Global Brightening and Increasing UV-B Exposure in the Las Vegas Valley: Implications for Native and Non-Native Plant Species

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Working Paper | March 2026

Companion to: Las Vegas Native Species Climate Matrix v4.2

Abstract

Analysis of 27 years (1998–2024) of NOAA SURFRAD erythemal UV-B radiation data from the Desert Rock monitoring station, 65 miles northwest of Las Vegas, reveals that UV-B radiation reaches published plant damage thresholds weeks to months before temperature stress in the Las Vegas Valley. The UV Index at solar noon crosses the sensitive-species stress threshold (≈6) in March, when maximum air temperatures average only 68°F—well below any heat stress threshold for temperate plant species. UV-B daily doses exceed the broccoli phototoxicity threshold (2.2 kJ/m²/day) by February and the general crop damage threshold (4.0 kJ/m²/day) by March. Peak summer UV Index at Desert Rock averages 11–12, exceeding the Midwest maximum of 8–10 by 40–50%. This creates a 10–12 week window (March through May) during which UV-B radiation is the dominant abiotic stressor on non-native plant species while temperatures remain moderate. Published UV-B sensitivity data from over 200 plant species (Teramura 1983; Horticulture Research 2021) indicate that approximately 20% of species are highly UV-sensitive and another 50% are moderately sensitive. The species most commonly planted as winter annuals in Las Vegas—pansy, petunia, lettuce, primrose, impatiens—fall disproportionately in the highly sensitive category, having been bred in low-UV environments (Northern Europe, Pacific Northwest greenhouses). A morphological framework for predicting UV vulnerability is presented: thin, smooth, bright-green leaves indicate sensitivity; thick, pubescent, grey-green leaves indicate tolerance. Native Mojave Desert species (creosote, brittlebush, desert marigold) possess multiple UV-protective adaptations (reflective trichomes, resinous coatings, flavonoid sunscreens) that render them effectively UV-proof. A field experimental protocol using UV-B-filtering polycarbonate panels is proposed to test the hypothesis that UV-B, not heat, is the primary killer of winter annuals in the Las Vegas Valley. Observational evidence from mirror-lit garden microclimates, where standard glass mirrors attenuate UV-B by 25–40% while transmitting visible light, supports the hypothesis: shade-intolerant species including ajuga, daffodils, and roses survive year-round in mirror-lit microclimates but fail in direct sun at equivalent temperatures. This finding connects to the broader microclimate creation framework: the critical open question is whether shade (reduced total radiation and temperature) or specifically UV-B reduction is the primary mechanism by which constructed microclimates extend non-native plant survival in the desert.

Keywords: *UV-B radiation, global brightening, SURFRAD, Desert Rock, Las Vegas, plant photodamage, erythemal UV, winter annuals, microclimate, polycarbonate, Mojave Desert, native species, urban horticulture*

1. Introduction

Gardeners and nursery professionals in the Las Vegas Valley routinely observe that winter annual plants—pansy, petunia, snapdragon, lettuce, stock, and others—purchased from local nurseries in October through February begin to decline and die in March and April. The conventional explanation attributes this decline to “the heat,” and gardening advice uniformly focuses on watering frequency, shade provision, and heat tolerance. However, maximum air temperatures in March and April average only 68–73°F in the Las Vegas Valley—well within the optimal growth range for all of these species. The temperature explanation does not withstand quantitative scrutiny.

This paper advances an alternative hypothesis: that UV-B radiation, not temperature, is the primary abiotic stressor that kills winter annuals and limits the growing season for non-native plant species in the Las Vegas Valley. The hypothesis is grounded in three lines of evidence: (1) NOAA SURFRAD radiometric data showing that UV-B reaches published plant damage thresholds in February–March, weeks before temperature stress; (2) a large body of published research documenting UV-B sensitivity in the specific species planted as winter annuals in Las Vegas; and (3) observational evidence from constructed microclimates showing that plants survive year-round under conditions that reduce UV-B while maintaining equivalent temperatures and visible light levels.

