



# Measuring Vegetation Health with PicturePosts

An Interactive Qualifying Project Report

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by

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Russell R. Kernan

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Jeffrey J. Madden

---

Cara M. Messier

Date: 4/27/2007

***Sponsoring Organization:***  
Boston Museum of Science

***Project Liaison:***  
Brian Rogan

***Project Advisors:***

---

Professor Kevin A. Clements, Major Advisor

---

Professor Chrysanthe Demetry, Co-Advisor



**Museum of Science™**

## **Abstract**

The Boston Museum of Science developed monitoring stations called PicturePosts as part of its Measuring Vegetation Health program. Despite their many educational applications, PicturePosts had not been implemented in an educational environment. To encourage and assist in their use, we formed an advisory board of educators who provided input and feedback as we developed an educator's guide and installation and software manuals for PicturePosts. The educators' impressions of the Posts support the program's far-reaching potential to enhance science education.

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Professor Kevin A. Clements

Professor Chrysanthe Demetry

Professor Fabio Carrera

### *PicturePost Advisory Board*

Rob Banks

Ellen Brenneman

Lisa Camp

Rebecca Schwer

Christina Connolly

Timothy Herrmann

Margaux Parino

Stephanie Selznick

Stephen Sousa

Christine Welk

Audubon Society of RI Education Center

Kennedy Middle School

River Valley Charter School

River Valley Charter School

Algonquin Regional High School

Hoosac Valley High School

Assabet Valley Collaborative Alternative High School

Dr. Joseph Coakley Middle School

Andover High School

Sullivan Middle School

### *Engineered Plastic Systems*

David Cook

## **Executive Summary**

The Boston Museum of Science launched the Measuring Vegetation Health (MVH) initiative in 2004, in an effort toward developing and educating the public about techniques for detecting environmental change. The program revolves around viewing plants as “green canaries,” our first warning signs for anything from large environmental shifts such as those brought about by climate change to local, adverse human activities. In an effort to observe and identify these changes, the Museum of Science’s MVH team has developed PicturePosts. PicturePosts are inexpensive stands that can be installed in environmentally interesting locations (“Introduction to PicturePosts”, 2006). They assist in taking panoramic pictures from the exact same location over a period of time, allowing for easy recognition of changes and, by extension, trends in the local environment. More broadly, PicturePosts and the MVH project are directly related to the Museum of Science’s mission of promoting “Citizen Science,” getting people “involved in projects, involved in hands-on science” (B. Rogan, personal communication, January 25, 2007). The creation of local connections and interactions with the environment creates a foundation for positive environmental change and the future advancement of the science.

Unfortunately, while the MVH project exhibits a wealth of important scientific concepts – including the study of plants, light, computer imaging, and environmental health – prior to this project it had yet to be implemented in an educational setting. No guide for integrating the program into classrooms and school curricula had been developed, and newly ordered PicturePosts did not include even a basic set-up manual. Our goal, therefore, was to substantially increase the utility of PicturePosts and the Measuring Vegetation Health program as engaging educational resources through the development of an educator’s guide.

### ***The PicturePost Educator Advisory Board***

To help accomplish our goal, we formed an advisory board comprised of ten educators from throughout Massachusetts and Rhode Island. This board greatly assisted us in gathering and processing ideas for the educational resources we had planned, as well as providing crucial feedback on all of our materials. They each excitedly accepted a complimentary PicturePost to install near their schools, spreading the program

throughout the state. Besides adding credibility to the guide and becoming PicturePost missionaries, the assembled board will continue to serve as a valuable resource of feedback for the Museum as they continue to promote the educational applications of MVH.

### ***Educator's Guide and Instruction Manuals***

The first step in creating educational resources was analyzing the MVH project's existing PicturePost resources – manuals, software, and activities – to determine gaps in the material. Also, by installing two new PicturePost stations in Arlington, Massachusetts, we experienced the entire PicturePost process first-hand, allowing us to identify more potential changes and additions. Drawing on these experiences, information provided on the Measuring Vegetation Health website, past Museum-constructed guides, and input from our advisory board, we developed an educator's guide, a PicturePost manual, and a manual for several useful MVH software programs. The educator's guide is organized by the following chapters:

- **Introduction:** background summary of the MVH and PicturePost programs
- **Getting Started:** descriptions of suggested materials, software, and the program's application to the Scientific Method
- **Indoor Unit:** three lessons examining the properties of color, digital imagery, and photosynthesis
- **Outdoor Unit:** two lessons describing the basics of the PicturePost program, using photos to measure vegetation health and applying said measurements over time
- **More Applications:** four lessons developed from educator suggestions, including material on erosion, vernal pools, elevation, and weed growth
- **Software Manual:** step by step instructions for using software mentioned in the lessons
- **PicturePost Manual:** step by step instructions for installing the PicturePost, taking pictures, and uploading pictures

The PicturePost installation and usage manual was also created as a separate document and sent to EPS Plastic Lumber for inclusion with all new PicturePosts.

Finally, all materials will soon be made available on the official Measuring Vegetation Health website, potentially sparking more teacher interest, or simply allowing ordinary citizens to make use of the materials at home.

Overall, the format and focus of the educator’s guide as well as the entire PicturePost program seemed very well embraced by the members of the advisory board. Besides the intended connections to environmental sciences, our board identified potential PicturePost applications in subject areas such as photography, technology, art, mapping, and GPS or orienteering. As one teacher proclaimed, “I really think I can use PicturePost as an overall theme or tying [the] knot with all of my units.” Another noted, after trialing the program with her students, “the use of the technology and the sciences has become enlivened [at my school] and is pulling in students we hadn’t been able to reach before...They are engaged and wanting to be a part of a team that goes out to photograph this summer.” These results are very promising.

## ***Recommendations***

In the process of achieving our project goal, we made a number of observations concerning aspects of PicturePosts that we consider prime candidates for further development and progress. The following are some of our recommendations for the Museum of Science and the MVH team.

- **Continue to work with the advisory board.** The teachers have not had much time to integrate their ideas into their teachings. Following up during and after lessons have been run would be most beneficial. Additionally, new ideas may form once teachers have formed a base of multiple years’ worth of measurements.
- **Post the manuals and the educator’s guide on the MVH website.** This will allow people to more easily see the educational merit of the project, hopefully sparking more teacher interest or simply helping people make use of the materials at home.
- **Expand and update the educator’s guide and manuals.** As more feedback is received, the guide and manuals will continue to improve. This will also allow some of the scientific topics that we were not able to cover, such as cloud and weather studies, to be adequately researched and added to the guide.

- **Develop a search mechanism for the image database.** With the addition of picture keywords and a search option, people will be able to make comparisons between pictures of similar environments from different sites around the country.
- **Integrate the PicturePost database into the MVH website.** Currently part of a third party website, an MVH-run photo database would allow for improvements such as deeper levels of organization for areas with multiple Posts, easier archiving, and better navigation. With the assistance of partner educational institutions, such a resource could be cheaply developed and integrated.

We have developed clear, thorough manuals and educator's guides for the PicturePost program, distributed the first wave of PicturePosts to schools throughout the state, and mass production of the new, low-maintenance, plastic lumber Posts is just beginning. With active marketing and the continued close involvement of educators, PicturePosts could rapidly become the premier avenue for hands-on environmental education country- and even world-wide. By introducing students to the availability and importance of Citizen Science investigations and instilling in them local connections to the environment, they are more likely to become interested in scientific and environmental processes. This not only ensures future development in all fields, but also the continued protection of the planet. If our green canaries ever come calling, we can all have hope that there may be scientists capable of answering.

