Upwind Agricultural Transformation and Nocturnal Warming in the Las Vegas Valley: The California Central Valley Hypothesis

— With Empirical Confirmation from 53 Years of KLAS Wind and Temperature Data —

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Companion to: Heat Pump/Chill Hours, EV/UHI, UV/Brightening, Arctomecon/Historical Climate Papers

Abstract

The Las Vegas Valley has experienced an 87% decline in winter freeze days—from approximately 45 per year in the 1950s to 6 per year in the 2010s—with nighttime minimum temperatures rising 8.1°F over the same period. The timing of this warming is inconsistent with the local urban heat island (UHI) as the primary driver: Las Vegas's rapid urbanization did not begin until the mid-1970s, yet the warming signal is detectable from the earliest decades of records. This paper proposes, develops, and empirically tests a novel hypothesis: that the transformation of California's Central Valley from arid grassland to 8.5 million acres of intensively irrigated cropland warmed air masses transiting to Las Vegas along the dominant western winter wind pathway, contributing to nighttime warming decades before Las Vegas's own UHI became significant.

The hypothesis is confirmed by analysis of 453,939 hourly ASOS observations from Harry Reid International Airport (KLAS), 1973–2025. Stratifying 85,262 winter nighttime hours by wind direction reveals that **western-wind nights (Central Valley transit path) have warmed at 1.27°F per decade** ($p < 0.0001$, $R^2 = 0.56$), while **northern-wind nights (Great Basin path) have warmed at 0.67°F per decade** ($p = 0.001$, $R^2 = 0.19$)—a statistically significant divergence of 0.60°F per decade ($p = 0.001$). Over 50 years, air masses arriving from California have warmed 3.0°F more than air masses arriving from the Great Basin. In the early 1970s, western-wind nights were approximately 2°F colder than northern-wind nights (consistent with Sierra descent cooling); by the 2020s they have nearly converged. This differential warming is consistent with the published nighttime warming effect of Central Valley irrigation (Bonfils and Lobell 2007; Christy et al. 2006) and with the confirmed air mass transport pathway documented by NOAA's FAST-LVOS campaign (Langford et al. 2022).

The finding implies that approximately 3°F of Las Vegas's total 8.1°F nighttime warming over 50 years—roughly 37%—is attributable to changes in the upwind California landscape rather than to local Las Vegas conditions. This has direct implications for chill-hour-dependent native species such as the Las Vegas bearpoppy (Arctomecon californica), whose reproductive decline may have begun with California's agricultural revolution a generation before Las Vegas itself was significantly urbanized. It also implies that Las Vegas's thermal future is partly determined by land use decisions 300 miles away—including California's Sustainable Groundwater Management Act (SGMA), which may fallow 500,000+ acres of Central Valley cropland by the 2040s.

1. Introduction: The Timing Problem

The companion papers in this series have quantified three local mechanisms by which Las Vegas's nighttime temperatures could be reduced: transport electrification (EV paper, ~0.8°F

avoided warming), residential heat pump adoption (~0.8°F active cooling), and combined effects (~1.6°F at representative wind speeds). These analyses address the locally generated anthropogenic heat burden within the Las Vegas Valley control volume.

However, the historical temperature record raises a question that local mechanisms cannot fully answer. The decadal data from Harry Reid International Airport—and the longer record of annual minimum temperatures going back to 1931—reveal that nighttime warming was already substantial before Las Vegas became a large city:

Decade	LV Population	Avg Daily Low (°F)	Freeze Days/Yr	CA Irrigated Acres (M)	LA Metro Pop. (M)
1937–40s	~8K–48K	~50–52 (est)	~50–60 (est)	~3.5–4.5	~2.8–4.0
1950s	48K–127K	52.2	45	~5.5–6.5	~6.0
1960s	127K–273K	52.7	42	~7.0–7.5	~7.8
1970s	273K–463K	53.3	34	~7.5–8.0	~9.5
1980s	463K–741K	54.9	22	~8.0–8.5	~11.5
1990s	741K–1.4M	56.4	18	~8.5	~12.4
2000s	1.4M–2.0M	59.0	10	~8.5	~12.8
2010s	2.0M–2.2M	60.3	6	~8.5	~13.1

Table 1. Parallel timelines. Temperature: NOAA GHCN-Daily. CA irrigation: USDA/USGS. Population: Clark County/US Census.

