proceedings

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Proceeding Paper

Economic Benefits of Biological Pest Control in Urban Forestry: A Sustainable Management Approach †

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† Presented at the 11th International Conference on Information and Communication Technologies in Agriculture, Food & Environment, Samos, Greece, 17–20 October 2024.

Abstract: This paper examines the potential economic benefits of biological pest control in urban forests by evaluating its effectiveness in controlling these pests and assessing its economic benefits. It also analyzes the advantages and disadvantages of using biological pest control as a sustainable method for managing specific pest populations. Urban forests improve the quality of life in cities, leading to more sustainable communities. Urban trees are more vulnerable to insect excursions, and pest infestations are increasingly threatening urban forests. Pest control methods are necessary to confront this threat, which risks tree health and vitality. However, traditional chemical pest control methods pose significant environmental and human health risks, highlighting the need for more sustainable solutions. Biological pest control methods have many advantages and few disadvantages compared with traditional chemical methods. Biological pest control is an environmentally friendly method that, as an investment, could lead to long-term economic benefits in terms of return on the initial investment, reducing costs over time, and a high benefit-to-cost ratio.

Keywords: environmental economics; urban trees; ecosystem services; sustainable pest management

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Academic Editors: Thomas Bournaris and Athanasios Ragkos

Published: 28 April 2025

Citation: Tsiaras, S.; Koulelis, P.P.; Petrakis, P.V. Economic Benefits of Biological Pest Control in Urban Forestry: A Sustainable Management Approach. *Proceedings* **2025**, *117*, 21. https://doi.org/10.3390/proceedings2025117021

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1. Introduction

Urban forests improve the quality of life in cities [1], leading to more sustainable communities [2]. Trees in urban areas provide essential ecosystem services [3], such as air purification [4,5], temperature regulation [6,7], pollution mitigation [8–10], and vital recreational spaces [11,12]. The COVID-19 pandemic has drastically increased the importance of urban forests [13,14], and the role of green spaces in cities was highly appreciated [15].

According to the Sustainable Development Report 2023 [16], over half of the global population currently lives in urban areas, a figure expected to rise to 70% by 2050. Sustainable Development Goal 11 (SDG 11: Sustainable Cities and Communities) aims to create sustainable cities and communities by prioritizing access to green spaces [16]. One of its indicators, monitored by the European Union, measures the proportion of people affected by noise pollution from neighbors or the street. In 2023, this affected 18.2% of the population across the EU [17]. To address these challenges, the EU's urban policy emphasizes enhancing urban green spaces to improve quality of life and environmental health [18].

Urban trees are vulnerable to insects and pathogens because they are often the first point of contact for exotic pests including insects and plant pathogens, and addition-

ally they are exposed to numerous pressures [19]. Pest infestations in urban forests are increasingly threatened, risking tree health and vitality [20]. Pest control methods are necessary to confront this threat. However, traditional chemical pest control methods pose significant environmental and human health risks [21], highlighting the need for more sustainable solutions.

This paper examines the potential economic benefits of biological pest control in urban forests by evaluating its effectiveness in controlling these pests and assessing its economic benefits. It also analyzes the advantages and disadvantages of using biological pest control as a sustainable method for managing pest populations.

2. Biological Pest Control vs. Chemical Pest Control

Chemical pest control is still used in many countries worldwide [22], although chemical pesticides severely affect human health and the environment [23], and chemical control is ineffective against some insects [24]. Moreover, the use of insecticides involves risks for humans, animals, and the environment, and therefore, in many urban areas worldwide, the use of insecticides is increasingly banned [25]. People are very critical regarding the use of chemical pesticides in urban areas [26] and are willing to pay more for biological pest control [27].

According to [21], the use of pesticides in urban areas must be viewed cautiously to protect human health and the environment. Applying biological pest control methods in urban forests is a sustainable option that is highly cost-effective [28]. Integrated pest management can control the number of insects safely and cost-effectively, leading to a more stable urban forest and increasing the net benefits [29]. However, other researchers believe that although biological pest control is an environmentally friendly method of suppressing harmful organisms in farming and other intensively managed agricultural ecosystems [30,31], it is more expensive, demands more systematic application, and requires more user knowledge than other methods [32].

2.1. Economic Efficiency of Biological Pest Control

According to Turner-Skoff and Cavender, money spent on urban forestry has a high return on investment [2]. Moreover, Shogren and Paine concluded that successful biological control in urban forests leads to substantial rates of return on investment [33]. Kenis et al. underlined that classical biological control (CBC), the introduction of a natural enemy of exotic origin to control a pest, though ecologically unjustified, could lead to substantial economic benefits in the long term since it aims at the permanent control of the pest where no action is needed after the CBC application to the invaded urban area [25]. Moreover, local species or varieties of natural enemies, such as entomopathogenic fungi, are more suitable for introduction since they are more specific, evolutionary, and efficient natural enemies of certain pests [34].

