Following a Self-guided Trail within an Accredited US Campus Arboretum: The Use of an AI-based App for Tree Identification and Tour Enrichment

Merve Kalayci Kadak

Being in an urban or developed area can adversely affect human well-being. On the other hand, human well-being is supported by recreational activities, which are often carried out outside, particularly in natural areas. Most research on such topics has focused on non-urban/non-developed areas, for which the term ecosystem services describes the direct and indirect benefits that people may receive. In developed regions, limited access to natural features can hinder these benefits. This study explored the specific case of a tree-walking route located within a developed campus in the US. This route is noteworthy for its diverse collection of 40 distinct woody species, which contributes to the campus's green infrastructure. Two on-site observations were carried out to visually document the trees on the route and to understanding ecological value. An AI-based mobile application, 'Picture This', was used to follow the route as a self-guided participant. The results indicate that it is possible to use the application as a guide with approximately 84% accuracy. Its accessibility enhances its potential as a free resource for researchers, students, and nature enthusiasts.

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INTRODUCTION

University campuses are established in many locations, with a general goal of increasing the number and value of educated people. One of the crucial missions is to provide a place and environment for the education of qualified people. At the same time, these campus areas are public or semi-public areas, which are organized as urban areas (Huang *et al.* 2023). Therefore, they also have another function, which is to provide services to the public. Besides, campuses are also significant for controlling the impact of climate change on urban areas. Campuses can include vegetation that is natural or culturally created (Paudel and States 2023; De Montis *et al.* 2024). Vegetation cover provides protection from climate change effects, especially focusing on landscape structures (De Montis *et al.* 2024; Kalayci Kadak *et al.* 2024). In this context, campuses should be designed to provide benefits from these areas to primary users, such as students, faculty and staff, along with the public. Therefore, providing some of the ecosystem services to all users, including the public, who are overwhelmed by the urban structures, can be possible. Most importantly, such services can help to alleviate the adverse effects of climate change (Kim *et al.* 2024; Gul 2025; Kalayci Kadak 2025; Kaya *et al.* 2025), such as urban heat islands and extreme precipitation, in urban areas, along with contributing to conservation of human well-being.

Ecosystem services, including those associated with trees on a university campus, are crucial for the sustainability of human's healthy life (Kalayci Kadak 2025). These services also have vital importance in improving living standards. Ecosystem services are conceptually categorized into four main classes according to their functions (Fig. 1): regulating services, provisioning services, supporting services, and cultural services (Leemans and De Groot 2003; King *et al.* 2014; Zhou *et al.* 2024; Kalayci Kadak 2025).

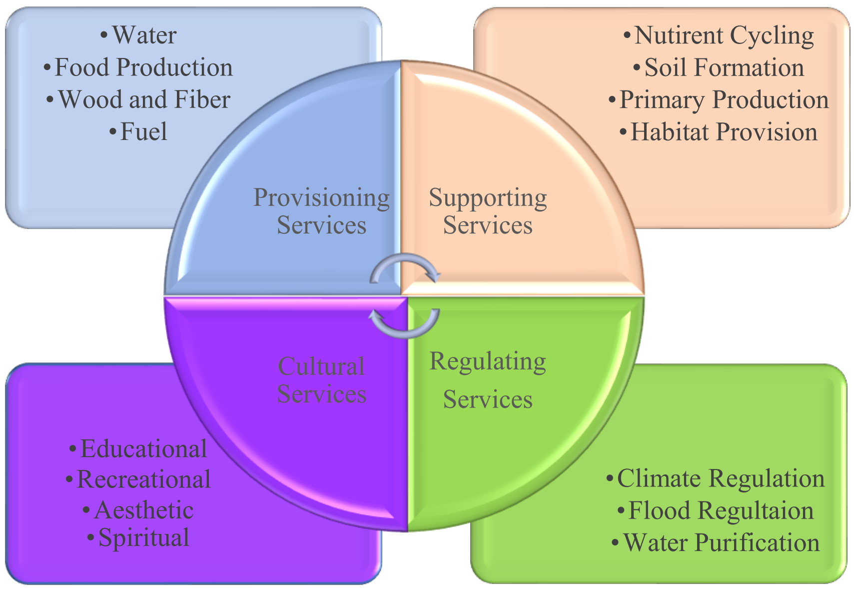


Fig. 1. Ecosystem Services (Millenium Ecosystem Assessment, 2005)

The first class, regulating services, has some benefits within ecosystem processes, such as regulating climate change effects, controlling epidemics or other types of diseases, and water purification. The provisioning services provide much help, including food security and supplying fresh water for all creatures. The supporting services provide critical benefits for soil formation and nutrient cycling. Finally, the fourth class, cultural services, has several benefits. Supporting services offer non-material benefits, such as recreational activities, educational issues, aesthetic gains, and engagement in community life from ecosystems (Castro *et al.* 2016; McInnes and Everard 2017; Cianchi *et al.* 2024). The perspective of ecosystem services has become progressively crucial in regulation, protection, and management of environmental rules due to providing an assessment frame for the ecosystem's benefits (Li *et al.* 2022; Liu *et al.* 2022; Lenhardt 2023; Gül and Esen 2024). Incorporating stakeholders in the assessment process is important regarding determining primary demands and needs, which can be obtained from ecosystem services by local administrations (Beaumont *et al.* 2017; Friedrich *et al.* 2020; Li *et al.* 2022). There has been an ever-increasing importance of mapping by using technology-based techniques for the assessment of ecosystem services' benefits to ease policy-making processes (Daily *et al.* 2009; Brunina *et al.* 2016; Friedrich *et al.* 2020).

Nowadays, there are a lot of advancements in geographic information systems (GIS) and remote sensing (RS) tools, which are used for mapping methodologies by many researchers. These improvements allow researchers to understand ecosystem services and benefits related to ecosystem services by analyzing relationships between natural and cultural systems (Burkhard *et al.* 2012; Bagstad *et al.* 2013; Vargas *et al.* 2018; del Río-Mena *et al.* 2020; Zhou *et al.* 2024). Advancing technology accompanies the development of artificial intelligence (AI) technology, which is used in all assessment areas, including innovative or scientific, for the commonly used applications in decision-making processes (Koumetio Tekouabou *et al.* 2023; Prodanovic *et al.* 2024). Accordingly, advancing technology tools have become considerably important in the utilization rate of ecosystem services in urban or semi-urban areas (Chee 2004; Morya and Punia 2022). Integrating state-of-the-art tools, particularly machine learning algorithms, into advancing innovative methodologies is essential for benefits that are used by people for sustainability of Earth. Thus, managing natural resource-based benefits can be more perceivable and sustainable (Raihan 2023; Kalayci Kadak *et al.* 2024). These approaches will eventually be used more widely in urban planning.

