



Suitability Assessment of Selected Range Sites for Cattle Grazing in Adamawa State, Nigeria

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ARTICLE HISTORY

Received: 01/06/2026

Accepted: 15/07/2026

Article Type:

Research Paper

Volume: 14

Issue: 1

Pp: 258 –267

ABSTRACT

Rangelands cover an estimated 54% of the Earth's ice-free land surface and sustain biodiversity, climate regulation, and pastoral livelihoods, yet site-specific, quantitative evaluations of cattle grazing suitability remain scarce for the Guinea Savanna rangelands of Adamawa State, Nigeria. Existing appraisals favour qualitative description over standardised scoring of habitat attributes, limiting their value for comparative management decisions. This study evaluated the status, health, and productive potential of four range sites, Gongoshi, Jibiro, Marke Sarajo, and Shashau, using the Habitat Evaluation Technique to assess six habitat attributes: forage species abundance, forage species diversity, and shrub and sapling density as top important attributes, and interspersions of cover types, stage of plant succession, and density of trees above 3 metres as less important attributes. Data were analysed using Relative Density, the Shannon-Wiener Diversity Index, and descriptive statistics. Relative densities differed across sites, with *Andropogon gayanus* (0.076) and *Tephrosia bracteolata* (0.112) recording the highest densities in Jibiro and Marke Sarajo, respectively. Shannon-Wiener indices ranged from 3.000 to 3.274, indicating high forage diversity despite heavy grazing. Mean shrub densities ranged from 57.2 to 64 stems per 0.1 ha, and mean tree densities above 3 metres ranged from 25.3 to 27.6 per 0.1 ha. All four sites qualified as medium value habitats; Jibiro, Marke Sarajo, and Shashau met all six attributes, while Gongoshi met five. All four rangelands satisfied over 70% of the required attributes, indicating an upward ecological trend, and support continued, closely monitored grazing to sustain forage availability for livestock in the study area.

Keywords: Habitat evaluation, Forage diversity, Shannon-Wiener index, Rangeland productivity, Seral succession.

INTRODUCTION

Rangelands are vast natural landscapes managed primarily through ecological processes rather than intensive agriculture; they are defined less by what grows on them than by how they are managed. Rangelands represent an estimated 54% of the Earth's ice-free land surface (Holechek, Pieper and Herbel, 2011). Rangeland evaluation is the systematic process of assessing the status, health, and productive potential of rangeland

resources to guide management decisions (Holechek, Pieper and Herbel, 2011). According to the Society for Range Management (2023), rangelands support biodiversity by sustaining specialised flora and fauna that cannot survive in forests or urban areas. They also function as carbon sinks; although rangelands store less carbon per acre than forests, their vast scale makes their aggregate contribution globally

significant. Rangelands further preserve the cultural heritage of indigenous nomadic and pastoral communities. Gaffney, Augustine, Kearney and Porensky (2021) and Acar (2022) described rangeland vegetation composition as the specific mixture and relative proportions of plant species, life forms, and functional groups that inhabit a rangeland ecosystem. Vegetation composition remains a critical attribute for assessing rangeland health, forage availability, and ecological integrity.

To systematically evaluate rangelands, land suitability assessment must transition from basic botanical inventories to structured, multi-criteria frameworks, such as the Food and Agriculture Organization (FAO) guidelines for land evaluation (Farazmand *et al.*, 2019). For cattle grazing specifically, suitability is not merely a function of standing forage biomass; it is a complex interplay of biophysical constraints, including forage palatability, terrain slope, soil susceptibility to erosion, and proximity to perennial water sources (Farazmand *et al.*, 2019). In the Guinea Savanna belt of Adamawa State, these biophysical dynamics are further compounded by seasonal moisture deficits, shifting transhumance corridors, and escalating land-use competition between pastoralists and crop farmers. Consequently, evaluating range sites based on standardized suitability criteria is an ecological necessity and a socio-economic imperative required to prevent overgrazing, determine sustainable carrying capacities, and mitigate resource-based conflicts in the region (Adenle and Ifejika Speranza, 2020).

