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Urban Forest Resilience: Assessment and Management Strategies for Stressed Trees in Diverse Environments

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Abstract: ***Variety of trees are found in both urban and wild areas; these trees are indispensable in maintaining ecosystem health and promoting human well-being. However, stressors affect the health of these trees; this makes them face management approaches. In this study, an assessment and management of five (5) different tree species at Southern University and A&M College in Baton Rouge-USA were carried out. The Southern Magnolia, Southern Red Oak, and Live Oak showed symptoms of stress, such as leaning and decay. The identified Loblolly Pine showed symptoms such as bark beetle infestations and resource competition. For each of these species, specific indicators of stress were identified and recommended management approaches. These include the installation of support systems, pruning of diseased branches, soil tillage, and pest control techniques. These practices allow the strengthening of urban forest, which ensures continued health and functioning of our ecosystems.***

Keywords: Urban Forestry, Ecosystem, Urban Tree Stress, Tree Stress Physiology.

1. INTRODUCTION

The urban landscape is teeming with human activity and is home to many species of plants, especially trees that are primarily important for the ecological balance of ecosystems and the quality of human life (Hunter, 2007). The Southern University and A&M College campus is situated in the city of Baton Rouge, Louisiana, United States. This university campus with its spacious lawns and tall trees is not just a haven for academic activity of pedagogical interest but also harbours humongous biotic diversity.

However, much like any urban landscape, the trees of Southern University and A&M College come under a battery of stressors that severely limit the tree health and longevity. The stressors include air and soil pollution, soil compaction, pest infestations, and resource

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competition (Cotrone, 2024). The health of these arboreal organisms would also be severely negatively impacted by anthropogenic-induced climate change, including acute weather and increased surface temperatures. As part of the city and metropolitan forestry network, healthy tree cover is of paramount concern on campus. To this end, a healthy population of urban trees is very important (Skendžić et al., 2021). In the context of this study, the tree stressors that affect selected five (5) prominent tree species within Southern University and A&M College campus were assessed and managed. Specifically, these stressors in conjunction with their effects on tree health were are evaluated and, in doing so, arrived at targeted management strategies to minimize their influences and secure the resilience of the campus tree population (Skendžić et al., 2021).

Assessment and management strategies for stressed trees in diverse environments are crucial for maintaining urban greenery and forest ecosystems. Understanding the impact of environmental stresses like drought, pollution, and high temperatures is essential (Moreno et al., 2023). Research suggests that diverse strategies are needed to address the challenges faced by urban trees, including innovative arboricultural techniques, species selection, and post-planting management techniques (Cannon et al., 2023). Additionally, the relationship between transposons and environmental stress responses in plants sheds light on the genetic mechanisms involved in stress tolerance (Pal, 2022). Furthermore, the conservation status of tree species globally, as highlighted by the Global Tree Assessment, emphasizes the importance of prioritizing conservation efforts and developing effective management strategies to protect tree diversity (Ito, 2022). These insights can guide the development of comprehensive strategies for assessing and managing stressed trees in diverse environments.
The tree species selected for this study, Southern Magnolia, Southern Red Oak, Live Oak, and Loblolly Pine, represent a good all-round sample of the campus tree community. These tree species were chosen because of their widespread abundance on campus and their susceptibility to the common stressors that occur in the urban environment. In doing so, this study anticipates providing critical information concerning the challenges that urban trees face in the context specific to Southern University and A&M College. In developing targeted management recommendations specific to the needs of each of these species, this study holds out hope of adding our effort to the many ongoing efforts to preserve and enhance urban forest ecosystem of this respected institution. In collaborative action, informed decision-making, and long-term continuity of the trees on the Southern University and A&M College ground, we all are striving.

