Appendix S2: characteristics of Mediterranean ecosystems

Climatic constraints and diversity of habitats (linked in particular to orographic and soil diversity), as well as diverse disturbances linked to human activities, have contributed to a wide diversity of evolutionary trajectories in Mediterranean marine and terrestrial ecosystems and socio-ecosystems. A remarkable endemic biodiversity coexists with widely distributed species at a global scale, which are often keystone species in terrestrial communities (e.g. oak and pine forests, shrublands like "garrigue" or "maquis"), olive groves) and marine environments (Posidonia meadows, coralligenous assemblages, planktonic assemblages in pelagic ecoregions).

Below we present adaptive characteristics of 7 selected Mediterranean ecosystems, detailing current knowledge for each of them on:
- context and pressures: what are the main current and future threats (if any);
- demography: what are the putative demographic trends in the context of global change (usually based on demographic models that do not take adaptation into account);
- adaptive abilities: differences in the response to major stressors, with a focus on their origin (acclimatisation or genetic adaptation). This includes:
 - population genetics: genetic diversity is the fuel of genetic adaptation that powers the engine of natural and man-made selection. This can be studied indirectly through neutral markers or directly by searching for adaptive loci through genomic approaches. Genetic structure and connectivity will also be important to understand range shift and the potential dispersal of adaptive alleles.

This material is the base for Table S1, which summarises the adaptive characteristics for 8 Mediterranean ecosystems and provides an estimate of their overall expected adaptive potential to environmental changes.

1. MARINE SYSTEMS

A. *Phytoplankton and zooplankton*

The basis of marine food webs is a set of small stream-dependent organisms - plankton - whose diversity and functions are still under-documented compared to higher trophic levels such as fishes or marine mammals. The biodiversity of plankton is immense and includes a very wide variety of living organisms, stemming from all branches of evolutionary history - virus, bacteria, archaea, unicellular and multicellular from different eukaryotic lineages (Brierley, 2017). The diversity of these planktonic microorganisms is also characterized by a very large size spectrum in depth spanning across several orders of magnitude (10^{-7} to 100 m), by metabolic diversity (photo-, mixo-, heterotrophy), and by complex life cycles of very variable duration (hour to several years) (Carlotti, 2019). Hereafter, we focus on phytoplankton and zooplankton adaptive characteristics, as structural and functional adaptation of the smaller marine forms has generated intense research in the last decades (Fuhrman & Caron, 2016).

A1. Phytoplankton

Context and pressures

Marine phytoplankton is the base of the marine food web. Their production is determined by light availability and access to nutrients. Developing in epipelagic waters due to their light dependence, phytoplankton and their associated microbial food webs are under multiple pressures, whom cumulated roles are partially unknown, including temperature (with their associated consequences on stratification and heat waves), acidification, changes in light (UV) and nutrient inputs from continents and atmosphere.

Temperature, stratification, deoxygenation

Earlier studies (e.g. Behrenfeld et al., 2006) reported an overall inverse relationship between anomalies in sea surface temperature and phytoplankton chlorophyll concentrations during the last decades. It is suggested that future climate change would decrease phytoplankton stocks and thus reduce ocean productivity (Boyce et al., 2010). This view has been largely challenged in the last decade, and there is now no consensus about the future projections of global ocean productivity (e.g. Behrenfeld et al., 2016). In theory, it is expected that increased stratification will reduce the mixing of nutrients necessary for photosynthesis, leading to a reduction of primary productivity, but also of the biologically-mediated carbon export to the deep ocean. In the Mediterranean Sea, the spring phytoplankton bloom is related to the intensity of previous winter mixing of the water column, and future water density changes are key players to project the evolution in primary productivity (Macias et al., 2015).

Nevertheless, a recent modelling study in the western Mediterranean Sea suggested that climate-change may not significantly modify the pelagic planktonic ecosystem (despite small impacts on plankton phenology and size spectrum), nor its associated carbon cycle (Herrmann et al., 2014). Basin-scale modelled projections for the end of the 21st century documented a stable net community production. This results from an increase in metabolic rates due to warming temperatures, leading to an increase by 5% of the gross primary production, which is compensated by increased community respiration rates and reduction of biomasses (Lazzari et al., 2014). Understanding and projecting how oceanic productivity will evolve under future climate requires further evaluation of how the multifaceted stressors of a warmer, higher-CO2 world will impact the overall activity and adaptation of plankton communities, as well as carbon sequestration.

When considering the natural nutrient limitation characterising the Mediterranean Sea, that could increase due to increased stratification, the direct effect of sea surface warming on phytoplankton growth and productivity may be smaller than anticipated because resource limitation overrides temperature effects (Marañón et al., 2014). Increased stratification may also lead to reduced oxygen dissolution. Deoxygenation potentially impacts all oceanic life, from microbes to higher trophic levels; its consequences range from ecological shifts (Levin, 2018 and references therein), adaptation (Levin, 2003), changes of biogeochemical activity (Breitburg et al., 2018), to mass mortality events through hypoxia (Diaz & Rosenberg, 2008) and biodiversity restructuring (Vaquer-Sunyer & Duarte, 2008). Although still not detected in

the open Mediterranean Sea, deoxygenation is underway in the Black Sea (Capet et al. 2016) and affects Mediterranean lagoons seasonally (Dedieu et al 2007).

UV

The sensitivity of plankton to UV depends on nutrient status, pre acclimatisation, mixing regime (mixing depth vs UV transparency), inherent optical properties of dissolved organic matter and particles (photoreactivity, absorption, diffusion, backscattering), presence of radical precursors, and community composition. From ecosystem-level experiments, it is difficult to discriminate between direct UV effects and cascading effects propagated through the food web (e.g. prey or grazer/predator, viruses, bacterial utilization of derived-detritus or DOC), and mesocosms experiments help analyse such questions (Belzile et al., 2006). UV-B generally leads to reduced Net Community Production (NCP) (Regaudie-de-Gioux et al., 2014; Agustí et al., 2014) by enhancing respiration more than photosynthesis, as warming does.

Acidification

Acidification directly affects photosynthesis and decreases calcium carbonate saturation states. Thus it might affect calcareous microorganisms directly. Indirectly, through cascade effects, it can impact multiple components of the plankton food web. Acidification effects are mainly studied through artificial pH decrease in enclosed sea water (from pure cultures in batch cultures to communities in enclosed mesocosms). The initial species diversity largely influences the outcome of acidification experiments (Eggers et al., 2014), as well as initial conditions of nutrient enrichments. Indeed, the nutrient limitation overrides a potential effect of ocean acidification (Maugendre et al., 2015). Thus, when maintaining oligotrophic conditions of the Mediterranean Sea, mesocosm acidification experiments show no clear effect of ocean acidification on plankton metabolic rates.

Aerosols

The Mediterranean Sea is submitted to significant pulsed nutrient and trace metal inputs from the atmosphere, like Saharan dust from the South and anthropogenic sources from the North (Djaoudi et al., 2018; Guerzoni et al., 1999). It is suggested that the increased temperature and decreased humidity will promote soil drying, and will increase dust emissions, particularly in the eastern Mediterranean. After few hours of addition of artificially aged Saharan dust in mesocosms, an increase in chlorophyll a production was observed, but heterotrophic bacteria were more impacted by dust deposition than primary producers, resulting in a more heterotrophic natural assemblage. The sinking of particulate organic carbon (POC) through DOM/dust ballast effect and aggregation processes was favoured under dust deposition, decreasing the residence time of nutrients in the euphotic layer by several days (Guieu et al., 2014). A dust deposition event of 10 g m^{-2} simulated at the surface of minicosms triggered the abiotic formation of transparent exopolymer particles (TEP), leading to the formation of organic-mineral aggregates. The amount of exported POC increased (Louis et al., 2017). Modelling the impact of atmospheric deposition of inorganic nutrients (ammonium phosphate and nitrate) on the whole Mediterranean Sea, Richon et al. (2018) calculated the fertilising effects of phosphate from dust to be low on average (6–10%)

for the period 1997-2012 but an increase of up to 30% in primary productivity could be observed during the months when surface water stratification occured.

Adaptive abilities

Because of their huge population sizes and short generation time (hours to days), phytoplankton species should display a high potential for genetic adaptation (Reusch & Boyd, 2013). Indeed these populations should have high levels of genetic diversity (both from mutation supply and sexual recombination when relevant), very low genetic drift and high efficiency at natural selection. Additionally, observed patterns of temperature optima suggest the possibility of adaptation to local conditions across distant latitudes in phytoplankton (Thomas et al., 2012), which remains to be better understood and tested (Peijnenburg & Goetze, 2013).

The adaptive abilities are often studied through changes in plankton functional types (Quéré et al., 2015) rather than taxonomic composition, as they are corresponding to simplified phytoplankton groups having characteristic nutrient requirements, growth capacities and fate (nitrogen fixing, calcifying organisms, pico, nano, and micro phytoplankton groups including silica-requiring phytoplankton). For example diatoms, developing during spring bloom specifically in some Mediterranean regions are mostly responsible for carbon export through sedimentation of particles (*cf* the silica pump, (Leblanc et al., 2005)). However, damming resulted in reduced silica inputs from rivers in the Mediterranean Sea. Theoretically, this means that silica-requiring phytoplankton, like diatoms, will be progressively replaced by other nano- and pico-sized microphytoplankton redirecting food webs towards small grazers and carbon export via dissolved organic matter. Nevertheless, diatoms can persist and adapt in changing Mediterranean Sea by developing in a micro niche (for instance a persistent fucoxanthin and biogenic silica accumulation layer was documented below the deep chlorophyll maximum depth in summer even in the eastern Mediterranean Sea (Crombet et al., 2011)), or by reducing in size (the nano sized diatom *Nannochloropsis* can bloom in the North western Mediterranean (Leblanc et al., 2018)). Long-term natural phytoplankton changes can be estimated from oceanographic time series at fixed points, but these are rare in the Mediterranean (Estrada & Vaqué, 2014) and the older ones mainly focus on chlorophyll stocks (or plankton functional types) derived from pigment distribution or size-fractionation of chlorophyll (Marty et al., 2002), and not on phytoplankton taxonomy (however see the REPHY initiative at https://www.seanoe.org/data/00361/47248/ or the LTER time series at http://www.iobis.org/explore/#/dataset/3500). Moreover, their analysis based only on a few decades is difficult due to the large interannual variability in thermohaline circulation, mixed layer dynamics, coastal effects or mesoscale variability.

Potential effects of climate change on phytoplankton are often based on experimentally artificial and abrupt changes of forcing factors (alone or in combination) in experimental enclosures (Guieu et al., 2010, Gazeau et al., 2017) or cultures. This may not reflect what will occur in nature. It has been shown for instance that the initial species composition largely influences the outcome of some acidification experiments (Eggers et al., 2014), and clearly little attention has been paid to the composition-functional relationships in these experiments. Not only taxonomic but also exploration of the total functional potential of

communities – with meta genomic approaches - coupled to such short-term manipulation of forcing factors on natural communities would help to interpret biogeochemical analysis based on marine waters' origin. Nevertheless existing experiments provide important information to study adaptive processes in marine phytoplankton (Reusch & Boyd, 2013). They can be used to study reaction norms and have revealed inter-clonal differences in several species. In agreement with the aforementioned properties of phytoplankton populations, an important variability of physiological traits exists within various phytoplankton species, traits that are important for adaptive abilities (Reusch & Boyd, 2013). Phenotypic plasticity has also been observed, which complements the adaptive abilities of phytoplanktonic species. Indeed experimental evolution, even if restricted in time and space, has demonstrated such possibility of adaptation in a few cases. Some pending questions remain to extrapolate this to the real world, including the possible interferences between genotypes and between selection regimes, or the importance of dispersal (Reusch & Boyd, 2013).

A2. Zooplankton

Context and pressures

Zooplankton (here defined as planktonic metazoans >200 μm) exhibits a very large taxonomic diversity at the level of holoplancton (continually living in full water) or meroplankton (larval stages of many benthic groups, and fish eggs and larvae). Because ocean currents provide an ideal mechanism for dispersal over a broad range of distances (from m to 1000 km), almost all marine animals have planktonic stages in their life cycles. Their diversity provides the main functions at the base of marine food webs in controlling primary production, linking microbial food webs to higher trophic levels and cycling and transporting biogenic elements in the ocean (Brierley, 2017). Climatic and anthropogenic forcing impact zooplankton vital rates, life cycles, population distributions and community structure and *in fine* the efficiency of these functions (Carlotti & Poggiale, 2010). Unlike other marine groups, such as fish and many intertidal organisms, zooplankton are generally not commercially exploited (with the exception of krill and some jellyfish species), and consequently studies of long-term trends in response to environmental changes are generally not confounded with trends in exploitation. The Mediterranean Sea presents strong hydrographic and biogeochemical characteristics, and environmental gradients that seem to allow the development of a wide variety of planktonic organisms, at different organisation levels, characterised by different environmental preferences (Durrieu de Madron et al., 2011).

Demography: zooplankton community changes in response to environmental changes

Data describing the diversity and composition of zooplankton in the Mediterranean Sea are widely dispersed in time and space (Siokou-Frangou et al., 2009) and regional patterns of planktonic biodiversity are still poorly understood, although the Mediterranean is one of the first basins to be studied (Bianchi & Morri, 2000). Copepods form the emblematic group of zooplankton. It is the most abundant multicellular metazoan group in the oceans, or even on earth (Bron et al., 2011), and dominates the composition and biomass of zooplankton in all oceans, as well as in the Mediterranean (Frangoulis et al., 2004; Mazzocchi et al., 2014; Siokou-Frangou et al., 2009). According to the copepod database http://copepodes.obs-

banyuls.fr/en (last accessed on May 10, 2019), about 560 different species of copepods are listed in the Mediterranean Sea. Most individuals are located in the 200 upper meters of the water column, at the deep maximum of chlorophyll a, and relatively few species perform large-scale diel migrations (Andersen et al., 2001; Brugnano et al., 2012; di Carlo et al., 1984). The bulk of the Mediterranean copepod communities is composed of small (< 2 mm) species belonging to very diverse genera.

Quantitative synthesis of the literature (including observed oceanic data, models and satellite analyses) shows that climatic changes will induce major changes in the Mediterranean sea, such as hydrographic properties including surface circulation, deep water winter convection and extended seasonal stratification, in addition to changes in temperature, pH, salinity,... all of which is expected to deeply modify zooplanktonic distributions as zooplankton is generally very sensitive to these changes (Richardson, 2008). However Mediterranean zooplankton time series are too few and too dispersed, with relatively short overlapping periods, some of them too close of coastal anthropogenic influence masking the climate signal, in highly spatially differentiated regional climate patterns, to allow drawing a clear pattern of planktonic spatial and temporal shifts at the Mediterranean scale, which could be comparable to the North Atlantic with the CPR data analysis (Beaugrand et al., 2002). At times, abrupt and dramatic changes in ecosystems occur in response to subtle climate or physical oceanic forcings. Such abrupt reorganisation, known as a regime shift, can transform systems from one stable state to another (Hare & Mantua, 2000). Comparative studies of physical and biological time series in the eastern and western Mediterranean Sea for several decades (Berline et al., 2012; Conversi et al., 2010) converge to show an abrupt period of change in the late 1980s, that involved Mediterranean surface circulation and pelagic biotic and abiotic properties. Larger scale climate indexes (NHT and NAO) changed around that time as well (Conversi et al., 2010), and results from zooplankton time series in the northwestern Mediterranean have shown that inter-annual abundance patterns fitted the inter-annual pattern of the winter NAO (Fernández de Puelles & Molinero, 2007; Molinero et al., 2005; Molinero et al., 2008). However, these Mediterranean "biological" time series are not yet sufficiently extensive in time, or do not have a sufficient taxonomic resolution (Berline et al., 2012) to confirm an impact of climate change neither on the community composition, nor on changes in phenology. At present, it is impossible to say which species (or functional groups) will be advantaged or disadvantaged by future temperature rises in the Mediterranean.

Mechanisms underlying this zooplanktonic community change are still poorly known. Global warming is expected to have great repercussions for marine ecosystems because temperature influences the water column stability, nutrient enrichment, and the degree of new production, and thus the abundance, size composition, diversity, and trophic efficiency of zooplankton (Richardson, 2008). The effects of variations within the ocean climate system on zooplankton populations and their phenology (Ji et al., 2010; Richardson, 2008) can be direct (rising temperature, rising salinity, rising CO2, decreasing pH, and decreasing O2) through alteration of physiological functions and life-history traits and consequently the fitness of individual zooplankters (Dam, 2013), and indirect for effects exerted through vertical density stratification, which alters phytoplankton abundance and size as well as changes in phytoplankton community structure (Doney, 2013; Litchman et al., 2012). These variables affect individual fitness, predator–prey dynamics, and competition among

zooplankton species. Other indirect effects are exerted through altered circulation patterns, which can in turn impact zooplankton spatial distribution (Reid, 2000). Projections of community changes based on key mechanisms (i.e. impact of temperature) have been realised using new approaches of ensemble niche modelling. The application of a population thermal preference curve of 106 copepod species in oceanic temperature fields in the Mediterranean projected by hydro-climatic model (Adloff et al., 2015) has been used to project changes between present and future distribution of zooplanktonic assemblages (Benedetti et al., 2018). Their projections contrasted with those reported for higher trophic levels (Albouy et al., 2015), suggesting that a more complex ecosystem based approach is required.

Adaptive abilities: physiology and life-history traits

Marine species often have complex life-cycles, as many have a dispersive planktonic stage, with distinct life stages potentially occupying different habitats, each with different exposure and sensitivity to changing climate (Rijnsdorp et al., 2009). Despite this apparent complexity, which could be seen as a disadvantage to resist climate and associated ecosystem changes, it is in reality an advantage because it gives a flexibility through modifications of the life cycle (by reducing some critical planktonic phases). Recent evidence suggests that many of the meroplanktonic life stages are even more sensitive to climate change than their holo-zooplanktonic neighbours living permanently in the plankton (Richardson, 2008).

Zooplankton are characterised by physiological and behavioural traits that affect their ecological function and influence their interactions with other trophic levels (Litchman, Ohman, & Kiørboe, 2013). Changes in species composition are for a large part the consequence of species-specific behavioural changes, as change in behaviour results in changes in the main demographic parameters, birth and mortality (Halsband-Lenk et al., 2004; Ohman, 1990), and consequently in the success or failure of the species in a changing ecosystem.

From a physiological point of view, zooplanktonic organisms are excellent sentinels of climate change for several reasons. Because zooplankton are poikilotherms, their physiological functions (ingestion, respiration, excretion, defecation, growth) and life-history traits (e.g. short time to maturity in the order of weeks to months, fecundity up to 1000 eggs/female, and flexible development rate) are strongly sensitive to temperature (Mauchline, 1998). Maximum rates of ingestion, growth, and respiration double or even triple in many zooplankters with a standardized temperature increase of 10°C (Halsband-Lenk et al., 2002; Hansen et al., 1997), and with typical generation times of weeks to months zooplankton populations can respond quickly to environmental changes by means of phenotypic plasticity and natural selection (Dam, 2013). Despite previous statements on the low capacity of evolution of zooplankton, there are several traits which are favourable to evolution and adaptation facing climate change (Peijnenburg & Goetze, 2013): as for phytoplankton, huge population sizes, along with the previously mentioned short generation time, are important traits favouring genetic adaptation through natural selection. Another important trait is that zooplankton nutrition and trophic interactions with phytoplankton, microzooplankton and other zooplankton are quite flexible (Kiørboe et al., 2018), even for zooplankton species identified as herbivorous, because most of the time phytoplankton species dominate for short duration. The change in individual size during the ontogenic

development (ratio 1 to 100 from egg size to adult size) makes this feeding flexibility as a rule.

One particular very flexible behaviour of zooplankton to limit predation and maximize feeding and reproduction in changing environments is its ability to swim vertically between surface and deep layers either by diel vertical migration (DVM) (Hays, 2003) or by ontogenic migration (Hidalgo et al., 2005). As in other oceans, zooplankton in the Mediterranean sea presents a high variability in diel vertical migration (several hundred of meters) within the same planktonic community (Andersen et al., 2001; Brugnano et al., 2012; Halsband-Lenk et al., 2002), and between different phases of their ontogenic life cycle for each species. Ontogenic migrations, generally for a long phase (overwintering or oversummering) to deep waters is another major behavioural trait. The high flexibility of these behavioural traits allows to swim across a variety of water layers of different physical and chemical characteristics, which allows zooplanktonic species to maximize their metabolic and developmental rates in response to rapid environmental changes (Bonnet et al., 2005; Carlotti & Nival, 1991; Halsband-Lenk et al., 2001; Halsband-Lenk et al., 2004; Halsband-Lenk et al., 2002; Svetlichny et al., 2000). Finally, the wide variety of coastal and deep-sea habitats, from continental shelf areas to canyons and mesopelagic and bathypelagic habitats, offer to these flexible organisms the capacity to overcome major climate changes in terms of adaptive abilities.

Population genetics and genomics

Although the number of studies that have rigorously tested for genetic adaptation in marine zooplankton is small, and limited to estuarine and coastal taxa that are amenable to laboratory experimentation (reviewed in Dam, 2013), unequivocal evidence exists for genetic adaptation in marine zooplankton. One example is the case of grazer populations exposed to toxic algal blooms that show higher fitness than non-exposed populations when facing toxic prey (Colin & Dam, 2007). The use of the water flea *Daphnia* also led to a lot of studies regarding adaptive evolution for this freshwater model species (e.g. Pantel et al., 2015). For open ocean zooplankton, the majority of which cannot be cultured in the laboratory, evolutionary responses to global change are important to study and have been explored for limited number of taxa (e.g. *Calanus* in the Nordic Seas). This should rely on a precise species delimitation and identification, which may require genetic confirmation (Choquet et al., 2018; Choquet Marvin et al., 2017). Most population genetics studies for Mediterranean zooplanktonic species have been carried out in comparative studies with populations in North Atlantic and Black sea, such as the copepod *Calanus helgolandicus*, the euphausiid *Meganyctyphanes norvegica*, the jellyfish *Pelagia noctiluca*, or the chaetognathe *Sagitta setosa* (Peijnenburg & Goetze, 2013). Such studies are still at the infancy, and clearly the Mediterranean pelagic habitat present obvious geographic isolating barriers that would be necessary for speciation in allopatry, the most common geographic mode of speciation.

Regarding the huge population sizes and geographical ranges of planktonic species, as well as their high adaptive potential, management tools are probably neither realistic, nor necessary.

Context and pressures

Seagrass meadows are one of the most productive coastal ecosystems, whom ecosystemic value has been estimated at a global scale to be one of the highest (29000 US$/ha/yr ; Costanza et al., 2014). Most seagrass species are ecosystem engineers and can act as ecological sentinels (Boudouresque et al., 2009; Boudouresque et al., 2012; Boudouresque et al., 2016). Six native seagrass species are present in the Mediterranean Sea, the endemic *Posidonia oceanica* (Linnaeus) Delile being the most common in the open sea (Boudouresque et al., 2009). We will focus here on *P. oceanica*, which is a key engineer species that forms dense meadows from sea level down to 40-45 m depth depending on water transparency (Boudouresque et al., 2012; Telesca et al., 2015). The structure constituted by live and dead parts of rhizomes, together with the sediment that fills the interstices, is called 'matte' (Boudouresque et al., 2009; Boudouresque et al., 2016). This structure is essential to stabilize coastal sediments and attenuate coastal wave action. Its photosynthetic activity plays an important role in carbon sequestration (Fourqurean et al., 2012; Marbà et al., 2014; Pergent et al., 2014) given its very high biomass production (Pergent & Pergent-Martini, 1991). While a little proportion of *P. oceanica* leaf primary production and associated epibiota is consumed by herbivores (Peirano et al., 2001), the majority is exported in the form of dead leaves that is consumed by detritus feeders and is then transferred to higher trophic levels (Guidetti, 2000; Pergent et al., 1997; Personnic et al., 2014; Boudouresque et al., 2016). This habitat also provides food and shelter, allowing high quality settlement and nursery habitats for many fish and invertebrate species (Boudouresque et al., 2012; Hughes, Williams, Duarte, Heck, & Waycott, 2009).

Due to its particular sensitivity to environmental perturbations and anthropogenic stresses, *P. oceanica* and its ecosystem are used as bioindicators to assess the quality of the environment (Montefalcone, 2009; Personnic et al., 2014). A regression of *P. oceanica* meadows has been observed in different regions of the Mediterranean Sea (Boudouresque et al., 2009). This species is impacted by direct and indirect effects of human activities such as coastal development, trawling, beach replenishment, increasing turbidity (Boudouresque et al., 2009; Boudouresque et al., 2012; Francour et al., 1999; González-Correa et al., 2008; Montefalcone et al., 2010; Pergent-Martini et al., 2006; Ruiz & Romero, 2003), and potentially by non-native species (but see discussion in Boudouresque et al., 2009). Regarding climate change, Marbà & Duarte (2010) observed an increase in shoot mortality following two heat waves (2003 and 2006). Additionally the rise in sea level could lead to a withdrawal of *P. oceanica* at its lower limit (Boudouresque et al., 2017a).

Demography

Posidonia oceanica is a long-lived species (up to several thousand years for some clones; see below), with a very slow growth of the rhizomes (a few cm per year). Its recolonisation abilities, either via asexual propagation or by seeds, are very low (Boudouresque et al., 2009 and references therein). Indeed full-recovery of *P. oceanica* meadows may not be possible at a human-time scale (Telesca et al., 2015). *P. oceanica* mainly reproduces asexually, through rhizome splitting and elongation (Marbà & Duarte, 1998), forming meadows that occupy between 2.5 and 5 x 10^{10} m^2 (Pasqualini et al., 1998). This flowering plant also reproduces

sexually. Sexual reproduction seems locally sporadic in time, and has therefore been considered as inefficient. Flowering records compiled for the second half of the twentieth century across the Mediterranean Sea showed that flowering occurs on average every 5 years and involve 8% of the shoot of any one meadow (Diaz-Almela et al., 2006). The survey of Diaz-Almela et al. (2006) indicated that the proportion of flowering meadows was on average 17%, but varied from 3 to 86% of meadows depending on the years. Flowering prevalence and intensity was shown to coincide with peaks of sea surface annual temperature maxima (Diaz-Almela et al., 2006).