Suitability, within land evaluation frameworks, denotes the fitness of a given land unit for a specified use, in this case cattle grazing, judged against the presence and adequacy of the attributes that use requires (Farazmand *et al.*, 2019). Assessing suitability therefore differs from general habitat description, since each attribute is measured against a defined threshold before a range site can be classified as fit for the

intended purpose. This distinction underlies the choice of the Habitat Evaluation Technique for the present study, as the technique scores individual attributes against fixed criteria rather than describing vegetation in general terms.

Despite growing recognition of rangeland value across Nigeria, site-specific and quantitative assessments of cattle grazing suitability remain scarce, particularly within the Guinea Savanna belt of Adamawa State. Existing appraisals in the region tend toward general vegetation description rather than standardised scoring of habitat attributes, which limits their usefulness for comparative management decisions across sites. This gap constrains the ability of extension agencies and pastoralists to prioritise which range sites merit rehabilitation, continued grazing, or rest. This study was born out of the need to close that gap by optimising the efficient utilisation of forage resources on four selected range sites, thereby assessing the suitability of forage species and range status for cattle grazing in Adamawa State. The specific objectives were to determine the relative density and diversity of forage species at each site, quantify shrub, sapling, and tree densities, assess interspersions of cover types and stage of plant succession, and classify each site's overall habitat value for cattle grazing.

MATERIALS AND METHODS

The study Area

Adamawa State lies between latitude 7°N and 11°N of the equator and between longitude 11°E and 14°E of the Greenwich Meridian. Thus, the State is located in the North Eastern part of Nigeria and shares boundaries with Taraba State to the South and West and Gombe State to the North West, while Borno State lies to the North. The State also shares an international boundary with the Republic of Cameroon along its Eastern border (Figure 1). Adamawa State covers a land area of about 39,972.3 km² with a population of 4,504,337 people, based on the 2006 census

projected figure. Figure 2 shows the map of Adamawa State and the Local Government

Areas containing the four range sites (Adebayo and Tukur, 2020).

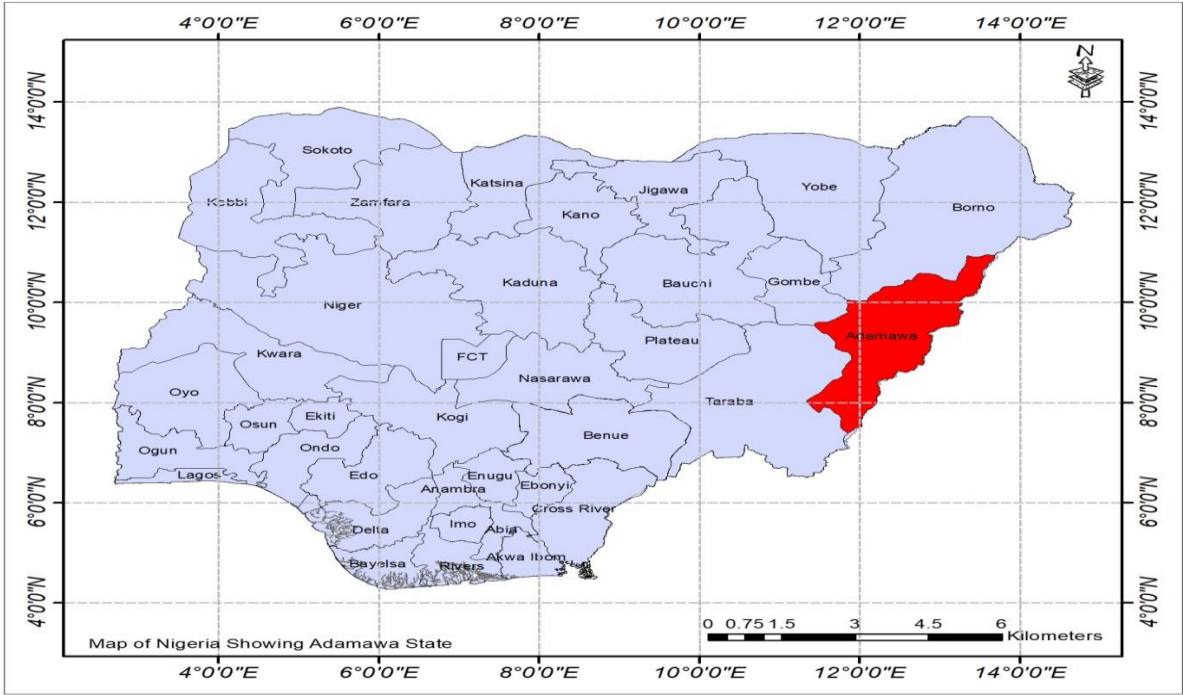


Figure 1: Map of Nigeria showing Adamawa State and its international boundary with Cameroon. Source: Adebayo and Tukur (2020).

