Governance of pine forests and carbon credits

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Theoretical framework

The forestry projects and activities aimed to reduce emissions or to increase sequestration of the carbon dioxide (CO_2) in atmosphere compared to the ***baseline scenario*** are able to generate Carbon Credits (1CC = 1 tCO_{2eq}), potentially marketable on **carbon credits voluntary market**.

The forest resources can generate CC mainly in three ways:

1. Afforestation or reforestation, where carbon is stocked, and offsets are generated through the reestablishment of forest area;

2. Avoiding emission from deforestation and degradation;

3. Improved forest management (IFM) aimed to increases the carbon stocked in the forest or in the wood products (semi-finished and finished products).
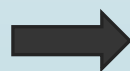
Aims of the LIFE FoResMit project

The main aim of this step of the LIFE FoResMit project is to analyze the economic impacts of silvicultural treatments (thinning) with special regard to the potential Carbon Credits (CC) generated by Sustainable Forest Management (SFM) activities.

Governance of the LIFE FoResMit project results:

✓ **International:** Aims of the *Paris Climate Agreement* (CoP21) concerning the reduction of greenhouses gas (GHG) emissions in atmosphere;

✓ **National:** National Law on forestry and forest-wood chain (D.lgs. n.34 del 4 April 2018) that provided the official national guideline for the generation of Carbon Credits from agricultural and forestry activities (art.7)

Material and methods

The impacts of two thinning (from below and selective) on climate change mitigation implemented in the Monte Morello forest during the LIFE FoResMit project were quantified through three steps:

✓ Step 1: Quantification of C-stock and C-sequestration changes due to the silvicultural treatments on five carbon pools (above- and below-ground biomass, deadwood, soil and litter);

✓ Step 2: Quantification of carbon dioxide (CO_2) emissions and other environmental impacts related to the realization of the cultural event "*Maggio in Centro*", held in Sesto Fiorentino - 20-22 May 2016;

✓ Step 3: Balance between carbon dioxide (CO_2) sequestration and emissions in term of Carbon Credits (CC).

Step 1: C-stock

The changes of C-stock – considering above- and below-ground biomass and deadwood – was quantified one year after the thinning.

The changes in C-stock were measured at the end of thinning considering **above- and below-ground biomass** using the following equation (eq.1):

$$C_{stock,i} = k \cdot [(1-b) \cdot (V_{i,SFM} - V_{i,baseline}) \cdot BEF \cdot WBD \, (1 + R_i)]$$

The changes in C-stock were measured at the end of thinning considering **deadwood** using the following equation (eq.2):

$$C_{stock-deadwood} = k \cdot \sum_n [(D_{i,SFM} - D_{i,baseline}) \cdot WBD]$$

Step 1: C-sequestration

C-sequestration was measured two years after thinning considering **above- and below-ground biomass, soil and litter**.

The effects of thinning from below and selective thinning on C-sequestration were estimated considering the difference compared to the baseline scenario:

$$\Delta_{C_t} = C_t - C_b$$

$$\Delta_{C_s} = C_s - C_b$$

Where:

C_b = tons of CO_2 sequestered by the annual wood increment in the baseline scenario (no SFM actions);

C_t = tons of CO_2 sequestered by the annual wood increment after the thinning from below;

C_s = tons of CO_2 sequestered by the annual wood increment after the selective thinning.

