An Evaluation and Field Testing of
A Self-instructional Guide to Plant identification

An Honors Thesis (ID 499)

by

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1. PROJECT INFORMATION

Tree identification has been a standard lesson for science teachers since the beginning of the century. Currently, almost all secondary science programs contain some type of plant identification unit within the introductory courses of the required sequence. Teachers have readily employed identification units to teach the anatomy and physiology of plants, the terminology associated with plants, and the ability to use a dichotomous key.

Most plant identification keys are the kind that deal exclusively with angiosperms or flowering plants. Keys for the gymnosperms or cone-bearing plants that have been written at a seventh to twelfth grade level have been almost non-existent due to the difficulties encountered when identifying these kind of trees. Most teachers feel that angiosperm naming is much simpler for the beginning science student.

Taking all of this into consideration, the authors of A Self-Instructional Guide To Plant Identification have attempted with this publication to write a gymnosperm key that could be used at the middle school/junior high level. In the guide, the authors state the following goals:

1. To enable the student to learn plant identification by using a dichotomous taxonomic key.
2. To enable students to begin to develop a knowledge of the technical language associated with plant systematics.

3. To provide teachers with materials which may be used as an individualized project for interested or gifted and talented students.

4. To develop an appreciation for plants by giving the student the opportunity to become acquainted with those found in their environment.

The following objectives are also presented by the authors:

By utilizing this material, the student should be able to:

1. Define terms associated with the taxonomic key.

2. Describe differences and/or similarities existing among the species or genera.

3. Identify different genera using the taxonomic key.

4. Identify different species using the taxonomic key.

5. By comparing different species keys, make comparisons between different geographic areas.

The guide is designed with two parts. The first part is to be the introduction. A short narrative is followed by an example of how to use a dichotomous key. Next is the actual key to be used in identifying order and genus. Economic descriptions and a glossary complete part A. Part B has several versions describing the different ranges or groupings.
of gymnosperms. The Deciduous Forest is the part B for the local area and so was accordingly used for this field testing. Part B begins with a description of the deciduous forest. It then has the key used for naming the species. Another economic section and glossary finish part B. The identification of order and genus in part A lead to the identification of species in part B.

My project was to design an evaluation form and field test the guide. This sequence of field testing is the initial analysis of the workability of the guide. My comments are based on the observations I made, opinions voiced by public school teachers, and on the evaluation form responses of students who tried to use the guide. I believe that the guide is excellent but will have to be streamlined if it is to be effectively used at middle school/junior high level.

The first part of my project was to design an evaluation form that eleven to sixteen year olds could comfortably use to express a degree of opinion. A copy of the form developed is on the next page. My experiences with this age group of students caused me to decide that the they would want to make their responses in the simplest manner possible. Circling of numbers seemed to be the answer to this problem. The authors indicated to me that they were more concerned with how students felt about the key rather than if they could accurately identify trees using it. Therefore, the evaluation form is more emotional or attitudenial than precise in it's focus. As I have seen on other types of evaluation forms, five choices on the opinion scale seem to give a briefly accurate indication of the
true response. Students can choose to agree, strongly agree, disagree, or strongly disagree with the statement made. The fifth option of no opinion gives the student a way to not express an opinion for whatever reason. The fourteen statements concisely note various aspects of the guide on which the authors wished to have feedback. Each statement and the reasons behind it are discussed later in this paper. To be extremely certain of getting accurate opinions, an "other comments" space was left at the bottom of the form so that students could further explain their opinion or elaborate on things that were not covered by the form. The fourteen statements on the form are stated from both positive and negative viewpoints. Nine of the statements are from a first person stance starting with "I can", "I have", "I felt", "I found", or "I learned". This way of stating the values helps the student personalize the statement and hopefully causes greater preciseness of responses. I believe that the form has served its purpose since measurable responses that vary with grade level have been received. No pretesting or outside examination was done for this form other than to have approval from the authors.

Three different schools were visited to perform the field tests. All three schools are located in Muncie, Indiana but have vast differences in the make-up of their respective student populations. Since each school has certain associated student characteristics, the results of the runs should be more valid since there is some variety of socio-economic classes and instructional strategies involved. Yet, the students have fairly similar backgrounds and beliefs due to the common experiences of living in the
same community. Therefore, the results should hold true for most students but mainly differing with respect to grade level.

Runs one through three were tested at Wilson Middle School. Wilson is located in the inner industrial area of Muncie. The school contains grades six through eight. Most of the students come from blue-collar backgrounds. Their families are generally in the low to middle class economic situation. There is great racial diversity. Students are separated by elementary school grades into A, B, or C groups in each grade level. Runs one and two were done with two seventh grade A classes. Run three was done with an eighth grade A class. Almost all of the Wilson students had no experience using a dichotomous key.

Runs four and five were done at Burris Laboratory School. Burris is located on the Ball State University campus and is frequently visited as a classroom for the college’s teaching majors. Burris is K-12 and tries to emulate the average student population ratios of Indiana’s public schools. Classes are a mixture of student backgrounds and abilities. Both runs at Burris were accomplished with two classes of eighth graders who had some previous experience with plant identification.

Runs six through eight took place at Northside High School which holds grades nine to twelve. Northside is located near the university. It is a predominantly white population of middle to upper class students. The classes are not separated according to abilities. Runs six and seven were performed by beginning ninth grade biology classes. Run eight was done by an honors-accelerated class of ninth grade biology students. About half of
the ninth graders had previously relied on a key to identify trees.

Although the runs were not evenly distributed across the schools and groups, I think that the results are still accurate enough to be useful in analyzing the guide.

As much as is humanly possible, I tried to present the evaluation in the same way and with a neutral attitude at each run. Of course, there were many variables in the run conditions including weather and time of day that I had no control over. But there were no variables that I feel would greatly effect the results. However, it must be noted that these field tests were accomplished late in the school year when students tend to be tired and unresponsive. I am unsure how the timing of the tests might have altered the results.

The same basic pattern was followed for each run:

1. Introduction- I would first introduce myself and explain why I was doing this test. I was always careful to explain that I had not written the guide and would not be offended by their honest opinions of the key. I would then briefly describe the order of our activities.

2. Instructions- First, I would have the students look at the example of how to use a key in part A. Next, I told them to find the order and genus using part A and then the species using part B once we had went outside. I told them that this was to be self-instructional and so I could give them only minimal help. I elaborated on the intent of the authors
concerning the terminology. The students then had a few minutes to look through the guide and ask questions.

3. Identification - I took the students out to a nearby tree to give them the chance to see if they could identify it using the key. Some kids worked in groups while some worked individually - the choice was left up to them. After working through part A, the students would get part B from me and work through it. The students were given around twenty minutes for this exercise. I continually circulated through the class to help them stay on task.

4. Evaluation - Students were told that this was the most important part of the whole process. After returning to the classroom, I gave them the aforementioned evaluation form and gave them all the time they needed to fill it out. I asked that they please include any suggestions, likes or dislikes, etc. that they had concerning the guide. I said that this was their chance to act as a curriculum director and decide how material like this could be presented in the classroom.

5. Closure - Finally, I thanked the students for their time and cooperation. This method of running the field tests seemed to work very well and I had no problem with interesting and involving the students.
In this section, the type and number of responses made will be stated and analyzed. The information gained will be looked at in three different manners. First, each of the fourteen statements will have their purpose explained and their results stated and discussed. Next, the "other comments" made by each run will be presented. Finally, the responses from each grade level will be grouped together and commented on.

The percentage responses do not total one hundred due to rounding.

RESULTS AND ANALYSIS OF EACH STATEMENT

1. The instructions were easy to follow.

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<th>disagree</th>
<th>no opinion</th>
<th>agree</th>
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</table>

The students were instructed during their evaluation time that this question only referred to the instructions contained in the guide. The general response seemed to be that the instructions could be understood...
but students were lost as to what to do next. Over twice as many students thought the instructions were difficult as compared to those students who thought they were easy. As expected, seventh graders found the instructions the most difficult. Unexpectedly, more ninth graders than eighth graders responded that the instructions were difficult but this can be attributed to more ninth graders choosing an answer rather than stating no opinion. One-fourth of the students felt the instructions were easy. Three-fourths of the respondents had no opinion or thought that the instructions were not easy to follow. The more experience the student had working with keys usually correlated as to how easy they saw the instructions as being.

2. The key was easy to read.

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<th>PERCENTAGE RESPONSE</th>
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<td></td>
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</tbody>
</table>

The intent of this question was to clarify whether the instructions could not be followed due to their readability or due to the style of
writing. In the total opinion, the number of students replying that the key was not easy to read was double of those who replied that it was easy to read. With eighty-five percent of grade seven responding that they could not read the key, it is obvious that they are incapable of effectively using the guide as it currently exists. Even forty percent of the ninth graders had difficulty reading the key. My interpretation of the data is that the readability level of the key must be significantly lowered if the guide is to become usable for the average middle school student.

3. I learned new terms from the key.

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<tr>
<td>disagree</td>
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<tr>
<td>no opinion</td>
</tr>
<tr>
<td>agree</td>
</tr>
<tr>
<td>strongly agree</td>
</tr>
</tbody>
</table>

| grade 7 | 31 | 8 | 35 | 21 | 6 |
| grade 8 | 8  | 19| 35 | 31 | 7 |
| grade 9 | 25 | 23| 25 | 23 | 6 |

| total opinion | 21 | 17 | 32 | 25 | 6 |

The authors intended for the guide to teach difficult terminology. Seventy-four percent of grade seven apparently did not recognize the new terminology prevalent throughout the guide. Grade eight seemed to recognize the terms as did grade nine. Yet, grade nine seemed to fully comprehend the intent of the statement. They said that they saw the new terms but did not grasp how they were to learn the meanings. The method
of bracketing the new terms after the definition should probably be mentioned in the instructions. In the totals, only thirty-one percent of all of the students felt that the goal of teaching terminology had been reached.

4. The words used were difficult to understand.

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<thead>
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<th>disagree</th>
<th>no opinion</th>
<th>agree</th>
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<td>14</td>
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<td>14</td>
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<td>36</td>
</tr>
</tbody>
</table>

This statement was presented to help clarify the first three statements. Grade seven overwhelmingly replied that the words were difficult. The successive grades found decreasingly that the words were difficult indicating that the maturing of reading level has a strong impact on how the guide was viewed. Still, the totals showed that fifty-nine percent of the students in all three grades found the words difficult. Again, this underscores the prevailing thought that the readability of the key must be substantially lowered if it is to be used in junior high/middle school classes.
5. I can identify trees by using this key.

