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Hot child in the city: Drivers of urban buffelgrass presence in Tucson, Arizona

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Abstract

Invasive species distributions and ecological impacts in natural ecosystems have been broadly studied, but invasive species urban distributions and impacts on human populations warrant further investigation. Urban areas are highly disturbed environments at high risk of invasion by non-native species, and urban infrastructure can influence the dispersal and abundance of invasive species. Furthermore, in areas with concentrated human populations, invasive species may pose a risk to human as well as native biota. Here, we examine (1) how high-traffic roadways and the presence of suitable habitat influence buffelgrass abundance in residential areas and (2) whether buffelgrass differentially invades residential areas across socioeconomic levels and racial diversity indices in Tucson, Arizona. We found that, within residential areas, the presence of vacant lots was positively associated with buffelgrass abundance; however, there was no relationship between other suitable habitat types and buffelgrass abundance. We found no relationship between road type and buffelgrass abundance in residential areas. We found that lower-income communities were more likely to be invaded by buffelgrass, but there was no relationship between racial diversity index and buffelgrass abundance. Understanding drivers of invasive species presence and abundance in urban areas is necessary to inform urban management strategies to prevent spread to surrounding wildlands.

KEYWORDS

buffelgrass, *Cenchrus ciliaris*, invasive species, *Pennisetum ciliare*, urban invasion, weed

1 | INTRODUCTION

Urban areas are highly disturbed environments because of concentrated anthropogenic activity. As a result, they are at high risk of invasion by non-native species (Padayachee et al., 2017). Non-native species can be repeatedly introduced, both intentionally and accidentally, to areas with high levels of anthropogenic activity, leading to increased non-native species richness in urban areas (Von der Lippe & Kowarik, 2008). Invasion patterns and processes in urban environments can vary significantly from invasions in natural/wildland areas

(Gaertner et al., 2017). However, the majority of invasion biology research focuses on the effects of non-native species on wildland systems. There are few studies that address risks that non-native species pose to urban areas (Gaertner et al., 2017).

Urban infrastructure and habitat richness can influence the distribution of invasive species within cities (Murphy et al., 2021; Štajerová et al., 2017). Some sites may be more susceptible to invasion by non-native species due to increased exposure to non-native propagules and high suitability (McGeoch et al., 2016). For example, traffic is a common vector of plant dispersal in urban and suburban areas, so areas near high-traffic roads may be especially at risk for invasion (Von der Lippe & Kowarik, 2008). Vehicles not only disperse seeds via wind generated by vehicle movement but can also carry seeds in wheel wells, bumpers, and mudguards (Ansong & Pickering, 2013). In a systematic review, Ansong and Pickering (2013) found that perennial grasses were most commonly dispersed by cars relative to other plant types. Urban riparian networks can also serve as vectors of native and invasive plant dispersal and promote the spread of invasive species (Aronson et al., 2017). Vacant lots have been shown to support a variety of weed species, with weed richness increasing with lot age (Crowe, 1979; Gulezian & Nyberg, 2010; Vincent & Bergeron, 1985).

Although roadways are known to be vectors of invasive species spread at landscape scales, less is known about the role roads play in neighborhood-scale invasive plant density in urban areas in conjunction with other urban features such as alleys, storm drainage infrastructure, and vacant lots, which may be vulnerable to invasion by non-native plants (Benedetti & Morelli, 2017; Von der Lippe & Kowarik, 2008). For example, vehicle traffic on busy roads may facilitate repeated introduction events via directional air turbulence (wind), leading to higher propagule pressure and likely higher overall invasive plant density (Hansen & Clevenger, 2005). Furthermore, habitat type within urban areas can influence the abundance of non-native species, with open canopy, disturbed habitat having higher abundance of non-native species than areas with high woody cover (Hansen & Clevenger, 2005).

To effectively manage harmful non-native species at a landscape scale in places where a matrix of urban and wildlands is present, it is critical to understand both (1) the distribution and spread of non-native species in urban and in wildland spaces and (2) the impacts of non-native species on native species and human communities. Here, we estimate the presence of buffelgrass (*Pennisetum ciliare* [L.] Link, syn. *Cenchrus ciliaris*), a globally significant invasive perennial grass, in urban Tucson, Arizona (AZ). While buffelgrass is well-studied in the wildlands surrounding Tucson, little is known about its presence or spread in urban areas (Van Devender & Dimmitt, 2006). Our approach fills knowledge gaps that are critical for buffelgrass management and is generalizable to other areas and species.

