the present vegetation layers. The importance of maximum tree diameter, which reflects the silvicultural management of a forest, is due to the dependency of some corticicolous bird species on large trees, and of some other bird species on crowns of old trees. Moreover, the presence of large, adult trees significantly contributes to the vertical and chronological diversity of the forest stands, thus directly and indirectly favouring both bird species richness and the persistence of highly-specialised forest-dwelling corticicoulous species.*

*The main guidelines for the silvicultural management of Sicilian forests which resulted from their analysis are the following: (i) individual large adult trees and understorey plants with high nutritive value for wildlife should be maintained, even in actively managed coppices, (ii) whenever possible, the understorey vegetation layer should not be removed, and the lower branches of trees should not be pruned. When these actions are necessary, they should be kept to the bare minimum, and only applied to the forest edges for wildfire prevention.*

**Additional information**

| | |
|---|---|
| **Website/ Bibliographic references** | *La Mantia T., Lo Duca R., Massa B., Nocentini S. & J. Rühl, 2014. La biodiversità dei boschi siciliani. Parte I: l'avifauna. L'Italia Forestale e Montana, 69: 173-193.* |
| **Contact details** | |

| Box | Title/Name of the "Case study" |
|---|---|
| n. 3 | **Bird community response in mountain pine forests of the Pyrenees managed under a shelterwood system** |

**Short description and geographic localization**

*The study area analysed was the subalpine mountain pine (Pinus uncinata Ram. ex DC) forests of the Catalan Pyrenees.*

*The mountain pine forests are classified as a Habitat of Community Interest (92/43/EEC), being the 9340 (siliceous substrates) and 9340* in the area (gypsum or limestone). Concretely, the survey was done in 120 stands. with a size stand of 5-15 ha, across the range of mountain pine forests over siliceous substrate. It is noted that in 30 stands no management had done for, at least, 5 decades and the other 90 stands a management were managed according to a shelterwood system. During the study, the bird abundance was sampled at three different steps of the shelterwood system in the managed and no-managed stands. In this way, all the forest structural variability was captured throughout rotation.*

*Therefore, the two objectives of the study were: "To assess abundance variability in several bird guilds – based on habitat specialization and nesting and foraging substrates – across successive management stages" and "to quantify and model the relationship between the main structural features that are modified by management and the abundance of different bird guilds".*

*According to the forest management, the shelterwood system is suggested to favour avian diversity through* *breaking the homogeneity of mountain pine forests at stand level because this action promotes the abundance of most common bird guilds. Specifically, different stand structures are created throughout the regeneration period (30–40 years in the study area) obtaining contrasted effects on the abundance of bird guilds. It is noted that the maximum total bird abundance was observed after the regeneration cuts. Quantitative relationships were obtained between the main structural features affected by tree harvests and the abundance of birds. In this way, the biodiversity conservation guidelines were reinforced for the mountain pine forests in the Pyrenees and management recommendations were generated which are valid for forests managed by a shelterwood system or by other silvicultural treatments.*

**Additional information**

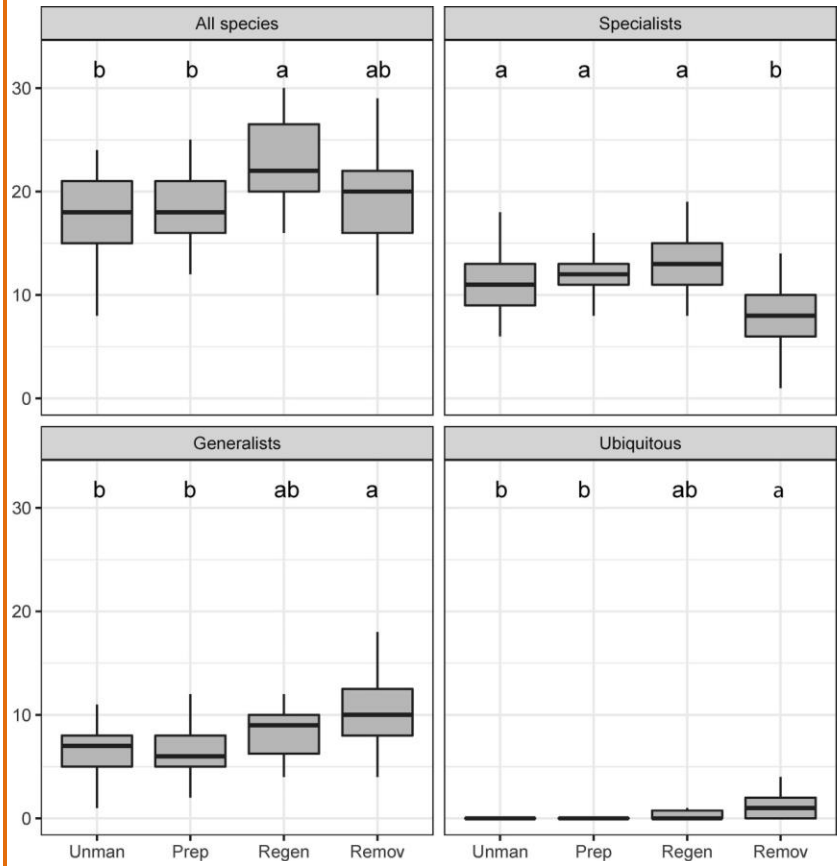


*Figure 1. "Differences in observed bird guild-specific abundance based on habitat breadth in Pinus uncinata forests in the Pyrenees across management stages. Differences were based on a non-parametric Kruskal-Wallis test. Stages with the same letter indicate non-significant differences according to Nemenyi tests for multiple comparisons (p > .05). Unman: unmanaged forests; Prep: after preparatory cuts; Regen: after regeneration cuts; Remov: after removal cuts. Lower and upper whiskers indicate the 5% and 95% quartiles of bird abundance, lower and upper hinges indicate the first and third quartile, and the central black line indicates the median value" (Ameztegui et al., 2018).*

| **Website/ Bibliographic references** | Aitor Ameztegui, Assu Gil-Tena, Jordi Faus, Míriam Piqué, Lluís Brotons, Jordi Camprodon. Bird community response in mountain pine forests of the Pyrenees managed under a shelterwood system. Forest Ecology and Management. Volume 407. 2018. Pages 95-105, ISSN 0378-1127, https://doi.org/10.1016/j.foreco.2017.09.002. (http://www.sciencedirect.com/science/article/pii/S0378112717300154) |
|---|---|
| **Contact details** | AitorAmeztegui [a, b, c] , AssuGilTena [b] , ,Jordi Faus [d], Míriam Piqué [e] , Lluís Brotons [a, b, f], Jordi Camprodon [b, g].<br>[a] CREAF, Cerdanyola del Vallés 08193, Spain<br>[b] CEMFOR – CTFC, InForest Joint Research Unit, Solsona 25280, Spain<br>[c] Centre for Forest Research (CEF), Département des Sciences Biologiques Université du Québec à Montréal, Montréal, Québec H3C 3P8, Canada |

[d] Consorci Espais d'Interès Natural del Ripollès (CEINR), 44 17534 Ribes de Freser, Spain
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[g] BETA Technological Center, UVic-UCC, Vic 08570, Spain

| Box | Title/Name of the "Case study" |
|---|---|
| **n. 4** | **PROFORBIOMED PROJECT: Assessment of forest biomass production and Assessment of environmental impact of forest biomass extraction** |

**Short description and geographic localization**

*VREMŠČICA – BLACK PINE (PINUS NIGRA) STAND*

*In the frame of PROFORBIOMED project we compared different felling methodologies to show the economic differences between two types of production and assessed the environmental impact of forest biomass extraction. In this case study we present values from the pilot area Vremščica black pine stand. This pilot area is located in Sub-Mediterranean eco-region (Kras-Vremsko gričevje) where also two pilot areas of ForBioEnergy project are located (Škocjan caves regional park and Pivka seasonal lakes nature park).*

*In black pine forests in Vrhe, field plots were accessed and analysed. Tree cover varies between 40 and 70%. Dominant specie is Pinus nigra, whereas codominant specie is Fraxinus ornus, except in one plot, where co-dominant specie is Ostrya carppinifolia. The average values of shrub and herbaceous cover is between 5 and 20%. It is composed mainly of Fraxinus ornus and Ostrya carpinifolia, with sub-dominant Cornus mas, Crateagus monogyna, Pinus nigra, Rosa canina, and Sorbus aria.*
*Black pine stands in Slovenia are mostly plantations planted in 19. century on degraded karst soil after deforestation of the original forest. Black pine was planted as a transitional tree species, as a pre-culture, for the time until natural tree species return.*

*ASSESSMENT OF FOREST BIOMASS PRODUCTION:*
*The forests at the study area can be classified as pine stands on limestone. The average age of the trees is 80 years. At the selected site two comparable plots were designated, each with an area of 0.25 ha, approximately 500 m apart. The major goal of the study was to compare different felling (bucking) methodologies while using the customary technology throughout the rest of the production chain and show the economic differences between two types of wood log production. At both plots the production of roundwood and green chips (from forest residues e.g. tree tops, twigs and needles) was foreseen. The methodologies differed in the degree of bucking (i.e. the degree to which a tree stem was processed); at plot 1 the forest worker performed the last cross-cut at the stem diameter of 10 cm and at plot 2, at a diameter between 6 and 7 cm. The methodology used at plot 2 is recognized as the most common practice to process a tree stem (to cut logs) in Slovenia, with a higher total amount of roundwood, but also a higher share of lower quality roundwood. However, at plot 1 a higher amount of forest residues (tree tops) was produced that can be used for production of green woodchips.*
*Along the production chain the forest owners themselves selected the contractors, and consequently, the technology (we had no influence over the selection of technology). The price of logging and skidding activities was 14 €/m3. The contractor who performed skidding of residues and production of green chips also bought the chips, at the price of 0.6 €/ loose m3.*
*The analysis of mechanisation costs recalculated for roundwood equivalent showed that in the case of plot 2, costs were 13% higher than at plot 1. The difference can be ascribed to significantly longer transport/skidding times of residues with a forwarder.*
*The production of green woodchips represents up to 80% of total costs (in roundwood equivalent – RWE) at both study plots. Within the cost structure of green woodchip production, transport or skidding of residues represents the highest share: 58% at plot 1 and 66% at plot 2, respectively.*
*In the case of roundwood production, skidding with a tractor and forest trailer represented almost 80 % and 81 %*

*of the cost at plots 1 and 2, respectively.*
*The calculated direct costs (recalculated for RWE) in the case of roundwood production are 4.60 €/RWE at plot 1 and 5.16 €/RWE at plot 2. The calculated values do not include labour and management costs. Direct costs of woodchip production amount to 17.68 €/RWE at plot 1 and 20.41 € / RWE at plot 2. The ratio between the cost of roundwood production and green woodchip production at both sites is 20:80.*
*In the case of the site presented (Vremščica) detailed data regarding cost and income is not available.*
*ASSESSMENT OF THE ENVIRONMENTAL IMPACT OF FOREST BIOMASS EXTRACTION:*
*For Proforbiomed pilot action, Slovenian Forestry Institute has evaluated possible environmental impact as a result of wood biomass (WB) extraction - potentially positive impact of WB extraction on lowering fire risk and potentially negative impact on forest productivity.*
*Forest nutrient (specifically nitrogen) pool recovery after different scenarios of biomass harvest was determined on 697 plots in Slovenia. Return periods for nitrogen (N) were derived based on nutrient extraction and yearly estimates of atmospheric deposition of nitrogen. Simplified mass balance was applied for N where main N input (yearly deposition = Ndep) and main output (direct export due to biomass extraction = Nharv) were compared. Nharv / Ndep ratio gives us the return periods: number of years needed for the deposition to supplement N lost due to harvest. For deposition estimates moss N concentration was used. N lost due to harvest was estimated for different scenarios of biomass extraction (stems only, stems + branches, stems + branches + leaves).*

*Lessons learned:*
*- Nutrient extraction is larger and return periods are longer for more productive forest stands; in these stands excessive nutrient export might occur when harvesting rotations are shorter than nutrient return periods.*
*- Smaller soil nutrient stock of the less productive forest stands less efficiently counteract abrupt nutrient losses due to biomass extraction than soil of the productive forest stands.*
*- Substantial differences between harvesting scenarios exist: compared to stem-only harvesting, stem + branches and stem + branches + leaves regimes increase nutrient export and return periods on average for 54% and 108%, respectively.*
*- Calculations for test sites revealed larger nutrient exports and return periods for variants where biomass (woodchips) was preferable in comparison to those where wood assortments were targeted but return periods are still within safe limits due to slow forest regrowth.*
*- For average forest stands of Slovenia even the most intensive harvesting rates (whole tree) do not possess large threat for forest production, because return rates are shorter than forest regrowth.*
*- However, return periods for some of the most productive forests are shorter than ten years which is dominant thinning frequency in Slovenia.*
*- Simple linear relationship between thinning rate and return period exist: twice the thinning intensity – twice the nutrient extraction and hence return period.*
*- Compared to stems only harvesting nutrient export is substantially increased when leaves and branches are also harvested and moderately when branches are also harvested.*
*- For deciduous trees whole-tree harvesting in leafless stage (winter) is preferable.*
*- To mitigate indirect losses after harvest (erosion, leaching; not estimated here) it is encouraged that certain percentage of harvested biomass is left in the forest.*

*Forest fire:*
*All harvesting and thinning operations impact on the increase amount of "ground" fuel, but also have positive impact on reduction of crown fire risk (density of canopy is lower). "Ground" fuel increases a height of flames. With extraction of this wood biomass we can achieve positive impact on lowering of fire rise and spreading of ground fires.*
*Dimension of fuel between 0.64 cm and 2.54 cm, presents 10 hours time lapse fuel. Bigger dimension fuel as bigger branches, small trunks and parts of trunks presents a 1OO to 1000 hours time lapse fuel. This fuel is important for the straight and development of fire. Presence of this fuel impact on the forest floor damages and trees damages. This can influence on longer period of succession process. Presence of bigger amount of wood residues and higher density of trees increase forest fire risk. Stacked forest residues prevent forest fires as stacked wood biomass is more humid and process of decomposition and not drying process is present. With stacking forest residues, we make a gap of empty "fuel places" and stop a fire.*

**Additional information**

*Table 1: Description of the test sites – Vremščica Black pine stand*

| | Plot 1 "Green woodchips" | Plot 2 "Roundwood" | Whole felling area |
|---|---|---|---|
| Locality | Vremščica | Vremščica | Vremščica |
| Elevation (m.a.s.l.) | 575-775 | 575-775 | 575-775 |
| Felling area (ha) | 0.25 ha | 0.25 ha | / |
| Average slope gradient (%) | 5 | 5 | 25 |
| Age (years) | 80 | 80 | 80 |
| Growing stock ($m^3$/ha) | | | 266 |
| Intensity of thinning (%) | 25 | 25 | 25 |
| Removal (No. trees/ha) | 128 | 300 | 3382 |
| Total removal (t/ha)*1 | 62.72 | 122 | 989.81 |
| Share of green woodchips in total removal (%) | 25.83 | 22.33 | / |
| Average DBH of removed trees (cm) *2 | 28.31 | 25.93 | 26.63 |
| Removal of roundwood ($m^3$, under bark) | 13.69 | 27.87 | 41,56 |
| Amount of green woodchips (loose $m^3$) | 17.0808 | 20.7636 | 37.84 |
| Water content (w %) for woodchips *3 | 17.1 | 25.9 | 21.5 |

*1 Total removal is sum of roundwood and green chips calculated in green t/ha

*2 DBH - Arithmetic average of diameter at breast height

*3 Water content (w %) for woodchips was measured according to EN 14774-2:2010

Table 2: Mean, minimum and maximum return periods for forests of Slovenia based on 697 sample plots for three different harvesting intensities and three different biomass extraction scenarios. Return periods correspond to the time (in years) needed for atmospheric deposition to supplement the nitrogen exported with biomass extraction.

| Harvesting intensity | Biomass extraction scenario | Mean return period [years] | Min return period [years] | Max return period [years] |
|---|---|---|---|---|
| 100% | Stems | 18.0 | 0.1 | 62.5 |
| | Stems+branches | 27.7 | 0.2 | 92.2 |
| | Stems+branches+leaves | 37.5 | 0.2 | 135.6 |
| 50% | Stems | 9.0 | 0.1 | 31.3 |
| | Stems+branches | 13.9 | 0.1 | 46.1 |
| | Stems+branches+leaves | 18.7 | 0.1 | 67.8 |
| 10% | Stems | 1.8 | 0.0 | 6.3 |
| | Stems+branches | 2.8 | 0.0 | 9.2 |
| | Stems+branches+leaves | 3.7 | 0.0 | 13.6 |

| **Website/ Bibliographic references** | *WEBSITE: http://proforbiomed.aifm.org/* <br><br> *Proforbiomed – Pilot action 1.1: Assessment of the structural diversity of forest habitats – Partners pilot action report. WP4: Setting up of Integrated Strategies for the Development of Renewable Energies* |
|---|---|

| | |
|---|---|
| | *Proforbiomed – Pilot action 1.3: Assessment of foret biomass production. WP4: Setting up of Integrated Strategies for the Development of Renewable Energies*<br>*Proforbiomed –Pilot action 1.4: Assessment of the environmental impact of forest biomass harvesting or extraction – Partners pilot action report. WP4: Setting up of Integrated Strategies for the Development of Renewable Energies* |
| **Contact details** | **Dr. Nike Krajnc**<br>**Slovenian Forestry Institute**<br>**nike.krajnc@gozdis.si** |

# 3 IMPACT ASSESSMENT ON ABIOTIC COMPONENTS

## 3.1 Abiotic components

The assessment of impacts on abiotic components of a forest ecosystem caused by increased biomass use in the protected areas will be carried out using the following indicators:

- Deadwood;
- Litter;
- Soil Organic Carbon;
- Erosion;
- Bulk density;
- Fire risk.