## Authorship

Sect. #	Section Title	Originally Drafted By
1.0	Introduction	Russell Kernan
2.0	Background	Russell Kernan
2.1	Principles of Effective Environmental Education	Russell Kernan
2.2	The Measuring Vegetation Health Project	Jeffrey Madden
2.3	Educational Standards and Design	Cara Messier
2.4	Conclusions	Cara Messier
3.0	Methodology	Russell Kernan
3.1	Analysis of PicturePost Implementation	Jeffrey Madden
3.2	Advisory Board Consultation	Cara Messier
3.3	Resource Construction	Russell Kernan
4.0	Findings	Jeffrey Madden
4.1	Gaps in PicturePost Documentation	Jeffrey Madden
4.2	Interactions with Advisory Board	Cara Messier
4.3	Development of Educational Resources	Russell Kernan
5.0	Conclusions and Recommendations	Cara Messier
5.1	Concluding Remarks	Jeffrey Madden
5.2	Recommendations for the Future of PicturePosts	Cara Messier

During our writing process, we decided on three main focus points; PicturePost, Advisory Board, and Educational Resource Development. Each team member focused on one area and provided expertise on that topic for the project. As seen above, Russell took on the responsibility of researching and creating the educational resources as well as writing many of the introductions. Cara extensively researched lesson plan and curriculum development as well as creating the advisory board. Jeffrey mainly focused on researching the Measuring Vegetation Health project, PicturePost specifics, and image data analysis.

After the framework for the report was laid out by each team member, the entire editing process throughout the duration of the project has been completed as a collaborative effort. Each member would first read over the memo as well as the entire section being reviewed. We then would read over our respective sections that we wrote and suggested ways to address issues brought up in these sections and the other team members would provide their input and suggestions.

We all have our respective sections in which we are particularly strong. Yet, shaping the report through this collaborative method allows us each to understand how the different concepts within the project fit together and ensure everyone's views are expressed.



# Table of Contents

<b>1 INTRODUCTION</b> .....	<b>1</b>
<b>2 BACKGROUND</b> .....	<b>4</b>
<b>2.1 Principles of Effective Environmental Education</b> .....	<b>4</b>
<b>2.2 The Measuring Vegetation Health Project</b> .....	<b>7</b>
2.2.1 PicturePosts .....	8
2.2.2 Scientific Principles Underlying MVH.....	10
2.2.3 Photo Analysis Tools .....	14
<b>2.3 Educational Standards and Design</b> .....	<b>15</b>
2.3.1 Overview of Curriculum .....	15
2.3.2 Correlation between State Academic Standards and MVH ..	17
2.3.3 Discovery Learning.....	19
<b>2.4 Conclusions</b> .....	<b>20</b>
<b>3 METHODOLOGY</b> .....	<b>22</b>
<b>3.1 Analysis of PicturePost Implementation</b> .....	<b>23</b>
3.1.1 Location Choice.....	23
3.1.2 PicturePost Installation and Data Collection.....	23
3.1.3 Image Analysis .....	24
<b>3.2 Advisory Board Consultation</b> .....	<b>24</b>
3.2.1 Assembly .....	25
3.2.2 Orientation .....	26
3.2.3 Continued Feedback .....	27
<b>3.3 Resource Construction</b> .....	<b>28</b>
<b>4 FINDINGS</b> .....	<b>29</b>
<b>4.1 Gaps in PicturePost Documentation</b> .....	<b>29</b>
<b>4.2 Interactions with Advisory Board</b> .....	<b>32</b>
4.2.1 Advisory Board Formation .....	32
4.2.2 Preparation for Orientation .....	33
4.2.3 Initial Impressions of MVH.....	35
4.2.4 Guide and Manual Feedback .....	38
<b>4.3 Development of Educational Resources</b> .....	<b>39</b>
4.3.1 Educator’s Guide .....	39

4.3.2 Manuals .....	41
<b>5 CONCLUSIONS AND RECOMMENDATIONS .....</b>	<b>43</b>
<b><i>5.1 Concluding Remarks</i></b> .....	<b>43</b>
<b><i>5.2 Recommendations for the Future of PicturePosts</i></b> .....	<b>45</b>
<b>REFERENCES.....</b>	<b>48</b>
<b>APPENDIX A: THE BOSTON MUSEUM OF SCIENCE .....</b>	<b>51</b>
<b>APPENDIX B: PHYSICAL SCIENCE OF LIGHT AND PLANTS.....</b>	<b>54</b>
<b>APPENDIX C: GANTT CHART .....</b>	<b>56</b>
<b>APPENDIX D: WEEKLY PICTUREPOST DATA .....</b>	<b>57</b>
<b>APPENDIX E: ADVISORY BOARD AD .....</b>	<b>63</b>
<b>APPENDIX F: ADVISORY BOARD CONTACTS .....</b>	<b>65</b>
<b>APPENDIX G: ORIENTATION MATERIALS .....</b>	<b>66</b>
<b>APPENDIX H: EDUCATOR’S GUIDE .....</b>	<b>70</b>

## List of Figures

Figure 1: The Three Topic Areas of MVH. ....	7
Figure 2: Connections between Plant Monitoring and the Environment. Courtesy of MVH.....	8
Figure 3: PicturePost Side and Top Views (adapted from the MVH website) .....	9
Figure 4: Chlorophyll Content Decreasing as the Seasons Change. Courtesy of the University of Bristol .....	11
Figure 5: Pure Green Packaging Appears Black through Filter (ideal situation) .	12
Figure 6: Plant Stresses Identified with Light Filter (circles show where the brown pine needles are located) Courtesy of MVH.....	13
Figure 7: Digital Picture of Forest (no filter and simulated filter respectively) Courtesy of www.goblinforest.com .....	13
Figure 8: Our MVH Project Plan.....	22
Figure 9: MVH Website Visuals, Before (left) and After (right) .....	31
Figure 10: Grade Distribution of the Advisory Board.....	32
Figure 11: Geographic Distribution of the Advisory Board .....	33
Figure 12: Class Time Available for PicturePost Activities Identified by Advisory Board .....	37
Figure 13: Light with Corresponding Wavelengths. Courtesy of NASA Science Atmospheric Data Center.....	54
Figure 14: Chlorophyll a and b Absorbance Courtesy of the University of Bristol .....	55

## List of Tables

Table 1: The Massachusetts State Academic Standards for Grades 6-8. Courtesy of the Massachusetts Department of Education .....	18
Table 2: Our Selection Criteria and Rating System.....	26
Table 3: Concepts Related to PicturePosts Identified by Advisory Board .....	35
Table 4: Potential PicturePost Activities Identified by Advisory Board .....	36
Table 5: Potential Club Interest Identified by Advisory Board .....	37
Table 6: Potential Barriers to Use of PicturePosts Identified by Advisory Board.	38

# 1 Introduction

Vegetation health is critically important to society as an indication of the quality of the environment. With continuing problems caused by pollution as well as new evidence of climate change accumulating, having a reliable way to measure the health of the environment will only become more important. For example, due to an increase in greenhouse gasses, it has been estimated that average temperatures could increase between 2.5 and 10.4 degrees before the year 2100, further disturbing rainfall patterns, snow and ice cover, and sea level (EPA, 2006). These changes will significantly impact the landscapes and species of the Earth, but the specific, local effects are almost impossible to predict. These small effects, however, may be our first indication of impending large-scale problems – indications which, if identified, could potentially allow for attempted last-minute corrections to prevent further damage.