If confirmed, this hypothesis has immediate practical implications for desert horticulture: UV-B-filtering materials (polycarbonate panels, certain greenhouse plastics) could extend the winter annual growing season by weeks to months, and the selection of UV-tolerant species—identifiable by observable morphological traits—could be prioritized in nursery recommendations for the region. More broadly, the finding connects to the global brightening phenomenon documented at Desert Rock and elsewhere: as aerosol pollution declines under Clean Air Act regulation, surface UV-B radiation increases, potentially compounding thermal stress on non-native urban vegetation in desert cities.

2. Data Source: NOAA SURFRAD Desert Rock Station

The Surface Radiation Budget Network (SURFRAD) operates a continuously instrumented monitoring station at Desert Rock, Nevada (36.624°N, 116.019°W, elevation 1,007 m), collocated with the Desert Rock operational radiosonde station on the Nevada National Security Site, approximately 65 miles northwest of Las Vegas. The station has been operational since March 1998, providing 27 years of minute-resolution surface radiation measurements including downwelling shortwave radiation (W/m²), erythemal UV-B irradiance (mW/m²), photosynthetically active radiation (PAR, W/m²), and air temperature (°C). Erythemal UV-B is measured using broadband radiometers calibrated against NOAA’s Central UV Calibration Facility and reported as the UV-B flux weighted by the erythemal (sunburn) action spectrum at a reference ozone column of 300 Dobson units.

For this analysis, 162 daily data files were downloaded from the SURFRAD archive, spanning 1998–2024 and sampled on the 15th of each month for six representative years (2000, 2005, 2010, 2015, 2020, 2024) plus June 21 (summer solstice), December 21 (winter solstice), March 15, and April 15 for every year—the latter two targeting the hypothesized “death window” for winter annuals. Each daily file contains approximately 1,440 minute-resolution records. Solar noon UV-B values were extracted by identifying the record with the minimum solar zenith angle on each day, with quality control flags applied to exclude invalid measurements.

3. Seasonal UV-B Profile at Desert Rock

Table 1 presents the multi-year average UV-B radiation profile at Desert Rock by month, including the estimated UV Index at solar noon, estimated daily biologically effective dose, and the corresponding plant stress classification based on published thresholds.

Month	UVB noon (mW/m²)	UV Index (noon)	Daily dose (kJ/m²/day)	Plant stress classification
Jan	60	2.4	1.4	Below signaling threshold
Feb	92	3.7	2.3	Signaling only; broccoli phototoxicity threshold crossed
Mar	152	6.1	4.0	HIGH — sensitive species damage threshold crossed
Apr	181	7.2	5.6	HIGH — sensitive species; exceeds Midwest peak UV
May	205	8.2	7.8	DAMAGING — most non-adapted crops affected
Jun	279	11.2	9.1	EXTREME — native species only
Jul	282	11.3	9.1	EXTREME — native species only
Aug	255	10.2	7.8	DAMAGING — most non-adapted crops affected
Sep	192	7.7	5.4	HIGH — sensitive species damage
Oct	118	4.7	3.0	MODERATE — above signaling, below damage for most
Nov	76	3.0	1.8	Signaling only
Dec	50	2.0	1.1	Below signaling threshold

Table 1. *Monthly average UV-B radiation at Desert Rock, NV (1998–2024 multi-year averages). Daily dose estimated from noon peak using sinusoidal integration over daylight hours. Plant stress classifications based on published thresholds (see Section 5).*