In each study area, a matrix should be compiled for each forest habitat type (sensu "Habitats Directive") present in the study area, and other matrices for: a) tree plantations for wood production; b) autochthonous broadleaved reforestation; c) allochthonous broadleaved reforestation; d) autochthonous coniferous reforestation and e) allochthonous coniferous reforestation. When different forest habitat types are assumed to suffer the same impact magnitude and show the same resilience time, for all the forestry activities, they can be lumped in a single matrix, given that the codes indicating the Forest Habitat types sensu "Habitats Directive" are explicitly mentioned in its heading.

The matrices (Tables 3.3 - 3.4) include indicators for each threat/impact, which are discussed in the following paragraphs. The potential impact associated with each operation with regard to each threat is assessed according to two factors:

- magnitude of impact
- reversibility of impact

The magnitude of the impact is an estimation of the damage that a given operation will cause to the abiotic components with regard to the threat considered. It is indicated with roman numerals according to the table reported below.

Table 3.1 Magnitude scale of impact

| Magnitude | Impact | Description |
|---|---|---|
| | None | The operation will cause no relevant impact or may be beneficial to abiotic components, with regard to the threat considered |
| I | Low | The operation will cause limited impact to abiotic components, with regard to the threat considered |
| II | Medium | The operation will cause significant impact to abiotic components, with regard to the threat considered |
| III | High | The operation will cause extreme impact to abiotic components, with regard to the threat considered |

The reversibility of impact is an estimation of the amount of time the abiotic components will need to return to its previous state after impact takes place. It depends on impact type, impact magnitude and ecosystem's resilience.

Table 3.2 Colour scale of the reversibility of impact

| Colour | Reversibility | Description |
|---|---|---|
| (green) | Short term | Abiotic components will be unaffected or recover in a short amount of time |
| (yellow) | Medium term | Abiotic components will recover over a period of time measured in years |
| (orange) | Long term | Abiotic components will recover over a period of time measured in decades |
| (red) | Irreversible | Abiotic components recover will take an extremely long time. Operation should preferably not be performed |

Table 3.3 - Potential impacts on habitats (according to Directive 92/43/EEC).

| **Natura 2000 Habitat Code:** | *(Indicate the habitat code or codes of the considered habitats*)* * When different forest habitat types are assumed to suffer the same impact magnitude and show the same resilience time, for all the forestry activities, they can be lumped in a single matrix. | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Action** | Silvicultural and harvesting practices (high forest and coppice) | | | | | | | | | | | | Post harvesting management | |
| | Thinning/Shelterwood cutting/Salvage cutting | | | | | Crown pruning | | Clear cutting | | | | | | |
| **Threat** | Felling and Arrangement | Storing (Winch) | Storing (Raceways) | Yarding (Raceways) | Yarding (Tractor) | Cutting | Yarding | Felling and Arrangement | Storing (Winch) | Storing (Raceways) | Yarding (Raceways) | Yarding (Tractor) | Chipping | **INDICATOR(S)** |
| Reduction of deadwood | | | | | | | | | | | | | | Deadwood |
| Reduction of litter cover | | | | | | | | | | | | | | Litter |
| Reduction of litter height | | | | | | | | | | | | | | |
| Reduction of SOC | | | | | | | | | | | | | | Soil Organic Carbon (SOC) |
| Presence of Rill erosion | | | | | | | | | | | | | | Erosion |
| Presence of Interrill erosion | | | | | | | | | | | | | | |
| Presence of Gully erosion | | | | | | | | | | | | | | |
| Increase of Soil Bulk Density | | | | | | | | | | | | | | Soil Bulk Density |
| Fuel model features | | | | | | | | | | | | | | Fire risk |

Table 3.4 - Potential impacts on forest categories not included in the "Habitats Directive)

| **Forest categories not included in the "Habitats Directive"** | ***(Indicate the forest categories not included in the "Habitats Directive)*** *autochthonous/ allochthonous broadleaved reforestation, autochthonous/ allochthonous coniferous reforestation, tree plantations for wood production* | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Action** | **Silvicultural and harvesting practices (high forest and coppice)** | | | | | | | | | | | | **Post harvesting management** | |
| | Thinning/Shelterwood cutting/Salvage cutting | | | | | Crown pruning | | Clear cutting | | | | | | |
| **Threat** | Felling and Arrangement | Storing (Winch) | Storing (Raceways) | Yarding (Raceways) | Yarding (Tractor) | Cutting | Yarding | Felling and Arrangement | Storing (Winch) | Storing (Raceways) | Yarding (Raceways) | Yarding (Tractor) | Chipping | **INDICATOR(S)** |
| Reduction of deadwood | | | | | | | | | | | | | | Deadwood |
| Reduction of litter cover | | | | | | | | | | | | | | Litter |
| Reduction of litter height | | | | | | | | | | | | | | |
| Reduction of SOC | | | | | | | | | | | | | | Soil Organic Carbon (SOC) |
| Presence of Rill erosion | | | | | | | | | | | | | | Erosion |
| Presence of Interrill erosion | | | | | | | | | | | | | | |
| Presence of Gully erosion | | | | | | | | | | | | | | |
| Increase of Soil Bulk Density | | | | | | | | | | | | | | Soil Bulk Density |
| Fuel model features | | | | | | | | | | | | | | Fire risk |

### 3.1.1 Selected indicators for the impacts assessment on abiotic components

The assessment of impacts on abiotic components caused by increased biomass use in the protected areas will be carried out using six different indicators, as shown in table 3.5. These indicators meet the following requirements: i) recognized by the international literature, ii) specific, iii) easily quantifiable variables that can be monitored over a period of time. According to the indicator and their requirements, we chose the impact(s)/thereat(s) to be monitored: i) the quantitative variations for deadwood, litter, SOC and soil bulk density; ii) the qualitative variations (i.e. fuel model change) for fire risk; iii) the observation of typical micromorphological forms suggesting erosion (rill, interrill and gully).

Table 3.5 – List of the selected indicators for the impacts assessment on abiotic components

| INDICATOR | Sampling unit | Data source | Before operations | During operations | After operations (short term) | After operations (medium term) | After operations (long term) |
|---|---|---|---|---|---|---|---|
| **Deadwood** | 2 plots per site (400 $m^2$ each) | Field survey | 1 year (2 surveys / year) | NO | 1st year (2 surveys / year) | 2nd year (2 surveys / year) | 3rd and 4th year (2 surveys / year) |
| **Litter** | 4 survey per each plot | Field survey | 1 year (2 replicas / year) | NO | 1st year (2 replicas / year) | 2nd year (2 replicas / year) | 3rd and 4th year (2 replicas / year) |
| **Soil Organic Carbon (SOC)** | 4 samplings per each plot | Field survey | 1 year (2 replicas / year) | NO | 1st year (2 replicas / year) | 2nd year (2 replicas / year) | 3rd and 4th year (2 replicas / year) |
| **Erosion** | survey per each plot | Field survey | 1 year (2 surveys / year) | NO | 1st year (2 surveys / year) | 2nd year (2 surveys / year) | 3rd and 4th year (2 surveys / year) |
| **Soil Bulk Density** | 4 samplings per each plot | Field survey | 1 year (2 replicas / year) | NO | 1st year (2 replicas / year) | 2nd year (2 replicas / year) | 3rd and 4th year (2 replicas / year) |
| **Fire risk** | survey per each plot | Field survey | 1 year (2 surveys / year) | NO | 1st year (2 surveys / year) | 2nd year (2 surveys / year) | 3rd and 4th year (2 surveys / year) |

#### *3.1.1.1 Deadwood*

Deadwood plays a key role in the functioning and productivity of forest ecosystems. Deadwood is an important habitat for vertebrate and invertebrate species, a key factor in the nutrient cycle, a valuable carbon pool, and a fundamental element in ecological, geomorphological and soil hydrological processes: it captures carbon, improves the hydro-geological efficiency of the mountainsides, contributes towards maintaining biological diversity, favours the formation of humus receptive to renewal and increases the overall forest productivity. Deadwood components are woody debris (WD), standing dead trees (SDT), snags (SN) and stumps (S): WD includes fallen dead trees and branches lying on the ground with a minimum end diameter (diameter of the narrower end section of the deadwood piece) ≥ 2.5 cm; SDTs and SNs include all dead trees still standing with a diameter at breast height (or DBH) ≥ 4.5 cm; Stumps include the portions of trees remaining after cutting or less frequently the stems truncated from natural hazards not reaching a height of 1.30 m and with a diameter at least 9.5 cm at the cut section (or breaking section). All of the above components are classified according to their species group (conifers or broadleaves) and class of decay, and are calculated their volumes. The volume of STD is estimated through volume equations (Tabacchi et al., 2011), while the volume of WD, SN and S is estimated through the cone trunk model.

<table>
<tr><td>Indicator name</td><td colspan="3">Deadwood</td></tr>
<tr><td colspan="4">Application</td></tr>
<tr><td>Potential impact/threat<br>Reduction of deadwood</td><td>Sector of bioenergy chain<br>Forest harvesting</td><td colspan="2">Action<br>All</td></tr>
<tr><td colspan="4">Indicator description<br>Deadwood plays a key role in the functioning and productivity of forest ecosystems. Deadwood is an important habitat for vertebrate and invertebrate species, a key factor in the nutrient cycle, a valuable carbon pool, and a fundamental element in ecological, geomorphological and soil hydrological processes. Deadwood components are woody debris (WD), standing dead trees (SDT), snags (SN) and stumps (S).</td></tr>
<tr><td colspan="4">Data sources and retrieval methods<br>In each plot, the deadwood components will be classified according to their species group (conifers or broadleaves) and class of decay, and will be calculated their volumes.</td></tr>
<tr><td>Sampling unit</td><td colspan="3">2 plots per site (400 $m^2$ each)</td></tr>
<tr><td rowspan="2">Monitoring timeframe</td><td>Short</td><td>Medium</td><td>Long</td></tr>
<tr><td>2 surveys / year</td><td>2 surveys / year</td><td>2 surveys / year</td></tr>
<tr><td>Links with other indicators</td><td colspan="3"></td></tr>
<tr><td colspan="4">References<br>Paletto A, De Meo I, Cantiani P, Ferretti F (2014). Effects of forest management on the amount of deadwood in Mediterranean oak ecosystems. Annals of Forest Science, Springer Verlag/EDP Sciences, 71(7): 791-800.<br>Lombardi F, Marchetti M, Corona P, Merlini P, Chirici G, Tognetti R, Puletti N (2015). Quantifying the effect of sampling plot size on the estimation of structural indicators in old-growth forest stands. For. Ecol. Manag., 346, 89–97.<br>Tabacchi G, Di Cosmo L, Gasparini P, Morelli S (2011). Stima del volume e della fitomassa delle principali specie forestali italiane. Equazioni di previsione, tavole del volume e tavole della fitomassa arborea epigea. Consiglio per la Ricerca e la sperimentazione in Agricoltura, Unità di Ricerca per il Monitoraggio e la Pianificazione Forestale, Trento, pp. 412.</td></tr>
</table>

### *3.1.1.2 Litter*

The accumulation of litter is a function of the annual amount of litterfall, which includes all non-living biomass with a diameter ≤ 2.5 cm, lying dead, in various states of decomposition above the mineral or organic soil. Live fine roots are included in litter where they cannot be distinguished from it empirically. The litter mass is also influenced by the time of last disturbance, and the type of disturbance. During the early stages of stand development, litter increases rapidly. Management such as timber harvesting, slash burning, and site preparation dramatically alter litter properties (Binkley and Fisher, 2012).

The approach to estimate changes in litter is to record the litter cover and litter height changes for each plot.

<table>
<tr><td>Indicator name</td><td colspan="2">Litter</td></tr>
<tr><td colspan="3">Application</td></tr>
<tr><td>Potential impact/threat<br>Reduction of litter cover;<br>Reduction of litter height</td><td>Sector of bioenergy chain<br>Forest harvesting</td><td>Action<br>All</td></tr>
</table>

<table>
<tr><td>Indicator name</td><td colspan="3">Litter</td></tr>
<tr><td colspan="4">Indicator description<br>The accumulation of litter is a function of the annual amount of litterfall, which includes all non-living biomass with a diameter ≤ 2.5 cm, lying dead, in various states of decomposition above the mineral or organic soil. Live fine roots are included in litter where they cannot be distinguished from it empirically.</td></tr>
<tr><td colspan="4">Data sources and retrieval methods<br>In each plot, the litter cover and litter height changes will be recorded through 4 surveys for each plot.</td></tr>
<tr><td>Sampling unit</td><td colspan="3">4 survey per plot</td></tr>
<tr><td rowspan="2">Monitoring timeframe</td><td>Short</td><td>Medium</td><td>Long</td></tr>
<tr><td>2 replicas / year</td><td>2 replicas / year</td><td>2 replicas / year</td></tr>
<tr><td>Links with other indicators</td><td colspan="3"></td></tr>
<tr><td colspan="4">References<br>Binkley D, Fisher RF (2012). Ecology and management of forest soils. Fourth edition. Wiley-Blackwell, 362 pp.</td></tr>
</table>

### *3.1.1.3 Soil Organic Carbon (SOC)*

Human activities and other disturbances alter the carbon dynamics of forest soils. Changes in forest type, productivity, decay rates and disturbances can effectively modify the carbon contents of forest soils. Different forest management activities, such as rotation length, harvesting practices, site preparation activities (prescribed fires, soil scarification), interfere more or less strongly with soil organic carbon (Johnson and Curtis, 2001).

Soil organic carbon, SOC (kg $Mg^{-1}$), can be measured by the Walkley–Black method on disturbed soil samples.

<table>
<tr><td>Indicator name</td><td colspan="3">Soil Organic Carbon (SOC)</td></tr>
<tr><td colspan="4">Application</td></tr>
<tr><td>Potential impact/threat<br>Reduction of SOC</td><td>Sector of bioenergy chain<br>Forest harvesting</td><td colspan="2">Action<br>All</td></tr>
<tr><td colspan="4">Indicator description<br>Human activities and other disturbances alter the carbon dynamics of forest soils. Changes in forest type, productivity, decay rates and disturbances can effectively modify the carbon contents of forest soils. Soil organic carbon, SOC (kg $Mg^{-1}$), can be measured by the Walkley–Black method on disturbed soil samples.</td></tr>
<tr><td colspan="4">Data sources and retrieval methods<br>In each plot, 4 soil samples will be collected for each plot. The disturbed soil will be used to determine SOC (kg $Mg^{-1}$) by the Walkley–Black method.</td></tr>
<tr><td>Sampling unit</td><td colspan="3">4 samplings per plot</td></tr>
<tr><td rowspan="2">Monitoring timeframe</td><td>Short</td><td>Medium</td><td>Long</td></tr>
<tr><td>2 replicas / year</td><td>2 replicas / year</td><td>2 replicas / year</td></tr>
<tr><td>Links with other indicators</td><td colspan="3"></td></tr>
<tr><td colspan="4">References<br>Johnson DW, Curtis PS (2001). Effects of forest management on soil C and N storage: meta analysis. Forest Ecology and Management 140, 227-238.</td></tr>
</table>

### *3.1.1.4 Erosion*

The protection of the forests in preventing soil erosion is determined by a combination of factors such as canopy density, dominant height, basal area, regeneration density, density of herb layer, volume and distribution of coarse woody debris, percentage of gap and tree species composition (Ferretti et al. 2014). Forest harvesting together with wildfires (Cerdá and Doerr, 2005; Smith et al., 2011) are the major factors that can lead to significant changes to erosion rates of forestland (Borrelli and Schutt, 2014). Typical micromorphological forms suggesting erosion are Rill erosion, Interrill erosion and Gully erosion: 1) Rill erosion results from the concentration of surface water into deeper, faster-flowing channel; 2) Interrill erosion is the detachment and transport of soil material from the surface of the soil matrix by raindrop impact and overland flow; 3) Gully erosion is an advanced stage of rill erosion where surface channels have eroded to the point where they cannot be removed by tillage operations.

Therefore, the main cause of the deterioration of the edaphic resource is water erosion and it constitutes the main environmental problem linked to the anthropic use of soils. Besides the physical loss, this process represents the most complex and integral form of degradation.

Hence, the observation of these phenomena, as well as the application of the Universal Soil Loss Equation (USLE) (Wischmeier, W.H. and D.D. Smith. 1978) will provide guidance on the effects of the forest harvesting.

<table>
<tr><th>Indicator name</th><th colspan="3">Erosion</th></tr>
<tr><td colspan="4" align="center">Application</td></tr>
<tr><td>Potential impact/threat<br>Presence of rill/interrill/gully erosion</td><td>Sector of bioenergy chain<br>Forest harvesting</td><td colspan="2">Action<br>All</td></tr>
<tr><td colspan="4">Indicator description<br>Forest harvesting together with wildfires are the major factors that can lead to significant changes to erosion rates of forestland. Soil erosion consists of three main components: rill erosion, interril erosion and gully erosion.</td></tr>
<tr><td colspan="4">Data sources and retrieval methods<br>In each plot, the observation of these phenomena and the application of the empirical equation (USLE) will provide guidance on the effects of the forest harvesting.<br><br>USLE equation:<br>A = R x K x LS x C x P (ton/ha/year)*<br>A = Annual soil loss (ton/ha and year)<br>R = Rain erosivity factor (hJ cm / m2h and year)<br>K = Soil erodibility factor (ton h m2 / ha hJ cm)<br>LS = Topographic factor: Factor length of the slope (L) and slope factor (S)<br>C = Coverage, crops and vegetation factor (dimensionless)<br>P = Practical factor of soil conservation (dimensionless)</td></tr>
<tr><td>Sampling unit</td><td colspan="3" align="center">survey per plot</td></tr>
<tr><td rowspan="2">Monitoring timeframe</td><td align="center">Short</td><td align="center">Medium</td><td align="center">Long</td></tr>
<tr><td align="center">2 surveys / year</td><td align="center">2 surveys / year</td><td align="center">2 surveys / year</td></tr>
</table>

| Indicator name | Erosion |
|---|---|
| | *1 survey/year in order to predict the long-term average annual soil loss |
| **Links with other indicators** | |

**References**
Borrelli P, Schutt B (2014). Assessment of soil erosion sensitivity and post-timber-harvesting erosion response in a mountain environment of Central Italy. Geomorphology 204 412–424
Cerdá A, Doerr SH (2005). Influence of vegetation recovery on soil hydrology and erodibility following fire: an 11-year investigation. Int. J. Wildland Fire 14, 423–437.
Ferretti F, Cantiani P, De Meo I, Paletto A (2014). Assessment of soil protection to support forest planning: an experience in southern Italy. Forest Systems 23(1): 44-51
Smith HG, Sheridan GJ, Lane PN, Bren LJ (2011). Wildfire and salvage harvesting effects on runoff generation and sediment exports from radiata pine and eucalypt forest catchments, south-eastern Australia. Forest Ecol. Manage. 261, 570–581.
LIFE10 ENV/ES/000458. Deliverable 9.b. Documento sobre las condiciones hidrológicas y edafológicas de las parcelas. 2016. Acción 2. LIFE+ECOGLAUCA ERGON. Proyecto de demostración sobre el uso de nicotina glauca como cultivo energético contra el cambio climático y la erosión de suelos.
Wischmeier, W.H. and D.D. Smith. 1978. Predicting Rainfall Erosion Losses. A guide to conservation planning. Agriculture Handbook No. 537. USDA-SEA, US. Govt. Printing Office, Washington, DC. 58pp.