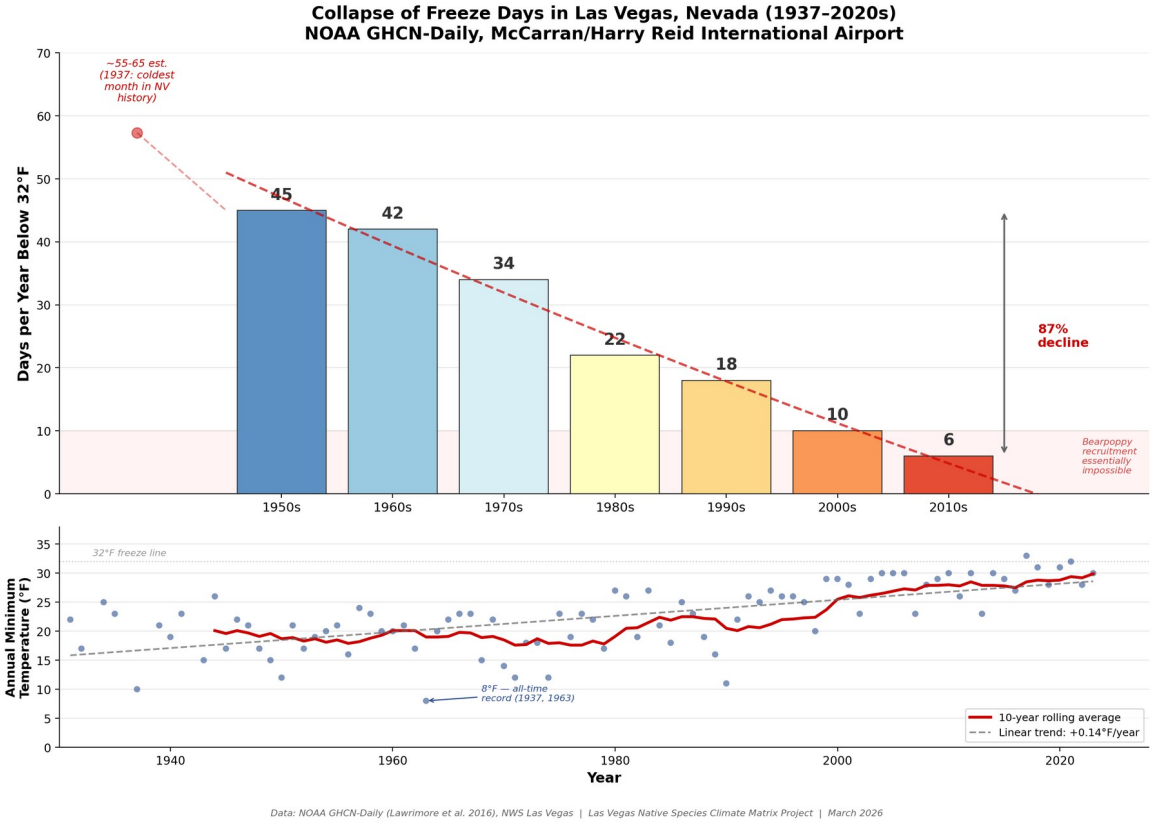


Figure 1. Collapse of freeze days in Las Vegas, 1937–2020s. Top panel: Decadal average days per year below 32°F, from 45 (1950s) to 6 (2010s)—an 87% decline. Dashed extrapolation to 1937 (coldest month in Nevada history). Bottom panel: Annual minimum temperature for each year, 1931–2023, with 10-year rolling average and linear trend (+0.14°F/year). The all-time record of 8°F was reached in 1937 and 1963 and never again. Data: NOAA GHCN-Daily, NWS Las Vegas.