Buffelgrass, a perennial invasive grass that has invaded wildlands in at least 13 US states, northern Mexico, Australia, and parts of Asia, has also spread into urban areas in the southwest. It was introduced to the southwestern United States in the 1940s to mitigate soil erosion and provide drought-tolerant forage for cattle (Ibarra et al., 1995; Marshall et al., 2012; Rodríguez-Rodríguez et al., 2017). Buffelgrass seeds are known to disperse via wind and animal vectors and likely can disperse much farther than the general estimated mean dispersal distance of 0.6–7.26 m away from parent plants (Cheplick, 1998; Hacker & Ratcliff, 1989; Stevens & Falk, 2009), and under field conditions can remain viable in the seedbank for 2–4 years (Reilley & Maher, 2019; Silcock & Smith, 1990; Winkworth, 1971). Buffelgrass seeds can germinate within 5 days following precipitation and require a minimum of 6.3 mm precipitation (Ward et al., 2006), and seedlings establish well in anthropogenically disturbed sites and bare areas with low vegetation cover (McIvor, 2003; Stevens & Falk, 2009). Buffelgrass can tolerate high temperatures (up to 50°C; Barrera & Castellanos, 2007) and a broad range of precipitation (250–2670 mm annually; Marshall et al., 2012). Due to its drought tolerance, rapid response to precipitation, seed longevity, and low water requirements for germination, buffelgrass thrives in the arid environment of the Sonoran Desert (Marshall et al., 2012; Wallace et al., 2016). Buffelgrass has been present in Tucson since before 1980, and it began spreading through the wildland-urban interface in the 1980s (Brenner & Franklin, 2017).

Ecological impacts of buffelgrass in wildland areas are well known. In the Sonoran Desert, buffelgrass outcompetes native vegetation (Jernigan et al., 2016), alters fire regimes by increasing the frequency and spatial extent of wildfire (McDonald and McPherson 2011), and influences soil microbiomes (Gornish et al., 2020) and wildlife communities (Guzmán-Ojeda et al., 2023). The impacts of buffelgrass invasion in urban areas are less well known, but the effects of buffelgrass in wildlands may translate to urban habitat. For example, buffelgrass is likely to invade disturbed areas with permeable substrate (i.e., roadsides and banks of washes) and displace native vegetation. Urban populations of buffelgrass may also serve as source populations furthering the spread of buffelgrass into nearby wildlands, threatening native vegetation and wildlife (Stevens & Falk, 2009; Van Devender & Dimmitt, 2006). Furthermore, in urban areas, buffelgrass likely has economic and social impacts in addition to ecological impacts. Urban populations of buffelgrass can enhance the risk of brushfires, increasing the likelihood of destruction of property, injury, loss of life, and reduced air quality (Brenner & Franklin, 2017; Plecki et al., 2021).

Humans can influence the distribution of invasive species by implementing management techniques to remove invasive species and reduce their spread (Niemiec et al., 2018). The complex social landscape of urban areas presents a challenge to invasive species management as the priorities and interests of government agencies, private and commercial landowners, interest groups, and individual residents often conflict (Lien et al., 2021; Niemiec et al., 2018). In Tucson, the ecological threat of buffelgrass to wildlands is well recognized by many government agencies, land managers, and residents (Brenner & Franklin, 2017; Plecki et al., 2021). Indeed, land managers, government agencies, and volunteer groups have taken collective action to reduce buffelgrass cover in wildlands surrounding Tucson (Brenner & Franklin, 2017). In 2005, the Arizona Department of Agriculture declared buffelgrass a noxious weed, and Pima County, where Tucson is located, adopted a resolution mandating the management of buffelgrass among other invasive species (Brenner & Franklin, 2017). Groups such as the Buffelgrass Working Group and the Southern Arizona Buffelgrass Coordination Center have led outreach efforts to educate the public about the threats buffelgrass poses to the environment (Brenner & Franklin, 2017; Lien et al., 2021). The Tucson Mountain Weedwackers and the Arizona Sonora Desert Museum regularly organize volunteers to manually remove buffelgrass from invaded sites surrounding Tucson (Brenner & Franklin, 2017). Although natural area managers are concerned about the risk buffelgrass poses to urban infrastructure as well as to the natural environment, many Tucson residents do not recognize buffelgrass as a threat to their own neighborhoods or the City of Tucson generally (Brenner & Franklin, 2017, Plecki et al., 2021). This highlights a need to assess the severity of buffelgrass invasion in Tucson, AZ, and determine characteristics of urban areas associated with high buffelgrass abundance. Furthermore, both risks caused by invasive species (e.g., brushfires) and invasive species mitigation efforts (e.g., exposure to herbicide) may differentially affect human populations where intensive management is warranted (Norgaard, 2007; Schelhas et al., 2021). Therefore, documenting the severity of buffelgrass invasion across a range of socioeconomic and racial diversity levels in Tucson will enable us to determine whether buffelgrass invasion and mitigation may present an environmental justice matter that would inform the development of effective management strategies in an urban context (Norgaard, 2007; Schelhas et al., 2021).