### *3.1.1.5 Soil bulk density*

Harvesting operations can cause some degree of soil compaction, depending on harvesting equipment, techniques, traffic intensity, soil properties (Wang et al. 2005). An important soil physical property reflecting soil structure degradation is soil bulk density (Froehlich et al. 1985). Disturbance and/or removal of surface soil horizons results in increasing soil bulk density, which reduces root growth and water availability, and causes nutrient loss over time (Froehlich and McNabb 1983). Decreases in porosity through the elimination of macropores and the reduction of soil infiltration capacity as well as the rate of water movement into the soils are all associated with compaction from timber harvesting (Murray and Buttle 2004). Quantification of soil bulk density changes, pre-harvest and post-harvest, will be allow to know the effects of the forest harvesting. 4 undisturbed soil cores will be collected at the 0- to 0.10-m depths in 4 randomly selected points and it will be used for laboratory determination of the dry soil bulk density, $\rho_b$ (Mg $m^{-3}$) (Cullotta et al. 2016).

| Indicator name | Soil bulk density | |
|---|---|---|
| **Application** | | |
| **Potential impact/threat**<br>Increase of soil bulk density | **Sector of bioenergy chain**<br>Forest harvesting | **Action**<br>All |
| **Indicator description**<br>An important soil physical property reflecting soil structure degradation is soil bulk density. Disturbance and/or removal of surface soil horizons results in increasing soil bulk density, which reduces root growth and water availability, and causes nutrient loss over time. Decreases in porosity through the elimination of macropores and the reduction of soil infiltration capacity as well as the rate of water movement into the soils are all associated with compaction from timber harvesting. | | |
| **Data sources and retrieval methods**<br>In each plot, 4 undisturbed soil cores will be collected at the 0- to 0.10-m depths in 4 randomly selected points and it will be used for laboratory determination of the dry soil bulk density, $\rho_b$ (Mg $m^{-3}$). Similarly, soil profiles (soil pits) | | |

| Indicator name | Soil bulk density | | |
| --- | --- | --- | --- |
| will be made, with representative control points of soil per plot, for checking *in situ* the depth of the water table and the effective depth of the roots. In addition, the characteristics such as colour, smell, moisture content, structure, granulometry and texture of each of the soils will be analysed and evaluated to get information about possible changes after forestry operations. | | | |
| **Sampling unit** | 4 samplings per plot | | |
| **Monitoring timeframe** | **Short** | **Medium** | **Long** |
| | 2 replicas / year | 2 replicas / year | 2 replicas / year |
| **Links with other indicators** | | | |
| **References**<br>Cullotta S, Bagarello V, Baiamonte G, Gugliuzza G, Iovino M, La Mela Veca DS, Maetzke FG, Palmeri V, Sferlazza S (2016). Comparing Different Methods to Determine Soil Physical Quality in a Mediterranean Forest and Pasture Land. Soil Science Society of America Journal, 80: 1038-1056<br>Froehlich HA, McNabb DH (1983). Minimizing soil compaction Pacific Northwest forests. Sixth North America forest soil conference on forest soils and treatment impacts, pp.159–192.<br>Froehlich HA, Miles DWR, Robbins RW (1985). Soil bulk density recovery on compacted skid trails in Central Idaho. Soil Science Society of America Journal 49: 1015–1017.<br>Murray CD, Buttle JM (2004). Infiltration and soil water mixing on forested and harvested slopes during spring snowmelt, Turkey Lakes Watershed, central Ontario. Journal of Hydrology 306: 1–20.<br>Wang J, LeDoux CB, Edwards P, Jones M (2005). Soil bulk density changes caused by mechanized harvesting: A case study in central Appalachia. Forest Products Journal 55(11): 37-40.<br>LIFE10 ENV/ES/000458. Deliverable 9.b. Documento sobre las condiciones hidrológicas y edafológicas de las parcelas. 2016. Acción 2. LIFE+ECOGLAUCA ERGON. Proyecto de demostración sobre el uso de nicotina glauca como cultivo energético contra el cambio climático y la erosión de suelos. | | | |

#### *3.1.1.6 Fire risk*

Fire is one of the most significant threats for the Mediterranean forests. The seasonality of the climate with a dry summer, high temperatures and low rainfall, and the fuel model features are the main factors in the ignition and progression of wildfires. Sustainable forest management must consider fire risk and fire losses (Costa Freitas et al. 2017). The fuel model is a classification of vegetation based on physical-chemical parameters that influence the behavior of the fire. Fuel models are especially suited to fine fuels, which are the main responsible for the fire behavior, and are developed on the following components of vegetation: the litter is made up of foliage and wood residues, the herbaceous layer, the renewal, the shrubs and trees (AA VV 2008). We discriminate four fuel models depending on the amount of fuel available in the woods, in an increasing order of danger: 1) Grasslands – this fuel model includes pasture and natural grasslands; 2) Shrublands – it includes shrubs and plantations with high density and considerable load of dead fuel; 3) Forest litter – it includes litter with short-term and long-term decomposition of both conifers and hardwoods, and woods with lots of dead fuel following pest and diseases and/or meteoric events; 4) Forest harvest residues – the degree of danger depends on the residues features left on the ground, their distribution and height. The classification of fuel model, pre-harvest and post-harvest, will be allow to know the effects of the forest harvesting on fire risk.

On the other hand, the quantitative assessment of the fire risk can be done through the application of biophysical variables (LAI and FAPAR) with remote sensing. For that purpose, in the study which is being implemented (Forest management models based on biophysical parameters at high spatial resolution estimated with data from the Sentinel-2 mission - *Modelos de gestión forestal a partir de parámetros biofísicos a alta resolución espacial estimados con datos de la misión Sentinel-2*), the methodology implemented in the context of the FP7 ImagineS (Implementing Multi-scale Agricultural Indicators Exploiting Sentinels) has been adapted and the image from the Sentinel-2A L2A of 10 m of spatial resolution has been used.

Concerning the biophysical variables, LAI – Leaf Area Index (invariable in perennial plants, variable in senescent plants) and FAPAR - Fraction of Absorbed Photosynthetically Active Radiation provides information of the stand. Concretely, LAI provides information related to the shape of the stand, being considered a structural parameter. Specifically, and regarding LAI variable (logarithmic relation with NDVI – Normalized Difference Vegetation Index), the greater the vegetation index is, the greater is the vegetative vigour. Therefore, more NDVI means that the stand has more vigour. Nevertheless, LAI has a logarithmic relation with NDVI, so at higher values of NDVI, LAI approaches an asymptote and its growth is not as pronounced. In the same way, the greater the dryness is, the greater is the risk of fires. The FAPAR variable has a linear relation with NDVI and provides also information on the structure of the stand and of the biophysical activity which is linked with the vigour. Therefore, with these variables and the information obtained directly through a forest inventory in the field (Third Forest Inventory - *Tercer Inventario Forestal Nacional* (IFN3), MAPAMA), the independent variable which is the biomass (W) is obtained.

| Indicator name | Fire risk | | |
|---|---|---|---|
| **Application** | | | |
| **Potential impact/threat**<br>Fuel model features | **Sector of bioenergy chain**<br>Forest harvesting | **Action**<br>All | |
| **Indicator description**<br>Fire is one of the most significant threats for the Mediterranean forests. The seasonality of the climate with a dry summer, high temperatures and low rainfall, and the fuel model features are the main factors in the ignition and progression of wildfires. We discriminate four fuel models depending on the amount of fuel available in the woods, in an increasing order of danger: 1) Grasslands, 2) Shrublands, 3) Forest litter and 4) Forest harvest residues. | | | |
| **Data sources and retrieval methods**<br>In each plot, the classification of fuel model, pre-harvest and post-harvest, will be allow to know the effects of the forest harvesting on fire risk | | | |
| **Sampling unit** | survey per plot | | |
| **Monitoring timeframe** | **Short** | **Medium** | **Long** |
| | 2 surveys / year | 2 surveys / year | 2 surveys / year |
| **Links with other indicators** | | | |
| **References**<br>AA VV (2008). Sistema Informativo Forestale Della Regione Siciliana; Istruzioni per il Rilievo Degli Attributi di Seconda Fase: Palermo, Italy; p. 261<br>Costa Freitas MB, Xavier A, Fragoso R (2017). Integration of Fire Risk in a Sustainable Forest Management Model. | | | |

| Indicator name | Fire risk |
| --- | --- |
| Forests 8, 270, 1-20. | |

# 4 IMPACT ASSESSMENT ON THE SOCIAL, ECONOMIC AND DEMOGRAPHIC COMPONENTS AND ECOSYSTEM SERVICES

From a social, economic, environmental and demographic point of view the impacts derived from the developing of a forest-wood-energy supply chain in rural areas, vary considerably from country to country. Consequently, also the methods addressing to the assessment of the impacts differ according to the reference context, the industry current state of the art, and the characteristics of target areas. Generally speaking, these impacts can concern both the firms directly and indirectly involved along the supply chain, and the population and the environment strictly related to the interested areas. Thus, the impact assessment of the of increase biomass use in the short, medium and long term in the protected areas and its utilization for the production of bioenergy, can be carried out through both in terms of demographic, social, and economic changes, and in terms of services provided by the ecosystem. It is predictable, indeed, that the development of a forest-wood-energy in a rural environment, not only can facilitate the strengthening of existing firms or the developing of new forest firms or firms involved in the entire wood supply chain, but also can represents an important flywheel effect for the whole interested area's economy. Besides, how emerges from the reference literature, from the utilisation of forests, and protected areas in particular, can arise some effects involving the ecosystems and their services which can have important impacts both social, economic, and natural. Differently to the metodology adopted for risks and benefits assessment of impacts derived from the biomass production on biotic and abiotic components, in which each considered effect is strictlt linked both to the plants and animals communities and abiotic components, and the silvicultural and harvesting practices, in the assessment of socio-demographic, socio-economic, and ecosystem services impacts, has been followed a diversified approach. More in detail, in the assessment of socio-demographics impacts, the wood-forest-energy supply chain has been treated like as an only one productive activity, without consider the different activities inside it. This is due to the fact that all the work activities included in the supply chain, through the creation of new incomes and job opportunities, are equally able to influence all the social and demographic conditions of the interested rural areas. On the contrary, for the assessment of socio-economics impacts, the forest-wood-energy supply chain, has been considered composed by four phases each of which include different works activities inherent to a specific working area. This is due to the fact that, in spite of all the firms involved in the supply chain are interested by the impacts generated by the development of a forest-wood-energy in a rural environment, however, the magnitude and the effect during the time, can differ significantly, on the basis of each individual productive activity.

Finally, just as in the assessment of socio-demographics impacts, also for the assessment of impacts on ecosystems services, could be hard separate the effects generated by each phase of the supply chain, even if, diversely from the socio-demographics impacts, the impacts on ecosystems services are essentially produced by the activities included in the second phase of supply chain, i.e., theactivities related to the biomass harvesting and extraction.

In light of this, several indicators have been developed and applied in order to measure these effects. Among these, some are not always adapt to be revealed by quantitative analysis, other are able to assess impact in the short (which mature over a relatively short period of time especially one year or less), medium (relating to a period of time that is neither very soon nor very far into the future, usually including between one and five years), or long term (generally, a time frame at least seven to ten years), even if the "short, medium or long term" time frames can vary depending on the type of impact to assess and according to the availability of data needed to calculate the indicators.

Selected Indicators

The assessment of impacts on social, economic and demographic components and ecosystem services caused by increased biomass use in the protected areas could be carried out using twenty-four different indicators, as shown in the table 3.6.

Table 3.6 – List of the indicators for the impacts assessment on social, economic and demographic components and ecosystem services

| INDICATORS | | Data source | Before operations | Short term (after one year) | Medium term (after five years) | Long term (after ten years) |
|---|---|---|---|---|---|---|
| Socio-Demographic Indicators | Population growth rate | *see reference sheet* | *Yes* | *No* | *No* | *Yes* |
| | Population structure | *see reference sheet* | *Yes* | *No* | *No* | *Yes* |
| | Per capita family income | see reference sheet | Yes | No | No | Yes |
| | Unemployment rate | see reference sheet | Yes | No | No | Yes |
| | Educational level | see reference sheet | Yes | No | No | Yes |
| | Energetic self-sufficiency | see reference sheet | Yes | No | No | Yes |
| Socio-Economic Indicators | Total firms | see reference sheet | Yes | Yes | Yes | Yes |
| | Legal form | see reference sheet | Yes | Yes | Yes | Yes |
| | Net income | see reference sheet | Yes | Yes | Yes | Yes |
| | Labour Productivity | see reference sheet | Yes | Yes | Yes | Yes |
| | Workforce | see reference sheet | Yes | Yes | Yes | Yes |
| | Workforce age | see reference sheet | Yes | Yes | Yes | Yes |
| | Type of contracts | see reference sheet | Yes | Yes | Yes | Yes |
| | Positions or Jobs | see reference sheet | Yes | Yes | Yes | Yes |
| | R&D investment | see reference sheet | Yes | Yes | Yes | Yes |
| | Innovations introduction | see reference sheet | Yes | Yes | Yes | Yes |
| | Tangible resources | see reference sheet | Yes | Yes | Yes | Yes |
| Ecosystem Services Indicators | Wood commercial use value (Vt) | see reference sheet | not available | Yes* | No | No |
| | Fuelwood use value (Vf) | see reference sheet | not available | Yes* | No | No |
| | Wood energy production value (Ve) | see reference sheet | not available | Yes* | No | No |
| | Sequestered Carbon value (Vc) | see reference sheet | not available | Yes* | No | No |
| | Cost of replacing the protective function (Vp) | see reference sheet | not available | Yes** | No | No |
| | Cultural service value (Vs) | see reference sheet | not available | Yes | Yes | Yes |

* The Estimation of this value must be considered annual
** The Estimation of this value must be considered for each intervention separately

The following paragraphs describe each of the indicators, data collection and analysis procedures.

## 4.1 The Socio-Demographic component

Like any productive activities able to provide new generation incomes, also the development of a forest-wood-energy chain could produce important impacts on the social and demographic conditions of the interested rural areas. Therefore, these impacts that can concern practically all components of social and economic life, from the community down to the family and individual units, can be measured on the basis of the demographic changes produced (del Rio and Burguillo, 2008) and by specific indicators.

Among these, the changes in the population (in terms of dimension and composition for ages), of wellness of families (in terms of per capita income), of the employment status (in terms of employment or unemployment rate), of the educational level of population, and in the specific case, of the level of energy independence (in terms of percentage of energy consumed by residents in the interested municipalities that is produced by the biomass plant). The data referred to the period previous the beginning of the operations, further to allow the assessment of the long term impacts generated by the development of the entire supply chain, also provide a descriptive framework of the interested areas.

