ADAPTIVE SILVICULTURE TO FACE UP TO THE NEW CHALLENGES: THE ManForCBD EXPERIENCE

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Goals of the ongoing LIFE+ 'Managing forests for multiple purposes: carbon, biodiversity and socio-economic wellbeing' are the design and implementation of adaptive silvicultural practices aimed at: (i) maintaining growth pattern, i.e. carbon sequestration and forest health and vitality over longer life-spans, (ii) reducing outstanding structural homogeneity and symmetrical competition, (iii) promoting as well the development of levels and types of biodiversity at the operational scale of silvicultural practice, i.e. at the stand level. Basic requirement of the applied practices is their economic feasibility. All of this seems to be the basic tool to face future unpredictability and provide wider adaptive ability to uncertain scenarios. Ten experimental trials, 7 in Italy and 3 in Slovenia, were established at the purpose. Four of them, all beech forests positioned along a latitudinal gradient, are considered in this paper. Cansiglio (Veneto) aged 120-140, Vallombrosa (Toscana) 110-160, Chiarano (Abruzzo) 70, Marchesale (Calabria) 75. The replicated experimental design compared (i) the customary practice of low to mixed thinnings over the full standing crop; (ii) the crown thinning at the older sites and the selective thinning releasing best phenotypes and removing direct crown competitors on a pre-fixed number (40-80 trees per unit area), at the younger sites. First results highlight the heavier harvesting of innovative vs. customary practice, this being allowed by the relatively high growing stocks due to full stand density. Stand structure is being moved and canopy arrangement changes as for crown texture, gaps' fraction size and distribution. Continuous monitoring as in the adaptive management protocol will provide further elements of analysis and suggest possible adjustments in the follow-up.

Keywords: adaptive management, pro-active silviculture, environmental change, ecosystem benefits, beech.
Parole chiave: gestione adattativa, selvicoltura pro-attiva, cambiamenti ambientali, benefici ecosistemici, faggio.

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1. Introduction

Forest ecosystems provide multiple goods and benefits through own woody and non-woody productions, protective and recreational functions and inherent biological diversity. Most of semi-natural forests in Europe have experienced however a long history of cultivation mainly focused on timber production. The long-lasting practices heavily modified the original stand structures, often originating stands with simplified structures far beyond the bio-ecological specific requirements.
Recent changes in forest management perspectives have resulted both in the decrease in wood exploitation and in the elongation of rotation periods. Harvesting time has become a somehow flexible concept and forests are experiencing as a matter of fact a lengthening of stand life-span. As a consequence, large forest areas are currently managed over the traditional rotation or are in a post-cultivation stage. Where applied, the former criteria of wood production-oriented silviculture are anyway, often less intensively, practiced. An early, exploratory phase between technical and biological permanence-time is therefore in progress. In these stands, trees are getting thicker and older, growing stocks are becoming higher and symmetrical competition acts as a lasting attribute. The diffuse protection regime in terms of cover, the onset of additional binding forces to pro-active management implementation, the less profitable wood harvesting, the other than productive functions prevailing, contribute the current condition (MCPFE, 2011; FAO, 2014).
Forests continue to keep a sustained growth even far beyond the former economic rotation (Spiecker *et al*., 1996; Kahle *et al*., 2008; Bertini *et al*., 2011) but they are reasonably unable to change their arrangement pro-actively, apart from natural, abrupt occurrences, unforeseeable to a great extent in their outcomes. The traditionally applied silviculture, when tailored to former main purpose of wood production, seems to be not suited to handle the current, new-targeted follow-up.

An additional, emerging benchmark to forest management is the progress of environmental conditions' shift. This involves directly both physics and chemistry of growth medium - atmosphere and soil - with concurrent and counteracting factors (increase of air temperature and CO_2 content, abrupt changes in rainfall regime, extreme events, airborne acidifying pollution, N fertilization, ozone level) (Ferretti *et al.*, 2014; Nabuurs *et al.*, 2013; Seidl *et al.*, 2014).