Population genetics

One major characteristic of the genetic diversity of *Posidonia oceanica* is clonality: one population can be composed of different clones with different spatial extent. The level of clonality (estimated by the clonal diversity), can be very variable depending on the meadows (Arnaud-Haond et al., 2007; Procaccini et al., 2001; Serra et al., 2010), with at the lower end some monoclonal populations (Ruggiero et al., 2002). Identical multilocus genotypes (MLGs, i.e. clones) can be observed at up to several kilometres of distance, potentially indicating a high longevity (hundreds to thousand years) and plasticity, or dispersal following fragmentation (Arnaud-Haond et al., 2012; Migliaccio et al., 2005). At higher spatial distances, *P. oceanica* from the western and eastern Mediterranean basins are well differentiated with a contact zone around the siculo-tunisian strait (Arnaud-Haond et al., 2007; Serra et al., 2010).

Adaptive abilities

Posidonia oceanica can be found in contrasted conditions, with populations dwelling in low salinity and low temperature areas (e.g. the Marmara Sea) and in high salinity and high temperature areas (e.g. the El-Biban Lagoon) (Meinesz et al., 2009; Tomasello et al., 2009; Vela et al., 2008), which suggests that adaptability is higher than previously expected. Information on the potential impact of warming comes from *in situ* correlations between shoot mortality and maximum sea water temperature (Marba & Duarte, 2010), and lepidochronology (Mayot et al., 2005). Experimental studies have shown that acidification seems to have no or reduced beneficial effect, which could buffer the effect of thermal stress (Cox et al., 2015; Cox et al., 2016). When considering the possible future warming trend, concerns about the future of this species along with climate change (Jordà et al., 2012) could have been overestimated. Regarding range shift, Boudouresque et al. (2017a) discussed if the warming could lead to a shrinking of the range of this species in its warmest locations (eastern Mediterranean), but also to an expansion at its cold limit (e.g. Adriatic, Gulf of Lions). Differences in thermotolerance have been demonstrated between depths or regions, which will influence the future evolution of this species (Marín-Guirao et al., 2018; Marín-Guirao et al., 2016). This could modulate the expected important range loss deduced from ecological niche modeling (Chefaoui et al., 2018).

From an adaptive point of view, asexual reproduction via clonality raises important questions. On one side, it might be expected that sexual reproduction should be important for adaptive evolution by the creation of important genetic diversity at each generation. Flowering could be induced by thermal stress in *P. oceanica*, which may enhance the production of new genotypes along with climate change (Marín-Guirao et al., 2019). In other

seagrasses some experiments also suggested a putative direct effect of genotypic diversity on the response of community to disturbances (Hughes & Stachowicz, 2004). On another side, very large and old clones could correspond to « general purpose genotypes » with important plasticity allowing them to cope with spatial and temporal environmental variations (Arnaud-Haond et al., 2012). The observation of very old clones means that some of them were indeed able to cope with past environmental changes. Such mixed reproductive mode, along with its long term persistence in the Mediterranean area, suggests higher adaptive abilities than expected for *P. oceanica*. The persistence of *P. oceanica* in the Mediterranean Sea, before and after the Messinian crises (5 to 6 million years ago), and during the Pleistocene 30 glaciation-deglaciation cycles, with abrupt changes in sea level and temperature, suggests that *P. oceanica* presents high adaptive characteristics and that it could be one of the most resistant species to climate change.

C. *Coralligenous ecosystems (including marine animal forests)*

Coralligenous assemblages are biogenic emblematic ecosystems of the Mediterranean Sea mainly built by calcareous encrusting algae (CEA). They are one of the biodiversity hotspots of the Mediterranean Sea (Ballesteros, 2006) and provide a wide variety of ecosystem services (de Ville d'Avray et al., 2019). Marine animal forests correspond to habitats structured by long-lived sessile metazoans, such as gorgonian octocorals, which also provide some habitat for other species (Paoli et al., 2017). In the Mediterranean these communities can be deeply intertwined, for example with octocorals and *Cystoseira* forests in coralligenous habitats (Boudouresque et al., 2017b). We will therefore group the study of these habitats here, with a focus on CEA and octocorals, i.e. the sister group of hexacorals that includes reef-building scleractinians. Nevertheless, there are specific characteristics to each of them such as ecological range (such as depth), main pressures, life history traits, or state of knowledge that can be very different depending on the species. Therefore we will separate the corresponding information whenever necessary.

Context and pressures

Coralligenous ecosystems (including marine animal forests) could be deeply impacted by climate change. Octocoral populations, along with other sessile organisms, have suffered in the last decades from mortality events induced by Marine Heat Waves (MHW) (Garrabou et al., 2009; Perez et al., 2000; Garrabou et al., 2019). The first reported mortality events in the Mediterranean dates back to 1983, and one of the most impressive mortality events was observed in 1999, followed by other ones with different impacts (Garrabou et al., 2019; Rivetti et al., 2014). Depending on the area and the date, the impact of the mortality could extend down to 70 m depth, and up to 1 000 km of coastline (Rivetti et al., 2014). The occurrence of such mortality events was linked with short acute thermal stress or longer milder stress (Crisci et al., 2011). The length of MHW may have increased after 2003 in the North-Western Mediterranean and in the Adriatic (Garrabou et al., 2021). The frequency and intensity of MHW is also expected to increase in the future in these areas along with climate change (Garrabou et al., 2021).

Calcareous encrusting algae produce carbonate structures and are particularly sensitive to ocean warming and acidification (Martin et al., 2013; Martin & Gattuso, 2009; Linares et al.,

2015; Lombardi et al., 2011; Nash et al., 2016; Rodríguez-Prieto, 2016). The red coral *Corallium rubrum*, a calcifying species, may also suffer from acidification (Bramanti et al., 2013).

Coralligenous habitats are jeopardized by other pressures such as physical damage (e.g. storms), chemical pollutants, increased sedimentation and invasive species (Balata et al., 2005; Balata et al., 2007; Ballesteros, 2006; Boudouresque et al., 2017b; Hong, 1980). Octocoral populations suffer from pollution, damages from fishing nets, detachment induced by recreational diving or mucilage development (Coma et al., 2004; Sini et al., 2015; Topçu & Öztürk, 2015). The red coral is harvested for jewellery, which led to an important reduction of the size of colonies in over-exploited populations (Garrabou et al., 2017).

Demography

On a long timescale, the accumulation rate of coralligenous constructions is very low (0.006–0.83 mm a^{-1}) and varies according to depth and time period (Sartoretto, 1996). The growth rates for two major species of CEA builders are very low: from 1.5 and 4.0 mm to 1.3 and 2.5 mm a^{-1} *in situ* (Garrabou & Ballesteros, 2000), and even slower when measured in the laboratory (Rodríguez-Prieto, 2016). The generation time of CEA is difficult to estimate: the age at first reproduction probably exceeds one-year old, and longevity probably exceeds one dozen, maybe several dozens of years. Thus the turnover of individuals is likely to be slow and suggests a generation time in the order of the decade. As far as *Cystoseira zosteroides* is concerned, it is a long-lived species : more than 50 years (Ballesteros et al., 2009), maybe centuries.

The growth rate of octocorals is variable depending on species, but very low for *C. rubrum* (less than 0.5 mm.a^{-1} for basal diameter (Marschal et al., 2004). The age at first reproduction is around 3-5 years for *C. rubrum* (Torrents et al., 2005), and this species could live more than 100 years (Garrabou et al., 2017). Nevertheless, harvesting has deeply modified the demographic structure of red coral populations towards small size colonies (Garrabou et al., 2017). These demographic characteristics question the future of coralligenous and octocoral species facing environmental changes. Modelling the demography of two Mediterranean octocorals (*Paramuricea clavata* and *C. rubrum*) following mortality events suggested possible recovery depending on the species (Santangelo et al., 2015). Conversely, Linares & Doak (2010) deducted high extinction risk for *P. clavata* populations following recurrent mortality events. Interestingly, long-lived species such as *C. rubrum*, may lead to demographic stability, but could also increase their sensitivity to mortality events (Montero-Serra et al., 2018). Immediate impacts of mortality events lead to an increase in the frequency of necrosis, and a decrease in population density (Garrabou et al., 2021). Sublethal effects can have long-term consequences on gorgonian populations for example through detrimental effects on reproductive success (Garrabou et al., 2021). A monitoring of *P. clavata* populations over 10 to 14 years after mortality events in France has shown that after an important initial decline in biomass, no sign of recovery was observed (Garrabou et al., 2021).

Population genetics and genomics

To date, data indicate frequent cases of significant genetic structure at short distances in metazoans from coralligenous habitat, with short estimated dispersal distances (Costantini et al., 2018; Ledoux et al., 2010), which is quite unusual among marine species with larval dispersal. Nevertheless, this observation may be driven by a taxonomic bias in the studied species. Among the main species of marine animal forest, a strong genetic structure has been observed in Mediterranean octocorals, with significant differentiation at short to moderate distances, including between depths at a same site in several cases (Costantini et al., 2011; Gazulla et al., 2021; Ledoux et al., 2010; Masmoudi et al., 2016; Mokhtar-Jamaï et al., 2011; Pérez-Portela et al., 2016; but see Padron et al., 2018 on *Eunicella singularis*). Recent studies on the bryozoan *M. truncata* also revealed a high genetic structure even at small spatial scale (Cahill et al., 2017, De Jode et al. pers. com.). Regarding CEA, De Jode et al. (2019) revealed the presence of several cryptic species among the engineering CEA of coralligenous reefs. The most abundant of these species harboured low genetic diversity and high genetic structure even at small spatial scales.

The observed genetic differentiation is often discussed with respect to the deep refugia hypothesis: as deeper populations may be less affected by extreme thermal events, they could "reseed" shallow sites (e.g. Bongaerts et al., 2017) provided dispersal from deep to shallow sites is frequent enough. The observation of significant genetic differentiation between depths or sites (as observed in the aforementioned cases), is sometimes interpreted as a lack of recolonisation abilities between populations. Nevertheless, such interpretation is far from straightforward. First, the different depth populations could correspond to different species (Pantel et al., 2015; Prada & Hellberg, 2013). Second, genetic differentiation is the result of interaction between gene flow and genetic drift, which depends on effective population size (Luikart et al., 2010). Low effective size can be an important factor leading to high differentiation. Third, current exchanges can be limited by available space and colonisation effects (Orsini et al., 2013): studies of recruitment on natural and artificial substrates show that recolonisation abilities may be important in Mediterranean octocorals (Cánovas-Molina et al., 2018; Aurelle et al., 2020), when free habitat is available. When different sites or environments are occupied by different cryptic species (as in CEA), the question of recolonization abilities remains: could the local loss of one species open the way to colonisation from a related one in a neighbouring site? Apart from demographic effects, the previously mentioned decline in population biomass following mortality events may have genetic consequences as well: depending on its intensity and duration, this decline may increase genetic drift in gorgonian populations. The genetic analysis of a declining population of red coral in Spain did not evidence any difference in population effective size compared to a pristine-like population (Ledoux et al., 2020). Nevertheless this last study suggested an higher biparental inbreeding in the declining population (Ledoux et al., 2020). Regarding the generally generation time of Mediterranean gorgonians, genetic effects may be visible on longer time intervals.

Microbial diversity and climate-linked diseases

Adaptation of an organism to different environments should be understood at the hologenome level. Similarly to tropical reef-building scleractinian corals, temperate octocorals are holobiont entities inhabited by a diverse bacterial assemblage (Bayer et al., 2013; La Rivière, et al., 2013; van de Water et al., 2018a). However, in contrast with the

ubiquitous association of scleractinian corals with the dinoflagellate alga *Symbiodinium*, *Eunicella singularis* is the only Mediterranean octocoral hosting symbiotic *Symbiodinium*.

The bacterial microbiomes of the Mediterranean octocorals are species-specific, although closely related hosts like *Eunicella cavolini* and *E. singularis* share some common bacterial phylotypes (La Rivière et al., 2015; van de Water et al., 2017). With the exception of *C. rubrum*, the octocoral microbiome is mainly composed of members of the Proteobacteria phylum, and largely dominated by a gammaproteobacterial symbiont affiliated to the genus *Endozoicomonas* (order Oceanospirillales) which can represent more than 90% of the microbiome (La Rivière et al., 2013). *Endozoicomonas* are also detected in the microbiome of *C. rubrum*, but the main associates of this species belong to the Spirochaetes phylum (van de Water et al., 2016).

Endozoicomonas are predominant bacteria in the microbiome of a wide range of tropical reef corals and have been suggested to play an important role in host fitness (Peixoto et al., 2017), which may rely on their potential capacities in nutrient acquisition or production of antimicrobial compounds (Neave et al., 2016). Their presence within the host tissues is also indicative of an intimate biological relationship, possibly resulting from a long-term coadaptation process (La Rivière et al., 2016; Neave et al., 2016). The abundance of *Endozoicomonas* decreases under altered environmental conditions, including climate stress, and in health-compromised colonies of various coral species (McDevitt-Irwin et al., 2017). In Mediterranean octocorals, a decreasing dominance by *Endozoicomonas* is observed in the microbiome of *P. clavata* populations subjected to anthropogenic impacts (Vezzulli et al., 2013). The loss of *Endozoicomonas* may trigger or facilitate a microbial shift toward opportunistic or disease-associated microorganisms such as vibrios. In *P. clavata*, microbial infection by *Vibrio coralliilyticus* has been identified as the cause of tissue lysis during mortality outbreaks induced by heat waves (La Rivière et al., 2016). This bacterium has previously emerged as a thermo-dependent pathogen of tropical corals, and its occurrence in the Mediterranean is correlated with the seawater temperature (Vezzulli et al., 2010). Susceptibility to pathogens under temperature stress may also be related to the down-regulation of some components of the immune defence system. For example, a mannose-binding lectin involved in recognition of a variety of bacteria, including *V. coralliilyticus*, is down-regulated in heat-stressed hexacorals (Kvennefors et al., 2008). Although a putative link between temperature stress and immune response has yet to be elucidated in Mediterranean octocorals, the overexpression of a lectin homologue observed in shallow colonies of *C. rubrum* may suggest the implication of adaptive mechanisms to counteract a higher pathogen pressure in warmer, low-depth environmental conditions (Pratlong et al., 2015).

In addition to the *Endozoicomonas*-dominated "core" microbiome consistently associated with each species, unique combinations of other bacterial taxa are present in different locations (van de Water et al., 2018b). In *Eunicella* species, the abundance and the diversity of locally stable bacterial associates increase in locations submitted to anthropogenic disturbances. In contrast, the relative amount of the core bacterial taxa in the octocoral *Leptogorgia sarmentosa* was greater in a disturbed site, indicating that each host species may exert different control over their microbial partners (van de Water et al., 2018). Notably, changes in diversity and abundances of various *Endozoicomonas* phylotypes were

observed in the microbiome of *Eunicella* spp. and *L. sarmentosa* from different locations, suggesting that the most adapted ecotypes are favoured in a given environment. In *C. rubrum*, changes in the microbiome were also evidenced at spatial scale, consisting in the readjustment of the relative abundance of members of the Spirochaetales and Oceanospirillales (van de Water et al., 2016). Overall, this suggests that octocoral holobionts may fluctuate in their microbial composition in response to environmental conditions, raising the question of the potential contribution of microbiome flexibility in local adaptation. This research area is emerging as a major topic in the future, which should be extended to other engineer species.

Research and management implications

Interactions between environmental diversity, especially along depth, and intrinsic dispersal abilities, have generated complex genetic and adaptive patterns, including at short distances, among coralligenous and animal forests in the Mediterranean Sea. Observations of mortality events mostly coincide with areas where warming trends are already recorded, and also with areas where other cumulative impacts are present (Rivetti et al., 2014). This raises several questions regarding the potential adaptive abilities of the affected species facing climate change. On the positive side, the available studies documented an important genetic diversity among populations, and in some cases an important adaptive diversity. Indeed a signal of local adaptation to depth has been shown (Ledoux et al., 2015) and more resistant individuals have been observed during mortality events (Garrabou et al., 2021). These results suggest a potential for acclimatisation or genetic adaptation with time. The presence of a given species along a depth gradient could also allow its persistence in deep refugia less affected by warming, but possibly at the expense of a range contraction (Galli et al., 2017). On the negative side, the slow growth rate and demographic dynamics of some engineer species could limit the rate of adaptive evolution, resulting in a slower adaptation than the environmental changes driving it. The reduced dispersal abilities could limit the exchange of adaptive alleles between populations (conversely, natural selection can increase their frequency). Interactions between pressures can be problematic as well, as demonstrated for acidification and temperature (Prada et al., 2017), but other non-climatic effects could act. For example, a reduction of population size through habitat destruction or harvesting could impact genetic drift.

There are several management tools for coralligenous or animal forests that could take this information into account in order to sustain adaptive evolution. Marine Protected Areas (MPAs) should be designed by favouring connectivity between populations (Palumbi, 2003). In the case of red coral, the modelling study of Montero-Serra et al. (2019) has shown that while MPAs can increase population growth if mass mortality events are rare, they are not efficient when the frequency of such events increases, as expected under future climate conditions. This is in line with observations on recent mass bleaching events in the Great Barrier Reef, where local protection had little effect on the resistance to bleaching (Hughes et al., 2017). Transplantations are increasingly proposed by environmental consulting firms as tools to sustain or recover octocoral populations in the Mediterranean Sea (Aurelle & Bally, pers. com.). This could be used to sustain the demography of populations or to restore gene flow for isolated populations. Nevertheless, such proposals usually do not take the possible adaptation to local conditions into account, nor do they fully estimate the required efforts. The potential effects of such practices and the best modalities sustaining biological

evolution could be evaluated through simulation approaches (Bay et al., 2017). In the case of tropical coral reefs, the possibility of using assisted evolution (i.e. acceleration of natural evolutionary processes, here to increase thermotolerance) in management plans is discussed (van Oppen et al., 2015). In all cases knowledge gaps remain. One major point is the determinism of adaptation and its heritability (with questions on genetic architecture, epigenetic effects, transgenerational acclimatisation, holobiont evolution): this will have major consequences on the possibility of evolution and on the corresponding management strategies. This is an evidently highly complex task which only starts to be understood in non-model species, e.g. Bay et al. (2017) on corals; and Perrier & Charmantier (2019) for examples and potential pitfalls with birds. These last examples show that this is now a timely and possible research line for Mediterranean marine species.

Adaptive abilities

The study of the possibility of adaptation to temperature or pH changes in non-model marine species, can take advantage of environmental gradients to study the current adaptive diversity. Indeed in the Mediterranean Sea, temperature regime can vary sharply along a short depth range (Haguenauer et al., 2013), which allow testing for local adaptation. Natural pH gradients were used to study the impact of acidification (Prada et al., 2017). In octocorals, higher thermotolerance levels were observed for shallower colonies (from 11 or 20 m depth) compared to deeper ones (40 m depth) in *C. rubrum* (Torrents et al., 2008) and *Eunicella cavolini* (Pivotto et al., 2015). Nevertheless in *P. clavata*, Crisci et al. (2017) did not observe a correlation between thermotolerance and the original thermal regime experienced *in situ* by colonies. This could be the consequence of genetic drift counter-acting local adaptation, or of the protocol: colonies were fed during the experiment, whereas energetic constraints during summer have been proposed as a factor shaping mortality events (Coma & Ribes, 2003). In *Eunicella singularis*, a reverse pattern of thermotolerance was observed with shallower colonies being less thermotolerant than deeper ones (15 vs 35 m depth) (Ferrier-Pagès et al., 2009). This could be due to the photosynthetic activity of *Symbiodinium* symbionts in this species (*Symbiodinium*), which could interact with thermal stress at lower depths. Additionally, it is not clear whether such diversity in thermotolerance corresponds to acclimatisation, to local, genetic adaptation, or to interactions between both processes. Acclimatisation could buffer the impact of environmental changes for long-lived species with long generation time as suggested for tropical corals (Munday et al., 2013a). There is little information on acclimatisation abilities of Mediterranean octocorals: one experiment in *C. rubrum* has shown a reduction of the expression of HSP70 in experimental thermal stress following a first similar stress (Haguenauer et al., 2013), but a reverse signal was observed for another temperate octocoral after acclimatisation to temperature (Lopes et al., 2018). In all cases, for such long lived species, acclimatisation abilities should be explored on a longer time interval, especially over different years. Transplant studies on the bryozoan *Myriapora truncata* showed that, at low pH, individuals were able to survive, but not to grow (Lombardi et al., 2011). Rodolfo-Metalpa et al. (2010) showed that under elevated pCO2 one event of prolonged high seawater temperature triggered the death of all individuals in the experiment. These last experiments on *M. truncata* were not dedicated to study the diversity of responses, but they showed the potential impact of acidification on this calcifying metazoan.

Laboratory studies on CEA species showed that their survival rate, calcification rate, photosynthesis declined with increased temperature and acidification(Rodríguez-Prieto, 2016; Martin et al., 2013). Thus, engineering species of coralligenous habitats have limited acclimatization abilities, especially when facing a combination of stresses (see also Prada et al., 2017; Rodolfo-Metalpa et al., 2011).

The possibility of genetic adaptation to local thermal conditions is supported by reciprocal transplant experiments between depths in *C. rubrum*, but in only one of the two investigated regions (Ledoux et al., 2015). Gene expression differences between depths have been demonstrated for this species at the transcriptome level (Pratlong et al., 2015). Some of the differentially expressed genes are involved in stress response in other coral species, but a demonstration of their role in adaptation is still lacking in *C. rubrum*. A population genomic study indicated a signal of local (genetic) adaptation to depth in the red coral (Pratlong et al., 2018). Nevertheless, in such species with important genetic differentiation, false positive induced by genetic drift are really problematic, and additional work is required to study genetic adaptation in this species (Pratlong et al., 2018). Regarding depth gradients, genetic studies have shown that CEA species community composition vary along a depth and light gradient suggesting that different species are adapted to different niches (De Jode et al., 2019). The case of CEA underlines that the diversity of adaptation should be considered at different levels: from within species to between related species.

At higher distances, different octocoral species are present in different parts of the Mediterranean Sea (North – South, East – West). It would be interesting to study the differences in adaptive abilities according to the different basins. In all cases, for such long-lived species with sometimes long generation time, the possibility of genetic adaptation along with environmental changes seems difficult, especially if extreme events strongly impact the population dynamics. The study of recurrent bleaching events in the Great Barrier Reef, conversely indicated that previous bleaching events could reduce the impact of new events, possibly as a consequence of selective effects (mortality affecting the most sensitive individuals or species) or of acclimatisation (Hughes et al., 2018). Additional studies would be required for a better understanding of this effect and its potential consequences on corals' evolution.

2. LAND SYSTEMS

D. *Microbial soil communities of pine and oak forests*

Drivers of forest soil diversity

Soil represents a huge reservoir of biodiversity including microorganisms (mainly bacteria, fungi and protozoa) and invertebrate animals (Gobat et al., 2004), all of which are actively involved in organic matter transformation. This fundamental ecosystem process sustains major ecosystem services, such as primary production and biogeochemical cycles (Bardgett et al., 2008). Forests are essential biomes in providing such services. The abundance and diversity of soil microorganisms is particularly high in such ecosystems (Buée et al., 2009; Lladó et al., 2017). Both bacterial and fungal communities are key soil components that produce extracellular enzymes involved in nutrient turnover and humification, leading to CO_2

emission and carbon storage (assimilation in the biomass, aggregation...) in soil. Forest soils can indeed act as both sinks and potential sources of carbon (Bardgett et al., 2008; DeAngelis et al., 2016) and this balance is driven by various environmental factors acting at different spatial scales. At a global scale, temperature and mean annual precipitation (Tedersoo et al., 2016) and edaphic properties - mainly pH - (Fierer & Jackson, 2006) have been identified as main drivers of soil microbial diversity, while locally it varies greatly according to above ground plant diversity (Haichar et al., 2008; Roesch et al., 2007; Tardy, 2015). At a local scale, soil microbial activities indeed depend on the nature and quantity of organic input coming from root exudates, litter fall or fire residues (Schmidt et al., 2011) as well as on physico-chemical processes (e.g. organo-mineral association, freezing and thawing) and interactions between soil organisms mainly related to trophic relationships (Scheu, 2002).

The Mediterranean context

The dynamics of Mediterranean forest stands react to various environmental drivers acting at different spatio-temporal scales. Of all these drivers, land use legacy and specific edaphic and climate conditions, play an important role (Ertlen et al., 2015). The surface and composition of European Mediterranean forests have been strongly structured by wildfires and human activities leading to agro-silvo-pastoral systems during the last century (Quezel & Médail, 2003). From the 1930s, abandonment of land previously devoted to agriculture and increasingly frequent wildfires promoted massive colonisation of natural spaces by resinous species such as *Pinus halepensis* Mill. and *Pinus sylvestris* (Tatoni & Roche, 1994), resulting in pure stands. The Mediterranean region is characterized by particularly dry summer periods that have selected plants producing leaf litters containing particularly high amounts of secondary metabolites (Chomel et al., 2016; Hashoum et al., 2017) and of recalcitrant phenolic compounds (Rovira & Ramón Vallejo, 2007) that were both shown to affect litter decomposition and soil nutrient cycling. In forests, vegetation assemblages are known to deeply impact soil organic matter composition. Broadleaved species, such as *Quercus* spp., enhance soil organic matter quality, increasing easily-degradable compounds and thus enhancing microbial metabolism (Polyakova & Billor, 2007). Conversely, some plant species that are specific to the Mediterranean area such as *Pinus* spp. contain particularly high amounts of recalcitrant molecules (such as cutin or lignin) and are poor in nutrients, which induces lower rates of decomposition. When both type of species (broadleaves and coniferous) are mixed, the tree-species identity and the function traits associated can strongly modify the stand 'print' on soil properties and thus on soil chemical signature (Laganière et al., 2009; Matos et al., 2010; Prescott & Grayston, 2013). This has been described as additive or non-additive (synergistic or antagonistic) effects (Brunel et al., 2017; Scheibe et al., 2015).