In an effort toward developing techniques for detecting environmental change and educating the public about these techniques, the Boston Museum of Science launched the Measuring Vegetation Health (MVH) initiative in 2004. The concept behind the program is that plants can serve as “green canaries,” our first warning signs for anything from large environmental shifts such as those brought about by climate change to local, adverse human activities. As John Pickle, the first principal investigator of the MVH project, explains, the genesis of their rationale was really quite simple: “plants don't move” (J. Pickle, personal communication, February 8, 2007). This fact obviously makes them easy to observe, but more importantly means that any changes to a plant's health can only be the result of something in its immediate surroundings. In an effort to observe these changes, the Museum of Science’s MVH team has developed PicturePosts. PicturePosts are inexpensive stands that can be installed in environmentally interesting locations (“Introduction to PicturePosts”, 2006). They assist in taking panoramic pictures from the exact same location over a period of time, allowing for easy recognition of changes and, by extension, trends in the local environment. Special light filters have been developed that provide a more objective technique for assessing vegetation health through photographs. The pictures can even be tied into an online map-based repository,

allowing anyone to get an overview of where PicturePosts are located in their area, and view the series of photos taken from each (“Introduction to PicturePosts”, 2006).

PicturePosts and the MVH project are strongly applicable to “Citizen Science,” the Museum of Science’s mission of getting people “involved in projects, involved in hands-on science” (B. Rogan, personal communication, January 25, 2007). In terms of educational programs, PicturePosts could easily provide the crucial entryway for getting children involved with their local environment in an active, hands-on format, collecting data from which they are then able to draw their own conclusions. There is widespread agreement that the most effective techniques for environmental education are found in hands-on activities. The importance of sparking a basic scientific interest in children is often overlooked in favor of traditional, fact-focused education. If interest in the various sciences is not transferred, future advancement is put at risk. The creation of local connections and firsthand interactions with the environment creates a foundation for positive environmental change.

While the Citizen Science and PicturePost concepts are well-founded, their organization with regard to easy integration with classrooms has not yet been developed. The MVH website is a trove of information about the posts, some of the basic concepts, as well as some very technical information regarding satellite imagery and processing (“Home”, 2006). However, not only are these sections of the site somewhat discontinuous, there is not yet any easy guide or curriculum module that teachers could access to introduce the concepts and technologies to their students. This means that few educators would be able to make use of the idea that photos taken in nature, particularly in conjunction with the MVH filters, have a wide range of educational applications to topics such as the study of plants, light, computer imaging, photosynthesis, in addition to the focus on environmental health. At this time, new PicturePosts that are ordered do not even include a basic set-up manual. Another possible area of development for MVH concerns the fact that the photos available in the PicturePost section of the website are all winter photos, primarily taken between October and December of 2005 (“SmugMug”, 2007). For those without the time to set up a post of their own, as well as to show the full effect of these photo comparisons, this particular repository of data should be expanded.

Our project's goal was to substantially increase the utility of PicturePosts and the Measuring Vegetation Health program as engaging educational resources through the development of an educator's guide. This goal was achieved in three phases: 1) by experiencing and evaluating the PicturePost installation and analysis process ourselves; 2) by creating an advisory board of educators to provide ideas, requirements, and feedback for the guide; and 3) by combining research into existing Museum guides and the MVH website with insight gathered during the first two phases to create an educator's guide. Adoption of these educational plans by schools and their communities could not only result in multiple, continuous data sources for the Measuring Vegetation Health project as a whole, but most importantly would provide all students involved with the active hands-on experience needed to create long lasting ties to, and concern for, the environment as we face modern challenges.

## **2 Background**

The Measuring Vegetation Health project is serving to advance the capabilities of scientists to analyze environmental trends. The Boston Museum of Science (refer to Appendix A) is also interested in its application for providing everyday people with a hands-on way to explore the environment. They call this focus, one the Museum applies to every project in which it is involved, “Citizen Science.” However, the science, technology and expectations involved in measuring the health of the environment can be extremely complex. This in turn makes forming a comprehensive yet understandable educational guide a very complex task. When planning educational resources for a program such as MVH, necessary considerations include: the importance of environmental education, the breadth of topics covered by the program, and the state’s educational standards and design guidelines. Therefore, in this chapter we discuss why environmental education is significant to our society, the educational potential of the MVH program, and finally, the educational standards and design guidelines that influence the extent to which PicturePosts can be used by educators.

### ***2.1 Principles of Effective Environmental Education***

The MVH project is a fascinating collection of environmental and scientific tools and principles. However, despite its applicability to a broad range of educational concepts and the basic importance of environmental education, the program has thus far been underutilized as an educational tool. If MVH and PicturePosts are going to be fully applied as educational resources, there are a number of principles to keep in mind that together illustrate the overall purpose of environmental education: its general benefit to society, its introduction of hands-on activities to children, and the formation of a local connection to the environment.

Education may be the most crucial element of a modern, functioning society, and environmental education has no less responsibility. In 1978, the first intergovernmental conference on environmental education produced three goals for all those in the field (Archie, 2005). These were: “To create new patterns of behavior...towards the environment,” “To provide...opportunities to acquire the knowledge, values, attitudes,



commitment and skills needed to protect and improve the environment,” and finally “To foster clear awareness of, and concern about, economic, social, political and ecological interdependence in urban and rural areas” (Archie, 2005). The North American Association for Environmental Education designates one of the key functions of an environmental educator as “encouraging learners to explore and understand their immediate surroundings” (Archie, 2005). As the Association suggests, “The sensitivity, knowledge, and skills gained by forging this local connection provide a base for moving out into larger systems, broader issues, and a lifetime of learning about causes, connections, and consequences” (Archie, 2005).

It would seem, therefore, that while the most basic part of an educator’s job is to inform, there is also a ‘higher’ aspiration to be imparted upon students. Avi Ornstein (2006) more clearly emphasizes this in a related study, stating, “how well students perform in academic science courses, over the long run, is not as important as their understanding of broad science concepts and their attitudes toward science” (Ornstein, 2006). This importance in fostering a positive attitude toward the field is vital to scientific progress. If children do not find science to be an interesting career choice, future advances in the field will be few and far between. In 2005, Bill Gates justified an expansion of research offices in China and India claiming that “with fewer students in math and science and a lack of national funding, the United States is destined to fall behind other countries in innovation” (Inskeep, 2005). Of course, with better science education, even those who do not end up being scientists will be more capable of making educated decisions in the political realm, whether as the head of a company or a citizen electing representatives.