2. RELATED WORK

There have been several studies on tree tress identification, assessment and management. In a study by Ito (2022) on Diversity and strategies of environmental stress-responsive transposons in plants, the study explored the relationship between transposons and environmental stresses in plants, highlighting the roles played by transposons in stress responses. The study concluded that the relationship between transposons and their host plants varies among plant species, and even within the same species, different types of transposons have distinct relationships with their hosts. Understanding these relationships

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requires knowledge of the regulatory mechanisms of transposons in various species. Furthermore, Ito's study revealed that while transposons are typically silenced in plant genomes to prevent mutations, they can be activated by environmental stimuli. This activation highlights the delicate balance between the benefits of transposon-mediated evolution and the risks of increased mutation rates in plants.

Cannon et al. (2023) did a study on the Global Tree Assessment tree diversity conservation. In this study, the special issue in Plants, People, Planet presents 13 articles examining the impact and potential of the Global Tree Assessment (GTA). Various methodologies, including national assessments and taxonomic analyses, were employed to evaluate tree the conservation status of trees globally, particularly focusing on regions like Papua New Guinea and Malaysia. The results from their study highlight the urgency of conservation efforts, underscored by the warning of widespread tree extinction. Limitations from their study include data deficiency in biodiverse regions and challenges in assessing threats not linked to rarity. Their proposed plant diversity conservation network outlines four primary activities: Document, Grow, Plant, and Manage, along with external factors like Reality and Funding. Collaboration and technology are emphasized for effective conservation strategies amidst rapid environmental change.

A study by Moreno et al. (2023) combined a greenhouse experiment with a soil-plant-atmosphere hydraulic model to investigate the impact of mixing drought avoidant (Pinus halepensis) and drought tolerant (Quercus ilex) tree species on plant water stress during extreme drought. Their results indicated a neutral effect on the drought-avoidant species and a positive effect on the drought-tolerant species in mixed stands. Model simulations suggested that changes in hydraulic connections contributed to the beneficial effect of mixture on plant water stress. However, the study's limitation lies in its controlled environment, which may not fully capture real-world complexities of forest ecosystems.

Aalipour and Nikbakht (2021) examined the impact of urban environmental stress on tree mortality and proposes strategies to increase urban tree stress tolerance. They highlighted factors such as small planting pits, drought, pollution, and pests, which hinder tree growth and health. Strategies involve innovative arboricultural techniques and species selection to mitigate adverse effects. Their study emphasizes the need for understanding tree responses to environmental threats from molecular to ecophysiological levels. However, the limitation lies in the complexity of urban ecosystems and the challenge of implementing practical strategies effectively.

Pal (2022) also examined the threats faced by Indian forests, including biodiversity loss, deforestation, and plastic pollution, through a comprehensive assessment of forest diversity. Methods include analysing forest cover data and discussing the impacts of factors such as wildfires, climate change, and anthropogenic activities on ecosystems. The results from this author's study highlight the alarming rate of biodiversity decline and habitat destruction, with implications for species survival. Limitations include the complexity of addressing multiple stressors simultaneously and the challenge of implementing effective conservation measures in the face of ongoing environmental degradation.

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Based on these related studies conducted by experts in the field of urban forestry, this study addresses the gap in understanding the specific stressors affecting tree species in urban environments and provides practical management strategies to address these issues. Focusing on five (5) different tree species at Southern University and A&M College in Baton Rouge, USA, our study offers insights into the challenges faced by urban trees and how they can be effectively managed. This contributes to the related studies on Urban Forest Resilience by providing concrete examples and recommendations for assessing and managing stressed trees in diverse urban environments. Additionally, this study emphasizes the importance of maintaining the health and functioning of urban ecosystems through targeted management practices, thereby enhancing overall urban forest resilience.

3. MATERIALS AND METHODS

Study Area

Southern University and A&M College as shown in Fig. 1 is the focal point of this study. It is located in Baton Rouge, Louisiana, USA. This city is located in the southern part of the United States of America, where the climate is generally hot and humid throughout the year. The climate is subtropical in nature with hot summers and mild winters. Its geographic location along the Mississippi River Delta adds to the richness of the biodiversity and vegetation in the region, making it an ideal setting for this study. The study area of Southern University and A&M College covers about 512 acres, including various landscapes, including manicured lawns, woodlands, and botanical gardens. The tree population in its campus varies from great big hardwood trees to ornamental shrubs and other native and introduced species (Southern University and A&M College, 2024).

