Establishment of a Regular Management Mechanism for Green Pest and Disease Control in Urban Street Trees

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Abstract: Frequent occurrences of pests and diseases in urban street trees severely impact urban ecosystem service functions and landscape aesthetics. The environmental pollution and pesticide resistance issues caused by traditional chemical control methods are becoming increasingly prominent, necessitating the establishment of a scientific and efficient regular management mechanism for green pest and disease control. This paper provides an in-depth analysis of the current practical challenges in monitoring and early warning, technology application, departmental coordination, and public participation in urban street tree pest and disease control. It proposes systematic mechanism optimization strategies from four dimensions: building an intelligent monitoring and early warning network, establishing an ecological control technology system, improving a coordinated management and operation mechanism, and fostering a social participation and co-governance framework. The aim is to provide long-term solutions for urban street tree pest and disease control and promote the modernization of urban ecological governance capabilities.

1. Introduction

Urban street trees, as the backbone of the urban green space system, play an irreplaceable role in regulating microclimates, purifying air, and mitigating heat island effects. They are essential for enhancing urban livability and residents' well-being. With the acceleration of urbanization and the increase in extreme climate events, the frequency and severity of pest and disease outbreaks are rising, posing serious challenges to urban ecological security. Under the guidance of ecological civilization construction and the "dual carbon" goals, the concept of green pest control has gradually become the mainstream direction for urban pest management. Replacing traditional chemical control with eco-friendly technologies such as biological and physical control, and establishing a regular management mechanism, has become an inevitable requirement for promoting sustainable urban development and an important pathway to achieving harmonious coexistence between humans and nature.

2. Value Orientation of Regular Management for Green Pest and Disease Control in Urban Street Trees

The value orientation of regular management for green pest and disease control in urban street trees reflects the intrinsic requirements of ecological civilization construction and high-quality urban development. As an important component of the urban ecosystem, the health of street trees directly affects urban ecological security and the quality of the living environment. By establishing a regular management system focused on prevention and integrated control, the passivity and extensiveness of traditional control models can be fundamentally transformed, enabling source control and full-process management of pests and diseases. This management model emphasizes ecological balance and natural regulation, enhancing the self-repair and resilience of urban green space systems by creating environments conducive to natural enemies, breeding resistant varieties,

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and optimizing planting structures. This ensures that street trees provide ecological services while being more resilient. Additionally, regular management integrates pest and disease control into the urban governance system, promoting a shift in management philosophy from post-event remediation to pre-event prevention, from single-department management to multi-stakeholder collaborative governance, and from reliance on chemical methods to ecological technology innovation. This fosters a new pattern of urban development characterized by harmonious coexistence between humans and nature.

3. Practical Challenges in Regular Management for Green Pest and Disease Control in Urban Street Trees

3.1 Gaps in the Monitoring and Early Warning System

The inadequacy of the urban street tree pest and disease monitoring and early warning system severely limits the proactivity and precision of control efforts. Manual inspections are constrained by the number of personnel and their professional expertise, resulting in low inspection frequency and limited coverage. Often, pests and diseases are only detected after significant damage has occurred. Meanwhile, technological means such as IoT sensors and smart image recognition are slow to be adopted due to high initial investment and maintenance costs. Monitoring efforts are overly concentrated in window areas such as main roads, commercial centers, and government buildings, while street trees in secondary roads, backstreets, and old residential areas—which bear the brunt of daily life—are left in monitoring vacuums. These areas are more prone to pest and disease outbreaks due to insufficient maintenance and aging trees [1]. Although various functional departments collect relevant data, the lack of a unified information-sharing mechanism and data standards prevents the interconnection and comprehensive analysis of meteorological warnings, pest monitoring, and maintenance records. This leads to delayed warnings and one-sided judgments, forcing grassroots units to rely on experience rather than scientific and precise control measures.