One of the most effective techniques for providing a rich science education for children is through the use of hands-on activities. Avi Ornstein (2006), in an article published by the *Journal of Science Education and Technology*, justified this claim with a study concerning the effect of hands-on activities in the classroom. He concluded that it is “critical” that these activities be implemented on a “fundamental, regular basis” if education is to meet the needs of society in terms of generating scientific interest (Ornstein, 2006). Ornstein (2006) calls on educators to recognize that “hands-on laboratory activities, inquiry and direct observation are an integral component of good

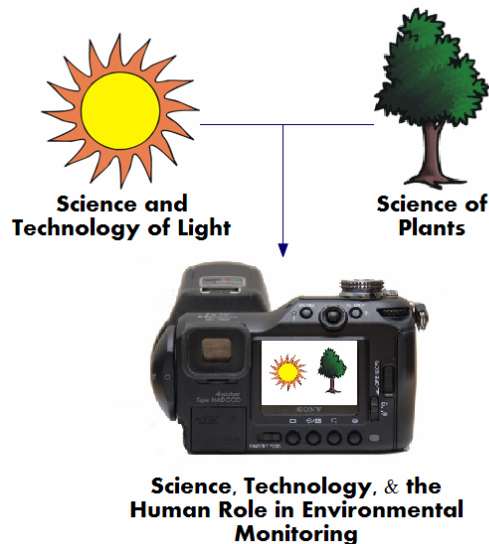
science classes”. Confirming the potential for societal impact, he added that these components “should play a part in influencing student attitudes” even suggesting that they are “as important as teaching students the fundamental concepts that make up the core of science curricula” (Ornstein, 2006). This means that purposeful hands-on activities, preferably allowing students to draw their own conclusions, should be introduced at the elementary level.

With a basic educational pedagogy established, it is important to consider what will turn the techniques and activities into a good environmental educational program. The North American Association for Environmental Education regularly publishes sets of guidelines for environmental educators (Michele, 2004). They believe not only in hands-on activities, but ones that get children outside to observe their surrounding environment. This creates what they call a “local connection” with nature, explaining that stressing “the importance of where one lives” will help keep interest levels high in the classroom (Michele, 2004). After all, if the environment’s many interconnected systems can be explained in a local setting, it is not a far leap to its larger implications. It is this concept of awareness of one’s surroundings and the ability to interact conscientiously within it that would be of such great benefit to all members of society.

In the study *Factors Influencing the Desire to Take Environmental Action in Communities*, Diane Pruneau and others put these suggestions to the test, applying a variety of engaging environmental activities to four different groups. Each sampling of people came from different social groups: the Knights of Columbus, fishermen, fourth grade students, and seventh grade students. At the completion of the activities, each party was offered the chance to help with a local environmental cause such as vegetation loss or damaged wetland areas (Pruneau, 1999). Every group accepted. “The visual observation of the problem” and “the impression that the task could be accomplished” were the primary reasons given for wanting to help, showing that hands-on activities and the formation of a local connection are certainly capable of creating interest and involvement in nature (Pruneau, 1999).

## **2.2 The Measuring Vegetation Health Project**

Environmental education plays an important role in society, and the MVH project has great potential to facilitate its effective implementation. Our main concern is PicturePosts, but first we will first describe the Measuring Vegetation Health project itself. Working from a 2.4 million dollar NASA grant in 2004 (NASA, 2006), the project has grown to involve seven partner organizations and encompass a wide range of environmental and remote sensing technologies. As seen in Figure 1, MVH integrates three topic areas: the science of plants, the science and technology of light, and the technology behind environmental monitoring.



**Figure 1: The Three Topic Areas of MVH.**

In typical Museum fashion, there is something intriguing about the MVH project for anyone from an elementary school student to a professional in the field of environmental monitoring – the MVH project was founded in an effort to spread environmental awareness to local communities. It encompasses a wide variety of subject areas, including biology, technology, and even art, all better enabling the evaluation of plant health. The project is based on the idea that assessing the health of the vegetation will give an indication of the overall quality of their surrounding environment, as expressed in Figure 2. Plants used in this way are referred to as “green canaries” – the first indication of approaching trouble. The overall goal of the MVH project is to get

middle and high school students actively thinking about plants and the quality of the environment around them, using the technology and methods developed by the MVH team (Home, 2006).

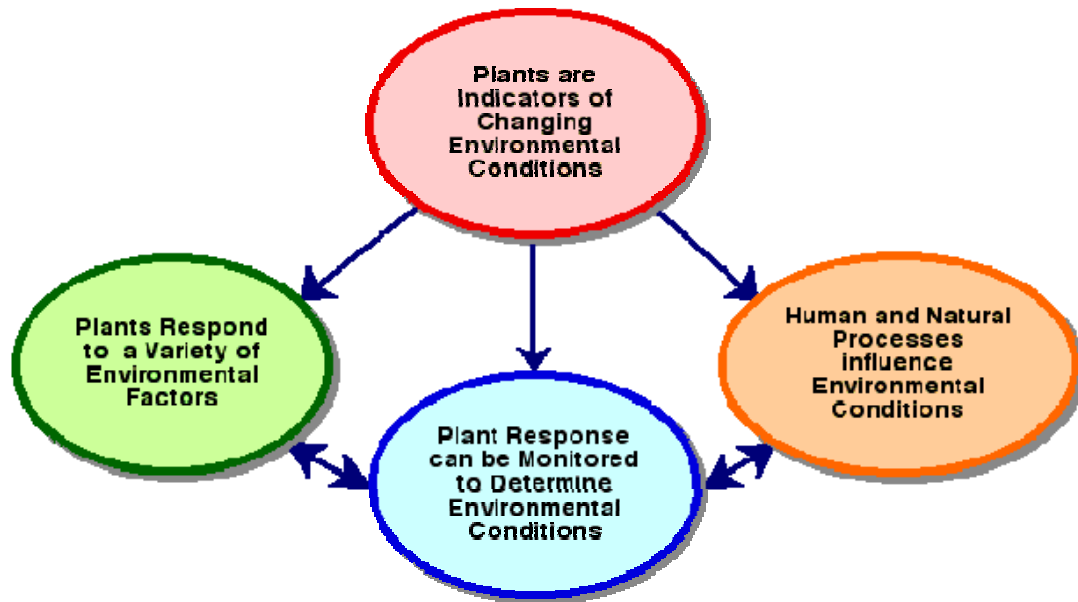


Figure 2: Connections between Plant Monitoring and the Environment. Courtesy of MVH.

### 2.2.1 PicturePosts

The PicturePost is one of the latest innovations of the MVH project. A PicturePost is a wooden post that is made from a four inch by four inch beam, with a nine inch diameter wooden circle with a five inch octagon mounted onto the beam (refer to Figure 3). There are some directions for building and installing these Posts available on the MVH website. The Posts create established locations for collecting environmental image data, as the circle and octagon provide a stationary picture taking platform. Each Post is oriented so that the sides of the octagon are facing the various cardinal and ordinal directions, such as North, Northeast, and East.



**Figure 3: PicturePost Side and Top Views (adapted from the MVH website)**

PicturePosts are used to take pictures with a digital camera, by holding the camera, with the lens facing away from the post, snug against one of the sides of the octagon. Images are collected from each of the eight positions, with an additional photo taken with the camera lens facing the sky to collect data about sunlight conditions and the tree canopy.

The intention behind designing PicturePosts was that the posts can be used by anyone who comes across them, not only scientists. Anyone can buy and install a post and take pictures of their own backyard, or use a post that has already been established. In March 2007, the greater Boston area was home to four separate PicturePost stations, two at Fresh Pond in Cambridge, Massachusetts and two at Menotomy Rocks Park in Arlington, Massachusetts. Anyone who uses the Posts can also upload their pictures to the MVH website following instructions posted on the MVH website. Although this project is intended to be used by the public, the only people recorded to have used the established posts are the Museum of Science team and students at Worcester Polytechnic Institute who have done a previous Interdisciplinary Qualifying Project on PicturePosts.