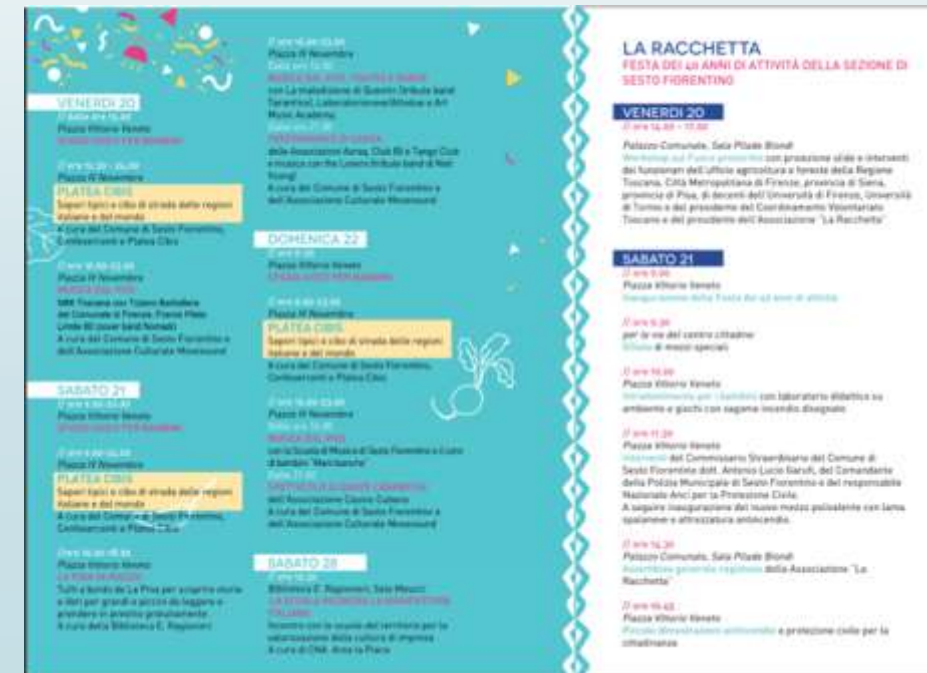# Step 2: CO$_2$ emissions from cultural event

The carbon dioxide (CO$_2$) emissions in the 3 days of the cultural event "*Maggio in Centro*" were estimated using *Life Cycle Assessment* (LCA) method collecting the following information:

1- **Direct measurements** collected during the 3 days of cultural event:

- ✓ Waste produced (n° waste bins and volume of each waste bin);
- ✓ Total number of visitors (quantified during the 3 days every 10 minutes).

2- **Indirect measurement** through face-to-face administration of a semi-structured questionnaires to the following actors:

- ✓ Organizers of the cultural event (Comune di Sesto Fiorentino municipality and "*La Rocchetta*" association);
- ✓ Exhibitors (18 exhibitors who attended the event);
- ✓ Sample of visitors (61 visitors).

Step 3: Balance of Carbon Credits

The final balance of impacts of the silvicultural treatments (thinning) on climate change mitigation was estimated in the following way:

- ✓ Quantification of CO_2 emissions from the realization of "*Maggio in Centro*" cultural event;

- ✓ Quantification of potential Carbon Credits (CC) that can be generated by silvicultural treatments (thinning from below and selective thinning);

- ✓ Governance of Carbon Credits (CC) in order to compensate CO_2 emissions of the cultural event or to allocate them in the voluntary carbon credits markets.

Voluntary carbon credit market is based on the Carbon Credit (CC) equivalent to one ton of carbon dioxide (CO_{2eq}) not emitted into the atmosphere from activities carried out with specific investments