Vectors of buffelgrass spread and impact in urban areas require further study to ensure the development of effective management strategies (Francis & Chadwick, 2015). Here, we examine (1) how a common vector of dispersal (traffic) and the presence of urban features representing habitat vulnerable to invasion influence buffelgrass abundance in residential areas and (2) whether buffelgrass differentially invades residential areas across socioeconomic levels and racial diversity indices in Tucson, AZ. We hypothesized that residential areas with higher traffic roads would have higher buffelgrass abundance than areas with lower traffic roads due to the increased likelihood of buffelgrass introduction via vehicle movement. We also hypothesized that residential areas with urban habitat particularly vulnerable to invasion, such as washes, alleys, and vacant lots, would have higher buffelgrass abundance than areas with less undeveloped substrate since washes, alleys, and vacant lots experience high levels of anthropogenic disturbance, abundant permeable substrate, and inconsistent management practices. We hypothesized that buffelgrass would be more prevalent in lower-income neighborhoods due to previous patterns relating invasive species abundance to landowner wealth (Gulezian & Nyberg, 2010; Niemiec et al., 2018). We did not have an a priori hypothesis about the relationship between buffelgrass abundance and neighborhood racial diversity levels, but we wished to document any potential patterns to determine whether buffelgrass invasion and mitigation present an environmental justice matter in the City of Tucson.

2 | METHODS

2.1 | Study design

We conducted counts of buffelgrass abundance in residential neighborhoods distributed across five median income categories and five racial diversity categories in Tucson, AZ, United States (Figure 1). We noted the presence of potential urban buffelgrass habitats in each sample unit (washes, alleys, and vacant lots) and classified each sample unit by the highest traffic road type it contained. The city of Tucson is approximately 241 square miles with a population of approximately 543,000 people and a population density of 2251.6 people per square mile as of the 2020 US census (United States Census Bureau, 2020). The median household income for 2017–2021 was $48,058 (United States Census Bureau).

Block level 2010 US Census Data and data delineating Tucson's jurisdictional boundaries, street network,