### 4.1.1 Selected indicators for the impacts assessment on socio-demographic component

- Population growth rate
- Population structure
- Per capita family income
- Unemployment rate
- Educational level
- Energetic self-sufficiency

#### *4.1.1.1 The Population Growth Rate*

| Indicator name: | Population growth rate |
|---|---|
| **Expected impact**<br>Increment of population number in the closer municipalities to the areas where the chain will be realized. | |
| **Indicator definition**<br>This indicator represents the rate at which the number of individuals in a population increases in a given time period, expressed as a fraction of the initial population. It refers to the change in population over a unit time period, often expressed as a percentage of the number of individuals in the population at the beginning of that period. | |
| **Data sources and retrieval methods** | |

| Indicator name: | Population growth rate | | |
|---|---|---|---|
| Elements to know: population in year t; population in year t +n.<br>National, Regional, Local bureau of statistic, Censuses, Data collected on a voluntary basis through ad hoc surveys. | | | |
| **Monitoring timeframe** | **Short** | **Medium** | **Long** |
| | No | No | Yes |
| **Links with other indicators** | Population structure, Per capita family income, Unemployment rate, Educational level, Energetic self-sufficiency | | |
| **References** | | | |

### *4.1.1.2 The Population Structure Changes*

| Indicator name: | Population structure | | |
|---|---|---|---|
| **Expected impact**<br>Increment of the work age population number in the closer municipalities to the areas where the chain will be realized. | | | |
| **Indicator definition**<br>This indicator shows the changes in terms of age of the population resident in the observed areas. It is calculated by the ratio of population number aged under 16, aged 15-64 years, and aged 65 years and over, and the total population, expressed in percentage. | | | |
| **Data sources and retrieval methods**<br>Elements to know: population aged under 15 years; population aged 15-64 years; population aged 65 years and over; total population.<br>National, Regional, Local bureau of statistic, Censuses, Data collected on a voluntary basis through ad hoc surveys. | | | |
| **Monitoring timeframe** | **Short** | **Medium** | **Long** |
| | No | No | Yes |
| **Links with other indicators** | Population growth rate, Per capita family income, Unemployment rate, Educational level, Energetic self-sufficiency | | |
| **References** | | | |

### *4.1.1.3 Per Capita Income*

| Indicator name: | Per capita income | | |
|---|---|---|---|
| **Expected impact**<br>Increment of the per capita income mean of population resident in the closer municipalities to the areas where the chain will be realized. | | | |
| **Indicator definition**<br>Per capita income measures the average income earned per person in a given area (city, region, country, etc.) in a specified year. It is calculated by dividing the area's total income by its total population. Per capita income is often used to measure an area's average income. This is used to measure a country's standard of living or compare the wealth of the population with those of others. It is usually expressed in terms of a commonly used international currency. | | | |
| **Data sources and retrieval methods**<br>Elements to know: GDP and populations.<br>National, Regional, Local bureau of statistic, Censuses, Data collected on a voluntary basis through ad hoc surveys. | | | |
| **Monitoring timeframe** | **Short** | **Medium** | **Long** |
| | No | No | Yes |
| **Links with other indicators** | Population growth rate, Population structure, Unemployment rate, Educational level, Energetic self-sufficiency | | |
| **References** | | | |

#### 4.1.1.4 Unemployment Rate

| Indicator name: | Unemployment rate | | |
|---|---|---|---|
| **Expected impact**<br>Decrement of the percentage of unemployment rate among the population resident in the municipalities around the area object of study. | | | |
| **Indicator definition**<br>This indicator shows the number of unemployed as a percentage of the labour force. It is calculated as the ratio of the number of unemployed persons to the labour force (given by the unemployed plus the employed persons). | | | |
| **Data sources and retrieval methods**<br>Elements to know: Number of persons in work age who are unemployed and looking for work, number of population in work aged.<br>National, Regional, Local bureau of statistic, Censuses, Data collected on a voluntary basis through ad hoc surveys. | | | |
| **Monitoring timeframe** | **Short** | **Medium** | **Long** |
| | No | No | Yes |
| **Links with other indicators** | Population growth rate, Population structure, Per capita family income, Educational level, Energetic self-sufficiency | | |
| **References** | | | |

#### 4.1.1.5 Educational Level Improvement

| Indicator name: | Educational Level Improvement | | |
|---|---|---|---|
| **Expected impact**<br>Increment of the educational level mean of people resident in the municipalities close to interested areas. | | | |
| **Indicator definition**<br>It is calculated as the percentage of the adult population holding at least an upper secondary degree education | | | |
| **Data sources and retrieval methods**<br>Elements to know: Number of persons who have an upper secondary degree education, number of adult population.<br>National, Regional, Local bureau of statistic, Censuses, Data collected on a voluntary basis through ad hoc surveys. | | | |
| **Monitoring timeframe** | **Short** | **Medium** | **Long** |
| | No | No | Yes |
| **Links with other indicators** | Population growth rate, Population structure, Per capita family income, Unemployment rate, Energetic self-sufficiency | | |
| **References** | | | |

#### 4.1.1.6 Energetic self-sufficiency

| Indicator name: | Energetic self-sufficiency |
|---|---|
| **Expected impact**<br>Increase of the bioenergy consumption among the consumers close to the studied areas. | |
| **Indicator definition**<br>This indicator provides the measure in which the level of energy provided by the plant that use the biomass harvested from the protected areas, effects on the energy consumption of the population interested. It is calculated by the ratio between the consumed energy provided by the biomass plant and the total energy consumed, and express in terms of percentage. | |
| **Data sources and retrieval methods**<br>Elements to know: energy produced by biomass and consumed by population, total energy consumption of population.<br>National, Regional, Local bureau of statistic, Data from companies involved in the generation, transmission and distribution energy, Data collected on a voluntary basis through ad hoc surveys. | |

| Indicator name: | Energetic self-sufficiency | | |
|---|---|---|---|
| **Monitoring timeframe** | **Short** | **Medium** | **Long** |
| | No | No | Yes |
| **Links with other indicators** | Population growth rate, Population structure, Per capita family income, Unemployment rate, Educational level | | |
| **References** | | | |

## 4.2 The Socio-Economic component

The utilisation of the forest biomass provided by protected areas and its use for the production of bioenergy in the rural areas, can produce several potential effects on the local social and economic conditions. Among these, as emerges from the reference literature, there are both the impacts on the local businesses, in terms of size, structure, composition, competitiveness and innovation, and on the job market, in terms of numbers and characteristics of jobs and workers.

Each of these impacts can be interest the entire supply chain, and so all the firms involved in its operation, however, the magnitude and the effect during the time, can differ significantly, on the basis of each individual productive activity. In light of these reason, it is more appropriate consider separately, each of these phases, each of which include different businesses recognizable through own NACE Code and attributable to the correct phase of the supply chain.

More in detail, the phases of the Forest-Wood-Energy Supply Chain are:

- the biomass harvesting and extraction, which include the businesses involved in the silviculture and other forestry activities including the logging and support services (Nace Codes 02.1; 02.2; 02.4);
- the processing and marketing of wood, which include the businesses interested in the sawmilling, the manufacture of products of wood, the operations of sale of timber (agents and wholesales), and the transportation services (Nace Codes 16.1; 16.2; 46.13; 46.73.1; 49.41);
- the electric power generation in the biomass plants, transmission and distribution (Nace Code 35.1);
- other satellite activities, like as the production of non-wood products, the hunting, trapping and related services, the nature reserves activities, the accomodation and restaurant services activities (Nace Codes 01.7; 02.3; 55.1; 56.1; 91.04).

### 4.2.1 Selected indicators for the impacts assessment on the Local Business

The market diversification, the creation of new local entrepreneurship, and the improvement of the internal organizational efficiency, represent some of the possible effects on the local firms directly and indirectly involved in the activities ascribable to the biomass harvesting from protected areas and its use for bioenergy production. These effects, in fact, can interest both the firms operating in the biomass harvesting and extraction, the processing and the trade of wood, the bioenergy production and distribution, but also, even if with modest effect, in other different industries (e.g. services for visitors and tourists of parks, accommodation and food (del Rio and Burguillo, 2008). In order to measure these impacts it is possible observe the evolution of the local businesses, for each of productive category, in terms of number, structure, income, and efficiency, through the data provided by the local chambers of commerce, and by the statistical institutions. These indicators can be calculated with the aim to obtain both a relatively short-term view, and medium and long-term view.

Table 4.1 – List of the indicators for the impacts assessment on the Local Business

| Action | INDICATORS Impact on the Local Business | |
|---|---|---|
| | Total Firms / Legal Forms / Net Income / Labour Productivity | |
| Biomass Harvesting and Extraction | NACE Code (Rev.2) and Description | |
| | 02.1 | SILVICULTURE AND OTHER FORESTRY ACTIVITIES |
| | 02.2 | LOGGING |
| | 02.4 | SUPPORT SERVICES TO FORESTRY |
| Processing and Marketing of Wood | 16.1 | SAWMILLING AND PLANING OF WOOD |
| | 16.2 | MANUFACTURE OF PRODUCTS OF WOOD, CORK, STRAW AND PLAITING MATERIALS |
| | 46.13 | AGENTS INVOLVED IN THE SALE OF TIMBER AND BUILDING MATERIALS |
| | 46.73.1 | WHOLESALE OF WOOD, CONSTRUCTION MATERIALS AND SANITARY EQUIPMENT |
| | 49.41 | FREIGHT TRANSPORT BY ROAD |
| Bioenergy Production and Distribution | 35.1 | ELECTRIC POWER GENERATION, TRANSMISSION AND DISTRIBUTION |
| Satellite Activities | 02.3 | GATHERING OF WILD GROWING NON-WOOD PRODUCTS |
| | 01.7 | HUNTING, TRAPPING AND RELATED SERVICE ACTIVITIES |
| | 91.04 | BOTANICAL AND ZOOLOGICAL GARDENS AND NATURE RESERVES ACTIVITIES |
| | 55.1 | HOTELS AND SIMILAR ACCOMODATION |
| | 56.1 | RESTAURANT AND MOBILE FOOD SERVICE ACTIVITIES |

### *4.2.1.1 The Total Firms*

| Indicator name: | Total firms | | |
|---|---|---|---|
| **Expected impact**<br>Increment of firms involved in each of the phases of the supply chain and in the satellite activities. | **Parts of the supply chain and activities involved (NACE Code Rev.2):**<br>−Biomass harvesting and extraction (02.1; 02.2; 02.4)<br>−Processing and marketing of wood (16.1; 16.2; 46.13; 46.73.1; 49.41)<br>−Bioenergy production and distribution (35.1)<br>−Satellite activities (02.3; 01.7; 91.04; 55.1; 56.1) | | |
| **Indicator definition**<br>The indicator explains if during the observation period, the businesses population experienced any changes in terms of number.<br>It is calculated as a ratio between the difference of the number of firms active in the year t+n and the number of firms active in the year t, and the number of firms active in the year t, expressed in terms of percentage. | | | |
| **Data sources and retrieval methods**<br>Elements to know: the number of firms active in the year t, the number of firms active in the year t+n.<br>Local Chambers of Commerce (CoC), National, Regional, Local bureau of statistic, Business cycle research institutes, Industry and services censuses, Data collected on a voluntary basis through ad hoc surveys. | | | |
| **Monitoring timeframe** | **Short** | **Medium** | **Long** |
| | Yes | Yes | Yes |
| **Links with other indicators** | Legal forms, Net income, Labour Productivity | | |
| **References** | | | |

### *4.2.1.2 The Legal Forms*

| Indicator name: | Legal Forms |
|---|---|

| Indicator name: | Legal Forms |
|---|---|
| **Expected impact**<br>Changes in the composition of business involved in each phase of supply chain is hypothesable. | **Parts of the supply chain and activities involved (NACE Code Rev.2):**<br>−Biomass harvesting and extraction (02.1; 02.2; 02.4)<br>−Processing and marketing of wood (16.1; 16.2; 46.13; 46.73.1; 49.41)<br>−Bioenergy production and distribution (35.1)<br>−Satellite activities (02.3; 01.7; 91.04; 55.1; 56.1) |
| **Indicator definition**<br>The indicator explains if during the observation period, the businesses population experienced any changes in terms of legal forms.<br>It is calculated in terms of variation of the percentage composition of companies (classified in individual firm, company, and cooperative) that participate the each phase of supply chain. | |
| **Data sources and retrieval methods**<br>Elements to know: the number of individual firms, companies, and cooperatives active in the supply chain in the year t, and in the year t+n.<br>Local Chambers of Commerce (CoC), National, Regional, Local bureau of statistic, Business cycle research institutes, Industry and services censuses, Data collected on a voluntary basis through ad hoc surveys. | |

| **Monitoring timeframe** | **Short** | **Medium** | **Long** |
|---|---|---|---|
| | Yes | Yes | Yes |
| **Links with other indicators** | Total firms, Net income, Labour Productivity | | |
| **References** | | | |

### 4.2.1.3 *The Net Income*

| Indicator name: | Net Income |
|---|---|
| **Expected impact**<br>Increase of the economic performance of firms involved in each phase of the supply chain. | **Parts of the supply chain and activities involved (NACE Code Rev.2):**<br>−Biomass harvesting and extraction (02.1; 02.2; 02.4)<br>−Processing and marketing of wood (16.1; 16.2; 46.13; 46.73.1; 49.41)<br>−Bioenergy production and distribution (35.1)<br>−Satellite activities (02.3; 01.7; 91.04; 55.1; 56.1) |
| **Indicator definition**<br>This indicator provide the measure of the growth of economic performance of firms involved in the supply chain during the observation period included between year t and the t+n.<br>It is calculated as the total income minus cost of goods sold, expenses and taxes. | |
| **Data sources and retrieval methods**<br>Elements to know: the net income of businesses for each year of reference.<br>Balance sheet provided by the Local Chambers of Commerce (CoC), Business research institutes, Data collected on a voluntary basis through ad hoc surveys. | |

| **Monitoring timeframe** | **Short** | **Medium** | **Long** |
|---|---|---|---|
| | Yes | Yes | Yes |
| **Links with other indicators** | Total firms, Legal form, Labour Productivity | | |
| **References** | | | |

### 4.2.1.4 *The Labour Productivity*

| Indicator name: | Labour Productivity |
|---|---|
| **Expected impact**<br>Increase of the productive efficiency of firms involved in each phase of the supply chain. | **Parts of the supply chain and activities involved (NACE Code Rev.2):**<br>−Biomass harvesting and extraction (02.1; 02.2; 02.4)<br>−Processing and marketing of wood (16.1; 16.2; 46.13; 46.73.1; 49.41)<br>−Bioenergy production and distribution (35.1) |

| Indicator name: | Labour Productivity | | |
|---|---|---|---|
| | −Satellite activities (02.3; 01.7; 91.04; 55.1; 56.1) | | |
| **Indicator definition**<br>Labour Productivity explains the relationship between production and factors of production<br>This indicator's value, if compared between two different years, provide the measure of the growth in terms of efficiency of firms involved in the supply chain during the observation period included between year t and the t+n. It is calculated as the ratio of annual turnover and the number of fixed employees of firm. | | | |
| **Data sources and retrieval methods**<br>Elements to know: the annual turnover (€), the number of permanent employees.<br>Balance sheet provided by the Local Chambers of Commerce (CoC), Business research institutes, Data collected on a voluntary basis through ad hoc surveys. | | | |
| **Monitoring timeframe** | **Short** | **Medium** | **Long** |
| | Yes | Yes | Yes |
| **Links with other indicators** | Total firms, Legal form, Net income | | |
| **References** | | | |

### 4.2.2 Selected indicators for the Impacts assessment on the Local Job Market

For each local area, and for each of segment of the supply chain, it is possible to observe different dynamics inherent the job market or the creation of new job opportunity, generated by the development of the project activity.

These new job opportunities may concern both qualified and unskilled labour, may be distinct in direct and indirect job opportunities, and can have temporary or permanent impacts (del Rio and Burguillo, 2008; FUTURIS Etrusca s.r.l., 2012).

As suggested by Domac et al. (2005) the employment impacts at local level resulting from the realization of a bioenergy production plant from the management of forests within protected areas can be of the following type:

- direct, closely linked to the need to find and employ staff to operate within the plant;
- indirect, or satellite activities, that are distributed throughout the forest-wood-energy supply chain.

If on one hand the impacts on the local job market in terms of growth of workforce, changes in terms of average age of workers, typology of contracts, or job positions, concerned to the single phases of supply chain, could be easy, on the other hand, the assessing of the same indicators for all indirect activities, could be a little bit complicated.

This because the employment on the direct impacts on local employment can be estimated with greater certainty because it is strictly dependent on the entity the forest and the plant, and are related to the forest utilization, and to the operations and maintenance of the plan (that can be considered as permanents or rather related to life of plant).

However, the occupational opportunities concerns both specialized professionals who require constant upgrades, and generic skills for which there is no need to update or acquire new skills and knowledge for the purpose of carrying out their duties, and that can have a temporary or a permanent nature.

The temporary one can be related both to the plant design activities, and the execution of works related to its realization (land movements, construction of structures and infrastructures, transport of materials and equipment, etc.), or to the activities related to the possible dismantling or reclamation of the plant.

The permanent are related to the forest biomass harvesting and extraction, the trade and transformation of timbers, the services linked to the forest utilisation and the energy production and distribution. These opportunities can be of interest to both young workers to enter through a first stage of training, and adult workers from other sectors, to be recruited and reintegrated into the world of work.