<table>
<thead>
<tr>
<th>PERCENTAGE RESPONSE</th>
<th>strongly disagree</th>
<th>disagree</th>
<th>no opinion</th>
<th>agree</th>
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<tbody>
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<tr>
<td>total opinion</td>
<td>30</td>
<td>21</td>
<td>21</td>
<td>24</td>
<td>4</td>
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</tbody>
</table>

This statement was included as a precursor to statements seven and eight. The function of a key is to assist students in correctly naming unknown specimens. Only ten percent of the seventh graders felt that they could use this particular guide for identification. The response of the ninth graders gives the most accurate view of the key. Thirty-five percent of the freshmen said they could identify trees while fifty-two percent said they could not. Many of the eighth graders expressed that they could understand and probably use the format of the key but they were extremely uncomfortable with the word length and usage. As the key is presently, twenty-eight percent of all of the students felt they could successfully identify unknown trees. This is an encouraging amount of students with a positive attitude towards the guide. Yet, over half of the respondents could not use the key for naming. This could be the result of two things. First, the instructions and example of how to use the key were not well liked by the students nor by teachers. A major overhaul of this portion could
greatly change the response ratios to statement five. Secondly, the results of questions two and four strongly suggest that the language is too difficult for this grade level. Modifications to the guide with respect to these two items would significantly increase the amount of students who could use the guide for identification.

6. The key's descriptions of characteristics were clear.  

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<tr>
<th>PERCENTAGE RESPONSE</th>
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<tr>
<td>strongly disagree</td>
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<td>grade 8</td>
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<td>grade 9</td>
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<tr>
<td>total opinion</td>
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</tbody>
</table>

The wordiness of the guide confused most of the students especially in regard to the descriptions. Several commented that the inclusion of some small simple pictures would facilitate their understanding of the structures. An example of a disastrous description is the "leaves grow one to the left the next to the right" term. Also, many of the numbers involved in the leaf description, such as 2" in length, were mistaken as the next step to where the student should go. Just twenty percent of the students comprehended the descriptions. This fact is a major pitfall for the key. A guide is only as good as the descriptions allow it to be. With
sixty-one of the students unable to work with the descriptions, it is obvious that changes must be made in this area.

7. I can correctly name the genus with the key.

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<thead>
<tr>
<th>PERCENTAGE RESPONSE</th>
<th>strongly disagree</th>
<th>disagree</th>
<th>no opinion</th>
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<td>20</td>
<td>18</td>
<td>20</td>
<td>33</td>
<td>8</td>
</tr>
</tbody>
</table>

| total opinion       | 30                | 24       | 21         | 20    | 6              |

8. I can correctly name the species with the key.

<table>
<thead>
<tr>
<th>PERCENTAGE RESPONSE</th>
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<th>disagree</th>
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<td>25</td>
<td>31</td>
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</tbody>
</table>

| total opinion       | 25                | 29       | 22         | 24    | 0              |

Statements seven and eight are further clarifications of number five. I did not ask about the students' ability to find the order since this was relatively easy and the majority of them accomplished that part with no
help. In my introduction of the project to the test groups, I did try to make clear that the part A would name the genus while part B would name the species. Twenty-five to twenty-six percent of the students could correctly find the genus and species. Twenty-one to twenty-two percent had no opinion. For both statements, exactly fifty-four percent said they could not find the genus nor the species. This high number is directly related to previous responses where descriptions, instructions, and readability were faulted.

9. I found the glossary useful.

<table>
<thead>
<tr>
<th>PERCENTAGE RESPONSE</th>
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<th>disagree</th>
<th>no opinion</th>
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</table>

Most of the students had no concept that a glossary was available. Of those who expressed an opinion, twenty-four percent found it somewhat useful while thirty-three percent felt it was not useful. The students were too lazy to invest much effort into finding out information that was not contained upon the page on which they were presently looking. This age level does not particularly like extra work.
10. I found the economic section informative.

PERCENTAGE RESPONSE

<table>
<thead>
<tr>
<th></th>
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<th>disagree</th>
<th>no opinion</th>
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As with the glossary, the majority of the students, over fifty percent, never even saw the economic section. While they thought it informative, the group saw the economic section as extra material that just added bulk to the booklet thereby making it not useful or relevant to them. Just seven percent saw any value to the economic section.

11. I have identified trees before.

PERCENTAGE RESPONSE

<table>
<thead>
<tr>
<th></th>
<th>strongly disagree</th>
<th>disagree</th>
<th>no opinion</th>
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</table>
Statement eleven was issued to help characterize the testing population. Half of the students had taxonomic experience while half did not. I think this is a fair ratio for getting accurate responses that would hold true in most classrooms. The results of this statement merely add validity to the evaluation.

12. I have used a key before.

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Again, statement twelve was made to help describe the test takers. Surprisingly, fifty-eight percent had previous key experience. Such experience would hopefully have given the students more insight into the mechanics of the guide. With statement eleven, I conclude that the responses indicate the majority of the students were acquainted with keys and tree identification. Therefore, the test population has expressed a relatively informed opinion on the guide. The minority of inexperienced students gives a good cross sectional perspective to the results. The test groups seem to be a reasonable imitation of ordinary class situations.
13. I felt comfortable using this key.

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<th></th>
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<td>grade 9</td>
<td>20</td>
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<td>total opinion</td>
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Statement thirteen is the most important one for determining the workability of the guide. I stressed during the runs that the student's attitude towards the key was more important than their ability to successfully complete the field test. Fifty-five percent of the students were uncomfortable with the key. Sixteen percent were comfortable with the workings of the guide but only in a limited manner. Just four percent felt extremely comfortable with the key. The junior high/middle school grade level cannot relax and use this guide.

14. If other keys were available, I would choose this key to use.

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<th>Percentage Response</th>
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<tr>
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<td>grade 9</td>
<td>29</td>
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<tr>
<td>total opinion</td>
<td>39</td>
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</table>
Statement fourteen is the second most important indicator of the attitude of the students. As indicated by the results to statements eleven and twelve, over half of the test population was experienced with keys. Comparing this key to others they had seen, a mere seven percent would choose this guide over the others. Teachers were of the same opinion. Although they would like to have a gymnosperm key, they felt this guide was at to difficult a level for junior high/middle school but could probably
be used - as is - with high school juniors and seniors.

ANALYSIS OF "OTHER COMMENTS"

In this section, I will list the responses of the students in the "other comments" section. I will group and discuss them by grade level but will separate them by run number. In the interest of conserving paper, the comments of individuals will be separated by a slash - ///. The comments are reported exactly as they appeared on the evaluations. Therefore, punctuation is often lacking.

SEVENTH GRADE

RUN #1

Needs easier to understand words, pictures - needs a real cover - but other than that good key/people need to read whole booklet/Key should have pictures and easy to understand words. Key is too complex and is hard to use. It speaks down to the user. I would use my own knowledge of trees
before using this key. I would try again./needs pictures- needs easier to understand words-needs to be in hard back cover-needs a lot of work/ It needs to be improved./It was hard./Junior high kids can't understand the key./It should be burned./This key is too difficult for middle school kids and it really is at a high school level.

RUN #2
Needs pictures- too hard to understand-didn't really have time to understand-needs to be in hardbound/needed to be easier to understand-needs pictures/I think this was kind of hard, but if you would explain yourselves more - it would help science. I couldn't really understand. Maybe I'm too young./NO/ Put it on a hard back book and make the directions a tad bit easier and don't use them technical words-p.s. it stinks-p.s.s. it would make good cockroach bait/key needs to be clearer to understand and either paper back or hardbound./Information needs to be clearer and easier to find. Needs to be bound in hard or paper back.-needs pictures/I think you should simplify the key. I don't mind reading all that information but I have to admit I wasn't very enthusiastic./ I can't understand it at all./If there were pictures, it would be easy./ have pictures/It should have pictures and words we could associate with. It should be burned./You need better instructions and easier words with pronounciations. Some kids might not read that good. Needs hardback, otherwise it was okay./Too hard to understand. Better for high school.
DISCUSSION OF SEVENTH GRADE COMMENTS

The seventh graders make several comments concerning the binding of the key. The day of their runs was very windy and so the students had great difficulty in dealing with the stapled pages. Repeatedly, the comments involve the phrase "too hard to understand". I think that this further substantiates the results of the statements. The general attitude of seventh graders towards the key is that it is too hard for them to use. They are scared by the wordlength and design of the key before they even use it.

EIGHTH GRADE

RUN #3
Pictures would be useful. Try understandable words./There should have been pictures./Characteristics should be made clear. Maybe have illustrated./Direct the vocabulary to a younger audience./hard to understand-boring/Needs pictures./ Needs pictures and not so big of words that us eighth graders can't understand./Needs pictures. Words need to be easier to understand. Needs to be hardbound./Need to make it easier to understand./too long-not basic-need pictures/Too long to read -not basic-boring/It was very boring and hard to understand./Need pictures./ hard to understand/no opinion/ This booklet is very stupid and I wouldn't use it unless I had to.
RUN #4
For #4, my answer was based on the use of the glossary. I found it very informative and helpful. I strongly suggest that this key be used in the middle school age group to help students better understand this subject. I thought that it was a hard key to use. It was confusing. This was hard to understand. I think the descriptions and vocabulary used in certain descriptions was too complex. Pictures would also be a nice and helpful addition. Pictures would help to identify certain trees easier. Need to add pictures. No comment/could use pictures. It was too long, complicated. It was okay to use, but I think that an easier way could be used especially for seventh graders. I thought this key was difficult to understand. I think we need more instructions at the beginning. I think you should add pictures. Needs pictures. None. I think it is a neat idea but it was hard for me to understand. I got mixed up with all the facts in there. It was easy!!! It was easy to follow.

RUN #5
Some of the descriptions need a little improvement. Too difficult to understand. Fun! Boring! I think it was difficult to understand. No opinion. Not a good activity - at least for a hot day with stupid bugs flying around. I believe there should have been instructions easier to understand. Didn't like it at all - too hard. This key was ok. However, use words easier to understand. I realize that learning the words is a part of this key. -still. Make the instructions easier to follow. It was hard and
uninteresting to me at least. This is confusing. I got one tree with a description wrong even though it fit perfectly. I found this key fairly easy to use. I think the glossary was helpful, but still the sentences were a little hard to understand. too hard. It is really boring (sorry) but to be honest it was.