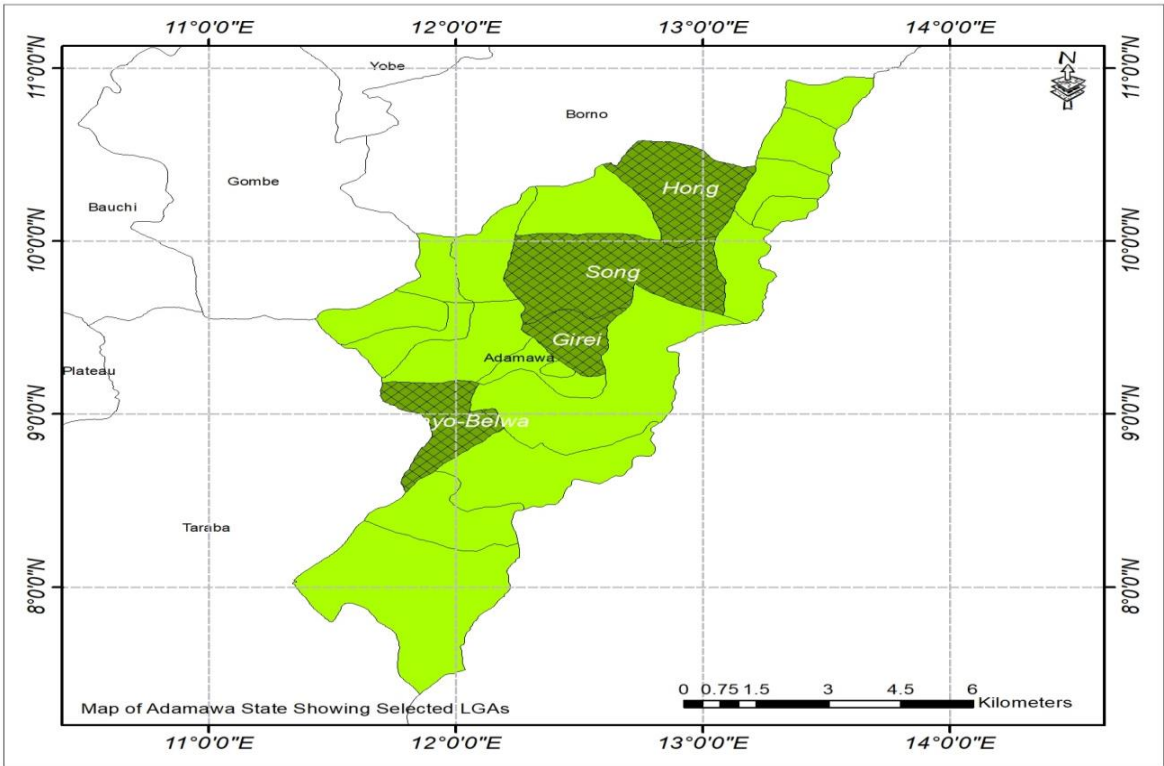


Figure 2: Map of Adamawa State showing the Local Government Areas of the four range sites Source: Adebayo and Tukur (2020)

Methods of Data Collection

Habitat evaluation technique

The habitat evaluation method described by Joseph (2015) guided this study through field assessment of habitat attributes relevant to cattle within each range site. These attributes comprised forage species abundance, forage species diversity, shrub and sapling density, interspersions of cover types, stage of plant succession, and density of trees exceeding 3 metres in height. Forage species abundance, diversity, and shrub-sapling density were classified as top important habitat attributes because they directly determine short-term forage availability for grazing cattle, while interspersions of cover types, succession stage, and tree density were classified as less important attributes because they influence habitat suitability more gradually, over longer time horizons.

