

Article

Designing for Coexistence: Narrative Landscape Strategies for Wetland Education through Species-Centred Design

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Abstract: Wetland parks are increasingly called upon to serve both biodiversity conservation and public access and environmental education, yet these functions frequently come into conflict. This study develops a species-centred landscape design framework to address this challenge, using the Yangtze alligator conservation area in Shanghai's Chongming Dongtan Wetland Park as a case study. Adopting a Research through Design approach, it combines landscape narrative, spatial composition, and visitor impact control to translate species sensitivities and habitat requirements into operational spatial and management strategies. The framework is structured around three interrelated dimensions: Protection, Education, and Coexistence. Protection is addressed through functional zoning, controlled circulation, buffer areas, and low-impact observation facilities. Education is embedded in visitor routes, interpretive nodes, and interactive experiences that convey wetland ecology and promote appropriate conduct. Coexistence is supported through spatial separation, temporal access control, and behavioural guidance intended to minimize ecological impact while retaining opportunities for public engagement. The study argues that landscape design can operate not only as an ecological and experiential measure, but also as a form of behavioural governance that makes conservation rules legible and actionable. Although the proposal has not yet been implemented or empirically evaluated, it offers a transferable design logic for linking species requirements, visitor management, and environmental education in wetland parks and other ecologically sensitive landscapes. This framework contributes to the growing discourse on integrating ecological restoration with public pedagogy, providing actionable guidance for landscape practitioners and policymakers working at the intersection of conservation and recreation.

Keywords: species-centred design; wetland landscape; environmental education; human-wildlife coexistence; Yangtze alligator

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1. Introduction

Wetland parks serve a dual function: they support biodiversity conservation while also accommodating public engagement and environmental education [1]. Thoughtful integration of human use with ecological integrity is essential for long-term sustainability. Public access, when well-organized, can foster greater ecological literacy, strengthen community stewardship, and generate broader societal support for conservation initiatives. However, unregulated or high-intensity recreational activities may introduce cumulative pressures on sensitive habitats—such as altered microclimates, increased ambient noise levels, artificial illumination during nocturnal hours, and extended human presence in ecologically critical zones. These factors can interfere with natural behavioral patterns, particularly during biologically sensitive periods including nesting, incubation, juvenile rearing, and crepuscular or nocturnal activity cycles. Urban wetland parks have historically prioritized infrastructure upgrades, landscape aesthetics, and visitor comfort in planning and management. While such efforts improve accessibility and user

satisfaction, they often do not systematically incorporate species-specific ecological thresholds or habitat vulnerability assessments into spatial design logic. As a result, there remains a notable shortfall in translating biological knowledge—especially regarding the behavioral ecology and physiological tolerances of focal species—into actionable, spatially explicit guidelines that govern circulation routes, viewing distances, facility placement, seasonal access windows, and operational protocols.

This study addresses that shortfall by reframing the design paradigm from one centered primarily on visitor convenience to one grounded in ecological responsibility and impact mitigation. The foundational premise is that public visitation must be structured so that anthropogenic influences remain within scientifically informed thresholds compatible with ecosystem resilience and species persistence. Achieving this objective demands more than informational signage or generalized appeals for environmental care [1]. Instead, conservation objectives must be operationally embedded into the physical and procedural fabric of the park—through carefully calibrated trail alignments, strategically located observation platforms, clearly demarcated buffer zones, time-based access scheduling, and integrated maintenance routines. Such design decisions should render appropriate behaviors intuitive and effortless for visitors, reducing reliance on enforcement and increasing voluntary compliance. Environmental interpretation then serves not as an add-on but as a reinforcing layer—clarifying the scientific rationale behind spatial arrangements, helping visitors understand why certain areas are designated for limited access, how observation distances protect animal welfare, and how lighting controls support natural circadian rhythms. This layered approach fosters deeper cognitive and affective engagement, transforming passive observation into active ecological participation grounded in shared understanding and mutual respect.