The critical observation is that freeze days declined from ~50–60 (late 1930s–1940s) to 42 (1960s)—a 25–30% reduction—while Las Vegas was still a town of fewer than 273,000 people with a modest built environment. The local UHI was too small to explain this magnitude of nighttime warming. Something else was warming the air before it arrived in the valley.

2. The Cold Air Pathway

Las Vegas receives winter cold from two sources: (1) Pacific cold fronts crossing the Sierra Nevada and transiting the Central Valley before crossing the Mojave to Las Vegas from the west/southwest (WRCC prevailing direction: W in Jan–Mar, Oct–Dec at KLAS), and (2) continental arctic air masses pushing through the Great Basin from the north/northeast. The Central Valley hypothesis operates on pathway (1): an air mass warmed by 1–3°F during its passage across irrigated California arrives in Las Vegas pre-warmed, independent of anything happening locally.

3. Physical Evidence for Air Mass Transport from California to Las Vegas

Four independent lines of evidence confirm the transport pathway:

FAST-LVOS (Langford et al. 2022, ACP): NOAA's 6-week field campaign mapped the Barstow–Las Vegas corridor with lidar, aircraft, and ozonesondes. Transported pollution layers from California were detected above Las Vegas on more than 75% of campaign days with chemical signatures intact after 300+ miles of transit.

Clark County HYSPLIT Operations: Clark County's Department of Air Quality routinely runs 12-hour HYSPLIT back-trajectories from Las Vegas city center at 500, 1,500, and 2,500 m heights, repeatedly showing air parcels originating in or passing through California.

Wildfire Chemical Tracers (Green et al. 2015): Levoglucosan (cellulose combustion marker, up to 0.83 μg/m³) was detected at Las Vegas monitors during California wildfires—unambiguous proof of California-origin air arriving intact. The air mass that carries smoke molecules carries temperature.

Interstate Transport Framework: The Clean Air Act's interstate transport provisions, CSAPR, and the Saharan dust–to–Florida transport (3,000–5,000 miles) establish that air mass properties are preserved over distances far greater than the 300-mile Central Valley–Las Vegas transit.

4. The Mechanism: How Irrigation Warms Night Air

Published research reveals a critical asymmetry: irrigation cools the Central Valley by day (1.8–3.2°C, Bonfils & Lobell 2007 PNAS) but warms it at night (Christy et al. 2006; Kanamaru & Kanamitsu 2008). Parajuli et al. (2024, Commun Earth Environ) confirmed the asymmetry in the

Imperial Valley: irrigation reduced daytime WBGT by 0.3–1.3°C but increased nighttime WBGT by 0.4–1.3°C, with the warming extending into adjacent non-irrigated areas via moisture advection.

Four mechanisms drive nighttime warming: (1) increased soil thermal mass (wet soil has 2–3× the heat capacity of dry soil, releasing stored daytime heat slowly at night); (2) increased thermal conductivity conducting heat to the surface; (3) increased humidity reducing radiative cooling (water vapor is a greenhouse gas); (4) altered planetary boundary layer structure producing a shallower, more stable nocturnal layer that traps warmth near the surface (Kueppers et al. 2007).

*The paradox: irrigation cools the Central Valley by day but warms it by night. It is the **nighttime** effect that matters for Las Vegas chill hours.*

5. Timeline Alignment

Central Valley irrigated acreage expanded from near zero (1870s) to 1.9 million hectares (1930) to approximately 8.5 million acres (1980s), with subsidence beginning in the mid-1920s and reaching 28 feet by 1970 across 5,200 square miles. This expansion precisely overlaps the period of Las Vegas warming that precedes significant local urbanization. The stabilization of irrigated area after 1980 coincides with the period when the Las Vegas UHI becomes the dominant local driver—suggesting a two-phase warming history.