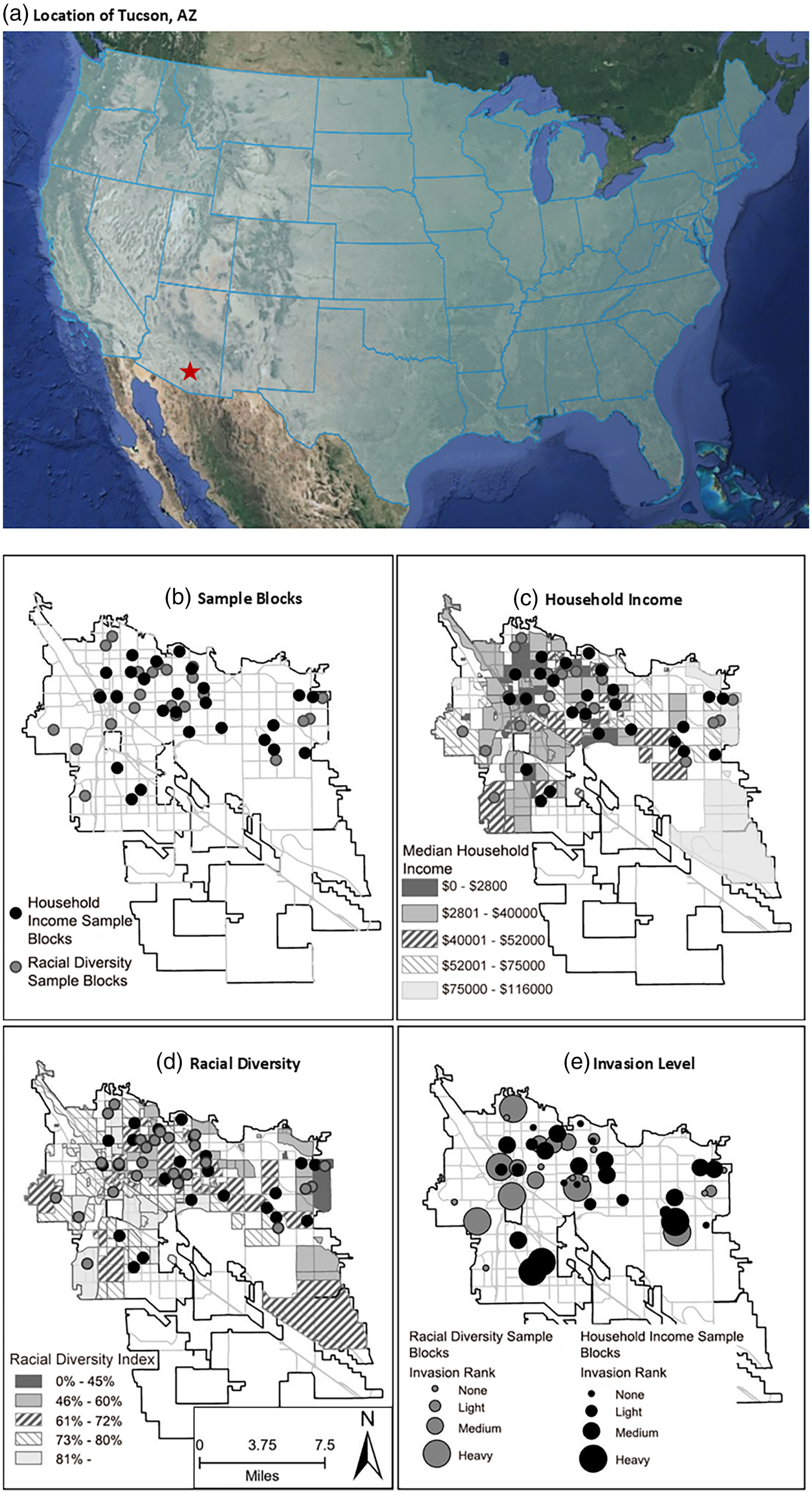

FIGURE 1 Map of study design. (a) Location of Tucson, AZ in North America; (b) locations of all sample units in Tucson, Arizona (AZ); (c) location of all sample units with income levels throughout Tucson; (d) locations of all sample units with racial diversity levels throughout Tucson; (e) invasion rank of each sample unit.

washes, basins, and watersheds, parks, and neighborhood associations were acquired from the City of Tucson's Geographic Information System (GIS)u services Open Data website (City of Tucson Information Techology Department 2019, 2021). The natural breaks method was used to classify Tucson residential areas into five classes of median household income and five classes of a racial diversity index (Chen et al., 2013). The racial diversity index is a metric developed by the United States Census Bureau to estimate the relative diversity of a geographic area. The racial diversity index reports the likelihood that any two random people drawn from the same geography will be of the same or different racial or ethnic groups, according to United States Census Bureau definitions of race and ethnicity. The higher the index value, the more likely it is that two individuals will be of different racial or ethnic groups. The lower the index value, the more likely it is that two individuals will be of the same racial or ethnic group. Using GIS, five Tucson residential neighborhood sample units were randomly selected from each household income classification (25 sample units) and from each racial diversity index classification (25 sample units) (50 total sample units). Sample unit sizes ranged from 500 to 900 feet in shapelength.

2.2 | Field sampling

In April 2022, we surveyed each sample unit on foot, walking on all publicly accessible sidewalks, alleys, and roads. We counted the total number of individual buffelgrass plants visible from public roads and walkways. Two people per team counted and averaged their counts. We recorded whether buffelgrass plants were evenly dispersed throughout the sample unit or clustered in one or a few areas. We also recorded the presence of alleys ("public ways used for the placement of utilities and refuse collection"), washes (dry streambeds that function as stormwater drainage during monsoon season), and vacant lots (unused areas of land) in each sample unit (Tucson, Unified Development Code 2013). Each sample unit was categorized according to its highest traffic road using City of Tucson definitions. Sample units could contain principal arterials (roads and streets that serve through traffic), minor arterials (streets that interconnect with principal arterials), major collectors (streets that connect local roads with arterials), minor collectors (streets that connect major collectors to residential neighborhoods), or interior neighborhood roads (streets entirely within residential subdivisions or developments). Each sample unit was categorized into one of four invasion levels on a logarithmic scale: uninvaded (0 buffelgrass plants), low (1–10 buffelgrass plants), medium (11–100 buffelgrass plants), or high (>100 buffelgrass plants) following Gulezian and Nyberg (2010).

TABLE 1 Parameter estimates, *z*-values, and *p*-values for the zero-inflated negative binomial regression model.