It is situated at the north and the east side of the campus with a housing complex of residential neighbourhoods. Therefore, the campus can be said to be an oasis of green in the middle of the urban sprawl of Baton Rouge. Its peaceful environment and scenic beauty are a magnet for students, faculty, and visitors alike. Within the campus grounds, there are tree-lined avenues, shaded walkways, and open green spaces. Strewn all over the campus, majestic live oaks adorned with Spanish moss, towering pines reaching to sky heights, and flowering magnolias cast their charms on the surrounding environment.

The campus, though a thing of natural beauty, also enjoys the whole host of problems associated with urban environments. These problems include soil compaction, pollution, infestations by pests, and struggle for nutrients. In addition, these would be compounded with the effects of climate change-increased temperatures and more frequent extreme weather.
Rooted against this background, this study is anchored in the areas of Southern University and A&M College, which will bring a rich and dynamic environment for the investigation of such urban tree stressors and management strategies. This unique location will hopefully result in insights that can guide decision-making to make urban trees more resilient not only within the campus grounds but in similar urban settings globally.

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Fig. 1 a Map of Southern University and A&M College

Materials Used

The study employed a variety of tools and equipment to conduct comprehensive assessments of tree health and identify key stressors affecting the urban tree population within the study area of Southern University and A&M College in Baton Rouge, Louisiana, USA. Visual inspection tools such as binoculars, hand lenses, and tape measures were utilized to examine tree canopy structure, foliage health, and spatial relationships between trees. Diagnostic equipment including soil testing kits, and bark inspection tools enabled the assessment of soil health, bark integrity, and internal wood density. Climbing and safety gear, including harnesses, ropes, helmets, and gloves, were used by certified arborists to access tree canopies safely for closer inspection and pruning work. Data collection and analysis tools such as notebooks, pens, GPS devices, and digital cameras facilitated the recording of observational data, geographic coordinates, and high-resolution images for documentation and analysis purposes. Personal protective equipment (PPE) including steel-toe boots, high-visibility vests, sunscreen, and insect repellent ensured the safety and well-being of the study team during outdoor fieldwork activities.

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Methods

The study focused on assessing and addressing stressors affecting the prominent tree species that inhabit the campus grounds of Southern University and A&M College in Baton Rouge, Louisiana, USA. It followed several key steps, which comprise the most comprehensive way to assess tree health and develop targeted management strategies for the specific needs of each species. A representative selection was carried out for a portion of samples of Southern Magnolia (Magnolia grandiflora), Southern Red Oak (Quercus falcata), Live Oak (Quercus virginiana), and Loblolly Pine (Pinus taeda) of the campus landscape. Trees which display visual evidences of stress indicators such as leaning, decay, pest infestations, or competition for space were prioritized and selected for further analysis.

Visual Inspections

The general health and condition of the selected trees were assessed by using binoculars, hand lenses, and tape measures. Canopy structure, foliage health, and spatial relationships were surveyed within each tree. Observations were recorded in detail as to the degree and spread of stress indicators.

Diagnostic Analyses

In order to understand the reason behind the stress of the selected trees, several analyses were performed. Bark and the tree trunk inspection tools, were applied in checking the tree trunks and branches for signs of decay or cavities. The visual and tactile evaluation of the branches was conducted to identify the presence of diseased or damaged branches, which can be removed. The canopies of the trees were accessed for close inspection and pruning work. Climbing and safety gear, such as harnesses, ropes, helmets, and gloves, was used. Tree climbers used these tools to climb safely for close inspection of the health of canopy structures and structural integrity. High-resolution pictures were taken using digital cameras to document the findings and support the analysis process (Pitarma et al., 2019).

Mapping

Data were collected for tree species, location coordinates, stress indicators, and recommended management actions during the study, all of which were captured meticulously to be analysed. Google map was used for mapping of tree locations and in spatially represented visualization of the stress patterns in the landscape of the campus (Saah et al., 2023; Osei et al., 2023). Following analysis by visual inspection of the data collected, management strategies were developed based on stress indicators and the results of the visual diagnostic tests. Such strategies entailed a collection of measures that were deemed necessary for a specific tree species and stressor, ranging from the installation of support systems to pruning branches, tilling of soils, and pest control activities (Georgieva & Vassileva, 2023).