Among the places to understand observing ecosystem services is the arboretum. Arboretums have many goals for conservation of natural resources and educational purposes. Crucial objectives for the ecosystem benefits include biodiversity protection and sustainable use of natural values. Key values such as ecological approaches, educational needs, and community engagement affect the objectives and managing/designing natural resource value of the arboretum (Roman *et al.* 2017, 2022). In this context, some campuses have been declared as arboretums as part of the Arboretum Accreditation Program (https://arbnet.org). The Storrs campus, the main campus of the University of Connecticut, was certified as a Level II arboretum in July 2024 (Reitz 2024). The arboretum character of semi-public or public areas, such as campuses, helps urban landscapes be in harmony with sustainable nature (Lee 2021; Li *et al.* 2022). Accreditation by national or international organizations supports not only natural resources conservation but also encourages community engagement *via* educational goals and recreational activities. In this regard, the design of a campus, which is among the semi-public areas, is a multifaceted effort to involve natural values in functional community solutions (McDonald *et al.* 2018; Boyd 2022). Also, university campuses are essential for promoting social connections by the public (Moreno and Franquesa 2023). In this context, some specific routes, which can be divided into two categories as self-guided and guided, have been created within campuses by the university administrations (Melo *et al.* 2020). These routes are significant for responsible usage and participatory approach on campuses. It allows users to explore natural or artificial values through the campus area (Al-hagla 2010; Moore *et al.* 2012; MacLeod and Hayes 2013; MacLeod 2016; Janeczko *et al.* 2021).

The effectiveness of self-guided trail routes can be advanced by utilizing new technologies, such as a mobile AI application. Participating in the community adds and enriches local memories and cultural values into the visitors' experience (D'Antonio *et al.* 2022; Marion 2023). These benefits also contribute to the cultural services, which is a type of ecosystem services (Koo *et al.* 2013). Additionally, using self-guided trails will support environmental literacy among visitors by attaching individual technological development, such as AI applications, on mobile phones. These trails can help individuals observe ecological issues (Janeczko *et al.* 2021; Marion 2023). Therefore, taking advantage of AI for trails is rational to ensure sustainability while planning a modern campus. Designers and researchers should be careful while integrating ecological factors into the strategic planning of campus needs. Thus, a balance can be achieved between protecting natural resources and usage goals (Orenstein *et al.* 2019). At present, this integration can be possible with technological support (Yang *et al.* 2020; Li *et al.* 2023). Overall, it is important to espouse innovative approaches, such as utilizing AI (Mashhood *et al.* 2023).

This research focused on the main campus of the University of Connecticut (UConn), located in Connecticut State, USA. The primary aim was to understand the opportunity to track the self-guided tree route, organized by the university administration, through an AI application. Additionally, the benefits obtained by self-guided routes from ecosystem services were considered. In this study, where striking results were derived, the value and importance of urban or semi-urban routes within the framework of different dynamics were also analyzed. Several previous studies (Kothencz *et al.* 2017; Gould *et al.* 2019; Zhou *et al.* 2022) concluded that outcomes of recreational use of ecosystem services, especially in urban or semi-urban areas, affect life quality favorably. The main goal of this paper is to reveal the possibility of assessing urban ecosystem services' benefits on life quality, by harnessing an innovative perspective by AI. The results of the study aimed to represent an approach, especially for decision-makers, in view of current technological improvements for the sustainability of the world. Additionally, the results of the article potentially will serve sustainable Development Goal 11 (SDG 11) of the United Nations. Because cultural ecosystem services can contribute to most of the SDGs (Xu and Peng 2024). These objectives can be summarized as follows: The urban areas must be sustainable, available for everyone, resilient, and safe. In summary, the study contributes to more liveable urban lifestyles.

EXPERIMENTAL

This study focused on the tree route located in the main campus of the University of Connecticut (UConn), which houses 40 special tree species (see Appendix) (Kask 2008; Reitz 2024). The AI application, called "Picture This," which can be downloaded to mobile phones (available on the Apple App Store and Google Play Store), was used in the tracking of this tree route.

Framework Definition and Study area

UConn's main campus, called the Storrs campus, is located in Mansfield Township, which is east of Hartford, in the Connecticut's Capital Planning Region, located near the coordinates 41° 48′ 26″ N and 72° 15′ 9″ W (Fig. 2).

The study area, the University of Connecticut's main campus, was awarded prestigious arboretum accreditation in 2024. The application for Level II Arboretum Accreditation, approved by ArbNet Arboretum Accreditation Program, is administered by the Morton Arboretum.

To be accredited as a Level II arboretum, the applicant must have the requirements listed below:

- ✓ There should be at least 100 species on the campus.
- ✓ There should be at least one person as the agent of maintaining the facility.
- ✓ The applicant must be able to show a reliable inventory of the collection.
- ✓ Educational and public benefit programs should be offered.