Parameter	Estimate	*z*-value	*p*-value
Alley	0.472	0.907	.365
Vacant lot	1.912	2.296	.022*
Wash	0.689	0.709	.478
Principal arterial	1.534	1.100	.272
Minor arterial	−17.947	−0.003	.997
Major collector	−17.947	−0.001	.998
Minor collector	−17.947	−0.002	.998

2.3 | Data analysis

We pooled the data from the household income sample units and racial diversity sample units for analysis. We performed a zero-inflated negative binomial regression to determine how the highest traffic road related to the presence of buffelgrass in sample units (zero-inflation model) and how the presence of washes, alleys, and vacant lots related to buffelgrass abundance in sample units (count model) (Yau et al., 2003). The zero-inflation model was:

$$\text{logit}[\Pr(Y=1)] = \alpha_0 + \beta_0 \times \text{highest traffic road},$$

where $\Pr(Y=1)$ is the probability that buffelgrass was present. The count model was:

$$\log(Y) = \alpha_1 + \beta_1 \times \text{presence of wash} + \beta_2 \times \text{presence of alley} + \beta_3 \times \text{presence of vacant lot},$$

where Y is the abundance of buffelgrass in the sample unit. We also performed a Fisher's exact test to determine whether buffelgrass invasion level varied by income level and racial diversity level. All analyses were performed in R Statistical Software v. 4.2.1 (R Core Team, 2022). Zero-inflated negative binomial regression was performed using the R package "pscl" (Jackman, 2020; Zeileis et al., 2008).

3 | RESULTS

The presence of vacant lots in sample units nearly doubles the expected log of buffelgrass abundance ($p = .02$;

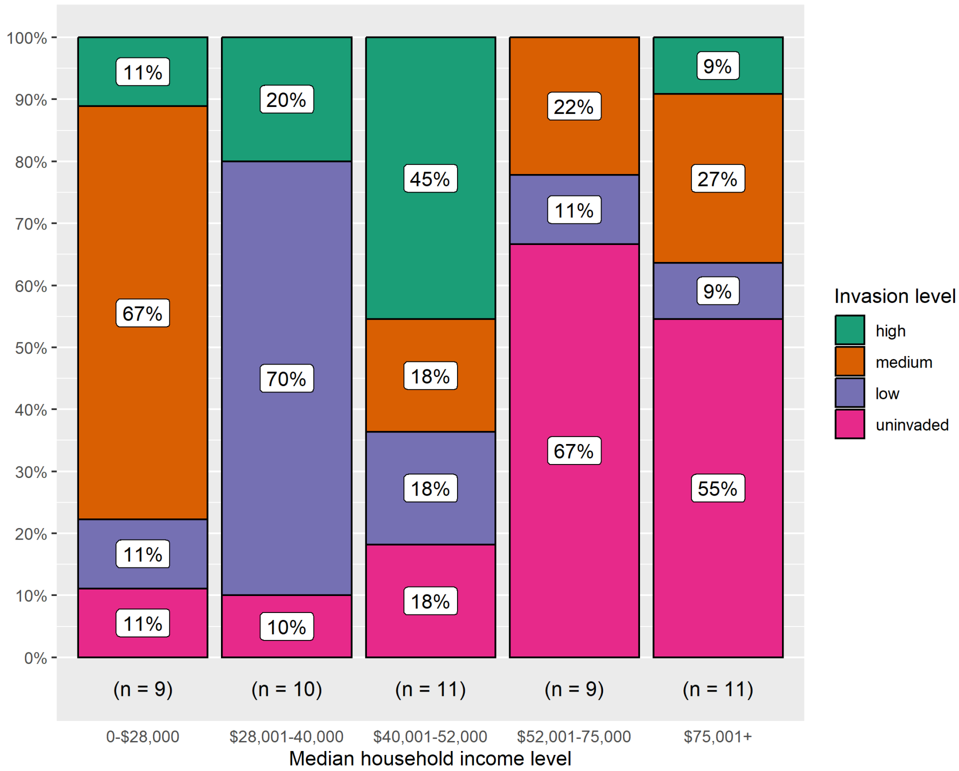

FIGURE 2 Percent of sample units in each invasion level category (uninvaded = 0 buffelgrass, low = 1–10 buffelgrass plants, medium = 11–100 buffelgrass plants, high >100 buffelgrass plants) in each income level.

TABLE 2 Mean buffelgrass abundance and standard error for each household income level and each racial diversity index level.

