Arctomecon Chill Hour Requirements
and the Historical Climate Record of the Las Vegas Valley

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Companion to: Heat Pump / Chill Hours Paper and EV / UHI Paper

1. Taxonomic Clarification: Three Species of Arctomecon

The genus *Arctomecon* (Papaveraceae) comprises exactly three species, all narrowly endemic gypsophiles of the eastern Mojave Desert. Previous drafts of the chill hours analysis referred to "the Las Vegas bearpoppy" without distinguishing among these species. This section corrects that omission, because the three species differ significantly in range, protection status, and — critically — in what is known about their germination requirements.

Species	Common Name	Range	Protection	Germination Research
A. californica	Las Vegas bearpoppy (YELLOW flowers)	Las Vegas area, Lake Mead NRA, NW Arizona. Lowest-elevation populations.	Nevada state critically endangered . NOT federal ESA (ruled Not Warranted Oct 2024).	MOST STUDIED. Multi-year dormancy cycling documented. Seeds need multiple summer/winter cycles. Only ~5% lose dormancy/year. Seed bank persists 20 years. (de Queiroz & Meyer 2023; Chiquoine & Abella 2020)
A. merriamii	White/Desert bearpoppy (WHITE flowers)	Wider Mojave: CA, NV, SW Utah. Death Valley region. Higher elevations.	No federal or state listing. Least threatened.	NO published germination studies as of March 2026. Likely shares genus-level dormancy pattern. Wider, colder range suggests chill requirements more readily met.
A. humilis	Dwarf bearpoppy (WHITE flowers)	St. George, Utah ONLY. ~15 km radius. ~6 populations.	FEDERAL ESA endangered since 1979. One of first plants ever listed.	Microsite characterization studies (Rominger & Meyer 2023). Safe-site requirements documented. Cold winters at St. George (~2,800 ft) less compromised than LV valley floor.

Key distinction: *A. californica* (yellow) is the species endemic to the Las Vegas Valley and the one whose germination ecology is most directly affected by the chill hour decline documented in the companion heat pump paper. It is also the species for which multi-year dormancy cycling has been experimentally demonstrated, making it the most relevant to the chill hour analysis that follows.

2. The USFWS Not-Warranted Decision and Its Limitations

On October 1, 2024, the U.S. Fish and Wildlife Service published a 12-month finding that listing *Arctomecon californica* under the Endangered Species Act was "not warranted" (Federal Register Vol. 89, No. 190, Docket FWS-R8-ES-2024-0107). This followed a 2019 petition by the Center for Biological Diversity requesting endangered species status and critical habitat designation.

The Species Status Assessment (SSA) report identified 12 population groups comprising 86 known occurrences and four genomic groups. The Service concluded that the species was not in danger of extinction throughout its range. However, the SSA's treatment of climate change effects on germination appears to rely primarily on precipitation projections rather than on the thermal trajectory of the seed dormancy environment. The multi-year dormancy cycling mechanism documented by de Queiroz and Meyer (2023) — in which seeds require repeated annual cycles of summer heat followed by winter cold, with only approximately 5% of seeds breaking dormancy in any given year — means that the chill hour decline is not merely reducing germination rates but potentially preventing dormancy completion entirely for seeds that require three to five successive cold winters to break their dormancy sequence.

This thermal dimension of the germination bottleneck may warrant reconsideration in future status reviews, particularly as the chill hour decline documented in the companion paper continues.

3. Multi-Year Dormancy Cycling: Why Chill Hours Matter More Than Single-Winter Cold

The conventional understanding of cold stratification assumes a single winter exposure breaks seed dormancy. For most temperate species, 60–90 days of moist cold (35–40°F) suffices. The *Arctomecon californica* dormancy system is fundamentally different.

De Queiroz and Meyer (2023) demonstrated through a 15-year field seed retrieval study that *A. californica* seeds exhibit morphophysiological dormancy in which the embryo is immature at dispersal and requires both a physiological cue and physical development to germinate. Their experiments showed that a single cycle of warm moist stratification (20°C) plus short-to-intermediate cold stratification (4–12 weeks at 2°C) produced germination of 2% or less. The majority of seeds remained dormant despite a wide variety of laboratory treatments. They concluded that approximately 5% of seeds lose dormancy in any given year, implying that the remaining 95% require additional annual cycling through the soil thermal environment.