All of the PicturePosts are constructed in the exact same way, and therefore provide consistent image data, not only when compared to previous images from that post but also when comparing different posts. With all of these images available on the MVH database, the user, whether a scientist or a home user, can compare their images to the

images that have been posted from that PicturePost in the past. Some images may speak for themselves by showing vivid images of the deterioration of the plants in that landscape, which leads the user to draw correlations between plant health and environmental stresses. However, in most cases the health of the plants can not be easily determined by simply viewing pictures, and the user must refer to the MVH website for more help with analyzing the photos. The MVH website provides several different tips as well as software downloads to assist the user in drawing accurate conclusions from the images collected.

The future of PicturePosts looks bright, as a serious problem with PicturePosts has been recently corrected. These posts began as wooden structures that could be built for around twenty dollars; however the wood can begin to warp and, therefore, fail to provide an accurate orientation. MVH is currently moving forward to a plastic model which will increase durability, prevent warping, and help prevent physical deterioration of the post itself. EPS™ Plastic Lumber Company has developed a plastic PicturePost model which can be purchased for forty-five dollars. John Pickle, the previous principal investigator who remains intimately involved in the MVH project, is extremely upbeat about this development and hopes that it will prompt parks to install PicturePosts on their sites nationwide (J. Pickle, personal communication, February 8, 2007).

The development of PicturePosts is an exciting new addition to the MVH project because it is a public way to combine their three main subject areas – the science of plants, the science of light, and tools and technology – in one project. The following sections describe the details of these subject areas in order to show how PicturePosts can be used to observe the local plant life.

### **2.2.2 Scientific Principles Underlying MVH**

PicturePosts enable a user to photograph vegetation, analyze its health, and monitor any changes that take place. To fully utilize and appreciate the data collected, however, it is essential to have a basic understanding of the physical science of plants and light. Light is a factor in our everyday lives: we couldn't see without it. Just as we rely on light from the sun for survival, plants rely on sunlight for photosynthesis. All green plants contain chlorophyll, a molecule built exclusively for gathering energy for the plant

(refer to Appendix B for more information). If some factor such as a lack of nutrients, pollution, human interaction, or acid rain has adversely affected a plant or its environment, the plant may experience a decrease in its supply of chlorophyll. A lack of chlorophyll causes a deficiency in photosynthesis, plants' energy-producing process, which puts stress on the plants.

Stresses on plants can be seen visibly, although sometimes not by the naked eye. Chlorophyll absorbs red and blue light to create its energy, reflecting unneeded green light – the green light we see as the color of a plant. Poorly functioning chlorophyll means more red and blue light is reflected by the leaves, resulting in a non-pure green color to be seen. If the pure green component of this tainted reflection can be removed, the amount of extraneous colors can be measured. The intensity of non-green coloring, then, is inversely proportional to the amount of functioning chlorophyll in the plant. This phenomenon is clearly visible in Figure 4, as plant leaves die during the fall season.



**Figure 4: Chlorophyll Content Decreasing as the Seasons Change. Courtesy of the University of Bristol**

The MVH project team has developed an objective technique for analyzing the photographs taken from PicturePosts, using properties of light. The primary colors of light are red, green, and blue. During photosynthesis a plant absorbs sunlight, or “white light,” which is composed of equal parts of the primary colors. As described, a healthy plant reflects only the green light, while an unhealthy plant will reflect red and blue light along with the green light. By using filters that precisely block out green light, the levels of a plant's red and blue light reflections – and thereby the health of the plant - can be measured. With the green color removed, objects that are pure green appear black, as shown with the normally green Nutri-Grain® wrapper in Figure 5.

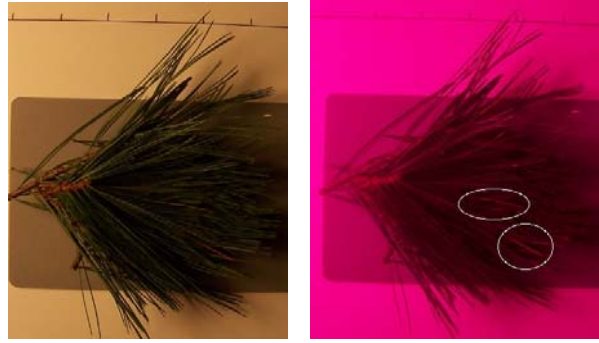


**Figure 5: Pure Green Packaging Appears Black through Filter (ideal situation)**

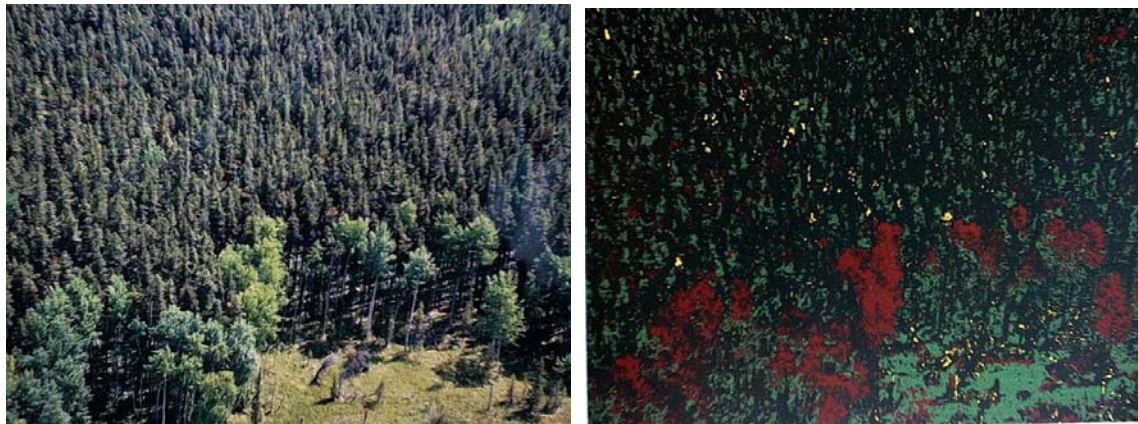
An ideal, healthy plant would reflect pure green light, and therefore appear black in a filtered photograph. Plants that are stressed, however, will not appear completely black, due to the reflected elements of red and blue light as well. (For more information about the workings of light, refer to Appendix B.) This color distribution can be measured and recorded very accurately using special filters, or appropriately colored theater gels, secured to the lens of a digital camera. This technique is very inexpensive and can be used on both small and large scale applications. The MVH project has recently started doing research on detecting plant stresses using this method (“Plant Stress Detection Filters”, 2006).

Figure 6 demonstrates the efforts of the MVH project to identify plant stresses using a light filter. The off-color, circled areas in the filtered image are damaged needles. This is a good example of small scale efforts with one single plant, even though this technology can be applied to large scale applications as well. As shown in Figure 7, larger forests and fields can be photographed using aerial photography to capture large amounts of vegetation. The red groups of trees in the bottom half of the filtered image are stressed compared to the healthy black forest that surrounds them. The filtering process can be effectively applied at any scale.