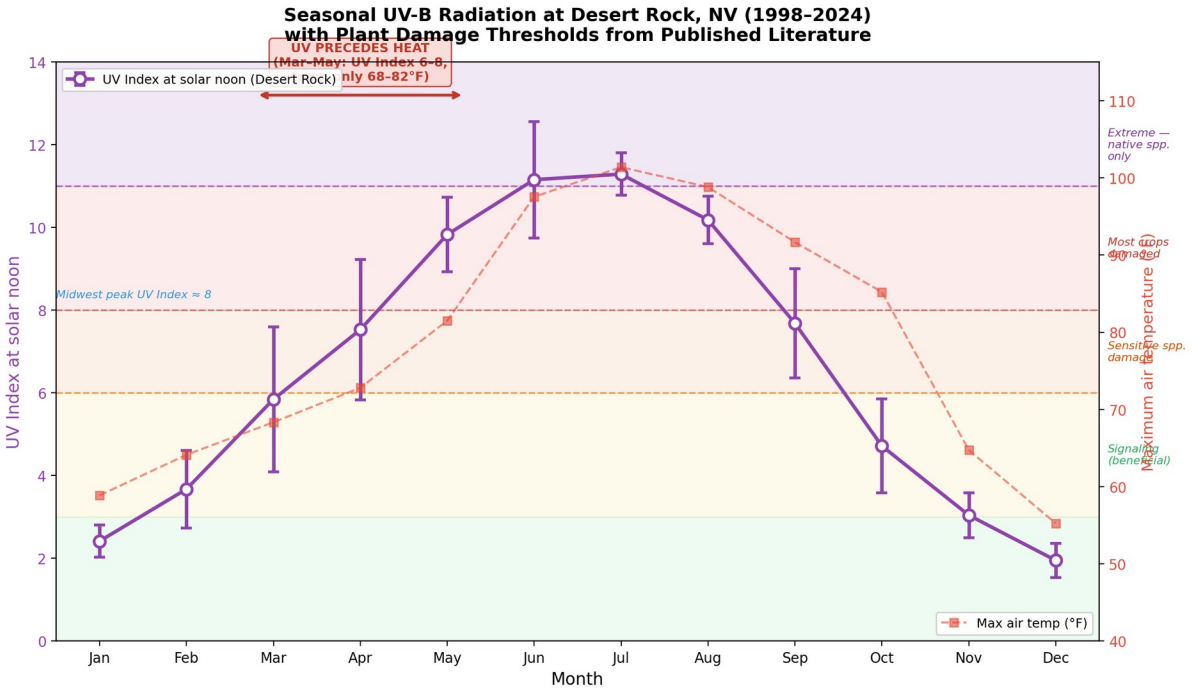


Figure 1. *Seasonal UV-B radiation at Desert Rock, NV (1998–2024) with plant damage thresholds from published literature. Purple curve: UV Index at solar noon (left axis). Red dashes: maximum air temperature (right axis). Colored zones indicate plant stress levels. Note that UV crosses the sensitive-species damage threshold (UV Index 6) in March while temperature is still 68°F.*

4. The “Death Window”: UV-B Precedes Heat

The central finding of this analysis is temporal: UV-B radiation crosses published plant stress thresholds in February–March, while temperature does not reach plant stress levels until June. This creates a period of 10–12 weeks during which UV-B is the only abiotic stressor operating above its damage threshold on sensitive species. Table 2 quantifies this separation.

Month	UV Index	UV stress?	Temp max °F	Heat stress?	Dominant stressor
Jan	2.4	No	59	No	Neither
Feb	3.7	No	64	No	Neither
Mar	6.1	YES	68	No	UV ONLY
Apr	7.2	YES	73	No	UV ONLY
May	8.2	YES	82	No	UV ONLY
Jun	11.2	YES	98	YES	UV + Heat
Jul	11.3	YES	101	YES	UV + Heat
Aug	10.2	YES	99	YES	UV + Heat
Sep	7.7	YES	92	No	UV ONLY
Oct	4.7	No	85	No	Neither

Table 2. *Monthly stressor analysis. UV stress threshold: UV Index ≥6 (sensitive species damage onset). Heat stress threshold: maximum air temperature ≥95°F. Four months (March, April, May, September) show UV stress without heat stress.*