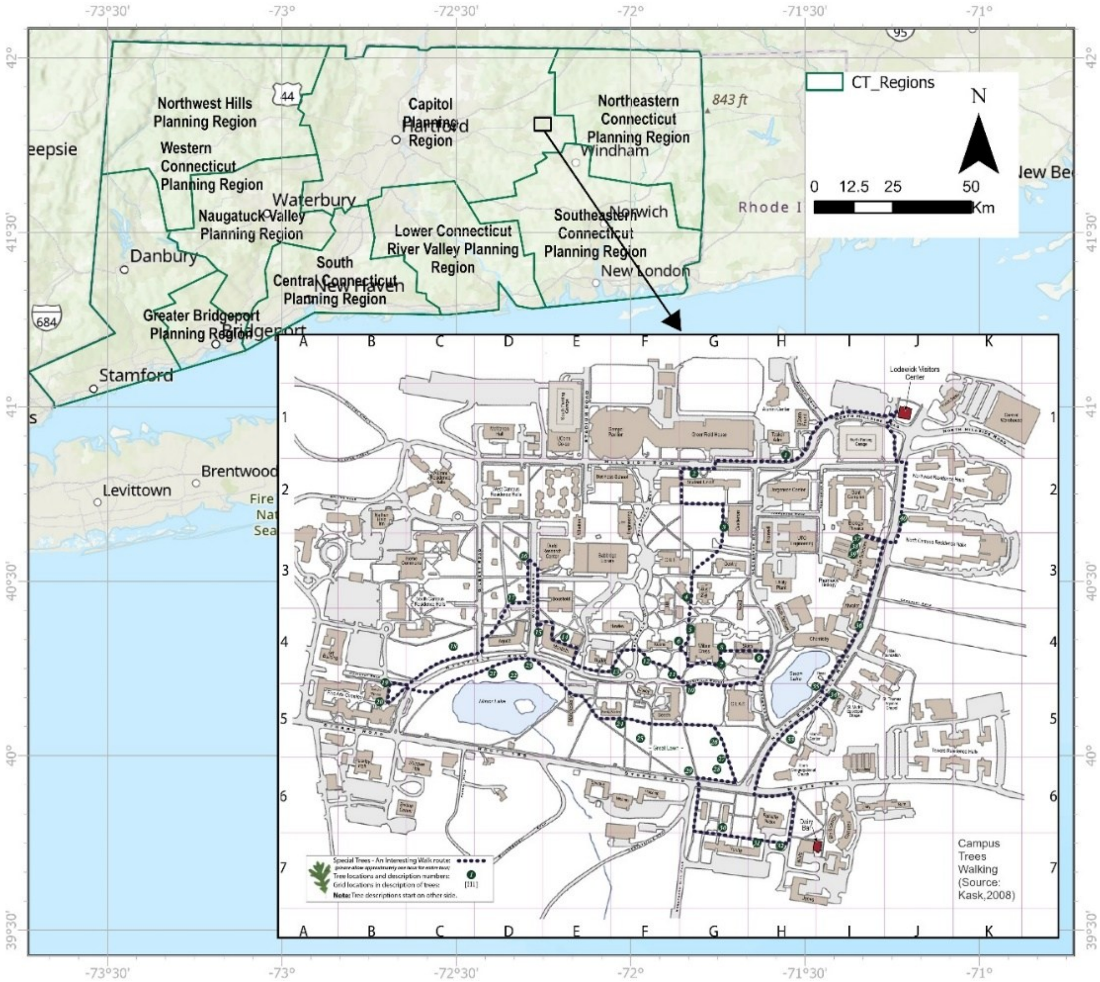


Fig. 2. Location of the tree route in the study area, CT (Original, 2025)

In this context, the campus of UConn has more than 425 species within 90 unique genera. It presents a system that is available for campus users and provides free and informative labelling for campus trees. This system is GIS-based and is being updated periodically.

Moreover, the campus was named Tree Campus, which is the first in the Connecticut state, by Arbor Day Foundation. There are many ongoing actions, including the following, to preserve the qualities of the campus by the Office of Sustainability (Office of Sustainability):

- ✓ Organizing an advisor committee for campus trees
- ✓ Managing campus tree-care plan
- ✓ Observing Arbor Day
- ✓ Connection with community beyond campus borders.

A self-guided tree walking route (Kask 2008) has been formed considering these goals, (Appendix: Supplementary Material (SM)-I).

Methodology

The study was carried out in four phases: Definition of framework, data and tool collection, study area research, and office work. The workflow chart in Fig. 3 shows the steps of the methodology.

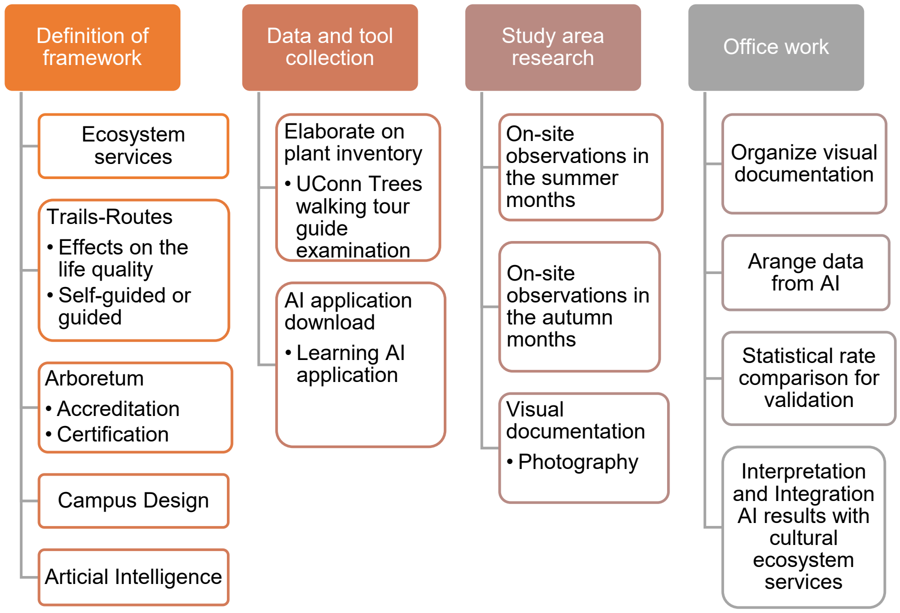


Fig. 3. Methodology workflow diagram

In the first phase, the concepts of the study subject were focused comprehensively to assess the study's outputs in terms of the knowledge gaps. In the second phase, the data and application, which are the main materials of the study, were obtained. The document related to the tree route (Appendix: SM-I) was examined and elaborated. Picture This™ (Glority Global Group) AI-aided application was downloaded to a mobile phone.

The third phase was the most critical stage of the study. This phase required high focus and precision. The study area was visited two times at different seasons (summer-autumn) due to foliation and defoliation periods. The visit was scheduled to examine the site survey along the route and take photos of trees in different hours of the day as bright as possible. Seasonal changes are essential for the machine learning of AI-based applications and visual documentation processing. This enables the application to be more productive. For these reasons, having high focus and precision was crucial.

In the fourth phase, visual documents, which were obtained by site survey, and the photographs, used to identify by AI, were organized. All tree data were tabulated. Afterwards, the information provided by AI and the tree walking tour guide information, prepared by the arboretum committee, were compared proportionally and graphed out. Thus, the results of the AI were verified with a cross-validation approach. By this means, all data were promoted to be more understandable for readers and researchers. Lastly, the possibility of using AI in self-guided or even unguided routes was interpreted based on the accuracy of AI identification. It is probable that these results and perspectives will support educational, recreational, aesthetic, and spiritual cultural services.

RESULTS

This section presents and discusses the main results of the research. These results were obtained by visiting the study site twice, in July 2024 and October 2024. The goal was to make the assessment more reliable by surveying and examining the plants in two different seasons (Primack *et al.* 2023). Seasonal changes affect the appearance of the plant habitus and foliation (Kuper 2013; Xu *et al.* 2022). The 'Picture This' AI-based application was used while visiting the study site as mentioned in the methodology section.