The Yangtze alligator conservation area within Shanghai's Chongming Dongtan Wetland Park provides a concrete context for applying and testing this integrated framework. As a critically endangered native crocodilian species with highly specific thermal, hydrological, and behavioral requirements, the Yangtze alligator offers an ideal case for examining how ecological sensitivity can inform spatial governance. The study investigates two interrelated questions: first, how can the species' documented habitat preferences—including basking site selection, nesting substrate conditions, water depth tolerances, and avoidance responses to human proximity—be systematically translated into functional zoning schemes, circulation hierarchies, observation infrastructure specifications, and adaptive access management protocols? Second, how can interpretive strategies—such as thematic wayfinding, contextual storytelling at key nodes, and interactive digital tools—be seamlessly woven into the spatial sequence so that guidance emerges organically from the visitor's movement and experience, rather than appearing as externally imposed restrictions? The resulting framework explicitly links species-level biological data, spatial configuration parameters, expected visitor conduct patterns, and responsive management actions [1, 2]. It is designed not to assert final ecological outcomes, but to provide a logically consistent, empirically grounded, and practically implementable structure that enables iterative refinement, monitoring, and evidence-based adaptation over time.

2. Theoretical Framework: Narrative, Composition and Impact Control

This study conceptualises landscape as an active narrative medium through which cultural, ecological, and historical meanings are deliberately structured and communicated across space. Landscape narrative extends far beyond the superficial addition of interpretive signage or textual overlays; rather, it constitutes a rigorous spatial pedagogy grounded in experiential sequencing. It entails the intentional orchestration of movement trajectories, visual framing, temporal pacing, sensory transitions, and embodied pauses—each calibrated to scaffold visitors' progressive understanding of place. Such design logic treats the visitor not as a passive recipient of information but as a participant co-constructing meaning through situated engagement. Spatial cues—including path alignment, threshold treatments, material shifts, vegetation density

gradients, and changes in elevation or acoustics—function as syntactic elements that guide perception and shape cognitive interpretation. In conservation contexts, this approach transforms regulatory measures—such as access boundaries, prescribed viewing distances, designated observation zones, and codes of conduct—into legible, coherent expressions of stewardship ethics, thereby fostering intrinsic compliance through experiential clarity rather than external enforcement alone [3, 4].

Spatial composition and legibility constitute the second foundational pillar, providing the physical grammar through which narrative intent is materially instantiated [5]. Drawing upon established environmental psychology and urban design principles, the legibility of a landscape depends on the clear articulation of paths, nodes, boundaries, districts, and landmarks—elements that collectively enable users to form accurate mental maps, anticipate spatial transitions, and navigate with confidence. Kevin Lynch's seminal work on city imageability remains highly relevant, as it demonstrates how consistent spatial structure supports both wayfinding and affective attachment. Furthermore, Gordon Cullen's concept of serial vision underscores that environmental cognition is inherently dynamic: understanding unfolds incrementally through successive frames of view, modulated by speed, direction, and duration of movement. Within protected-area management, this implies that guidance systems must be embedded continuously—not as isolated interventions—but as integrated features of the spatial sequence. For instance, a gently curving path may signal a shift from transitional to core habitat; a narrowing corridor may cue heightened attentiveness; a widened node with seating and interpretive surfaces may invite reflection and behavioural calibration; and a clearly demarcated boundary—through changes in paving texture, planting density, or subtle grade shifts—may communicate differential access rights without reliance on prohibitive signage. Thus, composition furnishes the tangible scaffolding, while narrative supplies the semantic continuity that binds discrete spatial events into a unified, intelligible experience.

The third essential component is impact control—a systematic, evidence-informed methodology for aligning human use with ecological integrity and experiential quality. This requires moving beyond reactive restrictions toward proactive, condition-based management frameworks. Desired resource conditions—such as soil stability, native species abundance, water quality, or acoustic tranquillity—are first explicitly defined alongside corresponding visitor experience goals, such as solitude, safety, educational resonance, or aesthetic coherence. Indicators—measurable proxies for these conditions—are then selected and monitored over time, allowing managers to detect early deviations before irreversible degradation occurs. Management variables—including permitted access routes, maximum group sizes, seasonal or diurnal time windows, minimum viewing distances, noise emission thresholds, artificial lighting intensity and spectral range, and protocols for temporary closures—are calibrated to maintain those indicators within predefined standards. Crucially, these variables are not arbitrary constraints but spatially embedded design parameters: a boardwalk's length and width determine footprint pressure; a viewing platform's orientation and height govern visual intrusion; a buffer zone's vegetation composition mediates sound propagation and microclimate. When integrated with narrative and composition, impact control ensures that conservation logic is not only comprehensible to visitors but also operationally enforceable, transparent, and adaptable to changing ecological or social conditions—rendering the landscape simultaneously meaningful, navigable, and sustainably governed [1, 6].