Step 1: Results C-stock

The results show that after the thinning from below the C-stock decreases of **145 tCO_2 ha^{-1}** (96% of changes are in the above-ground and below-ground biomass and 4% in deadwood), while after the selective thinning the C-stock decreases of **220 tCO_2 ha^{-1}** (95% of changes are in above-ground biomass and 5% in deadwood).
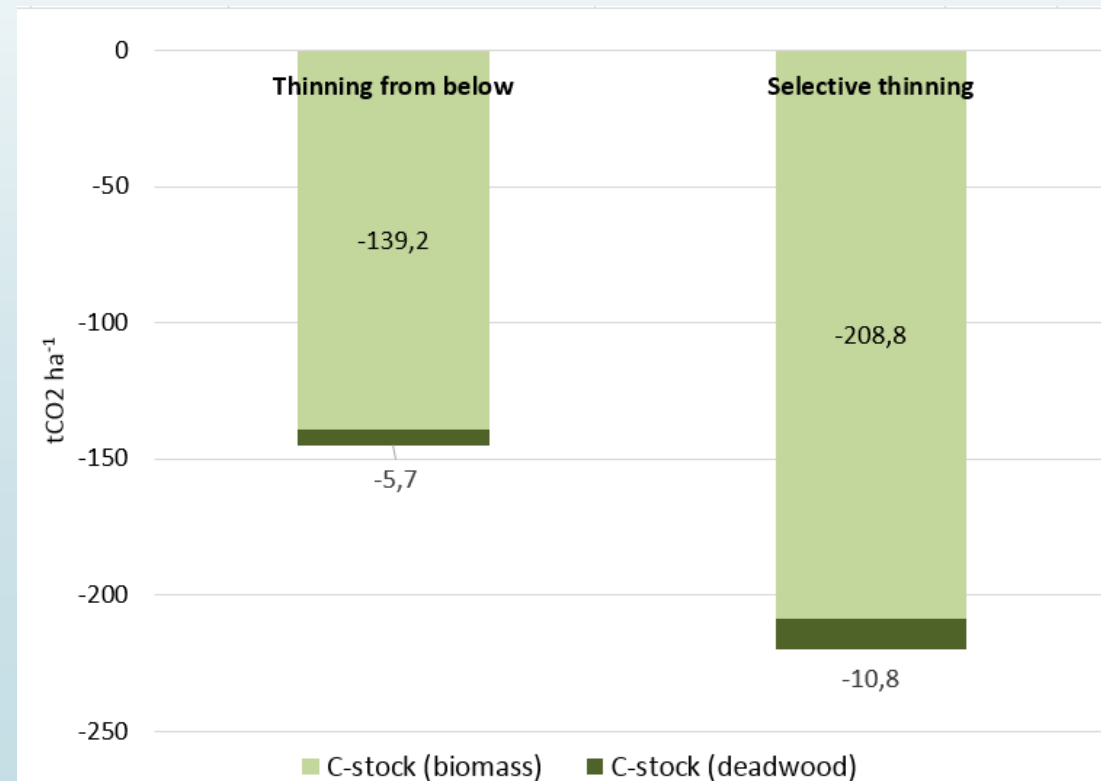
Step 1: Results C-sequestration

The annual increment before thinning is **12.2 m³ ha⁻¹ yr⁻¹** (baseline scenario), while the annual increment is **25.96** and **17.29 m³ ha⁻¹ yr⁻¹** after thinning from below and selective thinning respectively.

The C-stock can be recovered in 3 and 5 years respectively. After that, the degraded forest is able to generate a positive carbon flow equal to **51.3 tCO₂ ha⁻¹ yr⁻¹** (thinning from below) and **42.9 tCO₂ ha⁻¹ yr⁻¹** (selective thinning)
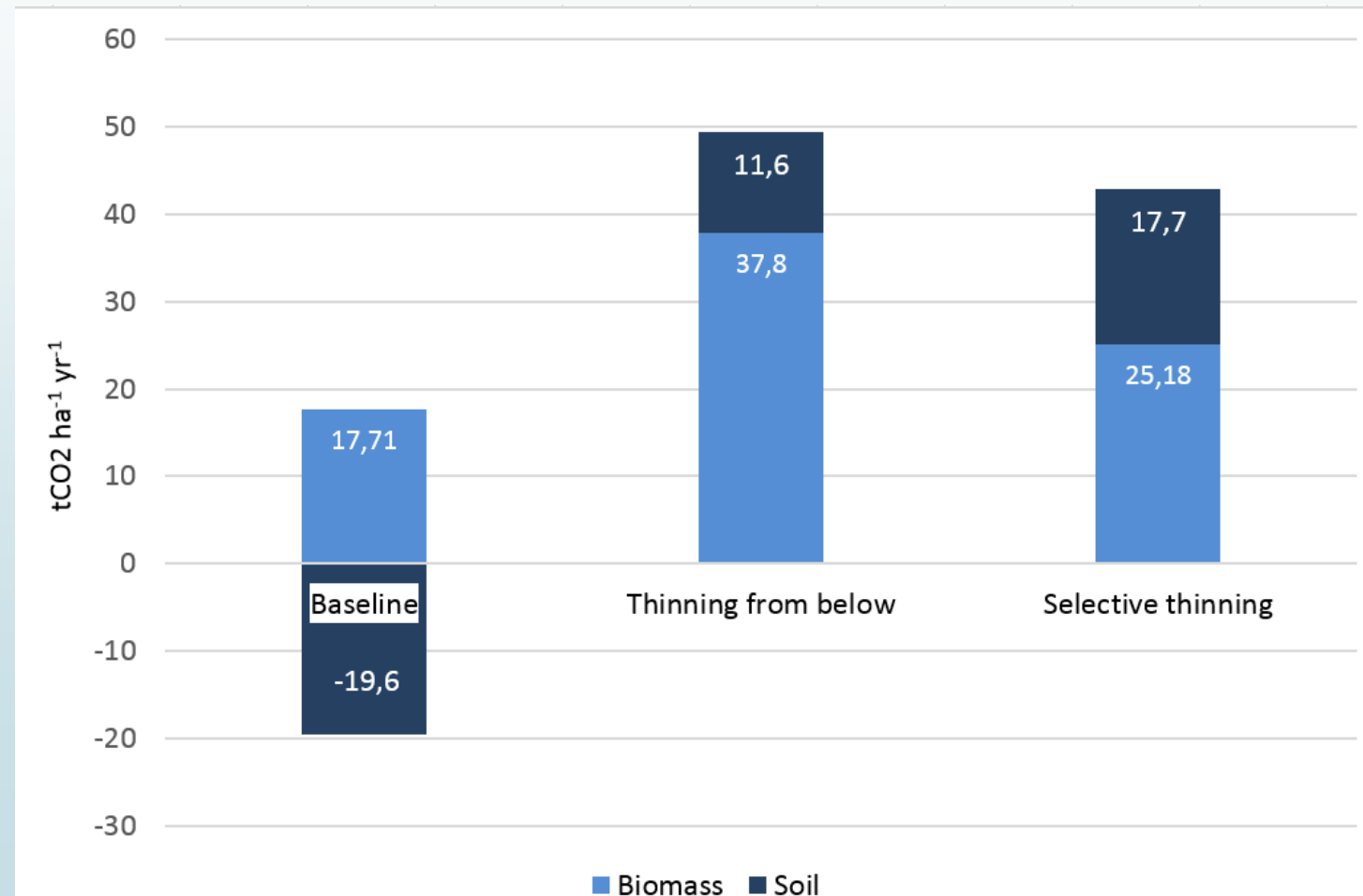
The data collected through direct and indirect measurements during the "*Maggio in Centro*" cultural event allowed to estimate the environmental impacts generated by event and the carbon dioxide (CO$_2$) emissions

