

## Better late than never: a synthesis of strategic land retirement and restoration in California

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**Abstract.** Strategic retirement and restoration of agricultural lands is a critical conservation opportunity globally. The objective of this synthesis was to examine whether ecological habitat assessments, endangered species historical occurrence data, and restoration research can be used to develop evidence-based strategy for retiring and restoring agricultural lands. The San Joaquin Desert (SJD) of California is a prominent example because it experienced an extensive conversion to agriculture. Now, new groundwater regulations will lead to retirement on large areas of agricultural lands over the next 20 yr. This presents an opportunity to not only restore some of these lands but also explore the challenges associated with balancing direct human needs with other ecosystem-level functions. California is thus an ideal case study for globally rethinking context-specific, single-case study solutions. We used a systematic review and synthesis to address the following three main questions for habitat recovery of endangered species in the SJD. (1) What are the habitat requirements for key endangered animal species in the region? (2) Is there historical evidence to support an assessment of suitable habitats for these species? (3) What restoration techniques apply to these species? Using the Web of Science and other resources, we reviewed over 1000 independent studies on this topic, refined the evidence, and selected a total of 266 relevant publications. Habitat requirements for each species were described, but there was a critical need to examine quantitative thresholds for these factors to better evaluate habitat suitability of retired lands. There was sufficient evidence of historical vegetation to model suitable habitats and design the physical restoration of retired lands. Direct interventions associated with restoration strategies have been infrequently tested. Sparse and diverse evidence associated with direct experimental manipulations is not uncommon in applied ecology, and synthesis is an excellent tool for highlighting these gaps for future research to examine. This review suggests that retired agricultural land is a viable asset for threatened and endangered species, but to effectively advance restoration research and management, direct tests of restoration techniques and an assessment of relative costs for interventions are needed for a given region.

**Key words:** agriculture; arid; desert; endangered species; fallowing; PRISMA; restoration; retired lands; San Joaquin Desert; semi-arid; synthesis; systematic review.

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