Protected-area precedents demonstrate the practical integration of these three interdependent components. At Hong Kong, China's Mai Po Nature Reserve, visitor experiences are carefully choreographed through a network of elevated boardwalks, strategically positioned stopping points, and purpose-built birdwatching hides—all designed to limit physical penetration into sensitive wetland habitats while maximising observational opportunity and interpretive depth. Similarly, Singapore's Sungei Buloh Wetland Reserve employs tightly controlled trail alignments, raised viewing decks, and clearly demarcated rest nodes to concentrate human presence along resilient corridors,

effectively discouraging off-trail movement that could disturb fragile mangrove root systems or nesting avifauna [7, 8]. Experimental studies further confirm that well-designed, low-impact education—delivered contextually at key decision points—can significantly reduce path deviation, littering, and proximity violations by reinforcing normative expectations through spatial reinforcement rather than admonition. These cases collectively illustrate how narrative provides the underlying rationale for conservation actions—transforming rules into stories of care; how composition organises permissible behaviours into intuitive spatial patterns—turning regulations into natural movement flows; and how impact control establishes measurable thresholds and responsive mechanisms—ensuring that both ecological health and visitor experience remain within scientifically supported, socially acceptable limits. Together, they validate a holistic framework wherein meaning, structure, and sustainability are inseparable dimensions of responsible landscape stewardship.

3. Methodology and Design Framework

The study adopts Research through Design (RtD), an approach in which design practice serves as a primary mode of inquiry to explore complex real-world challenges, integrate insights from multiple disciplinary domains, and formulate testable propositions for further validation. This methodology is especially well-suited for addressing multifaceted landscape questions, where ecological integrity, spatial configuration, pedagogical objectives, and operational governance must be considered simultaneously and iteratively [9]. Within such contexts, design functions not merely as an implementation tool but as a generative epistemic activity—capable of revealing emergent relationships among biophysical systems, human behavior, and institutional frameworks. Wetland landscapes, in particular, embody layered functional capacities: they sustain ecological processes, preserve cultural memory, support sustainable resource use, and serve as living laboratories for environmental education. Consequently, the present proposal is framed explicitly as a rigorously structured design investigation grounded in empirical observation and systemic analysis—not as a definitive demonstration of ecological performance or behavioral outcomes.

The research process unfolded across four interdependent stages [10]. First, a comprehensive review of scholarly literature and documented case studies from protected natural areas worldwide was conducted to distill foundational concepts related to species–human interface management, visitor flow optimization, landscape storytelling techniques, and principles of environmental interpretation. Second, intensive site analysis—including geospatial mapping, seasonal hydrological monitoring, vegetation surveying, and systematic field observation—was carried out to characterize the physical and ecological structure of Dongtan Wetland. As an estuarine wetland system, Dongtan features dynamic tidal flats, shallow aquatic zones, expansive mudflats, and heterogeneous vegetation patches distributed across gradients of salinity, inundation frequency, and soil composition. This inherent spatial variability generates pronounced micro-ecological differentiation; comparative studies of analogous coastal wetlands indicate that nutrient cycling rates, sediment retention efficiency, avian foraging patterns, and invertebrate community composition can differ significantly across adjacent habitat patches. Third, biological requirements of the Yangtze alligator—including preferred basking substrates, nesting site characteristics, thermal thresholds, and movement corridors—were systematically translated into spatial parameters such as buffer width, vegetation density, water depth continuity, and visual seclusion metrics. Fourth, these parameters were integrated into a coherent set of design strategies encompassing spatial zoning, circulation routing, observational infrastructure placement, interpretive content sequencing, and time-based access protocols calibrated to seasonal ecological rhythms.

The Dongtan wetland sustains a richly interconnected network of aquatic, terrestrial, and avian species whose survival depends on reciprocal habitat dependencies and trophic linkages. Within this web, the Yangtze alligator functions not as an isolated conservation target but as an integral node within a broader ecological continuum [11]. Its presence and

behavior reflect—and in turn influence—the health of riparian vegetation, water quality stability, prey population dynamics, and sediment transport regimes. Therefore, maintaining ecological functionality at key interfaces—particularly the transitional zones between open water and emergent vegetation, between tidal channels and vegetated banks, and between seasonally flooded and permanently saturated soils—is essential not only for the long-term viability of the focal species but also for sustaining the structural and functional integrity of the entire wetland ecosystem. Habitat continuity, hydrological connectivity, and vegetation structural diversity collectively underpin resilience against climatic fluctuations and anthropogenic pressures (As shown in Figure 1).