Table 4.2 – List of the indicators for the impacts assessment on the Local Job Market

| Action | INDICATORS Impact on the Local Job market | | | |
|---|---|---|---|---|
| | Workforce | Workforce Age | Type of Contract | Position or Job |
| Biomass Harvesting and Extraction | NACE Code (Rev.2) and Description<br>02.1 SILVICULTURE AND OTHER FORESTRY ACTIVITIES<br>02.2 LOGGING<br>02.4 SUPPORT SERVICES TO FORESTRY | | | |
| Processing and Marketing of Wood | 16.1 SAWMILLING AND PLANING OF WOOD<br>16.2 MANUFACTURE OF PRODUCTS OF WOOD, CORK, STRAW AND PLAITING MATERIALS<br>46.13 AGENTS INVOLVED IN THE SALE OF TIMBER AND BUILDING MATERIALS<br>46.73.1 WHOLESALE OF WOOD, CONSTRUCTION MATERIALS AND SANITARY EQUIPMENT<br>49.41 FREIGHT TRANSPORT BY ROAD | | | |
| Bioenergy Production and Distribution | 35.1 ELECTRIC POWER GENERATION, TRANSMISSION AND DISTRIBUTION | | | |
| Satellite Activities | 02.3 GATHERING OF WILD GROWING NON-WOOD PRODUCTS<br>01.7 HUNTING, TRAPPING AND RELATED SERVICE ACTIVITIES<br>91.04 BOTANICAL AND ZOOLOGICAL GARDENS AND NATURE RESERVES ACTIVITIES<br>55.1 HOTELS AND SIMILAR ACCOMODATION<br>56.1 RESTAURANT AND MOBILE FOOD SERVICE ACTIVITIES | | | |

### *4.2.2.1 The Workforce*

| Indicator name: | Workforce |
|---|---|
| **Expected impact**<br>It is hypothesized an increase of the number of employed in the businesses involved in each phase of the supply chain. | **Parts of the supply chain and activities involved (NACE Code Rev.2):**<br>– Biomass harvesting and extraction (02.1; 02.2; 02.4)<br>– Processing and marketing of wood (16.1; 16.2; 46.13; 46.73.1; 49.41)<br>– Bioenergy production and distribution (35.1)<br>– Satellite activities (02.3; 01.7; 91.04; 55.1; 56.1) |
| **Indicator definition**<br>The variation of the number of employed in the activities directly and indirectly involved in the supply chain, provide a | |

| Indicator name: | Workforce | | |
|---|---|---|---|
| measure of the impact of the project itself on the local job market.<br>This indicator is calculated as percentage variation of the number of employed in the specific activities between the year t and the year t+n for a period of n years. | | | |
| **Data sources and retrieval methods**<br>Elements to know: the number of employed in the businesses active in the several phase of supply chain in the years t and t+n.<br>Balance sheet provided by the Local Chambers of Commerce (CoC), Business research institutes, Data collected on a voluntary basis through ad hoc surveys. | | | |
| **Monitoring timeframe** | **Short** | **Medium** | **Long** |
| | Yes | Yes | Yes |
| **Links with other indicators** | Workforce age, Type of contracts, Positions or Jobs | | |
| **References** | | | |

### 4.2.2.2 *The Workforce Age*

| Indicator name: | Workforce Age | | |
|---|---|---|---|
| **Expected impact**<br>It is predictable a change in terms of average age of workers occupied in the several phases of the supply chain. | **Parts of the supply chain and activities involved (NACE Code Rev.2):**<br>−Biomass harvesting and extraction (02.1; 02.2; 02.4)<br>−Processing and marketing of wood (16.1; 16.2; 46.13; 46.73.1; 49.41)<br>−Bioenergy production and distribution (35.1)<br>−Satellite activities (02.3; 01.7; 91.04; 55.1; 56.1) | | |
| **Indicator definition**<br>The variation in terms of average age of employed operating along the supply chain, could signify, especially in case of its lowering, the need to introduce younger and more skilled workforce.<br>This indicator is calculable as comparison of average age of workers employed before the development of project and after n years. | | | |
| **Data sources and retrieval methods**<br>Elements to know: the average age of employed in the businesses active in the several phase of supply chain in the years t and t+n.<br>National, Regional, Local bureau of statistic, Business cycle research institutes, Industry and services censuses, Data collected on a voluntary basis through ad hoc surveys. | | | |
| **Monitoring timeframe** | **Short** | Medium | Long |
| | Yes | Yes | Yes |
| **Links with other indicators** | Workforce age, Type of contracts, Positions or Jobs | | |
| **References** | | | |

### 4.2.2.3 *The Type of Contract*

| Indicator name: | Type of Contract |
|---|---|
| **Expected impact**<br>It is predictable that the development of the supply chain, generates an impact on the local market job, in terms of change duration of contracts of workers. | **Parts of the supply chain and activities involved (NACE Code Rev.2):**<br>−Biomass harvesting and extraction (02.1; 02.2; 02.4)<br>−Processing and marketing of wood (16.1; 16.2; 46.13; 46.73.1; 49.41)<br>−Bioenergy production and distribution (35.1)<br>−Satellite activities (02.3; 01.7; 91.04; 55.1; 56.1) |
| **Indicator definition**<br>The variation in terms of type of contracts of employed operating along the supply chain, could signify, especially in case of increase of permanent contracts, a greater economic stability and a wider wellness of population. | |

| Indicator name: | Type of Contract | | |
|---|---|---|---|
| This indicator is calculable as comparison of share of workers employed with a fixed-term contracts and permanent contracts, before the development of project and after n years. | | | |
| **Data sources and retrieval methods**<br>Elements to know: the number of employees with fixed-term contract and permanent contract in the years t and t+n.<br>National, Regional, Local bureau of statistic, Business cycle research institutes, Industry and services censuses, Data collected on a voluntary basis through ad hoc surveys. | | | |
| **Monitoring timeframe** | **Short** | **Medium** | **Long** |
| | Yes | Yes | Yes |
| **Links with other indicators** | Workforce age, Workforce age , Positions or Jobs | | |
| **References** | | | |

### *4.2.2.4 The position or Job*

| Indicator name: | Type of Contract | | |
|---|---|---|---|
| **Expected impact**<br>It is feasible that the development of the supply chain, generates an impact on the local market job, in terms of variation of type or task of job. | **Parts of the supply chain and activities involved (NACE Code Rev.2):**<br>−Biomass harvesting and extraction (02.1; 02.2; 02.4)<br>−Processing and marketing of wood (16.1; 16.2; 46.13; 46.73.1; 49.41)<br>−Bioenergy production and distribution (35.1)<br>−Satellite activities (02.3; 01.7; 91.04; 55.1; 56.1) | | |
| **Indicator definition**<br>The variation in terms of type of job in the several activities directly and indirectly involved in the supply chain forest-wood-energy, could represent a signal of modernisation and professionalization of the entire chain.This indicator is calculated as comparison of percentage of skilled workers on the total of workers, before the development of chain and after n years. | | | |
| **Data sources and retrieval methods**<br>Elements to know: the number of skilled workers and unskilled workers employed in the years t and t+n. National, Regional, Local bureau of statistic, Business cycle research institutes, Industry and services censuses, Data collected on a voluntary basis through ad hoc surveys. | | | |
| **Monitoring timeframe** | **Short** | **Medium** | **Long** |
| | Yes | Yes | Yes |
| **Links with other indicators** | Workforce age, Workforce age , Type of contracts | | |
| **References** | | | |

### 4.2.3 Selected indicators for the Impacts assessment on the Organization and Innovation Orientation of businesses

The changes in the openness to innovation (Zaltman et al., 1973) and in the capacity to innovate (Burns and Stalker, 1977) understood as the capacity to introduce new processes, products, or idea in the organization (Hult et al., 2004) can represents another way to assess the impacts linked to the development of a forest-wood-energy supply chain, on the governance and internal organization of business.

If on the one hand, the Dynamic Capabilities' constructs (Teece et al., 1997) have been often used in order to explain the innovation orientation of firms and its effects on the management and strategic choices as consequence of the changes occurred in the market, on the other hand, the behaviour of firms expressed in terms of development of skills and competencies, research and development efforts, innovations introduction, and growth of internal resources, can be used in order to assess the ability to catch the opportunities offered by the dynamic markets, by the same firms. Some possible interesting socio-economic indicators, about the effect of the development of a forest-wood-energy supply chain on the local business, could be represented by the measure of the tangible and intangible resources of firms in terms of changes related to the investments in R&D activities, the third party certifications adoption, as well as, the value of the machinery and equipment of firms operating along the chain.

Table 4.3 – List of the indicators for the impacts assessment on Organization and Innovation Orientation of Business

| Action | INDICATORS<br>Impact on Organization and Innovation Orientation of Business | | |
|---|---|---|---|
| | R&D Investment | Innovations Introduction | Tangible Resources |
| Biomass Harvesting and Extraction | NACE Code (Rev.2) and Description<br>02.1 SILVICULTURE AND OTHER FORESTRY ACTIVITIES<br>02.2 LOGGING<br>02.4 SUPPORT SERVICES TO FORESTRY | | |
| Processing and Marketing of Wood | 16.1 SAWMILLING AND PLANING OF WOOD<br>16.2 MANUFACTURE OF PRODUCTS OF WOOD, CORK, STRAW AND PLAITING MATERIALS<br>46.13 AGENTS INVOLVED IN THE SALE OF TIMBER AND BUILDING MATERIALS<br>46.73.1 WHOLESALE OF WOOD, CONSTRUCTION MATERIALS AND SANITARY EQUIPMENT<br>49.41 FREIGHT TRANSPORT BY ROAD | | |
| Bioenergy Production and Distribution | 35.1 ELECTRIC POWER GENERATION, TRANSMISSION AND DISTRIBUTION | | |
| Satellite Activities | 02.3 GATHERING OF WILD GROWING NON-WOOD PRODUCTS<br>01.7 HUNTING, TRAPPING AND RELATED SERVICE ACTIVITIES<br>91.04 BOTANICAL AND ZOOLOGICAL GARDENS AND NATURE RESERVES ACTIVITIES<br>55.1 HOTELS AND SIMILAR ACCOMODATION<br>56.1 RESTAURANT AND MOBILE FOOD SERVICE ACTIVITIES | | |

#### *4.2.3.1 The R&D Investment*

| Indicator name: | R&D investment |
|---|---|
| **Expected impact**<br>It is possible that the development of the supply chain, generates an impact on the local businesses, in terms of increase of efforts in the research and development. | **Parts of the supply chain and activities involved (NACE Code Rev.2):**<br>– Biomass harvesting and extraction (02.1; 02.2; 02.4)<br>– Processing and marketing of wood (16.1; 16.2; 46.13; 46.73.1; 49.41)<br>– Bioenergy production and distribution (35.1)<br>– Satellite activities (02.3; 01.7; 91.04; 55.1; 56.1) |
| **Indicator definition**<br>The increase of investment in R&D could provide an evidence that the development of forest-wood-energy supply chain is a driver for the modernisation of firms and push them toward the realization of a competitive advantage. | |

| Indicator name: | R&D investment | | |
|---|---|---|---|
| This indicator could be calculated in terms of:<br>- % variation of annual turnover destined in the research and development activity;<br>- patents developed by firms;<br>- change of number of employees employed in the research & development activity.<br>during the period observed. | | | |
| **Data sources and retrieval methods**<br>Elements to know: the percentage of annual turnover destined in the research and development activity, the number of patents developed by firms, the workforce employed in the research & development activity.<br>National, Regional, Local bureau of statistic, Business cycle research institutes, Industry and services censuses, Data collected on a voluntary basis through ad hoc surveys. | | | |
| **Monitoring timeframe** | **Short** | **Medium** | **Long** |
| | Yes | Yes | Yes |
| **Links with other indicators** | Innovations introduction, Tangible resources | | |
| **References** | | | |

### *4.2.3.2 The Innovations Introduction*

| Indicator name: | Innovations introduction | | |
|---|---|---|---|
| **Expected impact**<br>The impact linked to the development of the forest-wood-energy supply chain, could push the local businesses toward a greater introduction of innovations. | **Parts of the supply chain and activities involved (NACE Code Rev.2):**<br>−Biomass harvesting and extraction (02.1; 02.2; 02.4)<br>−Processing and marketing of wood (16.1; 16.2; 46.13; 46.73.1; 49.41)<br>−Bioenergy production and distribution (35.1)<br>−Satellite activities (02.3; 01.7; 91.04; 55.1; 56.1) | | |
| **Indicator definition**<br>These innovation can interest both product and process innovations.<br>This indicator is calculated as variation of number of firms involved in the supply chain adopting one or more third party certifications. These certification may be concern both the forest management (PEFC, FSC, and others), and all the activities in terms of management systems of quality and environmental (ISO family certifications and others). | | | |
| **Data sources and retrieval methods**<br>Elements to know: the number of certifications adopted by each business involved in the supply chain, before and after n years from the beginning of the operations. National, Regional, Local bureau of statistic, Business cycle research institutes, Industry and services censuses, Data collected on a voluntary basis through ad hoc surveys, Certification bodies. | | | |
| **Monitoring timeframe** | **Short** | **Medium** | **Long** |
| | Yes | Yes | Yes |
| **Links with other indicators** | R&D investment, Tangible resources | | |
| **References** | | | |

### *4.2.3.3 The tangible Resources*

| Indicator name: | Tangible resources |
|---|---|
| Expected impact<br>An increase of the value of the internal tangible resources of firms is predictable. | **Parts of the supply chain and activities involved (NACE Code Rev.2):**<br>−Biomass harvesting and extraction (02.1; 02.2; 02.4)<br>−Processing and marketing of wood (16.1; 16.2; 46.13; 46.73.1; 49.41)<br>−Bioenergy production and distribution (35.1)<br>−Satellite activities (02.3; 01.7; 91.04; 55.1; 56.1) |

| Indicator name: | Tangible resources | | |
|---|---|---|---|
| **Indicator definition**<br>A consequence of the development of a forest-wood-energy supply chain could be represented by the increase of the value of the tangible resources of firms, like machineries and equipment. This indicator is represented by the comparison of the market value of machineries and equipment of firms involved in the supply chain, between the year t (previous to the beginning of the supply chain activity) and the year t+n. | | | |
| **Data sources and retrieval methods**<br>Elements to know: the market value of machineries and equipment of businesses before and after n years from the beginning of the operations.<br>Balance sheet provided by the local Chambers of Commerce (CoC), Business research institutes, Data collected on a voluntary basis through ad hoc surveys. | | | |
| **Monitoring timeframe** | **Short** | **Medium** | **Long** |
| | Yes | Yes | Yes |
| **Links with other indicators** | R&D investment , Innovations introduction | | |
| **References** | | | |

## 4.3 Ecosystem Services

Even if the utilisation of the forest biomass shows several advantages than the use of fossil fuels, it has, anyway, several potential effects on the environment and on ecosystems (Varun et al., 2009). These effects are not always positive or negative, but they depend on the category of ecosystem services (Hastik et al., 2015), and furthermore, thay can vary on the basis of the characteristics of areas considered and the reference context (Fisher et al., 2009).

As is well known, ecosystem services have an economic value that includes both use values (direct-use and indirect use values) and non-use values (option and existence values) (Plottu and Plottu, 2007). This value could be estimated in order to assess the impact of increase biomass use in the on the services provided by ecosystems (provisioning, regulating, and cultural services, particularly), with particular attention to the first part of the Forest-Wood-Energy Supply Chain, i.e., the forest utilization, the effects generated by the activities related to the biomass harvesting and extraction.

However, could be really complicated separate the effects produced by each individual phase of the supply chain, furthermore, these indicator differ from the previous indicators, because the ES Indicators can be assessed only after the beginning of the before mentioned activities, so it is precluded the possibility to compare these value with a reference data (and produce a rate or a percentage growth), but it is possible obtain an absolute value in economic terms.

### 4.3.1 Selected Indicators for the impacts assessment on the Ecosystem Provisioning Service

About the ecosystem provisioning service, the impact of forest biomass harvesting activity in protected areas, can be assessed in terms of wood production value or in terms of potential energy value. For this aim, Grilli et al. (2017; 2015) adopt the market price approach, considering different market prices, on the basis of destination of timbers. In order to calculate each of these indicators (value of extracted forest biomass destined for a commercial use, for fuelwood, and for the production of bioenergy) information about the characteristics of tree species and logs, the volume of timbers and the local market prices, need.

#### *4.3.1.1 The Wood Commercial Use Value (Vt)*

<table>
<tr><th>Indicator name:</th><th colspan="3">Wood commercial use value (Vt)</th></tr>
<tr><td colspan="4">Indicator definition<br>It represents the value of extracted forest biomass, when it is destined for a commercial use.<br>The following formula must be used in order to calculate the indicator:<br>$$V_t = \sum_{n}^{i} \sum_{m}^{i} Q_t \cdot p_t$$<br>where:<br>-Vt is the total value of timber (€);<br>-n is the number of tree species;<br>-m is the quality of logs;<br>-Qt is the quantity of timber subdivided per species and quality ($m^3$);<br>-pt is the local price of timber subdivided per species and quality (€/$m^3$).</td></tr>
<tr><td colspan="4">Data sources and retrieval methods<br>Data are provided from analysis that for each protected areas are aimed to know the forest management activities, the trees species, the quality of logs, the volume of timber extractable annually from the forests, and the local price for each of destinations.</td></tr>
<tr><td rowspan="2">Monitoring timeframe</td><td>Short</td><td>Medium</td><td>Long</td></tr>
<tr><td>Yes</td><td>No</td><td>No</td></tr>
<tr><td>Links with other indicators</td><td colspan="3">Fuelwood use value (Vf), Wood energy production value (Ve)</td></tr>
<tr><td colspan="4">References<br>Grilli et al. (2017; 2015).</td></tr>
</table>

#### *4.3.1.2 The Fuelwood Use Value (Vf)*

<table>
<tr><th>Indicator name:</th><th>Fuelwood use value (Vf)</th></tr>
<tr><td colspan="2">Indicator definition</td></tr>
<tr><td colspan="2">It represents the value of extracted forest biomass, when it is destined for fuelwood.<br>The following formula must be used in order to calculate the indicator:<br>$$V_f = \sum_{n}^{i} Q_f \cdot p_f$$<br>where:<br>-Vf is the total value of fuelwood (€);<br>-n is the number of tree species;<br>-Qf is the quantity of fuelwood subdivided per species (t);<br>-pf is the local price of fuelwood (€/t)</td></tr>
<tr><td colspan="2">Data sources and retrieval methods<br>Data are provided from analysis that for each protected areas are aimed to know the forest management activities,</td></tr>
</table>

| Indicator name: | Fuelwood use value (Vf) | | |
|---|---|---|---|
| the trees species, the quality of logs, the volume of timber extractable annually from the forests, and the local price for each of destinations. | | | |
| **Monitoring timeframe** | **Short** | **Medium** | **Long** |
| | Yes | No | No |
| **Links with other indicators** | Wood commercial use value (Vt), Wood energy production value (Ve) | | |
| **References** Grilli et al. (2017; 2015) | | | |

#### *4.3.1.3 The Wood Energy Production Value (Ve)*

| Indicator name: | Wood energy production value (Ve) | | |
|---|---|---|---|
| **Indicator definition**<br>Its represent the value of annual potential energy that can be obtained from forest biomass.<br>The following procedure must be used in order to calculate the indicator:<br>1 - Estimation of the annual volume of biomass extractable ($m^3 \cdot ha^{-1} \cdot year^{-1}$) that represents the annual potential primary energy;<br>2 - Measure of the specific wood density ($kg \cdot m^{-3}$) and calorific value ($kcal \cdot kh^{-1}$) of timber;<br>3 - Transform the calorific value of each tree species in energy content ($MJ \cdot kg^{-1}$) using the specific wood density;<br>4 - Convert it in monetary terms applying the local market price (Ve) | | | |
| **Data sources and retrieval methods**<br>Data are provided from analysis that for each protected areas are aimed to know the forest management activities, the trees species, the quality of logs, the volume of timber extractable annually from the forests, and the local price for each of destinations. | | | |
| **Monitoring timeframe** | **Short** | **Medium** | **Long** |
| | Yes | No | no |
| **Links with other indicators** | Wood commercial use value (Vt), Fuelwood use value (Vf) | | |
| **References**<br>Grilli et al. (2017; 2015) | | | |

### 4.3.2 Selected Indicators for the impacts assessment on the Ecosystem Regulating Service

Concerning the impacts of forest biomass harvesting from protected areas on the regulating services provided by ecosystem, two important indicators are the value of carbon sequestered, and the value of replacing the protective function.