DISCUSSION OF EIGHTH GRADE COMMENTS

The eighth graders seemed to be more positively in favor of the key. They were also very specific in mentioning what parts of the key bothered them most. Again, word difficulty and sentence length really turned the students off. The eighth graders found it more difficult to understand the intent of the words - such as in the descriptions. Many of the details of the characteristics did not translate well. This suggests a need for pictures or diagrams to clarify the terms. Most of these students had less difficulty in using the guide than in the seventh grade runs.

NINTH GRADE

RUN #6

I thought it was hard if you had never used a key before. I have never worked with anything like this before. I don't feel like I am in a position to make a comment since I didn't know what was going on. Written very well. Should be used in ninth grade level definitely. I felt that a seventh grader would be able to read this if a ninth grader couldn't. It was very hard to follow and stay with. It is long and hard to understand. I did not learn
anything by using this but I was more confused. It should have pictures and easier terms to understand. Not enough pictures—too much reading—too boring—It loses interest of reader and needs more pictures. We never found out what the name of the tree was.

RUN #7
The key was understandable in since that you couldn't be distracted by anything else such as the amount in a bundle. With this key, it tells you exactly what the tree looks like and it would be helpful in the future to have pictures. I really need to sit down and read the key. Well, I don’t like trees too much, so I’m not thrilled about finding their names. It’s not like I want to get to know them better or anything—so I’d really enjoy falling asleep indoors from now on./The key needed some pictures so it could be better understood.

RUN #8
I think I was accustomed to identifying trees other than pines, so that I found it confusing to tell certain characteristics from others. The key’s descriptions were not totally clear. The tree used had difficult characteristics to recognize—had some of one and some of the other. There are no cut and dry answers. When should the key be used? (What season) A few simple diagrams for the easier ideas might help. Descriptions are not especially clear. There was just too many long, wordy sentences./You need pictures and an easier way to follow the trees.
You had too many of the same terms in the same ones to choose from. It really needs to be simplified a little more. I thought the descriptions were hard to follow. I think pictures or shorter descriptions would allow me to read and key faster. It would be easier. It was hard because I was not as familiar with fir trees as I am with oak, maple, walnut, etc. I found it very confusing, but I haven't had much experience with identifying trees. The descriptions seemed repetitive and unhelpful. The descriptions should be more concise. The numbers and terms were too numerous and bunched together. Maybe it was hard to read. A little hard to follow. Maybe pictures would help. The key was too verbose in descriptions. The key was not very clear but it worked. Pictures would prove useful in identifying the more uncommon characteristics. It doesn't give instructions very well and it is too wordy. Strongly needed diagrams and pictures. I think that this isn't organized to awfully well. I think the descriptions could be much better and more thorough. Pictures could help a little bit and the booklet could be more clear as to what is going on. I don't like it.

**ANALYSIS BY GRADE LEVEL**

In this section, I will present the raw data and discuss the peculiarities associated with the responses from each grade level:
The seventh graders tested seemed to have little background in working with keys. They felt the instructions were unclear and the example of how to use the key was beyond their comprehension. These students were unable to accurately describe the workability of the key since they could not begin to use the guide. They were at a standstill before they even got started. The students were intimidated by the length of the sentences and words. One girl said the key was “not user friendly”. Although the majority of the pupils could read the key, very few could grasp the intent or meaning.
EIGHTH GRADE

RESPONSE NUMBER

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</table>

*=total number of responses for this grade level

%= percentage equivalent of response totals for this grade level

The eighth graders were more willing to try the guide. They were not as intimidated as the seventh graders were concerning the word and sentence difficulty. However, these students experienced problems with the same two things. If they had no experience with a key, the guide gave them absolutely no help as to what was to be done. If they had key experience, they were troubled by the word meanings and uses. The majority said that the guide was usable but confusing. Several had questions about the descriptions or characteristics given. The students were able to identify trees but only with much discussion on the authors' intent.
The ninth graders tested seemed capable of using the key but were very uncomfortable with its design, sentence structure, and word length. One of these runs was completely incapable of identifying the selected tree by using the key due to confusing descriptions within the guide. The packaging of the guide was an extreme turn off to most of the students. It
appears to them to be very serious and academic. Again, those who had very little experience with keys found no guidance within this key to assist them in using it. Those students who had keying knowledge required no assistance from the key in how to use it so they tended to ignore the introductory sections which contained pertinent information on how to use this specific key.

III. SUGGESTIONS

After doing this testing, I have formulated many ideals on how to improve the guide. My suggestions are based on personal observations, comments from teachers who examined the guide, and the results of the student surveys. Most of my opinions have already been expressed in conjunction with the results for clarity. The following four suggestions are just brief statements highlighting the major problems that need to be corrected:

1. FORMAT—The guide has an appearance that overwhelms students. The lettering and spacing are too close together for comfortable reading. The bracketing of terms behind their meanings is not clearly explained to the students. They tend to just ignore the bracketed words rather than associate them with the previous definition. Of course the guide is
4. **READABILITY** - Most of the students could read the guide. The seventh graders had the most trouble with comprehension. Possibly lowering the readability by a little would broaden the potential group of users especially in the lower grades.

5. **OTHER** - I agree with most of the other suggestions made by the students in the "other comments" section.

**VI. CONCLUSION**

I have enjoyed working on this project and have gained much insight from it. I hope the information contained in this report can be beneficial in the redesigning of the guide for use at middle school/junior high level. I believe that the guide could be a very valuable instructional tool for teachers if the few suggested improvements are made. Copies of the guide and key are attached in Appendix A and B. Appendix C is one of the actual survey forms.
Appendix A
A SELF-INSTRUCTIONAL GUIDE TO PLANT IDENTIFICATION

If one flew over the North American continent it would reveal that it is covered with three great types of vegetation, that is, forest, scrub and grassland. Upon closer examination it would be evident that these areas are themselves composed of strikingly different communities, such as the evergreen and deciduous forests which are found in climates that are very different. Each group is the highest type of vegetation possible under its particular climate, and this relation makes the term climax especially significant, as this term is derived from the same root as climate.

Each climax owes its characteristic appearance to the species or dominants that control it. These dominants exhibit the same vegetation or life form and thus serve to give the climax the imprint of its climate.

The first criterion of a climax is that all the climax dominants must belong to the same major life form, since this indicates a similar response to climate and hence, a long association with each other. Secondly that one or more of the dominate species must range well throughout the area or occur in the different associations to some degree. Thirdly, a large number and usually the majority of the dominant genera extend throughout the formation though represented by different species.

One of the most frustrating experiences for the novice plant taxonomist is their first encounter with the mass of new terminology. Most keys are designed for the individual, who has had previous experience with the use of descriptive terms. The more recent student of taxonomy, however, must spend much of his/her time in "looking-up" the definitions to all of these "new terms" and the process of identification becomes a tiresome and endless process.

The authors of these keys have made an effort to make learning terminology secondary to the identification process. The Keys are structured so that the terminology, written in boldfaced letters, follows the definition. By doing this it is possible for the student to identify a plant without knowing the technical terms. In the process of using the keys, however, the investigator will - through repeated use of them - begin to learn descriptive terms associated with the classification process.

The first key, encountered in this unit, will identify plants to the different orders. From there, keys will take the investigator to the genus. Keys to the genus are essential to the investigator no matter in which part of the North American continent they may happen to be residing. Still other, keys which will identify to the species, are available for the various geographic areas of North America. The geographic keys to species are: Tundra-Boreal Forest, Lake Forest, Deciduous Forest, Atlantic Coastal Forest, Southern Forest, Tropical, Rocky Mountain Forest, Pacific Coastal Forest, Desert/Sagebrush Forest and Southwestern Forests.

When used by classroom teachers it should be remembered that it is the intent of the authors that memorization of terminology should not be required of students rather that the students be allowed to learn these terms from repeated use of the key.
GOALS:
1. To enable the student to learn plant identification by using a dicotyledonous taxonomic key.
2. To enable students to begin to develop a knowledge of the technical language associated with plant systematics.
3. To provide teachers with materials which may be used as an individualized project for interested or gifted and talented students.
4. To develop an appreciation for plants by giving the student the opportunity to become acquainted with those found in their environment.

OBJECTIVES: By utilizing this material, the student should be able to:
1. Define terms associated with the taxonomic key.
2. Describe differences and/or similarities existing among the species or genera.
3. Identify different genera, using the taxonomic key.
4. Identify different species, using the taxonomic key.
5. By comparing different species keys, make comparisons between different geographic areas.

For the individual, who has had no experience with a dicotyledonous key, the following explanation will help get you started.

Compare the characteristics of your unknown plant to the descriptions provided in the two choices given in number 1. Take the choice which best fits your unknown plant and move to the number to which it refers at the end of the statement or description. Keep making the choices until the name of a plant appears at the end of the description. This is your unknown plant.

Try the following to make sure you understand the use of the dicotyledonous key:

I AM TAKING NOTES WITH AN:

1. instrument which uses fluid...2
2. instrument which uses lead...3

1. has a ball in the tip...Ball Point Pen
2. has a fiber tip...Felt Tip Pen

3. never needs sharpening...Mechanical Pencil
3. requires occasional sharpening...Wooden Pencil

KEY TO THE GYMNOSPERMS (GYMNOSPERMAE)

The gymnosperms are the most primitive of the seed-producing plants, where their ovules (seeds) are exposed on scale-like structures (sporophylls) and they are not enclosed in an ovary (fruit). Thus the name for naked seeds (gymnosperms). All of the members of this group are considered to be woody plants.
Some of the orders are extinct and are represented only by fossils. In the treatment of the gymnosperm plants, only the living members will be included. However, some of the plants which may have been introduced into certain areas as ornamentals or those found in botanical gardens, etc., may also be included. It is possible that one may come upon plants not included in the keys, especially those which have been introduced. If this should occur, the authors would welcome specimens and notes of its location so that it may be included in revisions.

Now take your key and go out and discover some gymnosperms, but keep in mind that all "evergreens" are not "pine" trees nor are all gymnosperms evergreens.

**KEY TO THE DIFFERENT ORDERS**

1. Leaves are palm-like; Plants are usually trees and/or shrubs of the tropical and/or subtropical zones. . . . . . CYCADALES

2. Leaves grow one to the left then the next to the right for the length of the stem (alternate); Leaves are broad and fan shaped and fall from the tree in autumn (deciduous). . . . . GINKGOALES

2. Leaves are long and narrow (needle-like) or are wide at the middle and taper to a point (lance-shaped); Seeds are usually borne in cones, cone-like or berry-like structures. . . . . . . . . . . . . . . . CONIFERALES

Now that you have identified the order, find the order in the following key and identify the genus.