Implementation of the management strategies was done in consultation with the arborists and grounds maintenance staff in the campus. Strategies were prioritized based on severity and urgency of the identified stressors, and measures were continuously put in place or adjusted in the future in the maintaining of the health and vitality of the campus tree population (Georgieva & Vassileva, 2023).

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4. RESULTS

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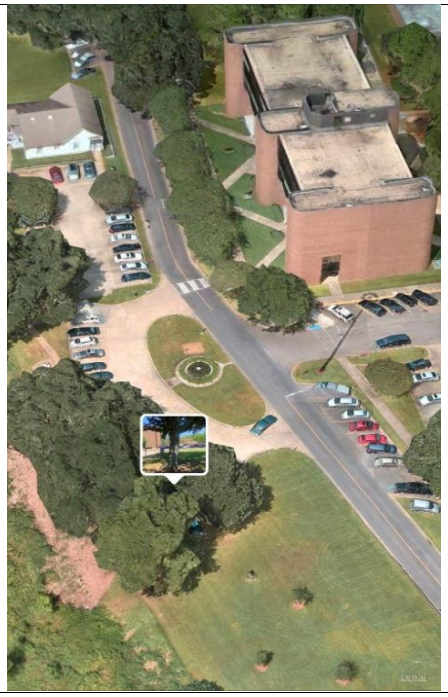
The results of the study revealed varying degrees of stress among the selected tree species within the campus grounds of Southern University and A&M College in Baton Rouge, Louisiana, USA. Each species exhibited distinct stress indicators, which were assessed and addressed through targeted management strategies as shown in Table 1.

Table 1. Tree stress analysis and management strategies

	
Tree type: Southern Magnolia **Location:** Lat 30.521^0 N, Long 91.197^0 W **Stress indicators:** The tree is slanting, Leaves are turning to brown. **Recommendation:** • Install a support system such as cables or braces to help stabilize the tree and prevent further leaning. • Soil tilling.	

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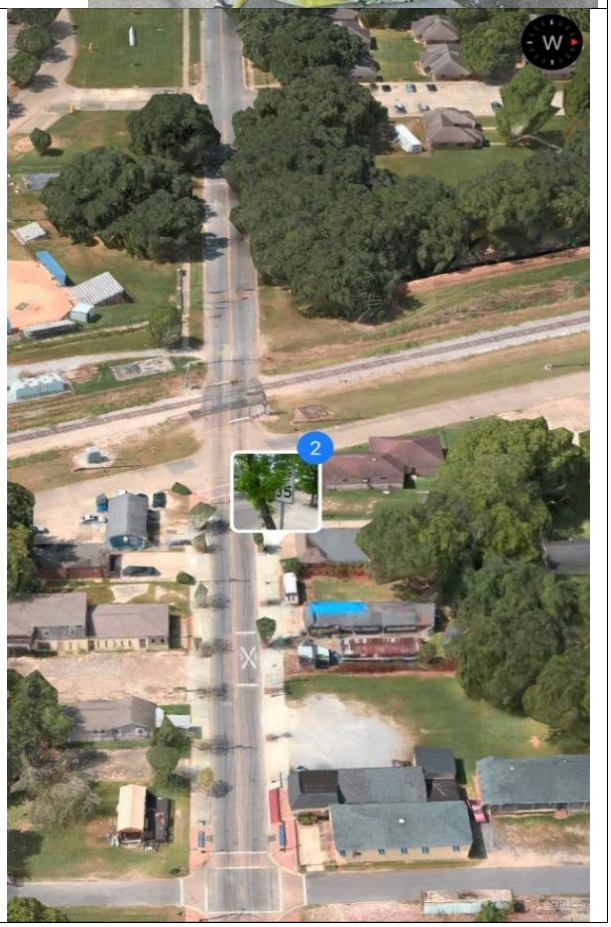
Tree type: Southern Red Oak
Location: Lat 25.380^0 N, Long 58.990^0 W
Stress indicators: The tree is slanting, Sign post is affecting the growth

Recommendation:

- Install a support system such as cables or braces to help stabilize the tree and prevent further leaning.
- Remove sign post.