The first one, can be assessed through the For-Est method, developed by Federici et al. (2008) on the basis of indications of Intergovernmental Panel on Climate Change (2003) and already applied by Grilli et al. (2017) for the evaluation of carbon sequestration in a case study concerning a Slovenian national park. It consists in the conversion of the total carbon sequestered by biomass in $CO_2$ in the corresponding economic value of Carbon Dioxide using its market price.

The second, aims to assess the impact on the ecosystem protection function against natural hazards (such as floods, soil erosion, landslides, avalanches, etc.). This impact can be evaluated through an economic indicator based on the replacement cost approach, as has been done by Grilli et al. (2017) for their case study. This approach considers the cost of replacing the protective function of the forests with artificial environmental engineering works that can be used like a proxy of the economic value of the function itself. In order to apply this approach, the interested area must be subdivided into direct and indirect protective forests, in order to indicate the main potential risks that can happen for the respective areas of competence; the direct protective forests are those that protect people and the human activities against natural hazards (e.g. landslides, rock falls, avalanche); the indirect protective forests play a role in term of soil erosion and water flow regulation. Furthermore, need to select the potential substitutive artificial works (e.g. the hydroseeding for the contrast to the erosion, or the palisades for the containment of landslides or rock falls, etc..), and for each one of these, must be taken into consideration also their lifetime and the annual interest rate in order to include the annual cost of maintenance.

#### *4.3.2.1 The Sequestered Carbon Value (Vc)*

| Indicator name: | Sequestered Carbon value (Vc) | | |
|---|---|---|---|
| **Indicator definition**<br>It represents the value of the total CO2 sequestered by the biomass harvested.<br>The following procedure must be used in order to calculate the indicator:<br>1 - Assess the carbon pools (excluding the carbon content in the deadwood, litter, and organic soil, due their limited contribution)<br><br>1A - Estimation of the quantity of Above-Ground Biomass (AGB) (kg/y)<br>$AGB = I \cdot BEF \cdot WBD$<br>where:<br>-I is the annual volume increment ($m^3$/y);<br>-BEF is the biomass expansion factor;<br>-WBD is the wood basal density (kg/$m^3$)<br><br>1B - Estimation of the Below-Ground Biomass (BGB) (kg/y)<br>$\mathrm{BGB = I \cdot WBD \cdot R}$<br>where:<br>-I is the annual volume increment ($m^3$/y);<br>-WBD is the wood basal density (kg/$m^3$);<br>-R is the roots/shoot ratio which converts AGB in roots biomass.<br>All the BEF, WBD, and R coefficients, vary on the basis of the tree species<br><br>2 - Calculate the value of carbon sequestration by forest biomass (€)<br>$V_c = [(AGB + BGB) \cdot 0{,}5] \cdot p_c$<br>where:<br>-0,5 is the coefficient of carbon content;<br>-pc is the carbon price of the voluntary carbon market (€/t) | | | |
| **Data sources and retrieval methods**<br>Data are provided from analysis that for each protected areas are aimed to know the forest management activities, the trees species, the quality of logs, the volume of timber extractable annually from the forests, and the local price for each of destinations, the market price of C. | | | |
| **Monitoring timeframe** | **Short** | **Medium** | **Long** |
| | Yes | No | No |

| Links with other indicators | Cost of replacing the protective function (Vp) |
|---|---|
| **References**<br>Federici et al. (2008), Intergovernmental Panel on Climate Change (2003), Grilli et al. (2017) | |

#### *4.3.2.2 The cost of Replacing the Protective Function (Vp)*

<table>
<tr><th>Indicator name:</th><th colspan="3">Cost of replacing the protective function (Vp)</th></tr>
<tr><td colspan="4">Indicator definition<br>It represents the cost needed to replace the indirect and direct protective forest functions after the harvesting of biomass.<br>The following formula must be used in order to calculate the indicator:<br>$$V_p = \frac{uC \cdot r}{(1+r)^{-t}}$$<br>where:<br>-uC is the unit cost of the substitute construction (€/m$^2$);<br>-r is the interest rate;<br>-t is the substitute construction lifetime (y).</td></tr>
<tr><td colspan="4">Data sources and retrieval methods<br>Data are provided from analysis of each protected areas that is aimed to know the forest management activities, the main potential risks that can happen, the most adapt protective actions, and the costs for their realization and maintenance.</td></tr>
<tr><td rowspan="2">Monitoring timeframe</td><td>Short</td><td>Medium</td><td>Long</td></tr>
<tr><td>Yes</td><td>No</td><td>no</td></tr>
<tr><td>Links with other indicators</td><td colspan="3">Sequestered Carbon value (Vc)</td></tr>
<tr><td colspan="4">References<br>Grilli et al. (2017)</td></tr>
</table>

### 4.3.3 Selected Indicators for the impacts assessment on the Ecosystem Cultural Service

The development of the forest biomass harvesting activity in a protected areas and the begin of a bioenergy production in a rural area, can produces impacts also on the cultural services provided by ecosystem. In a simply way, the number of the visits to the protected areas for year, could represents, for itself an indicators of the value of ecosystem cultural service, in terms of attractiveness of place. However, in order to assess the changes in terms of economic value of cultural service provided by ecosystem, several techniques have been developed. Generally, these techniques can be grouped in revealed preference techniques (indirect methods), and stated preference techniques (direct methods). More in detail, as regard the group of the revealed preferences, the most useful method for the assessment of recreational value is the Travel Cost Method (TCM) (Willis and Garrod, 1991; Breidert et al., 2006), while among the stated preferences methods the Contingent Valuation (CV) (Ciriacy-Wantrup, 1947; Davis, 1963), and the Choice Experiment (CE) (Louviere and Woodworth, 1983; Adamowicz et al., 1994) are the most widespread methods. The Benefit Transfer (BT), furthermore, is another method for the evaluation of environmental goods, that consists in the exam of results provided by other surveys carried out in specific contexts (study sites) and transferred to the interest context no yet studied (policy site) (Wilson and Hoehn, 2006). It is a well adapt method to evaluate an environmental service especially in the cases the resources needed to obtain primary data are missing and the budget available or the time are limited.

#### *4.3.3.1 The Cultural Service Value (Vs)*

| Indicator name: | Cultural service value (Vs) and Visitors Number | | |
|---|---|---|---|
| **Indicator definition**<br>It represents the economic value of cultural service provided by ecosystem.<br>The following methods can be used in order to calculate the indicator:<br>1 - Through the Travel Cost Method (TCM), the economic value of cultural service of ecosystem is assessed in terms of cost supported by visitors for the travel to the interested area is used such as a proxy of the individual value associated with forest recreation. In turn, TCM includes the zonal method and the individual method. The first is undertaken by subdividing the visitors' place of origin into concentric zones characterized by the same per capita visit cost, and calculating the number of visits per population per year. The second, instead, considers the number of trips per year per individual user and calculates the cost supported by each visitor.<br>2 - Through the Contingent Valuation method (CV), the economic value of of cultural service of ecosystem is assessed in terms of Willingness To Pay (WTP) by visitors for the considered environmental good.<br>3 - Through the economic Choice Experiment method (CE), the value of cultural service of ecosystem is assessed in terms of their relevant attributes. The respondent are asked to indicate their choice and their WTP among a series of available scenarios. Alternative scenarios are defined by the combination of attributes and their levels.<br>4 - Through the Benefit Transfer method (BT), the evaluation of environmental goods consists in the exam of results provided by other surveys carried out in specific contexts (study sites) and transferred to the interest context no yet studied (policy site). It is a well adapt method to evaluate an environmental service especially in the cases the resources needed to obtain primary data are missing and the budget available or the time are limited.<br>5 - Through a monitoring of number of the annual visitors of the protected areas, and its comparison between the years t (before the beginning of forest harvesting activities) and t+n (after n years from the beginning of the activities). | | | |
| **Data sources and retrieval methods**<br>Data come from ad hoc empirical surveys. | | | |
| **Monitoring timeframe** | **Short** | **Medium** | **Long** |
| | Yes | Yes | Yes |
| **Links with other indicators** | | | |
| **References**<br>Willis and Garrod (1991); Breidert et al. (2006); Ciriacy-Wantrup (1947); Davis (1963); Louviere and Woodworth (1983); Adamowicz et al. (1994); Wilson and Hoehn (2006) | | | |

| Box | Title/Name of the "Case study" |
|---|---|
| **n. 5** | ***Analysis of the potential economic effects of forest biomass use for energy on the main ecosystem services provided by protected areas*** |

**Short description and geographic localization**

*The potential effects of forest biomass harvesting on ecosystem services in the Triglav National Park (located in the North-Western part of Slovenia along the Italian the Austrian borders) have been analysed using a four-steps approach.*

*First step - Economic evaluation of the ecosystem services*

*The ecosystem services have been analysed from the economic point of view (through the assessment of the market price of the wood production and the sequestered carbon, the replacement costs of protection against natural hazards, and the benefit transfer of the outdoor recreation value).*

*Second step - Estimation of the harvestable forest biomass*

*The energy potential from biomass has been estimated by means of r.green.biomassfor, an open source Decision Support System implemented as an add-on of GIS software GRASS 7.*

*Third step - Assessment of the effects of biomass withdrawal*

*The potential positive and negative effects of forest biomass harvesting on ecosystem services have been quantified through a questionnaire survey submitted to the local experts.*

*Fourth step - Analysis of the spatial effects*

*Through the use of module "r.impact" have been evaluated the spatial effects of biomass harvesting on the ecosystem services. This module requires the map with the value of ecosystem services in the shapefile format and the raster map of the energy potential of forest biomass.*

**Additional information**

| | |
|---|---|
| **Website/ Bibliographic references** | Grilli, G., Ciolli, M., Garegnani, G., Geri, F., Sacchelli, S., Poljanec, A., Vettorato, D. and Paletto, A. (2017). "A method to assess the economic impacts of forest biomass use on ecosystem services in a National Park", Biomass and Bioenergy, Vol. 98, No. 1, pp. 252-263. |
| **Contact details** | |

| Box | Title/Name of the "Case study" |
|---|---|
| **n. 6** | ***Assessment of the environmental, economic and social sustainability of forest biomass harvesting for energy in the Alpine Region*** |

**Short description and geographic localization**

*The environmental, economic and social sustainability of forest biomass harvesting in four case studies located in the Alpine Region, has been assessed through a set of four indicators; two of these are focused on the experts' opinions, the others two, are focused on the cost-benefit analysis.*
*The four case studies are located in different parts of the Alps:*

- *Triglav National Parks (Gonška Region, Slovenia);*
- *Mis valley and Maè valley (Belluno Province, Veneto Region, Italy);*
- *Gesso-Vermenagna Valley (Cuneo Province, Piedmont Region, Italy).*

*These case studies have been selected on the basis of their forest cover, the high percentage of land under protected-area status, the high tourist importance, and the importance of primary sector for the local economy.*
*The indicators focused on the experts' opinion have been collected through a semi-structured questionnaire, submitted to four groups of experts (one for each case study) which have been selected on the basis of their professional experience in the forest management and planning, the environment conservation, the rural development, and the renewable energy development. Furthermore, the experts have been selected on the basis of their expertise and knowledge if the local context.*
*The economic indicators refer to the potential energy obtained from forest biomass, and to the unit cost for energy production.*
*The first one, considers the annual potential primary energy that can be obtained from the forest biomass harvesting in each case study. The key variables considered are the annual increment (m3·ha-1·year-1) and the tree composition. The second indicator considers the costs per ton of chips taking into account the local harvesting, extraction, chipping and transport costs.*
*Finally, the ecosystem services considered are:*

- *The forest products provision;*
- *The water provision;*
- *The natural hazard protection;*
- *The carbon sequestration;*
- *The habitat quality;*

*The recreation value*

**Additional information**

| | |
|---|---|
| **Website/ Bibliographic references** | Grilli, G., Curetti, G., De Meo, I., Garegnani, G., Miotello, F., Pojanec, A., Vettorato, D. and Paletto, A. (2015). "Experts' Perceptions of the Effects of Forest Biomass Harvesting on Sustainability in the Alpine Region", South-East European Forestry, Vol. 6, No. 1, pp. 77-95. |
| **Contact details** | |

| Box | Title/Name of the "Case study" |
|---|---|

| n. 7 | Effects of traditional forest management on carbon storage in a Mediterranean holm oak (Quercus ilex L.) coppice |
|---|---|

**Short description and geographic localization**

*In the last decade, there has been increased interest in measuring and modeling storage in the five forest carbon pools: the aboveground and belowground biomass (living biomass), the deadwood and litter (dead biomass), and the soil (soil organic matter). In this paper, we examined carbon storage in a holm oak coppice stand in the Madonie Mountains in Sicily (Italy), which is a typical case of managed coppice stands. Today, traditional coppice practices are only applied to a small number of forested areas in Sicily, such as the selected site, because of the decline in demand for wood and charcoal. The dendrometric parameters of the stands were recorded, and silvicultural indices were calculated immediately after cutting as well as during and at the end of the rotation period; they showed the trends typical of coppices. The carbon stocks in the five carbon pools were quantified to investigate the effects of coppicing on carbon storage in this Mediterranean area. Results showed that the lowest living biomass values were observed in the first years following coppicing, except for litter carbon. Belowground biomass and the soil carbon stock did not vary significantly with coppicing. During the rotation period, the aboveground biomass was completely restored, and the balance of the carbon stocks indicates that coppicing is a sustainable forest management choice from the point of view of the carbon balance, given that the logged trees are generally used for bioenergy production.*

**Additional information**

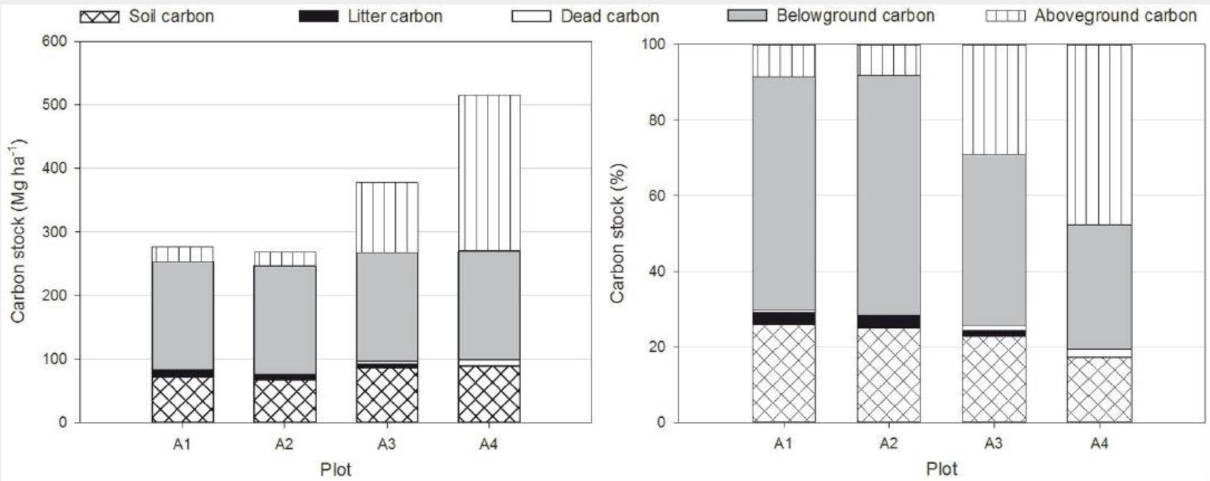



**Fig. 2** - Estimation of carbon stocks in the five carbon pools for each investigated plot.

**Tab. 3** - Carbon stocks in the living and dead biomass of each forest stand. For a given carbon pool, values followed by the same letter are not significantly different ($p>0.05$) according to Tukey's Honestly Significant Difference test.

| Plot | Living biomass | | Dead biomass | |
|---|---|---|---|---|
| | $C_{abv}$ (Mg ha$^{-1}$) | $C_{blw}$ (Mg ha$^{-1}$) | $C_{litter}$ (Mg ha$^{-1}$) | $C_{dead}$ (Mg ha$^{-1}$) |
| A1 | 23.87 $^{a}$ | 170.93 | 8.65 $^{a}$ | 1.61 $^{a}$ |
| A2 | 22.00 $^{a}$ | 170.93 | 8.71 $^{a}$ | 0.06 $^{a}$ |
| A3 | 109.82 $^{b}$ | 170.93 | 6.08 $^{b}$ | 4.89 $^{ab}$ |
| A4 | 245.67 $^{c}$ | 170.93 | 2.02 $^{c}$ | 9.56 $^{b}$ |

**Tab. 4** - Soil carbon stocks ($C_{soil}$, Mg ha$^{-1}$) and total carbon stock ($C_{stock}$, Mg ha$^{-1}$) of each forest stand (± standard error). For a given carbon pool, means followed by the same letter are not significantly different ($p>0.05$) according to Tukey's Honestly Significant Difference test.

| Plot | $C_{soil}$ (Mg ha$^{-1}$) | $C_{stock}$ (Mg ha$^{-1}$) |
|---|---|---|
| A1 | 71.83 ± 9.54 $^{*\,a}$ | 276.89 ± 31.37 $^{*\,a}$ |
| A2 | 67.25 ± 4.86 $^{a}$ | 268.95 ± 31.49 $^{a}$ |
| A3 | 85.89 ± 14.56 $^{a}$ | 377.61 ± 31.77 $^{a}$ |
| A4 | 87.90 ± 11.66 $^{a}$ | 516.08 ± 46.97 $^{a}$ |

| Website/ Bibliographic references | Sferlazza S, Maetzke FG, Iovino M, Baiamonte G, Palmeri V, La Mela Veca DS (2018). Effects of traditional forest management on carbon storage in a Mediterranean holm oak (*Quercus ilex* L.) coppice. iForest 11: 344-351. doi: 10.3832/ifor2424-011 |
|---|---|
| Contact details | sebastiano.sferlazza@unipa.it |

# 5 PRELIMINARY ASSESSMENT IN THE STUDY AREAS

In order to assess the impacts on the biotic and abiotic component, the methodology has been applied to the project study areas through the compilation of an assessment matrix for each forest habitat type (sensu "Habitats Directive") and for each forest categories not included in the "Habitats Directive”. Forest habitat types with the same impact magnitude and with the same resilience time, for all the forestry activities, were lumped in a single matrix.