Sampling design

At each of the four range sites, three transects of 100 metres were laid at 50 metre intervals, running perpendicular to the dominant slope or drainage line to capture vegetation variation across the site. Along each transect, five quadrats measuring 10 metres by 10 metres were placed at 20 metre intervals for shrub, sapling, and tree density counts, giving 15 quadrats per site. Within each 10 metres by 10 metre quadrats, a nested subplot of 1 metre by 1 metre was placed at the centre for forage species identification and count, giving 15 subplots per site. Density values were scaled to a standard 0.1-hectare unit area for comparability across sites, consistent with the values reported in Tables 1 through 4.

Tree height was assessed in the field as part of the tree-density count.

Data Analysis

Habitat value of the range sites

(a) Top important habitat attributes

Forage species abundance was determined from the relative density of forage species, calculated as:

$$RD = DN / TD$$

where RD is the relative density of each forage species, DN is the density of each forage species, and TD is the total density of all forage species recorded in the range site (Khobe, Akosim and Kwaga, 2016).

Forage species diversity was determined using the Shannon-Wiener Diversity Index:

$$H' = -\sum p_i \ln(p_i) \text{ (Shannon, 1948)}$$

where H' is the Shannon-Wiener diversity index, Σ is the summation of individuals of species i in the whole community, p_i is the proportion of the entire community made up of species i , and $\ln$ is the natural logarithm.

Data on shrub and sapling density were analysed using descriptive statistics, presented as tables and percentages (Joseph, 2015).

(b) Less important habitat attributes, comprising density of trees greater than 3 m in height, interspersions of cover types, and stage of plant succession, were likewise analysed using descriptive statistics (tables and percentages) (Joseph, 2015).

(c) Overall range habitat value followed the scoring method described by Joseph (2015), in which the mean scores for top and less important attributes are summed and multiplied by a factor of 2/3 to derive the final habitat value, classified as low, medium, or high value habitat depending on the number of attributes met.

RESULTS AND DISCUSSION

Evaluation of Habitat Attributes for Cattle Grazing Suitability

Evaluating the value of each range site for cattle grazing required determining the status of forage resources across four range sites: relative density and diversity of forage species, densities of saplings, shrubs, and trees above 3 metres in height, and the interspersions of cover types and stage of plant succession. Results are presented by site below, with each site's narrative findings immediately followed by its corresponding score card (Tables 1–4).

Gongoshi Range Site

Relative densities of forage species in Gongoshi ranged from 0.028 to 0.050. *Acalypha fimbriata*, *Brachiaria falcifera*, and *Brachiaria alata* shared the highest

relative density of 0.050, while *Digitaria sanguinalis* recorded the lowest, at 0.028. Shannon-Wiener diversity indices for individual forage species ranged from 0.100 to 0.146, and the overall Shannon-Wiener index for the site was 3.274, the highest of the four range sites. Sapling density ranged from 27 to 47 per 0.1 ha, with a mean of 38.5 per 0.1 ha, while shrub density ranged from 51 to 62 per 0.1 ha, with a mean of 57.2 per 0.1 ha. Density of trees above 3 metres in height ranged from 20 to 29 per 0.1 ha, with a mean of 25.3 per 0.1 ha. Table 1 summarises the score card evaluation for Gongoshi; the site fell within the medium value habitat category, meeting five of the six habitat attributes, with forage species abundance and sapling density identified as the two unmet attributes.

Table 1: Score card for Evaluation of Gongoshi Range Site Habitat Value for Cattle Grazing

Top important habitat attributes	Score (1–10)	Habitat value
Forage species abundance (relative density)	4.0	
Forage species diversity (Shannon-Wiener index)	7.0	
Density of saplings	4.0	
Density of shrubs	6.0	
Mean	5.3	
Less important habitat attributes	Score (1–5)	
Density of trees greater than 3 m in height	4.0	
Interspersions of vegetation types	3.0	
Stage in plant succession	4.0	
Mean	3.7	
Summation of top and less important attribute means	5.3 + 3.7 = 8.95	
Habitat value (summation × 2/3)	6.0	Medium value habitat; five (5) attributes met

Source: Field survey (2022).