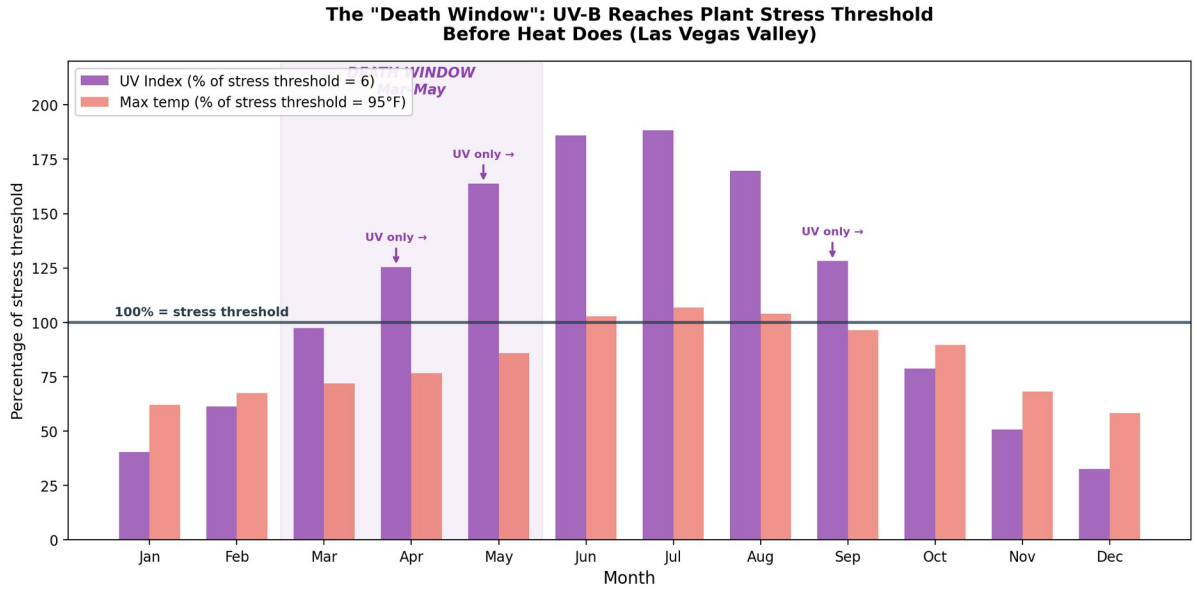


Figure 2. *UV-B and temperature normalized to their respective stress thresholds. Purple bars exceed 100% (UV stress) in March while red bars (temperature) remain below 100% until June. Months labeled "UV only" indicate UV is the sole above-threshold stressor.*

5. Published UV-B Damage Thresholds

The plant UV-B literature reports damage thresholds across a wide range of species and experimental conditions. Thresholds are typically expressed as biologically effective daily UV-B dose (kJ/m²/day, weighted by the Caldwell generalized plant action spectrum or the erythemal action spectrum) or as instantaneous intensity (W/m²). A comprehensive review in Horticulture Research (2021) noted that no universal threshold exists, but species-specific dose-response data provide a usable framework. The key finding from the literature is that species sensitivity spans more than an order of magnitude: broccoli florets show phototoxicity at 2.2 kJ/m²/day while sunflower cotyledons tolerate 30 kJ/m²/day.

Teramura (1983), in the landmark review of UV-B effects on over 200 crop species, found that approximately 20% of species tested were highly sensitive, 50% were moderately sensitive or tolerant, and 30% were effectively insensitive to UV-B radiation in terms of biomass reduction. Subsequent work has confirmed this distribution and identified the physiological basis: UV-B sensitivity correlates with epidermal UV transmittance, constitutive flavonoid content, and the rate of Photosystem II D1 protein repair—all traits that are genetically determined and observable through leaf morphology.