**KEY TO THE GENERA**

**CYCADALES - The Cycad Order**

1. Leaves have leaflets which appear opposite each other (pinnate) on a twig-like stem (rachis) and form a clump or crown at the top of the stem like that of the palm trees. . . . . . . CYCAS - Cycads

2. Leaves are few in number and develop one after another (alternate), the small leaflets (pinnae) are narrow, jointed (articulate) at the base and have smooth edges (margins). . . . . . . . . ZAMIA - Zamia

**GINKGOALES - The Ginkgo Order**

The order, family and genus of this group is composed on only one plant which is frequently planted as an ornamental. . . . . . . . GINKGO - Ginkgo or Maidenhair tree.

**CONIFERALES - The Conifer Order**

1. Seeds are cherry-like or tomato-like. . . . . . . . . . . . . . 2

2. Leaves are 1 1/2 to 4 inches long. . . . . . . . . . . . . . . . Podocarpus - Podocarpus

2. Leaves are not as described above. . . . . . . . . . . . . . . 3
3. Leaves are 1 to 3 inches long with 2 white lines on the underneath side; Branchlets are usually opposite. ... CYPRESSUS - Yew

3. Leaves are not as described above. ... 4

4. The pulpy covering (aril) enclosing the seed, is open at the tip (apex), the flesh is scarlet in color; Leaves are 1/2 to 2 inches long. ... TAXUS - Yew

4. The pulpy covering (aril) completely encloses the seed, the flesh is green or purple in color; Leaves are 1 to 3 inches long. ... TORREYA - Torrey

5. Leaves grow one to the left the next to the right on the stem (alternate) and are 1/4 of an inch wide at their base; Cones have one seed per scale. ... ARAUCARIA - Araucaria

5. Leaves grow one to the left the next to the right on the stem (alternate) or with two leaves growing at the same point on the stem (opposite) or in a ring encircling the twig (whorled); Leaves are long and narrow (needle-shaped) or gradually tapering from the base to a slender point (awl-shaped) or scale-like. ... 6

6. Leaves grow on the twig with two leaves growing from the same point (opposite), in a ring encircling the twig (whorled); Leaves are scale-like. ... 7

6. Leaves with one leaf growing to the left the next to the right on a stem (alternate) or in clusters (fascicles); Leaves are long and narrow (linear) or needle-like. ... 12

7. Leaves grow in whorls of three; Leaves are scale-like, narrow and sharp-pointed, gradually tapering from the base to a slender point (awl-shaped). ... 8

7. Leaves are not as described above; Cone is woody and splits at maturity. ... 9

8. Leaves are all scale-like 1/8 - 1/2 inch long; sharp-pointed, pressed tightly (appressed) against and densely covering the stems; Cone is woody, round, and splitting at maturity. ... SEQUOIADENDRON - (Giant Sequoia)

8. Leaves are scale-like, narrow and sharp-pointed, tapering to a slender point (awl-shaped); Cone is berry-like and does not split open at maturity. ... JUNIPERUS - Junipers

9. Branchlets are cylindrical or four-sided; Leaves are scale-like, small, flattened and pressed against each other (appressed) and minutely toothed (denticulate); Cone scales are stalked. ... CYPRESSUS - Cypress

9. Branchlets and leaves are not as described above. ... 10

10. Leaves usually have glands on their lower side; Leaves are scale-like, with two leaves arising from the same point on the stem (opposite) and pressed close together (appressed); Leaves, when young, are needle-shaped; Branches are flattened and fern-like; Cone scales are flattened and eight to twelve in number. ... THUJA - Arbor-Vitaes

10. Leaves are not as described above. ... 11
11. Branches are angled upward (erect) or spreading; Branchlets are flattened and fern-like; Leaves arise in pairs from the same point on the stem (opposite); Leaves are scale-like with bases running down the stem (decurrent); Cone-scales are flattened and four to six in number. .... LIBOCEDRUS - Incense-cedar

11. Branchlets are flattened; leaves arise in pairs from the same point on the stem (opposite); Leaves, when young, are needle-shaped; Cone-scales are stalked. .... CHAMAECYPARIS - False-cypress

12. Leaves are long and narrow (linear) when present scattered, 2 1/2 inches in length. .... 13

12. Leaves are in clusters (fascicles) or solitary. .... 14

13. Leaves fall off (deciduous) in the fall. .... Taxodium - Bald-Cypress

13. Leaves stay on the plant for a long time (persistent); Leaves are of two kinds, the long and narrow (linear) leaves are in two rows (ranks) on the branchlets. .... SEQUOIA - Sequoia

14. Leaves are clustered (fascicled). .... 15

14. Leaves are single or by themselves on the stem (solitary) .... 16

15. Leaves are in clusters (fascicles) of 2 to 5; The membranous-like casing at the base of the leaves (basal sheath) fall off (deciduous) or remain (persistent). .... PINUS - Pines

15. Leaves are in clusters (fascicles) of many (20-40); The membranous-like casing at the base of the leaves (basal sheath) is absent. .... 16

16. Leaves remain on the plant (persistent). .... 17

16. Leaves fall from the plant in the fall (deciduous). .... 17

17. Male (staminate) cones are clustered and hanging down (pendulous); Cone-scales are falling (deciduous) away from the main axis. .... PSEUDOLARIX - (Golden-Larch)

17. Male (staminate) cones are by themselves (solitary); at the tips of the branchlets, not as above; Cone-scales are staying attached (persistent). .... LARIX - (Larch/Tamarack)

18. The place where the old leaves were attached (leaf-scars) are circular in outline and smooth; Cones are erect and the scales fall off (deciduous). .... ABIES - Fir

18. Leaf-scars and cones are not as described above. .... 19

19. Branchlets are smooth, places where leaves were attached (leaf scars) are slightly raised, elliptical in outline; a conspicuous much reduced leaf-like structure (bract) extends from under each cone scale. .... PSEUDOTSUBA - Douglas-Fir

19. Branchlets and cones are not as described above. .... 20

20. Leaves do not have a stalk (petiole), square or 4-sided (rhomboid) in shape. .... PICEA - Spruce

20. Leaves have a short stalk (petiole) and are flattened. .... TSUGA - Hemlock.
**ORDER** | **FAMILY** | **GENUS** | **COMMON NAME**
---|---|---|---
CYCADALES | CYCADACEAE | CYCAS | CYCAS
CYCADALES | CYCADACEAE | ZAMIA | CYCAS/ZAMIA
GINKGOALES | GINKGOACEAE | GINKGO | GINKGO/MAIDENHAIR TREE
CONIFERALES | PODOCARPACEAE | PODOCARPUS | PODOCARPUS
CONIFERALES | CEPHALOTAXACEAE | CEPHALOTAXUS | PLUS-YEW
CONIFERALES | TAXACEAE | TAXUS | YEW
CONIFERALES | TAXACEAE | TORREYA | TORREYA
CONIFERALES | ARAUCARIACEAE | ARAUCARIA | ARAUCARIA
CONIFERALES | TAXODIACEAE | SEQUOIA | SEQUOIA
CONIFERALES | TAXODIACEAE | SEQUOIADENDRON | GIANT SEQUOIA/REDWOOD
CONIFERALES | TAXODIACEAE | TAXODIUM | BALD-CYPRESS
CONIFERALES | CUPRESSACEAE | CHAMAECYPARIS | FALSE-CYPRESS
CONIFERALES | CUPRESSACEAE | CYPRESSUS | CYPRESS
CONIFERALES | CUPRESSACEAE | JUNIPERUS | JUNIPER
CONIFERALES | CUPRESSACEAE | LIBOCEDRUS | INSENSE-CEedar
CONIFERALES | CUPRESSACEAE | THUJA | ARBOR-VITAE
CONIFERALES | PINACEAE | ABIES | FIR
CONIFERALES | PINACEAE | CEDRUS | CEDAR
CONIFERALES | PINACEAE | LARIX | LARCH/TAMARACK
CONIFERALES | PINACEAE | PICEA | SPRUCE
CONIFERALES | PINACEAE | PINUS | PINE
CONIFERALES | PINACEAE | PSEUDOLARIX | GOLDEN-LARCH
CONIFERALES | PINACEAE | PSEUDOTSUGA | DOUGLAS-FIR
CONIFERALES | PINACEAE | TSUGA | HEMLOCK

**DESCRIPTION, DISTRIBUTION AND ECONOMICS OF THE GENERA**

CYCAS- a genus of fifteen species which range in distribution from east Africa to southeast Asia, Australia and Polynesia. The plants and more or less palm-like trees and shrubs. The stems are thick and grow slowly. The plants are dioecious- that is bearing two different kinds of cones one of which is male and the other female. One species, the sago-palm of Indonesia and the Phillipines, is the source of sago starch. Representatives of the genus have been transplanted to North America and are found as ornamentals in the tropical and subtropical regions.
ZAMIA—a genus consisting of about thirty species and is endemic to tropical America. Only Florida can boast of naturally occurring representatives of this group of plants. The plants produce a massive underground stem which bears its leaves at the apex giving the general appearance of a fern and may be mistakenly identified as such. It has been transplanted and used as an ornamental in the tropical and subtropical regions. The Seminole Indians of Florida used the starchy underground stem, which when dried and ground, produced flour used to make bread. For this reason, the plants are sometimes called the Seminole bread plant.

GINKGO—only one representative of this genus remains today. As indicated by fossil records, the group was once abundant in the northern hemisphere; but, according to some, were lost in North America due to glacial advances. For the above reasons, the ginkgo is sometimes referred to as a "living fossil". The ginkgo was introduced into North America from China where it was used as an ornamental on the grounds surrounding Chinese and Japanese temples. It has been reported as growing wild in the forests of remote mountains in western China. A tree growing ninety feet in height at maturity makes a beautiful deciduous ornamental in lawns and on margins. The trees are dioecious with the male and the female reproductive structures growing on separate trees. The male or staminate tree is preferred for planting, since the female tree produces the seed within a fleshy covering which when crushed produces an odor similar to rancid butter. The sperm literally swim on currents of air from the male to the female trees. The leaves look like miniature fans drooping in clusters from spurs on the branches and has therefore earned another common name of maiden-hair tree.