Mediterranean forest soil functioning may be threatened by additional pressures linked to environmental changes. The Mediterranean basin, considered as a hotspot of biodiversity (Quezel & Médail, 2003), has also been identified as one of the most prominent "Hot-Spots" in climate change projections (Giorgi, 2006; Giorgi & Lionello, 2008). Climate scenarios project changes in the spatial and temporal distribution of precipitation as well as increased frequency and intensity of extreme events (heat waves, droughts, wildfires) that will impact ecosystem functioning (Giorgi & Lionello, 2008), including through soil-related processes.

Forest soil responses to drought stress

Soil ecologists are now extensively focusing their research on how climate change effects may alter soil diversity and functions (Kéfi et al., 2007). Most litter decomposition experiments have investigated litters from plants artificially exposed to global change factors such as warming, drought or elevated CO_2 (Suseela & Tharayil, 2018). Some studies have used field-scale experiments via rainfall exclusion to mimic drought constraints (Rodriguez-Ramirez et al., 2017; Santonja et al., 2017), while others are now using transplantation experiments across natural climate gradients to investigate the impact of climate conditions on forest soils *in situ* (Berger et al., 2016; Keiser & Bradford, 2017; Makkonen et al., 2012).

Previous studies showed that microbial communities frequently exposed to drought stresses are more resistant to drying/rewetting cycles than less exposed communities (Butterly et al., 2009; Farnet Da Silva et al., 2016; Fierer et al., 2003; Fierer & Schimel, 2002; Schmitt et al., 2010; Van Gestel, Merckx, & Vlassak, 1993), which has been interpreted as resulting from natural selection (Sparling et al., 1987). Several authors detected a shift in microbial composition towards fungal-dominant communities after repeated drying (Cleveland et al., 2004; Evans & Wallenstein, 2012; Yao et al., 2011), suggesting that this microbial group can resist to drought stress better than bacteria. More precisely, fungi may be more tolerant to drought stresses (fungal hyphae can transfer moisture from water-filled micropores) than bacteria, which are more connected to their immediate surroundings and require water films for motility and substrate diffusion as described above (Evans & Wallenstein, 2012). In fact, based on morphology and life history strategies (inherent resistance and acclimatisation abilities) of microbial groups, stresses linked to drying/rewetting cycles are likely to favour Gram-positive bacteria (with a strong, thick, interlinked peptidoglycan cell wall) and fungi rather than Gram-negative bacteria (with a single-layer cell wall and an outer membrane) (Schimel et al., 2007). Production of intracellular osmolytes is often observed as a physiological response to water potential stresses (Kakumanu & Williams, 2014), which is particularly energy-consuming for microorganisms and thus impacts their metabolism. However, the stability of decomposer microbial communities after stress also relies on other factors that shape community structure, composition and diversity, such as organic matter quality and quantity (Loreau et al., 2001; Loreau Michel, 2010; Wardle & Jonsson, 2014). Mixed forests have long been considered essential for sustainable forestry management (Gartner & Cardon, 2004; Rodríguez-Loinaz et al., 2008). Increased biodiversity creates more diverse habitats, produces more above-ground biomass (Vilà et al., 2007) and enhances resilience to stress and to disturbances like diseases (Pautasso et al., 2005), fires (Wirth, 2005) or extreme weather events (Dhôte, 2005).

Numerous previous studies (Rodriguez-Ramirez et al., 2017; Setiawan et al., 2016; Zimmer, 2002) have shown higher decomposition rates in mixed litter compared to monospecific litters, depending strongly on litter species within the mixture (Brunel et al., 2017; Cuchietti et al., 2014; Prescott & Grayston, 2013; Wu et al., 2013). The diversity of plant species within litter mixtures is also thought to maximize the diversity of nutrient resources, which in turn favours microbial diversity and abundance (Santonja et al., 2017, 2018). Any alteration of the plant species diversity should thus drive strong cascading effects on microbial decomposer communities. In other words, diversity begets diversity (Chapman & Newman, 2010). This can be related to the ecological concept of complementary ecological niches, underlying

better microbial exploitation of organic matter and better stability (Loreau et al., 2001; Loreau Michel, 2010). A meta-analyses by Cornwell et al. (2008) suggests that plant species traits have a strong effect on resistance to stresses and could be considered as a predominant driver of soil functioning within biomes worldwide. However, another concept based on the redundancy of functions in soil microbial communities supports the fact that there is no clear relationship between microbial diversity and the stability of function 'decomposition'. Many authors have indeed assumed that there is a high level of equivalence in functions within decomposer communities and thus a substantial potential of resilience in functional capacity. In other words, the loss of any group of species may not strongly impact decomposition processes since other microorganisms can sustain its function (Nannipieri et al., 2003; Swift, Izac, & van Noordwijk, 2004).

Many research outputs point to the need to take drivers at different spatio-temporal scales into account (mainly stress legacy, land use history, climate conditions at various spatial scales and litter chemical signature) to improve our projection capacity of functional and structural microbial community responses to environmental changes, and their consequences for ecosystem functioning and stability. This is particularly challenging for microbial communities of soils since only a very small fraction of the existing species diversity is known. Yet, it is crucial for the above ground communities that depend on soil biodiversity, such as forests.

E. *Semi-arid and arid Mediterranean steppes*

Mediterranean steppes host a unique biodiversity with rare and threatened species. Among them, steppe bird species (e.g. *Chersophilus duponti*, *Tetrax tetrax*, *Otis tarda*, *Pterocles alchata*, *Falco naumanni*) represent the most threatened group of birds in Europe (Laiolo & Tella, 2006). Steppes also host rich assemblages of arthropods with many species typical of oligotrophic and arid areas (Fadda et al., 2007), also including some endemic taxa (e.g. the grasshopper *Prionotropis rhodanica* Uvarov in the Plaine de La Crau, France). North African steppes are exceptionally rich with more than 2600 plant species of which 25% are endemic (Le Houerou, 1995). In North Africa, arid steppes potentially cover over 630 000 km² (Le Houerou, 1995). Today, only fragmented and reduced surface of semi-arid and arid steppes occur in the Mediterranean basin, especially in the western Mediterranean (Iberian Peninsula, and North Africa).

The openness of steppes confers them a long history of traditional agricultural practices such as sheep grazing, especially the gramineous steppes of *Stipa tenacissima* that are often the result of the degradation of former Mediterranean open forests (Gauquelin et al., 1998). However, arid and semi-arid ecosystems are especially prone to state changes as a result of scarce, variable rainfall and low soil fertility, and among the most sensitive ecosystems to global climate change (Kéfi et al., 2007; Reynolds et al., 2007). In North and South Mediterranean, recent industrial development, agricultural intensification, changes in agricultural practices or changes in fire regimes pushes arid and semi-arid ecosystems towards the edge of extinction (Kéfi et al., 2007; Puigdefábregas & Mendizabal, 1998). Desertification, land degradation in arid, semi-arid and dry sub-humid areas results from various factors, including climatic variations and human activities (Reynolds et al., 2007).

Many studies have reported the consequences of climate and land use changes in steppes on biodiversity. In North Africa, (Le Cuziat, et al., 2005) showed that human presence and pastoral activity affect the distribution of a steppe bird species, the Houbara bustard. Similar projections for steppe bird species in Spain showed a strong impact of land use on their potential distribution range (Brotons et al., 2004). Agricultural intensification also impacted the composition of steppe vegetation (Römermann et al., 2005). Trait-based modelling of plant abundances in the arid steppes of eastern Morocco showed that stress-tolerant sub-shrubs will become the dominant functional group in the next decades whatever the climate change scenario used, suggesting a process of desertification (Frenette-Dussault et al., 2013). In North Africa, a vegetation model simulating an increase of atmospheric CO_2 (500 ppmv) and of annual temperature (+2°C) with stable precipitation showed that a woody xerophytic vegetation might occupy a more extensive territory than today, and would replace part of the present steppe area (Cheddadi et al., 2001). The phenomenon of shrub encroachment, i.e. the increase in the density and cover of shrubs in former grassland, triggered by many factors ranging from climate change to grazing to fire suppression, has been largely reported. *Stipa tenacissima* – when preserved – might also have a direct key role of facilitation on these introduced shrubs in some arid and semi-arid steppes (Maestre et al., 2001).

In this context, the authors recommend enlarging the network of protected areas to prevent any further habitat degradation and to implement agri-environmental measures as well as active transnational management measures for the maintenance and survival of viable bird population (Brotons et al., 2004; Buisson & Dutoit, 2006) and biodiversity in general.

F. *Forests*

F1. Thermophilic oak-pine forests and shrubland

Downy oak (*Quercus pubescens* Willd.), Holm oak (*Quercus ilex* L.) and Aleppo pine (*Pinus halepensis* Miller) are the three most widespread forest tree species of the western part of the Mediterranean. They form vast monospecific or mixed forests as do many species of oaks and pines across the altitudinal vegetation belts throughout the region (Quezel & Médail, 2003). They are adapted to the long summer droughts of the Mediterranean and will probably increase their ecological role and distribution area as climate gets hotter and summers get drier throughout the 21st century.

Total forest cover of Allepo pine is estimated to be approximately 3.5 million hectares (Fady et al., 2003; Mauri et al., 2016). P. halepensis is mainly found at lower elevations in the thermo- and meso-Mediterranean belts, and up to 2 000 m above sea level in Morocco. Total forest cover of downy oak is at least 2.5 million hectares, with over 1.7 million hectares in France and Italy alone. Downy oak is a northern Mediterranean oak that can grow from coastal plains up to 1200-1300 m above sea level while it is most often found on hillsides between 200 and 800 m. Downy oaks prefer lime-rich and well drained soils in the northern part of their range, while they may also be common on acidic soils in its southern part (Pasta, de Rigo, & Caudullo, 2016). Total forest cover of holm oak is over 6 million hectares, with the largest forests in the western Mediterranean (Quezel & Médail, 2003). Holm oak is mostly found from 0 to 1000 m above sea level but can reach elevations of 2500 m in areas

where competition with other broadleaves is limited such as in Morocco and Spain. Holm oak can be the keystone species of various ecosystems, from open matorral type to late successional (de Rigo & Caudullo, 2016). It prefers well drained sites and is insensitive to soil pH.

The current distribution of these thermophilic, drought resistant forests and their associated biodiversity results from millennia of human disturbance and it is actually difficult to precisely characterize the limits of the ecological niche of these species (Covas & Blondel, 1998; Doblas-Miranda et al., 2017; Henne et al., 2013). Fire and land use change are the main drivers of their distribution and their recolonisation of low elevation sites has been spectacular during the second half of the 20th century onwards (Quezel & Médail, 2003).

The major challenge for these species during the 21st century will be to adapt to increased periods of summer drought and heat. Widespread mortality of Quercus pubescens in southern France over the past years, for example, have alarmed forest management agencies. Ongoing experiments in flux tower sites measuring gas exchange rates over Mediterranean oak and pine ecosystems reveal numerous adaptation potentials. In the O3HP Oak Observatory in Provence (France), rain exclusion experiments helped better understand the capacity of *Q. pubescens* to resist recurrent droughts projected by climatic models. After 4 years of reduced rain (30%), although water potential (Ψ) and net photosynthesis (Pn) were noticeably reduced, trees showed no reduced growth and no oxidative stress. Defences such as Volatil Organic Compound emissions actually decreased. However, growth decrease was observed at longer term (5th year) and antioxidant contents (carotenoids and isoprene) started to change (Saunier et al., 2018). Although *Q. pubescens* is a highly drought-resistant species that possesses efficient antioxidant mechanisms (tocopherol, xanthophyll cycle) to cope with oxidative stress, we can anticipate substantial decreases in gas exchange, adjustments of the photosynthetic pigment composition (chlorophylls, carotenoids), impaired growth in the long-term and maybe stronger compensatory mechanisms between antioxidants. The wide distribution of this taxon often occurring in the transition of several climatic influences (Quezel & Médail, 2003) still requires further research on its entire range in order to test its phenotypic plasticity.

Other effects of experimental reduction of rainfall in *Q. ilex* forests (in Catalunia (Spain) and Puechabon, near Montpellier, France) have included significant shifts in community composition of ectomycorrhizal communities (Richard et al., 2011), decreased soil enzyme activity (Sardans & Peñuelas, 2005), decreased species richness of recruited seedlings in a Mediterranean shrubland (Lloret et al., 2004) and phenological changes (Misson et al., 2011; Ogaya & Peñuelas, 2004). In the long run these shifts may offset the increased productivity projected by mechanistic process-based models focusing on CO_2 fertilisation (Keenan et al., 2011). Varying phenotypes under different environmental conditions are better projected by phenotypic plasticity than by genetic diversity (Valladares et al., 2002).

Increased risk of wildfires is another major challenge. Fire is a dominant ecosystem process of low elevation pine and oak forests, likely to become more prevalent under climate warming in the 21st century. Low elevation pines have developed serotinous cones that make them particularly adapted to recurrent fires at a frequency of over 20-30 years. It is likely that recurrent fires have impacted the genetic diversity of Aleppo pine, making it a relatively

low diversity species amongst pines. Oaks are resprouters and are also well adapted to fire. Nonetheless, an increase in fire frequency and intensity may negatively affect pine and oak forest composition, recovery rate and suitability as a habitat for other communities of plants and animals (Doblas-Miranda et al., 2017; Puerta-Piñero et al., 2012; Regos et al., 2015), with complex feedback loops associated to other changes such as drought and land-use (see review by (Doblas-Miranda et al., 2017).

Despite some sensitivity to late frosts and winter freezing, Aleppo pine is likely to resist and be one of the winners of climate warming in the Mediterranean. From an evolutionary ecology perspective, this eastern Mediterranean origin pine re-occupied its current distribution after the Glacial cycles from a few refugial areas via local diffusion and long-distance dispersal processes. The genetic diversity of this species is one of the lowest for trees worldwide, indicating strong past demographic bottlenecks (such as cold episodes and large wildfires) (Fady, 2012; Fady & Conord, 2010; Grivet et al., 2009; Grivet et al., 2011). Aleppo pine displays several strategies to withstand severe drought, including high resistance to embolism and a capacity to reduce wood-formation rates as water availability decreases (e.g. Camarero et al., 2015). However, water shortage can limit growth and productivity of Aleppo pine forests and increase tree mortality (del Río et al., 2014; Dorman et al., 2013). Depending on the origin of the populations in the vast and contrasted climatic zones the species occupies, from semi-desert to temperate climates, climate-growth response functions are highly variable (Luis et al., 2013). Although some evidence of differentiation for survival (xylem hydraulic conductance and resistance to embolism) has been found in semi-arid common gardens (David-Schwartz et al., 2016; Klein et al., 2013; Schiller & Atzmon, 2009), signatures of local adaptation are limited (Gómez et al., 2001; Grivet et al., 2011). This suggests that most of the variation is due to phenotypic plasticity (Baquedano et al., 2008; Chambel et al., 2007).

Similarly, *Q. ilex* is likely to be among the winners of environmental changes in the Mediterranean. Although there are fewer molecular studies in this oak than in other oak species or Aleppo pine, its genetic diversity is higher than that of Aleppo pine and among the highest within the oaks. *Quercus ilex* is made of three major genetic clusters: eastern, central and western Mediterranean (Vitelli et al., 2016). *Quercus ilex* has its highest diversity in the eastern Mediterranean cluster, similarly to Aleppo pine and many species in the Mediterranean (Conord et al., 2012).

F2. Beech-fir forest

Ecology

Some of the typical mixed broadleaf conifer forests of the mountain belts of the Mediterranean region are *Abies* sp. and *Fagus*. sp. Forests, collectively names beech-fir forest in this section. *Abies* sp. forests are found from 700-900 m and up to 2300 m above sea level while Fagus sp. forests are found between 700 and 1800 m in the Mediterranean. Their occurrence is highly dependent on soil and air moisture and the lowest elevation presence of beech is often associated with riverine forests (Quézel & Médail, 2003). While approx. 10 species of *Abies* have been described in Mediterranean mountains, there are only two for the genus *Fagus* (*F. sylvatica* and *F. orientalis),* and they are often considered as sub-

species level taxonomic entities (Quézel & Médail, 2003) (Table S1). *Abies* and *Fagus* species form both mixed and single species dominated forests.

Most Abies species occupy reduced distribution areas in isolated mountains except *Abies alba*, the European silver fir whose European distribution spans from Spain to Romania (Valladares et al., 2002; Wolf, 2003). In the westernmost part of its Alpine distribution, *Abies alba* grows under various biogeographical (from inner to outer Alps), bioclimatic (from Mid-European to Sub-Mediterranean influences) and edaphic conditions, with scattered locations under strict Mediterranean climate (Ozenda, 1981). Mediterranean climate occurrences of *Abies alba* are rare outside of France. Similarly to *Abies alba*, *Fagus sylvatica* is a typically medio-European forest tree, requiring moist habitats and able to colonise mountain belts under Mediterranean climate (i.e. where adaptation to summer drought is an issue) in Catalonia, southern France, southern Italy, Sicily and central Greece (Quezel & Médail, 2003). It has the same longitudinal span as *Abies alba* and is replaced by its more drought resistant congener, *Fagus orientalis*, in scattered places in northern Greece and Bulgaria and large forests in Turkey (Kandemir & Kaya, 2009; Von Wuehlisch, 2008).

Table S1 : Distribution and bioclimatic preferences of Mediterranean *Abies* (a) and *Fagus* (b) species, compiled from (Quezel & Médail, 2003) unless indicated otherwise. A sub-humid bioclimate receives between 600 and 800 mm of precipitation a year, a humid bioclimate over 800. Temperature variants are as follows: fresh when mean temperature of coldest month (m) is 0°C < m < 3°C, cold: -3°C < m < 0°C, very cold: -7°C < m < -3°C. Data for *A. alba* and *A. bornmuelleriana* are limited to their Mediterranean distribution. Elevation and surface data for *A. equi trojani* are from Kaya et al. (2008) and data for *A. bornmuelleriana* are from Özel & Erteki,(2012). MECC* (national forest inventory) data provided for Greece are from P. Dimopoulos and the project: National Cadastre & Mapping Agency S.A. & Ministry of the Environment and Climate Change (2015). Distribution data for *Fagus orientalis* in Turkey are from Ozturk et al. (2010). Distribution data for *Fagus sp.* in Greece were provided by P. Alizoti using the reference: Results of the first national forest inventory, 1992. Ministry of Agriculture, General Secretariat for Forests and Natural Environment, General Directorate for Forests and Natural Environment, Athens.

(a)

Species	Occupied surface (in ha)	Country of occur-rence	Altitudinal range (in m) (and extremes)	Bioclimate type and temperature variants	Substrate	Summer drought duration (months)
ABIES SPECIES						
A. cephalonica	200 000 (130 000 according to MECC*)	Greece	700 - 2000 (400 - 2300)	sub-humid to humid, fresh to cold	Limestone and dolomites	1 - 5
A. borisii regis	57 000 (according to MECC*)	Greece	1100 - 1900 (600 - 2000)	sub-humid to humid, cold to very cold	Limestone and serpentine	Probably between A. cephalonica and A. alba
A. bornmuel--leriana	200 000 (entire range)	Turkey	1200 - 2000	humid, cold to very cold	Schists and gneiss	0 – 2
A. equi-trojani	3600	Turkey	1300 - 1500 (400 - 1600)	humid, cold to very cold	Metamor-phic bedrock	0 - 2
A. cilicica	350 000	Lebanon, Syria and Turkey	1200 - 2100 (1100 - 2200)	humid, cold to very cold	Limestone and dolomites (some serpentines)	1 – 3
A. pinsapo and A. marocana	2300 (Spain) and 7000 (Morocco)	Spain, Morocco	900 - 1800 in Spain, 700 - 2200 in Morocco	humid, fresh to cold	Limestone and dolomites	1 – 4
A. numidica	300	Algeria	1750 - 2000	humid, cold	Limestone and dolomites	1 – 3
A. nebrodensis	150	Italy	1400 - 1600	humid, cold	Schists	0 – 1
A. alba (Medit. range)	20 000	France, Italy, Spain	1100 - 1600 (600 - 2000)	humid, fresh to cold	Limestone and dolomites	0 – 1

(b)

Species	Occupied surface (in ha)	Country of occurrence	Altitudinal range (in m) (and extremes)	Bioclimate type and temperature variants	Substrate	Summer drought duration (months)
FAGUS SPECIES						
F. sylvatica (Mediterranean range)	295 290 (in Greece)	France, Italy, Spain, Greece	800 - 1700 (600 - 2200)	sub-humid to humid, cold to very cold (locally, fresh)	Limestone and dolomites (locally acidic)	0 – 1
F. orientalis (Mediterranean range)	85 000 (in Turkey), 41 350 (in Greece)	Greece, Turkey (mostly)	1000 - 1800	sub-humid to humid, cold to very cold	Limestone and dolomites	0 – 1

Evolutionary history

Fir and beech survived the last glacial cycle of the Pleistocene and the Late Glacial Maximum (LGM) in refugia located in the Mediterranean, giving rise to highly differentiated and genetically rich local populations. The LGM refugial and Holocene colonisation history is rather well known for both *Fagus sylvatica* and *Abies alba*, the most largely distributed of all Euro-Mediterranean firs (Liepelt et al., 2009; Magri et al., 2006). Magri et al. (2006) showed using both paleoecological and genetic data that beech survived the last glaciation in at least 10 different refugia. Most of them were in the Mediterranean but did not contribute to the recolonisation of Europe, which instead sprung from refugia further north in the Massif Central, Slovenia and possibly Carpathians. The Mediterranean refugia may in fact be a long-term area of persistence for beech throughout the last two glacial / interglacial cycles of the Pleistocene. Liepelt et al. (2009), also using both paleoecological and genetic data, showed that *Abies alba* survived in multiple refugia during the LGM. As for beech, few of the Mediterranean refugia were effective sources for Holocene recolonisation, which sprung from refugia further north in the Apennines, Dinaric Alps and at least two areas in the northern Balkans (Gömöry et al., 2012). The Mediterranean refugia may again indicate areas of long-term persistence during the glacial periods of the Pleistocene.

Mediterranean *Abies* species are well differentiated, with few detected events of admixture and gene flow, indicating that Mediterranean *Abies* species have probably survived in separate refugia during the Pleistocene (Liepelt et al., 2010). *Abies* type pollen dating back to the late Miocene and the Pliocene are widespread in paleoecological archives, an indication of the long presence of firs in the Mediterranean. As for *Fagus* forests, their presence is attested in sediments since the Oligocene (Quézel & Médail, 2003).

Importance and effect of land use and management

Due to their importance for industry, from ship building as early as pre-Roman times, to mining and construction throughout recent history, both *Abies* sp. and *Fagus* sp. dominated forests have seen their distribution areas shrink considerably over historical times. They reached their lowest coverage during the 19th century on Europe's side of the Mediterranean (Lander et al., 2011), while they remain threatened by land use change to these days in North Africa and the Middle East (Awad et al., 2014). In Mediterranean Europe, the demographic dynamics are still towards habitat recolonisation despite increasing decline due to environmental changes.

Adaptation to environmental changes - decline

Reports of decline due to environmental changes and associated factors such as insect outbreaks (bark beetles for example) are alarming. In the words of Gazol et al. (2015): "Climate warming is distinctly modifying growth patterns and responses to climate in silver fir across most of the species' European distribution area. In south-western Europe the reduction in growth of many populations is related to an observed increase in aridity, whereas in more temperate areas warming is enhancing growth. Our results confirm a decline in the growth of silver fir at its south-western distribution limits as a consequence of climate warming". There are similar reports for beech, although the adaptive capacity of marginal populations located at the southern limit of this species' distribution is unclear. Some reports indicate strong growth decline (up to 49% compared to pre-climate change levels), whilst others highlight that sensitivity and low resistance to drought is greater at the core of the species range than at the xeric range edge (Cavin & Jump, 2017; Jump et al., 2006). Just as local differences were found at tree and plot level for water stress sensitivity in *A. alba* at range margins, it is likely that the same applies to beech (Cailleret et al., 2014). Their conclusion that "this study highlights the importance of local site and stand conditions on mortality and decline processes..." can probably be generalised to the entire range margins of the two species and their communities. There, drought is a strongly limiting factor that can be compensated by high local habitat heterogeneity, thus offering options for adaptation to increased drought under environmental changes.

Long standing variability in local site conditions has triggered local adaptation under natural selection processes, as identified in genomic signatures in both silver fir and European beech (Brousseau et al., 2016; Lalagüe et al., 2014; Roschanski et al., 2016). In these studies, stress related candidate genes (mostly cold resistance and drought resistance) showed significant population differentiation along environmental gradients both within and amongst sites. Despite relatively limited dispersal abilities, their habitat heterogeneity and their high diversity in stress related genes make Mediterranean populations of beech and fir both museums of past diversity and a cradle of possible adaptation to environmental changes of high conservation value.

G. Agrosystems

The terrestrial Mediterranean hotspot of biodiversity is dominated by agricultural lands, evergreen woodlands and shrubland habitats. Several traditional Mediterranean agro-ecosystems are multifunctional mosaic associations of diverse annual and perennial crops, grazing and semi-natural areas. The potential evolution of these systems under climate

change is deeply shaped by interactions management choice and land uses, and will have important consequences on associated landscapes and biodiversity. Agro-silvo-pastoral systems are present on both sides of the Mediterranean Sea. The design of such heterogeneous systems shapes a man-made landscape diversity and can support a rich specific biodiversity (Bagella et al., 2016; Blondel & Aronson, 1999). Blondel (2006) points out that the exceptional richness of annual plant species in the Mediterranean flora is due to long-standing but constantly changing human activities and heavily grazed areas.