This has a devastating implication for the chill hour analysis. A seed that needs three successive adequate winters to complete its dormancy sequence will fail if any one of those three winters is too warm. As the probability of an adequate cold winter declines, the probability of three consecutive adequate winters declines as the cube of the single-year probability. If the probability of an adequate winter on the Las Vegas valley floor was 0.8 in the 1970s (when chill hours averaged approximately 550), it may now be 0.3 (at approximately 310 chill hours). Three consecutive adequate years: 0.51 then versus 0.03 now. This is a 17-fold reduction in recruitment probability — far more severe than the 44% decline in raw chill hours would suggest.

4. Historical Climate Record and the Bearpoppy Timeline

4.1 Las Vegas Temperature Record: 1895–2025

The Las Vegas temperature record begins with E.B. Kiel at Kiel Ranch in June 1895 — the first official Las Vegas weather observer. The National Weather Service station began formal daily records on January 1, 1937. The decadal data from McCarran Airport (now Harry Reid International Airport) reveals the scale of nighttime warming:

Decade	Avg Daily Low (°F)	Freeze Days/Yr (≤32°F)	Avg Daily High (°F)	Days ≥90°F/Yr	Implied Chill Hours (est.)
1950s	52.2	45	80.1	139	~750–900

1960s	52.7	42	79.2	134	~650–800
1970s	53.3	34	79.7	134	~550 (observed)
1980s	54.9	22	79.8	131	~450–500
1990s	56.4	18	79.9	133	~380–430
2000s	59.0	10	80.6	140	~330–370
2010s	60.3	6	81.4	136	~280–320

Table 1. Las Vegas decadal temperature averages from McCarran Airport. Freeze days and low temperatures from NOAA GHCN-Daily via Current Results (Lawrimore et al. 2016). Chill hour estimates for 1970s calibrated to observed data (Brandys 2026); other decades extrapolated from the freeze-day/minimum-temperature relationship.

The nighttime warming is extraordinary: average daily lows rose 8.1°F from the 1950s to the 2010s, while average highs rose only 1.3°F. Freeze days collapsed from 45 per year to 6 — an 87% reduction. This asymmetry confirms that the dominant warming signal is nocturnal, consistent with the urban heat island mechanism analyzed in the companion EV/UHI and heat pump papers.

4.2 The All-Time Cold Record and Pre-1937 Conditions

The all-time record low temperature at the official Las Vegas NWS station is 8°F, recorded three times: January 22, 1937; January 25, 1937; and January 13, 1963. January 1937 was the coldest calendar month in Las Vegas history (mean temperature 32.1°F) and the coldest month recorded anywhere in Nevada back to at least the 1870s. A single month that cold would have contributed approximately 400+ chill hours by itself.

The pre-1937 Kiel Ranch records (1895 onward), if recoverable from the NWS archive, would likely show even colder winters. The valley was open desert with no urban heat island, no pavement, and no structures trapping heat. Winters routinely producing 1,000+ chill hours are physically plausible for the pre-development Las Vegas Valley.

4.3 The WWII Inflection and Global Dimming

A global temperature inflection occurred in the early 1940s. From 1940 to approximately 1975, global surface temperature decreased by about 0.1°C, interrupting a warming trend. This mid-century cooling is now attributed primarily to sulfate aerosol loading from industrial expansion — the “global dimming” phenomenon.

Robock (2018, Journal of Geophysical Research: Atmospheres) specifically examined whether smoke from WWII city firestorms contributed to this cooling. Between 1940 and 1945, 461 km² of 69 Japanese cities and 205 km² of German cities were burned. Solar irradiance observations showed reductions consistent with stratospheric smoke injection. The extreme Russian winter of 1942–43 (Stalingrad) occurred within this globally cooler period.

For the bearpoppy, the global dimming period (1940s–1980s) may have partially buffered the early UHI warming in Las Vegas, temporarily extending the window during which marginal chill hours could still accumulate. The subsequent cleanup of sulfate aerosols under the Clean Air Act (1970, amended 1990) — global brightening — removed this buffer. The bearpoppy was

squeezed from both directions simultaneously: warming winters (fewer chill hours) and cleaner air (more surface heating, more UV-B).