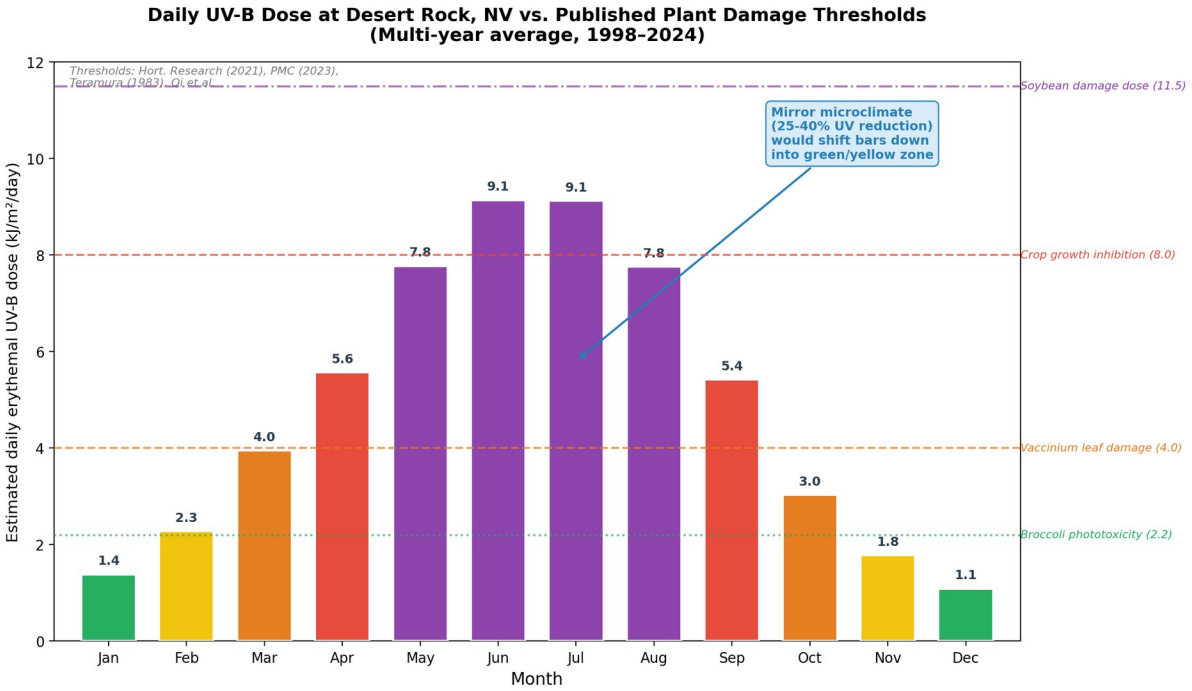


Figure 3. *Estimated daily erythemal UV-B dose at Desert Rock by month, with horizontal lines indicating published damage thresholds from the peer-reviewed literature. Las Vegas crosses the broccoli phototoxicity threshold by February and the general crop damage threshold by March. Annotation indicates that mirror-lit microclimates (25–40% UV-B reduction) would shift effective doses into the green/yellow zone year-round.*

6. A Morphological Framework for Predicting UV Sensitivity

Rather than requiring species-specific UV-B dose-response data—which exists for fewer than 300 species worldwide—UV vulnerability can be predicted from observable leaf morphology. The physiological basis is well established: UV-B radiation must penetrate the leaf epidermis to damage the photosynthetic machinery (Photosystem II) in the mesophyll. Any structural or chemical feature that reduces epidermal UV transmittance confers protection. The following morphological traits, observable without instrumentation, predict UV sensitivity with reasonable accuracy:

UV-Sensitive Traits	UV-Tolerant Traits
Thin, soft, translucent leaves	Thick, leathery, or waxy leaves
Broad, flat leaf orientation	Narrow, needle-like, or rolled leaf geometry
Smooth, glabrous (hairless) surface	Pubescent (hairy), tomentose, or trichome-covered surface
Bright green foliage color	Grey, silver, or blue-green foliage color
Large, thin petals (easily bleached)	Small petals or waxy/resinous floral structures
Northern latitude or forest understory origin	Mediterranean, tropical highland, or desert origin
Low constitutive flavonoid content	High flavonoid, terpenoid, or resinous leaf coatings

Table 3. *Observable morphological traits that predict UV-B sensitivity versus tolerance. These traits can be assessed visually or by touch at the nursery before purchase.*

This framework has immediate practical utility: a nursery customer selecting winter annuals for a Las Vegas garden can assess UV risk by examining the leaf. A pansy (thin, smooth, bright green, Northern European origin) presents maximum UV vulnerability. A dianthus (narrow, waxy, Mediterranean origin) presents moderate tolerance. A desert marigold (pubescent, grey-green, resinous, Mojave native) is effectively UV-proof. The morphological assessment takes seconds and requires no instrumentation or species-specific lookup.

7. Observational Evidence from Mirror-Lit Microclimates

Constructed microclimates in the author's Las Vegas Valley gardens provide observational evidence consistent with the UV-B hypothesis. Several garden areas receive supplemental light via wall-mounted mirrors that reflect sunlight into otherwise shaded planting zones. Standard aluminum-backed glass mirrors transmit approximately 85–92% of visible light in the reflected beam but only 60–75% of UV-B, because the glass substrate absorbs a significant fraction of short-wavelength radiation before it reaches the reflective aluminum coating (Runkle, 2020; manufacturer specifications for standard 3mm soda-lime mirror glass). This produces an inadvertent UV-B filtering effect: plants in mirror-lit microclimates receive supplemental PAR with 25–40% UV-B attenuation relative to direct sunlight.