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Tree type: Live Oak
Location: Lat 19.900^0 N, Long 49.580^0 W
Stress indicators: The tree is slanting, it has a lot of decay spots
Recommendation:

- Install a support system such as cables or braces to help stabilize the tree and prevent further leaning.
- Prune Diseased or decayed Branches.
- Ensure proper drainage around the tree and avoid overwatering.
- Monitor and Treat for Pests.

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Tree type: Loblolly Pine
Location: Lat 14.380^0 N, Long 49.090^0 W
Stress indicators: small holes in the pine tree done by the pine bark beetle. These beetles bore into the bark of pine trees to lay their eggs, and their larvae feed on the inner bark, creating tunnels. particularly accompanied by other signs such as sawdust-like material (frass) or resin oozing from the holes. This activity can weaken the tree and make it more susceptible to disease and other stressors.
Recommendation:

- Apply Insecticides.
- Remove Infested Branches.
- Monitor Regularly.

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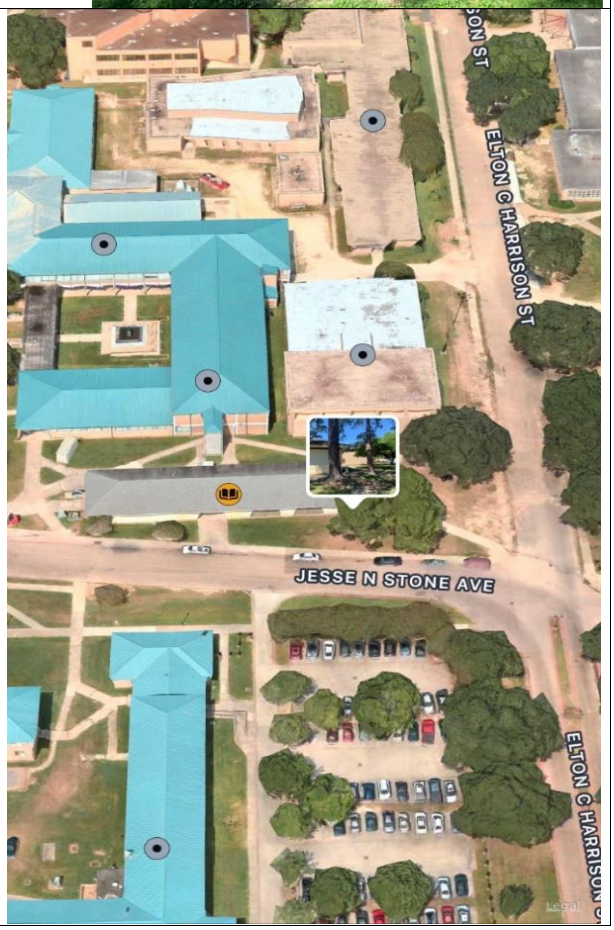
Tree type: Loblolly Pine
Location: Lat 16.750^0 N, Long 33.020^0 W
Stress indicators: The trees are very close, they are competing for sunlight and nutrients. This is the reason why one tree in slanting. Moreovern the soil is compacted and eroded which has exposed the roots of the tree.
Recommendation:

- Soil tilling.
- Check erosion.
- Install a support system such as cables or braces to help stabilize the tree and prevent further leaning.



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5. DISCUSSION

The types of stressors experienced by major tree species in the campus grounds of Southern University and A&M College, Baton Rouge, Louisiana, USA were described in the results derived from the study. Observation and evaluation sought to ameliorate the impacts of the stressors so as to enhance the resilience and longevity of the Southern University and A&M College campus trees.