PODOCARPUS—a genus of about 60 species, those representatives found in the United States have all been introduced. They occur naturally in tropical and subtropical regions of Asia, Australia, Africa and south and central America where some species are valued as a timber tree. The trees are known to grow to heights of 100 feet.

TAXUS—the largest genus of the family Taxaceae or the yew family consists of about nine species made up of shrubs and small trees. Several species are cultivated for ornamentals and through horticultural efforts, a large number of varieties are now present. Some species have been used in the manufacture of cabinets and others have historically been used to make bows used in archery (Taxix is the classical word for bow). Some of the shrubs, when kept pruned, make excellent foundation plantings. They are beautiful in winter when the bright red arils stand out against the dark green foliage.

TORREYA—a genus of only five species, three of which are endemic to Asia, one to California and one to Florida. The plants appear not to be valued as ornamentals, since only one of the species has been introduced into the United States and this only occasionally planted in the eastern states.
CEPHALOTAXUS- the plum-yews are native to Asia. Consisting of about six species of trees and shrubs, only one species- the Chinese plum-yew has been introduced as an ornamental into the United States. Here it grows favorably in the warmer climates. In the tropical regions, the plant appears to have escaped from cultivation and become established in the wild.

ARACARIA- this genus, consisting of about 25 species has no members native to the United States. They are found as native to the areas of Australia and temperate South America where they are valued as timber trees. The only species introduced into the United States is the Norfolk Island pine which is native to an island by that name which lies to the north of New Zealand. It has been so much accepted that many homes today have them as house plants.

PICEA- consisting of about forty-five species, the spruces are the world's most important source of material in the production of paper. Characterized by needles which are angular in cross section and ranging in size from the Yeddo spruce used in the production of bonsai trees to the Sitka spruce which reaches a height of 300 feet, the genus enjoys worldwide distribution in the north temperate and boreal regions. Its pyramid shape makes it a favorite in lawns. Many species are transplanted and have been introduced as ornamentals.

TSUGA- the hemlocks occur naturally in the forests of China, Japan and North America; but none are native to Europe. The genus is characterized by flat needles which have white lines running the length of the needle on the underside. In the eastern United States the plants are unique in that they do occasionally form monotypic stands. The western species are among the principal timber trees of the Pacific Northwest. Some of the hemlocks are cultivated, and, when pruned produce a beautiful ornamental in lawns. In some parts of the United States, they, like many other gymnosperms, are planted as windbreaks.

PSEUDOTSGUA- plants of western North America and eastern Asia, this genus is characterized by having three-lobed bracts extending from beneath the scales. These bracts have been described as having the appearance of the "tail and two hind legs of a mouse with its head and torso being under the scales". The best known representative of the genus is the Douglas fir, which is the foremost timber-producing tree of the North American continent.
ABIES- a genus of about forty species, the firs are distributed over Europe, Asia and North America. The majority of the North American species are found in the western portion of the continent and associated with the mountainous regions. The genus is characterized by deciduous cone scales and bracts. Once these fall from the cone, only the pointed spine remains on the tree. The firs which have been introduced have been transplanted from areas within North America. The species, indigenous to other parts of the world, do not appear to be especially preferred for cultivation into the United States.

PINUS- the largest group within it's family, the pines consist of about ninety different species. They are generally found in the north temperate zone, and if tropical, they would be found in the mountainous regions. The pines of North America have been transplanted within the continent as ornamentals as have species not endemic to North America. Besides their widespread use as ornamentals, many species are valued for timber production. The needle arrangement in the pines is of two types. The primary needles are single needles arranged on the branch. Secondary needles generally occur in groups or clusters called fascicles consisting of two to five needles each. In many species, the clusters are enclosed in a thin membrane-like sheath which appears at the base of the fascicle at the point of its attachment to the stem.

CEDRUS- the cedars are a group of only about four species, none of which are native to North America. The true cedars are native to the Mediterranean region where they are valued as a source of timber. It is important that one realizes that trees native to North America and called cedars are not really cedar trees at all but belong to entirely different genera and in most cases even in different families of plants.

LARIX- the larches, consisting of about ten species differ from most conifers in that they have deciduous leaves. The larches are found in the north temperate regions of the world and are important for their wood and as ornamentals.

PSEUDOLARIX- as indicated by its name, this is the "false larch" and has only one species which is native to China. It has been introduced into North America where it has been widely cultivated as an ornamental.

SEQUOIA- a genus consisting of only one species, found only in Oregon and California, is among the largest trees on earth. Indications from fossils provide evidence that these trees were once widespread throughout the northern hemisphere. Because of their enormous size and perhaps their restricted habitat, these trees are not normally found as introduced species in North America but remain relatively restricted to their natural regions.
SEQUOIADENDRON - Once classified as a species of the genus Sequoia, it has been classified as a monotypic genus. The tree is endemic to California and is among the largest living trees on earth. As with Sequoia, the single representative of this genus, remains relatively restricted to its natural habitat.

TAXODIUM - once enjoying a wide spread distribution; this genus is now restricted to only three endemic species. The one species, native to the United States, has been transplanted as an ornamental within its natural range. One species, the big cypress of Mexico, are trees of large diameter. One of these trees was found to have a circumference of 112 feet and was estimated to be about 3000 years old.

LIBOCEDRUS - a genus of only nine species, representative as trees, have a natural distribution along the shores of both North and South America. Other species are found in Asia and Australia, thus they essentially encircle the Pacific Ocean. Most of the species yield a valuable aromatic wood. It has not been transplanted to any great degree and therefore occurs only in its natural habitat in North America.

THUJA - The six species of this plant are endemic to North America and Asia. These plants are useful for both their timber as well as for ornamentals. The Asiatic species have been introduced into North America, where they now exist in a large number of varietal forms. It is not uncommon to find plant nurseries selling different varieties of these plants as "globe arborvitae" or "pyramid arborvitae". The name arborvitae comes from the Latin means "tree of life".

CUPRESSUS - twelve species comprise this genus of the true cypress trees which are found only in the northern hemisphere. Only one of the species is endemic to the United States. Other representatives are planted as ornamentals. One, which is favored, is the funeral cypress of China, which tends to droop as though wilted. It should be noted here that some species within other genera are misnamed cypress as are the cedars.

CHAMAECYPARIS - the six species of this group are useful both for their timber and as ornamentals. The genus has a natural distribution in North America, Japan and Formosa. Some of the Japanese species are familiar garden species in all temperate regions.
JUNIPERUS— the largest genus of the family, the junipers consist of about sixty different species which are distributed throughout the north temperate zone. The cones of these plants are berry-like and the oils, extracted from the cones, are used to flavor gin. The plants are useful for their timber as well as ornamentals. Some varieties are used as foundation plantings because of their low growth habit. Many of the species of junipers are miscalled cedars. The European species are most commonly used in the United States as ornamentals.
GLOSSARY OF TERMS USED IN THIS GENERAL SECTION

ALTERNATE - describing the condition in which a single leaf or bud occurs on a stem.
APEX - the tip of a leaf or stem.
APPRESSED - closely and flatly pressed against each other or stem.
ARIL - an appendage or an outer covering of a seed, sometimes it appears as a pulpy covering.
AWL-SHAPED - narrow and sharp-pointed; gradually tapering from the base of some leaves.
BASAL SHEATH - a membraneous covering at the base of leaves when there are more than one leaf at the same point.
BRACT - a mulch reduced leaf, particularly the small or scale-like leaves.
DECIDUOUS - referring to plant parts which fall off within a year of the time of their production.
DECURRENT - running down the stem.
DENTICULATE - minute or fine sharp teeth that are perpendicular to the edges.
FASCICLE - a condensed or close cluster of leaves.
FRUIT - the ripened ovary with the attached parts.
GYMNOSPERM - the division of the plants in which the seeds are not contained in an ovary, but borne naked on the reproductive structure.
LANCE-SHAPED - structures that are much longer than broad; widening above the base and tapering to the tip.
LEAF-SCAR - a scar left on a twig following the fall or removal of a leaf.
LINEAR - long and narrow, the sides are parallel or nearly so.
MARGIN - the edge of a leaf or cone-scale.
NEEDLE-LIKE - leaves that are very long and narrow.
OPPOSITE - bearing two leaves or two buds at the same point on the stem.
PENDULOUS - structures hanging downward towards the ground.
PERSISTENT - remaining attached to the plant; not falling off.
PETIOLE - leaf-stalk or leaf-stem.
PINNA - a leaflet or primary division of a leaf.
PINNATE - feather-formed; with leaflets of a compound leaf placed on either side of the common stalk.
RACHIS - the axis bearing leaves as in pinnately compound leaves.
RANKS - leaves appearing to be extremely flattened.
RHOMBOID - shape of leaves that are like a square but pushed off to one side.
SEEDS - the characteristic reproductive structure of seed plants, consisting of an embryo, enclosed by a seed coat and a food-storage tissue.
SOLITARY - a structure occurring by itself.
SPOROPHYLL - a spore-bearing leaf.
STAMINATE - the male or pollen bearing structure in plants.
WHORLED - three or more leaves or structures occurring at the same point on the stem, in a circle.
Appendix B
THE DECIDUOUS FOREST

This area is unique in that it is the only forest formation of the deciduous life form on the North American continent. It is related to similar forests of central Europe and Asia. It is essentially a temperate forest, in contrast with the other forests. The striking feature being the great wedge that has been driven into the forest by climatic changes, the apex of which lies in northwestern Indiana, while extensions of the movement are still to be found in Ohio and Michigan. The general northern limit runs from central Minnesota along the southern shore of Lake Superior eastward to Quebec, Nova Scotia and New Brunswick. From southern Maine it stretches south to central Georgia, southern Louisiana and eastern Texas. On the west, a fairly continuous belt of hardwoods extend from northeastern Texas through the southern half of Missouri and lower Illinois to Indiana and then through southern Wisconsin to southeastern Minnesota.

The climatic conditions of this forest are highly varied. The maximum rainfall is in the south and east where it reaches 50 to 60 inches per year, the minimum is found in the northwest where there is less than 30 inches per year. The temperature varies from north to south, where the growing season in the north is about 5 months with an average temperature of about 60°F, while in the southern part it is 2 or 3 months longer and the average is about 65°F.

In order to use this key to the species, you must have first used the general key to identify the genus. Only those species found in this particular geographic area are included. There are two things you must keep in mind, however, when using this key. First, some ornamentals and transplanted species may not be included although the authors have made every effort to do so. Secondly, if you are working near the boundaries of other geographic areas, you may need to use the key of those areas in making your identification.