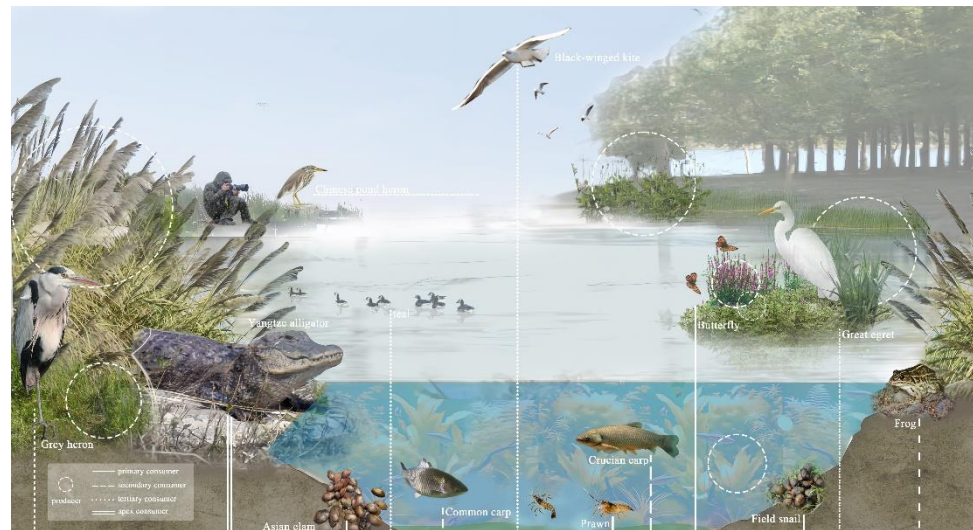


Figure 1. Representative Habitats and Ecological Relationships within the Dongtan Wetland Ecosystem.

The Yangtze alligator was selected as the focal species due to its critically endangered status and high responsiveness to changes in habitat configuration, landscape fragmentation, and proximity to human activity. It exhibits strong preference for sheltered riverbanks with dense riparian vegetation and calm, vegetated water bodies. Behavioral observations confirm that the species adjusts its activity patterns in response to ambient sound levels, artificial illumination intensity, and the frequency and proximity of human movement—especially during thermoregulatory basking periods and reproductive phases. Accordingly, the design analysis incorporated a suite of ecological and experiential variables: accessibility to aquatic habitats, bank slope and substrate composition, canopy coverage and vertical vegetation structure, spatial coherence of suitable habitat patches, minimum separation distances between visitor infrastructure and sensitive zones, acoustic attenuation capacity of intervening landforms, and nocturnal light pollution mitigation measures. These variables were evaluated contextually using on-site measurements and modeling rather than applied as fixed quantitative standards. The annual activity cycle illustrated in Figure 2 reveals pronounced temporal variation in physiological needs and behavioral expression: winter dormancy necessitates undisturbed underground refugia; spring emergence coincides with heightened mobility and territorial establishment; summer involves nest construction, egg incubation, and juvenile emergence; and autumn supports juvenile growth and dispersal. These cyclical patterns directly informed the development of adaptive temporal management protocols—including seasonal restrictions on certain pathways, timed closures of observation platforms near nesting sites, and nighttime lighting curfews in ecologically sensitive sectors.

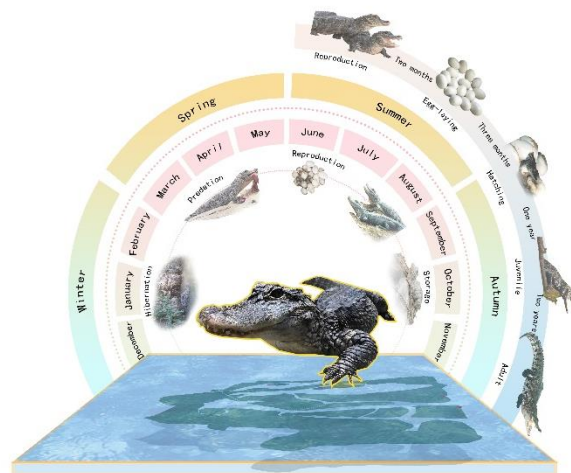


Figure 2. Seasonal Activity and Life-Cycle Pattern of the Yangtze Alligator.