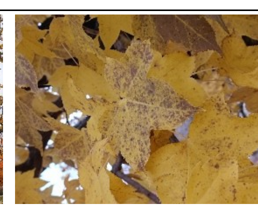
Table 1. Campus Trees of Walking Tour and their Status

ID	Scientific Name	Common Name	Status	ID	Scientific Name	Common Name	Status
1	*Platanus x acerifolia*	London Planetree	✓✓	**21**	*Pinus rigida*	Pitch Pine	xx
2	*Aesculus flava*	Yellow Buckeye	✓✓	**22**	*Betula davurica*	Dahurian Birch	_
3	*Cercidiphyllum japonicum*	Katsura tree	✓✓	**23**	*Salix x blanda*	Wisconsin Weeping Willow	✓✓
4	*Sciadopitys verticillata*	Japanese Umbrella Pine	✓x	**24**	*Abies holophylla*	Manchurian Fir	✓✓
5	*Pseudocydonia sinensis*	Chinese Quince	✓✓	**25**	*Liriodendron tulipifera*	Tulip Tree	✓✓
6	*Quercus imbricaria*	Shingle Oak	✓✓	**26**	*Ulmus glabra 'Camperdownii'*	Camperdown Elm	✓✓
7	*Ulmus parvifolia*	Lacebark Elm	✓✓	**27**	*Ginkgo biloba*	Ginkgo/Maidenhair Tree	✓✓
8	*Styphnolobium japonicum*	Japanese Pagoda Tree	✓✓	**28**	*Gymnocladus dioicus*	Kentucky Coffee tree	✓✓
9	*Celtis occidentalis*	Common Hackberry	✓✓	**29**	*Tsuga canadensis 'Sargentii'*	Sargent's Weeping Hemlock	✓✓
10	*Quercus alba*	White Oak	✓✓	**30**	*Metasequoia glyptostroboides*	Dawn Redwood	✓✓
11	*Nyssa sylvatica*	Black Tupelo	✓✓	**31**	*Larix decidua 'Varied Directions'*	Varied Directions European Larch	✓✓
12	*Koelreuteria paniculata*	Golden Rain Tree	✓x	**32**	*Kalopanax septemlobus*	Castor-aralia	✓x
13	*Acer palmatum var. dissectum atropurpureum*	Japanese Maples	✓✓	**33**	*Ilex opaca*	American Holly	✓✓
14	*Fagus sylvatica 'Atropunicea'*	European Copper Beech	✓✓	**34**	*Acer triflorum*	Three-flowered Maple	✓✓
15	*Heptacodium miconioides*	Seven-son Flower	✓✓	**35**	*Taxodium distichum*	Baldcypress	✓✓
16	*Sassafras albidum*	Sassafras	_	**36**	*Magnolia virginiana*	Sweetbay Magnolia	✓✓
17	*Magnolia acuminata*	Cucumber tree Magnolia	✓✓	**37**	*Styrax obassia*	Fragrant Snowbell	_
18	*Liquidambar styraciflua*	American Sweetgum	✓✓	**38**	*Hovenia dulcis*	Japanese Raisin Tree	_
19	*Styphnolobium japonicum 'Pendula'*	Weeping Japanese Pagoda tree	✓✓	**39**	*Sequoiadendron giganteum*	Giant Sequoia	xx
20	*Pinus parviflora*	Japanese White Pine	✓x	**40**	*Oxydendrum arboreum*	Sourwood	✓✓

✓✓: Available-Identified, _: Not present at their location, ✓x: Available-Misidentified, xx: Misidentified in the second tour

One of the most striking results is that the AI-based application named 'Picture This' showed the capability of detecting almost all plants on the tree walking route. Previous studies have shown that plants can be described using remote sensing technologies (Huang and Asner 2009; Cerrejón *et al.* 2021). On the other hand, the ecosystem services, especially cultural ecosystem services, were assessed using social media photos (Egarter Vigl *et al.* 2021; Tulek 2023). However, identification of plants using a free mobile AI-based application has not been commonly used so far, according to the current literature. AI-based applications or similar AI technologies employ machine learning procedures. Effective plant identification can be attributed to the fact that a machine learning process supplies access to more data (Willcock *et al.* 2018) and it assesses rarer values (Cerrejón *et al.* 2021). Thus, it provides more reliable results after assessment by using a bigger data repository. This substantial result should be compared with previous research that focus on identifying woody plants. Results of the statistical analysis showed that the application, 'Picture This' detected approximately 84% of all standing trees on the route. This result is a promising finding in terms of the use of AI-based applications on a seasonal basis.

Table 2. Misidentified Plants

ID	Name	SUMMER		AUTUMN	
4	*Sciadopitys verticillata*				
12	*Koelreuteria paniculata*				
20	*Pinus parviflora*				
32	*Kalopanax septemlobus*				

In the study, the plant identification application was used to determine the effectiveness of AI while using self-guided routes, which provide benefits from cultural ecosystem services to people. While following the route that houses forty species, it was found that four trees; *Sassafras albidum*, *Betula davurica*, *Styrax obassia*, and *Hovenia dulcis*, were not present in their intended locations (Table 1).

Therefore, the assessment of AI-based application, which is the primary material of the study, was performed with 36 species.

The application misidentified only four out of 36 species: *Sciadopitys verticillata*, *Koelreuteria paniculata*, *Pinus parviflora*, and *Kalopanax septemlobus*. The visual identification documents related to undetectable species are given in Table 2 (IDs in Table 2 refer to Table 1).

Furthermore, there were two species unidentified on the second tour, despite being identified correctly on the first tour: *Pinus rigida* and *Sequoiadendron giganteum* (Table 3).

Table 3. Misidentified Plants on the Second Tour

ID	Name	SUMMER		AUTUMN	
21	*Pinus rigida*				
39	*Sequoiadendron giganteum*				

In summary, 'Picture This' AI-based application successfully identified 30 out of 36 species in the route (Table 4).

The ecosystem's qualifications, such as aesthetics (Kaya and Corbaci 2025), cultural heritage values, and habitat provision, are variable (Sari and Karasah 2023; Tulek 2023). Besides, these depend on whether the woody plants are native or non-native (Sari *et al.* 2020).

At the end of the research, it was determined that 17 species are native, two species are hybrid, and 21 species are non-native. Besides, four out of 40 species (one native and three non-native) were not present at their location, as mentioned earlier.

The origins of the woody plants on the campus route were examined, and they were classified as native, non-native, or hybrid (Table 5).

