Forest planning and sporadic species

LIFE+ PProSpoT project: first experience in Italy

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The LIFE+ PProSpoT (Policy and Protection of Sporadic tree species in Tuscany) project, has developed a new methodology of forest planning. Surveying and planning actions are suitable for the application of tree-oriented silviculture criteria in sporadic species. Implementation of standard procedures by the Tuscan Regional Administration (SIPAFOR) will make this methodt applicable throughout all regional forests. A trial was carried out in the Complessi Forestali Regionali Colline Metallifere (GR) and Abetone - Melo Lizzano Spignana (Pistoia Province), in a forest of 800 ha.

A milestone of the LIFE+ PProSpoT (LIFE09 ENV /IT/000087) project is to refine and apply a new method in forest planning aimed to protect stand biodiversity. The relevance of this action consists of spreading tree-oriented silviculture criteria to sporadic species[1] at a regional scale.

The final aim of the action is to implement regional forest planning procedures as defined in the regional technical guide "Riferimenti tecnici per la redazione dei Piani di Gestione del Patrimonio Agricolo-Forestale della Regione Toscana" (D.G.R. n. 6679/2004). A secondary purpose is to introduce silviculture to target plants belonging to sporadic species in forest planning models at a compartment scale, to spread the use of this method as widely as possible.

Numbered metal plate affixed to the base of the stem of each target plant identified during Phase 2.

Methodology

Action 4 was carried out in the Complessi Forestali Regionali Colline Metallifere (GR) and Abetone - Melo Lizzano Spignana (Pistoia Province - hereinafter "Appennino Pistoiese"), a forest covering approximately 800 ha and divided into 2 portions, 600 ha and 200 ha, respectively.

Our work was divided into two phases. During Phase 1, the survey was extended to the whole area (800 ha). Phase 2 was concentrated in the forest compartments, where the presence of sporadic species was relevant enough to apply tree-oriented silviculture criteria. The following reports on Phase 2 only. During Phase 1, regional standard procedures were adopted according to "Riferimenti Tecnici per la redazione dei Piani di gestione del Patrimonio Agricolo-Forestale

***(1)** Within LIFE PProSpoT project sporadic species are defined according to the Tuscan Regional Administration laws, more specifically in art. 12 of DPGR 48/2003.*

della Regione Toscana".

The surveys from **Phase 1** were useful not only to distinguish important compartments for sporadic species management, but also to identify which species were present and their possible relevance in timber production and/or biodiversity. To register the presence of the species, all compartments were covered with walkways spaced about 100 meters apart, parallel to the contour lines. Direction of the walkways was selected to test the whole surface according to site conditions, such as morphology and stand accessibility. Each sporadic species plant (or group of plants) were georeferenced by GPS and described using a suitable form (Box 1).

During **Phase 2** the study focused only on forest compartments selected by:

- fair distribution of target species and, when possible, equitable presence of potentially productive plants;
- site conditions suitable for the ecological requirements of the identified species
- good forest road network: compartments located at a maximum distance of 100 m from a forest road were preferred.

The purpose of Phase 2 is to select target plants; a target plant (or tree, synonymous in this paper) will be the focus of silvicultural interventions in terms of planning and preservation.

The criteria followed to select the target trees (which will not be described here) are: vigor, health, quality of stem characteristics (even potential), growth stage, presence of minimum distance between plants, which must be at least equal to or greater than the radius of the crown at maturity.

The collection of data in Phase 2 implies an unavoidable increase in planning costs due to multiple surveys on the same compartment, to permanent marking of the plants and data collection on all plants belonging to the target species.

Phase 2 includes:

- **systematic survey** within the selected compartments to choose the target plants;
- **marking** of each target plant using paint (an orange ring at about 1.5 meters from the ground) and affixing a numbered metal plate at the plant collar or at the base of the stem;
- **attain the geographical coordinates** of each target plant by GPS;
- **data collection, using a specific form** (downloadable using the legend in the section "Approfondimenti" at ***www.rivistasherwood.it***), on the qualitative and quantitative attributes that characterize the target plant (e.g, dendrometric parameters, plant health, wood technological characteristics);
- **information on forestry interventions** according to tree-oriented silviculture criteria to be applied on the targets plants and their surroundings.

In order to catalogue (numbering and georeferencing) the target plants, it is necessary to identify the trees during silvicultural activities and to plan forest management and interventions that include specific actions for these trees.

The target plants are considered a forest's heritage and value, thus they are listed in the **Register of sporadic species**, which is analogous to the classical compartments register in forest management.

Phase 1 Results

In the Colline Metallifere forest (600 ha), 1,703 single plants and 772 groups of plants belonging to the target species[2] were identified. The total number of identified plants (considering an average number of 5-6 plants for each group) was about 6,480, which corresponds to a density of 27 plants/ha, referring to the area actually covered by this case study[3]. In the Appennino Pistoiese forest (200 hectares), 2,210 subjects were identified, which corresponds to a density of 17.5 plants/ha, referring to the area actually covered in the study.

The species registered in the two forest contexts are significantly different: in the Colline Metallifere (Table 1), the wild service tree [*Sorbus torminalis* L.) Crantz], true service tree (*Sorbus domestica*), field maple (*Acer campestris* L.) and common holly (*Ilex aquifolium* L.) are clearly prevalent and significantly widespread, while wild cherry (*Prunus avium* L.) and wild pear (*Pyrus pyraster* Burgds.), although frequently found, are much less pre-

BOX 1 - PHASE 1 INFORMATION TO BE COLLECTED ON EACH PLANT (OR GROUP OF PLANTS) BELONGING TO A SPORADIC SPECIES

Forest compartment
GPS coordinates
Species
Plant (or group of plants) classification:

Production - potentially productive plant: high or medium vigor, belonging to a species with a highly valuable wood, stem structure potentially suitable for a variety of end uses.

Biodiversity - plant relevant to only biodiversity protection or enhancement in terms of presence, seed production and/or related species. The plant has significant stem defects, which lowers its value for production purposes, but can be properly managed for species conservation and regeneration (seed production).

Height: plants are separated according to height classes.
Social position: defined according to the level of competition with surrounding trees (using the Kraft classification).
Stem/trunk Quality: a rapid assessment that will be studied more closely during Phase 2.

Species	Plants registered n.	%
Sorbus torminalis	1.694	26%
Sorbus domestica	1.307	20%
Acer campestris	1.305	20%
Ilex aquifolium	1.248	19%
Prunus avium	327	5%
Pyrus pyraster	300	5%
Acer pseudoplatanus	126	2%
Fraxinus oxycarpa	79	1%
Ulmus minor	32	0%
Acer campestris	24	0%
Sorbus aria	14	0%
Quercus patraea	12	0%
Quercus suber	4	0%
Quercus crenata	4	0%
Tilia cordata	3	0%
Malus sylvestris	2	0%
Totale	**6.481**	**100%**

Table 1 - Species registered (number and percentage) during Phase 1 in the Colline Metallifere.

Species	Plants registered n.	%
Acer pseudoplatanus	920	42%
Prunus avium	608	27%
Laburnum anagyroides	267	12%
Sorbus aria	184	8%
Sorbus aucuparia	184	8%
Fraxinus excelsior	19	1%
Pyrus pyraster	16	1%
Acer campestris	8	0%
Malus sylvestris	4	0%
Totale	**2.210**	**100%**

Table 2 - Species registered (number and percentage) during Phase 1 in the Appennino Pistoiese.

(2) *Species defined as sporadic according to Regional Law LR 48/2003, art. 12.*
(3) *The studied area was defined by a buffer of 20 m, starting from the walkways followed by the surveyors within the compartments (and georeferencing tracks with GPS). The total surveyed surface is less the total area of the 2 sites (600 and 200 ha), and is the actual surface examined and where the plants inventoried are located.*

sent. All other species, other than sporadic, are essentially rare and should therefore be all the more protected.

In the Appennino Pistoiese, the dominant species, in terms of presence, are the sycamore maple (*Acer pseudoplatanus* L.) and wild cherry, which together represent nearly 70% of the registered plants; common laburnum (*Laburnum anagyroides* Medik.), mountain ash (*Sorbus aucuparia* L.) and common whitebeam [*Sorbus aria* L. (Crantz.)] are less frequently found, while ash (*Fraxinus excelsior* L.), field maple, European crab apple (*Malus sylvestris* Mill.) and wild pear are very rare (Table 2).
On both sites, there is a significant variability in species distribution: in the Colline Metallifere (Figure 1), there are areas where the density of the target species is higher than 60 plants/ha; however, in others it falls below 20 plants/ha. The variability appears to be related not only to environmental factors of the site, but also, more frequently, to evolutionary and cultural factors.

In the Colline Metallifere, the prevalent forest physiognomic-cultural typologies are coppices of Turkey oak (*Quercus cerris*) or black hornbeam (*Ostrya carpinifolia*) - 89% of the surface. Almost half of these stands has already exceeded the 36 year threshold (according to Art. 2d, paragraph 19 of the Regional Forest Law, they are considered "aged coppices"). Some stands, treated as coppices in the past, in recent decades have been converted to high forest and are currently classified as "transitory stands" (Table 3).
In all coppices, there is a substantial reduction in terms of plant number belonging to sporadic species in the oldest stands; in particular, the 36 year threshold seems to highlight this difference quite well. This suggests that, with the gradual "aging" of the coppice, the sporadic species, especially the heliophilous ones, tend to lose the competition with the plants belonging to dominant species. The sporadic species presence in transition stands (that are not very representative in terms of area) seems to be related to the specific composition of the forest: in mixed formations the value is twice that of the Turkey oak pure stands.
In the Appennino Pistoiese, the distribution of the plants according to forest type and to stand age (Table 4) is more complex: sporadic species presence is higher in young

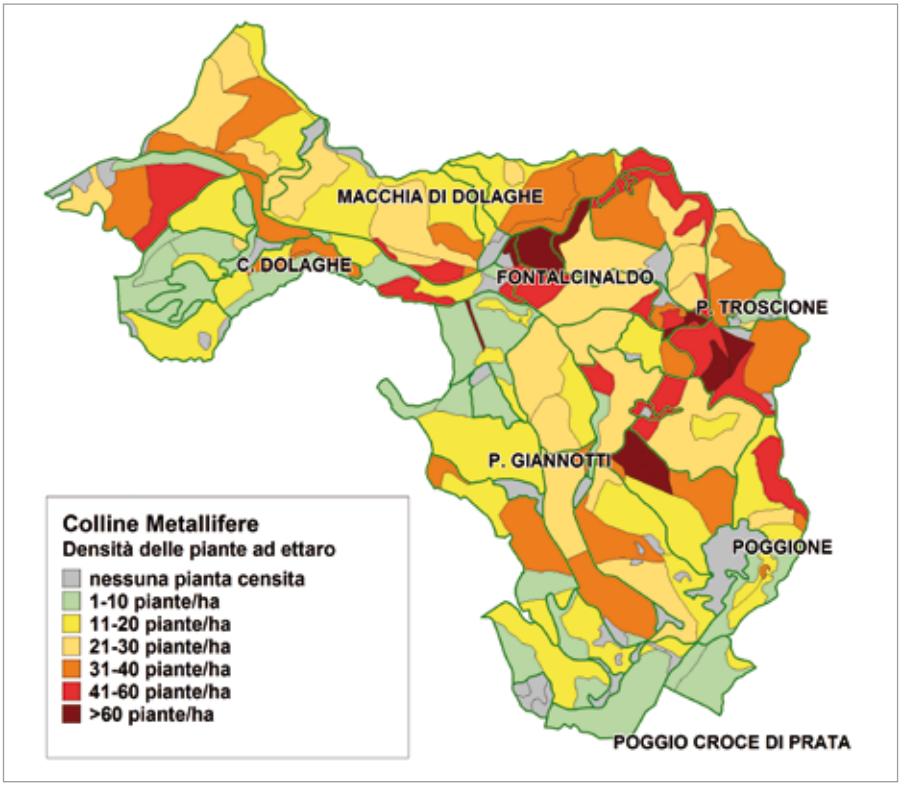

Figure 1 - Density of sporadic species in the Forest Complex Colline Metallifere.

Forest type	Surface (%)	Sporadic species plants (n/ha)
Black hornbeam coppice	12%	20,2
Black hornbeam aged coppice (age>36 years)	10%	21,3
Turkey oak coppice	23%	33,2
Turkey oak aged coppice (age>36 years)	15%	27,1
Mixed hardwood coppice	8%	23,1
Mixed hardwood aged coppice (age>36 years)	20%	22,4
Chestnut coppice	1%	25,5
Conifer high forest	6%	18,5
Turkey oak transitory stand	3%	22,5
Mixed hardwoods transitory stand	2%	45
Newly recolonized forest areas	0%	29,6

Table 3 - Forest types (surface) and sporadic species density inventoried in the Colline Metallifere during Phase 1.

Forest type	Surface (%)	Sporadic species plants (n/ha)
Chestnut adult coppice	3%	9,28
Chestnut and Turkey oak young coppice	13%	13,48
Beech aged coppice (age>50 years)	2%	10,98
Chestnut aged coppice	30%	27,16
Beech adult high forest	5%	2,77
Mixed hardwoods uneven-aged high forest	3%	38,42
Beech and mixed hardwoods mature high forest	13%	15,07
Conifers high forest	2%	30,80
Chestnut young high forest	4%	20,11
Conifers and hardwoods young high forest	5%	17,44
Beech young high forest	17%	22,10
Beech forest in (thicket) sapling stage	1%	43,84
Beech and mixed hardwood forest in pole stage	2%	63,00

Table 4 - Forest types (surface) and sporadic species density inventoried in the Appennino Pistoiese during Phase 1.

Species	Only biodiversity	%	Production and biodiversity	%
Sorbus torminalis	26	36%	347	50%
Sorbus aria	7	10%	255	36%
Acer campestris	6	8%	47	7%
Prunus avium	3	4%	27	4%
Pyrus pyraster	2	3%	17	2%
Acer monspessulanum	10	14%		
Ilex aquifolium	9	12%		
Acer pseudoplatanus			4	1%
Malus sylvestris	3	4%		
Quercus suber	2	3%		
Sorbus aria	2	3%		
Tilia cordata	1	1%		
Fraxinus oxycarpa	1	1%		
Quercus petraea	1	1%		
Total	**73**	**100%**	**697**	**100%**

Table 5 - Number of target plants selected, separated by species and purpose in the Colline Metallifere site.

Species	Only biodiversity	%	Production and biodiversity	%
Acer campestris			1	1%
Acer pseudoplatanus	28	21%	113	62%
Prunus avium	26	20%	25	14%
Fraxinus excelsior			4	2%
Laburnum anagyroides	40	30%	11	6%
Malus sylvestris	1	1%		
Pyrus pyraster	2	2%		
Sorbus aria	20	15%		
Sorbus aucuparia	16	12%	29	16%
Total	**133**	**100%**	**183**	**100%**

Table 6 - Number of target plants selected, separated by species and purpose in the Appennino Pistoiese site.

		Colline Metallifere		Appennino Pistoiese	
Stem quality class	**Use**	**Total of stem**	**%**	**Total of stem**	**%**
A	veneer log	222	32%	0	0%
B	valuable sawn timber	242	35%	68	37%
C	joinery	171	24%	99	54%
D	firewood	22	3%	16	9%
Only sub-measure		40	6%	0	0%
Total of plants		**697**	**100%**	**183**	**100%**

Table 7 - aaa.

stands (both in coppices and high forests) and tends to reduce with transition to adult and mature stages.

In most spread forests (chestnut and beech stands), this phenomenon is more evident in Fagus sylavtica forests, probably due to the shade-tolerance of this species; beech tends more than chestnut (which is more heliophilous) to create pure stands. Moreover, in chestnut coppices, wild cherry and sycamore maple standards are commonly present because they were considered valuable plants in the past and so traditionally left during logging.

Many sporadic species plants can be found close to past gaps or fields that have now been recolonized by the forest. Usually, the size of the trees is medium-big, but the quality of the stem is very low. The importance of their presence is linked to seed production, to regenerate and re-spread the species.

In both sites, included in the PProSpoT project action, the frequency of potentially productive plants (during this phase, stem quality assessment was evaluated very rapidly without using technical parameters) suggested a more accurate evaluation of the quality parameters, which were then examined during Phase 2 to verify if it were possible to preserve biodiversity in actions aimed to increase the value of wood production.

Phase 2 Results

In the Colline Metallifere site, 770 target plants were selected and marked; the density was, on average, 6.7 plants/ha. Seventy-three trees (belonging to all the inventoried species) were suitable for only biodiversity preservation purposes, while the others were also important for wood production. Sorbus trominalis and S. aria were particularly significant with regard to production (Table 5).

In the Appennino Pistoiese forest, 316 target plants were selected and marked; the mean density was 5.8 plants/ha. The trees suitable for production purposes numbered 183 (58%) and were primarily sycamore maple (Table 6). The plants selected only to preserve biodiversity numbered 133 and belonged to all of the inventoried sporadic species.

The qualitative and quantitative attributes collected for each candidate target plant were many and led to a wide range of elaborations and comments, too numerous to accurately reference here. So we decided to report briefly only the most important aspects that best contribute to describing the two samples of target plants. Further considerations and a more detailed review will be included in following papers and educational activities from the LIFE+ PProSpoT projects.

- The percentage of target plants with the same age as the overstory were 63% and 75%, respectively, in the Colline Metallifere and Appennino Pistoiese stands.
- In the Colline Metallifere site, the percentage of plants in the qualifying phase[4] was 34%, while in the Appennino Pistoiese there were 11%. The others were already in the sizing phase[5]. The Appenino Pis-

(4) *According to the definition adopted in the surveys, in the qualification stage the subjects are "young" and reactive, and usually smaller in dimension than the limit set for this stage - D <30% of the final diameter; height <40% of the final diameter - in which the shape of the stem can be actively formed through cultural intervention.*

(5) *According to the classification adopted in the surveys, the dimensions of the subjects are close to or slightly greater than the limit set for the qualification phase - diameter ≥ 30% of the final diameter; height ≥ 40% of the final diameter - in which the shape of the stem can now be only marginally influenced through cultural intervention*

(6) *According to the classification adopted in the surveys, it is in this phase that the plant is no longer able to expand the area of its canopy, but continues to grow in diameter. At this stage in the tree's development, silviculture interventions are no longer necessary (the tree is completely free).*

Marking of a target plant using paint (orange ring around 1.5 m from the ground).

BOX 2 - SILVICULTURAL INTERVENTIONS FOR EACH TARGET PLANT

According to the criteria of tree-oriented silviculture, the interventions required to promote target plants are:

In coppices:
- Localized thinning, eliminating direct competitors (every 8 years);
- Creation of a protection area around each target plant during coppicing
- Localized thinning within the protection area

The thinnings continue to the end of the qualifying and sizing phases of each target plant. When a plant reaches a mature growth stage, the thinnings stop.
After coppicing (about every 8 year), it is possible to identify and mark new target plants until optimal density is reached.

In high forests:
- Localized periodic thinnings, eliminating direct competitors

The thinnings continue to the end of the qualifying and sizing phases of each target plant. When a plant reaches a mature growth stage, the thinnings stop.
It is possible to identify and mark new target plants at the end of the stand rotation (after harvesting, during the seedling stage and the (thicket) sapling stage), until optimal density is reached.

toiese forest also contained plants in the mature stage[6](14%).

- In the Colline Metallifere forest, the maximum density of selected target plants was registered in young coppices (8.7 plants/ha).
- In the Colline Metallifere, the highest density of selected target plants was registered in young coppices (8.7 plants/ha); the possible causes can be: 1) the frequency of sporadic species, 2) the young age of the stand that increases the chance of finding potentially valuable stems. In the Appennino Pistoiese forest, the maximum plant density was found in beech forest in (thicket) sapling stage (13.7 plants/ha); high values (10-11 plants/ha) were also found in young pure beech high forest or in beech and mixed hardwoods high forest and in chestnut coppices over the usual rotation age (more than 50 years old).
- The assessment of the potential quality of the trunks (if all the appropriate cultural treatments are applied to the selected target plants according to tree-oriented silviculture principles) is good in the Colline Metalliefere and poor in the Appennino Pistoiese.

At the end of Phase 2, the main results found that are important to forest planning are the following:

- **In the Colline Metallifere**, the presence and the qualitative features of the target plants are suitable to start a process of enhancement aimed at producing high quality assortments, especially for valuable hardwoods, such as wild cherry, Sorbus domestica and S. torminalis. The best forest type for the selection of a higher number of target plants is the young coppice, and tree-oriented silviculture can provide the best results in these stands.
- **In the Appennino Pistoiese**, chances of improving wood production of the target plants is low and there is a higher need to preserve biodiversity. Consequently, it is necessary to apply a silvicultural method aimed to implement the presence of the target species plants without evaluating production aspects. In this case, plant selection criteria took into account the seed production ability of the trees. The best target plant candidates were found in younger stands (especially in beech forests), thus in the Appennino Pistoiese forest, this kind of stand is more suitable to the application of tree-oriented silviculture criteria.

Forest Planning

The main goal of forest planning is to define management and planning interventions to be implemented over the effective period. In this case, **two management levels** can be identified: one relates to forestry that can be defined as "extensive" and is applied to the entire forest area, the other one relates to tree-oriented silviculture, which occurs at a level of the single plant. Tree-oriented silviculture is actually not an alternative to "extensive" silviculture, but it is an additional activity that should be integrated with other interventions as much as possible.
This "integration" has been one of the most critical issues of planning due to the requirements of the silviculture, i.e. the degree of urgency, as the time interval for dominant species in the overstory is significantly different than sporadic species. However, savings can be obtained thanks to joint execution of tree-oriented silviculture interventions (almost always having a negative cost balance) with "extensive" intervention (especially if economically convenient).
To reconcile these conflicting needs, initially tree-oriented silviculture interventions are planned independently, based on the most appropriate year of execution. The timelines identified for each different intervention are then compared and, when possible, combined.
For this reason, an additional reference, **The sporadic species register**, containing the qualitative attributes and intervention lines for each target plant has been integrated into the program. The register is a database that can be expanded and upgraded over time, both in terms of plant attributes and in terms of intervention required.

For aspects of planning, we referred to the cultural models refined during other projects, even though they refered to simplified situations rather than actual cases. It must be taken into account that the cultivation periods of the target plants take a much longer time compared to forest planning (15 years), and lack of previous experience on tree-oriented silviculture methods in Tuscany makes it extremely difficult to forecast what actions will be required in 20 years or more.
The effective period of forest planning intervention **in the coppices was scheduled for every 8 years, while in the high forests, every 6-7 years.** The cultural practices to be applied to each target plant are briefly described in Box 2. In coppices, the density of the target plants is often insufficient; therefore, it is desirable to identify new candidates after coppicing, when the new generation of sprouts will be about 8 years old.
In the forest plan, a "fully operational" density of 20 plant/ha has been consid-

ered. Higher values are unsuitable because of the high incidence of protection areas required at each coppicing. In high forests, a much higher density of target plants may be sustainable or even desirable, especially if they consist of subjects with a good production potential, but currently there are not many suitable subjects available in the considered stands.

More in-depth evaluations on the "optimal" density, according to the purpose for which the plants are selected, can be provided thanks to the other projects currently in progress.

Conclusions

Action 4 of the LIFE+ PproSpoT project, concerning the refining and implementation of a new planning method which enhances forest biodiversity, led to the development of procedures to inventory and evaluate the potential application of silvicultural and management models for sporadic species within two agro-forest areas in Tuscany. Management, intervention forecast and cultivation planning were identified to promote sporadic tree species and, at the same time, extensive forestry interventions (relative to the other tree species).

The sporadic species register, which includes the description of each candidate plant, **is the management document where interventions are described and where all actions are recorded and updated.** According to the objectives of LIFE + Governance (which initiated the PProSpoT project), the archives and the interface for data insertion and management of the information system of the Patrimonio Agricolo Forestale della regione Toscana (SIPAFOR) are under implementation, thus it is possible to transfer the experience of this pilot project to all forests in the region.

INFO.ARTICOLO

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Abstract: ***Planning and sporadic tree species. First Italian experiments of the LIFE+ PProSpoT project.*** *The article describes a new planning method that has been elaborated within the LIFE+ PProSpoT project (Policy and Protection of Sporadic tree species in the Tuscan forest). The aim is to implement the standard Tuscan planning procedures by conducting a sporadic tree species survey and by considering the possibility of using silvicultural and management systems to improve them. This experimental method has been applied to two Tuscan forest complexes for a grand total of 800 hectares.*

Key words: *Planning, management plan, single tree silviculture, sporadic species, LIFE+ PProSpoT project, Tuscany.*

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