For a visual indication as to the generalized area covered by this forest type see the map on page 16.

GYMNOSPERM SPECIES FOR THE MID-WEST (DECIDUOUS FOREST REGION)

AELIIS - (Firs)

1. Leaves are dark green and glossy above, 3/4 to 1 1/4 inches long...
   A. BALSAMIFERA - (Balsam Fir)

2. Leaves are pale blue-green, 2 to 3 inches long...
   A. CONCOLOR - (Colorado or White Fir)

ARUGARTIA - (Norfolk-Island Pine)

1. Leaves are about 1/2 an inch long, mid-vein (midrib) is barely visible (obscure)...
   A. EXCELSA - (Norfolk-Island Pine)

CARPODIYAXUS - (Plum-Yew)

1. Leaves are short or abruptly pointed, 1 to 2 inches long...
   C. HARRINGTONIA HARRINGTONA - (Harrington Plum-Yew)

2. Leaves are gradually tapering to a long point, 2 to 3 inches long...
   C. FORTINII - (Chinese Plum-Yew)
**CHAMAECYPARIS** - (False-Cypress)

1. Leaves growing to the side (lateral) are larger than the facing (facial) ones; Leaves are blunt and rounded (obtuse) and without glands. . . . C. OBUSA - (Hinoki Cypress)

1. Leaves growing to the side (lateral) are the same size as the facing (facial) ones. . . 2

2. Leaves have showy (conspicuous) glands on the backs. . . . C.

**THYRIDES** - (White-Cedar)

2. Leaves are not as described above. . . . . .3

3. Small branches (branchlets) are round (tate) or only slightly flattened; Leaves are dark green and do not have white markings on the lower surface. . . . . . C. NOOTKATENSIS - (Alaska Cedar)

3. Small branches (branchlets) are flattened; Leaves are covered with a white substance (glaucescent) or white markings on the lower surface. . . . C. PISIFERA - (Sawara Cypress)

**CYCAS** - (Cycads)

1. The edges (margins) of the small leaflets (pinnae) are flat. . . . C. CIRCINALIS - (Cycad)

1. The edges (margins) of the small leaflets (pinnae) are rolled back or inward toward the lower surface (revolute). . . . C. REVOLUTA - (Sago-Palm)

**GINKGO** - (Ginkgo)

1. There is only one species of this deciduous broad-leaved plant originating from Eastern China. The first leaf grows to the left, the next grows to the right for the length of the stem (alternate) or in clusters of 3 to 5 on short lateral stems (spurs); Leaves are fan-shaped, with parallel veins. . . . . G. BILoba - (Ginkgo or Maidenhair-tree)

**JUNIPERUS** - (Junipers)

1. Leaves are needle-like (acicular) in threes on both the young and mature stems; Leaves have two white bands on the leaf which are wider than the green edges (margins). . . . . J. COMUNIS - (Common Juniper)

1. Leaves are not as described above. . . . . . . . 2

2. Leaves are needle-like (acicular), often in threes; Small leaves (scale-like) are pressed against (pressed) each other and rounded or blunt (obtuse); Cones are brown or purple and covered with a white substance called a bloom (glaucescent). . . . . J. CHINENSIS - (Chinese Juniper)

2. Leaves are needle-like (acicular) and grow from the stem in pairs (opposite); Leaves grow only in threes on the young shoots where they are small (scale-like) and sharp-pointed (acute). . . . . . 3
3. Plants are often creeping (prostrate); leaves are bluish-green or steel-blue in color, sharp-pointed (acute) or with an abrupt and sharp point (cuspidate) tip and aromatic. J. HORIZONTALIS - (Creeping Juniper)

3. Plants and leaves are not as described above. . . . . 4

4. Leaves are needle-like (acicular), 1/16 of an inch long and very sharp-pointed. J. EXCELSA - (Greek Juniper)

4. Leaves are needle-like (acicular), 1/4 of an inch long; Mature scale-like leaves overlap the ones above. J. VIRGINIANA - (Eastern Red Cedar)

LARIX - (Larch or Tamarack)

1. Leaves have two very showy white bands on the lower surface; Scales of the cones are bent downward at the tips (reflexed). L. LEPTOLEPIS - (Japanese Larch)

1. Leaves and scales of the cones are not as described above. . . . . 2

2. Branchlets are stiff, not drooping; Cones are 3/4 of an inch long. L. LARICINA - (American Larch/Tamarack)

2. Both the branches and branchlets are drooping (pendulous); Cones are more than 3/4 of an inch long. L. DECIDUA - (European Larch)

PICEA - (Spruce)

1. Twigs are gray to yellow-brown; Branchlets are smooth (glabrous); Cones are less than 2 inches long. P. GLAUCA - (White Spruce)

1. Twigs are not as described above. . . . . . 2

2. Branchlets are smooth (glabrous). . . . . 3

2. Branchlets are hairy (pubescent). . . . . 4

3. Leaves are slightly sharp-pointed; Leaves are green and pointing forward, fragrant (aromatic) when crushed; Both the branches and branchlets are drooping (pendulous). P. ABIES - (Norway Spruce)

3. Leaves are very sharp-pointed, green to blue-green; fragrant (aromatic) when crushed; branches and branchlets are stiff. . . 5

4. Leaves are green; Winter buds are light yellow-brown. P. PUNGENS - (Colorado Spruce)

4. Leaves are blue-green to silver-green and very stiff to the touch. P. PUNGENS GLAUCOA - (Colorado Blue Spruce)

5. White lines (stomata) are equal on both sides of the leaves and bluish-green; Winter buds are without long lasting (persistent) scales at their base; Branchlets are yellow-brown; Cones are 2 to 3 inches long. P. ENGLEMANII - (Englemann Spruce)

5. Plants are not as described above. . . . . . 6
6. Leaves are shiny; Cones are longer than they are broad (oblong) falling soon after formed (deciduous). ... P. RUGENS - (Red Spruce)
6. Leaves are dull green; Cones are round (ovoid) and lasting for several years (persistent). ... P. MARIANA - (Black Spruce)

PINUS - (Pines)

1. Leaves are in groups (fascicles) of five; The membranous sheath (basal sheath) falls off (deciduous). ... P. STROBUS - (Eastern White Pine)
1. Leaves are in groups (fascicles) of two or three ... 2

2. Leaves are 5 to 6 inches long. ... .3
2. Leaves are 1 to 4 inches long. ... .5

3. Leaves mostly occur in clusters (fascicles) of three; Cone-scales are armed with stout, stiff spines; Cones are 4 to 8 inches long. ... P. PONDEROSA - (Western Yellow Pine)
3. Leaves occur in clusters (fascicles) of two. ... .4

4. Leaves are slender, soft and flexible, that is: breaking in two when they are bent double; Bark of mature trunks is reddish-brown. ... P. RESINOSA - (Red Pine)
4. Leaves are coarse and stiff (not as above); Bark of trunks is grayish-brown in color. ... P. NIGRA - (Austrian Pine)

5. Buds of the young twigs are very sticky (resinous); Leaves 3/4 to 1 1/2 inches long, not twisting, but separating (divergent) from each other; Cones remain on the plant for many years (persistent) and pressed against (appressed) the twigs. ... P. BANKSII - (Jack Pine)
5. Buds of the young twigs are not very sticky (resinous). ... .6

6. A low shrub; Leaves are not twisted, and are dark or yellow-green in color. ... P. MUGO - (Mugho Pine)
6. Plants are not as described above. ... .7

7. Leaves are twisted (1 1/2 times in their length) and bluish-green; Bark of the tree and branches is usually reddish-brown and in irregular plates. ... P. SYLVESTRIS - (Scotch Pine)
7. Leaves are not twisted as much as above, stiff, minutely toothed (serrulate); Bark thin and scaly; Branchlets whitish (glaucescent); Cones are symmetrical; scales are armed with prickles or spines. ... P. VIRGINIANA - (Virginia or Scrub Pine)

PSEUDOLARIX - (Golden Larch)

1. Leaves are long and narrow (linear), 1 1/2 to 2 inches long; bluish-green but turn bright yellow in the fall; Cones are round, about 2 inches in diameter and reddish-brown. ... P. AMARILIS - (Golden-Larch)
**PSEUDOTSUGA** - (Douglas-Fir)
1. Leaves have smooth (entire) tips (apex); 2 year old branchlets are reddish-brown and usually hairy (pubescent). . . . **P. MENZIESII** - (Douglas-Fir)
2. Leaves are similar to the above, except that they are shorter and bluish-green; Cones are 2 inches long. . . **P. MENZIESII GLAUCA** - (Rocky Mountain Douglas-Fir)

**TAXUS** - (Yew)
1. Leaves gradually taper to a slight point (acuminate); Scales of the winter buds are not ridged (keeled). . . **T. BACCATA** - (English Yew)
2. Leaves are not as described above. . . . . . . .2 

2. Leaves are flat and usually appear in pairs, one on either side of the stem (opposite) (2-ranked); Plants are usually creeping in nature. . . **T. CANADENSIS** - (Ground Hemlock)
2. Leaves are irregular in appearance, one on either side of the stem (opposite), (2-ranked), 1/8 of an inch wide, with an evident (prominent) main vein (mid-vein) above; Leaves are on spreading branchlets and form a 'V'-shaped groove or trough. . . . **T. CUSPIDATA** - (Japanese Yew)

**TAXODIUM** - (Cypress)
1. Leaves are 2 1/2 inches long and narrow (linear), scattered and have a spreading appearance; Leaves grow in pairs from the same point on the stem (opposite) (2-ranked) and fall off (deciduous). . . . . . . **T. DISTICHUM** - (Bald-Cypress)

**THUJA** - (Arbor-Vitae)
1. Branchlets are usually in vertical planes; Leaves are green on both surfaces; Cone-scales are thick. . . . **T. ORIENTALIS** - (Oriental Arbor-Vitae)
2. Branchlets are usually in no definite arrangement; Leaves of the primary stem are widely spaced and end in a long point with a very prominent gland, yellowish or bluish-green; Cone-scales are thin. . . . **T. OCCIDENTALIS** - (American Arbor-Vitae)

**TSUGA** - (Hemlock)
1. Leaves have minute teeth (serrulate) on the edges (margins), and have well defined bands of white on the lower surface with distinct green edges (margins); Buds are egg-shaped (oval) and pointed on hairy (pubescent) branchlets. . . . **T. CANADENSIS** - (Common or Canadian Hemlock)
### Check List of Gymnosperm Plants Identified in the Key for Deciduous (Mid West) Cover Area