In the Mediterranean region like everywhere else, a decrease in biodiversity has accompanied the changes in land use and farming practices throughout the 20th century. In productive areas, agricultural intensification implies first a reduction of the diversity of cultivars and livestock varieties, while landscape simplification (Pinto-Correia & VOs, 2004), mechanisation and the use of chemicals are responsible for the decrease of the biodiversity within the whole agricultural landscape. The extinction of arable weeds (Chamorro et al., 2016; Saatkamp et al., 2009), or the declining populations of farmland bird species often with a high conservation status (Sirami et al., 2008) are particularly significant examples for the Mediterranean. Beside intensification, land abandonment in remote (often mountainous) areas of Mediterranean Europe is mostly followed by landscape closing due to woody encroachment, which affects negatively plant species diversity due to competition on light and water, or by inhibiting seed arrival and germination (Gabay et al., 2008). Even the disappearance of livestock in forests might reduce the biodiversity of understorey plant communities on a regional scale because of a greater homogenisation of plant composition (Fortuny et al., 2014). Rural land abandonment may lead to the return of forest birds when forests spreads (Gil-Tena et al., 2009) and it proves to be the most effective way to recover both habitat and bird populations in Mediterranean steppes (e.g. Laiolo & Tella, 2006). In contrast, Papanastasis et al. (2002) report that overgrazing in the mountains of Crete may have a negative impact on plant biodiversity, especially when associated with burning.

Regarding intensification, despite the continuous general use of synthetic fertilizers and pesticides in Mediterranean agroecosystems (like worldwide), agroecological practices that rely more on functional agrobiodiversity of the ecological system and less on external inputs are on the rise (Stojanovic, 2019) and has become an objective now supported by various institutions. More specifically, agroecology aims at enhancing species biodiversity delivering important services for agriculture, like pollination, soil fertility, or biological pest control (Gaba et al., 2018). For example, organic orchards in southern France hold a lot more earthworms - soil engineers - than other orchards (Sauphanor et al., 2009). Besides, the maintenance of on-farm diversity allows the conservation of threatened species, like the Great bustard *Otis tarda* that benefits from cereal/fallow rotations in Portugal (Moreira et al., 2004). Policies enhancing low-intensity management techniques such as organic farming are also the main way to promote plant diversity in dryland cereal fields of the Iberian Peninsula (José-María et al., 2010), or to favour bird communities and their resilience to climate change in the Mediterranean vineyards (Rollan et al., 2019).

Threats by environmental changes to Mediterranean agro-ecosystems are related to the increasing drought and heat stress in the first place (see part C in Main manuscript). More and more studies show how a change towards farming practices that favour the soil capacity to hold and keep water, like conservation farming, with the objective of stabilizing or

enhancing yields under Mediterranean climates (Jemai et al., 2013; Mrabet, 2011), may have a beneficial effect on biodiversity (e.g. arthropod population under no-tillage maize in Spain (Rodríguez, Fernández-Anero, Ruiz, & Campos, 2006)). The use of herbicides consequent to many no-tillage systems (used to fight competition by arable weeds) contradicts the agro-ecological objectives. Research now investigates organic conservation agriculture by using agro-ecological service crops and improved technology (Canali et al., 2013; Navarro-Miró et al., 2017). For example, conservation farming in organic systems often rely on the use of legume intercrops for both increasing soil fertility and reducing weed competition. Such systems increase biodiversity both within and and at the surface of the soil (see e.g. (Henneron et al., 2015; Rypstra et al., 1999). Organic systems have a greater abundance and diversity of arbuscular mycorrhizal fungi (Oehl et al., 2004), which play a crucial role in nutrient acquisition and soil fertility. Gianinazzi et al. (2010) highlight the fact that arbuscular mycorrhizas fungi alleviate stress salinity both in olive tree plantations in Spain, and in palm groves in arid North Africa where yields are considerably affected by drought and soil salinity (Bouamri et al., 2006; Porras-Soriano et al., 2009). Arbuscular mycorrhizas fungi also improve resistance of clover to hydric stress in arid Morocco (Meddich et al., 2000). Under climatic fluctuations, intercrop systems in Mediterranean environments have a greater land use efficiency than monocrops (Lithourgidis et al., 2011a), and are more stable to disturbances, this later effect being attributed to the larger on-farm diversity (Lithourgidis et al., 2011b). Under projected increase water stress, Falco & Chavas (2008) estimate the resilient ability of the south Italian cereal agro-ecosystem to be positively related to crop diversity.

Agroforestry and silvopastoral systems (crops and trees or livestock and trees association) that were partly abandoned (Eichhorn et al., 2006) are now rediscovered, thanks to a better understanding of their multiple ecosystem services. They appear to be well adapted to the Mediterranean climate (Joffre et al., 1999), providing a better temperate and less dry microclimate for crops or livestock between trees, and allowing a better water and nutrient availability due to tree roots plasticity (Cardinael et al., 2015), therefore increasing total productivity (Graves et al., 2007). At the same time, the land use mosaic of the silvopastoral systems in the Iberian Peninsula (named "Montado" in Portugal and "Dehesa" in Spain) supports a wide diversity of plant and animal species (Diaz et al., 1997). The appropriate management of such system benefits both farmland and forest bird species (Godinho & Rabaça, 2011; Leal et al., 2011), as well as plant and invertebrate diversity (Bugalho et al., 2011a; Bugalho et al., 2011b).

This review highlights the fact that the pressures on Mediterranean agroecosystems due to environmental changes may accelerate changes toward agroecology (already required to counter soil erosion, pollution, and biodiversity loss), bringing together enhanced sustainability and biodiversity in a positive feedback loop. In a nutshell, the best configuration for biodiversity is a mosaic landscape composed of open and woody patches (Gabay et al., 2008).

in order to complement the adaptive capacity expected from a progressive shift toward agroecological management, work to improve the selection of cultivars better adapted to the Mediterranean climate is ongoing (e.g. for drought tolerance (Cattivelli et al., 2008)). Anticipating future droughts, Habash et al. (2009) discuss the potential of designing a climate

change ready durum wheat through genomic approaches. Plant breeders must consider strategies to retain diversity from wheat landraces (Lopes et al., 2015), especially Mediterranean durum landraces, which represent a particularly important group of genetic resources because of their extensive genetic variability, and their documented tolerance to drought (Kyzeridis et al., 1995), resilience to pests, resistance to diseases (Talas et al., 2011), and adaptability to low-input farming systems (see Chapter 6 by Srivastava and Damania in Brown et al. (1989)). Not only the quantitative production is looked at, but also its quality. In order to avoid grapevine ripening during very hot days, (Costantini et al., 2008) show that breeding new late-ripening varieties is a way to increase the existing genetic variability and to adapt the grapevine phenology to environmental changes.

3. OVERVIEW

Table S2: characteristics of the different Mediterranean ecosystems examined and overall expectation according to authors' opinion as to their adaptive potential under changing environmental conditions. Cells in grey include a high level of uncertainty.

MEDITERRANEAN ECOSYSTEMS / **ADAPTIVE MECHANISMS**

NAME	ECOLOGICAL DIVERSITY	ACCLIMATIZATION	GENETIC ADAPTATION	RANGE SHIFT	COMMUNITY COMPOSITION MODIFICATIONS	MANAGEMENT	OVERALL ADAPTATIVE POTENTIAL
MARINE ECOSYSTEMS							
Plankton (phyto and zoo)	Coastal and oceanic	Medium to High	High	High	High	Low	High
Seagrass meadows (Posidonia oceanica)	Coastal (depth gradient 1-40m)	High	Low	Medium to High	High	Low	Medium / High
Coralligenous ecosystems and marine animal forests	Mostly coastal (depth gradient. C. rubrum : 10 - 1000 m Corallinaceae: 20-120 m)	Low to Medium	Low	Low	Low	Medium	Low / Medium
LAND ECOSYSTEMS							
Microbial soil communities of pine and oak forests	Similar to thermophilic oak-pine forests	High	High	High	High	Medium	High
Semi arid and arid steppes	High (altitude from sea level up to 3500 meters)	Data deficient	Data deficient	Low	Low	High	Unclear
Thermophilic oak-pine forests	High (altitude from sea level up to 2000 meters)	High	Medium (oaks) Low (pines)	High	Medium	High	High
Beech-fir forests	High (altitude from 800 up to 2200 meters)	Medium	Medium	Low	High	High	Medium
Agrosystems	High (altitude from sea level up to 2000 meters)	Low	High	High	High	High	Medium

BIBLIOGRAPHY

Adloff, F., Somot, S., Sevault, F., Jordà, G., Aznar, R., Déqué, M., Herrmann, M., Marcos, M., Dubois, C., Padorno, E., Alvarez-Fanjul, E., & Gomis, D. (2015). Mediterranean Sea response to climate change in an ensemble of twenty first century scenarios. *Climate Dynamics*, *45*(9), 2775–2802. https://doi.org/10.1007/s00382-015-2507-3

Agustí, S., Regaudie-de-Gioux, A., Arrieta, J. M., & Duarte, C. M. (2014). Consequences of UV-enhanced community respiration for plankton metabolic balance. *Limnology and Oceanography*, *59*(1), 223–232.

Albouy, C., Leprieur, F., Loc'h, F. L., Mouquet, N., Meynard, C. N., Douzery, E. J. P., & Mouillot, D. (2015). Projected impacts of climate warming on the functional and phylogenetic components of coastal Mediterranean fish biodiversity. *Ecography*, *38*(7), 681–689. https://doi.org/10.1111/ecog.01254

Andersen, V., Gubanova, A., Nival, P., & Ruellet, T. (2001). Zooplankton Community During the Transition from Spring Bloom to Oligotrophy in the Open NW Mediterranean and Effects of Wind Events. 2. Vertical Distributions and Migrations. *Journal of Plankton Research*, *23*(3), 243–261. https://doi.org/10.1093/plankt/23.3.243

Arnaud-Haond, S., Migliaccio, M., Diaz-Almela, E., Teixeira, S., Vliet, M. S. V. D., Alberto, F., Procaccini, G., Duarte, C. M., & Serrão, E. A. (2007). Vicariance patterns in the Mediterranean Sea: east–west cleavage and low dispersal in the endemic seagrass Posidonia oceanica. *Journal of Biogeography*, *34*(6), 963–976. https://doi.org/10.1111/j.1365-2699.2006.01671.x

Aurelle, D., Tariel, J., Zuberer, F. Haguenauer A., Ribout C., Masmoudi M., Kara H., Chaoui L., Garrabou J., Ledoux J.-B., Gambi M. C. (2020) Genetic insights into recolonization processes of Mediterranean octocorals. *Marine Biology*, *167*, 73. https://doi.org/10.1007/s00227-020-03684-z

Awad, L., Fady, B., Khater, C., Roig, A., & Cheddadi, R. (2014). Genetic Structure and Diversity of the Endangered Fir Tree of Lebanon (Abies cilicica Carr.): Implications for Conservation. *PLoS ONE*, *9*(2). https://doi.org/10.1371/journal.pone.0090086

Bagella, S., Caria, M. C., Farris, E., Rossetti, I., & Filigheddu, R. (2016). Traditional land uses enhanced plant biodiversity in a Mediterranean agro-silvo-pastoral system. *Plant Biosystems - An International Journal Dealing with All Aspects of Plant Biology*, *150*(2), 201–207. https://doi.org/10.1080/11263504.2014.943319

Balata, D., Piazzi, L., Cecchi, E., & Cinelli, F. (2005). Variability of Mediterranean coralligenous assemblages subject to local variation in sediment deposition. *Marine Environmental Research*, *60*(4), 403–421. https://doi.org/10.1016/j.marenvres.2004.12.005

Balata, D., Piazzi, L., & Cinelli, F. (2007). Increase of sedimentation in a subtidal system: Effects on the structure and diversity of macroalgal assemblages. *Journal of Experimental Marine Biology and Ecology*, *351*(1), 73–82. https://doi.org/10.1016/j.jembe.2007.06.019

Ballesteros, E. (2006). Mediterranean coralligenous assemblages: A synthesis of present knowledge. In R. N. Gibson, R. J. A. Atkinson, & J. D. M. Gordon (Eds.), *Oceanography and Marine Biology - an Annual Review, Vol 44* (Vol. 44, pp. 123-+).

Ballesteros, E., Garrabou, J., Hereu, B., Zabala, M., Cebrian, E., & Sala, E. (2009). Deep-water stands of Cystoseira zosteroides C. Agardh (Fucales, Ochrophyta) in the Northwestern Mediterranean: Insights into assemblage structure and population dynamics. *Estuarine, Coastal and Shelf Science*, *82*(3), 477–484. https://doi.org/10.1016/j.ecss.2009.02.013

Baquedano, F. J., Valladares, F., & Castillo, F. J. (2008). Phenotypic plasticity blurs ecotypic divergence in the response of Quercus coccifera and Pinus halepensis to water stress. *European Journal of Forest Research*, *127*(6), 495–506. https://doi.org/10.1007/s10342-008-0232-8

Bardgett, R. D., Freeman, C., & Ostle, N. J. (2008). Microbial contributions to climate change through carbon cycle feedbacks. *The ISME Journal*, *2*(8), 805–814. https://doi.org/10.1038/ismej.2008.58

Bay, R. A., Rose, N. H., Logan, C. A., & Palumbi, S. R. (2017). Genomic models predict successful coral adaptation if future ocean warming rates are reduced. *Science Advances*, *3*(11), e1701413. https://doi.org/10.1126/sciadv.1701413

Bayer, T., Arif, C., Ferrier-Pagès, C., Zoccola, D., Aranda, M., & Voolstra, C. R. (2013). Bacteria of the genus Endozoicomonas dominate the microbiome of the Mediterranean gorgonian coral Eunicella cavolini. *Marine Ecology Progress Series*, *479*, 75–84. https://doi.org/10.3354/meps10197

Beaugrand, G., Reid, P. C., Ibañez, F., Lindley, J. A., & Edwards, M. (2002). Reorganization of North Atlantic Marine Copepod Biodiversity and Climate. *Science*, *296*(5573), 1692–1694. https://doi.org/10.1126/science.1071329

Behrenfeld, M. J., O'Malley, R. T., Boss, E. S., Westberry, T. K., Graff, J. R., Halsey, K. H., Milligan, A. J., Siegel, D. A., & Brown, M. B. (2016). Revaluating ocean warming impacts on global phytoplankton. *Nature Climate Change*, *6*(3), 323–330. https://doi.org/10.1038/nclimate2838

Behrenfeld, M. J., O'Malley, R. T., Siegel, D. A., McClain, C. R., Sarmiento, J. L., Feldman, G. C., Milligan, A. J., Falkowski, P. G., Letelier, R. M., & Boss, E. S. (2006). Climate-driven trends in contemporary ocean productivity. *Nature*, *444*(7120), 752–755. https://doi.org/10.1038/nature05317

Belzile, C., Demers, S., Ferreyra, G. A., Schloss, I., Nozais, C., Lacoste, K., Mostajir, B., Roy, S., Gosselin, M., Pelletier, E., Gianesella, S. M. F., & Vernet, M. (2006). UV Effects on Marine Planktonic Food Webs: A Synthesis of Results from Mesocosm Studies. *Photochemistry and Photobiology*, *82*(4), 850–856. https://doi.org/10.1562/2005-09-27-RA-699

Benedetti, F., Guilhaumon, F., Adloff, F., & Ayata, S.-D. (2018). Investigating uncertainties in zooplankton composition shifts under climate change scenarios in the Mediterranean Sea. *Ecography*, *41*(2), 345–360. https://doi.org/10.1111/ecog.02434

Berger, T. W., Türtscher, S., Berger, P., & Lindebner, L. (2016). A slight recovery of soils from Acid Rain over the last three decades is not reflected in the macro nutrition of beech (Fagus sylvatica) at 97 forest stands of the Vienna Woods. *Environmental Pollution*, *216*, 624–635. https://doi.org/10.1016/j.envpol.2016.06.024

Berline, L., Siokou-Frangou, I., Marasović, I., Vidjak, O., Fernández de Puelles, M. L., Mazzocchi, M. G., Assimakopoulou, G., Zervoudaki, S., Fonda-Umani, S., Conversi, A., Garcia-Comas, C., Ibanez, F., Gasparini, S., Stemmann, L., & Gorsky, G. (2012). Intercomparison of six Mediterranean zooplankton time series. *Progress in Oceanography*, *97–100*, 76–91. https://doi.org/10.1016/j.pocean.2011.11.011

Bianchi, C. N., & Morri, C. (2000). Marine Biodiversity of the Mediterranean Sea: Situation, Problems and Prospects for Future Research. *Marine Pollution Bulletin*, *40*(5), 367–376. https://doi.org/10.1016/S0025-326X(00)00027-8

Blanfuné, A., Boudouresque, C. F., Verlaque, M., & Thibaut, T. (2019). The ups and downs of a canopy-forming seaweed over a span of more than one century. *Scientific Reports*, *9*(1), 5250. https://doi.org/10.1038/s41598-019-41676-2

Blondel, J. (2006). The 'Design' of Mediterranean Landscapes: A Millennial Story of Humans and Ecological Systems during the Historic Period. *Human Ecology*, *34*(5), 713–729. https://doi.org/10.1007/s10745-006-9030-4

Blondel, J., & Aronson, J. (1999). *Biology and Wildlife of the Mediterranean Region*. Oxford University Press.

Bongaerts, P., Riginos, C., Brunner, R., Englebert, N., Smith, S. R., & Hoegh-Guldberg, O. (2017). Deep reefs are not universal refuges: Reseeding potential varies among coral species. *Science Advances*, *3*(2), e1602373. https://doi.org/10.1126/sciadv.1602373

Bonnet, D., Richardson, A., Harris, R., Hirst, A., Beaugrand, G., Edwards, M., Ceballos, S., Diekman, R., López-Urrutia, A., Valdes, L., Carlotti, F., Molinero, J. C., Weikert, H., Greve, W., Lucic, D., Albaina, A., Yahia, N. D., Umani, S. F., Miranda, A., … Fernandez de Puelles, M. L. (2005). An overview of Calanus helgolandicus ecology in European waters. *Progress in Oceanography*, *65*(1), 1–53. https://doi.org/10.1016/j.pocean.2005.02.002

Bouamri, R., Dalpé, Y., Serrhini, M. N., & Bennani, A. (2006). Arbuscular mycorrhizal fungi species associated with rhizosphere of Phoenix dactylifera L. in Morocco. *African Journal of Biotechnology*, *5*(6), 510-516–516.

Boudouresque, C. F., Bernard, G., Pergent, G., Shili, A., & Verlaque, M. (2009). Regression of Mediterranean seagrasses caused by natural processes and anthropogenic disturbances and stress: a critical review. *Botanica Marina*, *52*(5), 395–418. https://doi.org/10.1515/BOT.2009.057

Boudouresque, C. F., Blanfuné, A., Harmelin-Vivien, M., Personnic, S., Ruitton, S., Thibaut, T., & Verlaque, M. (2017b). Where Seaweed Forests Meet Animal Forests: The Examples of Macroalgae in Coral Reefs and the Mediterranean Coralligenous Ecosystem. In S. Rossi, L. Bramanti, A. Gori, & C. Orejas (Eds.), *Marine Animal Forests: The Ecology of Benthic Biodiversity Hotspots* (pp. 369–396). Springer International Publishing. https://doi.org/10.1007/978-3-319-21012-4_48

Boudouresque, C. F., Pergent, G., Pergent-Martini, C., Ruitton, S., Thibaut, T., & Verlaque, M. (2016). The necromass of the Posidonia oceanica seagrass meadow: fate, role, ecosystem services and vulnerability. *Hydrobiologia*, *781*(1), 25–42. https://doi.org/10.1007/s10750-015-2333-y

Boudouresque, C.-F., Bernard, G., Bonhomme, P., Charbonnel, E., Diviacco, G., Meinesz, A., Pergent, G., Pergent-Martini, C., Ruitton, S., & Tunesi, L. (2012). *Protection and conservation of Posidonia oceanica meadows*. RAMOGE and RAC/SPA. https://hal.archives-ouvertes.fr/hal-00808491

Boudouresque, C.-F., BLANFUNÉ, A., Fernandez, C., Lejeusne, C., Pérez, T., RUITTON, S., Thibault, D., THIBAUT, T., & VERLAQUE, M. (2017a). Marine Biodiversity - Warming vs. Biological Invasions and overfishing in the Mediterranean Sea: Take care, 'One Train can hide another'. *MOJ Ecology & Environmental Science*, *2*(4), 1–13. https://doi.org/10.15406/mojes.2017.02.00031

Boyce, D. G., Lewis, M. R., & Worm, B. (2010). Global phytoplankton decline over the past century. *Nature*, *466*(7306), 591–596. https://doi.org/10.1038/nature09268

Bramanti, L., Movilla, J., Guron, M., Calvo, E., Gori, A., Dominguez-Carrió, C., Grinyó, J., Lopez-Sanz, A., Martinez-Quintana, A., Pelejero, C., Ziveri, P., & Rossi, S. (2013). Detrimental effects of ocean acidification on the economically important Mediterranean red coral (Corallium rubrum). *Global Change Biology*, *19*(6), 1897–1908. https://doi.org/10.1111/gcb.12171

Breitburg, D., Levin, L. A., Oschlies, A., Grégoire, M., Chavez, F. P., Conley, D. J., Garçon, V., Gilbert, D., Gutiérrez, D., Isensee, K., Jacinto, G. S., Limburg, K. E., Montes, I., Naqvi, S. W. A., Pitcher, G. C., Rabalais, N. N., Roman, M. R., Rose, K. A., Seibel, B. A., … Zhang, J. (2018). Declining oxygen in the global ocean and coastal waters. *Science*, *359*(6371), eaam7240. https://doi.org/10.1126/science.aam7240

Brierley, A. S. (2017). Plankton. *Current Biology*, *27*(11), R478–R483. https://doi.org/10.1016/j.cub.2017.02.045

Bron, J. E., Frisch, D., Goetze, E., Johnson, S. C., Lee, C. E., & Wyngaard, G. A. (2011). Observing copepods through a genomic lens. *Frontiers in Zoology*, *8*(1), 22. https://doi.org/10.1186/1742-9994-8-22

Brotons, L., Thuiller, W., Araújo, M. B., & Hirzel, A. H. (2004). Presence-absence versus presence-only modelling methods for predicting bird habitat suitability. *Ecography*, *27*(4), 437–448. https://doi.org/10.1111/j.0906-7590.2004.03764.x

Brousseau, L., Postolache, D., Lascoux, M., Drouzas, A. D., Källman, T., Leonarduzzi, C., Liepelt, S., Piotti, A., Popescu, F., Roschanski, A. M., Zhelev, P., Fady, B., & Vendramin, G. G. (2016). Local Adaptation in European Firs Assessed through Extensive Sampling across Altitudinal Gradients in Southern Europe. *PLOS ONE*, *11*(7), e0158216. https://doi.org/10.1371/journal.pone.0158216

Brown, A. H. D., Frankel, O. H., Marshall, D. R., & Williams, J. T. (1989). *The Use of Plant Genetic Resources*. Cambridge University Press.

Brugnano, C., Granata, A., Guglielmo, L., & Zagami, G. (2012). Spring diel vertical distribution of copepod abundances and diversity in the open Central Tyrrhenian Sea (Western Mediterranean). *Journal of Marine Systems*, *105–108*, 207–220. https://doi.org/10.1016/j.jmarsys.2012.08.009

Brunel, C., Gros, R., Ziarelli, F., & Farnet Da Silva, A. M. (2017). Additive or non-additive effect of mixing oak in pine stands on soil properties depends on the tree species in Mediterranean forests. *Science of The Total Environment*, *590–591*, 676–685. https://doi.org/10.1016/j.scitotenv.2017.03.023

Buée, M., Reich, M., Murat, C., Morin, E., Nilsson, R. H., Uroz, S., & Martin, F. (2009). 454 Pyrosequencing analyses of forest soils reveal an unexpectedly high fungal diversity. *New Phytologist*, *184*(2), 449–456. https://doi.org/10.1111/j.1469-8137.2009.03003.x

Bugalho, M. N., Caldeira, M. C., Pereira, J. S., Aronson, J., & Pausas, J. G. (2011a). Mediterranean cork oak savannas require human use to sustain biodiversity and ecosystem services. *Frontiers in Ecology and the Environment*, *9*(5), 278–286. https://doi.org/10.1890/100084

Bugalho, M. N., Lecomte, X., Gonçalves, M., Caldeira, M. C., & Branco, M. (2011b). Establishing grazing and grazing-excluded patches increases plant and invertebrate diversity in a Mediterranean oak woodland. *Forest Ecology and Management*, *261*(11), 2133–2139. https://doi.org/10.1016/j.foreco.2011.03.009

Buisson, E., & Dutoit, T. (2006). Creation of the natural reserve of La Crau: Implications for the creation and management of protected areas. *Journal of Environmental Management*, *80*(4), 318–326. https://doi.org/10.1016/j.jenvman.2005.09.013

Butterly, C. R., Bünemann, E. K., McNeill, A. M., Baldock, J. A., & Marschner, P. (2009). Carbon pulses but not phosphorus pulses are related to decreases in microbial biomass during repeated drying and rewetting of soils. *Soil Biology and Biochemistry*, *41*(7), 1406–1416. https://doi.org/10.1016/j.soilbio.2009.03.018

Cahill, A. E., De Jode, A., Dubois, S., Bouzaza, Z., Aurelle, D., Boissin, E., Chabrol, O., David, R., Egea, E., Ledoux, J.-B., Mérigot, B., Weber, A. A.-T., & Chenuil, A. (2017). A multispecies approach reveals hot spots and cold spots of diversity and connectivity in invertebrate species with contrasting dispersal modes. *Molecular Ecology*, *26*(23), 6563–6577. https://doi.org/10.1111/mec.14389

Cailleret, M., Nourtier, M., Amm, A., Durand-Gillmann, M., & Davi, H. (2014). Drought-induced decline and mortality of silver fir differ among three sites in Southern France. *Annals of Forest Science*, *71*(6), 643–657. https://doi.org/10.1007/s13595-013-0265-0

Camarero, J. J., Gazol, A., Sangüesa-Barreda, G., Oliva, J., & Vicente-Serrano, S. M. (2015). To die or not to die: early warnings of tree dieback in response to a severe drought. *Journal of Ecology*, *103*(1), 44–57. https://doi.org/10.1111/1365-2745.12295

Canali, S., Campanelli, G., Ciaccia, C., Leteo, F., Testani, E., & Montemurro, F. (2013). Conservation tillage strategy based on the roller crimper technology for weed control in Mediterranean vegetable organic cropping systems. *European Journal of Agronomy*, *50*, 11–18. https://doi.org/10.1016/j.eja.2013.05.001

Cánovas-Molina, A., Montefalcone, M., Bavestrello, G., Masmoudi, M. B., Haguenauer, A., Hammami, P., Chaoui, L., Kara, M. H., & Aurelle, D. (2018). From depth to regional spatial genetic differentiation of Eunicella cavolini in the NW Mediterranean. *Comptes Rendus Biologies*, *341*(9), 421–432. https://doi.org/10.1016/j.crvi.2018.09.002

Capet, A., Stanev, E., Beckers, J.-M., Murray, J., & Grégoire, M. (2016). Decline of the Black Sea oxygen inventory. *Biogeosciences*, *13*, 1287–1297.