The resulting conceptual framework is organized around three mutually reinforcing pillars: Protection, Education, and Coexistence [12]. Spatially, the site is articulated into three functionally differentiated yet ecologically linked zones. The core habitat zone prohibits routine public entry and is reserved exclusively for ecological processes—supporting natural succession, undisturbed breeding, unimpeded movement, and long-term habitat regeneration. A surrounding buffer zone permits carefully managed observational engagement via designated low-impact trails, concealed viewing structures, and acoustically buffered vantage points designed to minimize perceptible human presence. The public experience zone accommodates immersive interpretation, participatory learning activities, and sensory-based environmental education—all situated within areas where ecological sensitivity is comparatively lower and human activity can be safely integrated without compromising system integrity. This tripartite spatial logic aligns with internationally recognized conservation planning principles that emphasize the strategic deployment of core protected areas, transition buffers, and ecological corridors to enhance species persistence and landscape-scale resilience. Additionally, informal exchanges with park management personnel provided valuable contextual insights regarding operational constraints, maintenance logistics, and local stakeholder expectations—contributing practical grounding to the theoretical framework without constituting formal qualitative research.

Based on this integrated analysis, the framework is structured along three interrelated dimensions: Protection, Education, and Coexistence. As depicted in Figure 3, the Protection dimension translates ecological knowledge into actionable spatial configurations—including zonal boundaries, material specifications for infrastructure, and behavioral guidelines embedded in signage and digital interfaces. The Education dimension embeds layered interpretive content—ranging from scientific information about wetland hydrology and food webs to culturally grounded narratives about regional stewardship traditions—within the sequential progression of visitor movement, thereby transforming passive observation into active cognitive engagement. The Coexistence dimension orchestrates the dynamic alignment of ecological imperatives and human experience through coordinated spatial interventions—such as elevated boardwalks over sensitive soils—and temporally responsive protocols—such as rotating access schedules aligned with avian migration peaks or amphibian breeding windows—ensuring that ecological integrity and meaningful public engagement are advanced in parallel rather than in competition.

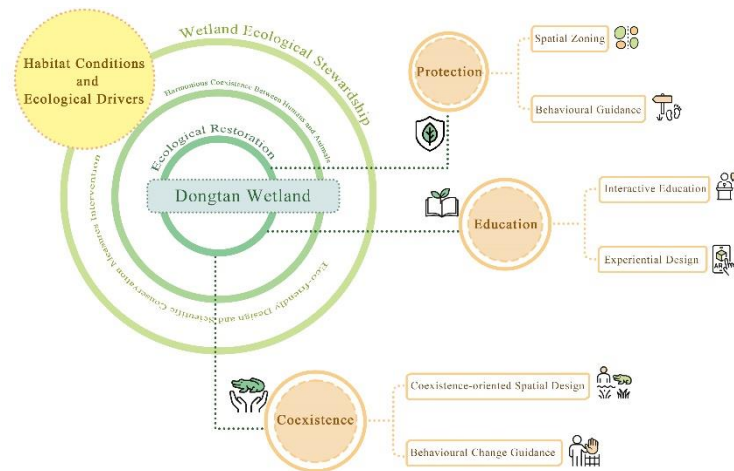


Figure 3. Protection--Education--Coexistence Design Framework for Dongtan Wetland Park.

3.1. Protection: Spatial Zoning and Visitor Guidance

Protection strategies are implemented through spatial zoning and structured visitor guidance to ensure ecological integrity and sustainable public engagement. These strategies define permissible access zones, regulate movement patterns, and designate appropriate stopping locations based on habitat sensitivity and conservation objectives. Core ecological areas—such as breeding grounds, nesting sites, and critical hydrological zones—are designated as non-accessible for routine visitation, thereby safeguarding essential biological processes. Visitor circulation is intentionally channeled along clearly marked, purpose-built pathways that follow ecologically appropriate alignments. Circular or one-way routing systems are employed not only to enhance wayfinding but also to prevent unauthorized deviations, minimize overlapping travel paths, and reduce cumulative environmental impact across sensitive microhabitats. Seasonal variations in ecological conditions—such as migratory bird presence, plant phenology, or water level fluctuations—inform adaptive management responses, including time-limited access restrictions or mandatory guided supervision during periods of heightened ecological vulnerability [13]. Such dynamic adjustments uphold long-term habitat resilience while maintaining opportunities for meaningful public connection with natural systems.

