Vulnerability of Piñon-Juniper Habitats to Climate Change in the Southwestern USA

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Wildlife managers are concerned about the impacts of climate change on piñon-juniper habitats and on the ecosystem services that they provide (Friggens et al. 2013). Contrary to common perception, this extensive ecosystem type is greatly varied in structure, composition, ecology, and habitat value (Comer et al. 2003; Moir and Carlton 1986; Romme et al. 2009), along with the expected manifestations of climate change vulnerability (Comer et al. 2012; Rehfeldt et al. 2006). This work resulted in a geospatial climate vulnerability surface that included five types of piñon-juniper across Arizona and New Mexico.

To predict vulnerability, the landscape was spatially stratified into recognizable ecosystem types that repeat across the landscape. Then, base-level polygons were generated for the analysis area with each segment representing similar site potential at the scale of individual plant communities. Segments were attributed with biophysical, contemporary climate, and projected climate for multiple Global Circulation Models (GCMs). Climate envelopes were developed for each type of piñon-juniper based on pre-1990 climate data and the most discriminating climate variables. The discriminant analysis of 21 climate variables resulted in the selection of five key variables for building climate envelopes for each piñon-juniper type. Finally, each segment was assigned a vulnerability score based on the projected departure in future climate from the characteristic climate—an inference of probable change in site potential climate envelopes. In the context of this analysis, vulnerability ratings are a consequence of the breadth of the envelope for a given type of piñon-juniper, the current climate status of a given location relative to its envelope, and the magnitude of projected change in climate at that location.

Of the five major types of piñon-juniper in the southwestern USA, the Piñon-Juniper Sagebrush system appears to be the most vulnerable with nearly 90 percent of its area occurring as high vulnerability (table 1). The percentage of high vulnerability in the remaining types varies considerably, between 22-64 percent.

In all cases, by the late 21st-century, the majority of area currently classified as piñon-juniper will have at least exceeded historic envelopes, suggesting important changes ahead for dependent wildlife. The efficacy of the vulnerability surface was tested by assessing contemporary fire severity patterns (Eidenshink et al. 2007) against the predicted vulnerability for all piñon-juniper types collectively, and found that low vulnerability sites were over 38 percent more likely to experience stand replacement fire than the background levels suggested in the vulnerability surface. Conversely, high vulnerability areas were nearly 33 percent less likely to experience stand replacement fire, with vulnerability playing a hypothetical role on plant productivity (Parks et al. 2016; Rocca et al. 2014). A follow-up study on the Lincoln

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Table 1—Vulnerability of the five major types of piñon-juniper to climate change in the southwestern USA.

Piñon-Juniper ERU	Vulnerability category	Percent
PJ Evergreen Shrub	Low	28
15,908 km^2	Moderate	50
	High+	22
PJ Woodland (persistent)	Low	8
22,199 km^2	Moderate	42
	High+	50
PJ Grass	Low	7
24,607 km^2	Moderate	30
	High+	64
Juniper Grass	Low	3
37,488 km^2	Moderate	43
	High+	55
PJ Sagebrush	Low	0
9,173 km^2	Moderate	12
	High+	88
All Piñon-Juniper	Low	8
109,375 km^2	Moderate	38
	High+	54

National Forest in south-central New Mexico is being conducted to evaluate the relationship of vulnerability and plant productivity, while also considering the respective influences of vulnerability and uncharacteristic fire on tree regeneration patterns. Finally, the vulnerability surface was focused on vegetation and not wildlife habitat specifically; but, because vegetation serves as the principle structural component of habitat, the surface can offer an inference of habitat vulnerability and a means for underpinning analyses for specific species of wildlife that utilize piñon-juniper.

In applying the vulnerability surface for a given type of piñon-juniper, biologists could focus adaptation management for habitat in those landscapes with the highest vulnerability. An adaptive capacity process of analysis, planning, and management can link outputs from the vulnerability surface to practitioners and decisionmakers by integrating vulnerability predictions with knowledge of resilience-resistance characteristics and plant functional traits. For example, prescribed burning and tree thinning, particularly in the fire-adapted types (Juniper Grass and Piñon-Juniper Grass) that have been substantially altered from reference conditions, may improve adaptive capacity and facilitate realignment, while reducing the risk of high-severity disturbance to piñon-juniper (Bradford and Bell 2017). For all vulnerable piñon-juniper types, managers can plan and apply treatments adaptively with particular emphasis on ecosystem function as a useful operational framework for responding to climate change for piñon-juniper habitat in the southwestern United States.

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