In these mirror-lit zones, species that are shade-intolerant but UV-sensitive—including ajuga, daffodils (Narcissus), and hybrid tea roses—survive year-round with no seasonal dieback. The same species, planted in direct full-sun locations within the same garden with identical soil, water, and temperature exposure, decline and die in March–April following the seasonal pattern predicted by the UV-B threshold analysis. Ajuga (Ajuga reptans) is a particularly informative case: it is classified as a part-shade to full-sun groundcover in its Northern European native range (peak UV Index 5–7), but in Las Vegas it fails rapidly in full sun while persisting indefinitely in mirror-reflected light. Its thin, glossy leaves lack any UV-protective morphological features.

This observational evidence is not controlled—mirror-lit microclimates differ from full sun in multiple ways, including total light intensity, spectral composition, and potentially air movement patterns. However, the observation that plants survive year-round in a microclimate where UV-B is specifically attenuated, while dying on a predictable seasonal schedule in full sun at equivalent temperatures, is consistent with the hypothesis that UV-B reduction, not shade per se, is the operative mechanism.

8. The Open Question: Shade vs. UV-B Reduction

The mirror microclimate evidence raises a fundamental question that this paper identifies but does not resolve: in constructed microclimates that extend non-native plant survival in the Las Vegas Valley, is the operative mechanism shade (reduced total radiation, reduced surface temperature, reduced evaporative demand) or specifically UV-B reduction?

Conventional shade reduces everything simultaneously: photosynthetically active radiation (PAR), UV-A, UV-B, near-infrared radiation (heat input), surface temperature, and evapotranspiration rate. When a 50% shade cloth extends lettuce survival by four weeks, the benefit could be attributable to any or all of these reductions. The existing horticultural literature uniformly attributes shade benefits to temperature reduction and reduced evaporative demand. UV-B reduction is never discussed as a contributing factor—a gap this paper seeks to fill.

Resolving this question requires experimental interventions that decouple UV-B from the other components of solar radiation. Two such interventions exist and are experimentally tractable:

UV-B-only removal: Clear polycarbonate panels (standard greenhouse grade) block approximately 97% of UV-B while transmitting 88% of visible PAR. A polycarbonate panel mounted overhead with open sides provides UV-B filtering without significant temperature modification. If plants under polycarbonate outlive plants in full sun by the same margin as plants under conventional shade, UV-B reduction is the dominant mechanism. If polycarbonate provides less benefit than shade, temperature reduction contributes independently.

UV-B partial removal (mirror effect): Mirror-reflected light provides PAR supplementation with 25–40% UV-B attenuation. Measuring UV-B levels in mirror-lit microclimates versus adjacent full-sun and shaded zones, using a calibrated UV Index meter (e.g., Solarmeter Model 6.5, ~$250), would quantify the UV-B reduction and correlate it with plant survival duration.

A companion paper in preparation (Brandys, 2026, “Creating Microclimates in Las Vegas Desert Landscapes”) addresses the full microclimate parameter space. The present paper identifies UV-B reduction as a previously unrecognized parameter that may be a primary—rather than incidental—mechanism of microclimate benefit for non-native species in desert environments. Future work will integrate the UV-B findings with the thermal, humidity, wind, and shade parameters analyzed in the companion paper to produce a unified microclimate design framework.

9. Proposed Experimental Protocol

A paired-plot field experiment is proposed to test the hypothesis that UV-B radiation, not heat, is the primary killer of winter annuals in the Las Vegas Valley. The experiment uses UV-B-filtering polycarbonate panels to create a UV-B-free environment while maintaining equivalent temperature, visible light, water, and soil conditions. Five test species span the UV sensitivity spectrum from highly sensitive to fully adapted. The experiment is designed to be executed by a master gardener group or nursery demonstration garden at a total materials cost of approximately $120–150.

Plot A (UV-filtered): Clear polycarbonate panel (4×8 ft, standard greenhouse grade) mounted horizontally at 18” height on a simple 2×4 lumber frame. Open on all four sides for air circulation. Blocks ~97% UV-B, transmits ~88% PAR.

Plot B (full-sun control): Identical plants, soil, water, orientation, and spacing. No overhead panel. All solar radiation reaches plants unfiltered.