Visitor guidance is thoughtfully integrated into the physical design of the route rather than depending exclusively on regulatory signage or prohibitive messaging. Interpretive elements positioned at key entry points, habitat transitions, and viewing nodes communicate principles of respectful observation—including recommended viewing distances, acoustic considerations, and the ecological rationale behind access limitations [14]. Strategically located observation hides serve a dual function: they facilitate high-quality wildlife observation while simultaneously reducing visual prominence, limiting ambient noise propagation, and eliminating the need for visitors to approach sensitive habitats closely. The architectural orientation of hide apertures and the calibration of viewing angles are carefully designed to focus attention on priority ecological features without incentivizing departure from designated routes. Boundary delineations—whether expressed through subtle topographic changes, native vegetation buffers, natural water margins, or low-profile landscape elements—are intentionally designed to be perceptible yet harmonious with the wetland's aesthetic and functional character, reinforcing spatial logic without compromising ecological continuity or scenic coherence.

The integration of spatial zoning, circulation planning, boundary definition, and observation infrastructure constitutes a multi-tiered protective framework. Physical separation between human activity zones and ecologically sensitive zones supports habitat stability by maintaining natural behavioral patterns and minimizing anthropogenic influence. Clearly articulated movement corridors promote predictable

visitor behavior and reduce the likelihood of unintended interactions with wildlife or fragile substrates. Interpretive communication fosters informed stewardship and encourages voluntary adherence to conservation-oriented practices through education and experiential learning. Complementary operational measures—including controlled entry scheduling, on-site professional oversight, real-time capacity monitoring, and responsive temporary access modulation—further strengthen this layered approach. These adaptive interventions are triggered when ecological monitoring data indicate emerging pressures on target species, vegetation structure, hydrological regimes, or other key indicators, ensuring that management remains evidence-informed, proactive, and aligned with long-term conservation goals.

3.2. Education: Experiential and Interpretive Landscape Design

Environmental education is thoughtfully embedded throughout the entire visitor journey, rather than being isolated within a dedicated exhibition space [7]. Interpretive elements—such as signage, tactile models, and contextual annotations—are strategically placed at key locations including entry points, circulation transitions, designated observation platforms, and rest zones. These materials convey scientifically accurate information about wetland ecosystem structure, hydrological dynamics, native species composition, interspecific ecological interactions, and long-term habitat resilience. Each interpretive node is carefully aligned with on-site features visible from that location, enabling visitors to directly correlate explanatory content with observable phenomena—for instance, linking water depth indicators to aquatic plant zonation or connecting bird call recordings to concurrent avian activity. This alignment reinforces the rationale behind conservation zoning and cultivates awareness of how individual visitor choices—including path adherence, noise levels, proximity to wildlife, and waste disposal practices—collectively influence ecological integrity and species well-being.

Within the public experience zone, interactive panels and digital media serve as complementary educational tools that enhance conceptual understanding without substituting direct sensory engagement [15]. These resources may illustrate dynamic ecological concepts such as species-specific habitat thresholds, phenological shifts across seasons, landscape-scale connectivity patterns, and evidence-based restoration methodologies. Immersive virtual experiences—designed with ecological fidelity—can simulate biological processes that are inherently difficult to witness in situ, including cryptic breeding behaviours, diel activity cycles, and microhabitat selection patterns. All such technological interventions are deliberately situated outside ecologically sensitive zones to prevent physical intrusion or behavioural disruption; their design philosophy prioritizes augmentation over replacement—guiding attention toward, rather than away from, the authentic landscape and its living components.

The educational sequence follows a pedagogically grounded progression: orientation, guided observation, and reflective synthesis. At the outset, visitors receive clear, principle-based explanations of site management protocols—not as arbitrary restrictions but as empirically informed measures supporting ecosystem stability and biodiversity persistence. Subsequently, they engage with wetland habitats through thoughtfully designed viewing infrastructure that balances accessibility with minimal environmental impact. Finally, structured reflection prompts encourage consideration of personal agency in sustaining ecological health—framing responsible conduct not as passive compliance but as active stewardship rooted in scientific literacy and ethical awareness [16]. Evaluation of this approach may encompass multi-dimensional metrics: retention of core ecological concepts, accurate interpretation of management guidelines, measurable shifts in pro-environmental attitudes, consistent adherence to designated pathways, and documented reductions in unintentional impacts on flora and fauna during visitation.