Table 4. Identified Plants

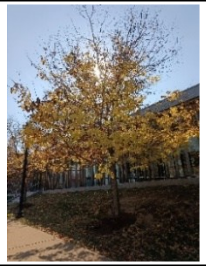
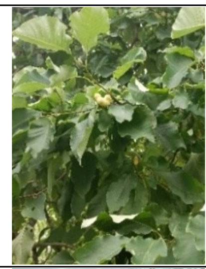
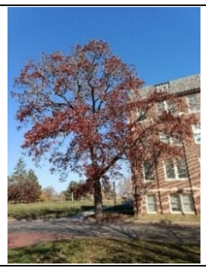
ID	1	2	3	5	6	7	8	9
	Platanus x acerifolia	*Aesculus flava*	*Cercidiphyllum japonicum*	*Pseudocydonia sinensis*	*Quercus imbricaria*	*Ulmus parvifolia*	*Styphnolobium japonicum*	*Celtis occidentalis*
SUMMER								
AUTUMN								
ID	10	11	13	14	15	17	18	19
	Quercus alba	*Nyssa sylvatica*	*Acer palmatum var. dissectum atropurpureum*	*Fagus sylvatica ‘Atropunicea’*	*Heptacodium miconioides*	*Magnolia acuminata*	*Liquidambar styraciflua*	*Styphnolobium japonicum ‘Pendula’*
SUMMER								
AUTUMN								

Table 4. Identified Plants (continued)

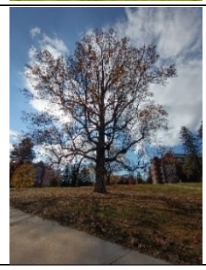
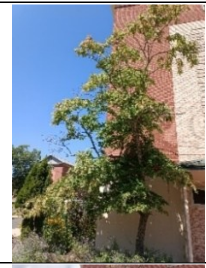
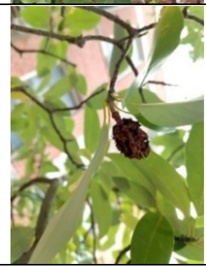
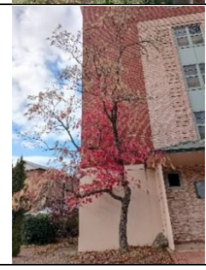
ID	23	24	25	26	27	28	29
	Salix x blanda	*Abies holophylla*	*Liriodendron tulipifera*	*Ulmus glabra 'Camperdownii'*	*Ginkgo biloba*	*Gymnocladus dioicus*	*Tsuga canadensis 'Sargentii'*
SUMMER							
AUTUMN							
ID	30	31	33	34	35	36	40
	Metasequoia glyptostroboides	*Larix decidua 'Varied Directions'*	*Ilex opaca*	*Acer triflorum*	*Taxodium distichum*	*Magnolia virginiana*	*Oxydendrum arboreum*
SUMMER							
AUTUMN							

Table 5. Origins of the Plants

ID	Scientific Name	Origin	Native To	ID	Scientific Name	Origin	Native To
1	*Platanus x acerifolia*	H		**21**	*Pinus rigida*	N	
2	*Aesculus flava*	N		**22**	*Betula davurica*	NonN	China, Manchuria, Korea
3	*Cercidiphyllum japonicum*	NonN	Japan, China	**23**	*Salix x blanda*	H	
4	*Sciadopitys verticillata*	NonN	Japan	**24**	*Abies holophylla*	NonN	Korea, China, Manchuria
5	*Pseudocydonia sinensis*	NonN	China	**25**	*Liriodendron tulipifera*	N	
6	*Quercus imbricaria*	N		**26**[2]	*Ulmus glabra 'Camperdownii'*	NonN	Scotland
7	*Ulmus parvifolia*	NonN	Asia	**27**[3]	*Ginkgo biloba*	NonN	China
8	*Styphnolobium japonicum*	NonN	China	**28**	*Gymnocladus dioicus*	N	
9	*Celtis occidentalis*	N		**29**	*Tsuga canadensis 'Sargentii'*	N	
10[1]	*Quercus alba*	N		**30**[4]	*Metasequoia glyptostroboides*	NonN	China
11	*Nyssa sylvatica*	N		**31**[5]	*Larix decidua 'Varied Directions'*	NonN	Europe
12	*Koelreuteria paniculata*	NonN	China	**32**	*Kalopanax septemlobus*	NonN	Asia
13	*Acer palmatum var. dissectum atropurpureum*	NonN	Japan, Korea, China	**33**	*Ilex opaca*	N	
14	*Fagus sylvatica 'Atropunicea'*	NonN	Europe	**34**	*Acer triflorum*	NonN	China, Korea
15	*Heptacodium miconioides*	NonN	China	**35**	*Taxodium distichum*	N	
16	*Sassafras albidum*	N		**36**	*Magnolia virginiana*	N	
17	*Magnolia acuminata*	N		**37**	*Styrax obassia*	NonN	Japan, Korea, Manchuria
18	*Liquidambar styraciflua*	N		**38**	*Hovenia dulcis*	NonN	Asia
19	*Styphnolobium japonicum 'Pendula'*	NonN	China	**39**	*Sequoiadendron giganteum*	N	
20	*Pinus parviflora*	NonN	Japan	**40**	*Oxydendrum arboreum*	N	

N: Native species to USA, NonN: Non-native species, H: Hybrid,
[1]1965 State Constitutional Convention (Source: SM-II)
[2]oldest class tree on campus (1895) (Source: SM-II)
[3]living fossil (Source: SM-II)
[4]first described as a fossil in 1941 (Source: SI-II)
[5]first introductions by UConn Prof. Sidney Waxman (Source: SI-II)

In the first survey in the summer of 2024, four species, all of them non-native, were misidentified (Fig. 4). In the second survey in the autumn of 2024, two species, both native and coniferous, were misidentified. This result was surprising, since coniferous species are evergreen. This evidence signifies a limitation regarding the use of AI-based applications. On the other hand, the plants that were misidentified in the first visit were identified correctly in the second visit because of the machine learning algorithm of AI in the background.

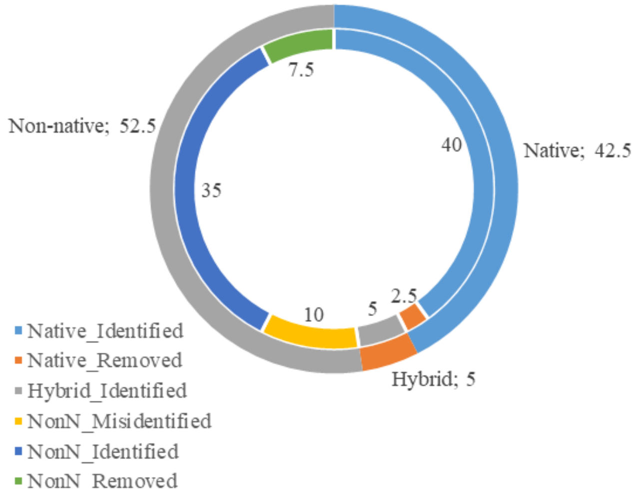


Fig. 4. Percentage of species identification according to originality on the first tour

DISCUSSION

By means of comparing the AI-based application, which uses machine learning, and the walking guide, which has been prepared by experts, it was determined that the approach used in this work could be a credible alternative. Results showed the AI-based identifications to be reliable and to have high potential statistically, as narrated in the Results and Discussion section. In this context, AI technologies and self-guided routes/trails can be mentioned on the same page in terms of ecosystem's benefits. However, in the use of AI to detect ecosystem services, it is critically important to understand the benefits and challenges of AI within the ecological perspective (Singh *et al.* 2025). Coordinating AI with green transformation is possible as AI technologies advance. Thus, the tree walking tours or trails support the green transformation with the development of AI (Sun *et al.* 2025). In this respect, the results of the study have served SDG 11, which is one of the 17 goals established by the United Nations. This is because SDG 11 aims to provide more safety, resilience, and eco-friendliness in urban areas, such as campuses and settlements. Green transformation is supported by ecosystem's benefits and ecology-based approaches.