Cardinael, R., Mao, Z., Prieto, I., Stokes, A., Dupraz, C., Kim, J. H., & Jourdan, C. (2015). Competition with winter crops induces deeper rooting of walnut trees in a Mediterranean alley cropping agroforestry system. *Plant and Soil*, *391*(1), 219–235. https://doi.org/10.1007/s11104-015-2422-8

Carlotti, F. (2019). *Plankton: Population Dynamics Models, 2019. In Cochran, J. Kirk; Bokuniewicz, J. Henry; Yager, L. Patricia (eds.) Encyclopedia of Ocean Sciences, 3rd Edition, vol.[5], pp. 571-582. Oxford: Elsevier.* (Cochran, J. Kirk; Bokuniewicz, J. Henry; Yager, L. Patricia). https://copepodes.obs-banyuls.fr/en/

Carlotti, F., & Poggiale, J. C. (2010). Towards methodological approaches to implement the zooplankton component in "end to end" food-web models. *Progress in Oceanography*, *84*(1), 20–38. https://doi.org/10.1016/j.pocean.2009.09.003

Carlotti, Francois, & Nival, S. (1991). Individual variability of development in laboratory-reared Temora stylifera copepodites: consequences for the population dynamics and interpretation in the scope of growth and development rules. *Journal of Plankton Research*, *13*(4), 801–813. https://doi.org/10.1093/plankt/13.4.801

Cattivelli, L., Rizza, F., Badeck, F.-W., Mazzucotelli, E., Mastrangelo, A. M., Francia, E., Marè, C., Tondelli, A., & Stanca, A. M. (2008). Drought tolerance improvement in crop plants: An integrated view from breeding to genomics. *Field Crops Research*, *105*(1), 1–14. https://doi.org/10.1016/j.fcr.2007.07.004

Cavin, L., & Jump, A. S. (2017). Highest drought sensitivity and lowest resistance to growth suppression are found in the range core of the tree Fagus sylvatica L. not the equatorial range edge. *Global Change Biology*, *23*(1), 362–379. https://doi.org/10.1111/gcb.13366

Chambel, M. R., Climent, J., & Alía, R. (2007). Divergence among species and populations of Mediterranean pines in biomass allocation of seedlings grown under two watering regimes. *Annals of Forest Science*, *64*(1), 87–97. https://doi.org/10.1051/forest:2006092

Chamorro, L., Masalles, R. M., & Sans, F. X. (2016). Arable weed decline in Northeast Spain: Does organic farming recover functional biodiversity? *Agriculture, Ecosystems & Environment*, *223*, 1–9. https://doi.org/10.1016/j.agee.2015.11.027

Chapman, S. K., & Newman, G. S. (2010). Biodiversity at the plant–soil interface: microbial abundance and community structure respond to litter mixing. *Oecologia*, *162*(3), 763–769. https://doi.org/10.1007/s00442-009-1498-3

Cheddadi, R., Guiot, J., & Jolly, D. (2001). The Mediterranean vegetation: what if the atmospheric CO2 increased? *Landscape Ecology*, *16*(7), 667–675. https://doi.org/10.1023/A:1013149831734

Chefaoui, R. M., Duarte, C. M., & Serrão, E. A. (2018). Dramatic loss of seagrass habitat under projected climate change in the Mediterranean Sea. *Global Change Biology*, *24*(10), 4919–4928. https://doi.org/10.1111/gcb.14401

Chomel, M., Guittonny-Larchevêque, M., Fernandez, C., Gallet, C., DesRochers, A., Paré, D., Jackson, B. G., & Baldy, V. (2016). Plant secondary metabolites: a key driver of litter decomposition and soil nutrient cycling. *Journal of Ecology*, *104*(6), 1527–1541. https://doi.org/10.1111/1365-2745.12644

Choquet, M., Kosobokova, K., Kwaśniewski, S., Hatlebakk, M., Dhanasiri, A. K. S., Melle, W., Daase, M., Svensen, C., Søreide, J. E., & Hoarau, G. (2018). Can morphology reliably distinguish between the copepods Calanus finmarchicus and C. glacialis, or is DNA the only way? *Limnology and Oceanography: Methods*, *16*(4), 237–252. https://doi.org/10.1002/lom3.10240

Choquet Marvin, Hatlebakk Maja, Dhanasiri Anusha K. S., Kosobokova Ksenia, Smolina Irina, Søreide Janne E., Svensen Camilla, Melle Webjørn, Kwaśniewski Sławomir, Eiane Ketil, Daase Malin, Tverberg Vigdis, Skreslet Stig, Bucklin Ann, & Hoarau Galice. (2017). Genetics redraws pelagic biogeography of Calanus. *Biology Letters*, *13*(12), 20170588. https://doi.org/10.1098/rsbl.2017.0588

Cleveland, C. C., Townsend, A. R., Constance, B. C., Ley, R. E., & Schmidt, S. K. (2004). Soil Microbial Dynamics in Costa Rica: Seasonal and Biogeochemical Constraints. *Biotropica*, *36*(2), 184–195. https://doi.org/10.1111/j.1744-7429.2004.tb00311.x

Colin, S. P., & Dam, H. G. (2007). Comparison of the functional and numerical responses of resistant versus non-resistant populations of the copepod Acartia hudsonica fed the toxic dinoflagellate Alexandrium tamarense. *Harmful Algae*, *6*(6), 875–882. https://doi.org/10.1016/j.hal.2007.05.003

Coma, R., Pola, E., Ribes, M., & Zabala, M. (2004). Long-Term Assessment of Temperate Octocoral Mortality Patterns, Protected Vs. Unprotected Areas. *Ecological Applications*, *14*(5), 1466–1478. https://doi.org/10.1890/03-5176

Coma, R., & Ribes, M. (2003). Seasonal energetic constraints in Mediterranean benthic suspension feeders: effects at different levels of ecological organization. *Oikos*, *101*(1), 205–215. https://doi.org/10.1034/j.1600-0706.2003.12028.x

Conord, C., Gurevitch, J., & Fady, B. (2012). Large-scale longitudinal gradients of genetic diversity: a meta-analysis across six phyla in the Mediterranean basin. *Ecology and Evolution*, *2*(10), 2600–2614. https://doi.org/10.1002/ece3.350

Conversi, A., Umani, S. F., Peluso, T., Molinero, J. C., Santojanni, A., & Edwards, M. (2010). The Mediterranean Sea Regime Shift at the End of the 1980s, and Intriguing Parallelisms with Other European Basins. *PLOS ONE*, *5*(5), e10633. https://doi.org/10.1371/journal.pone.0010633

Cornwell, W. K., Cornelissen, J. H. C., Amatangelo, K., Dorrepaal, E., Eviner, V. T., Godoy, O., Hobbie, S. E., Hoorens, B., Kurokawa, H., Pérez-Harguindeguy, N., Quested, H. M., Santiago, L. S., Wardle, D. A., Wright, I. J., Aerts, R., Allison, S. D., Bodegom, P. V., Brovkin, V., Chatain, A., … Westoby, M. (2008). Plant species traits are the predominant control on litter decomposition rates within biomes worldwide. *Ecology Letters*, *11*(10), 1065–1071. https://doi.org/10.1111/j.1461-0248.2008.01219.x

Costantini, F., Ferrario, F., & Abbiati, M. (2018). Chasing genetic structure in coralligenous reef invertebrates: patterns, criticalities and conservation issues. *Scientific Reports*, *8*(1), 5844. https://doi.org/10.1038/s41598-018-24247-9

Costantini, F., Rossi, S., Pintus, E., Cerrano, C., Gili, J.-M., & Abbiati, M. (2011). Low connectivity and declining genetic variability along a depth gradient in Corallium rubrum populations. *Coral Reefs*, *30*(4), 991–1003.

Costantini, L., Battilana, J., Lamaj, F., Fanizza, G., & Grando, M. S. (2008). Berry and phenology-related traits in grapevine (Vitis viniferaL.): From Quantitative Trait Loci to underlying genes. *BMC Plant Biology*, *8*(1), 38. https://doi.org/10.1186/1471-2229-8-38

Costanza, R., de Groot, R., Sutton, P., van der Ploeg, S., Anderson, S. J., Kubiszewski, I., Farber, S., & Turner, R. K. (2014). Changes in the global value of ecosystem services. *Global Environmental Change*, *26*, 152–158. https://doi.org/10.1016/j.gloenvcha.2014.04.002

Covas, R., & Blondel, J. (1998). Biogeography and history of the Mediterranean bird fauna. *Ibis*, *140*(3), 395–407. https://doi.org/10.1111/j.1474-919X.1998.tb04600.x

Cox, T. E., Gazeau, F., Alliouane, S., Hendriks, I., Mahacek, P., Fur, A. L., & Gattuso, J.-P. (2016). Effects of in situ CO_2 enrichment on structural characteristics, photosynthesis, and growth of the Mediterranean seagrass *Posidonia oceanica*. *Biogeosciences*, *13*, 2179–2194. https://doi.org/10.5194/bg-13-2179-2016

Cox, T. E., Schenone, S., Delille, J., Díaz-Castañeda, V., Alliouane, S., Gattuso, J.-P., & Gazeau, F. (2015). Effects of ocean acidification on Posidonia oceanica epiphytic community and shoot productivity. *Journal of Ecology*, *103*(6), 1594–1609. https://doi.org/10.1111/1365-2745.12477

Crisci, C., Ledoux, J.-B., Jamaï, K. M.-, Bally, M., Bensoussan, N., Aurelle, D., Cebrian, E., Coma, R., Féral, J.-P., Rivière, M. L., Linares, C., López-Sendino, P., Marschal, C., Ribes, M., Teixidó, N., Zuberer, F., & Garrabou, J. (2017). Regional and local environmental conditions do not shape the response to warming of a marine habitat-forming species. *Scientific Reports*, *7*(1), 5069. https://doi.org/10.1038/s41598-017-05220-4

Crisci, Carolina, Bensoussan, N., Romano, J.-C., & Garrabou, J. (2011). Temperature Anomalies and Mortality Events in Marine Communities: Insights on Factors behind Differential Mortality Impacts in the NW Mediterranean. *PLOS ONE*, *6*(9), e23814. https://doi.org/10.1371/journal.pone.0023814

Crombet, Y., Leblanc, K., Queguiner, B., Moutin, T., Rimmelin, P., Ras, J., Claustre, H., Leblond, N., Oriol, L., & Pujo-Pay, M. (2011). Deep silicon maxima in the stratified oligotrophic Mediterranean Sea. *Biogeosciences*, *8*, 459–475. https://doi.org/10.5194/bg-8-459-2011

Cuchietti, A., Marcotti, E., Gurvich, D. E., Cingolani, A. M., & Pérez Harguindeguy, N. (2014). Leaf litter mixtures and neighbour effects: Low-nitrogen and high-lignin species increase decomposition rate of high-nitrogen and low-lignin neighbours. *Applied Soil Ecology*, *82*, 44–51. https://doi.org/10.1016/j.apsoil.2014.05.004

Dam, H. G. (2013). Evolutionary Adaptation of Marine Zooplankton to Global Change. *Annual Review of Marine Science*, *5*(1), 349–370. https://doi.org/10.1146/annurev-marine-121211-172229

David-Schwartz, R., Paudel, I., Mizrachi, M., Delzon, S., Cochard, H., Lukyanov, V., Badel, E., Capdeville, G., Shklar, G., & Cohen, S. (2016). Indirect Evidence for Genetic Differentiation in Vulnerability to Embolism in Pinus halepensis. *Frontiers in Plant Science*, *7*. https://doi.org/10.3389/fpls.2016.00768

De Jode, A., David, R., Haguenauer, A., Cahill, A. E., Erga, Z., Guillemain, D., Sartoretto, S., Rocher, C., Selva, M., & Le Gall, L. (2019). From seascape ecology to population genomics and back. Spatial and ecological differentiation among cryptic species of the red algae Lithophyllum stictiforme/L. cabiochiae, main bioconstructors of coralligenous habitats. *Molecular Phylogenetics and Evolution*.

de Rigo, D., & Caudullo, G. (2016). *Quercus ilex in Europe: distribution, habitat, usage and threats*. 3.

de Ville d'Avray, L. T., Ami, D., Chenuil, A., David, R., & Féral, J.-P. (2019a). Application of the ecosystem service concept at a small-scale: The cases of coralligenous habitats in the North-western Mediterranean Sea. *Marine Pollution Bulletin*, *138*, 160–170.

de Ville d'Avray, L. T., Ami, D., Chenuil, A., David, R., & Féral, J.-P. (2019b). Application of the ecosystem service concept at a small-scale: The cases of coralligenous habitats in the North-western

Mediterranean Sea. *Marine Pollution Bulletin*, *138*, 160–170. https://doi.org/10.1016/j.marpolbul.2018.10.057

DeAngelis, D. L., Ni, W.-M., & Zhang, B. (2016). Effects of diffusion on total biomass in heterogeneous continuous and discrete-patch systems. *Theoretical Ecology*, *9*(4), 443–453. https://doi.org/10.1007/s12080-016-0302-3

Dedieu, K., Rabouille, C., Gilbert, F., Soetaert, K., Metzger, E., Simonucci, C., Jézéquel, D., Prévot, F., Anschutz, P., Hulth, S., Ogier, S., & Mesnage, V. (2007). Coupling of carbon, nitrogen and oxygen cycles in sediments from a Mediterranean lagoon: a seasonal perspective. *Marine Ecology Progress Series*, *346*, 45–59. https://doi.org/10.3354/meps07031

del Río, M., Rodríguez-Alonso, J., Bravo-Oviedo, A., Ruíz-Peinado, R., Cañellas, I., & Gutiérrez, E. (2014). Aleppo pine vulnerability to climate stress is independent of site productivity of forest stands in southeastern Spain. *Trees*, *28*(4), 1209–1224. https://doi.org/10.1007/s00468-014-1031-0

Dhôte, J.-F. (2005). Implication of Forest Diversity in Resistance to Strong Winds. In M. Scherer-Lorenzen, C. Körner, & E.-D. Schulze (Eds.), *Forest Diversity and Function: Temperate and Boreal Systems* (pp. 291–307). Springer Berlin Heidelberg. https://doi.org/10.1007/3-540-26599-6_14

di Carlo, B. S., Ianora, A., Fresi, E., & Hure, J. (1984). Vertical zonation patterns for Mediterranean copepods from the surface to 3000 m at a fixed station in the Tyrrhenian Sea. *Journal of Plankton Research*, *6*(6), 1031–1056. https://doi.org/10.1093/plankt/6.6.1031

Diaz, M., Campos, P., & Pulido, F. J. (1997). The Spanish dehesas: a diversity in land-use and wildlife. *Farming and Birds in Europe*, *178*, 178–209.

Diaz, R. J., & Rosenberg, R. (2008). Spreading Dead Zones and Consequences for Marine Ecosystems. *Science*, *321*(5891), 926–929. https://doi.org/10.1126/science.1156401

Diaz-Almela, E., Marbà, N., Álvarez, E., Balestri, E., Ruiz-Fernández, J. M., & Duarte, C. M. (2006). Patterns of seagrass (Posidonia oceanica) flowering in the Western Mediterranean. *Marine Biology*, *148*(4), 723–742. https://doi.org/10.1007/s00227-005-0127-x

Djaoudi, K., Van Wambeke, F., Barani, A., Hélias-Nunige, S., Sempéré, R., & Pulido-Villena, E. (2018). Atmospheric fluxes of soluble organic C, N, and P to the Mediterranean Sea: Potential biogeochemical implications in the surface layer. *Progress in Oceanography*, *163*, 59–69. https://doi.org/10.1016/j.pocean.2017.07.008

Doblas-Miranda, E., Alonso, R., Arnan, X., Bermejo, V., Brotons, L., de las Heras, J., Estiarte, M., Hódar, J. A., Llorens, P., Lloret, F., López-Serrano, F. R., Martínez-Vilalta, J., Moya, D., Peñuelas, J., Pino, J., Rodrigo, A., Roura-Pascual, N., Valladares, F., Vilà, M., … Retana, J. (2017). A review of the combination among global change factors in forests, shrublands and pastures of the Mediterranean Region: Beyond drought effects. *Global and Planetary Change*, *148*, 42–54. https://doi.org/10.1016/j.gloplacha.2016.11.012

Doney, S. C. (2013). Chapter 31 - Marine Ecosystems, Biogeochemistry, and Climate. In G. Siedler, S. M. Griffies, J. Gould, & J. A. Church (Eds.), *International Geophysics* (Vol. 103, pp. 817–842). Academic Press. https://doi.org/10.1016/B978-0-12-391851-2.00031-3

Dorman, M., Svoray, T., Perevolotsky, A., & Sarris, D. (2013). Forest performance during two consecutive drought periods: Diverging long-term trends and short-term responses along a climatic gradient. *Forest Ecology and Management*, *310*, 1–9. https://doi.org/10.1016/j.foreco.2013.08.009

Durrieu de Madron, X., Guieu, C., Sempéré, R., Conan, P., Cossa, D., D'Ortenzio, F., Estournel, C., Gazeau, F., Rabouille, C., Stemmann, L., Bonnet, S., Diaz, F., Koubbi, P., Radakovitch, O., Babin, M., Baklouti, M., Bancon-Montigny, C., Belviso, S., Bensoussan, N., … Verney, R. (2011). Marine ecosystems' responses to climatic and anthropogenic forcings in the Mediterranean. *Progress in Oceanography*, *91*(2), 97–166. https://doi.org/10.1016/j.pocean.2011.02.003

Eggers, S. L., Lewandowska, A. M., Ramos, J. B. e, Blanco-Ameijeiras, S., Gallo, F., & Matthiessen, B. (2014). Community composition has greater impact on the functioning of marine phytoplankton communities than ocean acidification. *Global Change Biology*, *20*(3), 713–723. https://doi.org/10.1111/gcb.12421

Eichhorn, M. P., Paris, P., Herzog, F., Incoll, L. D., Liagre, F., Mantzanas, K., Mayus, M., Moreno, G., Papanastasis, V. P., Pilbeam, D. J., Pisanelli, A., & Dupraz, C. (2006). Silvoarable Systems in Europe –

Past, Present and Future Prospects. *Agroforestry Systems*, *67*(1), 29–50. https://doi.org/10.1007/s10457-005-1111-7

Ertlen, D., Schwartz, D., Brunet, D., Trendel, J.-M., Adam, P., & Schaeffer, P. (2015). Qualitative near infrared spectroscopy, a new tool to recognize past vegetation signature in soil organic matter. *Soil Biology and Biochemistry*, *82*, 127–134. https://doi.org/10.1016/j.soilbio.2014.12.019

Estrada, M., & Vaqué, D. (2014). Microbial Components. In S. Goffredo & Z. Dubinsky (Eds.), *The Mediterranean Sea: Its history and present challenges* (pp. 87–111). Springer Netherlands. https://doi.org/10.1007/978-94-007-6704-1_6

Evans, S. E., & Wallenstein, M. D. (2012). Soil microbial community response to drying and rewetting stress: does historical precipitation regime matter? *Biogeochemistry*, *109*(1), 101–116. https://doi.org/10.1007/s10533-011-9638-3

Fadda, S., Orgeas, J., Ponel, P., Buisson, E., Torre, F., & Dutoit, T. (2007). Past cultivation is a factor driving organization of dry grassland ground-active beetle communities. *Environmental Conservation*, *34*(2), 132–139. https://doi.org/10.1017/S0376892907003839

Fady, B. (2012). Biogeography of neutral genes and recent evolutionary history of pines in the Mediterranean Basin. *Annals of Forest Science*, *69*(4), 421–428. https://doi.org/10.1007/s13595-012-0219-y

Fady, B., & Conord, C. (2010). Macroecological patterns of species and genetic diversity in vascular plants of the Mediterranean basin. *Diversity and Distributions*, *16*(1), 53–64. https://doi.org/10.1111/j.1472-4642.2009.00621.x

Fady, B., Semerci, H., & Vendramin, G. G. (2003). *EUFORGEN Technical Guidelines for genetic conservation and use for Aleppo pine (Pinus halepensis) and Brutia pine (Pinus brutia)*. Bioversity International.

Falco, S. D., & Chavas, J.-P. (2008). Rainfall Shocks, Resilience, and the Effects of Crop Biodiversity on Agroecosystem Productivity. *Land Economics*, *84*(1), 83–96. https://doi.org/10.3368/le.84.1.83

Farnet Da Silva, A. M., Boukhdoud, N., & Gros, R. (2016). Distance from the sea as a driving force of microbial communities under water potential stresses in litters of two typical Mediterranean plant species. *Geoderma*, *269*, 1–9. https://doi.org/10.1016/j.geoderma.2016.01.017

Fernández de Puelles, M. L., & Molinero, J. C. (2007). North Atlantic climate control on plankton variability in the Balearic Sea, western Mediterranean. *Geophysical Research Letters*, *34*(4). https://doi.org/10.1029/2006GL028354

Ferrier-Pagès, C., Tambutté, E., Zamoum, T., Segonds, N., Merle, P.-L., Bensoussan, N., Allemand, D., Garrabou, J., & Tambutté, S. (2009). Physiological response of the symbiotic gorgonian Eunicella singularis to a long-term temperature increase. *Journal of Experimental Biology*, *212*(18), 3007–3015. https://doi.org/10.1242/jeb.031823

Fierer, N., Allen, A. S., Schimel, J. P., & Holden, P. A. (2003). Controls on microbial CO2 production: a comparison of surface and subsurface soil horizons. *Global Change Biology*, *9*(9), 1322–1332. https://doi.org/10.1046/j.1365-2486.2003.00663.x

Fierer, N., & Jackson, R. B. (2006). The diversity and biogeography of soil bacterial communities. *Proceedings of the National Academy of Sciences*, *103*(3), 626–631. https://doi.org/10.1073/pnas.0507535103

Fierer, N., & Schimel, J. P. (2002). Effects of drying–rewetting frequency on soil carbon and nitrogen transformations. *Soil Biology and Biochemistry*, *34*(6), 777–787. https://doi.org/10.1016/S0038-0717(02)00007-X

Fortuny, X., Carcaillet, C., & Chauchard, S. (2014). Land use legacies and site variables control the understorey plant communities in Mediterranean broadleaved forests. *Agriculture, Ecosystems & Environment*, *189*, 53–59. https://doi.org/10.1016/j.agee.2014.03.012

Fourqurean, J. W., Duarte, C. M., Kennedy, H., Marbà, N., Holmer, M., Mateo, M. A., Apostolaki, E. T., Kendrick, G. A., Krause-Jensen, D., McGlathery, K. J., & Serrano, O. (2012). Seagrass ecosystems as a globally significant carbon stock. *Nature Geoscience*, *5*(7), 505–509. https://doi.org/10.1038/ngeo1477

Frangoulis, C., Christou, E. D., & Hecq, J. H. (2004). Comparison of marine copepod outfluxes: nature, rate, fate and role in the carbon and nitrogen cycles. *Advances in Marine Biology*, *47*, 254.

Frenette-Dussault, C., Shipley, B., Meziane, D., & Hingrat, Y. (2013). Trait-based climate change predictions of plant community structure in arid steppes. *Journal of Ecology*, 101, 484–492.

Fuhrman, J. A., & Caron, D. A. (2016). Heterotrophic Planktonic Microbes: Virus, Bacteria, Archaea, and Protozoa. *Manual of Environmental Microbiology, Fourth Edition*, 4.2.2-1-4.2.2-34. https://doi.org/10.1128/9781555818821.ch4.2.2

Gaba, S., Alignier, A., Aviron, S., Barot, S., Blouin, M., Hedde, M., Jabot, F., Vergnes, A., Bonis, A., Bonthoux, S., Bourgeois, B., Bretagnolle, V., Catarino, R., Coux, C., Gardarin, A., Giffard, B., Le Gal, A., Lecomte, J., Miguet, P., … Couvet, D. (2018). Ecology for Sustainable and Multifunctional Agriculture. In S. Gaba, B. Smith, & E. Lichtfouse (Eds.), *Sustainable Agriculture Reviews 28: Ecology for Agriculture* (pp. 1–46). Springer International Publishing. https://doi.org/10.1007/978-3-319-90309-5_1

Gabay, O., Perevolotsky, A., & Shachak, M. (2008). Landscape mosaic for enhancing biodiversity–at what scale and how to maintain it. *Options Méditerranénnes*, *79*, 45–50.

Galli, G., Solidoro, C., & Lovato, T. (2017). Marine Heat Waves Hazard 3D Maps and the Risk for Low Motility Organisms in a Warming Mediterranean Sea. *Frontiers in Marine Science*, *4*. https://doi.org/10.3389/fmars.2017.00136

Garrabou, J., Coma, R., Bensoussan, N., Bally, M., Chevaldonné, P., Cigliano, M., Diaz, D., Harmelin, J. G., Gambi, M. C., Kersting, D. K., Ledoux, J. B., Lejeusne, C., Linares, C., Marschal, C., Pérez, T., Ribes, M., Romano, J. C., Serrano, E., Teixido, N., … Cerrano, C. (2009). Mass mortality in Northwestern Mediterranean rocky benthic communities: effects of the 2003 heat wave. *Global Change Biology*, *15*(5), 1090–1103. https://doi.org/10.1111/j.1365-2486.2008.01823.x

Garrabou, J., Sala, E., Linares, C., Ledoux, J. B., Montero-Serra, I., Dominici, J. M., Kipson, S., Teixidó, N., Cebrian, E., Kersting, D. K., & Harmelin, J. G. (2017). Re-shifting the ecological baseline for the overexploited Mediterranean red coral. *Scientific Reports*, *7*, 42404. https://doi.org/10.1038/srep42404

Garrabou, J., & Ballesteros, E. (2000). Growth of Mesophyllum alternans and Lithophyllum frondosum (Corallinales, Rhodophyta) in the northwestern Mediterranean. *European Journal of Phycology*, *35*(1), 1–10.