Because of the full involvement of growth medium attributes, tree growth level and pattern (i) provide the evidence of this occurrence and (ii) synthesize the balance between positive and negative inputs in the short, as well as in the long run (Solberg *et al.*, 2009). The analysis of complex relationships between factors highlights the role of drivers, the onset of limiting factors and feedbacks (Magnani *et al.*, 2007; de Vries *et al.*, 2008; Hetzold *et al.*, 2014; Stephenson *et al.*, 2014). Time elapsing since the biological community is being affected is relatively short because of the rate of change in progress and of its cumulative effect, e.g. the rapid turning point of N in the soil from 'tree growth stimulating factor to nutritional unbalancing and acidifying factor'. That is why monitoring of 'tree growth level and pattern' may contribute significantly the understanding of condition in progress and the adjustment of management (Dobbertin *et al.*, 2008; Lindner *et al.*, 2010).

Mitigation to climate change, major global driver, is contributed by forests through the maintenance or enhancement of inherent carbon sequestration and stock ability in standing crop and soil. This adds a new goal to the already manifold forests' functions and involves directly the design of management criteria.

Further to these assumptions, is the awareness of the increasing 'uncertainty' about the progress of environmental conditions' shift. The question is: are we living a path of change - this underlying a start and an end point - or are we going to live a perennial transition well-known in its beginning, but quite completely unknown in its further course? How fast it will proceed and which will be the prevailing direction of change and predictable feedbacks on complex organisms as forest ecosystems is quite unknown. That is why 'risk management' comes to be a customary companion to forest ecologists, managers and planners.

The ongoing LIFE+ project ManForCBD (Managing forests for multiple purposes: carbon, biodiversity and socio-economic wellbeing) is aimed at developing and testing novel adaptive silvicultural practices for the maintenance/enhancement of carbon storage and sequestration, i.e. forest mitigation ability, forest health and vitality, productive functions, types and levels of biodiversity. Reference is made to Criteria 1 to 4 of SFM -MCPFE.

Focus is made on the design and implementation of practices aimed at: (i) reducing the outstanding structural homogeneity and implicit symmetrical competition, (ii) maintaining tree growth over prolonged life-spans, (iii) enhancing the diversity of stand structures. Experimental trials have been established to implement, test and monitor the effectiveness of the developed management options for the achievement of these multiple objectives and provide data and guidance of best practice.

2. Materials

Four out of the ten sites of the project, i.e. beech forests distributed along a latitudinal gradient, were considered here: Cansiglio (Veneto) aged 120-140, Vallombrosa (Toscana) 110-160, Chiarano (Abruzzo) 70, Marchesale (Calabria) 75.

Standing crop attributes at each site are the heritage of techniques ruling past silvicultural management. In Cansiglio, forestry is documented consistently since 1200-1300 under the Republic of Venice. First management plan dates 1638; the establishment of 'National forest' is dated 1871 and the first 'modern' plan (Morelli) was implemented in 1930 (Bessega, 2008). Stand regeneration is being successfully established following the group shelterwood system and the uniform physiognomy is carefully shaped here by the long-lasting standard techniques aimed at timber production throughout the forest compartments. Only few patches, irregular for position, reduced site-index and/or specific composition, are being excluded, as a rule, from management. This background and the site quality, optimal to beech vegetation, make this forest the prototypical pre-alpine beech forest regularly managed for purpose of wood-production.

The management history of Vallombrosa is closely linked to centuries of forestry activity implemented by the friars of local Benedictine Abbey and subsequently by the National Forest Service. Current standing crops at the test-site originated partly from the reafforestation of pastures beyond the pristine forest edge and partly from the conversion of former coppice into high forest (Galipò, 2012, personal communication). Current physiognomies varied between the more regular, grown dense even-aged crops, and the less homogeneous former coppice characterized by the scattered, grown-up standards and the stems selected on the original stools, now indiscernible from trees originated from seed. This composite history is still recognizable in the current physiognomy of the beech high forest.