**Figure 6: Plant Stresses Identified with Light Filter (circles show where the brown pine needles are located) Courtesy of MVH**



**Figure 7: Digital Picture of Forest (no filter and simulated filter respectively) Courtesy of [www.goblinforest.com](http://www.goblinforest.com)**

Plant stress detection using filters provides a very simple and effective way to more deeply analyze PicturePost images. Using PicturePost and stress detection filters, images taken via satellite or air photography can then be more closely analyzed from the ground directly.

The use of light filters is an innovative approach to detecting the health of plants. Currently, no research has been conducted with combining the PicturePost concept and the filters. Using filters in conjunction with PicturePosts allows for more environmental damage to be detected more easily than when non-filtered pictures are analyzed. With the filters, immense damage would stand out immediately, since the damaged plants would not appear black. However, when the damage is not enough to even be seen with filters, computer programs can also be used to analyze the photos.

### 2.2.3 Photo Analysis Tools

The MVH website currently provides several computer programs for download that can be used as tools for plant stress analysis based on digital images. All of these analysis tools can be applied on several different scales, from PicturePosts to satellite images. They make up the technical aspects behind the project.

The two main programs that can be used to analyze digital photos that are taken from PicturePosts are “PixelView”, “ColorPicture”, and “MVHimage”. “PixelView” allows the user to study the effects of pixilation, a changing of the size of pixels in any digital picture. Digital images are broken up into millions of tiny squares, called pixels, which average the colors in that area of the photograph. As fewer pixels are used, the picture becomes much less clear, as large portions of the image are being averaged into a single block of color (“PixelView”, 2006). PixelView can help beginners understand the way pixels make up an image, by allowing the number of pixels used in the representation to be easily varied by the user.

Both “ColorPicture” and “MVHimage” assist in drawing accurate conclusions from the image data collected from PicturePosts. “ColorPicture” is a program that allows users to load a digital picture that they have taken and analyze the percentages of the colors in the photograph. It takes a single pixel and tells the user what percentages of green, blue, and red light are in that pixel (“ColorPicture”, 2006). By selecting a pixel within a particular plant, the user can see if the plant is only reflecting green light, or if there is red and blue light being reflected as well. The ratios of these light measurements will signal the overall health of the plant, as described in the previous two sections.

“MVHimage” is a more complex ‘analysis suite’. It allows users access to more advanced tools for analyzing the spatial and color information within any digital image. The color makeup of single pixels, lines, or any area of the photo can be determined through a simple point-and-click interface. For example, single leaves can be selected, displaying the amount of red and blue light detected from each. It even supports the export of color, length, and area measurements directly to a tab-delimited text file which may be used by any graphing spreadsheet program, such as Excel, for further analysis of results. (“MVHimage”, 2006). Both of these programs are free to download and can be used by anyone to analyze the health of their surrounding environment.

What the user does with their analysis is left up to them. A scientist would be able to use the data to back up a thesis about environmental factors. However, citizens may not have or need so specific a goal. They might just use the PicturePost program as a lesson in light, color, digital imagery and plant health. Other people may want to inform others of their findings, or take action to help their environment. This is the goal of MVH: to get people interested enough to become environmentally active. In this sense, the value of PicturePosts is immeasurable. With an engaging and effective environmental education, citizens will be able understand the project's importance and what they can do to help the environment.

## ***2.3 Educational Standards and Design***

A primary factor in the success of a new program, such as Measuring Vegetation Health, is its ability to integrate with the construction of the backbone of the educational system: the curriculum. The processes of curriculum development and educator's guide development are similar, ignoring scale. Additionally, since any educator's guide activities will ultimately need to fit within the constraints of the established curriculum, it is important to consider these processes carefully. Knowledge of current state standards and the benefits of modern "inquiry-based" or "discovery" learning practices can also assist in producing a successful, and enjoyable, classroom experience.

### **2.3.1 Overview of Curriculum**

Andrew Porter and John Smithson (2001) have observed that curriculum can be divided into 4 subcategories: enacted, intended, assessed, and learned. The 'enacted' curriculum is what the majority of people think of when they hear the term curriculum; it refers to the actual content that the students are required to grapple with and absorb while in the classroom. The 'intended' curriculum refers to the guidelines and restrictions that the curriculum must follow such as national or state science standards. The 'assessed' curriculum is represented by the subject areas required to be covered for a student to perform well on standardized tests, like the Scholastic Aptitude Test (SAT) or the Massachusetts Comprehensive Assessment System (MCAS). Finally, the 'learned' curriculum, as the name indicates, is a measure of how much students learned what they

were being taught. Porter and Smithson suggest that it is important to know not only what the students have retained, but to what extent they have become adept in that subject area. Learned curriculum should consider both the depth and the breadth of the student's learning.

While these four components serve as an outline for curriculum development, any program should also account for the cognitive demand and mode of presentation it will assume (Porter and Smithson, p.7-10). 'Cognitive demand' refers to what the student will be required to do as part of the course, including activities and subject requirements, and how they will be accomplished. Some examples of cognitive demand are memorization and problem solving. 'Mode of presentation' refers to how the material is presented, whether through lecture, activity, experimentation, or any such method of education. The mode of presentation also includes the style and structure of the activities, such as the use of models, formulas, or hands-on activities, whether there are specific steps to follow or conclusion to reach. These particular attributes, cognitive demand and mode of presentation, are what makes a curriculum and its constituent parts unique (Porter and Smithson, p.7-10).

In addition to the considerations named above, there are some more practical aspects to keep in mind. Teachers work under strict expectations, not only for what they teach but when they teach it. These time constraints can limit an educator's ability to take on additional lesson plans and hands-on activities. As a result, it is difficult for a new program or set of lessons to unseat those that are already integrated. Therefore, it is vital that any developed guides are not only accurate and effective, but straightforward and tightly focused. The Museum works with schools on a regular basis, developing and implementing such guides. We contacted Henry Robinson in the Museum's Educational Resource Office and located a wide selection of past teacher's guides on many different subjects. We found useful examples of procedural explanations, ways of suggesting opportunities for further exploration, rubrics for student evaluation, and other included components and formatting tips. Such guidelines for past educational programs are exceedingly useful for quickly gaining insight when developing one of your own.

### **2.3.2 Correlation between State Academic Standards and MVH**

Any classroom activity developed needs to follow the state's academic standards if it is to be used in schools. However, even projects not necessarily used in a school setting – such as those used by summer camps or interested citizens at home – could benefit from following these standards. The Massachusetts Department of Education (2006) prepares and publishes a framework of standards for education every few years. The MVH project seems to strongly support both the life science and technology subject areas. The two age groups with the greatest correlation of required subject areas relating to the MVH project are grades 6-8 (middle school) and high school.

The state standards apply to the entire curriculum taught over a series of courses for several years. Therefore, it is difficult to read the requirements and determine which specific set of standards should be incorporated in a particular lesson plan. One that stands out remarkably well in all grade levels, be it high school, middle school, or elementary school, is the process of experimentation. The standards mention that a student needs to learn the process of experimentation, from designing an experiment to data collection to analysis and conclusions (MA Dept. of Education, 2006, p. 7). A lesson in MVH can cover all of these aspects of experimentation. The students would be able to write up a lab notebook about the process of using a PicturePost, which would be a great way to introduce the concepts of experimentation to students.

The life sciences aspects of MVH – photosynthesis in plants and the effect of the environment on plant health – fits in best with the state's middle school standards, as seen in Table 1.