<table>
<thead>
<tr>
<th>Family</th>
<th>Genus</th>
<th>Species</th>
<th>Variety</th>
<th>Common</th>
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<td>Abies</td>
<td>Balsamea</td>
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<td>Concolor</td>
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<td>Sylvesteris</td>
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<td>Scotch Pine</td>
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<td>Pinus</td>
<td>Virginiana</td>
<td></td>
<td>Virginia/Scrub Pine</td>
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<td>Pinaceae</td>
<td>Pseudolarix</td>
<td>Ambilis</td>
<td></td>
<td>Golden-Larch</td>
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<tr>
<td>Pinaceae</td>
<td>Pseudotsuga</td>
<td>Menziesii</td>
<td></td>
<td>Douglas-Fir</td>
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<tr>
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<td>Menziesii Blauca</td>
<td></td>
<td>Colorado-Douglas-Fir</td>
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<td>Taxodiaceae</td>
<td>Taxodium</td>
<td>Distichum</td>
<td></td>
<td>Bald Cypress</td>
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<tr>
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<td>Taxus</td>
<td>Baccata</td>
<td>Many</td>
<td>English Yew</td>
</tr>
<tr>
<td>Taxaceae</td>
<td>Taxus</td>
<td>Canadianis</td>
<td></td>
<td>Canadian Yew</td>
</tr>
<tr>
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<td>Taxus</td>
<td>Cuspidata</td>
<td>Many</td>
<td>Japanese Yew</td>
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<td>Cupressaceae</td>
<td>Thuja</td>
<td>Occidentalis</td>
<td></td>
<td>Northern White Cedar</td>
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<td>Cupressaceae</td>
<td>Thuja</td>
<td>Orientalis</td>
<td></td>
<td>Oriental Absor-Vitaes</td>
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<tr>
<td>Pinaceae</td>
<td>Tsuga</td>
<td>Canadensis</td>
<td></td>
<td>Eastern Hemlock</td>
</tr>
</tbody>
</table>
GLOSSARY OF TERMS USED IN THE
DECIDUOUS (MID-WEST) FOREST SECTION

ACICULAR - needle-shaped; long and narrow.
ACUTE - sharp-pointed; ending in a point
ALTERNATE - describing the condition in which a single leaf or
bud occurs on a stem.
APEX - the tip of a leaf or stem.
APPRESSED - closely and flatly pressed against each other or
stem.
AROMATIC - having a smell or fragrance.
AWL-SHAPED - narrow and sharp-pointed; gradually tapering from
the base of some leaves.
BASAL SHEATH - a membranous covering at the base of leaves when
there are more than one leaf at the same point.
BRANCHLET - a small branch, usually referring to stems of the
current and preceding years growth.
BRACT - a much reduced leaf, particularly the small or
scale-like leaves.
CONSPICUOUS - very showy or evident structure on the plant.
CUSPIDATE - sharp-pointed; ending in a sharp pointed tooth.
DECIDUOUS - referring to plant parts which fall off within a
year of the time of their production.
DECURRENT - running down the stem.
DIVERGENT - two structures spreading apart.
ENTIRE - without teeth or dividing; smooth.
FACIAL - a structure facing the observer.
FASCICLE - a condensed or close cluster of leaves.
GLABROUS - not hairy; smooth.
GLAUCOUS - covered with a bloom; bluish white or bluish gray.
KEEL - a central ridge in the center of a leaf or cone.
LATERAL - structures along the sides, that is in leaves,
buds, etc.
LANCE-SHAPED - structures that are much longer than broad;
widening above the base and tapering to the tip.
LINEAR - long and narrow, the sides are parallel or nearly
so.
MARGIN - the edge of a leaf or cone-scale.
MID-RIB - the central vein in a leaf.
NEEDLE-LIKE - leaves that are very long and narrow.
OBLONG - several times longer than wide and with nearly
parallel sides.
OBSCURE - not very evident to the unaided eye.
OBSTUSE - blunt or rounded at the tip.
OPPOSITE - bearing two leaves or two buds at the same point on
the stem.
OVOID - having a shape like an hens egg.
PENDULOUS - structures hanging downward towards the ground.
PERSISTENT - remaining attached to the plant; not falling off.
PINNER - a leaflet or primary division of a leaf.
PROLIFIC - very conspicuous or evident.
PROSTRATE - creeping along the ground.
PURIFIC - covered with some type of hairs on the surface.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>RANKS</td>
<td></td>
</tr>
<tr>
<td>REFLEXED</td>
<td>Leaves appearing to be extremely thickened.</td>
</tr>
<tr>
<td>REVOLUTE</td>
<td>Abruptly turned downward.</td>
</tr>
<tr>
<td>SEQUENTIATE</td>
<td>Edges rolled towards the lower side of surface.</td>
</tr>
<tr>
<td>Plicate</td>
<td>Covered with a sticky substance.</td>
</tr>
<tr>
<td>SCALE-LIKE</td>
<td>Small structures closely pressed together.</td>
</tr>
<tr>
<td>SEARULATE</td>
<td>Edges with very small or minute teeth.</td>
</tr>
<tr>
<td>SPUR</td>
<td>Stems with very reduced internodal regions.</td>
</tr>
<tr>
<td>STOMATA</td>
<td>Gas exchange structures that are arranged in lines on leaves.</td>
</tr>
<tr>
<td>TEREITE</td>
<td>Structures that are round in cross-section.</td>
</tr>
<tr>
<td>TWO-RANKED</td>
<td>Leaves appearing to be located on either side of the stem.</td>
</tr>
</tbody>
</table>
AZEDES CONCOLOR - the white or Colorado fir, a native of the western United States, has been introduced into the temperate zone and the eastern part of the country and extending into the Atlantic coastal region. Its distribution in the east as an ornamental is a result of its preference for its vigorous growth which exceeds that of other transplanted species of fir. In its native habitat, the tree is found on high mountain slopes but is capable of adaptation in the more mild regions as far south as Arizona. Although occasionally used for its lumber, it is more highly valued as an ornamental.

AZEDES EXCELSA - the Norfolk Island pine is an ornamental which is a native of an island in the South Sea, north of New Zealand. Members of this genus are found naturally in the south of Chile where they grow to heights of 100 feet or more. The Norfolk Island Pine is a good house plant, but when well maintained will soon outgrow its surroundings. New growth from the main stem appears as a wheel of branches which grow horizontally with the main stem continuing growth vertically. The young branches, when viewed from the top resemble the spokes of a wheel rotating around the center. The branches are fern-like and are feathery to the touch.

AZEDES FORTUNEI - the Chinese pine-pine is one of six species of trees and shrubs which are endemic to a range from the Himalayas to Japan in Asia. This species is used in ornamental plantings in the warmer climates; but is not winter hardy in the colder temperate regions of North America.

AZEDES HARRIMANIA - a native of China and Japan, this plant has been introduced into the United States as an ornamental. In Japan the plant becomes a small tree with reaching heights of about 15 feet, but in cultivation, it rarely exceeds more than 60-90 feet.

AZEDES NOOTKA - one of six species of the genus which occur in North America, Japan and Russia. This species is often referred to as the Alaskan yellow cedar or yellow cypress, is an important timber tree. It is found naturally occurring from Alaska to Oregon.
CHAMAECYPARIS OBUSA - a native of Japan, the plant has become widely planted as an ornamental. It has a large number of varieties many of which are noted for their slow growth and densely compacted branches. In its native habitat, the plant grows to heights of 120 feet, but most varieties, which are cultivated in the United States, are dwarf representatives.

CHAMAECYPARIS PISIFERA - a commonly cultivated ornamental from Japan, this species has become highly hybridized and today there are many different varieties. Most of the varieties are simply referred to as the Sawara Cypress.

CHAMAECYPARIS THYOIDES - a small tree 75 to 80 feet in height, this species is commonly referred to as the Atlantic cedar or the white cedar. It is an inhabitant of cold swamps from Maine to Florida but occupying only a narrow band in that distance along the coast. In its southernmost limits, however, it is found as far west as Mississippi. It has been transplanted as an ornamental both in the United States and in Europe.

CYCAS CIRCINALIS - the sago plant of Indonisia and the Philipines has been introduced as an ornamental especially to the tropical and subtropical parts of the North American Continent. It is found in botanical gardens and greenhouses in the temperate regions. It is a source of sago starch.

CYCAS REVOLUTA - a plant originating from southeastern China and southern Japan has been introduced as an ornamental especially to the tropical and subtropical parts of the North American continent. It is found in botanical gardens and greenhouses in the temperate regions but cannot withstand the external environmental temperatures of these regions.

GINKGO BILoba- a tree which is often planted as an ornamental. The ginkgo or "maiden hair" tree has been reported as growing wild in the forests of remote mountains of western China; but for centuries was grown on ground surrounding Chinese and Japanese temples. It is desirable as a street or avenue tree because of its resistance to smoke and decreased moisture and its ability to withstand temperatures as low as -30°F. It is characterized by its fan shaped leaves which are borne on short spurs arising from the stem. The plant occurs as male or female. The female representative is least preferred for planting because the ripened seed is covered by a fleshy covering, which when crushed, produces an odor similar to that of rancid butter. For this reason one should purchase trees from a reputable nursery in order to obtain the sex of the plant which is desired.

JUNIPERUS CHINENSIS - the Chinese juniper, which has been introduced into the United States as an ornamental, occurs as either a tree reaching heights of 60 feet or shrubs which simply spread over the surface of the ground. Its growth pattern is of course dependent upon the variety of which there are ten known at the present time.
JUNIPERUS COMMUNIS - a circumboreal shrub which is often planted as an
ornamental. This species is commonly found in poor rocky soil from
Newfoundland to southern New England and north westward beyond the
Great Lakes.
Commonly referred to as the common juniper, varieties are found in
both Europe and Asia. The plant is also known to occur at the
higher elevations further south than indicated above, some having
been found in North Carolina and in the high Sierras. In the more
severe conditions, the plant takes on a more dwarf-like appearance,
a characteristic which enables it to withstand the extreme cold and
arid conditions of its natural habitat especially in the tundra.

JUNIPERUS EXCELSA - the Greek juniper has found widespread use as an
ornamental in North America. The tree grows rather rapidly
maintaining a slender shape. The branches grow upright forming
clusters of vertical shoots and branches toward the center of the
plant. The small scale-like leaves are extremely sharp, which
makes the task of pruning etc. extremely difficult.

