CALIFORNIA FIRE SCIENCE CONSORTIUM

JOINT FIRE SCIENCE PROGRAM

Research Brief for Resource Managers

Release:	Contact:	Phone:	Email:
April 2016	Jon E. Keeley	(559) 565-3170	*jon_keeley@usgs.gov*
	Marti Witter	(805) 370-2333	*marti_witter@nps.gov*
	Liz van Mantgem		*evanmantgem@usgs.gov*

Central and Southern California Team, USGS Sequoia and Kings Canyon Field Station, Three Rivers, CA 93271

Convergent Evolution for Differing MTE Biomes

Rundel, P.W., M.T.K. Arroyo, R.M. Cowling, J.E. Keeley, B.B. Lamont, P. Vargas. 2016. Mediterranean biomes: evolution of their vegetation, floras, and climate. Annual Review of Ecology, Evolution, and Systematics 47:383-407. doi: 10.1146/annurev-ecolsys-121415-032330

Management Implications

- Stable Mediterranean type climate, time to adapt, and predictable fire regimes have resulted in evolutionary convergence among these otherwise disparate Mediterranean Type Ecosystems (MTEs). The evidence for this convergence is similar community function with analogous vegetation.
- While speciation rates differ dramatically among the five MTEs, all owe their high species richness and endemism to very low extinction rates. That is, these MTEs retain high persistence of species at very fine spatial scales.
- All five of these MTEs are classified as **biodiversity hotspots** for two reasons**:** they have extremely high species richness and they are threatened by human impacts.

There are five distinguished **Mediterranean Type Ecosystems (MTEs)** distributed throughout the world (Fig.1). Despite their dissimilar locations and geologic histories, their differing climatic histories, and other unique ecological factors, these systems evolutionarily converged in function with five analogous vegetation types. There is *kwongan* in southwest Australia (SWA), *fynbos* in the Cape region of Africa, *maquis* in the Mediterranean Basin (MB), *chaparral* in California (CA; Fig. 6), and *mattoral* in central Chile. Boasting very low extinction rates in similar Mediterranean type climates (MTCs), each of these MTEs is now host to more biodiversity and endemism at all spatial scales than every other terrestrial ecosystem outside of the wet tropics (Fig. 2).

With relatively gradual species diversification rates, the SWA and Cape regions owe most of their diversity to older vegetation lineages that evolved in nutrient poor (aka edaphic "ghettos"), climate buffered and fire-prone landscapes of the aseasonal Cretacious period (145-66Ma). These origins occurred well before our modern, seasonal, Mediterranean type climates (MTCs) and cold ocean currents were established.

In contrast, the MB, CA, and central Chile MTEs owe most of their species richness to younger vegetation lineages and faster species diversification rates since the development of global seasonality during the mid-Miocene epoch (15-6 Ma; within the Neogene period, 23-2.58 Ma). This newer diversity is the direct result of species immigrations, and active plate tectonics, as well as the relatively novel MTC and ocean

currents. For the MB and CA, it is also the result of the predictably seasonal crown fire regimes that came with the MTC.

Of all the MTE biomes, the Cape region of Africa is the richest in plant species per area while central Chile is the poorest per area (Fig. 2). The relatively low species richness of Chile comes from biogeographic isolation (d/t Atacama Desert and Andes Mts.) and the lack of a fire regime.

There are many other important differences among the five MTE biomes. For instance, CA and Chile have the longest, driest summers with the greatest interannual variation in precipitation. The Cape and SWA have the least interannual variation, with small but significant amounts of winter rain, while the MB is intermediate in winter precipitation among the five MTEs. More detailed descriptions of the specific pressures causing both species diversification and convergence in each MTE is included in the paper, along with a beautiful set of representative photos for each biome (e.g., see Fig.6).

Figure 1
Global occurrence of mediterranean-type ecosystems: southwestern Australia, the Cape Region, Mediterranean Basin, California, and central Chile. Figure courtesy of the U.S. National Park Service.

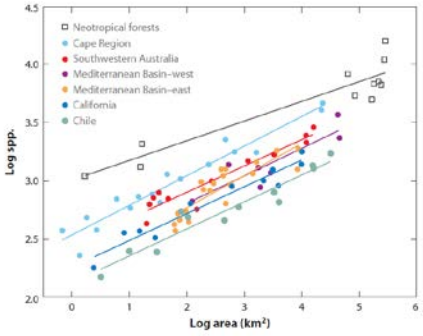

Figure 2
Plant species–area relationships for six mediterranean-type ecosystems (MTEs) and neotropical forests. Note the Mediterranean Basin is divided into western (Iberia) and eastern (Greece) sectors. Slopes of regression curves are homogeneous among MTEs, but the slope for neotropical rainforests is significantly shallower than those for MTEs, suggesting that at larger areas there is convergence in richness between the richest MTEs (Cape and southwestern Australia) and neotropical forests. Data from Cowling et al. (2015).

Figure 6
California. Centerpiece, chaparral in the San Gabriel Mountains of southern California. From upper left clockwise: *Ceanothus megacarpus* (Rhamnaceae), *Heteromeles arbutifolia* (Rosaceae), *Malosma laurina* (Anacardiaceae), *Adenostoma fasciculatum* (Rosaceae), *Hesperoyucca whipplei* (Asparagaceae), *Ribes speciosum* (Grossulariaceae), *Eriogonum fasciculatum* (Polygonaceae), *Quercus berberidifolia* (Fagaceae), *Encelia californica* (Asteraceae), *Salvia mellifera* (Lamiaceae), and *Arctostaphylos bookeri* (Ericaceae).