**Table 1: The Massachusetts State Academic Standards for Grades 6-8. Courtesy of the Massachusetts Department of Education**

<b>Life Science (Biology), Grades 6–8</b>	
LEARNING STANDARD	IDEA 3 FOR DEVELOPING INVESTIGATION 3 AND LEARNING EXPERIENCE 3
<b>Energy and Living Things</b>	
<b>14. Explain the roles and relationships among producers, consumers, and decomposers in the process of energy transfer in a food web.</b>	Distribute pictures of various producers, consumers, and decomposers to groups of students. Have each group organize the pictures according to the relationships among the pictured species and write a paragraph that explains the roles and relationships.
<b>15. Explain how dead plants and animals are broken down by other living organisms and how this process contributes to the system as a whole.</b>	Observe decomposer organisms in a compost heap on the school grounds, a compost column in a plastic bottle, or a worm bin. Use compost for starting seeds in the classroom or in a schoolyard garden.
<b>16. Recognize that producers (plants that contain chlorophyll) use the energy from sunlight to make sugars from carbon dioxide and water through a process called photosynthesis. This food can be used immediately, stored for later use, or used by other organisms.</b>	Test for sugars and starch in plant leaves.
<b>Changes in Ecosystems Over Time</b>	
<b>17. Identify ways in which ecosystems have changed throughout geologic time in response to physical conditions, interactions among organisms, and the actions of humans. Describe how changes may be catastrophes such as volcanic eruptions or ice storms.</b>	Study changes in an area of the schoolyard or a local ecosystem over an extended period. Students might even compare their observations to those made by students in previous years.
<b>18. Recognize that biological evolution accounts for the diversity of species developed through gradual processes over many generations.</b>	

A guide designed around the use of PicturePosts can be adapted for use by all age groups. The high school standards don't directly deal with the issues covered in MVH; however, many high schools are offering environmental science classes that are not mandatory to graduate. The process of using PicturePosts would lead into a discussion about middle school topics such as photosynthesis (see point 16 on Table 1) as well as how human interaction affects the environment (see point 17 on Table 1). This type of guide would also discuss the qualities of light, pixels, and using computer programs for analysis, which is beyond the standards. However, as our world becomes increasingly technological, knowledge in these subject areas will certainly prepare today's students for the future. A high school group would be more likely to go in depth into the methods for

environmental monitoring. They could simply review the concepts and focus on the details of the changing environment. Meanwhile, elementary school students could be introduced to topics such as how light combines and reflects and why leaves change color. No matter what the age group, however, PicturePosts can help teachers meet their requirements in a more hands-on way than providing students straight facts. Additionally, if aspects of “inquiry-based” or “discovery” learning processes were included in an educator’s guide, the potential for the program to foster environmental interest in the students is again increased.

### **2.3.3 Discovery Learning**

Educational philosophies such as inquiry-based or discovery learning have been rapidly gaining in popularity, and for good reason. The traditional process of experimentation in grade schools uses strongly controlled, packaged activities with straightforward and often expected results. The answer is known by the instructor ahead of time, and students are led to “the answer.” Some would argue that this method does not truly emphasize the scientific process of drawing conclusions based on facts, as students are rarely tasked or trusted to make conclusions on their own (Arvai, 2004).

Inadequate ability to reach conclusions has several typical causes (Arvai, 2004). Many times the lack of information or the poor quality or inaccuracy of information will lead to a faulty conclusion. This is easily remedied by teaching the students to record their actions (part of the process of experimentation) and to take complete data (i.e. pictures from all angles). The progression from data to conclusion can also be influenced by how the material is presented. A study conducted by Arvai et al. (2004) has shown that one group of students will snub information that another group embraced simply because the second time it was expressed in a more negative way. Teaching students how to see through these biases, by breaking down the data in an objective way, will help them more easily discover the significance of information. For example, constructing matrices to show the various implications of each piece of information can help students find an unbiased way of weighing their importance (pp. 1-33). This will, in turn, help them be able to see all of the potential consequences of various human actions, so that they may impact their local environment in a positive way.

PicturePosts can help develop a user's skill in developing conclusions. Since they do not necessarily represent controlled experiments, there is no need for a 'control' group or 'proper' result for the program to be effective. The plants may be affected in ways that are unexpected, providing teachers the opportunity to help students reach conclusions based only on their environmental knowledge and the observed reality. Answers are not 'right' or 'wrong' and must often be imaginative. These inquiry-based or discovery learning techniques more effectively engage students in critical thinking and may help spark a lasting interest in experimentation and science.

## **2.4 Conclusions**

This chapter has described how to provide engaging environmental education, activities and information developed by the MVH and PicturePost programs, and the guidance of the educational system and its design. All of these components could be combined to create a program with the potential to influence its local community. An educator's guide involving PicturePosts that gets students excited, includes discovery learning, and is supported by school faculty has a high chance for success in being such an influence. Illustrating this point, we present the following case study of a program with an educational goal similar to MVH that was implemented in Molokai, Hawaii. In it, an educational program developed by the local community achieved extremely encouraging results with regard to its positive impact on society.

The community in Molokai decided to employ an educational program called "Investigating and Evaluating Environmental Issues and Actions" at the fifth and sixth grade levels. This program introduced the students to local environmental problems while they collected and analyzed relevant data. Within 5 years of implementing this curriculum, there had been a measurable impact on the community (Volk et al., 2003).

After polling a group of students involved in the program and a group of students who were not involved in the program, some interesting results were revealed. Over 88% of the students in the program, compared to 25% of those not, afterwards "consider[ed] themselves knowledgeable about the environment." Similarly, 75% of the students in the program said that they had individually taken steps to protect the environment. Only 43% of the students who were not involved could say the same (Volk et al., 2003). One



community member said, “the children, students, the young people--they are setting the example for the entire island. When adults say to people, 'Pick up litter; don't litter the land,' it goes in one ear and out the other. But when you see these kids actually researching and doing, I think that it makes an impact on the entire island” (Volk et al., 2003). This curriculum has caused this community to be awakened in an environmentally conscious sense (Volk et al., 2003).

From this example it seems clear that a successful lesson plan based on MVH does indeed have the potential to impact the community around it. The fact that the Molokai program caused 75% of its students to take environmental action is impressive and significant. The goal of MVH is to create environmentally aware citizens, and this program seems to have confirmed it as possible. However, to succeed a program needs to be carefully developed and supported by the school's administration and faculty. The next chapter will discuss how we attempted to produce a program of that caliber.

### 3 Methodology

Our project’s goal was to substantially increase the utility of PicturePosts and the Measuring Vegetation Health program as engaging educational resources through the development of an educator’s guide. We envisioned three smaller tasks as integral to this accomplishment. This chapter will discuss these discrete goals and what specific actions were taken to accomplish them. First, we analyzed the MVH project’s existing PicturePost implementation resources, manuals, software, and other materials that were available on the MVH website. By installing two new PicturePost stations in Menotomy Rocks Park in Arlington, Massachusetts, we were able to experience the entire PicturePost process first-hand, allowing us to identify potential changes and additions. Second, we formed an Advisory Board of teachers and educators who could aid in the formation of an educator’s guide and give feedback on the PicturePost process. Finally, using our experiences, information provided on the Measuring Vegetation Health website, and past Museum-constructed examples, we developed an educator’s guide based on PicturePosts and the MVH project for educators and interested environmental groups. These three main objectives are illustrated by Figure 8. For a Gantt chart outlining this process, refer to Appendix C.