The main goal of SDG 11 can be realized by improving life quality, protecting the benefits obtained from ecosystem services, and providing sustainable cities and communities in balance. There is a close relationship between ecosystem services and improving human well-being (Villa *et al.* 2009). In this context, some methods are presented to describe the ecosystem services' values (Jordan *et al.* 2010). The method used in this study is among them and exhibits a novel approach.

Ecological assessment approaches, which are similar to the evaluation of natural ecosystems, are used while assessing the benefits of ecosystem services. Deep learning methods are used for species description, detection of plant diseases, and population modeling (Wäldchen and Mäder 2018). Deep learning, which is a subfield of machine learning, is also increasingly used as a research method for natural resource assessment, including ecosystem service assessment and biological diversity mapping (Willcock *et al.*

2018; Scowen *et al.* 2021; Manley and Egoh 2022). The reason for it to be commonly preferred in such broad disciplines is that it can be trained and improved, which is unlike deterministic approaches. This might lead to better understanding of the omnipresent uncertainty in nature.

CONCLUSIONS

1. It was found that the ‘Picture This’ application could even describe the differences between *Styphnolobium japonicum* (ID:8) and *Styphnolobium japonicum ‘Penrecrdula’* (ID:19). These species are originally from China and are not native species of the US. In addition, the application was able to differentiate Sargent’s Weeping Hemlock from Eastern Hemlock, despite the minor differences in the photographs of these native species. This implies that AI-based identification can be achieved whether the species is native or non-native.
2. Site surveys of this study were carried out in July and October of 2024. Due to the plants that were not present at their location, it was apparent that the tree route guide needs revision. However, the UConn Arboretum Committee updated the campus tree walking guide in February 2025. The new guide covers three routes (SI-II). The non-standing trees (called 16, 22, 37, and 38 IDs in Table 1) were now removed from new guide routes.
3. The species that the AI misidentified included both native and non-native, and both coniferous and broad-leaved species. This suggests that there was no correlation between species in terms of origin or leaf type. Thus, this misidentification may be due to the AI’s training dataset not containing sufficient examples. Furthermore, it is conceivable that some morphologically similar species may have made the identification process more difficult. As a way to overcome this limitation, it is recommended to train the AI with a more balanced dataset across a wider range, taking into account all environmental factors.
4. Future research can overcome the limitations described in the Results and Discussion section by scheduling pre-visits to the route of interest to train AI. Afterwards, the real visit(s) can be carried out for the study site examination. Additionally, future research may investigate how similar applications can be used in education, such as in landscape architecture, forestry, or horticulture. These suggested solutions are expected to inspire the researcher when employing this novel approach.

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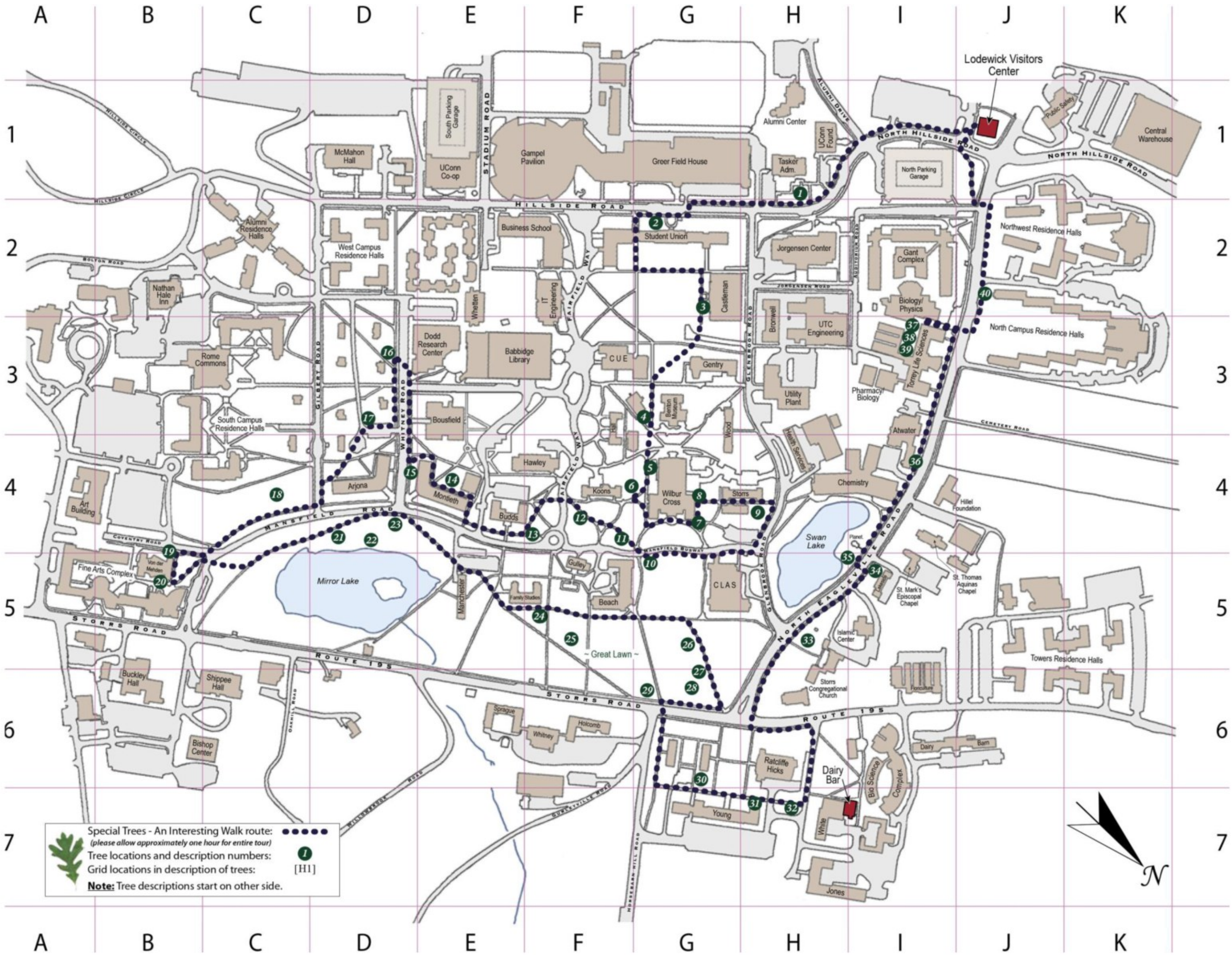
APPENDIX

SM-I



SM-II

American Beech (*Fagus grandifolia*) -- this native North American is typical of beeches with smooth gray bark, edible nuts, low branching, and a trunk that resembles an elephant's leg.