Chiarano is the typical beech transitory crop becoming established since the suspension of former coppice harvesting since mid 1900 and undergoing periodical thinning aimed at reducing progressively shoots' number on each stool and maintaining a full crown cover all over the conversion cycle. Number of standards is quite reduced resulting in a fairly homogeneous stand structure. The age-related tree density is high and crowns are small-sized and upper-inserted. An outstanding symmetrical competition is frequently observed in these crops (Del Rio *et al.*, 2014), it being temporarily settled by periodical thinning in the still young forest. Marchesale, geographically opposite to Cansiglio, summarizes the distinctiveness of southern beech forests as for the management history and the higher diversity of Mediterranean-mountain environments. Last, unfinished regeneration cutting: an arrangement between the group shelterwood, the clear-cut and the clear cut with reserves systems, released around the first half of 1900 grouped or single stems of former cycle, at now standing out among the dominant crop. The patchy presence of silver fir mother trees and of close regeneration cohorts scattered in the beech forest, provides further spots of specific and structural diversity. The resulting physiognomy is therefore less regularly distributed throughout the full cover. Bedrock and climate (Table 1) are optimal to beech vegetation at all sites from the pre-alpine environment up to the very southern Apennines outcrops. Main mensurational parameters at the sites are reported in Table 2.

3. Methods

3.1 Rationale of silvicultural practices

Customary technique, common to all case-studies, is the mass tending of standing crop according to main, but not exclusive, wood production purpose. Low (first stage) to mixed (following stages up to harvesting) thinnings rule the applied criteria following the mass regeneration pattern under the shelterwood system. Such technique is canonical to beech requirements and aimed at getting quality timber as well as at matching the specific bio-ecological attributes, i.e. beech shade tolerance and its natural trend to build up evenaged, one-storied stands. This was the context of management under the quite steady environmental conditions and before the shift in progress.

The working hypothesis moved from the following rationale: face up to the emerging changes by a pro-active silviculture, to meeting mitigation demand whilst maintaining tree 'health and vitality' and promoting biological diversity. The economic sustainability of techniques employed is a basic requirement to make them easily enforceable in the practice of management. Carbon sequestration implies the maintenance of a consistent growth efficiency for the expected prolongation of stand life-time, this being too the basic awaited attribute for growing out 'healthy and vital' higher stocks. In the meantime, role of the applied practices is to reduce current evenness while implementing cost-effective interventions.

The proposed adaptive silvicultural practices focused on tree canopy, i.e. the physical layer where tree growth takes place, where individual potential is being naturally developed or may be promoted through crown differentiation, where an active interface works between inner, outer and the full range of intermediate conditions. The assumption was the design of manipulative practices usefully addressed to the main crown layer to make available further growing space, promote a more effective crown-stem-root ratio, ensure further growth, differentiate current evenness, get patches inside housing more diverse living communities. Basically, move from a mass tending aimed at growing trees sized and shaped likewise as in the customary practice, to a targeted crop tending supporting and promoting both growth and the more balanced development of best phenotypes or a selected set of trees within the dominant layer, as in the 'crown' and in the 'selective' thinning practice. The progress of shifting conditions calls for its enforcement even at different, intermediate ages of stand lifespan as in the case-studies, in spite of the canonical application ruling each thinning type since earlier stages of stand development. Both method and context of practices' enforcement inform the typical attributes of an adaptive approach.

3.2 Experimental design

LIFE rules foresee, among others, the 'demonstration' character of implementation practices, this allowing to work on a wide area in the case - 30 hectares at each site - i.e. an operational scale as for silviculture and forest management.The replicated design compared (i) the customary practice i.e. the low to mixed thinning over the full standing crop; (ii) the innovative criterion, i.e. (a) the crown thinning at the older sites, Cansiglio and Vallombrosa; (b) the selective thinning releasing a pre-fixed number of trees (40-80 per unit area) and removing direct crown competitors at the younger sites, Chiarano and Marchesale. The thesis of no intervention has been added at the three high forest sites both as 'control' and as possible, current management choice in progress.