3.2 Uneven Application of Control Technologies

The uneven application of control technologies reflects deeper issues of inadequate implementation of green control concepts and an underdeveloped technology promotion system. Grassroots maintenance units generally exhibit an inertial mindset of "prioritizing chemicals over ecology," believing that chemical pesticides are fast-acting, easy to apply, and cost-effective. In contrast, they are hesitant about biological control due to its longer cycle and the high cost of physical control equipment. Coupled with a lack of systematic technical training and practical guidance, even if natural enemies are distributed, units often do not know how to release them scientifically. Improper use of plant-derived pesticides can further reduce control effectiveness. Maintenance funding is calculated based on traditional models, failing to fully account for the specificities of green control technologies. This places units adopting ecological control methods under short-term cost pressure, while performance evaluations overemphasize immediate results, further reinforcing reliance on chemical control. This structural imbalance in technology application not only leads to ecological issues such as pesticide residue accumulation, increased pest resistance, and reduced natural enemy populations but also causes control costs to spiral, trapping efforts in a cycle of "more pesticides, worse pests, higher costs."

3.3 Lack of Coordination in Management Mechanisms

Fragmented and poorly coordinated management mechanisms are systemic obstacles hindering the effectiveness of pest and disease control. The greening department is responsible for technical guidance but lacks enforcement power; the landscaping department manages green spaces but not street trees; the sanitation department cleans fallen leaves but does not address pests; and street offices handle local management but lack professional expertise. This "nine dragons ruling the water" scenario results in unclear responsibility boundaries and inconsistent control measures. The absence of regular communication and coordination mechanisms means that emergency teams are

only formed after severe pest outbreaks, while operate independently with poor information sharing, leading to both duplicated efforts and control gaps. Cross-regional pest and disease control is even more challenging, as adjacent administrative regions act independently in terms of control timing, technical standards, and pesticide selection, creating opportunities for pest migration and spread [2]. The current evaluation system overly focuses on visible indicators such as pest incidence and tree mortality, while neglecting deeper factors like control technology innovation, ecosystem health, and sustainable development capabilities. This incentivizes managers to adopt emergency or campaign-style control measures rather than establishing long-term mechanisms.

3.4 Low Level of Social Participation

Insufficient social participation highlights weaknesses in public awareness cultivation and participation mechanism building for urban street tree pest and disease control. Most residents view street trees purely as municipal facilities, believing their maintenance is solely the government's responsibility. This lack of ownership and conservation awareness leads to daily behaviors that harm tree health and create conditions for pest invasions, such as nailing objects to trunks, dumping wastewater into tree pits, and unauthorized pruning. Community organizations, property management companies, and street-side businesses, which should be key players in street tree protection, often adopt a wait-and-see attitude due to unclear participation pathways and lack of interest alignment. Even when pests are detected, they rarely report or take action. Environmental education in schools lacks content on urban ecology and pest control, leaving young people with superficial understanding and failing to foster deep ecological conservation awareness. The professional service market is underdeveloped, with few social organizations capable of pest monitoring, biological control, and technical consulting. Their small scale and limited numbers prevent them from effectively government-transferred service functions, hindering the socialization and marketization of control efforts.

4. Strategies for Establishing a Regular Management Mechanism for Green Pest and Disease Control in Urban Street Trees

4.1 Building an Intelligent Monitoring and Early Warning Network

The construction of an intelligent monitoring and early warning network requires the full application of modern information technology to achieve precise monitoring and timely warnings of pests and diseases. Install IoT monitoring points every 500 meters in areas with dense street trees, such as main roads, parks, and residential areas. These points should be equipped with integrated sensors for temperature and humidity, high-definition cameras, and insect monitoring lamps to collect environmental parameters and pest activity data 24/7. Transmit data in real-time to the urban greening management center’s data platform via 5G networks. Use deep learning algorithms to train pest identification models for automatic image analysis, identifying pest species, density, and damage levels. Automatic warnings should be triggered when monitoring data exceed preset thresholds. Divide the city into grid units of 1 square kilometer, each 2–3 dedicated inspectors using mobile terminals with GPS and photo functions to conduct daily patrols along designated routes. Abnormalities should be photographed, uploaded, and geo-tagged immediately [3]. Integrate data from meteorological departments (temperature, humidity, rainfall), landscaping departments (tree species, age, maintenance records), and sanitation departments (garbage collection frequency) to build a multi-dimensional data fusion analysis model. This model should predict pest and disease occurrence probability and spread trends 7–15 days in advance.