Demographic variable	Mean abundance	Standard error
Median income level		
0–$28,000	70.56	33.07
$28,001–40,000	114.30	96.15
$40,001–52,000	92.45	34.70
$50,000–75,000	9.33	5.94
$75,001–116,000	22.55	14.71
Racial diversity index		
0%–45%	11.89	6.72
46%–60%	17.75	5.74
61%–72%	28.58	14.53
73%–80%	183.50	93.08
81%–100%	86.38	46.65

Table 1). However, there was no relationship between buffelgrass abundance and the presence of washes or alleys ($p = .48$ and $p = .36$, respectively; Table 1). The highest traffic road type had no influence on whether an area was invaded by buffelgrass ($p > .05$; Table 1).

There were higher levels of buffelgrass invasion in lower-income communities (<0.001; Figure 2). Specifically, there were significantly higher than expected "medium" invaded sites in the lowest income level communities ($p = .04$; Figure 2), higher than expected "low" invaded sites in the second lowest income level communities ($p < .001$; Figure 2), and higher than expected uninvaded sites in the second highest income level communities ($p = .03$; Figures 1d and 2; Table 2). There was no significant relationship between racial diversity index and buffelgrass invasion level ($p = .102$; Figures 1d and 3; Table 2).

4 | DISCUSSION

Human activities such as land use change and elevated human population density influence the distribution of invasive plants globally (Essl et al., 2019). Invasive species richness at large scales is also correlated with human activities (Essl et al., 2011). Urban areas are vulnerable to invasion by non-native species, in large part due to increased human activities disturbing and degrading habitats and human-facilitated introduction of non-native species. In areas where invasive species are recognized as a threat, lower-income communities may be more likely to be invaded due to higher incidences of unmanaged vacant lots (properties with no buildings where owners lived elsewhere) (Niemiec et al., 2018). We found that urban land features such as vacant lots influenced the invasion intensity of buffelgrass and that lower-income communities were more likely to be

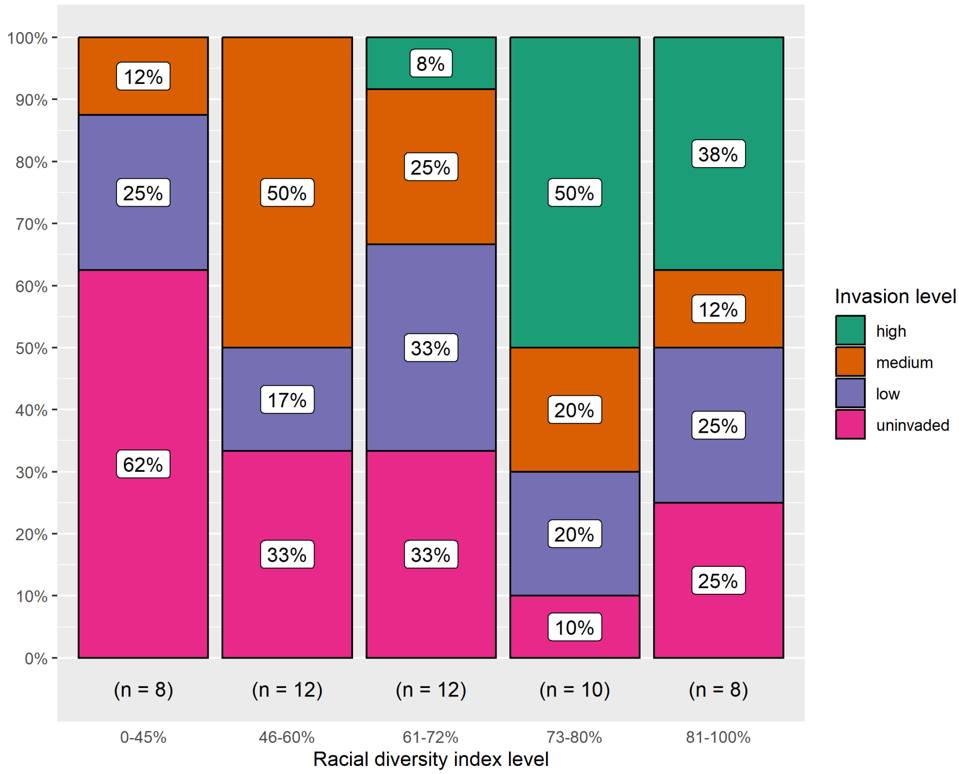

FIGURE 3 Percent of sample units in each invasion level category (uninvaded = 0 buffelgrass, low = 1–10 buffelgrass plants, medium = 11–100 buffelgrass plants, high >100 buffelgrass plants) in each racial diversity index level.

invaded by buffelgrass than higher-income communities in Tucson, AZ.