4. First results

Main mensurational parameters at the sites (Table 2) provide values and range at the time of survey as a function of site-index, dominant stand age and origin (seed or agamic), cultivation history, namely applied regeneration cutting type and thinning regime over the life-span. Standard deviation summarizes variability within the standing crop. Tree density drops as a function of stand age and thinning intensity, being also influenced by the distributive pattern. Its value at Cansiglio and Vallombrosa, two stands aged about likewise, suggests the more conservative management at the latter site, whilst Marchesale averages out the inner tree density variability due to the patchy release of former cycle trees. Chiarano exhibits vice versa the customary density of coppice forests undergoing the intermediate phase of conversion into high forest. Basal area is age-dependent but much less sensitive to tree density variation where, as in the case-studies, crown cover is quite complete and the growing space almost saturated. The higher value at Vallombrosa, slightly older than Cansiglio, is due to tree density as well as to growth space efficiency due to the complementary dendrotypes. The gap mean to dominant tree height at Vallombrosa compared to Cansiglio strengthens this assumption. Trees of the older cycle raise dominant height at Marchesale, in spite of the young stand age. Standing volume summarizes the other variables and highlights its maximum at Vallombrosa, approaching 800 m^3ha^{-1}. The relatively higher tree density and the quite similar dominant tree height raise standing volume at Marchesale close to value found at Cansiglio, partly reflecting the higher productivity of southern beech forests (Fabbio *et al.*, 2006). Results (Table 3 and 4) highlight the heavier harvesting of innovative vs. customary practice. According to the innovative criterion, removal in basal area and volume is quite similar in Cansiglio and Vallombrosa and more intensive (up to 40%) at Chiarano, i.e. the densest stand. The removal drops at Marchesale at about one half, but tree density is here about one-third than at Chiarano, due to the high forest system. Customary removal is less heavy than innovative but not so widely diverging, with the exception of Vallombrosa, where it is close to zero. This owing to the advice of local staff responsible for tree marking of customary practice (as at all the other sites) to follow strictly the planned thinning time ruled by the management plan. The apparent pre-post change in mean/dominant dbhs and tree heights is vice versa the output of the different target layer(s) manipulated by each thinning type. All of this, as for the quantitative side of removal.

Values of crown cover and overlapping, crown layer texture, i.e. gaps' size and shape, their spatial distribution, fragmentation/connection - before and after thinning operation - give the evidence of crown layer manipulation operated by each practice. A first dataset is provided for the forest of Cansiglio (Fig. 1 and 2). Total number of gaps was similar between the theses after the intervention.

The innovative thinning produced a gap fraction 10% higher than the customary intervention and almost a double mean gap size. As a consequence, mean gap perimeter/area ratio dropped significantly under the innovative thinning, while it remained steady under the customary removal. Finally, edge density increased at both theses. The increase was slightly higher (10%) under the innovative one.

5. Discussion

The outcome of thinning is the less homogeneous physiognomy of stand structure; this reducing too the progress of symmetrical competition detrimental to individual growth course and stand growth pattern. Canopy arrangement has been changed as for crown texture, gaps' fraction size, shape and distribution, according to each applied criterion. Specifically, the innovative thinning released wider and less fragmented gaps. They are expected to produce more lasting openings at the main crown level, whilst customary intervention gives rise to more temporary gaps. The higher radiation and throughfall amount to the soil are expected to trigger bio-geo-chemical processes able to establish further habitats and ecological niches for the enrichment of types of biodiversity inside. The more differentiated tree crown sizes will contribute resistance to disturbances and enhance growth pattern within tree population. Thinning operations provided a positive outcome, i.e. a revenue, at all sites and for both the applied theses, in proportion to the harvested volumes and independently of the position of harvested trees, both of thinning types foreseeing - within own different distribution (mass or spotty) - removals over the full area. The high removal of the innovative criterion has been allowed by the relatively high growing stocks due to the quite full stand densities.

Data immediately after thinning implementation provide the baseline condition and the reference to the content and design of surveys to be carried out in the following monitoring phase, this being an integral part of the procedure to test the effectiveness of any adaptive approach. A previous study (Becagli *et al.*, 2013) documented the impact of silvicultural practices on forest structure by a set of structural diversity and tree competition metrics at the sites of Cansiglio and Marchesale. Results highlighted the effectiveness of tree spatial competition indexes to promptly assess response to thinning and the great capability of crown-based indexes to differentiate thinning criteria compared with mensurational parameters. Conversely, most of spatial and non-spatial tree diversity indexes tested showed slight or null sensitivity to the applied practices. Their use will become more relevant at later steps after thinning occurrence.