JUNIPERUS HORIZONTALIS - a species with a large number of varieties, the
creeping juniper is often used as a foundation planting because of
its tendency to promote growth in a horizontal direction. It can be
utilized in front of low windows, since it rarely produces a
vertical growth of more than one foot. Many plants, when properly
pruned, produce a mat like growth which will extend over a large
area. For this reason, it is also planted along the tops of walls
and in corners of walkways.

JUNIPERUS VIRGINIANA - This species is commonly referred to as the
eastern red cedar. The wood has been used for making pencils as
well as in the manufacture of "cedar" chests. The tree, sometimes
reaching heights of about 100 feet, is also known in varieties
which are dwarf-like in nature. Mature trees are columnar in
appearance although some of the horticultural varieties are
pyramidal in shape. The plant enjoys a widespread distribution,
especially in the eastern United States. It is often referred to
as an indicator of poor soil since it thrives on gravelly or shaley
outcrops sharing its habitat with other poor soil species such as
broom sedge. Its role as the alternate host for apple rust (a
fungus) has caused its planting to be illegal in states where
apples are a primary crop.

LARIX DECIDUA - a native of Europe, the European larch grows naturally in
the forests of the Alps and Carpathians. Like all members of the
genus, which has a total of ten species, the leaves are deciduous.
The plants are useful for their wood but are much more desirable as
an ornamental in North America. This particular species is a
source of Venetian turpentine.

LARIX LARICINIA - the American larch or tamarack is abundant throughout
the boreal forests of Canada. Its southern most natural occurrence
is in Cranberry Swamp in the mountains of northern West Virginia.
It is useful as an ornamental because of its deciduous leaves which
turn golden brown in the fall. During the summer, the soft needles
and slender shape make it desirable as a lawn tree, providing the
evergreen appearance in summer but not shading in the winter. The
tree ranges in heights of 15 to 90 feet.
LARIX LEPTOLEPIS- the Japanese larch, a native of Asia, is used as an ornamental especially in the cooler climates of North America.

PICEA ABIES- The Norway spruce is a valuable timber tree of Europe which has been planted as an ornamental and shade tree in North America. The plant has escaped from cultivation and can be found growing wild especially in New England.

PICEA ENGELMANNII- The Engelmann spruce is a native plant species which is found at high elevations in the Rocky Mountains. It displays the normal characteristic shape of evergreens being tall and slender.

PICEA GLAUCA- The white spruce of North America is one of the species which characterizes the boreal forest but has also remained in the colder regions of North America to the south. The tree has been used as an ornamental in the cooler climates, where it grows to heights of about 135 feet and where there is little or no competition. When mature, the tree resembles the balsam fir.

PICEA MARIANA- The black spruce of the boreal forest, like the white spruce, is found farther to the south, where temperatures are cool enough to support it. It is found naturally occurring in cold bogs and along mountain slopes from New Jersey and along the Great Lakes and to the northwest. It is smaller than the white spruce, attaining maximum heights of only about 105 feet.

PICEA PINNENS- The Colorado spruce is probably one of the best known of all of the species because of the characteristic bluish-green color of its leaves (seen in variety GLAUCA). When viewed from a distance, the tree has a nice pyramidal shape with the lower branches hanging close to the ground. The tree has long been prized as an ornamental and is often seen as a lawn tree.

PICEA RUBENS- The red spruce is a tree which is primarily associated with the Appalachian Mountains, where it inhabits the environs of the higher peaks. Some scientists have inferred that the red spruce is a relict species, which came about as a result of the black spruce migrating north with the receding glaciers. These trees, which were unfortunate enough to be left behind, survived by taking their place higher up into the mountains. After long periods of isolation from the spruce, those remaining in the mountain peaks evolved into the present day red spruce. The tree, which grows to heights of 135 feet has been valued for its timber.

PINUS BANKSIANA- This two needle pine is found throughout the boreal forests of Canada. Commonly referred to as the Jack pine, this tree grows to heights of about 70 feet; but is more frequently seen as a shrub. In the United States, the jack pine is restricted to New York and the Hudson Bay area westward to Minnesota. It has not been transplanted as an ornamental because of its slender appearance.

PINUS HUGO- the hugu pine of central and southern Europe has become widely used as an ornamental planting. Because of its slow growth, it is useful in decorating around foundations of homes and in rock gardens. Growth is extremely slow.
PINUS NIGRA- the Austrian pine is native to southern Eurasia occurring from Spain to Asia Minor. It has been planted as an ornamental in the cooler parts of North America.

PINUS PONDEROSA - the yellow or bull pine of the western part of the continent is a relatively tall tree achieving heights of 150 to 200 feet. It occurs from western Texas and Nebraska westward to the Pacific coast. The variety (SCOPULORUM) is associated with the Rocky Mountains and can be found throughout the states of Wyoming, Montana, Colorado, Arizona and New Mexico. Its value as a timber tree is second only to the Douglas fir, producing in excess of three billion board feet of lumber annually.

PINUS RESINOSA- the red pine from eastern North America is a tall tree reaching heights of 150 feet and a diameter of up to about 4 1/2 feet. It has been widely used for reforestation often in areas once inhabited by the white pine.

PINUS STROBUS - the white pine is one of the most valuable timber trees of the eastern United States. It has been utilized in reforestation projects within its natural range which is quite widespread. The plant naturally occurs in the mountains from New England southward to Georgia and westward to Iowa. It occurs in several shrub-like varieties. The five needles per fascicle gives the appearance of the terminal fascicles on the branches similar to paint brushes. During the early history of the United States, the trees were harvested for the purpose of building ship masts. Their strength and lightness made this narrow tree ideal for this purpose.

PINUS SYLVESTRIS- the Scotch pine is an endemic of Eurasia with a range extending from Scotland to Siberia. A highly cultivated species in North America, the plant has escaped from cultivation and established itself as a naturally occurring species in the temperate regions especially in the northeast. It has been used commercially for Christmas trees and along highways as a soil binder where cuts have been made in hillsides. The tree grows rapidly, and although it can reach a considerable height, the trunk is rarely straight which does not make it valuable for lumber production.

PINUS VIRGINIANA- the scrub pine is an extremely distorted tree in its growth patterns. It ranges in height from 15 to 30 feet. It favors growth in barren and dry soils throughout its range.

PSEUDOLARIX AMABILIS- the only species within this genus, the golden larch is a native of China. It resembles the genus Larix therefore the genus name is Pseudolarix which translates to "false Larix". It is easily differentiated from the genus Larix because upon ripening the cones disintegrate whereas in Larix the cones remain intact.
PSEUDOTSUGA MENZIESII - the Douglas fir or sometimes the Douglas spruce is among the tallest trees known sometimes reaching heights of 250 feet. They are best known for their value as a timber tree; producing up to about six billion board feet of lumber annually. Its rapid growth makes it valuable as an ornamental in parks and lawns where the pyramidal shape becomes quite attractive. It is widely distributed from the Rocky Mountains westward in the Pacific coast and from Washington to the higher elevations of the mountains of northern Mexico. The variety (GLAUCA) appears to be much hardier and tends to grow at a reduced rate, which would make it more preferential for plantings in smaller areas.

TAXUS BACATA- The English yew has been introduced into the North America from Europe. The plant usually occurs as a tree reaching heights of no more than 60 feet.

TAXUS CANADENSIS- depending upon habitat or trimming this plant may occur as a tree or a shrub. When growing in the wild, the plant will appear as a small tree. By pruning, the plant can be maintained indefinitely as a shrub and is used as a foundation for planting. When the plant matures, it begins to produce red "berries" called arils. The single black seed contained within the aril is extremely poisonous. The wood of the yew has been used in cabinet making and in the making of bows for archery. (TAXUS is the classical word for bow).

TAXUS CUSPIDATA- The Japanese yew has been widely planted as an ornamental in the cooler part of the North American continent.

TAXODIUM DISTICHUM- the bald-cypress is an important timber tree of coastal swamps in the southeastern United States. A unique feature of the tree are the cypress "knees" which project upwards above the water in the swamps. Although the knees do not project above the level of soil when grown in land, they do occasionally appear at the surface of the ground. Although once widespread, the species is now limited to only three species. The leaves appear on small branchlets which are deciduous as well as are the leaves. Although the tree provide shade in the summer and allows for the penetration of sunlight in winter, it is not as well preferred as larch because of the debris created by the deciduous branchlets.

THUJA OCCIDENTALIS - one of six species of arborvitae, this plant is native to North America with the other species being found only in Asia. The name arborvitae means "tree of life". The plant is characterized by its vertically flattened fan shaped branchlets which have been extensively used as a background and filler in floral arrangements. The wood has been used to some degree in the manufacture of furniture. In the wild, the tree preferentially grows in swamps and cool rocky environments. It ranges in size from 30 to 60 feet in height. The plant has been a number of horticultural varieties, many of which are dwarf forms, often used as foundation plantings.
HOAERAMUS - a species from northeastern China and Korea, this plant is often grown as an ornamental especially in the temperate regions of North America. There are a large number of horticultural varieties which occur as shrubs. The tree in its native habitat reaches heights of only about 25 feet.

HOAERAMUS - One of twelve species of hemlocks which characterizes the forests of China, Japan and North America. There are no species found in Europe. The leaves are flat with two white lines on the underside of the leaf which run the full length of the leaf. This species is one of the most distinctive trees of the forests of the eastern United States found in association with hardwoods. During the winter months, these trees become quite obvious when surrounded by the stark bare hardwoods. At higher altitudes, hemlocks grow in large stands of the plant but at lower elevations one may find a single plant growing among a large number of hardwoods. The young trees are sometimes collected and pruned to make hedges or foundation plantings.
Appendix C
KEY EVALUATION FORM

Your Grade ___________________

Circle the number that best corresponds with your impressions about the key:

<table>
<thead>
<tr>
<th></th>
<th>strongly disagree</th>
<th>disagree</th>
<th>no opinion</th>
<th>agree</th>
<th>strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The instructions were easy to follow.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. The key was easy to read.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. I learned new terms from the key.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4. The words used were difficult to understand.</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>5. I can identify trees by using this key.</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>6. The key's descriptions of characteristics were clear.</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>7. I can correctly name the genus with the key.</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>8. I can correctly name the species with the key.</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>9. I found the glossary useful.</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>10. The economic section informative.</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>11. I have identified trees before.</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>12. I have used a key before.</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>13. I felt comfortable using this key.</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>14. If other keys were available, I would choose this key to use.</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

OTHER COMMENTS: