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**Euro-Mediterranean Wildland Fire Laboratory,**  
**a “wall-less” Laboratory**  
**for Wildland Fire Sciences and Technologies**  
**in the Euro-Mediterranean Region**

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**Plant functional traits database**  
**for Euro-Mediterranean ecosystems**

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## Summary

This report summarises the activities developed in the subtask T3c (*Plant species traits database*) of EUFirelab WP4 (*Fire, ecosystems functioning and biodiversity*).

The objectives of this subtask were:

- to develop the structure of a database for including standardised information on plant functional traits from Euro-Mediterranean fire-prone ecosystems; and
- to compile as many information as possible on plant traits from different ecosystems and sources (expertise, specific measures and "grey" bibliography).

The database was aimed to be able to deal with mixed types of data (i.e. quantitative, qualitative and binary) related to different accuracy levels.

The first section of this report includes a concise introduction of the importance and the usefulness of the plant functional trait databases.

Then, we describe the criteria followed to design the database, including the justification of selected traits and structure, and the types of sources and its relation with the data accuracy.

In the third section all traits and their attributes (units, classes) are defined.

A brief description of the ecological significance of most traits is also included.

The data compiled until now (Dec 2005) is described in the section four and include seven data sets from six partners.

This information comprises 216 species of 44 families and a total of 5113 entries.

Sections five and six include a brief discussion and the references.

Finally, the list of the contributors and their data sets, and the list of species and traits included in the database are shown in the three appendices.

The three levels of accuracy for continuous traits offered in the database, the wide taxonomic spectrum gathered and the great amount of data compiled related to post-fire responses are the main contributions of the EUFireLab Plant Traits Database.

All EUFireLab partners are invited to increase the information during the remaining period of the project.

## 1 INTRODUCTION: OBJECTIVES AND JUSTIFICATION

The performance of any species is determined by attributes conferring significant influence on fitness, called functional traits (Reich et al. 2003).

Because plant functional traits are often very dispersed in the scientific literature, a great effort is currently being made to compile this information in a systematic way using standard protocols (Cornelissen et al. 2003).

Databases on plant functional traits serve to:

- establish ecological strategies in relation to specific environmental scenarios,
- unearth physiological trade-offs that explain ecological functioning,
- help to understand biodiversity, and
- provide tools for conservation (see Table 1).

One of the most stressful environmental features of Mediterranean ecosystems is the presence of recurrent fires, but many plants have evolved strategies that allow them to survive (Gill 1981).

Models that predict global climate change suggest that the water deficit should increase, and consequently changes in the fire regime should be expected (Pausas 2004).

Moreover, changes in land uses are:

- modifying the landscape pattern,
- increasing the size and abundance of areas with dense vegetation, and therefore
- promoting larger and more frequent fires (Moreno et al. 1998; Pausas & Ramos 2004).

Under this scenario, a great deal of effort is currently being focused on understanding fire effects in Mediterranean areas at several levels (economic, sociological and ecological).

In this framework, the objective of this task was to design a database on plant response to fire for EU-Mediterranean species, incorporating ample information from references and from the experimental background of the EUFireLab consortium.

Specifically, this database was to be designed to compile all available information on traits potentially related to the fire response of European species, and should serve:

- to identify gaps in our knowledge of plant functional traits and fire responses;
- to detect variability in plant functional traits;
- to identify regeneration syndromes (e.g., functional types) and compare them with the syndromes detected in other fire-prone regions;
- to offer a tool for long-term monitoring and management of biodiversity.

The EUFireLab database would be built to include life history traits and traits related with to the post-fire recruitment strategy.

Although some relationships between these traits have already been studied specifically, many others have not yet been addressed systematically (Pausas et al. 2004).

Moreover, many of these compilations refer to Mediterranean ecosystems but not to Mediterranean Basin species.

Due to the different evolution in both the flora and the fire history, differences in the traits that permit persistence after fire (and correlated traits) should be expected between plants from the Mediterranean Basin and plants from other Mediterranean ecosystems (Pausas 1999a, Pausas et al. 2006).

Database	Spatial scope	Objective	References
Ecological Flora	British Isles	Ecology and life history	Fitter & Peat 1994
BIOPOP	Germany	Conservation	Poschlod et al. 2003
(unnamed)	NSW Australia	Biodiversity and management in fire-prone ecosystems	Bradstock & Kenny 2003
PLANTS	United States	Ecology, life history and conservation	Frappier & Eckert 2003
LEDA	Central and North Europe	Conservation and restoration	Knevel et al. 2003
CALIF	California, US	Post-fire strategies and evolutionary trends	Pausas et al. 2006
EIBER	Eastern Iberian Peninsula	Post-fire strategies and evolutionary trends	Pausas et al. 2004, Pausas & Verdú 2005
PLANTRAITS	World wide	Functional syndromes along environmental gradients	Vile & Garnier 2005

Table 1. Examples of plant functional traits databases

## 2 DESIGN AND STRUCTURE OF THE DATABASE

### 2.1 CHOOSING TRAITS

Although this database is anchored in traits related to regeneration after fire, it also includes sets of traits describing several aspects of the life history of the plant species.

The traits selected were grouped in several categories:

- taxonomy,
- general vegetative traits,
- vegetative traits related to flammability,
- regeneration traits, and
- sexual reproductive traits.

These groups of traits are not exclusive, as some of the traits included in "general vegetative traits" may be to some extent related to flammability or regeneration.

Because of the large spatial extent aimed in this database, our focus was on easily measured ("soft") traits.

These soft traits can be considered surrogates of hard traits that are much more difficult to obtain (i.e. SLA against relative growth rate; Wright & Westoby 1999), and hence similar information can be obtained for more species (Weiher et al. 1999, McIntyre et al. 1999, Díaz et al. 1999).

The traits selected are related to the persistence after disturbance found at the four hierarchical levels proposed by Pausas and Lavorel (2003):

- individual,
- population,
- community and
- landscape.

Differences in persistence at all these levels could account for a significant percentage of the vegetation dynamics observed in ecosystems submitted to recurrent disturbances, even when data accuracy is low.

Therefore, this database provides important information that can be used to predict and model vegetation dynamics in EU-Mediterranean ecosystems within the framework of changes in disturbance regimes.

### 2.2 COMPILING DATA

To compile the information from the different partners a template was designed in Excell format.

Each contributor completed at least one of these templates (see below).

This database has been designed to collect geographical variations in European fire-prone ecosystems.

In general, each template is related to a specific regional, that is, to a homogeneous region smaller than a country (e.g., Eastern Iberian Peninsula or Strait of Gibraltar).

Exceptionally, if there is a large data set from a smaller site, a template could gather only a local study area (e.g., Montseny Montains).

In this way, some contributors filled more than one template.

The data related to species and traits appears on the sheet called *DBase*, which is organised in a matrix format with:

- the species (taxa) in columns and
- the traits in rows.

In every *Dbase* matrix (one for each contribution), species data appears in only one row.

If for a specific combination of species and traits there is more than one datum, the most common one appears in the matrix and the other possibilities appear on the *Comments* sheet.

Any other observations are also included in this sheet.

The database is designed to gather as much relevant information as possible without needing to include very detailed quantitative data (which is unavailable for many species/ecosystems).

Thus, we have chosen an intermediate level of accuracy and detail.

For most of the traits, different levels of accuracy are possible, including quantitative, semi-quantitative and binary data.

Moreover, different data source are allowed, including several degrees of precision.

The sources are indicated next to each data entry, to enable checking its degree of accuracy, with any of the following categories being possible:

- measure: if it is our own measured data (for published or unpublished data);
- observation: provided by visual (rough) estimation or personal experience;
- specific bibliography: data from a specific published study by another researcher;
- general bibliography: e.g., floras.

For "measures", "specific bibliography" and "general bibliography", the complete reference should be included in *Comments*.

The database includes 47 traits, but not all are obligatory.

We have divided the traits in three groups in relation to their importance:

- OT: Obligatory traits, those that are very important for our purpose (e.g., post-fire resprouting capacity), and those that are easy to obtain, at least from floras. All the species should include data with these traits.
- VIT: Very important traits, these are not obligatory but they should appear in most of the species (at least in ca. 50% of the species for each contribution).
- IT: Important traits (IT), these are not obligatory, but they should appear in as many species as possible.

### 3 TRAITS AND ATTRIBUTES

#### 3.1 INTRODUCTION

Precise definitions and standardised measuring protocols have been established to assure that comparisons between different contributions are possible.

Except for post-fire regeneration traits, measurements should be made on robust and non-damaged plants, preferably unshaded, because many traits are plastic in response to light.

Moreover, because some traits are known to vary with disturbance recurrence (e.g., height), plants on low disturbance recurrence sites are preferred.

Since data should reflect the average of the features in the study area, extremes should be excluded (e.g., exceptionally tall plants should be ignored when measuring height).

For traits that concern leaf features, the selected leaves should be:

- the youngest of the full expanded leaves,
- exposed to direct sunlight (for shade species, collected from the least shaded position), and
- free from herbivore damage (Garnier et al 2001).

For leafless plants, these data should be referred to the functional analogue (e.g., cladodes).

For traits related to seedlings and saplings, plants used in forestry plantations should be discarded for measurements, because they have been grown in nurseries under optimal conditions.

#### 3.2 TAXONOMIC DESCRIPTORS (OT)

These include taxonomic characterisation of the species from family level to subspecies or variety level.

For family names Angiosperm Phylogenetic Group standards should be used (APG 1998). The taxonomic descriptors are: *Genera* (T01), *Species* (T02), *Subspecies or Variety* (T03) and *Family* (T04).

#### 3.3 GENERAL VEGETATIVE TRAITS

##### 3.3.1 Life Form (T05; OT)

Morphology of the whole plant in relation to the position in height of perennating tissues (i.e., buds or bud-forming tissues).

For some life form classes, more than one of the Raunkiaer's categories suggested by (Du Reitz 1931; Raunkiaer 1934) are included (see Table 2):

- Tree: very tall woody plants (more than 2 m in height). Frequently with one main, primary stem and with the green crown rarely reaching the ground.
- Shrub: tall woody plants (ca. between 0.25 and 2 m). Frequently with several shoots growing from soil level and/or with the green crown reaching the ground.
- Liana: woody climber.
- Scrub: short woody plants (less than 0.25 m in height). Frequently with several shoots growing from soil level and/or with the green canopy reaching the ground.
- Perennial forb: perennial broad-leaved herbaceous plant.
- Perennial grass: perennial grass-like plant.
- Annual forb: annual broad-leaved herbaceous plant.
- Annual grass: annual grass-like plant.
- Geophyte: perennial herbs with bulbs, rhizomes or other subterranean storage organs.

##### 3.3.2 Lifespan (T06; IT)

Longevity of the species measured as the average maximum age (in years).

When quantitative data are not available, one of the following classes of lifespan should be assigned:

- Annual:  $\leq 1$  yr.
- Biannual: 2 yr.
- Perennial (unknown): at least 2 years. The lifespan could be longer, but data are not available.
- Perennial (short): 2-5 yr.
- Perennial (medium): 5-25 yr.
- Perennial (long): 25-150 yr.
- Perennial (very long):  $> 150$  yr.

##### 3.3.3 Average Height (T07; OT)

Maximum height of the plant (in meters).

Only vegetative tissues should be included, discarding the inflorescences projected above the foliage (e.g. reproductive shoots in shoot shedders should be excluded).

In general, plant height is associated with competitive vigour and whole plant fecundity (Cornelissen et al. 2003).

Differences in height could reflect differences in the allocation patterns, i.e., diverting resources to several stems (many resprouters) versus maintaining vertical extension of one or few stems (many non-resprouters; Pausas et al. 2004).

Moreover, tall plants may avoid the effects of surface fires because flames do not reach photosynthetic tissues (Bond et al. 2001).

### 3.3.4 Average Stem Diameter (T08; IT)

Average stem diameter measured at the base of the main stem or, if there is no primary stem, on the thickest one (in centimetres).

This trait is referred exclusively to woody plants.

Burls or other swellings on the base of the stems should be excluded.

Stem diameter at breast height, which is a usual measure in trees, is not possible for many species; thus, it was discarded as a standard method to measure this variable.

### 3.3.5 Bark Thickness (T09; IT)

Average bark thickness of the main stem at breast height for trees and one-third of the height for other woody species (in millimetres).

This trait is not applicable for herbaceous species but is very relevant for trees.

Bark thickness at the base is not considered because:

- bark at the base is usually not uniform;
- many data on bark thickness of trees at breast height are already available.

For semi-quantitative data, one of the following classes should be introduced:

- Thin:  $\leq 2$  mm
- Moderate: 2-15 mm
- Thick:  $> 15$  mm

The bark provides protection of vital tissues against damage, and very thick barks can decrease mortality by fire or accelerate post-fire recovery (Cornelissen et al. 2003; Pausas 1997).

### 3.3.6 95% Rooting Depth (T10; IT)

Average depth above, which 95% of root biomass is located (in meters).

This trait summarises the root depth distribution (i.e., how the root biomass is distributed vertically through the soil) in a single value, allowing easy comparisons between species (Cornelissen et al. 2003).

Rooting distribution in depth is related to soil resources uptake ability (Schenk & Jackson 2002).

### 3.3.7 Root Symbiosis (T11; IT)

Root symbiosis increases the efficiency of soil nutrient uptake, mainly nitrogen and phosphorous (Smith et al. 2003).

It has been suggested that early colonisation of roots by mycorrhizal fungi after fire facilitates the establishment of seedlings (Milne 2003), being especially relevant nitrogen-fixing nodules in legumes (Papavassiliou 2001).

Root symbiosis classes are defined by the symbiont:

- Ectomycorrhizal fungi: fungi symbiont does not penetrate in the roots, but surrounds it with a mantle of hyphaes.
- Endomycorrhizal fungi: fungi symbiont penetrates in the root, forming branched tree-like structures and/or vesicles between the root cells.
- Nitrogen-fixing bacteria: usually forms nodules attached to fine roots, which can be seen with the naked eye.
- Others: if the plant establishes another type of symbiosis (e.g., ericoid mycorrhizas) or combinations of several types of symbiosis (e.g., endo- and ectomycorrhizas).
- Yes (unknown): if the species has root symbiosis, but the symbiont is unknown
- No: when the species has no root symbiosis.

### 3.3.8 Clonality (T12; IT)

Clonality permits colonising a space through vegetative reproduction.

Several classes have been defined according to the location of the buds:

- Stolons (i.e., above-ground stems).
- Rhizomes (i.e., below-ground stems) or superficial roots.
- Tubers or bulbs: only if the plant shows a notable capacity of clonality by tubers or bulbs, not when this occurs only in exceptional cases.
- Yes: if the clonal ability has been detected, but the location of buds is unknown.
- No: for species without any clonal ability.

### 3.3.9 Shoot - Root Ratio (T13; IT)

Partitioning between aboveground biomass (shoot) and belowground biomass (root) in samplings up to 3-years-old.

Biomass should be measured as dry weight.

If accurate data is not available, semi-quantitative data can be introduced by means of the following classes:

- Low: lower than 1.5
- High: at least 1.5

Resprouting ability involves a high allocation to belowground storage organs, permitting post-fire regeneration (Iwasa & Kubo 1997).

Therefore, it has been suggested that there is a physiological trade-off in terms of a lower allocation to aboveground tissues, thus reducing the shoot -root rate in resprouting seedlings (Pate et al. 1990; Pausas 1999a; Verdaguer & Ojeda 2002).

**3.3.10 Average Height of Seedlings (T14; IT)**

Average height of 1-year-old seedlings (in centimetres).

Height of seedlings has been employed as a surrogate of seedling vigour (Pausas et al. 2003; Quintana et al. 2004).

**3.3.11 Spinescence (T15; VIT)**

Presence or absence of spines, thorns, prickles and/or spined leaves.

Only spinescence in vegetative organs is considered.

**3.3.12 Average Leaf Lifespan (T16; IT)**

Longevity of leaves measured as the average time period during which an individual leaf is alive and physiologically active (in months).

Leaf lifespan indicates the potential rate of return on the investment in leaves, and hence is closely related to resource use strategies (Reich et al. 1992).

**3.3.13 Leaf Phenology (T17; OT)**

Leaf phenology is related to the maintenance of green leaves in the canopy through a complete phenological period.

Therefore, unlike average leaf lifespan (T16), this trait is defined at plant level and not for individual leaves.

Leaf phenology classes are defined by the time and season during which the plant maintains green leaves:

- Evergreen: plants maintain green leaves all year. Leaves are long-lived (at least 1 year).
- Winter deciduous: plants lose all their leaves in winter.
- Winter semi-deciduous: plants lose their leaves partially in winter. Sometimes the plant maintains brownish leaves in the canopy (e.g., marcescent plants).

Drought semi-deciduous: plants partial (or totally) drop their leaves during most of the dry period.

In some cases, new summer leaves may appear (i.e., seasonal dimorphic shrubs).

Leaf dropping only in extreme drought years should be discarded.

**3.3.14 Average Specific Leaf Area (T18; IT)**

Average one-sided area of fresh leaf divided by its oven-dry mass ( $\text{mm}^2/\text{mg}$ ).

Petioles (or rachis in divided leaves) should be excluded from the measures (Garnier et al 2001).

Since SLA is related to leaf thickness and density (Niinemets 1999), the consistency and texture of the leaves can be employed as an indicator of the SLA.

Therefore, the semi-quantitative classes are defined as follows:

- Low: for sclerophyllous leaves (thick and/or tough leaves, with thick cuticles).
- Moderate: for lightly coriaceous leaves (leathery leaves, moderately cuticularized).
- High: mesophytic leaves (soft, thin and highly flexible leaves).

SLA is highly correlated with several physiological traits related to resource uptake and use efficiency and it is frequently considered a pivotal trait in plant growth strategies (Reich et al. 1997; Garnier et al. 2001).

**3.3.15 Leaf Division Degree (T19; OT)**

Leaf division is defined by the number of units that form the leaf blade, with:

- *simple* leaves being constituted by one unit and
- *divided* leaves being constituted by several units (also called compound leaves).

**3.3.16 Basic Leaf Shape (T20; OT)**

According to the shape of the leaf blade (or that of the leaflets, for divided leaves), leaves can be classified as *broad*, *needle-like*, *linear*, *scale-like*, *spines* or *succulent* (any of the following leaf shapes but swollen by water storage).

**3.3.17 Average Leaf Size (T21; IT)**

Average one-sided projected surface area of an individual leaf (in  $\text{mm}^2$ ).

If accurate measures of leaf size are not available, semi-quantitative classes can be introduced (see Table 2).

These classes have their equivalents in the categories suggested by Raunkiaer (1934; see Table 3).

Leaf size influences energetic and chemical fluxes through the leaves, and therefore affects resource uptake and use efficiency (Fonseca et al. 2000; Ackerly et al. 2002).

### 3.4 VEGETATIVE TRAITS RELATED TO FLAMMABILITY

Flammability is considered here as both the ability to start a fire (ignitability) and the ability to spread a fire (combustibility).

The latter is more related to plant structure while the former to tissue characteristics (Behm et al. 2004).

It has been suggested that flammability and regeneration traits should be related (Bond & Migdley 1995; Schwilk & Ackerly 2001).

#### 3.4.1 Flammable Compounds (T22; IT)

Presence in a plant's vegetative organs of chemical compounds that increase flammability, because their temperature of ignition is lower than that of the dry matter (Elvira & Hernando 1989).

Usually, these compounds are aromatic and sticky.

The dominant flammable compound defines each of the following classes:

- Oils: main flammable compounds are oils.
- Waxes: main flammable compounds are waxes.
- Resins: main flammable compounds are resins.
- Yes: if the plant has flammable compounds, but their composition is unknown. Also, if other types of flammable compound have been identified, or for a combination of the previous, if none of them predominates over the rest.
- No: plants have no flammable compound.

#### 3.4.2 Dead Fine Fuel (T23; IT)

Proportion of standing fine dead biomass attached to the plant during the dry season in relation to the total aboveground biomass.

Fine fuel refers to fuel with a diameter of less than 6 mm, and includes twigs, leaves, inflorescences and bark.

Senescent individuals should be excluded because they tend to have higher dead material attached to the plant (e.g., Baeza et al. 2002).

If accurate quantitative data are not available, one of the following categories should be assigned:

- Low: if dead fuel comprises less than (or equal to) 5% of the total aboveground biomass.
- Moderate: if dead fuel represents between 5 and 20 % (excluding these values) of the total aboveground biomass.
- High: if dead fuel is equal to (or larger than) 20% of the total aboveground biomass.

A higher proportion of dead biomass increases flammability since dead fuel has very low water content (Elvira & Hernando 1989).

#### 3.4.3 Coarse - Fine Fuel Ratio (T24; IT)

Ratio between the proportion of aboveground biomass assigned to coarse fuel (at least 6 mm in diameter) and that assigned to fine fuel (with diameter less than 6 mm).

Coarse and fine fuels include alive and dead biomass.

When quantitative data are not available, one of the following semi-qualitative classes can be selected:

- Low: plants with no coarse fuel (all aboveground biomass corresponds to fine fuel).
- Moderate: plants with abundant fine fuel and light coarse fuel. Thus, the contribution of coarse fuel to the aboveground biomass is low.
- High: plants with abundant fine fuel and heavy coarse fuel. Therefore, the contribution of coarse fuel to aboveground biomass is high.
- Very high: when fine fuel is very scarce and coarse fuel is very heavy. Aboveground biomass is comprised mainly of coarse fuel.

Fuel size affects the amount of potential fuel that would combust in a wildfire, with fine fuel being more flammable than coarse fuel (Bond & van Wilgen 1996; Baeza et al. 2002).

### 3.5 REGENERATION TRAITS

#### 3.5.1 Resprouting Capacity after Fire (T25; OT)

Average proportion of adult plants that show vigorous resprouting six months after 100% scorching.

Alternative semi-quantitative classes are the following:

- No: none of the plants resprout.
- Low: plants resprout only after low fire severity. In general, plants show low resprouting vigour and/or high mortality.
- High: plants resprout after fires with either low and high severity. In general, plants show high resprouting vigour and/or scarce mortality.
- Yes: plants have resprouting capacity, but the degree of resprouting is unknown.

#### 3.5.2 Resprouting Capacity after Clipping (T26; IT)

Average proportion of adult plants that show vigorous resprouting six months after undergoing 100% harvest.

For semi-quantitative data, one of the following classes can be selected:

- No: without any resprouting capacity.
- Low: plants resprout, but sprouts are scarce and/or weak.
- High: plants resprout, and the sprouts are abundant and/or vigorous.
- Yes: if species have resprouting capacity, but the degree of resprouting is unknown

#### 3.5.3 Bud Source (T27; VIT)

Location of bud bank, protected from disturbances, allowing the regeneration of removed biomass by means of resprouting:

- Epicormic buds: buds close to or just below the surface of the bark.
- Root crown: buds at base of the trunk.
- Lignotuber or burls: buds in a woody swelling below or just above the soil.
- Rhizome or root: buds in rhizomes or shallow roots.
- Bulb: belowground storage organ formed by swelling leaves.
- Yes: if plants have bud bank, but its location is unknown.
- No: if plants have no bud bank.

#### 3.5.4 Seed Bank (T28; VIT)

Location of persistent seed bank (only if seeds remain alive in the bank more than one year)

- Soil: when persistent seed bank is located in the soil.
- Canopy: when persistent seed bank is located in the canopy.
- No: for species with no seed bank or with a transient seed bank (seeds remain alive in the seed bank for a maximum of one year or less).

#### 3.5.5 Heat-Stimulated Germination (T29; IT)

This takes place if the germination of seeds exposed to temperatures higher than 45°C increases in relation to that of seeds not exposed to heat treatments (control).

The degree of heat-stimulated germination is established according to the intensity of the heat treatment, defined by temperature and time of exposition (see Table 4 for intensity of heat-treatments classes):

- High: stimulation is detected after exposure to a high-intensity heat treatment.
- Moderate: stimulation is at least detected when seeds have undergone a moderate intensity heat treatment.
- Low: stimulation is at least detected when seeds have undergone a low intensity heat treatment.
- No: germination is not stimulated by any heat treatment.
- Inhibition: germination of seeds exposed to high temperatures is lower than germination of control seeds control one, even when seeds are submitted to the lower intensity heat treatment.

#### 3.5.6 Average Seed Bank Longevity (T30; IT)

Average number of years that seeds remain viable in the seed bank (independently of the location of the dormant seeds).

When accurate quantitative data are not available, one of the following classes should be selected:

- Not applicable: for species with no seed bank or with a transient seed bank (seeds remain alive in the seed bank for a maximum of one year).
- Short-term persistent: seeds remain alive in the seed bank for more than 1 year, but less or equal to 5 years.
- Long-term persistent: seeds remain alive in the seed bank for more than 5 years. Seed bank longevity could be longer but data are not available.
- Very long-term persistent: seeds remain alive in the seed bank for at least 15 years.
- Yes (unknown): seeds remain alive for more than one year, but maximum seed longevity is unknown.

#### 3.5.7 Post-fire Seedling Emergence (T31; VIT)

Average density of seedlings per pre-fire mature individuals that emerged during the first year after fire.

If quantitative data are not available, one of the following classes can be selected:

- No: if emergence of post-fire seedlings is not detected.
- Low: the number of post-fire seedlings is lower than the number of pre-fire mature individuals.
- High: the number of post-fire seedlings is higher than the number of pre-fire mature individuals.
- Yes: if emergence of post-fire seedlings is detected but its abundance in relation to pre-fire mature individuals is unknown.

### 3.5.8 Post-fire Seedling Survival (T32; IT)

Average survival of post-fire seedlings (in percentage) measured after the first dry season.

Alternative semi-quantitative classes are the following:

- No: no post-fire seedlings survive.
- Low: lower than 25% survival.
- High: at least 25% survival.
- Yes: if some post-fire seedling survival is observed, but the quantity of live seedlings after the first dry season in relation to emerged seedlings is unknown.

### 3.5.9 Age at Maturity of Resprouts (T33; IT)

Average age (in years) of resprouts at first successful reproduction, i.e., when most of the resprouted plants produce the first viable seeds.

When quantitative data is not available, one of the following classes should be assigned:

- Early: < 5 years.
- Medium: 5-10 years.
- Late: > 10 years.

### 3.5.10 Age at Maturity of Saplings (T34; IT)

Average age of saplings at first successful reproduction, i.e., when most of the saplings produce the first viable seeds.

This trait refers to both resprouters and non-resprouters.

The following classes were defined for semi-quantitative data:

- Early: < 5 years.
- Medium: 5-10 years.
- Late: > 10 years.

Because the saplings of resprouters should allocate resource to store reserves for boosting resprouting, it has been suggested that resprouters should flower later than non-resprouters.

This relationship between fire response and age at maturity of saplings has been found for several fire-prone ecosystems (see Pausas et al. 2004).

## 3.6 SEXUAL REPRODUCTIVE TRAITS

### 3.6.1 Mating System (T35; IT)

Mating system classes are defined by the distribution of male and female organs between individuals of the same population:

- Monoecy: male and female structures appear on the same individual; all individuals are co-sexual.
- Dioecy: male and female structures appear in different individuals; there are female and male individuals.
- Gynodioecy: female and co-sexual individuals coexist in the same population.
- Androdioecy: male and co-sexual individuals coexist in the same population.
- Androgynodioecy: male, female and co-sexual individuals coexist in the same population.
- Others: for other types of mating system (e.g. monodioecy).

### 3.6.2 Average Annual Seed Production (T36; IT)

Average number of seeds per plant produced each year.

When masting occurs, seed production refers exclusively to the reproductive year.

### 3.6.3 Average Seed Dry Weight (T37; IT)

Average seed dry weight (in milligrams).

Classes for semi-quantitative data are as follows:

- Very light: < 3 mg.
- Light: 3-30 mg.
- Moderate: 30-300 mg.
- Heavy: > 300 mg.

Seed weight is a widespread measure of seed size (see examples in Westoby et al. 2002).

It is closely related to:

- seedling survival (Leishman & Westoby 1994a, b),
- seed bank longevity (Thompson et al. 1993, Moles et al. 2000) and
- dispersal (Hughes et al. 1994).

### 3.6.4 Basic Seed Shape (T38; IT)

Ratio between the two maximum diameters.

Structures attached to the seed coat (as wings or pappus) should be excluded.

Two classes were defined for semi-quantitative data:

- Regular: ratio close to one, as spherical or lens-shaped seeds.
- Irregular: ratio far from one, as elongated seeds.

Seed shape is correlated with longevity of seed bank, probably because regular seeds may be buried easily, thus diminishing predation (Thompson et al. 1993, Moles et al. 2000).

### 3.6.5 Fruit Type (T39; OT)

Fruit classification (including single or aggregated fruits) according to their consistence:

- Fleshy: at least one fruit tissue is succulent at maturity (berries)
- Dry: no fruit tissue is succulent at maturity.

The pulp of fleshy fruits is widely recognised as an award to seed dispersers, although its considerable role in seed defence has also been suggested (Mack 2000)

In the Mediterranean Basin, most resprouters have fleshy fruit whereas most seeders have dry fruits (Verdú 2000; Pausas & Verdú 2005), although there are some important exceptions.

### 3.6.6 Average Fruit Dry Weight (T40; IT)

Average fruit dry weight measured in milligrams. Single or aggregated fruits should be included.

When accurate data are not available, one of the following classes should be assigned:

- Very light: < 3 mg
- Light: 3-30 mg
- Moderate: 30-300 mg
- Heavy: 300-3000 mg
- Very heavy: > 3000 mg.

### 3.6.7 Dispersal of sexual structure (T41; VIT)

The sexual structure that is dispersed is called a propagule and can correspond to *seeds* or *fruits*.

The following traits are related to the spatial dispersal of sexual propagules.

Since propagules can be dispersed by different mechanisms, the structure of the database makes it possible to describe at least two of them without the need to indicate any priority (either by frequency, order or efficiency).

Spatial dispersal ability indicates the capacity to colonise new habitats and therefore determines the persistence of plants at landscape level in disturbance-prone ecosystems (Pausas & Lavorel 2003).

### 3.6.8 Dispersal Mode (T42 and T45; IT)

The *Dispersal Mode* is defined according to the vector of the propagule dispersal.

- Autochory: propagules are dispersed by themselves, without the assistance of any dispersal vector. They simply fall by gravity.
- Anemochory: propagules are equipped with special structures, such as pappus or wings, which allow them to fly or float in the air.
- Hydrochory: when propagules are spread by water.
- Ballistichory: also named ballochory. Dehiscence of fruit occurs as an explosion, launching seeds far away from the plant.
- Myrmerochory: propagules are scattered by ants that are lured by an attached structure called elaiosomes that is rich in nutrients.
- Endozoochory: propagules are dispersed with the aid of animals that eat and excrete them.
- Epizoochory: the propagule sticks to the animal by means of barbs, hooks or spines.
- Hoarding: animals, usually mammals scatter and hoard the propagules. Dispersal by ants should be excluded.

### 3.6.9 Dispersal Distance (T43 and T46; IT)

Dispersal distance (in metres) covered by 50% of the sexual propagules produced by an individual plant (i.e., median dispersal distance).

When accurate data is not available, one of the following semi-quantitative classes can be chosen:

- Very short:  $\leq 5$  m (in big plants, propagules remain under the parental canopy).
- Short: 5-30 m.
- Medium: 30-100 m.
- Long: 30-1000 m.
- Very long: > 1000 m.

### 3.6.10 Maximal Dispersal Distance (T44 and T47; IT)

Maximal dispersal distance (in metres) covered by sexual propagules.

Very extreme and very infrequent maximal distances reached by propagules (e.g. maximal distances occurring only in rare years) should be excluded.

Semi-quantitative classes are the same as those established for the last traits (T43 and T46):

- Very short:  $\leq 5$  m (in big plants, propagules remain under the parental canopy).
- Short: 5-30 m.
- Medium: 30-100 m.
- Long: 30-1000 m.
- Very long: > 1000 m.

EUFireLab Plant Database classes	Raunkiaer's categories
Tree	Megaphanerophyte
	Mesophanerophyte
	Microphanerophyte
Shrub	Nanophanerophyte
Liana	(climbing) Phanerophyte
Scrub	Chamaephyte
Perennial forb Perennial grass	Hemicriptophyte
Annual forb Annual grass	Terophyte
Geophyte	Geophyte

Table 2. Correspondence between the life form classes employed in the EUFireLab Plant Database and the Raunkiaer categories.

EUFireLab Plant Database classes	Leaf area (mm <sup>2</sup> )	Raunkiaer categories
Very small	< 25	Leptophyll
Small	25-225	Nanophyll
Intermediate	225-2025	Microphyll
Large	2025-4550	Notophyll
		Mesophyll
		Macrophyll
Very large	> 4550	Megaphyll

Table 3. Correspondence between the leaf size classes employed in the EUFireLab Plant Database and the Raunkiaer categories (1934).

		Temperature	
		< 100 °C	≥ 100 °C
Time	≤ 5 min	LOW	MODERATE
	> 5 min	MODERATE	HIGH

Table 4. Classes of intensity of heat treatments applied to seeds (in capitals) according to the temperature and time of exposition.

## 4 RESULTS

### 4.1 DESCRIPTION OF THE DATABASE AT TAXONOMIC LEVEL

The database consists of seven data sets, five from the Iberian Peninsula and one from Greece; it was compiled by 6 contributors (Table 5 and Appendix 1).

It includes 216 species of gymnosperms, dicots and monocots from 153 genera and 44 families (see Figure 1 and Appendix 2).

75% of the entries correspond 13 families; the five top families are Fabaceae, Lamiaceae, Pinaceae, Asteraceae and Cistaceae (Figure 1A).

At genus level, only seven genera comprise ca. 25% of the entries, with *Pinus* and *Quercus* being the best represented (Figure 1B).

Most of the species included in the data set are resprouters, and five of them showed different resprouting capacity in different data sets (see Table 5).

Regarding the other species, 125 were resprouters and 86 non-resprouters (see Table 5).

In general, each species appears once in each data set (i.e., 1 record per species and data set), except *Pinus pinaster*, which has 13 records in one of the data sets summing a total of 17 records for this species.

This species is the best represented in the database as for the number of records, number of entries and percentage of traits filled, followed by *Quercus coccifera*, *P. halepensis* and *Q. ilex* (Tables 6 and 7).

Regarding, all species have data for at least 35% of the traits (Table 8).

This minimum number of traits, with at least one entry, corresponds mainly to “obligatory traits” (OT) and “very important traits” (VIT).

Differences in traits filled between species were due to differences in the number of “important traits” filled (Figure 2).

### 4.2 DATA GATHERING

The database comprises a total of 5113 entries.

Of the 43 traits proposed:

- five were completed for all the records,
- four of which were “obligatory traits” (OT; Life Form, Average Height, Leaf Division Degree and Resprouting Capacity after Fire) and
- one, a “very important trait” (VIT; Bud Source).

No traits are completely empty in the database, but seven traits have data for less than ten records.

Very few records have data for flammability traits (in all cases less than 10%).

Traits related to leaf properties (included in general traits, T16-T21) are the best represented in the database.

More than the 50% of these traits have data for at least 75% of the records.

Around 50% of the general traits (excluding leaf traits) and the sexual reproduction traits have data for less than the 25% of the records.

More than the 50% of the regeneration traits have data for at least 75% of the records (see Figure 3).

The accuracy of the data can be evaluated by:

- the source of each entry (accuracy at source level)
- and, with respect to continuous variables, the type of data (quantitative, semi-quantitative or binary) (accuracy at data level).

Thus, at source level, we could consider two levels of accuracy:

- high, when the source was “measure” or “specific bibliography”, and
- low, when the source was “observation” or “general bibliography”.

Considering these two levels of accuracy, 82% of the entries have low accuracy, and the remaining 18% have high accuracy.

Morphological traits that are easily defined by simple observation are those with no high-accuracy data (Spinescence, Leaf division Degree and Leaf Shape, T15, T19 and T20 respectively; Figure 3).

In a similar way, data that usually appears in floras or other types of general bibliography, such as Life Form (T05) or Average Height (T07) are mainly of low accuracy (Figure 3).

Traits with high accuracy at source level are mainly continuous.

Traits with data from high accurate sources have few entries, except for Heat-Stimulated Germination (T29) and Maximal Dispersal Distance (T44; Figure 3).

Traits showing most entries with high accuracy are Average Seed Dry Weight (T37) and Average Leaf Size (T21; Figure 3).

Resprouting Capacity after Fire (T25) and Post-fire Seedling Emergence (T31), both very relevant for post-fire regeneration, show many high-accuracy entries, although low-accuracy data are the most common (Figure 3).

Among the categorical variables, Root Symbiosis (T11) is the trait with most accurate data at source level (Figure 3).

For continuous variables, data that come from high-accuracy sources are mainly quantitative (Figure 4A), whereas traits from low-accuracy sources are mostly semi-quantitative and binary (Figure 4B).

Remarkable exceptions are Resprouting Capacity after Fire (T25) and Post-Fire Seedling Emergence (T31), both having high-accuracy information in a binary form (Figure 4).

At the other extreme, all the Average Height (T07) data come mainly from low-accuracy sources and are quantitative (Figure 4).

Table 5. Taxonomic variability and resprouting capacity (R+: yes; R-: no) information in each data set in the EUFireLab Plant Database.

Data set	Study area	Families	Genera	Species	R+	R-
CEAM	E Spain	35	68	95	66	29
CREAF1	NW Spain	6	9	16	14	2
CREAF2	NW Spain	2	4	9	4	5
INIA	Spain	1	1	1*	0	1
UAECO	C & N Greece	29	77	83	39	44
UCLM	E Spain	12	38	55	28	27
UTAD	N & C Portugal	3	3	3	1	2
GLOBAL		44	141	216	91(5)**	130(5)**

(\*) 13 records for one species (*Pinus pinaster*).

(\*\*) *Helichrysum stoechas*, *Santolina chamaecyparissus*, *Teucrium capitatum*, *T. pseudochamaeypytis*, *Thymus vulgaris* had different resprouting capacity in different data sets.

Table 6. Species most represented in the EUFireLab Plant Database at several levels: number of records, number of entries, percentage of traits filled (total, obligatory, very important, important traits).

Species	Records	Entries	%traits	%OT*	%VIT*	%IT*
<i>Pinus pinaster</i>	17	475	91	100	80	90
<i>Quercus coccifera</i>	3	75	77	100	80	71
<i>Pinus halepensis</i>	3	69	77	100	80	71
<i>Quercus ilex</i>	4	66	74	100	80	68

(\*) OT: obligatory traits; VIT: very important traits; IT: important traits

Table 7. Number of species (including % of species and examples) with different number of records.

# records	# species	% species	Examples
1	178	82.4	<i>Ulex parviflorus</i> , <i>Erica umbellata</i>
2	32	14.8	<i>Rosmarinus officinalis</i> , <i>Quercus suber</i>
3	4	1.9	<i>Quercus coccifera</i> , <i>Pinus halepensis</i>
4	1	0.5	<i>Quercus ilex</i>
>4	1	0.5	<i>Pinus pinaster</i> (17 records)

Table 8. Number of species (including % of species and examples) with different percentage of traits having data.

% traits	# species	% species	Examples
<50	136	63	<i>Myrtus communis</i> , <i>Olea europaea</i>
50-75	77	36	<i>Rosmarinus officinalis</i> , <i>Erica umbellata</i>
75-100	3	1	<i>Pinus pinaster</i> , <i>Quercus coccifera</i>

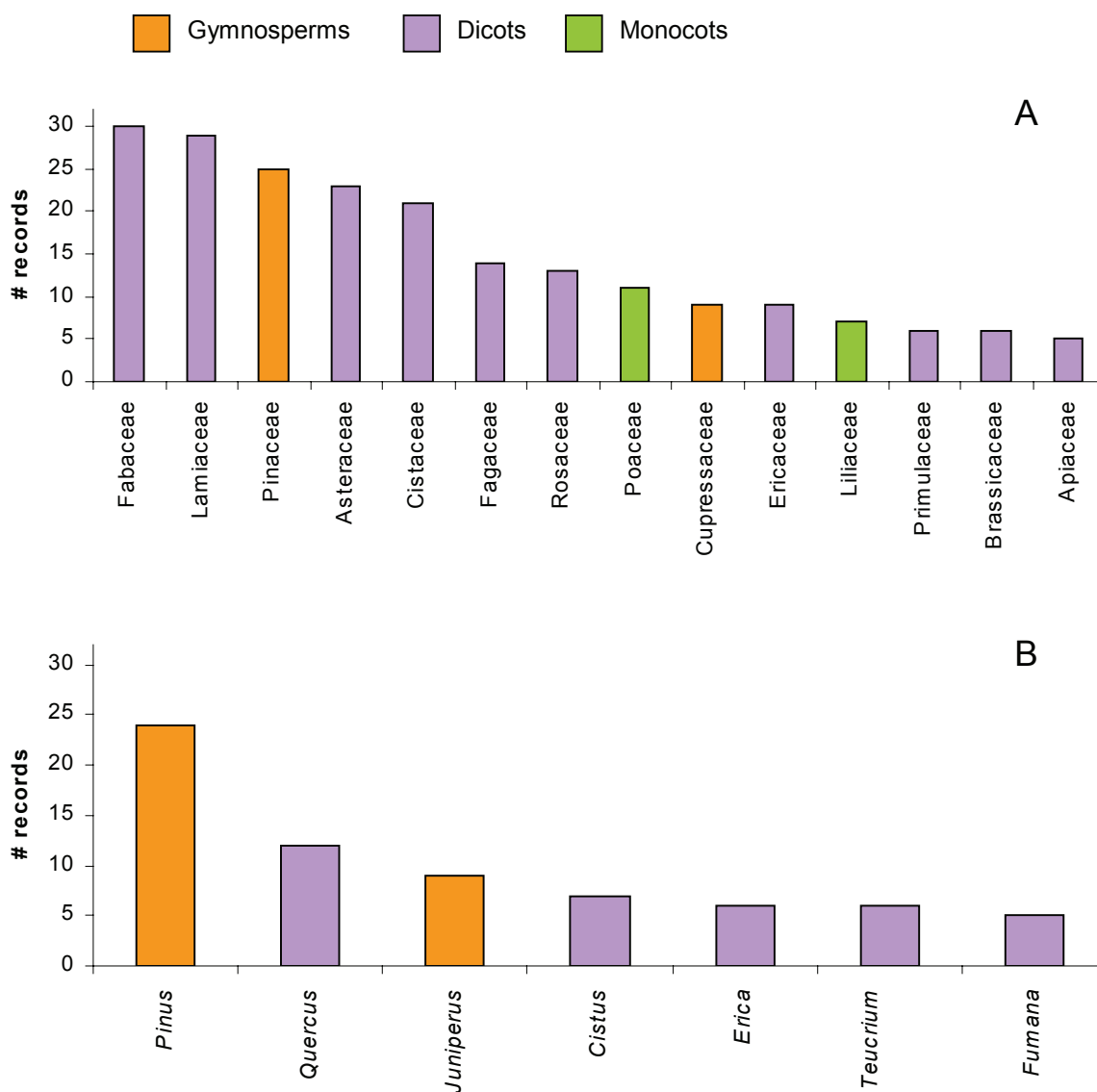


Figure 1. Families (A) and genera (B) with highest number of records in the EUFireLab Plant Database. The families listed represent 75% of the records, whereas the genera include 25% of the records

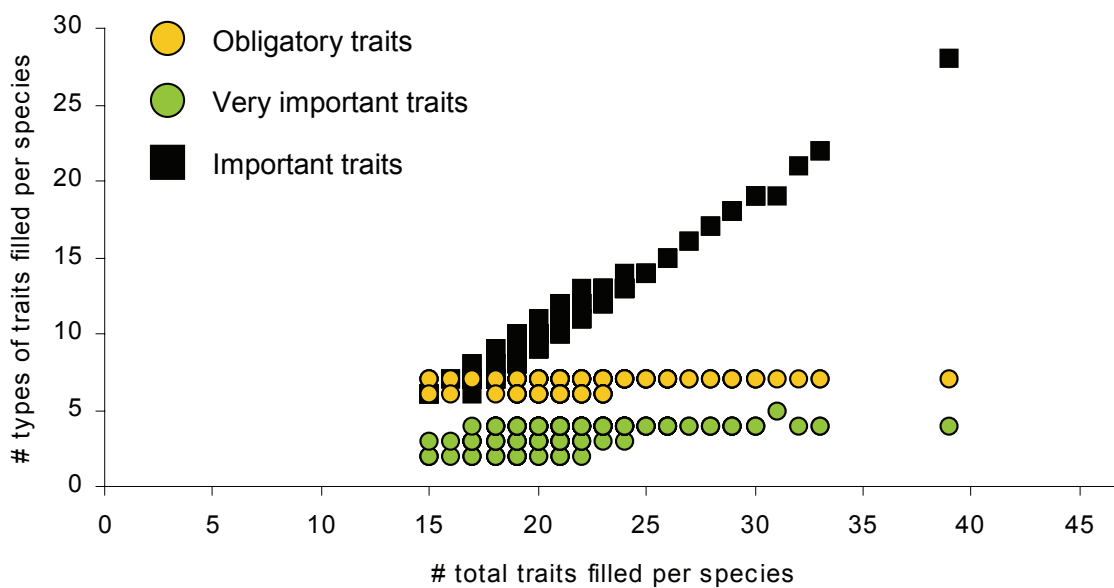


Figure 2. Contribution of the different types of traits to the total traits filled per species.

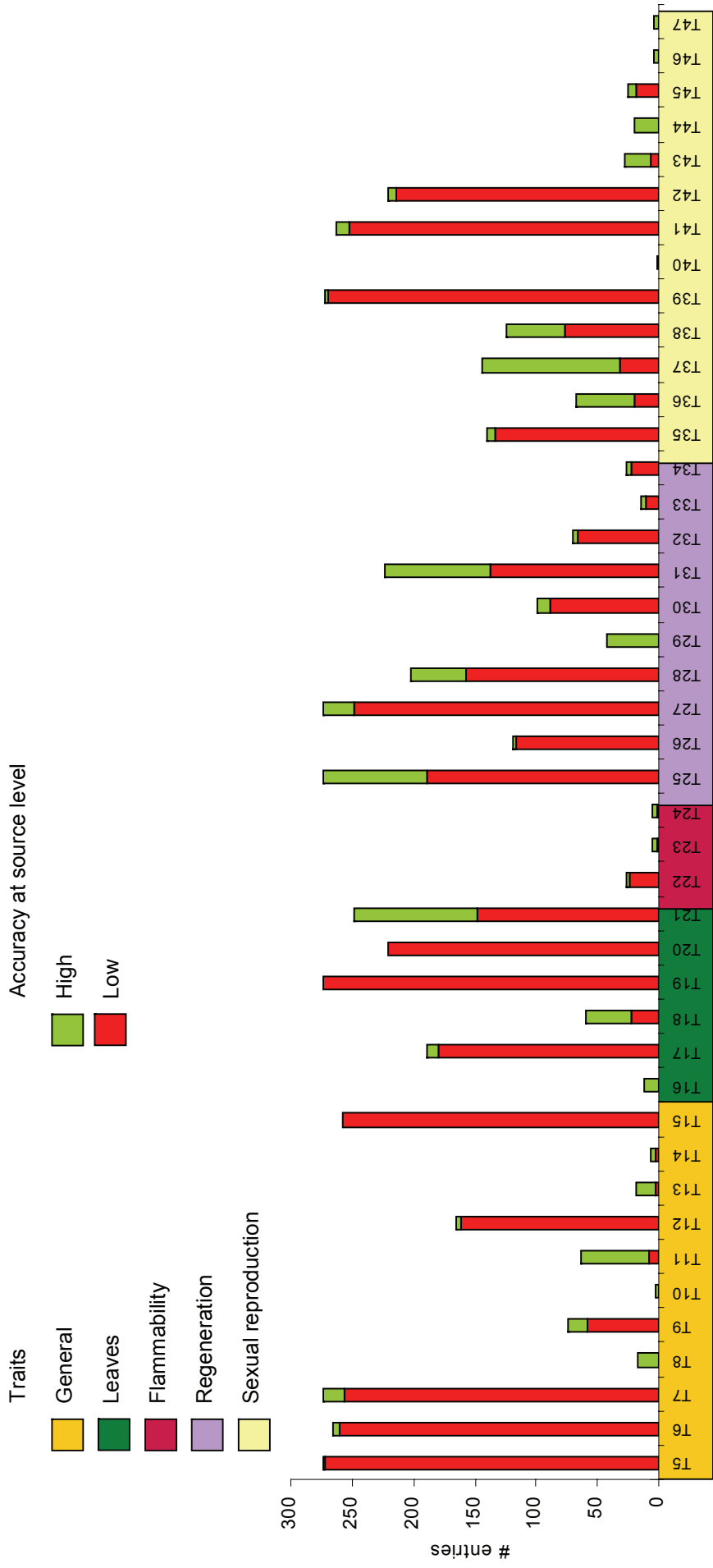


Figure 3. Accuracy of the entries for each trait at source level.

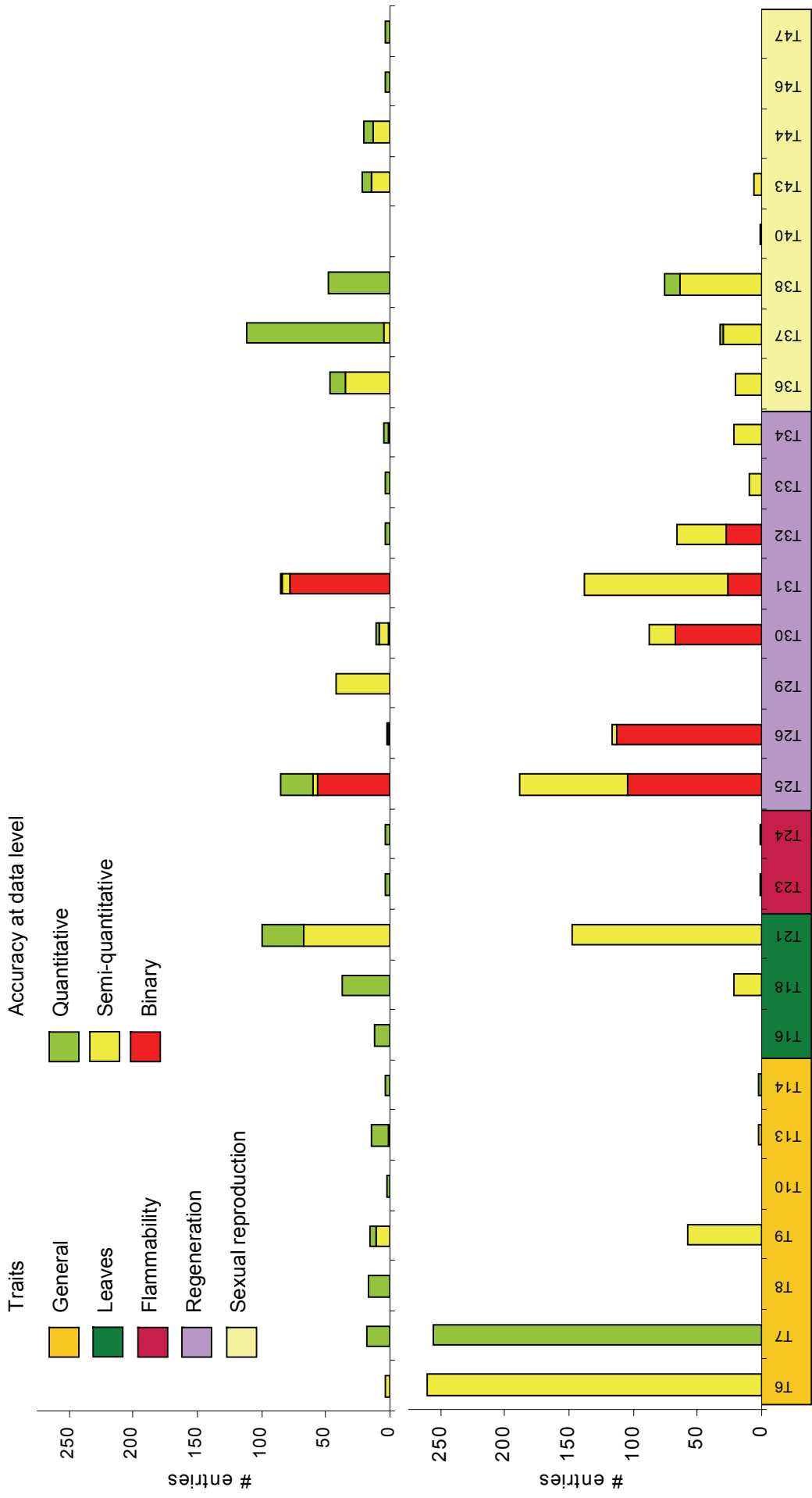


Figure 4. Accuracy of the entries for each trait at data level. A: high-accuracy sources; B: low-accuracy source.

## 5 DISCUSSION

The database structure and trait definition made for the EUFireLab attempt to standardise data gathering and compilation for many sources and localities in fire-prone ecosystems.

This EUFireLab standard may complement the LEDA standards (Knevel et al. 2005) elaborated for North-West European ecosystems by providing standards for fire-related traits that are very relevant in South European regions.

The consideration of three alternative levels of accuracy for continuous traits (i.e., quantitative, qualitative and binary data) is an interesting novelty that permits compile great amount of information that would not be depicted otherwise.

The compiled database includes a wide taxonomic spectrum of different vegetation types (from pine forest to shrublands like maquis or heathlands).

Considering both the number of entries and the accuracy of the information, leaf traits are the best represented in the database.

This is important because leaf traits are related to efficiency in resource use and uptake.

On the other hand, other basic traits (e.g., plant height, life span) are very poorly represented.

This is because some of these traits are obtained from general references, such as floras, that do not provide accurate information on ecological traits and most of the researchers trust this information and do not collect it in the field.

The use of these sources makes it difficult to account for geographical variability. In other cases, information is simply very scarce, even for traits that are very relevant in plant resource strategies (e.g., leaf longevity or rooting depth).

Regeneration traits are probably the most important traits in fire-prone ecosystems.

In general, our database includes information on post-fire regeneration for most species, although in most cases the data is not quantitative.

Furthermore, the information on other very important regeneration traits, such as heat-stimulated germination and age at maturity, is very scarce.

Similarly, flammability and dispersal traits are very badly represented in the database.

The current low number of data sets makes it very difficult to analyse trait variability.

In general, however, in the few cases in which the same species has been recorded in more than one data set, variability is low, which is possibly due partially to the low accuracy of the information on many traits.

An exception is the case of *Pinus pinaster*, in which we have quantitative information for many different localities.

This species shows some variability, especially in post-fire seedling survival and in seed characters such as seed production and seed bank longevity.

To provide a better characterisation of plant functional traits for European fire-prone ecosystems, effort should be directed toward:

- Gathering more data sets (more localities).
- Improving the quality of existing data sets by increasing the number of entries (i.e., more information for each species).
- Improving the quality of existing data sets by increasing the accuracy of the data (i.e., quantifying continuous traits).

The compiled database is the first attempt to homogenise and synthesise data on plant function traits in fire-prone European ecosystems.

The use of this database can be valuable at very different levels.

These include:

- to identify accurate post-fire regeneration syndromes (Keeley & Zedler 1998),
- to predict post-fire vegetation dynamics (Pausas 1999b; Kazanis & Arianoutsou 2004),
- to improve biodiversity management decisions in fire-prone ecosystems (Bradstock & Kenny 2003) and
- to identify of evolutive trends in fire traits (Pausas & Verdú 2005).

A continuous update of this database would be advisable.

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**APPENDIX 1: DESCRIPTION OF CONTRIBUTORS AND DATA SETS OF THE EUFIRELAB PLANT TRAITS DATABASE (WP4T3C).**

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<b>EuFireLab partner:</b>	P09
<b>Data sets:</b>	1
<b>Study area:</b>	Eastern Iberian Peninsula (Valencia region, Spain)
<b>Families:</b>	35
<b>Genera:</b>	68
<b>Species:</b>	95
<b>Entries:</b>	1890

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<b>Data sets:</b>	2
<b>Study area:</b>	North-Western Spain (Catalonia)
<b>Families:</b>	6 (data set CREAM1) + 2 (data set CREAM2)
<b>Genera:</b>	9 (data set CREAM1) + 4 (data set CREAM2)
<b>Species:</b>	16 (data set CREAM1) + 9 (data set CREAM2)
<b>Entries:</b>	249 (data set CREAM1) + 145 (data set CREAM2)

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<b>Data sets:</b>	1
<b>Study area:</b>	Spain
<b>Families:</b>	1
<b>Genera:</b>	1
<b>Species:</b>	1 (13 records)
<b>Entries:</b>	381

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<b>Data sets:</b>	1
<b>Study area:</b>	Central (Attica) and Northern (Halkidiki) Greece
<b>Families:</b>	29
<b>Genera:</b>	77
<b>Species:</b>	83
<b>Entries:</b>	1370

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<b>Data sets:</b>	1
<b>Study area:</b>	Eastern Iberian Peninsula (province of Cuenca, Spain)
<b>Families:</b>	12
<b>Genera:</b>	38
<b>Species:</b>	55
<b>Entries:</b>	982

<b>Author(s):</b>	Fernandes P
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<b>Data sets:</b>	1
<b>Study area:</b>	Northern and Central Portugal
<b>Families:</b>	3
<b>Genera:</b>	3
<b>Species:</b>	3
<b>Entries:</b>	96

## APPENDIX 2: SPECIES INCLUDED IN THE EUFIRELAB PLANT TRAITS DATABASE (WP4T3C).

## LEGEND

**Resprouting** (after 100% scorched)

R+: resprouters

R-: non-resprouters

Species	Family	Resprouting	Records	Data sets
<i>Acer campestre</i>	Sapindaceae	R+	1	CREAF1
<i>Acer granatense</i>	Sapindaceae	R+	1	CEAM
<i>Acer monspessulanum</i>	Sapindaceae	R+	2	CEAM, CREAM1
<i>Acer opalus</i>	Sapindaceae	R+	1	CREAF1
<i>Achillea ageratum</i>	Asteraceae	R+	1	UCLM
<i>Aira elegantissima</i>	Poaceae	R-	1	UAECO
<i>Ajuga chamaepitys</i>	Lamiaceae	R-	1	UAECO
<i>Amelanchier ovalis</i>	Rosaceae	R+	1	CREAF1
<i>Amelanchier rotundifolia</i>	Rosaceae	R+	1	CEAM
<i>Anagallis arvensis</i>	Primulaceae	R-	2	CEAM, UAECO
<i>Anarrhinum bellidifolium</i>	Scrophulariaceae	R+	1	UCLM
<i>Anemone coronaria</i>	Ranunculaceae	R+	1	UAECO
<i>Anthyllis cytisoides</i>	Fabaceae	R+	1	CEAM
<i>Anthyllis hermanniae</i>	Fabaceae	R+	1	UAECO
<i>Arbutus andrachne</i>	Ericaceae	R+	1	UAECO
<i>Arbutus unedo</i>	Ericaceae	R+	1	CEAM
<i>Arctostaphylos uva-ursi</i>	Ericaceae	R+	1	CEAM
<i>Asparagus acutifolius</i>	Liliaceae	R+	1	UAECO
<i>Asterolinon linum-stellatum</i>	Primulaceae	R-	2	CEAM, UAECO
<i>Atractylis cancellata</i>	Asteraceae	R-	1	UAECO
<i>Biscutella didyma</i>	Brassicaceae	R-	1	UAECO
<i>Bituminaria bituminosa</i>	Fabaceae	R+	1	UAECO
<i>Brachypodium phoenicoides</i>	Poaceae	R+	1	CEAM
<i>Brachypodium retusum</i>	Poaceae	R+	2	CEAM, UAECO
<i>Bupleurum fruticosum</i>	Apiaceae	R+	1	CEAM
<i>Bupleurum semicompositum</i>	Apiaceae	R-	1	UAECO
<i>Buxus sempervirens</i>	Buxaceae	R+	1	CEAM
<i>Calicotome spinosa</i>	Fabaceae	R+	1	CEAM
<i>Calicotome villosa</i>	Fabaceae	R+	1	UAECO
<i>Campanula drabifolia</i>	Campanulaceae	R-	1	UAECO
<i>Capsella bursa-pastoris</i>	Brassicaceae	R-	1	UAECO
<i>Celtis australis</i>	Ulmaceae	R+	1	CEAM
<i>Centaurea pinae</i>	Asteraceae	R-	1	UCLM
<i>Centaurea raphanina</i>	Asteraceae	R+	1	UAECO

Species	Family	Resprouting	Records	Data sets
<i>Ceratonia siliqua</i>	Fabaceae	R+	1	CEAM
<i>Chaenorhinum minus</i>	Scrophulariaceae	R-	1	CEAM
<i>Chamaerops humilis</i>	Arecaceae	R+	1	CEAM
<i>Chamaespartium tridentatum</i>	Fabaceae	R+	1	UTAD
<i>Chondrilla juncea</i>	Asteraceae	R-	1	UCLM
<i>Cistus albidus</i>	Cistaceae	R-	1	CEAM
<i>Cistus clusii</i>	Cistaceae	R-	1	CEAM
<i>Cistus creticus</i>	Cistaceae	R-	1	UAECO
<i>Cistus crispus</i>	Cistaceae	R-	1	CEAM
<i>Cistus monspeliensis</i>	Cistaceae	R-	2	CEAM, UAECO
<i>Cistus salviifolius</i>	Cistaceae	R+	1	UAECO
<i>Clematis flammula</i>	Ranunculaceae	R+	1	CEAM
<i>Colutea arborescens</i>	Fabaceae	R+	1	UAECO
<i>Convolvulus althaeoides</i>	Convolvulaceae	R+	1	CEAM
<i>Convolvulus elegantissimus</i>	Convolvulaceae	R+	1	UAECO
<i>Coridothymus capitatus</i>	Lamiaceae	R+	1	UAECO
<i>Coris monspeliensis</i>	Primulaceae	R+	1	CEAM
<i>Cornus sanguinea</i>	Cornaceae	R+	1	CREAF1
<i>Coronilla minima</i>	Fabaceae	R+	1	CEAM
<i>Crataegus monogyna</i>	Rosaceae	R+	3	CEAM, CREAM1, UAECO
<i>Crepis hellenica</i>	Asteraceae	R-	1	UAECO
<i>Crucianella angustifolia</i>	Rubiaceae	R-	1	UAECO
<i>Cuscuta epithymum</i>	Convolvulaceae	R-	1	UAECO
<i>Cyclamen graecum</i>	Primulaceae	R+	1	UAECO
<i>Cynosurus echinatus</i>	Poaceae	R-	1	UAECO
<i>Cytinus hypocistis</i>	Rafflesiaceae	R-	1	UAECO
<i>Dactylis glomerata</i>	Poaceae	R+	1	CEAM
<i>Daphne gnidium</i>	Thymelaeaceae	R+	1	CEAM
<i>Desmazeria rigida</i>	Poaceae	R-	1	UAECO
<i>Diploaxis eruroides</i>	Brassicaceae	R-	1	CEAM
<i>Dorycnium hirsutum</i>	Fabaceae	R+	2	CEAM, UAECO
<i>Dorycnium pentaphyllum</i>	Fabaceae	R+	1	CEAM
<i>Erica arborea</i>	Ericaceae	R+	1	UCLM
<i>Erica cinerea</i>	Ericaceae	R-	1	UCLM
<i>Erica manipuloflora</i>	Ericaceae	R+	1	UAECO
<i>Erica multiflora</i>	Ericaceae	R+	1	CEAM
<i>Erica scoparia</i>	Ericaceae	R+	1	UCLM
<i>Erica umbellata</i>	Ericaceae	R-	1	UTAD
<i>Eruca vesicaria</i>	Brassicaceae	R-	1	UAECO
<i>Euphorbia acanthothamnus</i>	Euphorbiaceae	R+	1	UAECO

Species	Family	Resprouting	Records	Data sets
<i>Euphorbia apios</i>	Euphorbiaceae	R+	1	UAECO
<i>Euphorbia characias</i>	Euphorbiaceae	R-	1	UAECO
<i>Euphorbia serrata</i>	Euphorbiaceae	R+	1	CEAM
<i>Fagus sylvatica</i>	Fagaceae	R+	1	CREAF2
<i>Foeniculum vulgare</i>	Apiaceae	R+	1	CEAM
<i>Fraxinus angustifolia</i>	Oleaceae	R+	1	CEAM
<i>Fraxinus ornus</i>	Oleaceae	R+	1	CEAM
<i>Fritilaria graeca</i>	Liliaceae	R+	1	UAECO
<i>Fumana ericoides</i>	Cistaceae	R-	2	CEAM, UCLM
<i>Fumana procumbens</i>	Cistaceae	R-	1	UCLM
<i>Fumana thymifolia</i>	Cistaceae	R-	2	CEAM, UAECO
<i>Fumaria officinalis</i>	Papaveraceae	R-	1	UAECO
<i>Gagea graeca</i>	Liliaceae	R+	1	UAECO
<i>Galium frutescens</i>	Rubiaceae	R+	1	UCLM
<i>Genista acanthoclada</i>	Fabaceae	R+	1	UAECO
<i>Genista scorpius</i>	Fabaceae	R+	2	CEAM, UCLM
<i>Geranium lucidum</i>	Geraniaceae	R-	1	UAECO
<i>Globularia alypum</i>	Plantaginaceae	R+	1	CEAM
<i>Halimium viscosum</i>	Cistaceae	R-	1	UCLM
<i>Helianthemum apenninum</i>	Cistaceae	R-	1	UCLM
<i>Helianthemum hirtum</i>	Cistaceae	R-	2	CEAM, UCLM
<i>Helianthemum marifolium</i>	Cistaceae	R-	1	CEAM
<i>Helianthemum rotundifolium</i>	Cistaceae	R-	1	UCLM
<i>Helianthemum syriacum</i>	Cistaceae	R-	1	CEAM
<i>Helichrysum serotinum</i>	Asteraceae	R-	1	UCLM
<i>Helichrysum stoechas</i>	Asteraceae	R+, R-	2	CEAM, UCLM
<i>Hippocrepis scorpioides</i>	Fabaceae	R+	1	UCLM
<i>Hippocrepis unisiliquosa</i>	Fabaceae	R-	1	UAECO
<i>Hornungia petraea</i>	Brassicaceae	R-	1	CEAM
<i>Hymenolobus procumbens</i>	Brassicaceae	R-	1	UAECO
<i>Hypericum empetrifolium</i>	Clusiaceae	R+	1	UAECO
<i>Hypochoeris achyrophorous</i>	Asteraceae	R-	1	UAECO
<i>Ilex aquifolium</i>	Aquifoliaceae	R+	1	CREAF2
<i>Inula montana</i>	Asteraceae	R+	1	UCLM
<i>Inula viscosa</i>	Asteraceae	R+	1	CEAM
<i>Jasonia tuberosa</i>	Asteraceae	R+	1	UCLM
<i>Juniperus communis</i>	Cupressaceae	R-	2	CEAM, CREAM1
<i>Juniperus oxycedrus</i>	Cupressaceae	R+	2	CEAM, CREAM1
<i>Juniperus phoenicea</i>	Cupressaceae	R-	3	CEAM, CREAM1, UAECO
<i>Juniperus sabina</i>	Cupressaceae	R-	1	CEAM

Species	Family	Resprouting	Records	Data sets
<i>Juniperus thurifera</i>	Cupressaceae	R-	1	CEAM
<i>Lathyrus cicera</i>	Fabaceae	R-	1	UAECO
<i>Lavandula latifolia</i>	Lamiaceae	R-	1	UCLM
<i>Lavandula pedunculata</i>	Lamiaceae	R-	1	UCLM
<i>Leucanthemopsis pallida</i>	Asteraceae	R-	1	UCLM
<i>Leuzea conifera</i>	Asteraceae	R+	1	UCLM
<i>Logfia gallica</i>	Asteraceae	R-	1	UAECO
<i>Lonicera implexa</i>	Caprifoliaceae	R+	1	CEAM
<i>Medicago littoralis</i>	Fabaceae	R-	1	UAECO
<i>Medicago suffruticosa</i>	Fabaceae	R+	1	UCLM
<i>Micromeria juliana</i>	Lamiaceae	R-	1	UAECO
<i>Muscari neglectum</i>	Liliaceae	R+	1	CEAM
<i>Myrtus communis</i>	Myrtaceae	R+	1	CEAM
<i>Olea europaea</i>	Oleaceae	R+	1	CEAM
<i>Onobrychis ebenoides</i>	Fabaceae	R+	1	UAECO
<i>Ononis fruticosa</i>	Fabaceae	R+	1	UCLM
<i>Ononis minutissima</i>	Fabaceae	R-	1	CEAM
<i>Ononis spinosa</i>	Fabaceae	R+	1	UCLM
<i>Osyris alba</i>	Santalaceae	R+	2	CEAM, UAECO
<i>Papaver rhoeas</i>	Papaveraceae	R-	1	UAECO
<i>Paronychia argentea</i>	Caryophyllaceae	R+	1	CEAM
<i>Paronychia capitata</i>	Caryophyllaceae	R-	1	UCLM
<i>Phagnalon graecum</i>	Asteraceae	R-	1	UAECO
<i>Phillyrea angustifolia</i>	Oleaceae	R+	1	CEAM
<i>Phillyrea latifolia</i>	Oleaceae	R+	1	CEAM
<i>Phlomis lychnitis</i>	Lamiaceae	R+	1	UCLM
<i>Pinus halepensis</i>	Pinaceae	R-	3	CEAM, CREAM2, UAECO
<i>Pinus nigra</i>	Pinaceae	R-	2	CEAM, CREAM2
<i>Pinus pinaster</i>	Pinaceae	R-	17	CEAM, CREAM2, INIA, UTAD
<i>Pinus pinea</i>	Pinaceae	R-	2	CEAM, CREAM2
<i>Pinus sylvestris</i>	Pinaceae	R-	2	CEAM, CREAM2
<i>Piptatherum miliaceum</i>	Poaceae	R+	2	CEAM, UAECO
<i>Pistacia lentiscus</i>	Anacardiaceae	R+	2	CEAM, UAECO
<i>Pistacia terebinthus</i>	Anacardiaceae	R+	1	CEAM
<i>Plantago albicans</i>	Plantaginaceae	R+	1	CEAM
<i>Plantago sempervirens</i>	Plantaginaceae	R-	1	UCLM
<i>Polygala rupestris</i>	Polygalaceae	R-	1	CEAM
<i>Prunella laciniata</i>	Lamiaceae	R+	1	UCLM
<i>Prunus spinosa</i>	Rosaceae	R+	1	CREAF3

Species	Family	Resprouting	Records	Data sets
<i>Psoralea bituminosa</i>	Fabaceae	R-	1	UCLM
<i>Quercus cerrroides</i>	Fagaceae	R+	1	CREAF2
<i>Quercus coccifera</i>	Fagaceae	R+	3	CEAM, UAECO, UCLM
<i>Quercus faginea</i>	Fagaceae	R+	2	CEAM, UCLM
<i>Quercus ilex</i>	Fagaceae	R+	4	CEAM, CREAM, UAECO, UCLM
<i>Quercus pubescens</i>	Fagaceae	R+	1	UAECO
<i>Quercus suber</i>	Fagaceae	R+	2	CEAM, CREAM
<i>Reichardia picroides</i>	Asteraceae	R+	1	UAECO
<i>Reseda lutea</i>	Resedaceae	R+	1	UAECO
<i>Rhamnus alaternus</i>	Rhamnaceae	R+	2	CEAM, UCLM
<i>Rhamnus lycioides</i>	Rhamnaceae	R+	1	CEAM
<i>Rosmarinus officinalis</i>	Lamiaceae	R-	2	CEAM, UCLM
<i>Rubia peregrina</i>	Rubiaceae	R+	1	CEAM
<i>Salvia lavandulifolia</i>	Lamiaceae	R+	1	UCLM
<i>Salvia pratensis</i>	Lamiaceae	R+	1	UCLM
<i>Salvia verbenaca</i>	Lamiaceae	R+	1	UCLM
<i>Sanguisorba minor</i>	Rosaceae	R+	1	CEAM
<i>Santolina chamaecyparissus</i>	Asteraceae	R+, R-	2	CEAM, UCLM
<i>Sarcopoterium spinosum</i>	Rosaceae	R+	1	UAECO
<i>Satureja thymbra</i>	Lamiaceae	R+	1	UAECO
<i>Scabiosa columbaria</i>	Dipsacaceae	R-	1	UAECO
<i>Scabiosa turoloensis</i>	Dipsacaceae	R+	1	UCLM
<i>Scilla autumnalis</i>	Liliaceae	R-	1	UAECO
<i>Scorpiurus muricatus</i>	Fabaceae	R-	2	CEAM, UAECO
<i>Scorzonera crocifolia</i>	Asteraceae	R+	1	UAECO
<i>Sedum sediforme</i>	Crassulaceae	R+	1	CEAM
<i>Sideritis angustifolia</i>	Lamiaceae	R+	1	CEAM
<i>Sideritis hirsuta</i>	Lamiaceae	R+	1	UCLM
<i>Silene colorata</i>	Caryophyllaceae	R-	1	UAECO
<i>Silene mellifera</i>	Caryophyllaceae	R+	1	UCLM
<i>Smilax aspera</i>	Smilacaceae	R+	2	CEAM, UAECO
<i>Sonchus terrenimus</i>	Asteraceae	R+	1	CEAM
<i>Sorbus aria</i>	Rosaceae	R+	2	CEAM, CREAM
<i>Sorbus domestica</i>	Rosaceae	R+	2	CEAM, CREAM
<i>Sorbus torminalis</i>	Rosaceae	R+	1	CREAF4
<i>Stachys cretica</i>	Lamiaceae	R-	1	UAECO
<i>Staehelina dubia</i>	Asteraceae	R-	1	UCLM
<i>Stipa parviflora</i>	Poaceae	R+	1	CEAM
<i>Stipa tenacissima</i>	Poaceae	R+	1	CEAM

Species	Family	Resprouting	Records	Data sets
<i>Teucrium capitatum</i>	Lamiaceae	R+, R-	2	UAECO, UCLM
<i>Teucrium chamaedrys</i>	Lamiaceae	R+	1	UCLM
<i>Teucrium expansum</i>	Lamiaceae	R-	1	UCLM
<i>Teucrium gnaphalodes</i>	Lamiaceae	R+	1	UCLM
<i>Teucrium polium</i>	Lamiaceae	R+	1	CEAM
<i>Teucrium pseudochamaepestis</i>	Lamiaceae	R+, R-	2	CEAM, UCLM
<i>Thesium bergeri</i>	Santalaceae	R+	1	UAECO
<i>Thymelaea tartonraira</i>	Thymelaeaceae	R+	1	UAECO
<i>Thymus leptophyllus</i>	Lamiaceae	R-	1	UCLM
<i>Thymus mastichina</i>	Lamiaceae	R-	1	UCLM
<i>Thymus piperella</i>	Lamiaceae	R+	1	CEAM
<i>Thymus vulgaris</i>	Lamiaceae	R+, R-	2	CEAM, UCLM
<i>Tordylium apulum</i>	Apiaceae	R-	1	UAECO
<i>Torilis arvensis</i>	Apiaceae	R-	1	UAECO
<i>Tremastelma palaestinum</i>	Dipsacaceae	R-	1	UAECO
<i>Trifolium campestre</i>	Fabaceae	R-	1	UAECO
<i>Tuberaria guttata</i>	Cistaceae	R-	1	UAECO
<i>Tuberaria lignosa</i>	Cistaceae	R-	1	UCLM
<i>Ulex parviflorus</i>	Fabaceae	R-	1	CEAM
<i>Urginea maritima</i>	Liliaceae	R+	1	UAECO
<i>Verbascum rotundifolium</i>	Scrophulariaceae	R-	1	UCLM
<i>Viburnum lantana</i>	Caprifoliaceae	R+	1	CREAF5
<i>Viburnum tinus</i>	Caprifoliaceae	R+	2	CEAM, CREAM1
<i>Vicia sativa</i>	Fabaceae	R-	1	UAECO

## APPENDIX 3: TRAITS INCLUDED IN THE EUFIRELAB PLANT TRAITS DATABASE (WP4T3C).

## LEGEND

**Trait group**

T: Taxonomic  
 G: General  
 L: Leaves  
 F: Flammability  
 R: Regeneration  
 S: Sexual reproduction

**Trait importance**

OT: obligatory  
 VIT: very important  
 IT: important

**Trait type**

CA: categorical (qualitative data)  
 CO: continuous (quantitative, semi-quantitative and binary data)

Code	Trait	Trait group	Trait importance	Trait type
T01	Genera	T	OT	CA
T02	Species	T	OT	CA
T03	ssp/var	T	OT	CA
T04	Family	T	OT	CA
T05	Life Form	G	OT	CA
T06	Lifespan	G	IT	CO
T07	Average Height	G	OT	CO
T08	Average Stem Diameter	G	IT	CO
T09	Average Bark Thickness	G	IT	CO
T10	95% Rooting Depth	G	IT	CO
T11	Root Symbiosis	G	IT	CA
T12	Clonality	G	IT	CA
T13	Shoot:Root Ratio	G	IT	CO
T14	Average Height of Seedlings	G	IT	CO
T15	Spinescence	G	VIT	CA
T16	Average Leaf Lifespan	G(L)	IT	CO
T17	Leaf Phenology	G(L)	OT	CA
T18	Specific Leaf Area	G(L)	IT	CO
T19	Leaf Division Degree	G(L)	OT	CA
T20	Leaf Shape	G(L)	OT	CA
T21	Average Leaf Size	G(L)	IT	CO
T22	Flammable Compounds	F	IT	CA
T23	Dead Fine Fuel	F	IT	CO
T24	Coarse:Fine Fuel Ratio	F	IT	CO
T25	Resprouting Capacity after Fire	R	OT	CO
T26	Resprouting Capacity after Clipping	R	IT	CO
T27	Bud Source	R	VIT	CA
T28	Seed Bank	R	VIT	CA
T29	Heat-Stimulated Germination	R	IT	CA
T30	Average Seed Bank Longevity	R	IT	CO
T31	Post-fire Seedling Emergence	R	VIT	CO

<b>Code</b>	<b>Trait</b>	<b>Trait group</b>	<b>Trait importance</b>	<b>Trait type</b>
T32	Post-fire Seedling Survival	R	IT	CO
T33	Age at Maturity of Resprouts	R	IT	CO
T34	Age at Maturity of Saplings	R	IT	CO
T35	Mating System	S	IT	CA
T36	Average Annual Seed Production	S	IT	CO
T37	Average Seed Dry Weight	S	IT	CO
T38	Basic Seed Shape	S	IT	CO
T39	Fruit Type	S	OT	CA
T40	Average Fruit Dry Weight	S	IT	CO
T41	Propagule	S	VIT	CA
T42	Dispersal Mode 1	S	IT	CA
T43	Dispersal Distance 1	S	IT	CO
T44	Maximal Dispersal Distance 1	S	IT	CO
T45	Dispersal Mode 2	S	IT	CA
T46	Dispersal Distance 2	S	IT	CO
T47	Maximal Dispersal Distance 2	S	IT	CO