The careful monitoring of standing crop parameters following manipulation, will provide the elements to verify both consistency of the applied theses and the progress towards the awaited goals, possible failures or need of adjustment. At the same time, which components, directions, extents have to be better addressed-tuned. Stand attributes are only a part of the system to be surveyed, this including the other relevant communities and the soil system. As for standing crop, a special focus will be devoted to the rearrangement of canopy interface, it holding a leading role to achieving most of expected benefits as for structural attributes of forest stand (Pretzsch, 2014), but also for herbs, shrubs, tree regeneration layers, soil organic content and microbial activity, all of them contributory to the ecosystem functioning and balance.

In this respect, any manipulation of upper canopy interface drives radiation regime and throughfall inside with direct relapses on inner microclimate, heat and water availability, evapo-transpiration, litterfall amount, decomposition rate, respiratory losses, all of them contributing to handle the overall carbon allocation and release, i.e., the carbon budget. Beech bio-ecological attributes as the own reaction ability to late thinnings and the inherent crown plasticity to recover the space made available, provide foreseeable elements of posi-tive reaction to the implemented practices (Fichtner *et al.*, 2013).

6. Conclusions

The paper provides a first insight into the ongoing experience. Continuous monitoring as in the adaptive management rationale will test out the implementations and provide further elements of analysis and adjustement in the follow-up. Current scenario and future uncertainty call for an adaptive management approach taking into account drivers, feedbacks and limiting factors, comparing heritage and new criteria but moving from the former 'steady' condition to a more dynamic approach as in the AFM protocol.

The design and implementation of innovative practices consistent with growth environments and specific bio-ecological requirements, the comparison with customary silviculture and with the post-cultivation phase where this option is in progress in the management practice, seems to be the main, technically feasible, reliable and operational tool to tackle the challenge.

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Table 1. Site characteristics.
Tabella 1. Caratteristiche dei siti.

	Cansiglio	*Vallombrosa*
Area (ha)	30 - 35	30
Geographical coordinates (UTM-WGS84)	46° 03'N, 12°23' E	43°44'N, 11°34'E
Altitudinal range (m a.s.l.)	1100 - 1200	470-1440
Landscape morphology	Gently sloping mountainsides and plains	Gently sloping mountainsides
Bedrock	limestone, marlstone (Cretaceous)	Sandstone (Chianti formation)
Mean Temp °C	5.6	9.7
Max Temp °C (average warmest month)	14.8, August	24.1, July
Min Temp °C (average coldest month)	-4, January	-0.8, January
Total Rainfall (mm)	2004	1337
	Chiarano Sparvera	*Marchesale*
Area (ha)	30	30
Geographical coordinates (UTM-WGS84)	41°51' N, 13°57' E	38° 30'N, 16°14'E
Altitudinal range (m a.s.l.)	1700 - 1800	1100
Landscape morphology	Upper mountain slope range 22°÷28,5°	Uneven mountain terrain (slope up to 40%)
Bedrock	Cretaceous limestone	Granite (Serra and Sila formation)
Mean Temp °C	8.5	10.1
Max Temp °C (average warmest month)	17, July	18.4, July
Min Temp °C (average coldest month)	-0.2, January	2.2, February
Total Rainfall (mm)	1000	1808

Table 2. Main mensurational parameters at the sites.
Tabella 2. Principali parametri dendrometrici dei soprassuoli.

Parameter	*Cansiglio*	*Vallombrosa*	*Chiarano*	*Marchesale*
Tree density	323±65.9	532±117	1367±353	510±130
Basal area (m^2)	40.9±5.2	54.9±3.5	38.8±4.4	41.2±7.3
Mean height (m)	26.6±0.5	28.2±1.6	14.3±0.8	23.3±1.5
Mean dbh (cm)	40.6±3	37.3±5.6	19.4±2.4	32.9±6.1
Dominant dbh (cm)	49±3.6	50.5±6.0	35.8±4.6	54.0±6.8
Dominant height (m)	27±0.6	31.9±1.2	18.0±0.9	27.7±1.2
Standing volume (m^3)	543±72	795±80.3	183±24.4	497±110.8

Table 3. Main mensurational parameters before and after thinning operation. (I) innovative thinning, (C) customary thinning.
Tabella 3. Principali parametri dendrometrici prima e dopo il diradamento. (I) innovativo, (C) tradizionale.