Environmental impacts of the cultural event

~ 5000 Visitors

ENVIRONMENTAL IMPACTS		CO$_2$ ECONOMIC VALUES		ECONOMIC RESULTS	
Climate change	83.27 t CO$_2$ eq.	EUA (Min)	474,50 €	Events income	33,021.38 €
Particulate matter	0.16 t PM$_{10}$ eq.	EUA (Max)	504,47 €	Direct profits from products	29,021.38
Photochemical oxidant formation	0.53 t NMVOC eq.	CER (Min)	33,30 €	Gross profits	671.22 €
Terrestrial acidification	0.44 t SO$_2$ eq.	CER (Max)	34,13 €	Net profits	97.67 €
Freshwater eutrophication	0.01 t N eq.			VAT and taxes	6,995.86 €

EUA = European Union Allowances
CER = Certified Emission Reductions

Step 3: Balance of Carbon Credits

➢ Improved capacity of C-sequestration thanks to the forestry interventions (thinning) can be provide economic benefits (in term of CC) between 16 e i 43 € ha^{-1} yr^{-1} considering the current value of 1 CC (approximately 2.12 € ton of CO_{2eq}).

➢ The C-stock lost during the silvicultural treatments can be recovered in a few years (from 3 to 5 years) after which a positive balance is produced.

➢ The CO_2 emissions produced by small cultural event – e.g. "*Maggio in Centro*" – can be recovered through the active forest management of a few hectares of forest.

Conclusions

- The silvicultural treatments (thinning) in degraded pine forests: an initial loss of C-stocks (due to the conversion of biomass and deadwood in bioenergy), followed by a positive C-sequestration in the medium-long term;

- The differences between two thinning are limited. The selective thinning has a more positive impact on soil C-sequestration, while thinning from below has a more positive impact on above- and below-ground biomass C-sequestration;

- Carbon Credits (CC) are un interesting marketing tool (e.g., to compensate the CO_2 emissions from cultural and sportive events), but CC are also important economic repercussions if the silvicultural treatments are applied on wide area managed in a sustainable way (e.g., whole Monte Morello forest).