Test species: Pansy (highly UV-sensitive, primary test subject); butterhead lettuce (documented UV-B sensitive, Teramura 1983); dianthus (moderate UV tolerance, Mediterranean origin, control); calendula (moderate UV tolerance, resinous leaf coating, control); desert marigold (Baileya multiradiata, Mojave native, negative control—zero difference expected between plots).

Timeline: Plant in early February (UV Index 3–4, temperatures 60–68°F). Critical observation window: March–April (UV Index 6–8, temperatures 68–82°F). Endpoint: date of death or functional failure for each species in each plot. The survival difference (days) between Plot A and Plot B for each species quantifies the UV-B attribution.

Instrumentation: A UV Index meter (Solarmeter Model 6.5 or equivalent, ~$250) should be used to measure UV-B levels in Plot A, Plot B, and in any existing mirror-lit microclimates at solar noon on each weekly observation day. A min/max thermometer in each plot confirms

temperature equivalence. The UV Index meter readings are directly comparable to the 27-year SURFRAD Desert Rock dataset because both use erythemal weighting.

Replication: Minimum 3 plants per species per plot (30 plants total). Weekly photography of upper leaf surfaces to document symptom progression (bleaching, chlorosis, tip burn).

Predicted outcome: If the hypothesis is correct, UV-filtered pansies and lettuce will survive 3–6 weeks longer than full-sun controls—dying in late April or May (from heat) rather than mid-March (from UV-B). Dianthus and calendula will show a smaller survival difference (1–2 weeks). Desert marigold will show zero difference between plots. The survival delta, plotted against the SURFRAD UV Index seasonal curve, will demonstrate that plant death tracks UV-B threshold crossings, not temperature threshold crossings.

10. Global Brightening and the UV Trend

The UV-B stress documented in this paper exists within a broader context of increasing surface solar radiation—the global brightening phenomenon. Augustine (2021) documented a brightening trend of +7.4 W/m² per decade at Desert Rock during 1996–2012 in total shortwave radiation, attributed primarily to reductions in atmospheric aerosol loading following the 1990 Clean Air Act Amendments. National SO_2 emissions have declined 94% since 1980, and PM2.5 concentrations have declined 28% nationally (2006–2020) and 34% in the Los Angeles Basin (2014–2024)—the upwind source region for Las Vegas under prevailing WSW winds.