Parameters	*Cansiglio*				*Vallombrosa*			
	Before thinning		*After thinning*		*Before thinning*		*After thinning*	
	I	*C*	*I*	*C*	*I*	*C*	*I*	*C*
Tree density	320	326	187	235	511	598	316	567
Basal area (m^2)	41.8	40.7	26.3	30.3	56.9	54.3	36.4	52.6
Mean height (m)	26.8	26.5	27.0	26.5	28.5	27.7	26.4	25.3
Mean dbh (cm)	40.3	40.	43.7	40.5	38.5	34.5	30.0	27.0
Dominant dbh (cm)	49.6	47.8	48.1	46.9	61.0	50.1	58.9	50.1
Dominant height (m)	27.8	27.6	27.0	26.6	33.6	31.4	33.2	31.4
Standing volume (m^3)	561.0	529.0	358	402	838.0	768.0	542.0	741.0

Parameters	*Chiarano Sparvera*						*Marchesale*			
	Before thinning			*After thinning*			*Before thinning*		*After thinning*	
	I-80	*I 40*	*C*	*I-80*	*I 40*	*C*	*I*	*C*	*I*	*C*
Tree density	1293	1515	1293	684	655	613	528	479	409	408
Basal area (m^2)	40.3	39.9	36.1	23.1	24.2	23.5	43.5	38.7	33.7	31.6
Mean height (m)	14.1	14.6	14.3	15.0	15.1	15.3	23.4	23.5	24.2	23.5
Mean dbh (cm)	20.3	18.6	19.3	22.8	21.7	21.7	32.3	32.5	33.0	33.4
Dominant dbh (cm)	36.5	35.5	36.2	36.0	35.1	36.1	42.7	55.8	54.2	48.8
Dominant height (m)	18.2	18.0	18.2	18.1	17.9	18.1	25.6	27.9	27.6	26.7
Standing volume (m^3)	304	292	272	180	192	177	528	468	401	377

Table 4. Thinnings' removal.
Tabella 4. Intensità dei diradamenti.

	Percentage removal		
	N	G	V
CANSIGLIO			
Innovative	41	37	36
Customary	28	26	24
VALLOMBROSA			
Innovative	38	36	35
Customary	3.6	3.1	3.0
CHIARANO			
Customary	53	36	34
I-80	47	40	37
I-40	57	41	40
MARCHESALE			
Innovative	22	21	24
Customary	15	19	20

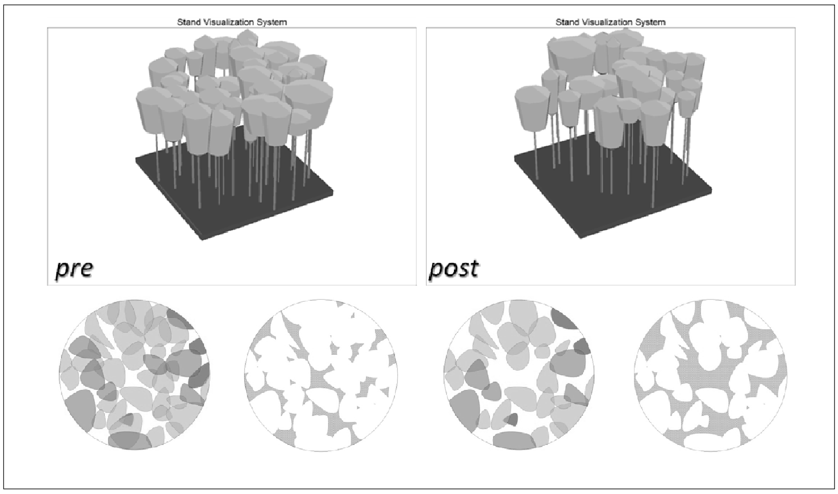

Figure 1. Sample plot before and after customary thinning implementation at Cansiglio.
Figura 1. Area campione prima e dopo il diradamento tradizionale a Cansiglio.

