

forest management

Projecting Nonnative Douglas Fir Plantations in Southern Europe with the Forest Vegetation Simulator

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In Italy, Douglas-fir has great potential in terms of wood production and drought tolerance. However, a growth reference for mature stands is lacking. We calibrated and validated the Pacific Northwest variant of the Forest Vegetation Simulator (FVS) for Douglas-fir plantations in Italy and then ran the calibrated model to test management alternatives. We calibrated the height-diameter, crown width, crown ratio, and diameter increment submodels of the FVS using multipliers fitted against tree measurements ($n = 704$) and increment cores ($n = 180$) from 20 plots. Validation was carried out on tree-level variables sampled in 1996 and 2015 in two independent permanent plots (275 trees). Multiplier calibration improved the error of crown submodels by 7–19%; self-calibration of the diameter growth submodel produced scale factors of 1.0–5.2 for each site. Validation of 20-year simulations was more satisfactory for tree diameter (–6% to +1% mean percent error) than for height (–10% to +8%). Calibration reduced the error, relative to that of yield tables, of the predicted basal area and yield after 50 years. Simulated responses to thinning diverged, depending on site index and competition intensity. The FVS is a viable option for modeling the yield of Douglas-fir plantations in Italy, reflecting the current understanding of forest ecosystem dynamics and how they respond to management interventions.

Keywords: empirical forest models, growth and yield, calibration, plantation management, *Pseudotsuga menziesii* (Mirb.) Franco

Plantations are a resource with global importance for wood and pulp production (Forest Europe 2015). In Europe, Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco) has been planted on a large scale and is now the most economically important exotic tree species (Schmid et al. 2014, Ducci 2015). Douglas-fir usually has a high growth rate in comparison with those of other forest tree species in Europe, has a higher resistance to drought (Eilmann and Rigling 2012), and may provide high-value-added timber (especially after the first thinning) (Monty et al. 2008). In Southern Europe, no indigenous conifer has similar characteristics of productivity and timber quality (Corona et al. 1998).

In Italy, Douglas-fir was introduced in 1882 (Pucci 1882) using seeds from the Pacific Northwest Coast of the United States (Pavari and De Philippis 1941). Between 1922 and 1938, the “Stazione Sperimentale di Selvicoltura” established 98 exper-

imental plantations (Pavari 1916, Pavari and De Philippis 1941, Nocentini 2010). These trials demonstrated that a variety of sites in central and northern Italy were suitable for the species (Pavari 1958). Currently, Douglas-fir plantations cover an area of approximately 0.8 million ha in Europe (Forest Europe 2015). In Tuscany (Central Italy), Douglas-fir covers 3,360 ha in pure stands and 2,112 ha in mixed stands (Regional Forest Inventory of Tuscany 1998).

The key to successful management of productive Douglas-fir plantations is a proper understanding of growth dynamics in relation to tree characteristics, stand structure, and environmental variables. The productivity of Douglas-fir stands in Italy was studied by Pavari and De Philippis (1941) and, particularly, by Cantiani (1965), who established a yield table for stands up to 50 years old, based on 115 plots of different ages.

Manuscript received March 7, 2016, accepted August 11, 2016; published online November 24, 2016.

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Acknowledgments: We acknowledge the technical staff of Consiglio per la Ricerca in Agricoltura e l'Analisi dell'Economia Agraria for supporting field sampling, Corpo Forestale dello Stato for historical plot localization and field sampling, and Nicholas Crookston and Erin Smith-Matheja from the USDA Forest Service, Forest Management Service Center, for support in calibrating and running FVS.

This article uses metric units; the applicable conversion factors are: millimeters (mm): 1 mm = 0.039 in.; centimeters (cm): 1 cm = 0.394 in.; hectares (ha): 1 ha = 2.471 ac; meters (m): 1 m = 3.28 ft; square meters per hectare (m²/ha): 1 m²/ha = 4.356 ft²/ac.