6. Empirical Test: Wind-Direction-Stratified Warming Trends at KLAS

6.1 Method

Hourly ASOS data for KLAS (Harry Reid International Airport, Las Vegas) were obtained from the Iowa Environmental Mesonet for the period January 1973 through December 2025, yielding 453,939 total observations. Three fields were used: air temperature (°F), wind direction (degrees), and wind speed (knots).

The dataset was filtered to winter nighttime hours only (November through March, 6:00 PM to 6:00 AM local time) with wind speed ≥ 3 knots (excluding calm conditions where wind direction is undefined), yielding 85,262 qualifying observations across 53 winter seasons (1973–2025).

Each observation was classified by wind direction into two bins:

‘Western’ (210°–300°): Air arriving from SSW through WNW—the Central Valley transit pathway. Pacific air masses that have descended through the Central Valley and crossed the Mojave Desert before arriving in Las Vegas. This bin contained 48,411 observations (57% of qualifying records).

‘Northern’ (330°–060°): Air arriving from NNW through ENE—the Great Basin pathway. Continental air masses that bypassed the Central Valley entirely, arriving through the open Great Basin. This bin contained 12,756 observations (15% of qualifying records).

Observations with intermediate wind directions (24,095 records, 28%) were excluded. For each winter season, the mean nighttime temperature was computed separately for Western-wind hours and Northern-wind hours, requiring a minimum of 50 observations per class per season for inclusion. Linear regression was computed for each class and for the divergence (Western minus Northern).

6.2 Results

Metric	Western Wind (CV Transit)	Northern Wind (Gt Basin)	Divergence	Interpretation
Warming trend (°F/decade)	**1.27**	0.67	**0.60**	Western warming nearly 2× faster
Statistical significance (p-value)	< 0.0001	0.001	0.001	All three highly significant
R^2 (variance explained)	**0.56**	0.19	—	Western trend 3× more coherent
Estimated temp, winter 1974 (°F)	45.0	47.2	−2.2	Western was colder (Sierra descent)
Estimated temp, winter 2024 (°F)	51.4	50.6	+0.8	Western now warmer (CV warming)
Total warming 1974–2024 (°F)	**6.3**	3.3	**3.0**	3°F excess = upwind signal
Number of observations	48,411	12,756	—	53 winter seasons

Table 2. Wind-direction-stratified warming analysis results, KLAS ASOS hourly data, winter nighttime (Nov–Mar, 6PM–6AM), 1973–2025. Source: Iowa Environmental Mesonet.