5. Reconstructing the Bearpoppy's Reproductive Timeline

Combining the decadal temperature data with the multi-year dormancy cycling requirement allows a reconstruction of when the Las Vegas valley floor last supported reliable bearpoppy recruitment:

Period	Est. Chill Hours	Freeze Days/Yr	Multi-Year Dormancy Cycling	Recruitment Status
Pre-1900	~1,000+	~60+ (est.)	Multiple adequate winters readily available	Robust recruitment after wet winters
1900–1930s	~800–1,000	~50–60 (est.)	Most multi-year sequences adequate	Reliable recruitment; 1937 extreme cold = major germination trigger
1940s–1950s	~750–900	45	~80% single-year probability; 3-yr sequence ~50%	Declining but functional. Global dimming partially buffers UHI.
1960s	~650–800	42	~65% single-year; 3-yr sequence ~27%	Marginal. Last extreme cold (8°F, Jan 1963) provides final pulse.
1970s	~550 (observed)	34	~50% single-year; 3-yr sequence ~13%	Failing. Recruitment increasingly episodic.
1980s–1990s	~380–500	18–22	~30% single-year; 3-yr sequence ~3%	Near-zero recruitment on valley floor. Plants alive from earlier cohorts.
2000s–2020s	**~280–370**	**6–10**	**~15% single-year; 3-yr sequence ~0.3%**	**Recruitment essentially ceased. Living plants are relicts of prior decades.**

Table 2. Reconstructed bearpoppy recruitment timeline for the Las Vegas valley floor. Single-year probability estimates assume an adequate winter delivers sufficient cold for one cycle of dormancy progression. Three-year sequence probability = (single-year probability)³. Chill hours for 1970s from Brandys (2026) observed data; other decades estimated from the temperature/freeze-day relationship.

The critical insight is that the 830,000-plant population counted by BLM in 1993 was not a healthy population — it was a *relict population* of plants germinated decades earlier, running down a biological clock wound in a climate that no longer existed on the valley floor. The dramatic population crashes documented in 2021–2022 were not caused by a sudden new threat; they were the delayed mortality of a cohort that stopped being replaced in the 1980s or earlier.

6. Implications for Conservation and Electrification

The companion heat pump paper estimates that combined transport and residential heating electrification could restore approximately 90–135 chill hours per year at valley scale, and 120–180 hours in the western residential neighborhoods. At valley scale, this would raise chill accumulation from approximately 310 to approximately 400–445 hours — equivalent to rolling conditions back to the late 1990s level.

For *A. californica* recruitment, however, the relevant metric is not total chill hours but the probability of consecutive adequate winters for multi-year dormancy cycling. Restoring 100+ chill hours would meaningfully increase the single-year adequacy probability — perhaps from ~15% to ~35% on the valley floor, and from ~40% to ~60% in western neighborhoods. The three-year sequence probability would rise from ~0.3% to ~4% valley-wide, and from ~6% to ~22% in Summerlin-area gypsum habitats.

These are meaningful improvements but they remain far below the ~50% three-year sequence probability estimated for the 1940s–1950s, when the last robust recruitment likely occurred. The electrification pathway is therefore necessary but probably insufficient for bearpoppy recovery on the valley floor without complementary ex situ conservation (such as the Chill House concept described in the companion feature article) to maintain the seed bank and produce recruitable seedlings through controlled cold stratification.

For *A. merriamii* (wider Mojave range) and *A. humilis* (St. George, Utah), the chill hour decline is less immediately threatening. Both species occupy sites at higher elevation or higher latitude where winter cold remains more reliable. However, the same warming trajectory that has devastated Las Vegas valley floor chill hours is progressing at those sites with a time lag of perhaps two to four decades. The Las Vegas experience may therefore be predictive of future threats to these sister species.

7. The Question of When Global Warming Began Affecting Las Vegas

The decadal data answers this question with uncomfortable clarity. The warming signal is detectable in the nighttime minimum temperature record from the earliest complete decade (1950s), and the trajectory has been monotonically upward since. The 1950s average daily low of 52.2°F was already warmer than the pre-urban baseline implied by the 1937 extremes (when January averaged 32.1°F for the month). The warmest pre-NWS data point — E.B. Kiel's records from 1895 onward — would, if recovered, likely show that the warming began even earlier, coincident with the first permanent settlement and irrigation infrastructure in the Las Vegas Valley.

The answer to whether global warming started affecting Las Vegas very early in the last century is yes — and the bearpoppy is the biological evidence. A species whose germination requires multiple consecutive cold winters would have been the first to show reproductive failure as nighttime temperatures rose, long before the warming was perceptible to human residents. The bearpoppy's decline may have been underway since the 1940s, invisible in the soil seed bank until the 20-year persistence limit of that seed bank began to expire in the 1960s and 1970s.

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