The assessment matrices have been elaborated in order to define, at a preliminary level, the potential impacts that could be determined by the operations for the extraction of biomass in forest areas included in the protected areas taking into account the rules for the protection of the envisaged Natura 2000 sites.

The assessment matrices were compiled by experts in habitat/species based on their experience and knowledge of the study areas.

Project study areas and the Natura 2000 sites that insist inside them, present different ecological as well social and economic characteristics and this reflect to the assessment of the potential impacts. For example the distribution as well as the quality and importance of an habitat in a site affect the assessment; therefore the assessment of the impacts on the same habitat in another site may bring to different evaluations.

With reference to the effects that could derive from the development of a forest-wood-energy supply chain on the socio-economic and demografic situation of each study area, were applied some of the indicators selected to measure these effects, using for each study area, the available statistic data needed to calculate the indicators.

The study areas in which the methodology was applied and the annexes containing the respective reports, are listed in the following table:

| Country | Study Area | PPs | Annexes |
|---|---|---|---|
| **Italy** | Regional Natural Park of Madonie | LP | Annex 1 – Study area report_ITALY |
| | | PP1 | |
| | | PP2 | |
| **Slovenia** | Škocjanske Caves Regional Park | PP3 | Annex 2 – Study area report_SLOVENIA |
| | | PP4 | |
| **Spain** | SPA ES0000212 "Sierra de Martés-Muela de Cortes" (including SAC Serra d'Enguera and Navalón forest V-074) | PP5 | Annex 3 – Study area report_SPAIN |
| **Croatia** | Nature Park Telašćica<br>Nature Park Vransko jezero<br>Nature Park Velebit | PP7 | Annex 4 - Study area report_Zadar County_CROATIA |
| | | PP8 | Annex 5 - Study area report_ Lika Senj County _CROATIA |

# 6 FINAL REMARKS AND RECOMMENDATIONS

This deliverable has been produced to provide the decision makers and the operators with an appropriate tool to assess and monitor the impacts determined by the extraction of biomass in the protected areas, taking into account the social and economic factors characterizing the areas.

The methodological approach focus to the forest operations that could determine direct effects to the habitats and the species of the protected areas in order to safeguard their ecological functions.

The indicators that were selected and shared with all partners refer to a wide range of forest operations and the potential threats that may will occur. The indicators were defined basing on common technical and scientific documents and comply with EU directives and guidelines. Therefore the adopted methodology guarantees a wide flexibility as well as the transferability in the whole MED area.

The indicators set allow to assess, ex ante and ex post, the forest operations for the biomass extraction and more generally the management of the forest areas in the protected areas, ensuring the compliance with the conservation objectives established by the management plans of the Natura sites 2000.

In the following tables the forest habitat type (sensu "Habitats Directive") and the forest categories not included in the "Habitats Directive" present in the Natura 2000 sites of each country are listed:

Table 6.1: List of forest habitat type (sensu "Habitats Directive") present in the Natura 2000 sites of each country

| Country | Natura 2000 Habitat Code |
|---|---|
| **Italy** | 91M0Pannonian-Balkanic turkey oak –sessile oak forests |
| | 91AA* Eastern white oak woods |
| | 9210*Apennine beech forests with Taxus and Ilex |
| | 9220* Apennine beech forests with Abies alba and beech forests with Abies nebrodensis |
| | 9260 Castanea sativa woods |
| | 92A0 Salix alba and Populus alba galleries |
| | 92D0 Southern riparian galleries and thickets (Nerio-Tamaricetea and Securinegion tinctoriae) |
| | 9330 Quercus suber forests |
| | 9340 Quercus ilex and Quercus rotundifolia forests |
| | 9380 Forests of Ilex aquifolium |
| | 9540 Mediterranean pine forests with endemic Mesogean pines |
| **Spain** | 9340: Quercus ilex and Quercus rotundifolia forests |
| | 9540 Mediterranean pine forests with endemic Mesogean pines |
| | 92A0: Salix alba and Populus alba galleries |
| | 92D0: Southern riparian galleries and thickets (Nerio-Tamaricetea and Securinegion tinctoriae) |
| **Slovenia** | 9110 Luzulo-Fagetum beech forests |
| | 91K0 Illyrian Fagus sylvatica forests (Aremonio-Fagion) |

| | |
|---|---|
| | 9410 Acidophilous Picea forests of the montane to alpine levels (Vaccinio-Piceetea) |
| **Croatia** | 5210 Arborescent matorral with Juniperus spp. |
| | 91K0 Illyrian Fagus sylvatica forests (Aremonio-Fagion) |
| | 91L0 Illyrian oak-hornbeam forests (Erythronio-Carpinion) |
| | 9410 Acidophilous Picea forests of the montane to alpine levels (Vaccinio-Piceetea) |
| | 9530 (Sub-) Mediterranean pine forests with endemic black pines |

Table 6.2: List of forest categories not included in the "Habitats Directive" present in the Natura 2000 sites of each country

| Country | Forest categories not included in the "Habitats Directive |
|---|---|
| **Italy** | Broadleaved reforestation |
| | Coniferous reforestation |
| | Tree plantations for wood production |
| **Spain** | - |
| **Slovenia** | Coppice beech and oak forests |
| | Black pine plantations |
| **Croatia** | Allochthonous coniferous reforestation (Pinus halepensis) |
| | Autochthonous broadleaved reforestation (Ostryo-Quercetum pubescentis (Ht.) Trinajstić 1979, Querco – Carpinetum orientalis H-ić 1939., Fraxino orni – Quercetum cerris Stefanović 1971 ) |

In the next paragraphs summary considerations regarding the assessments carried out in the involved study areas are reported.

Furthermore measures and recommendations to mitigate the impacts deriving from forest operations or improve the impact reversibility are exposed.

## 6.1 Biotic component

### 6.1.1 Plant communities

Biomass extraction impact assessment, independently evaluated by local partners, shows significant trends in estimated magnitude and reversibility regarding plant communities, proving the flexibility and consistency of the proposed methodology,  notwithstanding the variety of phytocoenoses considered.

Within all study areas some particularly sensitive habitats are present, where felling and arrangement operations would produce significant impact, especially for what regards the direct removal of natural vegetation, the alteration of floristic composition and the interference on natural regeneration. Nonetheless, in several Natura 2000 habitats, thinning operations could be considered and might even prove beneficial in some instances, as long as they are aimed at favouring the creation of more evolved communities and proper care is taken in storing and yarding activities. Infact, the use of machinery might cause damage to vegetation and alter floristic composition. Of course, the most significant impacts are associated with clear cutting operations, that should be avoided or, if deemed absolutely necessary (and allowed by local regulations), properly assessed and mitigated. As expected, foreseen impacts on plantations are limited.

The main general threats to several habitats, non related to biomass extraction, are the progressive aging of coppices and the risk of fire.

Sustainable biomass extraction, although posing different potential threats on its own, might actually prove advantageous to some extent. Silvicultural actions such as thinning, aimed at constituting coppice with standards systems and high forest systems, would be beneficial in some instances, with the long-term goal of creating more evolved ecosystems and favouring seed reproduction instead of agamic reproduction. These type of operations should take place following a proper harvesting plan, in strict compliance with Management Plan directives, regional rules and other existing regulations. Felling operations should be performed under favourable conditions, trying to minimize the adverse effects on natural vegetation and regeneration. The use of heavy machinery should be avoided as much as possible.

Clear cutting should be avoided and, if considered and properly assessed, should take place only on very small surfaces, on gentle slopes, and when it could favour the natural evolution of vegetation, always in strict compliance with existing regulations.

Regarding storing activities, the use of winch is more damaging than raceways, which should be preferred when technically possible. In both cases, proper planning is advised, reducing landings and the number of trails to a minimum. A smaller number of trails will reduce direct impact on natural vegetation and regeneration and associated impacts due to personnel activity.

Yarding activities using raceways should produce very limited impacts. The use of tractors should be restricted to existing pathways, preferably outside of wooded areas. As a general rule, the use of pre-existent access roads and forest trails should always be preferred and new forest trails should be created only to allow personnel or work animals to access the areas instead of using heavy machinery.

Fire prevention measures should take place as well, taking into account vegetation spatial distribution and different plant adaptations to fire. Fire hazard reduction policies should be aimed at intervening on key factors such as ease of ignition and fire suppression difficulty. Load and arrangement of live and dead fuel should be controlled through firebreaks, deadwood removal, grazing (after assessing appropriate grazing capacity), proper pruning and thinning.

Even though an amount of deadwood removal may be beneficial, the extent of intervention should be properly assessed. Infact, deadwood is an aspect of the process of nutrient cycling, providing a steady, slow-release source of nitrogen, and may play a significant role in carbon storage. Deadwood in various stages of decomposition and diverse spatial arrangements provides habitat for numerous organisms. Standing dead trees and fallen debris provide a diverse array of microhabitats suitable for a wide range of saproxylic (deadwood-dependent) organisms including fungi, lichens, and mosses, many of them having very specific requirements, and some specialising exclusively on one particular microhabitat. Colonization of deadwood by vascular plants is as important, with species richness and abundance of plants increasing with log diameter and decomposition and for small-seeded plants. Therefore, a constant deadwood supply is crucial to maintain the diversity of this substrate and allow the natural dynamics of deadwood-dependent species populations.

Phytosanitary interventions should be assessed on a case by case basis, especially in regard to old age trees.

### 6.1.2 Animal communities

In spite of the ecological, compositional and structural differences among the forest types present in the different study-areas included in present project, the possible threats to the animal communities independently evaluated by the local partners show some clear trends in their estimated magnitude and reversibility, which support the soundness and exportability of the produced matrices as a planning tool to other case-studies.

In particular, felling and arrangement linked with clear cutting practices are univocally pinpointed as the most threating practices for the animal communities, both as their impact and their reversibility are concerned. Conversely, a general agreement is achieved on the scarce impact and rapid reversibility of the evaluated silvicultural and harvesting practices as noise and casualties are concerned.

In good accordance with the available scientific literature, produced results thus confirms that, with the noteworthy exception of tree plantations for wood productions (where even clear-cutting practices might have a limited impact on the occurring animal communities, e.g. see the matrices dealing with the Sicilian study-area), only thinning and salvage cuttings or (in limited cases) crown pruning activities should ideally be carried out in protected areas. Moreover, under the scientific supervision of the local managing authorities, such “less-impacting” silvicultural practices are expected to be beneficial on the long-term, leading the conversion to forest coppices to high-stands with the subsequent increase in habitat complexity and resource availability for the most precious and specialised taxa linked with forest ecosystems (e.g. the saproxylic beetles).

However, it should also be stressed that the peculiarities of some study-areas lead to some differences in the compiled matrices, which further confirm their nature of a flexible tool exportable to markedly different situations. In the Croatian study area, the risks associated with the decrease of habitat suitability and with the decrease of the availability of trophic resources are considered equally pernicious and poorly reversible for all the possible silvicultural activities considered, included thinning and salvage cutting. This is due to the presence in the study area of old forests and of a rich and vulnerable fauna of forest-specialised taxa, which would be likely threatened by any forestry activity. In such cases, the carrying out of any silvicultural practice should be cautiously considered and discussed, with a dedicated in-deep evaluation of the risks and potential benefits associated with the planned activities.

Local biodiversity loss due to biomass extraction is mostly due to forest degradation and the consequent alteration or complete disappearance of microhabitats (such as dead wood, cavities, or mature trees) that host most of the forest biodiversity.

However, as clearly stressed by the matrices here produced for all the countries involved in the project, some silvicultural practices might have a heavier influence on forest animal species than others, due to differences in habitat structure and connectivity after the biomass harvest.

In particular, thinnings and salvage cuttings, which leave on-site individual old trees and\or groups of trees, are expected to allow to maintain most of the pre-existing structural diversity of the forest, with a consequent positive effect on the maintenance of habitat suitability for forest-specialised plant and animal taxa. In fact, such silvicultural practices are actually similar to the effects of natural small-scale disturbance, resulting in a *post-operam* increased environmental heterogeneity, and possible long-term beneficial effects on the local biological communities. Conversely, clear cuttings prevents from maintaining high biological diversity in the affected forest stands, disrupting not only the local ecosystem themselves, but also the connectivity among residual forest stands.

Accordingly, both literature data (e.g. see the boxes presenting relevant case-studies) and present analyses are concordant in strongly recommending the realisation of thinnings or salvage cuttings as preferred silvicultural practices when a sustainable biomass extraction from protected areas is desired or needed.

## 6.2 Abiotic component

Each partner assessed the impacts of biomass extraction for bioenergy purposes from forest stands included in the Habitat Directive and plantations. Notwithstanding the study areas showed differences in habitat and harvesting practices considered, the threats to the abiotic components highlighted some common trends in terms of magnitude and reversibility of impacts:

1. More intensive harvesting practices, such as clear cutting or shelterwood cutting performing an excessive reducing of canopy density may have tangible impacts on amount of deadwood and litter, on the activation of erosive phenomena, on changes of fuel model features;
2. Thinning and salvage cuttings or (in limited cases) crown pruning activities may be more sustainable;
3. Storing and yarding operations by tractors and winches have more impacts than by raceways;

Chipping is always a sustainable post-harvesting practice.

Below, we propose a list of possible mitigation measures aimed at water regulation and hydrogeological protection on steep mountainous slopes and/or under open forest canopies that can be adapted according to the regional context, modulating them according to local management rules and practices:

**Increase the amount of deadwood**. In Mediterranean region the amount of deadwood is quite low because of the faster decay rate and because of local people gathering deadwood (collecting logging residues and stump harvesting). Deadwood is not just important for water regulation and hydrogeological protection, it also has considerable ecological value for wide range of plant and animal species which depend on deadwood as a habitat or food source for all or part of their life cycle such as fungi, bryophytes, invertebrates, lichens, birds and mammals. Creating, maintaining and managing deadwood habitats is seen as a key component of improving the condition of forests and of the sustainable management of plantations. Types of interventions:

- Leave a proportion of deadwood component: concentrate it in areas of high ecological value, where there is existing deadwood and where linkages can be provided between deadwood habitats; avoid uniform distribution across the forest stand and excessive accumulation of woody debris that can make forests more vulnerable to fire risk.
- Retain any snags, stumps and fallen deadwood where insufficient exists.
- Identify and retain potential old-growth trees or trees with decaying wood, select and manage suitable individuals to eventually take their place.

**Reduced-Impact Logging (RIL).** Conventional logging practices are often highly destructive to forest ecosystems. Heavy machinery (i.e. tractors with winch) can compact the soil with an increase of bulk density and remove of the litter, while high-volume harvesting can contribute to erosion, and reduce species diversity and regenerative capacity.

The RIL prescriptions include:

- Drawing up a forest harvesting plan.
- Conducting felling operations under favorable conditions (e.g. dry soils).
- Felling and arrangement operations in the cutting area as a practice of low environmental impact aimed at limiting the effects on soil of the train (tractor with winch) during storing and yarding operations.
- Using raceways for storing and yarding operations.
- Limiting the cutting site according to regional rules.
- Minimizing the number of skid trails for log removal, linking felling directions to them, and using minimal size landings.
- Using pre-existent access roads and forest trails.
- Creation of new forest trails for people and work animals without packs the aid of machineries.
- Avoiding clear cutting or apply it limiting the cutting site on slopes with low slope.
- Biomass including the tops and limbs of felled trees, logs, stumps, dead and rotten trees, and non-merchantable timber can be chipped and burned as a source of fuel or grinded to produce finer chips for pulp. Low amount of biomass chipped can be left in the soil aimed at increasing SOC or it can be distributed along forest trails to reduce the impact of machineries.

**Fire risk prevention**. Fire prevention requires knowledge of the spatial distribution of the vegetation and the adaptations that vegetation can exploit to respond to fire. The fire behavior depends on the composition, structure and phenology of the fuel elements, on their mass, compactness and continuity, both horizontal and vertical ("fuel ladder"), and on their moisture content. Fire prevention aims to manage fuel conditions by reducing fire hazard over a given territory, i.e. the level of both ease of ignition and fire suppression difficulty. The load and the arrangement of both live and dead fuels (i.e. reducing tree density and canopy cover, decreasing basal area, increasing the height-to-live crown base) can be modified through:

1. horizontal, linear isolation of fuel (e.g. through firebreaks);
2. fuel reduction through physical removal;
3. surface fuel reduction also by prescribed grazing;
4. change of fuel bed compactness by lopping and scattering and chipping;

5. breaking vertical continuity through pruning;
6. change of fuel moisture content through dead fuel removal and/or introduction of understory vegetation;
7. thinning types: thinning type affects vertical fuel continuity and crown fire potential. It includes low (thinning from below), crown (thinning from above) and selective thinning. All the three types reduce average canopy density but their influence on canopy structure differ.

The most successful methods to change potential crown fire occurrence and severity are to:

1. reduce surface fuels;
2. increase the canopy base height;
3. reduce canopy density;
4. reduce continuity of the forest canopy;
5. keep big trees of resistant species.

## 6.3 Social, economic and demographic components and ecosystem services

The methodology approach that has been adopted, not only have allowed to define a valid instrument for the assessment of risk and benefits arising from the extraction of biomass on the social, demographic, and economic components, and introduce a possible criteria for the assessment of potential impacts on the ecosystem services, but also, it allowed to us to outline, from a social, demographic and economic point of view, although not always with the utmost precision, a preliminary scenario of areas in which the project is and will be developed, achieving a multiple objective.