American Elm (*Ulmus americana* 'Valley Forge') -- the premier street tree in the USA until Dutch Elm Disease (DED) was accidently imported in 1928 on European logs; this is one of the most DED-resistant cultivars developed.

American Holly (*Ilex opaca*) -- a classic holly; it bears toothed and spiny, evergreen leaves and showy red fruits on the female plants; uncommon this far north.

American Linden (*Tilia americana*) -- fragrant flowers that are attractive to honeybees and moths; other common name is basswood referring to the tough inner bark.

American Sweetgum (*Liquidambar styraciflua*) -- desirable shade tree with distinctive star-shaped leaves and good fall color; fruits are spiky 1" diameter balls that look like miniature medieval maces.

Amur Cork Tree (*Phellodendron amurense*) -- bark is conspicuously ridged and furrowed and spongy or cork-like; an urban-adaptable tree.

Amur Maackia (*Maackia amurensis*) -- native to the Far East; a small tree with white spiky flowers in midsummer; it can fix atmospheric nitrogen.

Baldcypress (*Taxodium distichum*) -- a long-lived conifer that loses all of its leaves in the winter (hence, its name); commonly found in swamps of the SE U. S. where it often has "knees" protruding above the water that supply the roots with oxygen.

Black Tupelo (*Nyssa sylvatica*) -- medium to large shade tree native to Connecticut; leaves turn yellow, orange, red and purple in the fall; honeybees love the flowers; birds relish the blue-black fruits.

California Incense-cedar (*Calocedrus decurrens*) -- native to West Coast; distinctive flattened evergreen branches; bark on older trees is orange, grey, furrowed and fire resistant; wood is used for pencils and aromatic cedar chests.

Camperdown Elm (*Ulmus glabra* 'Camperdownii') -- oldest class tree on campus (1895); note the union where the tree was grafted, 4' up on the trunk.

Castor-aralia (*Kalopanax septemlobus*) -- from eastern Asia; tropical looking, palmate leaves; member of the ginseng family; flowers are held in umbels, rose-like thorns on the stout branches.

Chinese Quince (*Pseudocydonia sinensis*) -- a small tree in the rose family; soft pink spring flowers and an egg-shaped fruit used in Chinese medicine; leaves turn orange and red in the fall; bark is also multi-colored and exfoliating.

Cinnamon Flake Maple (*Acer* x 'Cinnamon Flake') -- a Prof. Sid Waxman (noted UConn plant breeder) hybrid between Paperbark and Nikko maples; bark is a rich brown "cinnamon stick" color peeling away in flakes.

Columnar Red Maple (*Acer rubrum* 'Columnare') -- species name refers to the early spring red flowers and fall foliage; upright growth form makes this a good choice for small areas.

Common Hackberry (*Celtis occidentalis*) -- native to NE US; distinguished by corky bark with warty protuberances; distinctly asymmetrical leaf base; fruits taste like dates and are relished by wildlife.

Common Smoketree (*Cotinus coggygria*) -- small tree/shrub presents a wispy "smoke- like" appearance from the plumy hairs on the flowers; purple-leaved cultivars are popular.

Crimean Linden (*Tilia* x *euchlora*) -- a hybrid that originated in Ukraine and Crimea; fruits are sterile, thus propagated by cuttings; distinctive flattened branches exhibiting compression wood.

Cucumbertree Magnolia (*Magnolia acuminata*) -- one of the largest and most cold hardy magnolias; native to the Appalachian Mts.; common name refers to unripe green fruits that resemble cucumbers; plants bear greenish/yellow flowers that hide amongst the foliage.

Dawn Redwood (*Metasequoia glyptostroboides*) -- another conifer losing its needles each fall; notable flared buttressed trunks look like braided bread; first described as a fossil in 1941 and thought extinct; subsequently, a small stand of living trees was found in China and introduced into the US.

European Hornbeam (*Carpinus betulus*) -- a popular and tough street tree; various cultivars selected from this standard form; easily pruned, coppiced or pollarded.

Fernleaf European Beech (*Fagus sylvatica* 'Asplenifolia') -- distinctive cut leaves suggestive of a fern frond; Beeches may live to 400 years.

Flowering Dogwood (*Cornus florida*) -- small native tree with showy white or pink flowers and brilliant fall color; this is one of the 52 trees planted around Mirror Lake in1953 by the UConn Horticulture Club on "Plant a Dogwood Day".

Giant Sequoia (*Sequoiadendron giganteum*) -- in the Sierra Nevada Mountains can grow to heights of more than 275' and live to be over 3,000 years old; they cannot reach that size in Connecticut where their growth is limited because the ground often freezes before it snows.

Ginkgo (*Ginkgo biloba*) -- an ancient tree with separate males and females; distinctive fan shaped deciduous leaves; a "living fossil" it is recorded in Chinese records from the 13th century; female Ginkgo trees have odiferous fruits.

Golden Larch (*Pseudolarix amabilis*) -- leaves emerge bright green and transition to golden copper in the autumn before they fall; native to China; distinctive cones resemble small artichokes.

Golden Rain Tree (*Koelreuteria paniculata*) -- small/medium-sized tree prized for summer yellow flowers and fruits that resemble paper lanterns.

Honeylocust (*Gleditsia triacanthos* var. *inermis*) -- this hardy tree can tolerate poor soils; tiny leaflets and open canopy will not shade out lawn; *triacanthos* refers to large thorns but most landscape trees are var. *inermis* or thornless.

Horsechestnut (*Aesculus hippocastanum*) -- known for showy flowers in May and spiny fruit in autumn; European native and not a true chestnut; poisonous.

Japanese Falsecypress (*Chamaecyparis pisifera*) -- typically grown as compact cultivars, this tree is the straight species; native to Japan; *pisifera* means 'pea bearing' in reference to the small, rounded cones.

Japanese Pagoda Tree (*Styphnolobium japonicum*) -- medium-sized Asian tree that thrives in urban locations; produces large, pendulous clusters of creamy white, pea-like flowers in August that turn to green pods resembling a dangling string of beads.

Japanese Snowbell (*Styrax japonicus*) -- vase-shaped when young but with age develops into a broadly rounded crown as you see here; has pendulous clusters of bell-shaped flowers and olive-shaped fruits.

Japanese Umbrella Pine (*Sciadopitys verticillata*) -- largest of several planted on campus; an evergreen native to Japan and is a "living fossil"; long, stout needles held in whorls at the end of the stems.