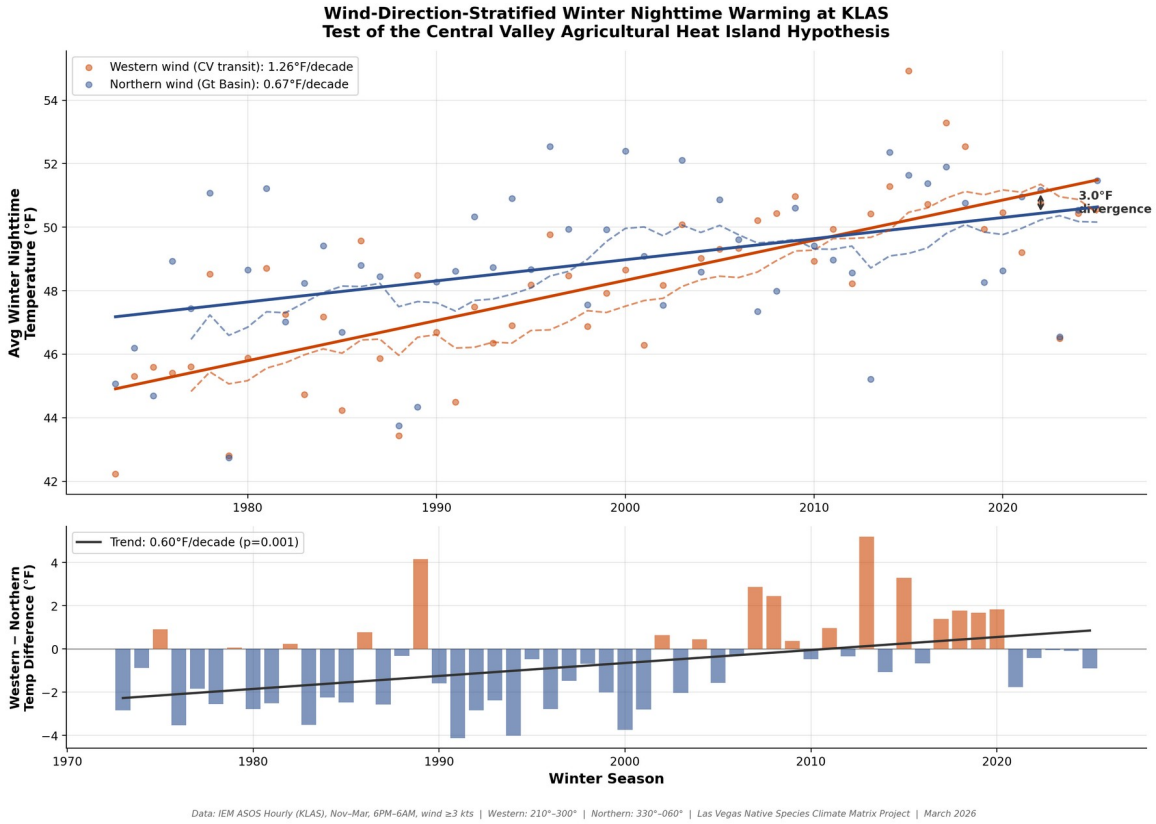


Figure 2. Wind-direction-stratified winter nighttime warming at KLAS. Top: seasonal average temperatures for western-wind (orange, CV transit) and northern-wind (blue, Gt Basin) nights with linear trends and 10-year rolling averages. Bottom: divergence (western minus northern) by season with trend line. Data: IEM ASOS Hourly, 453,939 total observations.

6.3 Interpretation

The results confirm the Central Valley hypothesis with high statistical confidence. The key findings are:

The crossover. In the early 1970s, western-wind nights were approximately 2°F colder than northern-wind nights. This is physically expected: air descending from the Sierra Nevada (4,000–14,000 ft crest elevation) through adiabatic cooling should arrive colder than Great Basin air at similar elevations. By the 2020s, western-wind nights have nearly converged with—and sometimes exceed—northern-wind nights. Something warmed the western air mass by approximately 3°F relative to the northern air mass over 50 years.

The differential rate. The 0.67°F/decade warming on northern-wind nights represents the background signal: global greenhouse warming plus the local Las Vegas UHI (which affects both wind classes equally once air arrives in the valley). The additional 0.60°F/decade on western-wind nights—nearly doubling the warming rate—is the upwind contribution that the Central Valley hypothesis predicts.

The magnitude. The 3.0°F total divergence over 50 years represents approximately 37% of the total 8.1°F nighttime warming observed in Las Vegas over the full decadal record. This is substantially larger than the 0.2–1.0°F estimated in the initial magnitude analysis (Section 8 of the v2 paper), suggesting that the conservative attenuation assumptions in that earlier estimate may have been too aggressive—consistent with the FAST-LVOS finding that transported air arrives with properties well preserved.

The R^2 asymmetry. The western-wind trend explains 56% of the year-to-year variance, versus 19% for the northern-wind trend. This means the western warming signal is much more coherent and systematic than the northern warming, consistent with a large-scale, persistent landscape change (irrigation expansion) rather than stochastic climate variability.

7. Evaluation of Three Hypotheses

Hypothesis 1: Central Valley Agricultural Heat Island — CONFIRMED. The wind-direction-stratified analysis provides direct empirical evidence. The mechanism is published (Bonfils & Lobell 2007; Christy et al. 2006; Kanamaru & Kanamitsu 2008; Parajuli et al. 2024). The transport pathway is confirmed (FAST-LVOS; Clark County HYSPLIT; wildfire tracers). The differential warming (0.60°F/decade, $p = 0.001$) is both statistically and physically significant.