We expected alleys, vacant lots, and washes to be especially vulnerable to buffelgrass invasion in residential areas because these features are highly disturbed and have primarily undeveloped substrate, leading to higher buffelgrass abundance in sample units where these features were present. However, only vacant lots had a significant influence on buffelgrass abundance in residential areas. It may be that alleys experience regular professional maintenance performed by the city compared to an absence of maintenance on privately owned vacant lots. Alleys in Tucson are typically kept clear by the city to allow access for trash collection. Washes intermittently flood during the monsoon season and buffelgrass does not tolerate flooding (Marshall et al., 2012), so they may not be suitable for buffelgrass. Furthermore, Pima County Flood Control District is required to keep washes free of brush to prevent flooding, so brush-clearing activities may result in unintended buffelgrass control in washes. Vacant lots may represent uniquely neglected urban areas that are particularly susceptible to invasion by non-native plants, especially when no weed control measures are enacted. Areas with absentee landowners result in reduced weed management activities even when weeds are acknowledged as a problem (Klepeis et al., 2009; Yung et al., 2015); and these areas become sources for reinvasion of neighboring property (Yung et al., 2015).

Although high-traffic roads are known to promote the dispersal of plant propagules via wind generated by passing vehicles (Hansen & Clevenger, 2005), the presence of higher traffic roads in some sample units did not influence buffelgrass presence. In a large-scale survey of invasive species in urban areas, "unaided dispersal" (i.e., wind) was the most prominent vector of spread within urban areas (Padayachee et al., 2017). Furthermore, birds have been shown to disperse non-native seeds in urban landscapes (Cruz et al., 2013). It may be that within Tucson, buffelgrass has already been repeatedly introduced to many areas, so it is not a matter of whether buffelgrass seeds arrive in an area but whether buffelgrass plants can persist in that area that determines whether buffelgrass is likely to be present. Our results suggest that in places where buffelgrass is already prevalent, vehicular traffic does not increase the probability of buffelgrass being present. This indicates that in urban areas within already-invaded ecosystems, land management practices may be a much more important factor determining invasive species presence.

We observed differential invasion across income levels but not across racial diversity levels. Invasive species abundance has been shown to be negatively correlated with median income, largely due to increased vacant land in lower-income areas (Gulezian & Nyberg, 2010). Vacant lots were only observed in the lowest-income levels in our study. Furthermore, residents in higher-income areas may have resources to remove undesirable weeds from their properties. For example, household income influences the amount consumers spend on landscaping projects and services (Jin et al., 2013). Higher-income levels also predict increased likelihood of residents forming a homeowners association (HOA) (Cheung & Meltzer, 2014). Plecki et al. (2021) found that HOA involvement of residents in Tucson had a positive effect on their participation in buffelgrass control. Also, public outreach regarding the threat of buffelgrass invasion in Tucson, such as that following the Buffelgrass Summit in 2007, focused on wealthy neighborhoods in the wildland-urban interface of the Santa Catalina Mountain foothills, where buffelgrass was considered a significant threat (Brenner & Franklin, 2017).

That lower-income neighborhoods are differentially affected by buffelgrass invasion in Tucson puts these communities at disproportionate risk of brushfire, as buffelgrass is a major fuel source (Brenner & Franklin, 2017; Esque et al., 2006; McDonald & McPherson, 2013). This creates an inequity in which already vulnerable communities are put at greater risk due to invasive species. The Southern Arizona Buffelgrass Coordination Center recognized this, and a portion of a Federal Emergency Management Agency (FEMA) pre-disaster mitigation grant to reduce wildfire risk for Tucson infrastructure was earmarked to reduce buffelgrass cover in low-income neighborhoods (Brenner & Franklin, 2017). Techniques used to manage buffelgrass include the use of herbicide, manual or mechanical removal, reseeding with native species, and fire (Friedel et al., 2011). The most effective of these techniques for removing buffelgrass is application of herbicide in combination with other methods such as manual removal or seeding with native species (Farrell & Gornish, 2019). Conflict has arisen around the use of herbicides to control invasive species when humans are likely to be exposed to the herbicide in question (Norgaard, 2007). To reduce potential social controversy, cities and municipalities may consider differential risks that both the presence of invasive species and strategies to eradicate invasive species may pose to vulnerable communities when developing plans for the management of invasive species.