A biological control program that took place in California, USA, regarding the preservation of the aesthetic beauty of an urban forest showed that the respective benefit-to-cost ratios were substantial, and the overall economic benefits were significant. The authors calculated the change in aesthetic value (CAV = Appraised Value without defoliation—Appraised Value with defoliation), and the average benefit per host tree was equal to its change in appraised value (CAV) due to the insect damage [35].

Another study in California that examined the economic benefits of applying biological pest control to ornamental street trees resulted in similar findings, and a substantial rate of return per dollar spent was also documented. The authors calculated the total value of the preserving trees by multiplying the number of trees by the respective aesthetic value change (AVC) per tree. The change of AVC (a per-tree estimate of the economic benefit) was

the difference between the appraised value in the absence of the pest minus the appraised value in the presence of the pest (change in AVC = appraised value in the absence of the pest—appraised value in the presence of the pest) [36].

Finally, a cost–benefit analysis for biological control programs conducted in urban landscapes of California concluded that the return derived from protecting the value of the urban trees through the biological control efforts, per dollar expended, ranged from US$428 to US$1070. The authors estimated the appraised value of eucalypt street trees by calculating the basic tree cost, taking into consideration the unique tree cost, the appraised trunk increase, and the installed tree cost [28].

The substantial returns on investment from the biological pest control of invasive alien plants in natural environments were also documented in studies in other geographical regions, such as Australia [37] and South Africa [38]. A biological control program in eucalypt trees in Portugal also resulted in a positive benefit-to-cost ratio [39]. Moreover, a study in Russia concluded that early detection of pests in combination with insect pest monitoring and biological pest control could prevent the economic losses caused by invasive alien insects [24]. Finally, a study in China that tested a biological pest control method in walnut orchards revealed that the method was effective and could promote economic benefits [40].

2.2. Advantages and Disadvantages of Biological Pest Control

Table 1 presents the main advantages and disadvantages of biological pest control based on the literature review.

Table 1. Advantages and disadvantages of biological pest control.

Advantages	Explanation	Disadvantages	Explanation
Long-term Cost Efficiency [2,25,33].	Biological pest control leads to substantial economic benefits in the long term [2,25,33].	Initial Setup Cost/Research and Development cost [41].	This kind of program can be expensive due to research and development costs [41].
Enhanced Ecosystem Services [3].	Healthier urban forests, improved ecosystem services (air and water purification, indirect economic benefits for the local community) [3].	Unpredictable Effectiveness /Often failures [42].	Variable effectiveness of biological control can lead to unsuccessful treatment of the pests and potential financial risks [42].
Improved Public Health [43].	Reduced pesticide, fewer health issues among residents [43], decreasing healthcare costs.	Time-Intensive/Slow Effect [44].	Biological control methods often take longer to show results compared to chemical treatments [44], potentially leading to higher short-term management costs.

Table 1. *Cont.*

Advantages	Explanation	Disadvantages	Explanation
Tourism and Recreation [45].	Attractive and healthy urban forests can boost local tourism and recreation-related revenue [45].	Systematic application/More knowledge required [32].	Biological control methods demand more systematic application and require more knowledge from the user compared with other methods [32] and more trained personnel [44].
Increased Property Values [46].	Well-maintained urban forests can enhance property values in surrounding areas [46].		
Energy Savings [47].	Healthier trees, better shade and wind protection, reduced energy costs for cooling, and heating nearby buildings [47].		

3. Discussion and Conclusions

Biological pest control methodologies of insect pest control have many advantages compared with traditional chemical methods, while their disadvantages are less severe than those of chemical methods. The main challenges that biological pest control involves are the high initial costs, since the costs are concentrated at the beginning of the biological pest control projects, and the high research and development costs because the costs increase when studies need to be conducted in order to detect new candidate natural enemies [48]. Another major challenge related to biological pest control is that it requires more knowledge from the users than chemical methods. Therefore, stakeholders are unwilling to adopt biological pest control methods [32].

Biological pest control methods can effectively reduce the population numbers of many pests [28]. In conclusion, biological pest control is an environmentally friendly method that could lead to long-term economic benefits in terms of (i) return on initial investment, (ii) reducing costs over time, and (iii) a high benefit-to-cost ratio. The biological pest control methods could finally strengthen the global efforts for sustainable cities and communities, adopting the spirit of Agenda 2030 for sustainable development.

Author Contributions: Conceptualization, S.T., P.P.K., and P.V.P.; methodology, S.T. and P.P.K.; software, S.T.; validation, S.T., P.P.K., and P.V.P.; formal analysis, S.T., P.P.K., and P.V.P.; investigation, S.T., P.P.K., and P.V.P.; resources, S.T., P.P.K., and P.V.P.; data curation, S.T., P.P.K., and P.V.P.; writing—original draft preparation, S.T.; writing—review and editing, S.T., P.P.K., and P.V.P.; visualization, S.T.; supervision, P.P.K., and P.V.P. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: No new data were created or analyzed in this study. Data sharing is not applicable to this article.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

SDG	Sustainable Development Goal
EU	European Union
CBC	Classical Biological Control
CAV	Change in Appraised Value
AVC	Aesthetic Value Change

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