Garrabou, J., Gómez-Gras, D., Ledoux, J.-B., Linares, C., Bensoussan, N., López-Sendino, P., … Harmelin, J. G. (2019). Collaborative Database to Track Mass Mortality Events in the Mediterranean Sea. *Frontiers in Marine Science*, *6*, 707. doi: 10.3389/fmars.2019.00707

Garrabou, J., Ledoux, J. B., Bensoussan, N., Gómez-Gras, D., & Linares, C. (2021). Sliding Toward the Collapse of Mediterranean Coastal Marine Rocky Ecosystems. In Ecosystem Collapse and Climate Change (pp. 291-324). Springer, Cham.

Gartner, T. B., & Cardon, Z. G. (2004). Decomposition dynamics in mixed-species leaf litter. *Oikos*, *104*(2), 230–246. https://doi.org/10.1111/j.0030-1299.2004.12738.x

Gauquelin, T., Bertaudiere, Montes, & Badri. (1998). CYCLE BIOGÉOCHIMIQUE ET HÉTÉROGÉNÉITÉ ÉDAPHIQUE DES GROUPEMENTS FORESTIERS PRÉ-STEPPIQUES À GENÉVRIER THURIFÈRE DU HAUT ATLAS DE MARRAKECH (MAROC)* - ProQuest. *Ecologie*, 1-2: 177-180.

Gazeau, F., Sallon, A., Maugendre, L., Louis, J., Dellisanti, W., Gaubert, M., Lejeune, P., Gobert, S., Borges, A. V., Harlay, J., Champenois, W., Alliouane, S., Taillandier, V., Louis, F., Obolensky, G., Grisoni, J.-M., & Guieu, C. (2017). First mesocosm experiments to study the impacts of ocean acidification on plankton communities in the NW Mediterranean Sea (MedSeA project). *Estuarine, Coastal and Shelf Science*, *186*, 11–29. https://doi.org/10.1016/j.ecss.2016.05.014

Gazol, A., Camarero, J. J., Gutiérrez, E., Popa, I., Andreu-Hayles, L., Motta, R., Nola, P., Ribas, M., Sangüesa-Barreda, G., Urbinati, C., & Carrer, M. (2015). Distinct effects of climate warming on populations of silver fir (Abies alba) across Europe. *Journal of Biogeography*, *42*(6), 1150–1162. https://doi.org/10.1111/jbi.12512

Gazulla, C. R., López-Sendino, P., Antunes, A., Aurelle, D., Montero-Serra, I., Dominici, J.-M., … Ledoux, J.-B. (2021). Demo-Genetic Approach for the Conservation and Restoration of a Habitat-Forming Octocoral: The Case of Red Coral, Corallium rubrum, in the Réserve Naturelle de Scandola. *Frontiers in Marine Science*, *8*, 655. doi: 10.3389/fmars.2021.633057

Gianinazzi, S., Gollotte, A., Binet, M.-N., van Tuinen, D., Redecker, D., & Wipf, D. (2010). Agroecology: the key role of arbuscular mycorrhizas in ecosystem services. *Mycorrhiza*, *20*(8), 519–530. https://doi.org/10.1007/s00572-010-0333-3

Gil-Tena, A., Brotons, L., & Saura, S. (2009). Mediterranean forest dynamics and forest bird distribution changes in the late 20th century. *Global Change Biology*, *15*(2), 474–485. https://doi.org/10.1111/j.1365-2486.2008.01730.x

Giorgi, F. (2002). Variability and trends of sub-continental scale surface climate in the twentieth century. Part I: observations. *Climate Dynamics*, *18*(8), 675–691. https://doi.org/10.1007/s00382-001-0204-x

Giorgi, Filippo, & Lionello, P. (2008). Climate change projections for the Mediterranean region. *Global and Planetary Change*, *63*(2), 90–104. https://doi.org/10.1016/j.gloplacha.2007.09.005

Gobat, J.-M., Aragno, M., & Matthey, W. (2004). *The Living Soil: Fundamentals of Soil Science and Soil Biology*. Science Publishers.

Godinho, C., & Rabaça, J. E. (2011). Birds like it Corky: the influence of habitat features and management of 'montados' in breeding bird communities. *Agroforestry Systems*, *82*(2), 183–195. https://doi.org/10.1007/s10457-010-9345-4

Gómez, A., Alía, R., & Bueno, M. A. (2001). Genetic diversity of Pinus halepensis Mill. populations detected by RAPD loci. *Annals of Forest Science*, *58*(8), 869–875. https://doi.org/10.1051/forest:2001170

Gömöry, D., Paule, L., Krajmerová, D., Romšáková, I., & Longauer, R. (2012). Admixture of genetic lineages of different glacial origin: a case study of Abies alba Mill. in the Carpathians. *Plant Systematics and Evolution*, *298*(4), 703–712. https://doi.org/10.1007/s00606-011-0580-6

González-Correa, J. M., Torquemada, Y. F., & Sánchez Lizaso, J. L. (2008). Long-term effect of beach replenishment on natural recovery of shallow Posidonia oceanica meadows. *Estuarine, Coastal and Shelf Science*, *76*(4), 834–844. https://doi.org/10.1016/j.ecss.2007.08.012

Graves, A. R., Burgess, P. J., Palma, J. H. N., Herzog, F., Moreno, G., Bertomeu, M., Dupraz, C., Liagre, F., Keesman, K., van der Werf, W., de Nooy, A. K., & van den Briel, J. P. (2007). Development and application of bio-economic modelling to compare silvoarable, arable, and forestry systems in three European countries. *Ecological Engineering*, *29*(4), 434–449. https://doi.org/10.1016/j.ecoleng.2006.09.018

Grivet, D., Sebastiani, F., Alía, R., Bataillon, T., Torre, S., Zabal-Aguirre, M., Vendramin, G. G., & González-Martínez, S. C. (2011). Molecular Footprints of Local Adaptation in Two Mediterranean Conifers. *Molecular Biology and Evolution*, *28*(1), 101–116. https://doi.org/10.1093/molbev/msq190

Grivet, D., Sebastiani, F., González-Martínez, S. C., & Vendramin, G. G. (2009). Patterns of polymorphism resulting from long-range colonization in the Mediterranean conifer Aleppo pine. *New Phytologist*, *184*(4), 1016–1028. https://doi.org/10.1111/j.1469-8137.2009.03015.x

Guerzoni, S., Chester, R., Dulac, F., Herut, B., Loÿe-Pilot, M.-D., Measures, C., Migon, C., Molinaroli, E., Moulin, C., Rossini, P., Saydam, C., Soudine, A., & Ziveri, P. (1999). The role of atmospheric deposition in the biogeochemistry of the Mediterranean Sea. *Progress in Oceanography*, *44*(1), 147–190. https://doi.org/10.1016/S0079-6611(99)00024-5

Guidetti, P. (2000). Differences Among Fish Assemblages Associated with Nearshore Posidonia oceanica Seagrass Beds, Rocky–algal Reefs and Unvegetated Sand Habitats in the Adriatic Sea. *Estuarine, Coastal and Shelf Science*, *50*(4), 515–529. https://doi.org/10.1006/ecss.1999.0584

Guieu, C., Ridame, C., Pulido-Villena, E., Bressac, M., Desboeufs, K., & Dulac, F. (2014). Impact of dust deposition on carbon budget: a tentative assessment from a mesocosm approach. *Biogeosciences*, *11*(19), 5621–5635. https://doi.org/10.5194/bg-11-5621-2014

Guieu, Cécile, Dulac, F., Desboeufs, K., Wagener, T., Pulido-Villena, E., Grisoni, J.-M., Louis, F., Ridame, C., Blain, S., Brunet, C., Bon Nguyen, E., Tran, S., Labiadh, M., & Dominici, J.-M. (2010). Large clean mesocosms and simulated dust deposition: a new methodology to investigate responses of marine oligotrophic ecosystems to atmospheric inputs. *Biogeosciences*, *7*, 2765–2784. https://doi.org/10.5194/BG-7-2765-2010

Habash, D. Z., Kehel, Z., & Nachit, M. (2009). Genomic approaches for designing durum wheat ready for climate change with a focus on drought. *Journal of Experimental Botany*, *60*(10), 2805–2815. https://doi.org/10.1093/jxb/erp211

Haguenauer, A., Zuberer, F., Ledoux, J.-B., & Aurelle, D. (2013). Adaptive abilities of the Mediterranean red coral Corallium rubrum in a heterogeneous and changing environment: from population to functional genetics. *Journal of Experimental Marine Biology and Ecology*, *449*, 349–357. https://doi.org/10.1016/j.jembe.2013.10.010

Haichar, F. el Z., Marol, C., Berge, O., Rangel-Castro, J. I., Prosser, J. I., Balesdent, J., Heulin, T., & Achouak, W. (2008). Plant host habitat and root exudates shape soil bacterial community structure. *The ISME Journal*, *2*(12), 1221–1230. https://doi.org/10.1038/ismej.2008.80

Halsband-Lenk, C., Nival, S., Carlotti, F., & Hirche, H.-J. (2001). Seasonal Cycles of Egg Production of Two Planktonic Copepods, Centropages typicus and Temora stylifera, in the North-western Mediterranean Sea. *Journal of Plankton Research*, *23*(6), 597–609. https://doi.org/10.1093/plankt/23.6.597

Halsband-Lenk, Claudia, Carlotti, F., & Greve, W. (2004). Life-history strategies of calanoid congeners under two different climate regimes: a comparison. *ICES Journal of Marine Science*, *61*(4), 709–720. https://doi.org/10.1016/j.icesjms.2004.03.020

Halsband-Lenk, Claudia, Hirche, H.-J., & Carlotti, F. (2002). Temperature impact on reproduction and development of congener copepod populations. *Journal of Experimental Marine Biology and Ecology*, *271*(2), 121–153. https://doi.org/10.1016/S0022-0981(02)00025-4

Hansen, P. J., Bjørnsen, P. K., & Hansen, B. W. (1997). Zooplankton grazing and growth: Scaling within the 2-2,-μm body size range. *Limnology and Oceanography*, *42*(4), 687–704.

Hare, S. R., & Mantua, N. J. (2000). Empirical evidence for North Pacific regime shifts in 1977 and 1989. *Progress in Oceanography*, *47*(2), 103–145. https://doi.org/10.1016/S0079-6611(00)00033-1

Hashoum, H., Santonja, M., Gauquelin, T., Saatkamp, A., Gavinet, J., Greff, S., Lecareux, C., Fernandez, C., & Bousquet-Mélou, A. (2017). Biotic interactions in a Mediterranean oak forest: role of allelopathy along phenological development of woody species. *European Journal of Forest Research*, *136*(4), 699–710. https://doi.org/10.1007/s10342-017-1066-z

Hays, G. C. (2003). A review of the adaptive significance and ecosystem consequences of zooplankton diel vertical migrations. In M. B. Jones, A. Ingólfsson, E. Ólafsson, G. V. Helgason, K. Gunnarsson, & J. Svavarsson (Eds.), *Migrations and Dispersal of Marine Organisms* (pp. 163–170). Springer Netherlands.

Henne, P. D., Elkin, C., Colombaroli, D., Samartin, S., Bugmann, H., Heiri, O., & Tinner, W. (2013). Impacts of changing climate and land use on vegetation dynamics in a Mediterranean ecosystem: insights from paleoecology and dynamic modeling. *Landscape Ecology*, *28*(5), 819–833. https://doi.org/10.1007/s10980-012-9782-8

Henneron, L., Bernard, L., Hedde, M., Pelosi, C., Villenave, C., Chenu, C., Bertrand, M., Girardin, C., & Blanchart, E. (2015). Fourteen years of evidence for positive effects of conservation agriculture and organic farming on soil life. *Agronomy for Sustainable Development*, *35*(1), 169–181. https://doi.org/10.1007/s13593-014-0215-8

Herrmann, M., Estournel, C., Adloff, F., & Diaz, F. (2014). Impact of climate change on the northwestern Mediterranean Sea pelagic planktonic ecosystem and associated carbon cycle. *Journal of Geophysical Research: Oceans*, *119*(9), 5815–5836. https://doi.org/10.1002/2014JC010016

Hidalgo, P., Escribano, R., & Morales, C. E. (2005). Ontogenetic vertical distribution and diel migration of the copepod Eucalanus inermis in the oxygen minimum zone off northern Chile (20–21° S). *Journal of Plankton Research*, *27*(6), 519–529. https://doi.org/10.1093/plankt/fbi025

Hong, J.-S. (1980). *Etude faunistique d'un fond de concrétionnement de typre coralligène soumis à un gradient de pollution en Méditerranée nord-occidentale (Golfe de Fos)* [PhD Thesis].

Hughes, A. R., & Stachowicz, J. J. (2004). Genetic diversity enhances the resistance of a seagrass ecosystem to disturbance. *Proceedings of the National Academy of Sciences*, *101*(24), 8998–9002. https://doi.org/10.1073/pnas.0402642101

Hughes, A. R., Williams, S. L., Duarte, C. M., Heck, K. L., & Waycott, M. (2009). Associations of concern: declining seagrasses and threatened dependent species. *Frontiers in Ecology and the Environment*, *7*(5), 242–246. https://doi.org/10.1890/080041

Hughes, T. P., Kerry, J. T., Álvarez-Noriega, M., Álvarez-Romero, J. G., Anderson, K. D., Baird, A. H., Babcock, R. C., Beger, M., Bellwood, D. R., Berkelmans, R., Bridge, T. C., Butler, I. R., Byrne, M., Cantin, N. E., Comeau, S., Connolly, S. R., Cumming, G. S., Dalton, S. J., Diaz-Pulido, G., … Wilson, S. K. (2017). Global warming and recurrent mass bleaching of corals. *Nature*, *543*(7645), 373–377. https://doi.org/10.1038/nature21707

Jemai, I., Ben Aissa, N., Ben Guirat, S., Ben-Hammouda, M., & Gallali, T. (2013). Impact of three and seven years of no-tillage on the soil water storage, in the plant root zone, under a dry subhumid Tunisian climate. *Soil and Tillage Research*, *126*, 26–33. https://doi.org/10.1016/j.still.2012.07.008

Ji, R., Edwards, M., Mackas, D. L., Runge, J. A., & Thomas, A. C. (2010). Marine plankton phenology and life history in a changing climate: current research and future directions. *Journal of Plankton Research*, *32*(10), 1355–1368. https://doi.org/10.1093/plankt/fbq062

Joffre, R., Rambal, S., & Ratte, J. P. (1999). The dehesa system of southern Spain and Portugal as a natural ecosystem mimic. *Agroforestry Systems*, *45*(1), 57–79. https://doi.org/10.1023/A:1006259402496

José-María, L., Armengot, L., Blanco-Moreno, J. M., Bassa, M., & Sans, F. X. (2010). Effects of agricultural intensification on plant diversity in Mediterranean dryland cereal fields. *Journal of Applied Ecology*, *47*(4), 832–840. https://doi.org/10.1111/j.1365-2664.2010.01822.x

Jump, A. S., Hunt, J. M., & Peñuelas, J. (2006). Rapid climate change-related growth decline at the southern range edge of Fagus sylvatica. *Global Change Biology*, *12*(11), 2163–2174. https://doi.org/10.1111/j.1365-2486.2006.01250.x

Kakumanu, M. L., & Williams, M. A. (2014). Osmolyte dynamics and microbial communities vary in response to osmotic more than matric water deficit gradients in two soils. *Soil Biology and Biochemistry*, *79*, 14–24. https://doi.org/10.1016/j.soilbio.2014.08.015

Kandemir, G., & Kaya, Z. (2009). *EUFORGEN Technical guidelines for genetic conservation and use for Oriental beech (Fagus orientalis)*. Bioversity International. http://www.euforgen.org/fileadmin/bioversity/publications/pdfs/EUFORGEN/ 1369_Oriental_beech__Fagus_orientalis_.pdf

Keenan, T., Serra, J. M., Lloret, F., Ninyerola, M., & Sabate, S. (2011). Predicting the future of forests in the Mediterranean under climate change, with niche- and process-based models: CO2 matters! *Global Change Biology*, *17*(1), 565–579. https://doi.org/10.1111/j.1365-2486.2010.02254.x

Kéfi, S., Rietkerk, M., Alados, C. L., Pueyo, Y., Papanastasis, V. P., ElAich, A., & de Ruiter, P. C. (2007). Spatial vegetation patterns and imminent desertification in Mediterranean arid ecosystems. *Nature*, *449*(7159), 213–217. https://doi.org/10.1038/nature06111

Keiser, A. D., & Bradford, M. A. (2017). Climate masks decomposer influence in a cross-site litter decomposition study. *Soil Biology and Biochemistry*, *107*, 180–187. https://doi.org/10.1016/j.soilbio.2016.12.022

Kiørboe, T., Saiz, E., Tiselius, P., & Andersen, K. H. (2018). Adaptive feeding behavior and functional responses in zooplankton: Functional responses in zooplankton. *Limnology and Oceanography*, *63*(1), 308–321. https://doi.org/10.1002/lno.10632

Klein, T., Di Matteo, G., Rotenberg, E., Cohen, S., & Yakir, D. (2013). Differential ecophysiological response of a major Mediterranean pine species across a climatic gradient. *Tree Physiology*, *33*(1), 26–36. https://doi.org/10.1093/treephys/tps116

Kvennefors, E. C. E., Leggat, W., Hoegh-Guldberg, O., Degnan, B. M., & Barnes, A. C. (2008). An ancient and variable mannose-binding lectin from the coral Acropora millepora binds both pathogens and symbionts. *Developmental & Comparative Immunology*, *32*(12), 1582–1592. https://doi.org/10.1016/j.dci.2008.05.010

Kyzeridis, N., Biesantz, A., & Limberg, P. (1995). *Comparative trials with durum-wheat landraces and cultivars in different ecological environments in the Mediterranean region*. http://agris.fao.org/agris-search/search.do?recordID=DE9620275

La Rivière, M., Garrabou, J., & Bally, M. (2015). Evidence for host specificity among dominant bacterial symbionts in temperate gorgonian corals. *Coral Reefs*, *34*(4), 1087–1098. https://doi.org/10.1007/s00338-015-1334-7

La Rivière, M., Roumagnac, M., Garrabou, J., & Bally, M. (2013). Transient Shifts in Bacterial Communities Associated with the Temperate Gorgonian Paramuricea clavata in the Northwestern Mediterranean Sea. *PLOS ONE*, *8*(2), e57385. https://doi.org/10.1371/journal.pone.0057385

Laganière, J., Paré, D., & Bradley, R. L. (2009). Linking the abundance of aspen with soil faunal communities and rates of belowground processes within single stands of mixed aspen–black spruce. *Applied Soil Ecology*, *41*(1), 19–28. https://doi.org/10.1016/j.apsoil.2008.08.005

Laiolo, P., & Tella, J. L. (2006). Fate of unproductive and unattractive habitats: recent changes in Iberian steppes and their effects on endangered avifauna. *Environmental Conservation*, *33*(3), 223–232. https://doi.org/10.1017/S0376892906003146

Lalagüe, H., Csilléry, K., Oddou-Muratorio, S., Safrana, J., de Quattro, C., Fady, B., González-Martínez, S. C., & Vendramin, G. G. (2014). Nucleotide diversity and linkage disequilibrium at 58 stress response and phenology candidate genes in a European beech (Fagus sylvatica L.) population from southeastern France. *Tree Genetics & Genomes*, *10*(1), 15–26. https://doi.org/10.1007/s11295-013-0658-0

Lander, T. A., Oddou-Muratorio, S., Prouillet-Leplat, H., & Klein, E. K. (2011). Reconstruction of a beech population bottleneck using archival demographic information and Bayesian analysis of genetic data. *Molecular Ecology*, *20*(24), 5182–5196. https://doi.org/10.1111/j.1365-294X.2011.05356.x

Lazzari, P., Mattia, G., Solidoro, C., Salon, S., Crise, A., Zavatarelli, M., Oddo, P., & Vichi, M. (2014). The impacts of climate change and environmental management policies on the trophic regimes in the Mediterranean Sea: Scenario analyses. *Journal of Marine Systems*, *135*, 137–149. https://doi.org/10.1016/j.jmarsys.2013.06.005

Le Cuziat, J., Lacroix, F., Roche, P., Vidal, E., Médail, F., Orhant, N., & Béranger, P. M. (2005). Landscape and human influences on the distribution of the endangered North African houbara bustard (Chlamydotis undulata undulata) in Eastern Morocco. *Animal Conservation Forum*, *8*(2), 143–152. https://doi.org/10.1017/S1367943005001903

Le Houerou. (1995). Bioclimatologie et biogéographie des steppes arides du Nord de l'Afrique. Options Méditerranéennes Ser B. *Études et Recherches*, 10 : 1-396.

Leal, A. I., Martins, R. C., Palmeirim, J. M., & Granadeiro, J. P. (2011). Influence of habitat fragments on bird assemblages in Cork Oak woodlands. *Bird Study*, *58*(3), 309–320. https://doi.org/10.1080/00063657.2011.576235

Leblanc, K., Hare, C. E., Boyd, P. W., Bruland, K. W., Sohst, B., Pickmere, S., Lohan, M. C., Buck, K., Ellwood, M., & Hutchins, D. A. (2005). Fe and Zn effects on the Si cycle and diatom community structure in two contrasting high and low-silicate HNLC areas. *Deep Sea Research Part I: Oceanographic Research Papers*, *52*(10), 1842–1864. https://doi.org/10.1016/j.dsr.2005.06.005

Leblanc, Karine, Quéguiner, B., Diaz, F., Cornet, V., Michel-Rodriguez, M., Madron, X. D. de, Bowler, C., Malviya, S., Thyssen, M., Grégori, G., Rembauville, M., Grosso, O., Poulain, J., Vargas, C. de, Pujo-Pay, M., & Conan, P. (2018). Nanoplanktonic diatoms are globally overlooked but play a role in spring blooms and carbon export. *Nature Communications*, *9*(1), 953. https://doi.org/10.1038/s41467-018-03376-9

Ledoux, J.-B., Garrabou, J., Bianchimani, O., Drap, P., Féral, J.-P., & Aurelle, D. (2010). Fine-scale genetic structure and inferences on population biology in the threatened Mediterranean red coral, Corallium rubrum. *Molecular Ecology*, *19*(19), 4204–4216. https://doi.org/10.1111/j.1365-294X.2010.04814.x

Ledoux, J.-B., Aurelle, D., Bensoussan, N., Marschal, C., Féral, J.-P., & Garrabou, J. (2015). Potential for adaptive evolution at species range margins: contrasting interactions between red coral populations and their environment in a changing ocean. *Ecology and Evolution*, *5*(6), 1178–1192. https://doi.org/10.1002/ece3.1324

Ledoux, J.-B., Frias-Vidal, S., Montero-Serra, I., Antunes, A., Casado Bueno, C., Civit, S., ... Garrabou, J. (2020). Assessing the impact of population decline on mating system in the overexploited Mediterranean red coral. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *30*(6), 1149–1159. doi: 10.1002/aqc.3327

Levin, D. A. (2003). Ecological Speciation: Lessons From Invasive Species. *Systematic Botany*, *28*(4), 643–650. https://doi.org/10.1043/02-70.1

Levin, L. A. (2018). Manifestation, Drivers, and Emergence of Open Ocean Deoxygenation. *Annual Review of Marine Science*, *10*(1), 229–260. https://doi.org/10.1146/annurev-marine-121916-063359

Liepelt, S., Cheddadi, R., de Beaulieu, J.-L., Fady, B., Gömöry, D., Hussendörfer, E., Konnert, M., Litt, T., Longauer, R., Terhürne-Berson, R., & Ziegenhagen, B. (2009). Postglacial range expansion and its genetic imprints in Abies alba (Mill.) — A synthesis from palaeobotanic and genetic data. *Review of Palaeobotany and Palynology*, *153*(1), 139–149. https://doi.org/10.1016/j.revpalbo.2008.07.007

Linares, C., & Doak, D. F. (2010). Forecasting the combined effects of disparate disturbances on the persistence of long-lived gorgonians: a case study of Paramuricea clavata. *Marine Ecology Progress Series*, *402*, 59–68. https://doi.org/10.3354/meps08437

Linares, Vidal M., Canals M., Kersting D. K., Amblas D., Aspillaga E., Cebrián E., Delgado-Huertas A., Díaz D., Garrabou J., Hereu B., Navarro L., Teixidó N., & Ballesteros E. (2015). Persistent natural acidification drives major distribution shifts in marine benthic ecosystems. *Proceedings of the Royal Society B: Biological Sciences*, *282*(1818), 20150587. https://doi.org/10.1098/rspb.2015.0587

Litchman, E., Edwards, K. F., Klausmeier, C. A., & Thomas, M. K. (2012). Phytoplankton niches, traits and eco-evolutionary responses to global environmental change. *Marine Ecology Progress Series*, *470*, 235–248. https://doi.org/10.3354/meps09912

Litchman, E., Ohman, M. D., & Kiørboe, T. (2013). Trait-based approaches to zooplankton communities. *Journal of Plankton Research*, *35*(3), 473–484. https://doi.org/10.1093/plankt/fbt019

Lithourgidis, A. S., Dordas, C. A., Damalas, C. A., & Vlachostergios, D. N. (2011b). Annual Intercrops: An Alternative Pathway for Sustainable Agriculture. *Australian Journal of Crop Science*, *5*(4), 396.