Jibiro Range Site

In Jibiro, relative densities of forage species ranged from 0.030 to 0.076. *Andropogon gayanus* recorded the highest relative density (0.076), while *Loudetia simplex* recorded the lowest (0.030). Shannon-Wiener diversity indices ranged from 0.103 to 0.194 across species, and the overall site index was 3.016. Sapling density ranged from 26 to 33 per 0.1 ha, with a mean of 28.5 per 0.1 ha, and shrub density ranged from 55 to 68 per 0.1 ha,

with a mean of 64 per 0.1 ha, the highest shrub density recorded among the four sites. Density of trees above 3 metres ranged from 23 to 34 per 0.1 ha, with a mean of 27.6 per 0.1 ha. Table 2 summarises the score card evaluation for Jibiro; the site fell within the medium value habitat category, meeting six of the six habitat attributes, with sapling density identified as the only attribute scoring below the threshold for full attainment.

Table 2: Score Card for Evaluation of Jibiro Range Site Habitat Value for Cattle Grazing

Top important habitat attributes	Score (1–10)	Habitat value
Forage species abundance (relative density)	5.0	
Forage species diversity (Shannon-Wiener index)	6.0	
Density of saplings	3.0	
Density of shrubs	6.5	
Mean	5.1	
Less important habitat attributes	Score (1–5)	
Density of trees greater than 3 m in height	4.0	
Interspersion of vegetation types	3.0	
Stage in plant succession	4.0	
Mean	3.7	
Summation of top and less important attribute means	5.1 + 3.7 = 8.8	
Habitat value (summation × 2/3)	5.9	Medium value habitat; six (6) attributes met

Source: Field Survey (2022).**Marke Sarajo Range Site**

In Marke Sarajo, relative densities of forage species ranged from 0.034 to 0.112. *Tephrosia bracteolata* recorded the highest relative density (0.112) among all species across all four sites, while *Setaria pallidifusca* recorded the lowest (0.034). Shannon-Wiener diversity indices ranged from 0.112 to 0.191, and the overall site

index was 3.000, the lowest among the four sites, though still indicating high forage diversity. Shrub density ranged from 52 to 69 per 0.1 ha, with a mean of 61.1 per 0.1 ha, and density of trees above 3 metres ranged from 20 to 29 per 0.1 ha, with a mean of 25.5 per 0.1 ha. Table 3 presents the score card evaluation for Marke Sarajo.

Table 3: Score Card for Evaluation of Marke Sarajo Range Site Habitat Value for Cattle Grazing

Top important habitat attributes	Score (1–10)	Habitat value
Forage species abundance (relative density)	5.0	
Forage species diversity (Shannon-Wiener index)	6.0	
Density of saplings	3.0	
Density of shrubs	6.5	
Mean	5.1	
Less important habitat attributes	Score (1–5)	
Density of trees greater than 3 m in height	4.0	
Interspersion of vegetation types	3.0	
Stage in plant succession	4.0	
Mean	3.7	
Summation of top and less important attribute means	5.1 + 3.7 = 8.8	
Habitat value (summation × 2/3)	5.9	Medium value habitat; six (6) attributes met

Source: Field survey (2022).**Shashau Range Site**

In Shashau, relative densities of forage species ranged from 0.033 to 0.070. *Eragrostis tremula* recorded the highest relative density (0.070), while *Cassia tora* recorded the lowest (0.033). Shannon-Wiener diversity indices ranged from 0.110 to 0.188, and the overall site index was 3.000. Shrub density ranged from 46

to 69 per 0.1 ha, with a mean of 60.4 per 0.1 ha, and density of trees above 3 metres ranged from 23 to 31 per 0.1 ha, with a mean of 26.3 per 0.1 ha. Table 4 presents the score card evaluation for Shashau; the site fell within the medium value habitat category, meeting six of the six habitat attributes.

Table 4: Score Card for Evaluation of Shashau Range Site Habitat Value for Cattle Grazing

Top important habitat attributes	Score (1–10)	Habitat value
Forage species abundance (relative density)	5.0	
Forage species diversity (Shannon-Wiener index)	2.5	
Density of saplings	6.5	
Density of shrubs	5.0	
Mean	6.0	
Less important habitat attributes	Score (1–5)	
Density of trees greater than 3 m in height	4.0	
Interspersion of vegetation types	3.0	
Stage in plant succession	4.0	
Mean	3.7	
Summation of top and less important attribute means	5.0 + 3.7 = 8.7	
Habitat value (summation × 2/3)	5.8	Medium value habitat; six (6) attributes met

Source: Field survey (2022).