Japanese White Pine (*Pinus parviflora*) -- small evergreen tree that develops a flat-topped, spreading crown; slow growth makes this tree an excellent choice for residential landscapes and an ideal species for bonsai.

Katsuratree (*Cercidiphyllum japonicum*) -- fast growing trees native to Japan and China; can reach over 100' in the wild but smaller in cultivation; leaves turn yellow, orange, and red in the fall and smell like cotton candy.

Kentucky Coffeetree (*Gymnocladus dioicus*) -- 3' long and 2' wide doubly compound leaves are held on very stout twigs with the diameter of cigars; female trees produce seeds in leathery pods that settlers are believed to have used as a coffee substitute; seeds are poisonous if not roasted.

Kobus Magnolia (*Magnolia kobus*) -- species name from Japanese word meaning fist, referring to flower bud's shape; one of the earliest spring flowering magnolias.

Korean Stewartia (*Stewartia koreana*) -- small tree notable for its exfoliating colorful bark and large creamy white flowers.

Lacebark Elm (*Ulmus parvifolia*) -- medium-sized tree and the best elm for landscape use in Connecticut; handsome, flaking bark of mottled grays with tans and reds.

Mountain Silverbell (*Halesia monticola*) – medium-sized tree native to Appalachian Mts.; bell-shaped white spring flowers giving way to four winged 2-inch-long dry fruits in the fall.

Needle Fir (*Abies holophylla*) -- large conifer that is native to parts of western Asia; chunky, upright cones near the treetops disintegrate scattering seeds while still attached to the tree.

Norway Spruce (*Picea abies*) -- pyramidal evergreen that can reach 200'; native to the mountains of northern and central Europe; resistant to deer browsing and often used in windbreaks; secondary branches become pendulous as the tree matures.

Paper Birch (*Betula papyrifera*) -- name refers to thin white bark that peels like paper; can be short-lived; state tree of New Hampshire.

Pin Oak (*Quercus palustris*) -- fast growing and pollution tolerant tree; unusual branching habit: the lower branches angle downward, the middle branches are horizontal, and the upper branches ascend; often hold their dry leaves through the winter.

Pitch Pine (*Pinus rigida*) -- found on sandy, acidic soils in CT; fire resistant due to thick, plate-like bark and ability to resprout from the trunk; the primary tree of the NJ Pine Barrens.

Pond Cypress (*Taxodium distichum* var. *imbricarium*) -- deciduous conifer (cone bearing); can withstand extended periods of flooding; native to the swamps of the SE US where it develops knobby, conical "knees".

Purple-leaf Beech (*Fagus sylvatica* 'Atropunicea') -- known for its "jumbo" proportions and copper-colored foliage; massive trunk measures over 20' in circumference and looks like an elephant's leg.

Red Oak (*Quercus rubra*) -- fast growing (50'-75' tall and wide) and tolerant of salt and air pollution, thus good for urban areas; native to eastern US.

River Birch (*Betula nigra*) -- a popular fast-growing birch; attractive pink to reddish brown exfoliating bark; native to riverbanks in the eastern US; resistant to bronze birch borer.

Sargent's Weeping Hemlock (*Tsuga canadensis* 'Sargentii') -- a cultivar of the native Eastern Hemlock with a distinctly pendulous habit.

Sassafras (*Sassafras albidum*) -- CT native; can grow in a root sucker colony; distinctive "mitten-shaped" leaves can have two thumbs, single thumbs on either side or none at all.

Scotch Pine (*Pinus sylvestris*) -- most widely distributed pine in the world; Scotland's national tree; orange red bark; needles in groups of two; conical when young becoming more rounded as it matures.

Seven-son Flower (*Heptacodium miconioides*) -- multi-stemmed small tree; fragrant white flowers, with red sepals in August that attract pollinators; trunks covered in light tan exfoliating bark.

Shingle Oak (*Quercus imbricaria*) -- distinguished from most oaks by its leaves, which are shaped like laurel leaves and lack the typical oak lobes.

Silver Maple (*Acer saccharinum*) -- fast-growing native tree usually found along waterways; fast growth produces brittle wood and planting location should be carefully considered.

Slippery Elm (*Ulmus rubra*) – sometimes an ingredient in throat lozenges taken from its inner, slippery, bark; native; susceptible to Dutch Elm Disease.

Sugar Maple (*Acer saccharum* 'Commemoration') -- best known as the source for maple syrup and stunning fall foliage; this cultivar was developed for its fast growth and glossy, tatter-resistant, leaves.

Sycamore Maple (*Acer pseudoplatanus*) -- native to Central Europe/Asia; hardy tree that tolerates coastal and windy exposures.

Three-flowered Maple (*Acer triflorum*) -- small tree of multi-season interest; attractive peeling bark and fall foliage; native to NE China and Korea.

Tortuosa European Beech (*Fagus sylvatica* 'Tortuosa') -- note branch pattern to see the contorted habit of this cultivar.

Trident Maple (*Acer buergerianum*) -- native to Far East; withstands harsh conditions; glossy, duck foot-shaped leaves with showy fall foliage; exfoliating bark.

Tulip Tree (*Liriodendron tulipifera*) – tallest tree on campus at 113'; native to CT; name refers to either the tulip-shaped leaves or the yellow-green flowers.

Turkish Filbert (*Corylus colurna*) -- like birch, it bears male and female catkins; a great tree for urban environments where it makes a formal statement.

Varied Directions Larch (*Larix decidua* 'Varied Directions') -- striking horizontal and pendulous branches growing in random directions; one of the first introductions by UConn Prof. Sidney Waxman whose work focused on selecting dwarf conifers.

Weeping Japanese Pagodatree (*Styphnolobium japonicum* 'Pendula') -- cascading green stems create the illusion of a waterfall; this is a very large, mature example of this unique weeping form that is priceless.

White Ash (*Fraxinus americana*) -- a fast-growing deciduous tree native to New England adaptable to urban conditions; one of the first trees to show fall color; Emerald Ash Borer, an invasive beetle, has killed many of the CT ash, this one is treated to protect it from this pest.

White Oak (*Quercus alba*) -- State tree of CT; one of 2 Charter Oak descendants planted at UConn to commemorate the 1965 State Constitutional Convention; long-lived; acorns are an important source of food for wildlife; valuable hard wood.

Willow Oak (*Quercus phellos*) -- leaves are long and narrow, like the leaves of willows; native to the SE US floodplains; acorns are favored wildlife food.

Wisconsin Weeping Willow (*Salix* x *blanda*) -- one of many species of willows that are known as weeping willows; grows better in moist soils; particularly notable if given sufficient space.

Yellow Buckeye (*Aesculus flava*) – large US tree; 6-inch-long panicles of yellow flowers in May; brown nutlike fruits ("buckeyes") at the end of the summer.