Lithourgidis, A. S., Vlachostergios, D. N., Dordas, C. A., & Damalas, C. A. (2011a). Dry matter yield, nitrogen content, and competition in pea–cereal intercropping systems. *European Journal of Agronomy*, *34*(4), 287–294. https://doi.org/10.1016/j.eja.2011.02.007

Lloret, F., Peñuelas, J., & Estiarte, M. (2004). Experimental evidence of reduced diversity of seedlings due to climate modification in a Mediterranean-type community. *Global Change Biology*, *10*(2), 248–258. https://doi.org/10.1111/j.1365-2486.2004.00725.x

Lombardi, C., Gambi, M. C., Vasapollo, C., Taylor, P., & Cocito, S. (2011). Skeletal alterations and polymorphism in a Mediterranean bryozoan at natural CO2 vents. *Zoomorphology*, *130*(2), 135–145. https://doi.org/10.1007/s00435-011-0127-y

Lopes, A. R., Faleiro, F., Rosa, I. C., Pimentel, M. S., Trubenbach, K., Repolho, T., Diniz, M., & Rosa, R. (2018). Physiological resilience of a temperate soft coral to ocean warming and acidification. *Cell Stress and Chaperones*, *23*(5), 1093–1100. https://doi.org/10.1007/s12192-018-0919-9

Lopes, M. S., El-Basyoni, I., Baenziger, P. S., Singh, S., Royo, C., Ozbek, K., Aktas, H., Ozer, E., Ozdemir, F., Manickavelu, A., Ban, T., & Vikram, P. (2015). Exploiting genetic diversity from landraces in wheat breeding for adaptation to climate change. *Journal of Experimental Botany*, *66*(12), 3477–3486. https://doi.org/10.1093/jxb/erv122

Loreau, M., Naeem, S., Inchausti, P., Bengtsson, J., Grime, J. P., Hector, A., Hooper, D. U., Huston, M. A., Raffaelli, D., Schmid, B., Tilman, D., & Wardle, D. A. (2001). Biodiversity and Ecosystem Functioning: Current Knowledge and Future Challenges. *Science*, *294*(5543), 804–808. https://doi.org/10.1126/science.1064088

Loreau Michel. (2010). Linking biodiversity and ecosystems: towards a unifying ecological theory. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *365*(1537), 49–60. https://doi.org/10.1098/rstb.2009.0155

Louis, J., Pedrotti, M. L., Gazeau, F., & Guieu, C. (2017). Experimental evidence of formation of transparent exopolymer particles (TEP) and POC export provoked by dust addition under current and high pCO2 conditions. *PLOS ONE*, *12*(2), e0171980. https://doi.org/10.1371/journal.pone.0171980

Luikart, G., Ryman, N., Tallmon, D. A., Schwartz, M. K., & Allendorf, F. W. (2010). Estimation of census and effective population sizes: the increasing usefulness of DNA-based approaches. *Conservation Genetics*, *11*(2), 355–373. https://doi.org/10.1007/s10592-010-0050-7

Luis, M. de, Čufar, K., Filippo, A. D., Novak, K., Papadopoulos, A., Piovesan, G., Rathgeber, C. B. K., Raventós, J., Saz, M. A., & Smith, K. T. (2013). Plasticity in Dendroclimatic Response across the

Distribution Range of Aleppo Pine (Pinus halepensis). *PLOS ONE*, *8*(12), e83550. https://doi.org/10.1371/journal.pone.0083550

Macias, D. M., Garcia-Gorriz, E., & Stips, A. (2015). Productivity changes in the Mediterranean Sea for the twenty-first century in response to changes in the regional atmospheric forcing. *Frontiers in Marine Science*, *2*. https://doi.org/10.3389/fmars.2015.00079

Maestre, F. T., Bautista, S., Cortina, J., & Bellot, J. (2001). Potential for Using Facilitation by Grasses to Establish Shrubs on a Semiarid Degraded Steppe. *Ecological Applications*, *11*(6), 1641–1655. https://doi.org/10.1890/1051-0761(2001)011[1641:PFUFBG]2.0.CO;2

Magri, D., Vendramin, G. G., Comps, B., Dupanloup, I., Geburek, T., Gömöry, D., Latałowa, M., Litt, T., Paule, L., Roure, J. M., Tantau, I., Knaap, W. O. V. D., Petit, R. J., & Beaulieu, J.-L. D. (2006). A new scenario for the Quaternary history of European beech populations: palaeobotanical evidence and genetic consequences. *New Phytologist*, *171*(1), 199–221. https://doi.org/10.1111/j.1469-8137.2006.01740.x

Makkonen, M., Berg, M. P., Handa, I. T., Hättenschwiler, S., Ruijven, J. van, Bodegom, P. M. van, & Aerts, R. (2012). Highly consistent effects of plant litter identity and functional traits on decomposition across a latitudinal gradient. *Ecology Letters*, *15*(9), 1033–1041. https://doi.org/10.1111/j.1461-0248.2012.01826.x

Marañón, E., Cermeño, P., Huete-Ortega, M., López-Sandoval, D. C., Mouriño-Carballido, B., & Rodríguez-Ramos, T. (2014). Resource Supply Overrides Temperature as a Controlling Factor of Marine Phytoplankton Growth. *PLOS ONE*, *9*(6), e99312. https://doi.org/10.1371/journal.pone.0099312

Marbà, N., Díaz-Almela, E., & Duarte, C. M. (2014). Mediterranean seagrass (Posidonia oceanica) loss between 1842 and 2009. *Biological Conservation*, *176*, 183–190. https://doi.org/10.1016/j.biocon.2014.05.024

Marbà, N., & Duarte, C. M. (1998). Rhizome elongation and seagrass clonal growth. *Marine Ecology Progress Series*, *174*, 269–280. https://doi.org/10.3354/meps174269

Marbà, N., & Duarte, C. M. (2010). Mediterranean warming triggers seagrass (Posidonia oceanica) shoot mortality. *Global Change Biology*, *16*(8), 2366–2375. https://doi.org/10.1111/j.1365-2486.2009.02130.x

Marín-Guirao, L., Bernardeau-Esteller, J., García-Muñoz, R., Ramos, A., Ontoria, Y., Romero, J., Pérez, M., Ruiz, J. M., & Procaccini, G. (2018). Carbon economy of Mediterranean seagrasses in response to thermal stress. *Marine Pollution Bulletin*, *135*, 617–629. https://doi.org/10.1016/j.marpolbul.2018.07.050

Marín-Guirao, Lazaro, Entrambasaguas, L., Ruiz, J. M., & Procaccini, G. (2019). Heat-stress induced flowering can be a potential adaptive response to ocean warming for the iconic seagrass Posidonia oceanica. *Molecular Ecology*, *28*(10), 2486–2501. https://doi.org/10.1111/mec.15089

Marín-Guirao, Lazaro, Ruiz, J. M., Dattolo, E., Garcia-Munoz, R., & Procaccini, G. (2016). Physiological and molecular evidence of differential short-term heat tolerance in Mediterranean seagrasses. *Scientific Reports*, *6*, 28615.

Marschal, C., Garrabou, J., Harmelin, J. G., & Pichon, M. (2004). A new method for measuring growth and age in the precious red coral Corallium rubrum (L.). *Coral Reefs*, *23*(3), 423–432. https://doi.org/10.1007/s00338-004-0398-6

Martin, S., Cohu, S., Vignot, C., Zimmerman, G., & Gattuso, J.-P. (2013). One-year experiment on the physiological response of the Mediterranean crustose coralline alga, Lithophyllum cabiochae, to elevated pCO2 and temperature. *Ecology and Evolution*, *3*(3), 676–693. https://doi.org/10.1002/ece3.475

Martin, S., & Gattuso, J.-P. (2009). Response of Mediterranean coralline algae to ocean acidification and elevated temperature. *Global Change Biology*, *15*(8), 2089–2100. https://doi.org/10.1111/j.1365-2486.2009.01874.x

Marty, J.-C., Chiavérini, J., Pizay, M.-D., & Avril, B. (2002). Seasonal and interannual dynamics of nutrients and phytoplankton pigments in the western Mediterranean Sea at the DYFAMED time-series station (1991–1999). *Deep Sea Research Part II: Topical Studies in Oceanography*, *49*(11), 1965–1985. https://doi.org/10.1016/S0967-0645(02)00022-X

Masmoudi, M. B., Chaoui, L., Topçu, N. E., Hammami, P., Kara, M. H., & Aurelle, D. (2016). Contrasted levels of genetic diversity in a benthic Mediterranean octocoral: Consequences of different demographic histories? *Ecology and Evolution*, *6*(24), 8665–8678. https://doi.org/10.1002/ece3.2490

Matos, E. S., Freese, D., Ślązak, A., Bachmann, U., Veste, M., & Hüttl, R. F. (2010). Organic-carbon and nitrogen stocks and organic-carbon fractions in soil under mixed pine and oak forest stands of different ages in NE Germany. *Journal of Plant Nutrition and Soil Science*, *173*(5), 654–661. https://doi.org/10.1002/jpln.200900046

Mauchline, J. (1998). The biology of calanoid copepods. *Adv. Mar. Biol.*, *33*, 1–710.

Maugendre, L., Gattuso, J.-P., Louis, J., de Kluijver, A., Marro, S., Soetaert, K., & Gazeau, F. (2015). Effect of ocean warming and acidification on a plankton community in the NW Mediterranean Sea. *ICES Journal of Marine Science*, *72*(6), 1744–1755. https://doi.org/10.1093/icesjms/fsu161

Mauri, Di Leo, De Rigo, & Caudullo,. (2016). *Pinus halepensis and Pinus brutia in Europe: distribution, habitat, usage and threats.* (In: San-Miguel-Ayanz, J., de Rigo, D., Caudullo, G., Houston Durrant, T., Mauri, A. (Eds.), European Atlas of Forest Tree Species. Publ. Off. EU, Luxembourg, p. e0166b8+). San-Miguel-Ayanz, J., de Rigo, D., Caudullo, G., Houston Durrant, T., Mauri, A. https://scholar.google.fr/scholar?hl=fr&as_sdt=0%2C5&q=Mauri+et+al.+2016+alep&btnG=

Mayot, N., Boudouresque, C.-F., & Leriche, A. (2005). Unexpected response of the seagrass Posidonia oceanica to a warm-water episode in the North Western Mediterranean Sea. *Comptes Rendus Biologies*, *328*(3), 291–296. https://doi.org/10.1016/j.crvi.2005.01.005

Mazzocchi, M. G., Siokou, I., Tirelli, V., Bandelj, V., Fernandez de Puelles, M. L., Ak Örek, Y., de Olazabal, A., Gubanova, A., Kress, N., Protopapa, M., Solidoro, C., Taglialatela, S., & Terbiyik Kurt, T. (2014). Regional and seasonal characteristics of epipelagic mesozooplankton in the Mediterranean Sea based on an artificial neural network analysis. *Journal of Marine Systems*, *135*, 64–80. https://doi.org/10.1016/j.jmarsys.2013.04.009

McDevitt-Irwin, J. M., Baum, J. K., Garren, M., & Vega Thurber, R. L. (2017). Responses of Coral-Associated Bacterial Communities to Local and Global Stressors. *Frontiers in Marine Science*, *4*. https://doi.org/10.3389/fmars.2017.00262

Meddich, A., Oihabi, A., Abbas, Y., & Bizid, E. (2000). Rôle des champignons mycorhiziens à arbuscules de zones arides dans la résistance du trèfle (Trifolium alexandrinum L.) au déficit hydrique. *Agronomie*, *20*(3), 283–295. https://doi.org/10.1051/agro:2000127

Meinesz, A., Cirik, Ş., Akcali, B., Javel, F., Migliaccio, M., Thibaut, T., Yüksek, A., & Procaccini, G. (2009). Posidonia oceanica in the Marmara Sea. *Aquatic Botany*, *90*(1), 18–22. https://doi.org/10.1016/j.aquabot.2008.04.013

Migliaccio, M., De Martino, F., Silvestre, F., & Procaccini, G. (2005). Meadow-scale genetic structure in Posidonia oceanica. *Marine Ecology Progress Series*, *304*, 55–65.

Misson, L., Degueldre, D., Collin, C., Rodriguez, R., Rocheteau, A., Ourcival, J.-M., & Rambal, S. (2011). Phenological responses to extreme droughts in a Mediterranean forest. *Global Change Biology*, *17*(2), 1036–1048. https://doi.org/10.1111/j.1365-2486.2010.02348.x

Mokhtar-Jamaï, K., Pascual, M., Ledoux, J.-B., Coma, R., Féral, J.-P., Garrabou, J., & Aurelle, D. (2011). From global to local genetic structuring in the red gorgonian Paramuricea clavata: the interplay between oceanographic conditions and limited larval dispersal. *Molecular Ecology*, *20*(16), 3291–3305. https://doi.org/10.1111/j.1365-294X.2011.05176.x

Molinero, J. C., Ibanez, F., Nival, P., Buecher, E., & Souissi, S. (2005). North Atlantic climate and northwestern Mediterranean plankton variability. *Limnology and Oceanography*, *50*(4), 1213–1220. https://doi.org/10.4319/lo.2005.50.4.1213

Molinero, J. C., Ibanez, F., Souissi, S., Buecher, E., Dallot, S., & Nival, P. (2008). Climate control on the long-term anomalous changes of zooplankton communities in the Northwestern Mediterranean. *Global Change Biology*, *14*(1), 11–26. https://doi.org/10.1111/j.1365-2486.2007.01469.x

Montefalcone, M. (2009). Ecosystem health assessment using the Mediterranean seagrass Posidonia oceanica: A review. *Ecological Indicators*, *9*(4), 595–604. https://doi.org/10.1016/j.ecolind.2008.09.013

Montefalcone, M., Parravicini, V., Vacchi, M., Albertelli, G., Ferrari, M., Morri, C., & Bianchi, C. N. (2010). Human influence on seagrass habitat fragmentation in NW Mediterranean Sea. *Estuarine, Coastal and Shelf Science*, *86*(2), 292–298. https://doi.org/10.1016/j.ecss.2009.11.018

Montero-Serra, I., Garrabou, J., Doak, D. F., Ledoux, J., & Linares, C. (2019). Marine protected areas enhance structural complexity but do not buffer the consequences of ocean warming for an overexploited precious coral. *Journal of Applied Ecology*, *56*(5), 1063–1074.

Montero-Serra, I., Linares, C., Doak, D. F., Ledoux, J., & Garrabou, J. (2018). Strong linkages between depth, longevity and demographic stability across marine sessile species. *Proceedings of the Royal Society B: Biological Sciences*, *285*(1873), 20172688.

Moreira, F., Morgado, R., & Arthur, S. (2004). Great bustard Otis tarda habitat selection in relation to agricultural use in southern Portugal. *Wildlife Biology*, *10*(1), 251–260. https://doi.org/10.2981/wlb.2004.030

Mrabet, R. (2011). Effects of residue management and cropping systems on wheat yield stability in a semiarid Mediterranean clay soil. *American Journal of Plant Sciences*, *2*(2), 202–216.

Munday, P. L., Warner, R. R., Monro, K., Pandolfi, J. M., & Marshall, D. J. (2013a). Predicting evolutionary responses to climate change in the sea. *Ecology Letters*, *16*(12), 1488–1500. https://doi.org/10.1111/ele.12185

Nannipieri, P., Ascher, J., Ceccherini, M. T., Landi, L., Pietramellara, G., & Renella, G. (2003). Microbial diversity and soil functions. *European Journal of Soil Science*, *54*(4), 655–670. https://doi.org/10.1046/j.1351-0754.2003.0556.x

Nash, M. C., Martin, S., & Gattuso, J.-P. (2016). Mineralogical response of the Mediterranean crustose coralline alga <i>Lithophyllum cabiochae</i> to near-future ocean acidification and warming. *Biogeosciences*, *13*(21), 5937–5945. https://doi.org/10.5194/bg-13-5937-2016

Navarro-Miró, D., Caballero-López, B., Blanco-Moreno, J. M., Pérez, A., Depalo, L., Masetti, A., Burgio, G., Canali, S., & Sans, F. X. (2017). Agro-ecological Service Crops with roller crimper termination enhance ground-dwelling predator communities and pest regulation. *Proceedings of the 5th ISOFAR Scientific Conference "Innovative Research for Organic*, *3*.

Neave, M. J., Apprill, A., Ferrier-Pagès, C., & Voolstra, C. R. (2016). Diversity and function of prevalent symbiotic marine bacteria in the genus Endozoicomonas. *Applied Microbiology and Biotechnology*, *100*(19), 8315–8324. https://doi.org/10.1007/s00253-016-7777-0

Oehl, F., Sieverding, E., Mäder, P., Dubois, D., Ineichen, K., Boller, T., & Wiemken, A. (2004). Impact of long-term conventional and organic farming on the diversity of arbuscular mycorrhizal fungi. *Oecologia*, *138*(4), 574–583. https://doi.org/10.1007/s00442-003-1458-2

Ohman, M. D. (1990). The Demographic Benefits of Diel Vertical Migration by Zooplankton. *Ecological Monographs*, *60*(3), 257–281. https://doi.org/10.2307/1943058

Orsini, L., Vanoverbeke, J., Swillen, I., Mergeay, J., & Meester, L. D. (2013). Drivers of population genetic differentiation in the wild: isolation by dispersal limitation, isolation by adaptation and isolation by colonization. *Molecular Ecology*, *22*(24), 5983–5999. https://doi.org/10.1111/mec.12561

Özel, H. B., & Ertekin, M. (2012). The change of stand structure in Uludağ fir (Abies nordmanniana subsp. bornmuelleriana Mattf.) forests along an altitudinal gradient. *Kastamonu Üniversitesi Orman Fakültesi Dergisi*, *12*(3), 96–104.

Ozturk, M., Gucel, S., Kucuk, M., & Sakcali, S. (2010). Forest diversity, climate change and forest fires in the Mediterranean region of Turkey. *Journal of Environmental Biology*, *31*(1), 1.

Padrón, M., Costantini, F., Baksay, S., Bramanti, L., & Guizien, K. (2018). Passive larval transport explains recent gene flow in a Mediterranean gorgonian. *Coral Reefs*, *37*(2), 495-506.

Palumbi, S. R. (2003). Population Genetics, Demographic Connectivity, and the Design of Marine Reserves. *Ecological Applications*, *13*(sp1), 146–158. https://doi.org/10.1890/1051-0761(2003)013[0146:PGDCAT]2.0.CO;2

Pantel, J. H., Duvivier, C., & Meester, L. D. (2015). Rapid local adaptation mediates zooplankton community assembly in experimental mesocosms. *Ecology Letters*, *18*(10), 992–1000. https://doi.org/10.1111/ele.12480

Paoli, C., Montefalcone, M., Morri, C., Vassallo, P., & Bianchi, C. N. (2017). Ecosystem functions and services of the marine animal forests. *Marine Animal Forests: The Ecology of Benthic Biodiversity Hotspots*, 1271–1312.

Papanastasis, V. P., Kyriakakis, S., & Kazakis, G. (2002). *Plant diversity in relation to overgrazing and burning in mountain mediterranean ecosystems*. *2*, 11.

Pasqualini, V., Pergent-Martini, C., Clabaut, P., & Pergent, G. (1998). Mapping ofPosidonia oceanicausing Aerial Photographs and Side Scan Sonar: Application off the Island of Corsica (France). *Estuarine, Coastal and Shelf Science*, *47*(3), 359–367. https://doi.org/10.1006/ecss.1998.0361

Pasta, S., de Rigo, D., & Caudullo, G. (2016). *Quercus pubescens in Europe: distribution, habitat, usage and threats*. 3.

Pautasso, M., Holdenrieder, O., & Stenlid, J. (2005). Susceptibility to Fungal Pathogens of Forests Differing in Tree Diversity. In M. Scherer-Lorenzen, C. Körner, & E.-D. Schulze (Eds.), *Forest Diversity and Function: Temperate and Boreal Systems* (pp. 263–289). Springer Berlin Heidelberg. https://doi.org/10.1007/3-540-26599-6_13

Peijnenburg, K. T. C. A., & Goetze, E. (2013). High evolutionary potential of marine zooplankton. *Ecology and Evolution*, *3*(8), 2765–2781. https://doi.org/10.1002/ece3.644

Peirano, A., Niccolai, I., Mauro, R., & Bianchi, C. N. (2001). Seasonal grazing and food preference of herbivores in a Posidonia oceanica meadow. *Scientia Marina*, *65*(4), 367–374. https://doi.org/10.3989/scimar.2001.65n4367

Peixoto, R. S., Rosado, P. M., Leite, D. C. de A., Rosado, A. S., & Bourne, D. G. (2017). Beneficial Microorganisms for Corals (BMC): Proposed Mechanisms for Coral Health and Resilience. *Frontiers in Microbiology*, *8*. https://doi.org/10.3389/fmicb.2017.00341

Perez, T., Garrabou, J., Sartoretto, S., Harmelin, J.-G., Francour, P., & Vacelet, J. (2000). Mortalité massive d'invertébrés marins : un événement sans précédent en Méditerranée nord-occidentale. *Comptes Rendus de l'Académie Des Sciences - Series III - Sciences de La Vie*, *323*(10), 853–865. https://doi.org/10.1016/S0764-4469(00)01237-3

Pérez-Portela, R., Cerro-Gálvez, E., Taboada, S., Tidu, C., Campillo-Campbell, C., Mora, J., & Riesgo, A. (2016). Lonely populations in the deep: genetic structure of red gorgonians at the heads of submarine canyons in the north-western Mediterranean Sea. *Coral Reefs*, *35*(3), 1013–1026. https://doi.org/10.1007/s00338-016-1431-2

Pergent, G., Bazairi, H., Bianchi, C. N., Boudouresque, C. F., Buia, M. C., Calvo, S., Clabaut, P., Harmelin-Vivien, M., Mateo, M. A., Montefalcone, M., Morri, C., Orfanidis, S., Pergent-Martini, C., Semroud, R., Serrano, O., Thibaut, T., Tomasello, A., & Verlaque, M. (2014). Climate change and Mediterranean seagrass meadows: a synopsis for environmental managers. *Mediterranean Marine Science*, *15*(2), 462–473. https://doi.org/10.12681/mms.621

Pergent, Gérard, & Pergent-Martini, C. (1991). Leaf renewal cycle and primary production ofPosidonia oceanica in the bay of Lacco Ameno (Ischia, Italy) using lepidochronological analysis. *Aquatic Botany*, *42*(1), 49–66. https://doi.org/10.1016/0304-3770(91)90105-E

Pergent, Gérard, Rico-Raimondino, V., & Pergent-Martini, C. (1997). Fate of primary production in Posidonia oceanica meadows of the Mediterranean. *Aquatic Botany*, *59*(3), 307–321. https://doi.org/10.1016/S0304-3770(97)00052-1

Pergent-Martini, C., Boudouresque, C.-F., Pasqualini, V., & Pergent, G. (2006). Impact of fish farming facilities on Posidonia oceanica meadows: a review. *Marine Ecology*, *27*(4), 310–319. https://doi.org/10.1111/j.1439-0485.2006.00122.x

Perrier, C., & Charmantier, A. (2019). On the importance of time scales when studying adaptive evolution. *Evolution Letters*, *3*(3), 240–247. https://doi.org/10.1002/evl3.86

Personnic, S., Boudouresque, C. F., Astruch, P., Ballesteros, E., Blouet, S., Bellan-Santini, D., Bonhomme, P., Thibault-Botha, D., Feunteun, E., Harmelin-Vivien, M., Pergent, G., Pergent-Martini, C., Pastor, J., Poggiale, J.-C., Renaud, F., Thibaut, T., & Ruitton, S. (2014). An Ecosystem-Based Approach to Assess the Status of a Mediterranean Ecosystem, the Posidonia oceanica Seagrass Meadow. *PLOS ONE*, *9*(6), e98994. https://doi.org/10.1371/journal.pone.0098994

Pinto-Correia, T., & Vos, W. (2004). Multifonctionality in Mediterranean landscapes - Past and future. In *The new dimensions of the European landscape, 4, 135-164.*

Pivotto, Nerini D., Masmoudi M., Kara H., Chaoui L., & Aurelle D. (2015). Highly contrasted responses of Mediterranean octocorals to climate change along a depth gradient. *Royal Society Open Science*, *2*(5), 140493. https://doi.org/10.1098/rsos.140493

Polyakova, O., & Billor, N. (2007). Impact of deciduous tree species on litterfall quality, decomposition rates and nutrient circulation in pine stands. *Forest Ecology and Management*, *253*(1), 11–18. https://doi.org/10.1016/j.foreco.2007.06.049

Porras-Soriano, A., Soriano-Martín, M. L., Porras-Piedra, A., & Azcón, R. (2009). Arbuscular mycorrhizal fungi increased growth, nutrient uptake and tolerance to salinity in olive trees under nursery conditions. *Journal of Plant Physiology*, *166*(13), 1350–1359. https://doi.org/10.1016/j.jplph.2009.02.010

Prada, F., Caroselli, E., Mengoli, S., Brizi, L., Fantazzini, P., Capaccioni, B., Pasquini, L., Fabricius, K. E., Dubinsky, Z., Falini, G., & Goffredo, S. (2017). Ocean warming and acidification synergistically increase coral mortality. *Scientific Reports*, *7*, 40842. https://doi.org/10.1038/srep40842

Pratlong, M., Haguenauer, A., Chabrol, O., Klopp, C., Pontarotti, P., & Aurelle, D. (2015). The red coral (Corallium rubrum) transcriptome: a new resource for population genetics and local adaptation studies. *Molecular Ecology Resources*, *15*(5), 1205–1215. https://doi.org/10.1111/1755-0998.12383

Pratlong, Marine, Haguenauer, A., Brener, K., Mitta, G., Toulza, E., Garrabou, J., Bensoussan, N., Pontarotti, P., & Aurelle, D. (2018). Separate the wheat from the chaff: genomic analysis of local adaptation in the red coral Corallium rubrum. *BioRxiv*, 306456. https://doi.org/10.1101/306456

Prescott, C. E., & Grayston, S. J. (2013). Tree species influence on microbial communities in litter and soil: Current knowledge and research needs. *Forest Ecology and Management*, *309*, 19–27. https://doi.org/10.1016/j.foreco.2013.02.034

Procaccini, G., Orsini, L., Ruggiero, M. V., & Scardi, M. (2001). Spatial patterns of genetic diversity in Posidonia oceanica, an endemic Mediterranean seagrass. *Molecular Ecology*, *10*(6), 1413–1421. https://doi.org/10.1046/j.1365-294X.2001.01290.x

Puerta-Piñero, C., Espelta, J. M., Sánchez-Humanes, B., Rodrigo, A., Coll, L., & Brotons, L. (2012). History matters: Previous land use changes determine post-fire vegetation recovery in forested Mediterranean landscapes. *Forest Ecology and Management*, *279*, 121–127. https://doi.org/10.1016/j.foreco.2012.05.020

Puigdefábregas, J., & Mendizabal, T. (1998). Perspectives on desertification: western Mediterranean. *Journal of Arid Environments*, *39*(2), 209–224. https://doi.org/10.1006/jare.1998.0401

Quéré, C. L., Moriarty, R., Andrew, R. M., Canadell, J. G., Sitch, S., Korsbakken, J. I., Friedlingstein, P., Peters, G. P., Andres, R. J., Boden, T. A., Houghton, R. A., House, J. I., Keeling, R. F., Tans, P., Arneth, A., Bakker, D. C. E., Barbero, L., Bopp, L., Chang, J., … Zeng, N. (2015). *Global Carbon Budget 2015* [Text]. https://doi.org/info:doi/10.5194/essd-7-349-2015

Quézel, P., & Médail, F. (2003). Ecologie et biogéographie des forêts du bassin méditerranéen. *Paris: Éditions Scientifiques et Médicales Elsevier SAS*.