3.3. Coexistence: Spatial and Temporal Strategies

In this context, coexistence is understood as a carefully structured arrangement that prioritizes ecological integrity without compromising meaningful human engagement [1]. It entails deliberate spatial segregation and precise temporal alignment between human

recreational use and wildlife behavioral cycles. Specifically, designated birdwatching zones, contemplative rest spaces, elevated observation platforms, and visitor service facilities are sited exclusively outside ecologically critical core habitats and are physically isolated from sensitive zones—such as nesting, roosting, or foraging areas—by purpose-designed vegetative or topographic buffer zones. Observation infrastructure is engineered to afford unobstructed visual access while inherently discouraging proximity-based interaction; sightlines are optimized through strategic placement and elevation, not through trail incursions into undisturbed terrain. Crucially, habitat connectivity corridors remain fully functional and unimpeded, enabling essential animal movement—including seasonal migration, dispersal, and genetic exchange—across the landscape matrix.

Operational scheduling—including daily opening windows, guided-access time slots, and seasonally calibrated access protocols—is dynamically aligned with key biological rhythms: avian breeding phenology, reptilian thermoregulatory basking periods, mammalian diurnal resting phases, and nocturnal foraging patterns. Core and buffer zones are maintained in a state of restricted access during nighttime hours to safeguard natural circadian behaviors, and temporary access limitations may be implemented proactively in response to elevated environmental sensitivity—for instance, during extreme weather events, post-fire recovery, or heightened predation pressure. Artificial illumination near ecologically significant zones is either eliminated entirely or rigorously minimized using shielded, low-intensity, warm-spectrum fixtures that reduce photic intrusion. Activities generating elevated sound levels or requiring concentrated human presence are systematically confined to the designated public experience zone, ensuring acoustic and spatial separation from wildlife-dominant areas.

Collectively, these integrated strategies sustain rich opportunities for public visitation, immersive observation, environmental education, and scientific appreciation—while simultaneously guaranteeing secure, uninterrupted habitat conditions and predictable periods of minimal anthropogenic influence for native species. Coexistence is thus realized not through convergence—where human and wildlife activities compete for overlapping space and time—but through intentional differentiation: distinct spatial domains, staggered temporal windows, and functionally specialized zones that collectively uphold both conservation imperatives and societal values of nature connection. This paradigm reflects a mature, evidence-informed approach to landscape stewardship, grounded in long-term ecological monitoring, adaptive management feedback loops, and participatory planning processes involving conservation professionals, local communities, and educational institutions.

4. Discussion

The framework illustrates how landscape design can serve as a mechanism for guiding visitor behaviour in ecologically sensitive environments. Physical elements such as pathways delineate designated movement corridors, perimeter features demarcate zones requiring heightened stewardship, and focal points—such as observation platforms or interpretive installations—serve to concentrate attention and facilitate understanding. Collectively, these spatial strategies help maintain appropriate spatial separation between human activity and vulnerable ecological components, thereby supporting habitat integrity and species well-being. Interpretive communication plays a complementary role by explicitly connecting spatial arrangements to observable environmental conditions—for instance, explaining how proximity to nesting areas may affect avian breeding success or how foot traffic near hydrologically sensitive margins influences soil compaction and vegetation recovery. When visitors grasp the ecological rationale behind spatial guidelines, their willingness to align personal conduct with conservation objectives tends to increase. Empirical work has consistently indicated that stronger emotional connections to natural places—often cultivated through aesthetic engagement and meaningful interpretation—are associated with higher levels of voluntary pro-environmental action. However, visual appeal and explanatory content alone are insufficient to ensure consistent adherence to management guidelines; formal regulatory clarity, routine

monitoring protocols, and responsive on-site stewardship remain indispensable components of effective site governance [7].