As the species of the trees in the study are Southern Magnolia, Southern Red Oak, Live Oak, and Loblolly Pine, so the categories of stressors were quite diverse, although all species were exposed to several kinds of stressors. The significant attributes noticed include leaning trees, browning foliage, decay spots, and pest infestations. The interaction of natural stressors with human-induced stressors on tree health is complex (Côté et al., 2016). All the species of the trees showed leaning. A leaning tree would be a pragmatic safety hazard; the underlying causes of stressful conditions include the problem of soil compaction, lack of proper root anchorage, or competition for resources. The installation of support systems for leaning trees, such as cables or braces, became a critical management approach in maintaining and preserving a stable structure (Jim, 2003).

Diseased or decayed branches on Live Oak were predominant. Therefore, proactive tree care and maintenance should be taken into account. Diseased branches should be cut off, as well as excessively watered, which could lead to overwatering and root rot (Sudden Oak Death, 2021). Monitoring for pests also showed certain management strategies to be taken into account for Live Oaks, which could be conducive for the well-being and resilience of the trees (Sudden Oak Death, 2021). Moreover, the occurrence of the decay spots became an indication that one should be careful about finding the anomaly of fungal infection or wood decay that could destroy the structural integrity and longevity of the trees.

The infestation of Loblolly Pines by pine bark beetles is a good example of the vulnerability of some tree species to insect pests, especially in the context of urban environments (Schowalter, 2012). It does indicate that insecticide applications, removals of infested branches, and constant monitoring were necessary practices in beetle population management and pining of pine trees. While looking at competition for sunlight and nutrients among Loblolly Pines indicated that tree density and canopy spacing were necessary for reducing stress and enhancing optimal growth conditions, this study reported soil compaction and erosion as important stressors in tree health at the study area. Soil tilling was also recommended in managing the soil for increased aeration, drainage, and nutrient availability-all factors that promote root health and vitality of trees (Weltecke & Gaertig, 2012). In addition, erosion needs to be treated using proper landscaping and erosion control to protect tree roots from exposure and lose less soil for erosion, leading to stress and unsteadiness.

This study, therefore, adds to the importance of proactive tree management in the urban environment. Identification and application of proper management practices to reduce stress in prominent tree species at the Southern University and A&M College grounds contribute to the preservation of urban green spaces and ecosystem resilience. In the process, continued monitoring and adaptive management are necessary for tree health and vitality in the face of changing environmental stressors.

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6. CONCLUSIONS

Consequently, this study has offered valuable insights into the assessment and management of stressors affecting prominent tree species within the campus grounds of Southern University and A&M College in Baton Rouge, Louisiana, USA. With in-depth visual inspections, diagnostic analyses, and selective management interventions, the study attemptedto mitigate the impacts of environmental, biological, and anthropogenic stressors affecting urban tree health.

The results of the study reflect the variability of stress indicators across Southern Magnolia, Southern Red Oak, Live Oak, and Loblolly Pine specimens, reflecting the diversity of factors affecting tree health within urban landscapes. Leaning trees, saplings with browned foliage, decay spots, and infestations of pests speak to the need for proactive care for urban trees. The relevant management practices suggested for each tree species and stressor include support systems for leaning trees, pruning of diseased branches, tillage of the soil, pest control, and erosion control practices.

These recommendations function within the framework of addressing the root causes of tree stress and contributing to tree resilience, thereby enhancing the long-term sustainability of the campus tree population. The targeted management interventions that have been recommended and the promotion of sustainable practices in urban forestry shall further contribute to biodiversity conservation, ecosystem service enhancement, and human well-being at the campus and beyond. This process suggests monitoring and adaptive management practices are an integral part of the efficacy of management interventions in response to emerging environmental pressures.

This research substantiates the proactive management and conservation of trees in the context of conservation in urban settings. The conclusions of the research show the importance of identification and mitigation of the stressors to the plant life and commonly growing tree species, particularly the prominent ones studied in the area. The significance and recommendations made form an important contribution to preserving and enhancing the urban green spaces toward the purpose of providing healthy and resilient ecosystems for future generations.

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Declaration of Conflict of Interest
The authors declare no conflict of interest.

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