Table 1 Vinecology integrates across domains, such as natural habitat, water, and soil, and at multiple scales to address conservation issues and seek ecosystem benefits

Vinecology domain (scale) and mode of engagement	Conservation challenges	Vinecology practices	Ecosystem benefits	Supporting studies
		Wildlife habitat (H1)		
Growing regions, appellations, winefarms, vineyards—major watersheds, catchments, riparian corridors ($10^{>6}$ m^2) regional grower and sustainability groups (e.g., Biodiversity & Wine Initiative South Africa, Lodi	Conversion and fragmentation of natural habitat, especially shrublands, threatens endemic and rare species, disrupts connectivity, gene flow, and effective range size.	Maintain and conserve contiguous areas of native habitat.	Provides core native habitats and corridors to support wildlife, improves ecosystem functioning, and sustains ecosystem services.	(Heaton and Merenlender 2000; Merenlender 2000; Nicholls *et al.* 2001)
		Water resources (W1)		
Winegrape Commission California); conservation planning tools (e.g., InVEST, Vista); water-user associations and watershed councils; land trusts and conservancies	Wine, through viticultural and oenological operations, uses roughly 1000 L of water for each 1 L of wine produced. Production practices consume water and diminish water quality.	Develop and implement a catchment level assessment of water resources (e.g., water footprint analysis to determine hydrological balance); sustain hydrological functioning through restoration of streams, riparian zones, and wetlands.	Integrates operations into more holistic catchment perspective; integrates industry operations with broader ecosystem and societal objectives.	(Hoekstra and Chapagain 2007)
		Soil health (S1)		
	Vineyards on steep slopes accelerate erosion and loss of soil. Deep ripping of soil horizons can disrupt local hydrogeology.	Design vineyard blocks with row orientation to minimize downslope processes; employ mulching and cover cropping with (native) perennials to reduce soil exposure.	Reduces erosion, increases organic matter and infiltration rate, lowers soil temperature, and improves nutrient cycling.	(Battany and Grismer 2000; Ruiz-Colmenero *et al.* 2011)
		Wildlife habitat (H2)		
Vineyard blocks, rows, vines—habitat patches, hedgerows, field margins (10^{2-5} m^2); conservation easements; cost-share and incentive programs; stream rehabilitation teams; alien species eradication councils	Land clearing, especially of wetlands and riparian areas, diminishes ecosystem functioning, degrades habitat, and eliminates higher trophic levels.	Maintain wetland and riparian areas, establish hedgerows and vegetation strips, and incorporate habitat islands.	Allows for wildlife movement and migrations; improves biochemical cycling; sustains trophic interactions; buffers against pesticide drift; and serves as source for beneficial insects.	(Hilty and Merenlender 2004; Baumgartner *et al.* 2006; Smukler *et al.* 2010; Jedlicka *et al.* 2011; Williams *et al.* 2011)
		Water resources (W2)		
	Seasonal water abstraction (e.g., frost protection) can critically	Utilize seasonal storage ponds filled in winter to augment supply during	Replenishes ecosystems during seasonal dry periods; reduces impact	(Lohse *et al.* 2008; Deitch *et al.* 2009; Grantham *et al.* 2012)

Continued

Table 1 Continued

Vinecology domain (scale) and mode of engagement	Conservation challenges	Vinecology practices	Ecosystem benefits	Supporting studies
	impair aquatic ecosystems.	deficit and climatic extremes; drain in summer to prevent biological invasion (e.g., American bullfrog).	on native aquatic and riparian biota; prevents critical stream drawdowns that harm fishes and other aquatic organisms.	
		Soil health (S2)		
	Vineyard floor management alters soil dynamics (i.e., structure, water holding capacity, and nutrient cycling).	Employ cover cropping and flower strips between rows; establish and maintain sediment barriers and traps between vineyard blocks and stream courses.	Increases organic matter, improves soil structure and water holding capacity, sequesters carbon, and accelerates nutrient cycling.	(Wheeler *et al*. 2005; Guerra and Steenwerth 2012)
		Wildlife habitat (H3)		
Vines, berries, phenolics—lone trees, fruits, nectars, carbon, nutrients ($10^{0\text{-}1}$ m^2); viticulture and resource management extension specialists; continuing education workshops; worker training and skill development programs	Viticulture is a monocrop often heavily managed with biocides, and thus biologically depleted.	Plant and maintain flowering strips between vine rows (can be in conjunction with cover crops and integrated pest management) as "planned" biodiversity.	Serves to increase insectary habitat as part of integrated pest management strategy; improves biodiversity by attracting pollinators and predatory insects (i.e., parasitoids).	(see Gurr *et al*. 2004)
		Water resources (W3)		
	Irrigated viticulture can deplete local surface water stores and aquifers.	Employ improved technology, such as drip irrigation and real-time evapotranspiration and soil moisture monitoring, in conjunction with viticultural practices such as shoot thinning and leaf pulling.	Reduces consumptive use and overall water footprint; reduces mildew and weeds; reduced deficit irrigation can improve fruit quality.	(Chaves *et al*. 2007; Schultz and Stoll 2010)
		Soil health (S3)		
	Farming practices deplete beneficial soil biota.	Mulch vine rows with pomace and other green manure.	Reduces pestilence and adds source of nutrients and organic matter; sustain microbial functions.	(Jacometti *et al*. 2007a,b; Steenwerth and Belina 2008; Steenwerth and Belina 2010)