The central scholarly contribution of this study lies in articulating a systematic translation process: ecological sensitivity data—derived from species-specific behavioural ecology, reproductive phenology, and microhabitat requirements—are first converted into spatial parameters; these parameters are then organized into functional landscape units—including access zones, circulation routes, and observation nodes; finally, each unit is explicitly linked to corresponding visitor expectations, operational rules, and adaptive management responses. This integrative methodology offers a replicable logic model applicable to other urban wetland contexts, though successful transfer necessitates careful calibration to local biological composition, hydrological dynamics, visitor demographics and usage patterns, as well as regional cultural norms surrounding nature engagement. Furthermore, the framework establishes a robust foundation for performance evaluation. Quantitative metrics—including visitor distribution density, deviation frequency from designated paths, ambient sound intensity profiles, average dwell duration at key locations, rates of rule adherence observed during field audits, and utilization rates of interpretive infrastructure—can be systematically recorded and correlated with ecological indicators such as species occupancy patterns, nesting success rates, vegetation cover stability, and evidence of physical habitat resilience. Such integrated assessment enables managers to iteratively refine access configurations, adjust interpretive messaging, reconfigure facilities, and recalibrate seasonal access windows using evidence-informed adaptive management principles grounded in longitudinal monitoring.

Several methodological considerations warrant acknowledgment [6]. The current approach prioritizes select indicator species to anchor spatial planning decisions; while this enhances feasibility and focus, it inherently limits scope and may not fully represent broader community-level ecological dynamics or interspecific interactions. Subsequent applications should therefore adopt a multi-species lens, incorporating functional guilds and ecosystem service indicators to ensure holistic representation of ecological value. As the proposed framework remains conceptual and has not undergone empirical implementation, its real-world efficacy in shaping visitor conduct or influencing ecological outcomes has yet to be verified through direct observation or longitudinal measurement. Technical specifications—including buffer distances around critical habitats, maximum concurrent visitor thresholds per zone, and temporal access windows aligned with sensitive life-cycle stages—remain provisional and require empirical validation via field-based spatial analysis, species-specific behavioural studies, and collaborative input from ornithologists, herpetologists, hydrologists, and landscape ecologists. Future research initiatives should integrate multimodal data collection across diverse urban wetland settings: synchronized GPS-based movement tracking, time-lapse behavioural coding, structured visitor interviews assessing comprehension and motivation, and parallel ecological surveys documenting vegetation structure, water quality parameters, and wildlife activity indices. Such comprehensive, cross-disciplinary inquiry will clarify which design and management strategies demonstrate broad applicability and which demand context-specific refinement to achieve balanced outcomes for both human experience and ecological health.

5. Conclusion

This study introduces a species-centred landscape framework designed to harmonise three interdependent objectives: the long-term ecological integrity of wetland habitats, the delivery of meaningful environmental education, and the provision of thoughtful, low-impact visitor access. Grounded in the ecological characteristics of the Yangtze alligator within Dongtan Wetland Park, the framework systematically translates biological requirements—including microhabitat preferences, thermal and hydrological tolerances, breeding season constraints, and behavioural responses to human proximity—into spatially explicit design strategies. These include ecologically calibrated zoning boundaries, circulation pathways that minimise spatial overlap between human use and

critical life-stage areas, strategically sited observation nodes with non-intrusive viewing infrastructure, layered interpretive systems that embed ecological knowledge into the visitor experience, and time-based access protocols aligned with species phenology. Protection defines biophysical thresholds; Education fosters understanding of those thresholds through experiential and narrative engagement; Coexistence operationalises shared space by embedding ecological logic into the physical and temporal structure of the landscape.

The framework synthesises landscape narrative, spatial composition, and impact mitigation into a coherent, implementable system—transforming abstract conservation principles into tangible spatial configurations and observable behavioural guidelines. It does not purport to deliver definitive ecological validation but instead advances testable propositions and measurable indicators—such as species occupancy stability, visitor compliance rates with access protocols, interpretive engagement depth, and habitat condition indices—that can be tracked over time through iterative monitoring and adaptive management. Future application requires rigorous multi-species ecological assessment to account for interspecific interactions and cumulative habitat needs, alongside site-specific calibration informed by local hydrology, soil dynamics, vegetation succession patterns, and long-term climate projections. As urban expansion continues to exert pressure on peri-urban wetlands, this approach offers a replicable methodology for designing and managing publicly accessible landscapes where ecological resilience and human experience are co-constituted rather than mutually exclusive.

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