Managing invasive species in urban areas is a challenge because there are a variety of stakeholders and rightsholders who may have conflicting views on management practices (Colodner et al., 2022; Gaertner et al., 2016; Lien et al., 2021). For example, in Australia, buffelgrass can provide economic benefits to pastoralists as forage for livestock while it has negative effects on native flora and fauna and alters fire regimes (Grice et al., 2012). Even with conflicting management objectives, common ground may be found among diverse stakeholders and rightsholders to develop policies and strategies for the management of contentious invasive species (Friedel et al., 2011). In Tucson, stakeholders and rightsholders are generally in agreement about the negative ecological impacts of buffelgrass on wildlands but do not always agree about the risks buffelgrass poses in urban settings (Plecki et al., 2021). For example, greater than 90% of Tucson resident survey respondents considered buffelgrass an ecological threat to wildlands, but less than half considered buffelgrass a threat to the City of Tucson (Plecki et al., 2021). Furthermore, in Tucson many volunteer efforts exist to remove buffelgrass from wildland areas, but little action is taken to reduce the risk of buffelgrass to residential neighborhoods within the city limits (Brenner & Franklin, 2017).

The spread of buffelgrass into wildland-urban interfaces increases the risk of wildfires spreading from wilderness biomes into residential areas (Brenner & Franklin, 2017; Olsson et al., 2012; Wilder et al., 2021). For example, in 2020, the Bighorn Fire in the Santa Catalina Mountains north of Tucson, AZ, resulted in the mandatory evacuation of 200 residences in suburban neighborhoods on the urban fringe of the city (Wilder et al., 2021). Buffelgrass invasion also poses a risk to Tucson residents from brushfires; at least two buffelgrass-fueled brushfires have occurred within Tucson city limits, one of which resulted in the loss of one human life (Downing, 2006; Kreuutz, 2013). Given the relative lack of concern Tucson residents have for risks of buffelgrass in urban environments, educational outreach efforts to inform stakeholders and rightsholders of the dangers of buffelgrass invasion within the city of Tucson would be an important component of urban buffelgrass mitigation (Brenner & Franklin, 2017; Plecki et al., 2021).

Policy makers and regulators may find that different strategies for assessing risk and targeting and managing invasive plants in urban areas relative to wildland or wildland-urban interfaces increase the efficacy of invasive plant management efforts (McGeoch et al., 2016). A prioritization framework that utilizes both published literature on invasive species and stakeholder and rightsholders' assessments of the risks and positive and negative effects of invasive species and their potential for control improves collaboration between different stakeholder groups when developing strategies for urban invasive species management (Potgieter et al., 2021). For urban invasive species management, Potgieter et al. (2022) propose prioritizing sites based on their susceptibility to invasion and their sensitivity to the negative effects of invasion. Our results suggest that vacant lots are particularly susceptible to invasion by buffelgrass, so management efforts that target monitoring and treatment of buffelgrass in vacant lots may have a large impact. Furthermore, it is critical to consider socioeconomic impacts of weeds when prioritizing invasive species management in urban areas (McGeoch et al., 2016). Our study suggests that lower-income human communities may be particularly sensitive to the negative effects of buffelgrass invasion, so differential risks that buffelgrass poses to human populations in Tucson could also be an important factor to include in urban invasive species management strategies. There is a long history of cooperation among stakeholders and rightsholders to manage buffelgrass in wildland areas surrounding Tucson and recognition of the ecological harm that buffelgrass causes in wildlands (Brenner & Franklin, 2017). With coordinated efforts to educate the public about the risks that urban buffelgrass invasion poses to human safety and targeted efforts to treat particularly vulnerable sites of invasion, Tucson has the potential to significantly mitigate urban buffelgrass invasion in residential areas.

AUTHOR CONTRIBUTIONS

Research conceptualization was undertaken by Katherine Hovanes, Elise S. Gornish, Elizabeth Baldwin, and Aaron Lien. Methodology was designed by Katherine Hovanes, Aaron Lien, and Sawyer Thies. Data were collected by Katherine Hovanes, Sawyer Thies, and Lia Ossanna. Data curation and analysis were conducted by Katherine Hovanes and Lia Ossanna. Data visualization was conducted by Katherine Hovanes and Sawyer Thies. Writing of the original draft was conducted by Katherine Hovanes. Review and editing were undertaken by Elise S. Gornish, Sawyer Thies, Elizabeth Baldwin, Lia Ossanna, Elena Dosamantes, and Aaron Lien.

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CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest to declare.

DATA AVAILABILITY STATEMENT

The authors have created a Zenodo repository containing the data, metadata, and R script used for data analysis. The repository (https://doi.org/110.5281/zenodo.8102066) will be published upon publication of this manuscript.

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