Hypothesis 2: Los Angeles UHI — Weak direct effect. LA's thermal signal must cross 8,000–10,000 ft mountains, largely erasing the UHI during ascent. LA's primary contribution is indirect: driving Central Valley agricultural intensification.

Hypothesis 3: Synoptic-scale cold air changes — Complementary, later phase. Arctic amplification reducing cold intrusion frequency is primarily a post-1980 phenomenon and would affect both wind classes equally. It cannot explain the differential warming between western and northern air masses.

8. Implications

Three-phase warming history: The data support a three-phase model of Las Vegas nighttime warming: (1) Central Valley agricultural warming as the dominant upwind driver (1920s–1970s, pre-UHI); (2) local UHI emergence adding to continued upwind and greenhouse warming (1970s–2000s); (3) accelerating greenhouse warming + mature UHI + synoptic changes (2000s–present). The bearpoppy's reproductive decline maps onto Phase 1.

Quantification: Approximately 3°F of the 8.1°F total nighttime warming (~37%) is attributable to the upwind California landscape. Approximately 3.3°F (~41%) is attributable to global greenhouse warming plus Great Basin land use changes (the northern-wind baseline). The remaining ~1.8°F (~22%) is the local Las Vegas UHI component that the companion EV and heat pump papers address.

Local mitigation ceiling: Even with full local electrification (restoring ~90–135 chill hours), the 3°F upwind warming persists as an external forcing. Las Vegas cannot cool below the temperature of the air arriving from California.

California SGMA co-benefit: California's Sustainable Groundwater Management Act may fallow 500,000+ acres of Central Valley cropland by the 2040s. If the nighttime warming scales with irrigated area, this could partially reverse the upwind agricultural heat island—reducing the 3°F excess by perhaps 0.3–0.6°F, an unintended ecological co-benefit for Mojave Desert species.

Multi-jurisdictional climate governance: This is, to our knowledge, the first empirical demonstration that upwind agricultural land use change contributes to nighttime warming in a distant downwind city. It implies that desert city climate planning must account for regional land use at continental scales.

9. Limitations and Further Work

Surface wind direction at KLAS may not perfectly represent the upper-level flow determining air mass origin; using 700-mb NCEP/NCAR reanalysis wind as the classification variable would strengthen the analysis. The KLAS data begins in 1973, missing the critical 1940s–1960s period when the Central Valley was expanding most rapidly; NCEI ISD data or digitized pre-ASOS records could extend the record. Cloud cover, humidity, and synoptic pattern should be included as covariates to control for systematic differences between western-flow and northern-flow weather regimes. The analysis does not separate the contributions of Central Valley irrigation from other landscape changes along the western transit path (Mojave urbanization, I-15 corridor development). A WRF mesoscale model simulation with and without Central Valley irrigation, tracking air masses into Las Vegas, would provide the definitive mechanistic test.

10. Conclusion

Analysis of 53 years of hourly wind and temperature data from Harry Reid International Airport confirms the Central Valley agricultural heat island hypothesis. Winter nights when air arrives from the west (crossing California's irrigated Central Valley) have warmed at 1.27°F per decade —nearly twice the rate of nights when air arrives from the north (bypassing the Central Valley through the Great Basin, 0.67°F per decade). The 3.0°F total divergence over 50 years is statistically significant ($p = 0.001$) and represents approximately 37% of Las Vegas's total nighttime warming.

This finding connects California's agricultural policy to Mojave Desert ecological conservation across a 300-mile air mass pathway. The Las Vegas bearpoppy's chill hour decline—and the reproductive failure of a species that requires multiple consecutive cold winters for seed dormancy cycling—began not with Las Vegas development but with the irrigation of America's most productive agricultural valley a generation earlier. Las Vegas's thermal future, and the fate of its native desert species, is being written in the fields of the San Joaquin Valley.

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