Regaudie-de-Gioux, A., Agustí, S., & Duarte, C. M. (2014). UV sensitivity of planktonic net community production in ocean surface waters. *Journal of Geophysical Research: Biogeosciences*, *119*(5), 929–936. https://doi.org/10.1002/2013JG002566

Regos, A., D'Amen, M., Herrando, S., Guisan, A., & Brotons, L. (2015). Fire management, climate change and their interacting effects on birds in complex Mediterranean landscapes: dynamic distribution modelling of an early-successional species—the near-threatened Dartford Warbler (Sylvia undata). *Journal of Ornithology*, *156*(1), 275–286. https://doi.org/10.1007/s10336-015-1174-9

Reid, P. C. (2000). Plankton, fisheries and climate change - insights into ocean ecosystems. In B. Earll (Ed.), *Coastal Management for Sustainability - Review and Future Trends. Proceedings of a meeting held February 9th-10th 2000, London* (Vol. 7, pp. 63–68). Bob Earll. http://www.coastms.co.uk/

Reusch, T. B. H., & Boyd, P. W. (2013). Experimental Evolution Meets Marine Phytoplankton. *Evolution*, *67*(7), 1849–1859. https://doi.org/10.1111/evo.12035

Reynolds, J. F., Smith, D. M. S., Lambin, E. F., Turner, B. L., Mortimore, M., Batterbury, S. P. J., Downing, T. E., Dowlatabadi, H., Fernández, R. J., Herrick, J. E., Huber-Sannwald, E., Jiang, H., Leemans, R., Lynam, T., Maestre, F. T., Ayarza, M., & Walker, B. (2007). Global Desertification: Building a Science for Dryland Development. *Science*, *316*(5826), 847–851. https://doi.org/10.1126/science.1131634

Richard, F., Roy, M., Shahin, O., Sthultz, C., Duchemin, M., Joffre, R., & Selosse, M.-A. (2011). Ectomycorrhizal communities in a Mediterranean forest ecosystem dominated by Quercus ilex: seasonal dynamics and response to drought in the surface organic horizon. *Annals of Forest Science*, *68*(1), 57–68. https://doi.org/10.1007/s13595-010-0007-5

Richardson, A. J. (2008). In hot water: zooplankton and climate change. *ICES Journal of Marine Science*, *65*(3), 279–295. https://doi.org/10.1093/icesjms/fsn028

Richon, C., Dutay, J.-C., Dulac, F., Wang, R., Balkanski, Y., Nabat, P., Aumont, O., Desboeufs, K., Laurent, B., Guieu, C., Raimbault, P., & Beuvier, J. (2018). Modeling the impacts of atmospheric deposition of nitrogen and desert dust-derived phosphorus on nutrients and biological budgets of the Mediterranean Sea. *Progress in Oceanography*, *163*, 21–39. https://doi.org/10.1016/j.pocean.2017.04.009

Rijnsdorp, A. D., Peck, M. A., Engelhard, G. H., Möllmann, C., & Pinnegar, J. K. (2009). Resolving the effect of climate change on fish populations. *ICES Journal of Marine Science*, *66*(7), 1570–1583. https://doi.org/10.1093/icesjms/fsp056

Rivetti, I., Fraschetti, S., Lionello, P., Zambianchi, E., & Boero, F. (2014). Global Warming and Mass Mortalities of Benthic Invertebrates in the Mediterranean Sea. *PLOS ONE*, *9*(12), e115655. https://doi.org/10.1371/journal.pone.0115655

Rodolfo-Metalpa, R., Houlbrèque, F., Tambutté, É., Boisson, F., Baggini, C., Patti, F. P., Jeffree, R., Fine, M., Foggo, A., Gattuso, J.-P., & Hall-Spencer, J. M. (2011). Coral and mollusc resistance to ocean acidification adversely affected by warming. *Nature Climate Change*, *1*(6), 308–312. https://doi.org/10.1038/nclimate1200

Rodolfo-Metalpa, R., Lombardi, C., Cocito, S., Hall-Spencer, J. M., & Gambi, M. C. (2010). Effects of ocean acidification and high temperatures on the bryozoan Myriapora truncata at natural CO2 vents. *Marine Ecology*, *31*(3), 447–456. https://doi.org/10.1111/j.1439-0485.2009.00354.x

Rodríguez, E., Fernández-Anero, F. J., Ruiz, P., & Campos, M. (2006). Soil arthropod abundance under conventional and no tillage in a Mediterranean climate. *Soil and Tillage Research*, *85*(1), 229–233. https://doi.org/10.1016/j.still.2004.12.010

Rodríguez-Loinaz, G., Onaindia, M., Amezaga, I., Mijangos, I., & Garbisu, C. (2008). Relationship between vegetation diversity and soil functional diversity in native mixed-oak forests. *Soil Biology and Biochemistry*, *40*(1), 49–60. https://doi.org/10.1016/j.soilbio.2007.04.015

Rodríguez-Prieto, C. (2016). Light and temperature requirements for survival, growth and reproduction of the crustose coralline Lithophyllum stictaeforme from the Mediterranean Sea. *Botanica Marina*, *59*(2–3), 95–104. https://doi.org/10.1515/bot-2015-0070

Rodriguez-Ramirez, N., Santonja, M., Baldy, V., Ballini, C., & Montès, N. (2017). Shrub species richness decreases negative impacts of drought in a Mediterranean ecosystem. *Journal of Vegetation Science*, *28*(5), 985–996. https://doi.org/10.1111/jvs.12558

Roesch, L. F. W., Fulthorpe, R. R., Riva, A., Casella, G., Hadwin, A. K. M., Kent, A. D., Daroub, S. H., Camargo, F. A. O., Farmerie, W. G., & Triplett, E. W. (2007). Pyrosequencing enumerates and contrasts soil microbial diversity. *The ISME Journal*, *1*(4), 283–290. https://doi.org/10.1038/ismej.2007.53

Rollan, À., Hernández-Matías, A., & Real, J. (2019). Organic farming favours bird communities and their resilience to climate change in Mediterranean vineyards. *Agriculture, Ecosystems & Environment*, *269*, 107–115. https://doi.org/10.1016/j.agee.2018.09.029

Römermann, C., Dutoit, T., Poschlod, P., & Buisson, E. (2005). Influence of former cultivation on the unique Mediterranean steppe of France and consequences for conservation management. *Biological Conservation*, *121*(1), 21–33. https://doi.org/10.1016/j.biocon.2004.04.006

Roschanski, A. M., Csilléry, K., Liepelt, S., Oddou-Muratorio, S., Ziegenhagen, B., Huard, F., Ullrich, K. K., Postolache, D., Vendramin, G. G., & Fady, B. (2016). Evidence of divergent selection for drought and

cold tolerance at landscape and local scales in Abies alba Mill. in the French Mediterranean Alps. *Molecular Ecology*, *25*(3), 776–794. https://doi.org/10.1111/mec.13516

Rovira, P., & Ramón Vallejo, V. (2007). Labile, recalcitrant, and inert organic matter in Mediterranean forest soils. *Soil Biology and Biochemistry*, *39*(1), 202–215. https://doi.org/10.1016/j.soilbio.2006.07.021

Ruggiero, M. V., Turk, R., & Procaccini, G. (2002). Genetic identity and homozygosity in North-Adriatic populations of Posidonia oceanica: An ancient, post-glacial clone? *Conservation Genetics*, *3*(1), 69–72. https://doi.org/10.1023/A:1014207122382

Ruiz, J. M., & Romero, J. (2003). Effects of disturbances caused by coastal constructions on spatial structure, growth dynamics and photosynthesis of the seagrass Posidonia oceanica. *Marine Pollution Bulletin*, *46*(12), 1523–1533. https://doi.org/10.1016/j.marpolbul.2003.08.021

Rypstra, A. L., Carter, P. E., Balfour, R. A., & Marshall, S. D. (1999). Architectural Features of Agricultural Habitats and Their Impact on the Spider Inhabitants. *The Journal of Arachnology*, *27*(1), 371–377. JSTOR.

Saatkamp, A., Affre, L., Dutoit, T., & Poschlod, P. (2009). What tell us seed counts in soil samples about seed persistence?-evidence from a burial experiment with rare arable weeds. *Annals of Botany*, *104*, 715–724.

Santangelo, G., Cupido, R., Cocito, S., Bramanti, L., Priori, C., Erra, F., & Iannelli, M. (2015). Effects of increased mortality on gorgonian corals (Cnidaria, Octocorallia): different demographic features may lead affected populations to unexpected recovery and new equilibrium points. *Hydrobiologia*, *759*(1), 171–187. https://doi.org/10.1007/s10750-015-2241-1

Santonja, M., Foucault, Q., Rancon, A., Gauquelin, T., Fernandez, C., Baldy, V., & Mirleau, P. (2018). Contrasting responses of bacterial and fungal communities to plant litter diversity in a Mediterranean oak forest. *Soil Biology and Biochemistry*, *125*, 27–36. https://doi.org/10.1016/j.soilbio.2018.06.020

Santonja, M., Rancon, A., Fromin, N., Baldy, V., Hättenschwiler, S., Fernandez, C., Montès, N., & Mirleau, P. (2017). Plant litter diversity increases microbial abundance, fungal diversity, and carbon and nitrogen cycling in a Mediterranean shrubland. *Soil Biology and Biochemistry*, *111*, 124–134. https://doi.org/10.1016/j.soilbio.2017.04.006

Sardans, J., & Peñuelas, J. (2005). Drought decreases soil enzyme activity in a Mediterranean Quercus ilex L. forest. *Soil Biology and Biochemistry*, *37*(3), 455–461. https://doi.org/10.1016/j.soilbio.2004.08.004

Sartoretto, S. (1996). *Vitesses de croissance et de bioérosion des concrétionnements «coralligènes» de Méditerranée nord-occidentale. Rapport avec les variations Holocènes du niveau marin* [PhD Thesis].

Saunier, A., Ormeño, E., Havaux, M., Wortham, H., Ksas, B., Temime-Roussel, B., Blande, J. D., Lecareux, C., Mévy, J.-P., Bousquet-Mélou, A., Gauquelin, T., & Fernandez, C. (2018). Resistance of native oak to recurrent drought conditions simulating predicted climatic changes in the Mediterranean region. *Plant, Cell & Environment*, *41*(10), 2299–2312. https://doi.org/10.1111/pce.13331

Sauphanor, B., Simon, S., Boisneau, C., Capowiez, Y., Rieux, R., Bouvier, J.-C., Defrance, H., Picard, C., & Toubon, J.-F. (2009). Protection phytosanitaire et biodiversité en agriculture biologique. Le cas des vergers de pommiers. *Innovations Agronomiques*, *4*, 217–228.

Scheibe, A., Steffens, C., Seven, J., Jacob, A., Hertel, D., Leuschner, C., & Gleixner, G. (2015). Effects of tree identity dominate over tree diversity on the soil microbial community structure. *Soil Biology and Biochemistry*, *81*, 219–227. https://doi.org/10.1016/j.soilbio.2014.11.020

Scheu, S. (2002). The soil food web: structure and perspectives. *European Journal of Soil Biology*, *38*(1), 11–20. https://doi.org/10.1016/S1164-5563(01)01117-7

Schiller, G., & Atzmon, N. (2009). Performance of Aleppo pine (Pinus halepensis) provenances grown at the edge of the Negev desert: A review. *Journal of Arid Environments*, *73*(12), 1051–1057. https://doi.org/10.1016/j.jaridenv.2009.06.003

Schimel, J., Balser, T. C., & Wallenstein, M. (2007). Microbial Stress-Response Physiology and Its Implications for Ecosystem Function. *Ecology*, *88*(6), 1386–1394. https://doi.org/10.1890/06-0219

Schmidt, M. W. I., Torn, M. S., Abiven, S., Dittmar, T., Guggenberger, G., Janssens, I. A., Kleber, M., Kögel-Knabner, I., Lehmann, J., Manning, D. A. C., Nannipieri, P., Rasse, D. P., Weiner, S., & Trumbore, S. E.

(2011). Persistence of soil organic matter as an ecosystem property. *Nature*, *478*(7367), 49–56. https://doi.org/10.1038/nature10386

Schmitt, A., Glaser, B., Borken, W., & Matzner, E. (2010). Organic matter quality of a forest soil subjected to repeated drying and different re-wetting intensities. *European Journal of Soil Science*, *61*(2), 243–254. https://doi.org/10.1111/j.1365-2389.2010.01230.x

Serra, I. A., Innocenti, A. M., Maida, G. D., Calvo, S., Migliaccio, M., Zambianchi, E., Pizzigalli, C., Arnaud-Haond, S., Duarte, C. M., Serrao, E. A., & Procaccini, G. (2010). Genetic structure in the Mediterranean seagrass Posidonia oceanica: disentangling past vicariance events from contemporary patterns of gene flow. *Molecular Ecology*, *19*(3), 557–568. https://doi.org/10.1111/j.1365-294X.2009.04462.x

Setiawan, N. N., Vanhellemont, M., De Schrijver, A., Schelfhout, S., Baeten, L., & Verheyen, K. (2016). Mixing effects on litter decomposition rates in a young tree diversity experiment. *Acta Oecologica*, *70*, 79–86. https://doi.org/10.1016/j.actao.2015.12.003

Sini, M., Kipson, S., Linares, C., Koutsoubas, D., & Garrabou, J. (2015). The Yellow Gorgonian Eunicella cavolini: Demography and Disturbance Levels across the Mediterranean Sea. *PLOS ONE*, *10*(5), e0126253. https://doi.org/10.1371/journal.pone.0126253

Siokou-Frangou, I., Christaki, Mazzocchi, Montresor, d'Alcalá, Ribera, Vaqué, & Zingone. (2009). Plankton in the open Mediterranean Sea: a review. *Biogeosciences Discussions* . *2009, Vol. 6 Issue 6, P11187-11293. 106p.*, 11187–11293.

Sirami, C., Brotons, L., Burfield, I., Fonderflick, J., & Martin, J.-L. (2008). Is land abandonment having an impact on biodiversity? A meta-analytical approach to bird distribution changes in the north-western Mediterranean. *Biological Conservation*, *141*(2), 450–459. https://doi.org/10.1016/j.biocon.2007.10.015

Sparling, G. P., Milne, J. D. G., & Vincent, K. W. (1987). Effect of soil moisture regime on the microbial contribution to Olsen phosphorus values. *New Zealand Journal of Agricultural Research*, *30*(1), 79–84. https://doi.org/10.1080/00288233.1987.10430480

Stojanovic, M. (2019). Conceptualization of Ecological Management: Practice, Frameworks and Philosophy. *Journal of Agricultural and Environmental Ethics*, *32*(3), 431–446. https://doi.org/10.1007/s10806-019-09783-2

Suseela, V., & Tharayil, N. (2018). Decoupling the direct and indirect effects of climate on plant litter decomposition: Accounting for stress-induced modifications in plant chemistry. *Global Change Biology*, *24*(4), 1428–1451. https://doi.org/10.1111/gcb.13923

Svetlichny, L. S., Hubareva, E. S., Erkan, F., & Gucu, A. C. (2000). Physiological and behavioral aspects of Calanus euxinus females (Copepoda: Calanoida) during vertical migration across temperature and oxygen gradients. *Marine Biology*, *137*(5), 963–971. https://doi.org/10.1007/s002270000405

Swift, M. J., Izac, A.-M. N., & van Noordwijk, M. (2004). Biodiversity and ecosystem services in agricultural landscapes—are we asking the right questions? *Agriculture, Ecosystems & Environment*, *104*(1), 113–134. https://doi.org/10.1016/j.agee.2004.01.013

Talas, F., Longin, F., & Miedaner, T. (2011). Sources of resistance to Fusarium head blight within Syrian durum wheat landraces. *Plant Breeding*, *130*(3), 398–400. https://doi.org/10.1111/j.1439-0523.2011.01867.x

Tardy, F. (2015). *Caractérisation fonctionnelle des stratégies de compétition pour les ressources aériennes et souterraines au sein d'une gamme d'espèces végétales : application à la régulation biologique des adventices par les plantes de services dans l'agrosystème bananier antillais* [Phdthesis, Université de Montpellier]. https://tel.archives-ouvertes.fr/tel-01243264/document

Tatoni, T., & Roche, P. (1994). Comparison of old-field and forest revegetation dynamics in Provence. *Journal of Vegetation Science*, *5*(3), 295–302. https://doi.org/10.2307/3235852

Tedersoo, L., Bahram, M., Cajthaml, T., Põlme, S., Hiiesalu, I., Anslan, S., Harend, H., Buegger, F., Pritsch, K., Koricheva, J., & Abarenkov, K. (2016). Tree diversity and species identity effects on soil fungi, protists and animals are context dependent. *The ISME Journal*, *10*(2), 346–362. https://doi.org/10.1038/ismej.2015.116

Telesca, L., Belluscio, A., Criscoli, A., Ardizzone, G., Apostolaki, E. T., Fraschetti, S., Gristina, M., Knittweis, L., Martin, C. S., Pergent, G., Alagna, A., Badalamenti, F., Garofalo, G., Gerakaris, V., Louise Pace, M., Pergent-Martini, C., & Salomidi, M. (2015). Seagrass meadows (*Posidonia oceanica*) distribution and trajectories of change. *Scientific Reports*, *5*, 12505. https://doi.org/10.1038/srep12505

Thomas, M. K., Kremer, C. T., Klausmeier, C. A., & Litchman, E. (2012). A global pattern of thermal adaptation in marine phytoplankton. *Science*, *338*(6110), 1085–1088.

Tomasello, A., Maida, G. D., Calvo, S., Pirrotta, M., Borra, M., & Procaccini, G. (2009). Seagrass meadows at the extreme of environmental tolerance: the case of Posidonia oceanica in a semi-enclosed coastal lagoon. *Marine Ecology*, *30*(3), 288–300. https://doi.org/10.1111/j.1439-0485.2009.00285.x

Topçu, E. N., & Öztürk, B. (2015). Composition and abundance of octocorals in the Sea of Marmara, where the Mediterranean meets the Black Sea. *Scientia Marina*, *79*(1), 125–135. https://doi.org/10.3989/scimar.04120.09A

Torrents, O., Garrabou, J., Marschal, C., & Harmelin, J. G. (2005). Age and size at first reproduction in the commercially exploited red coral Corallium rubrum (L.) in the Marseilles area (France, NW Mediterranean). *Biological Conservation*, *121*(3), 391–397. https://doi.org/10.1016/j.biocon.2004.05.010

Torrents, O., Tambutté, E., Caminiti, N., & Garrabou, J. (2008). Upper thermal thresholds of shallow vs. deep populations of the precious Mediterranean red coral Corallium rubrum (L.): Assessing the potential effects of warming in the NW Mediterranean. *Journal of Experimental Marine Biology and Ecology*, *357*(1), 7–19. https://doi.org/10.1016/j.jembe.2007.12.006

Valladares, F., Balaguer, L., Martinez-Ferri, E., Perez-Corona, E., & Manrique, E. (2002). Plasticity, instability and canalization: is the phenotypic variation in seedlings of sclerophyll oaks consistent with the environmental unpredictability of Mediterranean ecosystems? *New Phytologist*, *156*(3), 457–467. https://doi.org/10.1046/j.1469-8137.2002.00525.x

van de Water, J. A. J. M., Allemand, D., & Ferrier-Pagès, C. (2018a). Host-microbe interactions in octocoral holobionts - recent advances and perspectives. *Microbiome*, *6*(1), 64. https://doi.org/10.1186/s40168-018-0431-6

van de Water, J. A. J. M., Melkonian, R., Junca, H., Voolstra, C. R., Reynaud, S., Allemand, D., & Ferrier-Pagès, C. (2016). Spirochaetes dominate the microbial community associated with the red coral *Corallium rubrum* on a broad geographic scale. *Scientific Reports*, *6*, 27277. https://doi.org/10.1038/srep27277

van de Water, J. A. J. M., Melkonian, R., Voolstra, C. R., Junca, H., Beraud, E., Allemand, D., & Ferrier-Pagès, C. (2017). Comparative Assessment of Mediterranean Gorgonian-Associated Microbial Communities Reveals Conserved Core and Locally Variant Bacteria. *Microbial Ecology*, *73*(2), 466–478. https://doi.org/10.1007/s00248-016-0858-x

van de Water, J. A. J. M., Voolstra, C. R., Rottier, C., Cocito, S., Peirano, A., Allemand, D., & Ferrier-Pagès, C. (2018b). Seasonal Stability in the Microbiomes of Temperate Gorgonians and the Red Coral Corallium rubrum Across the Mediterranean Sea. *Microbial Ecology*, *75*(1), 274–288. https://doi.org/10.1007/s00248-017-1006-y

Van Gestel, M., Merckx, R., & Vlassak, K. (1993). Microbial biomass responses to soil drying and rewetting: The fate of fast- and slow-growing microorganisms in soils from different climates. *Soil Biology and Biochemistry*, *25*(1), 109–123. https://doi.org/10.1016/0038-0717(93)90249-B

van Oppen, M. J. H. van, Oliver, J. K., Putnam, H. M., & Gates, R. D. (2015). Building coral reef resilience through assisted evolution. *Proceedings of the National Academy of Sciences*, *112*(8), 2307–2313. https://doi.org/10.1073/pnas.1422301112

Vaquer-Sunyer, R., & Duarte, C. M. (2008). Thresholds of hypoxia for marine biodiversity. *Proceedings of the National Academy of Sciences*, *105*(40), 15452–15457. https://doi.org/10.1073/pnas.0803833105

Vela, A., Pasqualini, V., Leoni, V., Djelouli, A., Langar, H., Pergent, G., Pergent-Martini, C., Ferrat, L., Ridha, M., & Djabou, H. (2008). Use of SPOT 5 and IKONOS imagery for mapping biocenoses in a Tunisian Coastal Lagoon (Mediterranean Sea). *Estuarine, Coastal and Shelf Science*, *79*(4), 591–598. https://doi.org/10.1016/j.ecss.2008.05.014

Vezzulli, L., Colwell, R. R., & Pruzzo, C. (2013). Ocean Warming and Spread of Pathogenic Vibrios in the Aquatic Environment. *Microbial Ecology*, *65*(4), 817–825. https://doi.org/10.1007/s00248-012-0163-2

Vezzulli, L., Previati, M., Pruzzo, C., Marchese, A., Bourne, D. G., & Cerrano, C. (2010). Vibrio infections triggering mass mortality events in a warming Mediterranean Sea. *Environmental Microbiology*, *12*(7), 2007–2019. https://doi.org/10.1111/j.1462-2920.2010.02209.x

Vilà, M., Vayreda, J., Comas, L., Ibáñez, J. J., Mata, T., & Obón, B. (2007). Species richness and wood production: a positive association in Mediterranean forests. *Ecology Letters*, *10*(3), 241–250. https://doi.org/10.1111/j.1461-0248.2007.01016.x

Vitelli, M., Vessella, F., Cardoni, S., Pollegioni, P., Denk, T., Grimm, G. W., & Simeone, M. C. (2016). Phylogeographic structuring of plastome diversity in Mediterranean oaks (Quercus Group Ilex, Fagaceae). *Tree Genetics & Genomes*, *13*(1), 3. https://doi.org/10.1007/s11295-016-1086-8

Von Wuehlisch, G. (2008). EUFORGEN Technical Guidelines for genetic conservation and use for European beech (Fagus sylvatica). *Bioversity International, Rome, Italy*, 6.

Wardle, D. A., & Jonsson, M. (2014). Long-term resilience of above- and belowground ecosystem components among contrasting ecosystems. *Ecology*, *95*(7), 1836–1849. https://doi.org/10.1890/13-1666.1

Wirth, C. (2005). Fire Regime and Tree Diversity in Boreal Forests: Implications for the Carbon Cycle. In M. Scherer-Lorenzen, C. Körner, & E.-D. Schulze (Eds.), *Forest Diversity and Function: Temperate and Boreal Systems* (pp. 309–344). Springer Berlin Heidelberg. https://doi.org/10.1007/3-540-26599-6_15

Wolf, H. (2003). *EUFORGEN Technical Guidelines for genetic conservation and use for for silver fir (Abies alba)*. Bioversity International.

Wu, D., Li, T., & Wan, S. (2013). Time and litter species composition affect litter-mixing effects on decomposition rates. *Plant and Soil*, *371*(1), 355–366. https://doi.org/10.1007/s11104-013-1697-x

Yao, S.-H., Zhang, B., & Hu, F. (2011). Soil biophysical controls over rice straw decomposition and sequestration in soil: The effects of drying intensity and frequency of drying and wetting cycles. *Soil Biology and Biochemistry*, *43*(3), 590–599. https://doi.org/10.1016/j.soilbio.2010.11.027

Zimmer, M. (2002). Is decomposition of woodland leaf litter influenced by its species richness? *Soil Biology and Biochemistry*, *34*(2), 277–284. https://doi.org/10.1016/S0038-0717(01)00173-0