4.2 Establishing an Ecological Control Technology System

The establishment of an ecological control technology system requires systematic advancement from source control and process intervention to ensure the scientific and operational feasibility of technical measures. In new road greening and street tree renewal projects, ensure that locally

adapted pest-resistant tree species such as ginkgo, pagoda tree, and goldenrain tree account for over 70% of plantings. Plant insect-repelling plants like mint and rosemary around tree pits, and configure ground cover plants such as clover and liriope under street trees to provide habitats for natural enemies. Install insect hotels every 100 meters to offer overwintering sites for beneficial insects like ladybugs and lacewings. Establish natural enemy insect breeding bases with an annual output of 50 million Chouioia cunea and 1 million Harmonia axyridis. Release natural enemies in batches 15 days before peak pest periods, with the number per tree determined by pest density, typically 3–5 times the pest population. Promote the use of plant-derived pesticides such as 0.3% neem oil emulsion and 1.2% nicotine·matrine, with application concentrations controlled at 0.1%–0.3% and used no more than three times per year. Install solar-powered insect traps in sensitive areas such as schools, hospitals, and residential neighborhoods, with each trap covering a radius of 30 meters. Combine with yellow sticky boards and pheromone traps to form a physical control network, achieving a trapping rate of over 60%.

4.3 Improving Coordinated Management and Operation Mechanisms

The core of improving coordinated management and operation mechanisms lies in clarifying responsibility boundaries and establishing efficient coordination and linkage mechanisms to ensure the systematic and continuous nature of control efforts. Issue the "Urban Street Tree Pest and Disease Control Management Measures," clearly defining that municipal greening departments are responsible for annual control plans, technical standards, and fund allocation; district landscaping departments are responsible for implementation and technical guidance; street offices are responsible for daily inspections and information reporting; and maintenance enterprises are responsible for executing specific control tasks as per contracts. This forms a four-tier linkage system at the municipal, district, street, and enterprise levels. Hold monthly pest control meetings, with emergency meetings convened within 72 hours for major pest outbreaks. Establish WeChat work groups for real-time communication and coordination. Implement joint prevention and control for cross-regional pests, with synchronized control operations in adjacent areas. Incorporate pest control into comprehensive urban management evaluations, with green control technology application rate accounting for 30% of the weight, chemical pesticide reduction rate for 25%, public satisfaction for 20%, and emergency response timeliness for 25%. Evaluation results should be directly linked to maintenance funding, and units failing to meet standards for two consecutive years should have their maintenance qualifications revoked.

4.4 Fostering a Social Participation and Co-Governance Framework

The formation of a social participation and co-governance framework requires establishing comprehensive participation channels and incentive mechanisms to fully mobilize the enthusiasm and initiative of various social actors. Develop a "Urban Tree Health" mobile application allowing citizens to report pest conditions by uploading photos. The system should automatically geo-locate and notify nearby maintenance units, with feedback on handling results within 24 hours. Select 10 outstanding reporters monthly and reward them with 200 yuan. Set up street tree maintenance bulletin boards in communities, updating pest control knowledge quarterly. Organize "Little Tree Guardians" practical activities for primary and secondary school students, offering four class hours of ecological education per semester [4]. Launch a corporate sponsorship and adoption program with a three-year term, placing identification plates on adopted trees. Adopting enterprises should receive corresponding carbon sink certificates and tax benefits. Support the development of 10 professional pest control service companies, with the government purchasing services such as natural enemy breeding and supply, pest monitoring and assessment, and emergency control. Service fees should be paid at 80% of market rates. Establish a volunteer points system, awarding 2 points for one hour of patrol participation, 5 points for and 3 points for providing valid information. Points can be exchanged for rewards such as annual park passes and parking coupons. The top 100 volunteers annually should be awarded the "Green Guardian" honorary title.

5. Conclusion

The establishment of a regular management mechanism for green pest and disease control in urban street trees is a systematic project requiring coordinated efforts in technological innovation, institutional improvement, and social mobilization. By building an intelligent monitoring and early warning network, an ecological control technology system, a coordinated management and operation mechanism, and a social participation and co-governance framework, thescientific nature, precision, and sustainability of pest and disease control can be effectively enhanced. This is not only a practical need for maintaining urban ecological security but also an important manifestation of advancing the modernization of urban governance systems and capabilities. It holds significant meaning for building beautiful, ecologically livable cities.

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