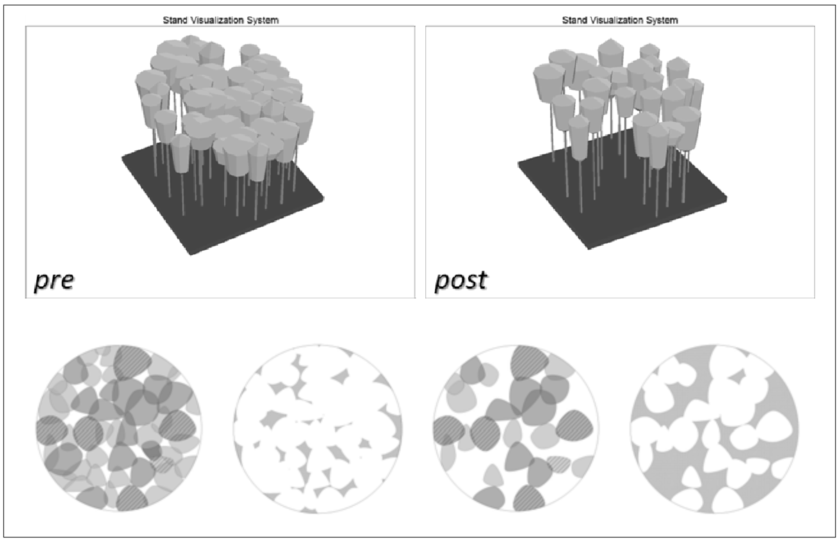

Figure 2. Sample plot before and after innovative thinning implementation at Cansiglio.
Figura 2. Area campione prima e dopo il diradamento innovativo a Cansiglio.

RIASSUNTO

Selvicoltura adattativa per affrontare le nuove sfide: l'esperienza ManForCBD

Selvicoltura adattativa per affrontare le nuove sfide: l'esperienza ManForCBD.
Obiettivi del progetto LIFE+ 'Managing forests for multiple purposes: carbon, biodiversity and socio-economic wellbeing' sono il disegno e la realizzazione di pratiche colturali adattative per: (i) mantenere l'accrescimento del bosco, quindi la capacità di sequestro di carbonio nel soprassuolo e nel suolo e la 'salute e vitalità' del sistema su tempi di permanenza prolungati, (ii) ridurre la evidente omogeneità strutturale e il livello di competizione simmetrica, (iii) promuovere una maggiore biodiversità. Requisito essenziale alle pratiche colturali applicate è quello della sostenibilità economica. Questo è ritenuto essere l'approccio necessario per affrontare l'incertezza futura e realizzare una maggiore capacità adattativa a scenari non predittibili. Il progetto si attua su dieci siti, 7 in Italia e 3 in Slovenia. Si riportano qui i primi risultati relativi a quattro faggete disposte lungo il gradiente latitudinale Cansiglio (Veneto) età 120-140, Vallombrosa (Toscana) 110-160, Chiarano (Abruzzo) 70, Marchesale (Calabria) 75. Il disegno con repliche ha posto a confronto: (i) il diradamento tradizionale di tipo basso o misto sull'intera superficie; (ii) il criterio innovativo del diradamento di tipo alto nei siti di età maggiore e diradamento selettivo su un numero prefissato (40-80 soggetti) per ettaro nei siti più giovani.
I primi risultati evidenziano la intensità di prelievo superiore della pratica innovativa rispetto a quella ordinaria, supportata comunque dalle provvigioni relativamente elevate per la densità piena. La struttura si differenzia e si pongono le basi per una ulteriore differenziazione. Si modificano anche tessitura, dimensioni e distribuzione relativa dei vuoti nel piano delle chiome. Il monitoraggio continuo, come prassi nelle applicazioni di carattere adattativo, produrrà elementi ulteriori di analisi e di aggiustamento nel seguito del progetto.

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