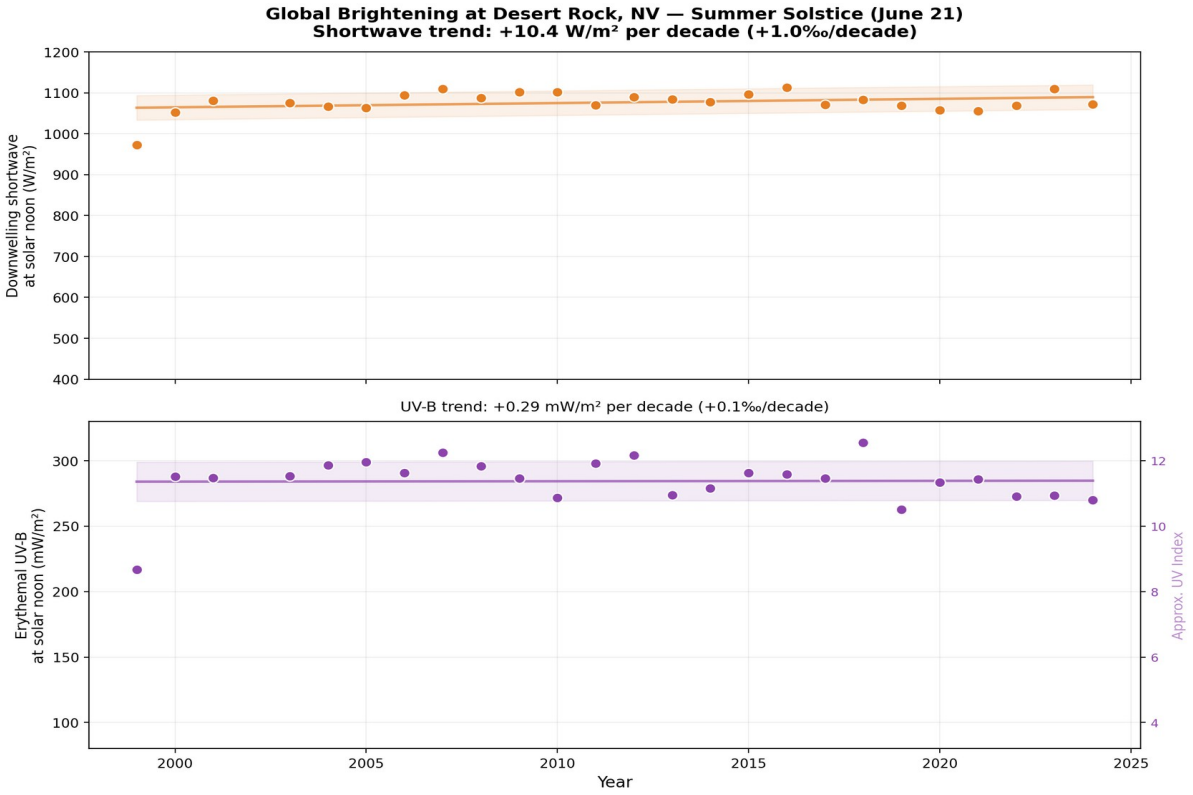


Figure 4. *Summer solstice (June 21) shortwave and UV-B trends at Desert Rock, 1999–2024. Top panel: downwelling shortwave at solar noon shows modest brightening trend (+10.4 W/m²/decade). Bottom panel: erythemal UV-B shows near-zero trend at peak summer (+0.3 mW/m²/decade), consistent with UV-B being near its atmospheric ceiling at this latitude and season. Brightening effects on UV-B are more significant during shoulder seasons (spring, fall) when aerosol scattering has a larger relative impact.*

The analysis of the SURFRAD June 21 data shows a total shortwave brightening trend of +10.4 W/m²/decade at Desert Rock. The UV-B trend at peak summer is near zero (+0.3 mW/m²/decade) because June–July UV-B at this latitude is already near the atmospheric ceiling—limited by ozone column depth, not aerosol scattering. The brightening effect on UV-B is more consequential during the spring shoulder season (March–May), when aerosol optical depth has a larger relative impact on surface UV transmission. This is precisely the period identified in this paper as the critical “death window” for winter annuals, suggesting that the brightening trend may be progressively compressing the growing season for UV-sensitive species—an effect that would compound over decades and would not be detected by temperature monitoring alone.

11. Conclusions

Twenty-seven years of SURFRAD radiometric data from Desert Rock demonstrate that UV-B radiation reaches published plant damage thresholds in February–March in the Las Vegas Valley, 10–12 weeks before temperature stress becomes a factor. The conventional attribution of winter annual decline to “heat” does not withstand quantitative scrutiny: pansy, lettuce, and primrose die at temperatures of 68–73°F that are optimal for their growth. The UV-B levels at those same dates, however, exceed the documented damage thresholds for thin-leaved, shade-origin species by 50–100%.

The morphological framework for UV sensitivity—thin/smooth/green = vulnerable, thick/pubescent/grey = tolerant—provides an immediately actionable diagnostic for nursery professionals and home gardeners. The proposed polycarbonate panel experiment offers a low-cost, field-deployable test of the hypothesis. And the mirror microclimate observations, documenting year-round survival of ajuga, daffodils, and roses under conditions of partial UV-B attenuation, provide preliminary support that merits formal investigation.

The critical open question—whether the operative mechanism in constructed microclimates is shade (total radiation reduction) or specifically UV-B reduction—is identified but not resolved in this paper. Resolving it will require the paired experimental interventions described in Section 9, combined with UV Index measurements in existing microclimates. If UV-B reduction proves to be the primary mechanism, it would transform microclimate design: UV-B-filtering materials could replace or supplement shade structures, and species selection could be guided by UV tolerance ratings rather than generic “sun/shade” classifications that do not distinguish between visible light and UV radiation.

This paper contributes a new parameter—UV-B radiation—to the Las Vegas Native Species Climate Matrix framework, joining the existing analyses of temperature, irrigation timing, chill hours, evaporative demand, and the urban heat island. The convergence of these findings suggests that desert horticulture requires a radiation-aware approach that goes beyond the temperature-and-water paradigm that dominates current practice.

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