Unfortunately, large proportion of data collected for each area under study do not present a high degree of homogeneity. Without other, this inconvenience is to be correlated with the use of different sources for the collection of data themselves, moreover the effect can results more amplified when the different sources come from countries that show profound differences in terms of organization and management of data, and, in addition, since they are related to rural and / or marginal areas, for which, generally, access to detailed information is not easy if not impossible. For example, some data refer to different time periods or are related to different territorial levels, which implies further difficulties. However, the carried out work and the obtained findings, even if need to be better processed, represent a good starting point for the next foreseen steps and activities by the project.

Taking into account the towns and municipalities, and the relative populations and business activities therein living and operating, which are potentially involved by the effects produced by the realization of a forest-wood-energy supply chain, the areas object of study, located in each of four countries, show several and deep differences both from social, economic and demographic point of view. In terms of surface, number of municipalities and/or towns, and number of inhabitants involved by the project and by the possible effects related, we found a great diversification.

The Spanish area is composed by the higher number of municipalities, that is 17, all included in the Valencian province. It shows the higher number of inhabitants (more than 95,000), while the Italian area (in turn composed by 15 municipalities, all belonging to the Palermo province) shows the higher value of population density (41.2 inhabitants/km$^2$).

The area the widest, instead, is those of Croatia with a territorial extension greater than 5,500 km$^2$ (considering both the Lika-Senj County and the Zadar County), but, in spite of the bigger territorial extension, the Croatian area shows the lowest population density (from 3.6 people/km$^2$ in the Lika-Senj County to 13.1 people/km$^2$ in the Zadar County) (Table 6.3).

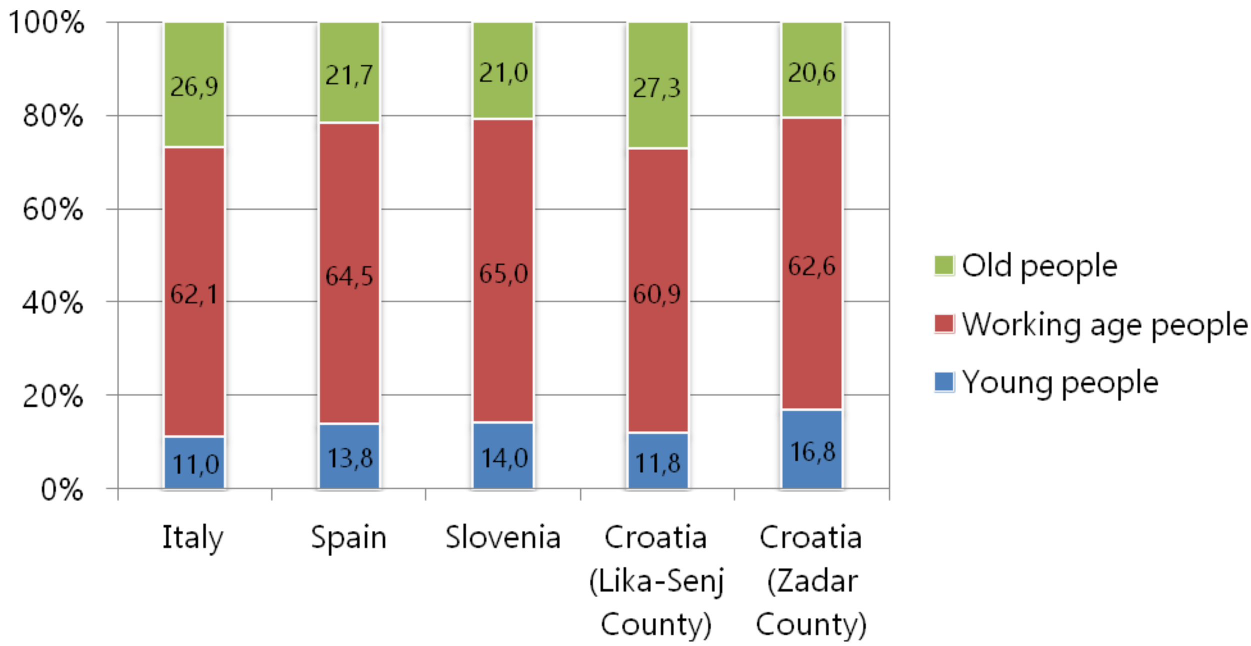
Table 6.3 – Socio-demographic characteristics (part one)

| | Italy | Spain | Slovenia | Croatia Lika-Senj | Croatia Zadar |
|---|---|---|---|---|---|
| Municipalities/Towns (n.) | 15 | 17 | 3 | 6 | 8 |
| Surface (km$^2$) | 1,308.8 | 3,873,8 | 851.1 | 3,195.7 | 2393.7 |
| Population (n. of inhabitants)[a] | 53,915 | 95,769 | 23,559 | 11,514 | 31,437 |
| Population density (inhabitants/km$^2$) | 41.2 | 24.7 | 27.7 | 3.6 | 13.1 |

[a] For Italian, Spanish, and Slovenian data are referred to 2017, while Croatian data are referred to 2011

Socio-demographic data show that Slovenian and Spanish populations are those characterized by the highest share of people in working age (65.0% and 64.5% respectively). Quite different is the status in Croatia. If on one hand the population resident in the Zadar County in Croatia show the highest percentage of young (people aged under 15 years) and the lowest percentage of old people (over 65 years old), respectively 16.8% and 20.6%, on the other hand, in the Lika-Senj County we found the lowest percentage of people in working age (only 60.9%) and the highest share of old people (27.3%), followed by Italian population which shows also the lowest percentage of young (11.0%) (Figure 6.1).

Figure 6.1 – Populations' distribution (on the basis of the age)




With reference to the only populations living in the studied area, Italian people shows the lower educational level, inasmuch only 41.7% of residents have an upper secondary degree; vice versa, Slovenian, and Croatian people living in the Lika-Senj County, show the highest level of education (72.0% of Slovenian people, and until 79.6% of Croatian population).

The lowest unemployment rate is shown by Spanish area, where only the 7.4% of people in work age are unemployed. More serious is the employment situation in the Italian area, where the rate is 16.3% and in some of municipalities of Croatian area, in which the unemployment accounts for 19.2% (especially in some municipalities in the Lika-Senj County).

Considering the diverse sources from which each partner received data, a correct comparison among the economic data characterizing the observed population is very difficult, in particular in light of the diverse nature of the collected data and the difficulties linked to the lack of information in particular at local level in the rural areas. Furthermore, the comparison among populations from different countries from an economic perspective, even through the most used economic indicators, is not easy because these cannot take into account of possible influencing factors. However, the collected data allow us to describe four heterogeneous scenarios. In the Spanish area people have the highest average value of per capita income (year 2013) that is 11,300 euro, followed by Italian (9,000 euro) and Slovenian (8,700 euro). In Croatia, where the national currency is not euro, the estimated per capita income shows a range between 266.6 euro and 333,3 euro in the Lika-Senj County and 625 euro per employed person in the Zadar County (Table 6.4).

Table 6.4 – Socio-demographic characteristics (part two)

| | Italy | Spain | Slovenia | Croatia | |
|---|---|---|---|---|---|
| | | | | Lika-Senj | Zadar |
| Educational level (%)[a] | 41.7 | 50.9 | 72.0 | 62.6÷79.6 | 51.4 |
| Unemployment rate (%)[b] | 16.3 | 7.4 | 9.8 | 14.2÷19.2 | 13.7 |
| Income (€)[c] | 8,950 | 11,320 | 8,738 | 266÷333 | 625 |

[a] Italian and Croatian data are referred to 2011 while Slovenian data are referred to 2016; [b] Italian and Slovenian data are referred to 2016 while Croatian data are referred to 2012 and 2013; [c] Italian, Spanish and Lika-Senj County data are referred only to the involved municipalities, while those of Slovenia and Zadar County are regional data.

About the information on the energetic production and utilization in the areas object of study, data show that only in Slovenia, and on a smaller scale, in Croatia, a share of consumed energy by public and private users is produced by biomass plants. In Slovenia this share is 42.0%, while in Croatia the same percentage shows a range from 0,2% represented by the energy used by service sector provided by district heating in the Lika-Senj County, to 12.0.% represented by the energy from biomass used in industrial sector in the Zadar County.

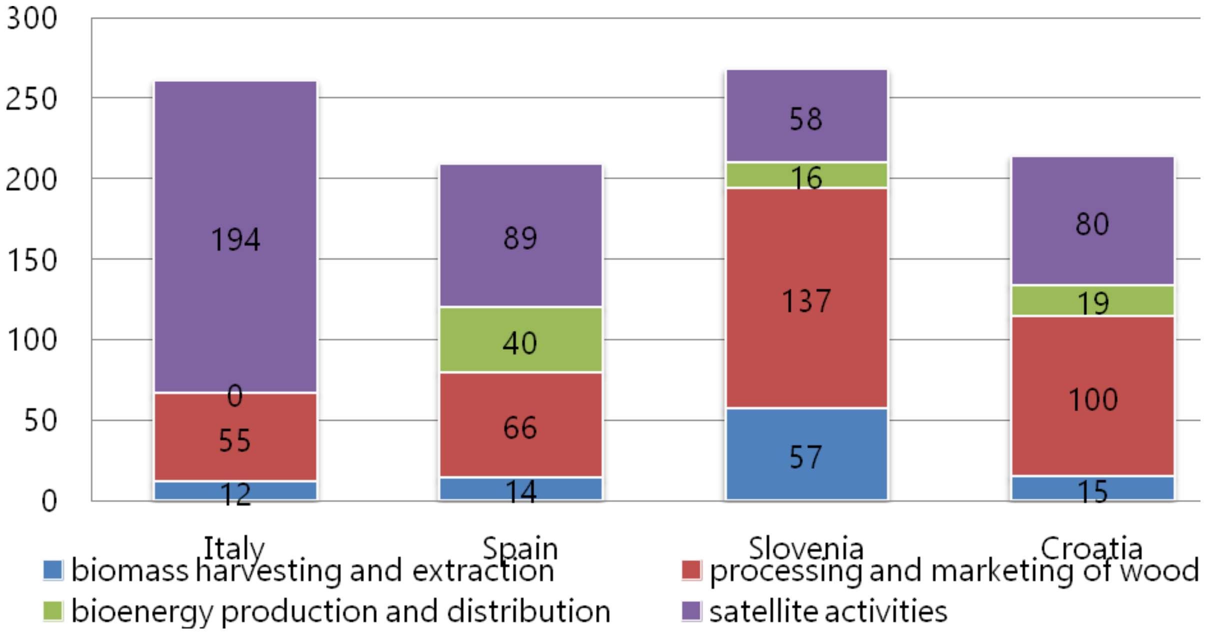
The socio-economic data contribute to provide a more detailed framework of interested areas involved in the project. In particular, as emerges from the collected data by each partners, the business activities operating along the forest-wood-energy supply chain, of each area differs, in terms of specialization and orientation on the basis to the vocation and to the characteristics of sites.

In terms of overall number of firms operating in each of area, the data collection results show that in Slovenia operate the greater number of firms (268), followed by Italy (261), Croatia (214), and Spain (209). Diversely from Italian firms, Slovenian firms operating in the supply chain are particularly concentrated in the first two steps of chain inasmuch 51.1% of firms operate in the processing and marketing of wood, and more than 21.3% of firms are involved in the utilization of forest through activities linked to the harvesting and extraction of wood. On the contrary, Italian firms are less involved in the activities inherent to the forest and wood utilization (25.6% in total), while are more oriented toward the activities linked to accommodation and tourist and recreational services (74.3%).

Among the other observed areas, the Spanish area shows the lesser number of work activities inasmuch there are only 209 firms that operate along the forest-wood-energy supply chain. In particular is present the highest number of firms involved in the production and distribution of energy (that represent the 19.1% of total firms registered).

Finally, in the Croatian area operate 214 firms (85 operate in the Lika-Senj County and 129 in the Zadar County) from which emerge, on the whole, a high number of firms involved in the production and distribution of energy from renewable sources (19), even if many of these use renewable sources diverse from biomass, like as sun and wind, and a good share of firms involved in the processing and marketing of wood (46.7%), while in the Zadar County there is a great concentration of firms operating in the satellite activities than in the Lika-Senj County, probably because the first County is closer to the Adriatic coast where tourism is more developed and the sights are more widespread (Figure 6.2).

Figure 6.2 – Firms distribution for each area




From the available emerges that in Italy and in Slovenia, the most part of investigated firms are individual firms, both those operating along the supply chain, and those operating in satellite activities. On the contrary Spanish firms are mainly companies, while those operating in Zadar County, are in part individual firms (especially those which operate in the first phases of supply chain), and in part companies (especially those operating in the other sectors) (Table 3).

From the economic point of view, the highest mean value of net income of firms has been revealed among firms operating in the process and trade of wood, with the exception of firms operating in the Zadar County where the most successful companies are those involved in the production and distribution of energy. But if in the Italian, Spanish, and Croatian (both Counties) cases, firms operating in the satellite activities show the second value in terms of net income, in the Slovenian area the second most performer firms are those involved in the biomass harvesting and extraction (Table 6.5).

Table 6.5 – Firms' characteristics

| | Italy | Spain | Slovenia | Croatia | |
|---|---|---|---|---|---|
| | | | | Lika-Senj | Zadar |
| Main legal forms (%): | | | | | |
| *- biomass harvesting and extraction* | 58.3[a] | 92.9[b] | 51.0[a] | - | 84.0[a] |
| *- processing and marketing of wood* | 68.4[a] | 95.5[b] | 66.0[a] | - | 79.0[a] |
| *- bioenergy production and distribution* | - | 90.0[b] | 56.0[c] | - | 100.0[b] |
| *- satellite activities* | 51.0[a] | 89.9[b] | 74.0[a] | - | 95.0[b] |
| Income (€): | | | | | |
| *- biomass harvesting and extraction* | 7,250 | 7,579 | 191,030 | 2,421 | 69,301 |
| *- processing and marketing of wood* | 541,693 | 58,116 | 821,807 | 39,607 | 73,613 |
| *- bioenergy production and distribution* | - | 5,071 | 24,644 | 5,828 | 921,605 |
| *- satellite activities* | 158,259 | 18,359 | 172,686 | 14,295 | 263,220 |

[a] Individual firm; [b] Company; [c] Complementary activity on the farm.

The physical size of firms, measured through the ratio between the number of employees on the number of firms for each of phases of supply chain, shows a great diversification. If in Spain and in the Zadar County the bigger firms are those operating inside the forests, in Slovenia and in the Lika-Senj County, the greater firms are those operating in the processing and marketing of wood. Diversely, in Italy the firms with the highest average number of employees are those which operate in the satellite activities.

In terms of efficiency, the specific adopted index, which takes into consideration both the physical and economic dimensions, show that firms with the highest mean value of Labour Productivity differ in each Countries.

If in Italy, Slovenia, and Lika-Senj County those operating in the processing and marketing wood are the most successful firms in terms of efficiency, in Spain and in the Zadar County, the most performing are those involved in the energy production and distribution. The limited available of data about employees and net income of companies, do not allow to provide a precise value of indicator, which, however, provide us an acceptable overall assessment.

How the reference literature suggests, the utilisation of forests, and protected areas can produce effects involving the ecosystems which can have important impacts both social, economic, and natural, that, how before mentioned can be positive or negative on the basis of type of ecosystem and the intrinsic characteristics of areas (Hastik et al., 2015; Fisher et al., 2009).

As already mentioned, the assessment of impacts that utilisation of forests can produce on ecosystem, can be obtained in terms of value of services provide by them, that as is known can be use values and non-use values (Plottu and Plottu, 2007), once the activities of harvesting and extraction of biomass began.

However, currently is not possible (with some exception) define an initial overview, as has been done for the socio-demographic and economic characteristics of observed areas, due to the lack of objective information about the extracted biomass, such as the volume, the characteristics of wood like species, quality, local prices, intended use, etc... that do not allow to assess the provisioning service's value, let alone of regulation service's value (like as the value of carbon sequestered by the harvested biomass or the protective function carried out by ecosystems), and the cultural service for which is need conduct specific investigation. With particular attention to the cultural, social and the integrating role that a protected area can plays, it is conceivable that the activities connected to the utilization of biomass (maintenance, cleaning, monitoring, etc...), can only that improve its accessibility and the usability, allowing to the parks to represent an important opportunity of development and growth (also in economic terms) for resident populations and local activities.

## GLOSSARY

**Thinning**: Trees cutting for the decrease of the number of trees from a forest.

**Shelterwood cutting**: the removal of most of the mature trees stand at the end of the rotation, but a portion of the mature stand is left standing. The shelterwood system involves a sequence of 3 cuttings:

1. Preparatory Cuttings: make the seed trees more vigorous and set the stage for regeneration.
2. Establishment/Seed Cuttings: open up enough vacant growing space to allow establishment of the new regeneration.
3. Removal Cuttings: uncover the new crop to allow it to fill the growing space.

**Salvage cutting**: the removal of dead trees or trees being burned, withering and malformed.

**Crown pruning**: the selective removal of lower branches to give a balanced arrangement of tree and to increase air and light.

**Clear cutting**: the complete and contemporary removal of the mature stand trees. This type of cut is performed on small areas (1-2 ha) and is practiced for the regeneration cutting of mature woods composed of heliophilous species (especially conifers) and in the coppising in the coppice woods.

**Cutting** or **felling**: it is the process of downing individual trees.

**Arrangement**: it is the process to reduce the cutted down trees into timber products.

**Storing:** Storage of timber products in storage areas using raceways or winches.

**Yarding**: it is the dragging of timber products from forest to roadside using raceways or tractors.

**Chipping**: it is the process of chipping by-products (biomass) generated from harvesting operations into boiler fuel. Biomass includes the tops and limbs of felled trees, cull logs, stumps, dead and rotten trees, and non-merchantable timber.

# Forest Bioenergy in the Protected Mediterranean Areas

**www.interreg-med.eu\ForBioEnergy**

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