Interspersion of Cover Types and Stage of Plant Succession

Interspersion of cover types was similar across all four range sites, each comprising a mosaic of open Savanna woodland, shrub, and herbaceous vegetation communities. Likewise, all four sites were classified at the seral or mid-stage of plant succession. These two less important attributes therefore carried identical scores across sites, consistent with the narrative description above; this consistency should nonetheless be verified against the same raw scoring sheets requested for Table 3. Gongoshi recorded two unmet habitat attributes, both falling under the top important category: forage species abundance and sapling density. Jibiro, Marke Sarajo, and Shashau each recorded only one unmet attribute, sapling density, also a top important attribute. All four range sites therefore met over 70% of the habitat attributes assessed for cattle grazing. Joseph (2015) considers a range site to be on an upward ecological trend once it meets over 60% of the habitat attributes required for the livestock or wildlife species under consideration; the four sites in this study, having each met over 70% of the assessed attributes, can accordingly be described as being on an upward trend.

Forage species abundance, one of the top important habitat attributes, was found to be low to intermediate across all four sites. Heavy grazing, wildfire, drought, and invasion by undesirable plant species are the factors most plausibly responsible for this status. This observation agrees with Khobe, Akosim and Kwaga's (2016) earlier assessment of threat severity across Adamawa rangelands, which identified similar pressures acting on forage resources in the same agro-ecological zone. Despite these pressures, forage species diversity remained relatively high across all four sites, a pattern explained by the dominance of early successional forage species in combination with desirable mid-successional species. Ezenwatah, Ukpaka, Onyemeka and Afulukwe (2021), working in a comparable Guinea Savanna transition zone in Anambra State, similarly reported that mixed-stage vegetation communities sustained higher Shannon-Wiener diversity than single-stage stands, supporting the interpretation that successional heterogeneity, rather than site-specific management alone, underlies the diversity values recorded here. Bidwell and Woods (2017) likewise reported that rangelands dominated by early successional plants in combination with mid- or late-successional forage species tend to provide more desirable forage for cattle grazing than

single-stage stands, consistent with the pattern observed across the four sites in this study.

The relatively high incidence of trees above 3 metres in height across all four sites is consistent with a seral vegetation state transitioning from woodland toward open grassland savanna, a process driven by wildfire, lopping for cattle browsing, drought, and logging for timber and fuelwood. Mamman (2014), studying fire regimes in the Gashaka Gumti National Park savannah zones, similarly observed that repeated burning and browsing pressure shifted woody vegetation structure toward more open, grass-dominated states over time; the tree and shrub density patterns recorded across Gongoshi, Jibiro, Marke Sarajo, and Shashau in the present study are broadly consistent with that trajectory. Slayi and Jaja (2025), examining grazing patterns of two cattle breeds across communal and commercial systems in South Africa, found that forage selection and utilisation efficiency varied significantly with vegetation structure and seasonal forage availability; this reinforces the present study's finding that continued, well-monitored grazing management, rather than unregulated access, will be necessary to sustain the current forage base across the four Adamawa range sites.

CONCLUSION

This study evaluated four range sites in Adamawa State, Nigeria, for their suitability to support cattle grazing using the Habitat Evaluation Technique. All four sites, Gongoshi, Jibiro, Marke Sarajo, and Shashau, were classified as medium value habitats, with habitat values ranging from 5.8 to 6.0 on the evaluation scale. Jibiro, Marke Sarajo, and Shashau met all six assessed habitat attributes, while Gongoshi met five of six, falling short on forage species abundance and sapling density. Because all four sites met over 70% of the

assessed habitat attributes, they are considered to be on an upward ecological trend under current management. Forage species diversity remained high across all sites, with overall Shannon-Wiener indices between 3.000 and 3.274, despite forage abundance being constrained by heavy grazing, wildfire, and drought pressure. These findings suggest that continued grazing on the four range sites is ecologically justifiable, provided management interventions specifically target the recovery of forage species abundance and sapling regeneration in Gongoshi, and that periodic re-evaluation using the same scoring protocol is adopted to track whether the upward trend is sustained.

ACKNOWLEDGEMENTS

The authors thank the field assistants and data collectors who supported vegetation sampling and species identification across the four range sites in Adamawa State. The authors also acknowledge the Department of Forest Resources and Wildlife Management, Federal University of Agriculture, Mubi, for logistical support during data collection. No external research grant funded this study.

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