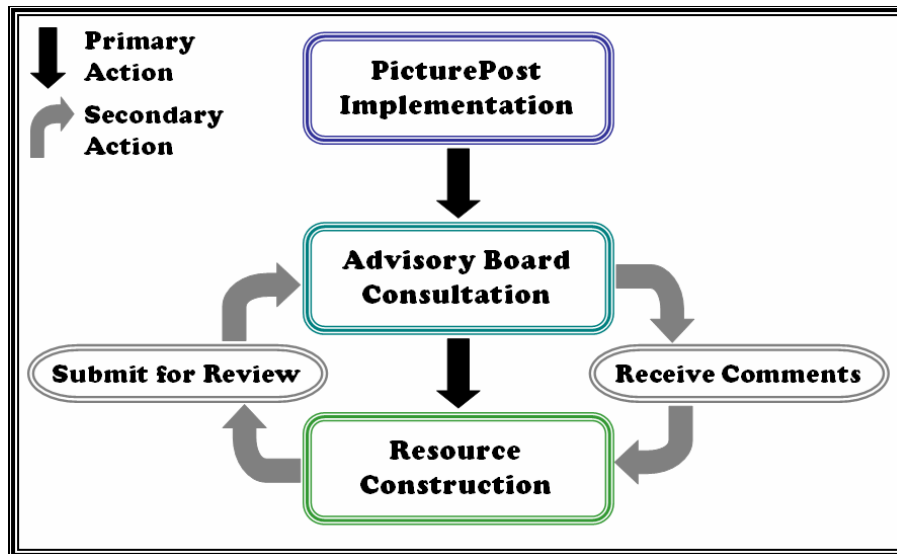


Figure 8: Our MVH Project Plan

### **3.1 Analysis of PicturePost Implementation**

In order to better teach others how to use PicturePosts, we needed to learn how to install and use PicturePosts ourselves. We understood that by performing the entire PicturePost process (installing posts, taking pictures, and analyzing data), we would find gaps in the documentation of that process. Installing a new PicturePost was a straightforward process. After we learned how to choose a suitable spot, the post needed to be secured in the ground in its proper orientation. A few important tasks included adding the new post to the MVH database and website, doing extensive analysis of both the new photos as well as existing ones, and, of course, carefully documenting every step of the process to address the gaps. We used the process learned to draft an installation manual for PicturePosts.

#### **3.1.1 Location Choice**

Choosing an ideal PicturePost location is crucially important as it will directly influence the quality of data collected in that area. However, there were no criteria available for choosing a new PicturePost location. To address this gap, we discussed the problem with John Pickle, the co-founder of the MVH project. We also inspected the existing locations to find similarities that may have led to the selection of those locations. We examined the environmental criteria and outside factors that would have influenced the decision to place the posts in their prospective locations. Before installing the new posts, we ensured that the locations chosen abided by the criteria that we developed.

#### **3.1.2 PicturePost Installation and Data Collection**

The PicturePost installation was a necessary part of the entire PicturePost process, which we documented in order to create an installation manual. The Engineered Plastic Systems Company began mass producing a recycled plastic PicturePost product. The new plastic posts remained very inexpensive and also had much better weather resistance. We installed two posts at the Menotomy Rocks locations that were chosen by the Friends of Menotomy Rocks Park association. We approved these sites based on our location criteria before installing. The new PicturePosts were one of the team's primary deliverables.

Data collection from all the posts, including the newly installed posts, was performed on a weekly basis (see Appendix D). We took pictures with a bare lens, but also with the purple filters. We uploaded all of the image data collected during the term to the smugmug database website alongside the previously collected data. These photos are made available to the public and interested scientists for analysis. We uploaded these photos following the instructions provided on the MVH website and were able to analyze those instructions for gaps that we later addressed.

### **3.1.3 Image Analysis**

The next important step in the PicturePost process was data analysis. We spent time working with all of the software provided by the MVH website. We used the information obtained by using the software and developed a software guide to teach users how to analysis PicturePost data.

As well as using the software, we also drew our own conclusions based on the unaltered images, which was also important for analysis. Color and plant health variances could be seen by observing both regular PicturePost images as well as filtered images, which was helpful when identifying the possible causes of the plant stress, something the software cannot do. This completed the PicturePost process.

## **3.2 Advisory Board Consultation**

Having experienced the PicturePost process ourselves, we wanted to begin as soon as possible to make use of both available and discovered information to form a resource for educators. We believed that the best way to know what teachers would want from an educator's guide was to get ideas and feedback from teachers themselves. There are several ways in which we could have done this. We could have surveyed teachers, visited local schools, interviewed individual teachers, or created an advisory board of interested educators. We decided to create an advisory board for several reasons. First, with an advisory board, we were able to teach them enough about the MVH project and PicturePosts to get quality ideas and feedback from the board. With any other method, the teachers would not know enough about the project to truly understand what we were doing. Another advantage to an advisory board was that we all met in the same room,

which enabled teachers to brainstorm and bounce ideas off of one another and improved the value and depth of their ideas. An advisory board also gave our sponsor interested teachers to pilot test the educator's guide on after we have completed our project. An advisory board was also able to enhance the credibility of the educator's guide; in addition to having the support of the Boston Museum of Science, we were able to say our educator's guide was developed with the help of an advisory board of Massachusetts teachers.

### **3.2.1 Assembly**

The first step in assembling any kind of group is making sure each member has sufficient interest and incentive. To that end, we created an advertisement that was posted on the Massachusetts Area Science Teachers (MAST) website, as well as sent via email to area science teachers through the University of Massachusetts. This advertisement (see Appendix E) introduced PicturePosts and mentioned that we were looking for an advisory board to help create a guide for educators. We also offered a complimentary PicturePost and \$100 stipend to the teachers who were chosen in return for their ideas and feedback. We received 38 responses to our initial advertisement, and a secondary email was sent to those teachers asking for detailed information about their school, what grades and subjects they teach, if they have a wooded area to place a PicturePost, and how they would be able to use a PicturePost with their classes.

In order to ensure that we got a fair sampling of opinions, we decided to have a board of ten teachers. We created a decision matrix, so that the teachers would be picked in the most objective way possible. They were rated in four categories: "Wooded Area", "Multiple Classroom/Community Use", "Classroom Opportunity", and "Quality of Idea/Enthusiasm" as can be seen in Table 2:

**Table 2: Our Selection Criteria and Rating System**

Heading	Scoring	Meaning
Wooded Area	0 or 10	Knew a specific area to place their post
Multiple Classrooms / Community Use	0 or 10	Specifically named or mentioned that more teachers at their school who would use the post or was installing the post in a public place
Classroom Opportunity	0 to 10	Explained that they would be able to use in classroom (higher points for specific details on which classes would be able to use a post)
Quality of Idea / Enthusiasm	0 to 10	Explained a well thought out use for the post (scoring subjective)

The Wooded Area and Multiple Classrooms categories were only able to get a score of 0 or 10 because these were straightforward issues; either they have a wooded area or they do not. The Classroom Opportunity and Quality of Idea categories were given a rank between 0 and 10 because of the variability in answers. Each member of our group rated each teacher individually. We then tallied all of the totals and invited the top ten teachers to be on our board, as well as created a list of alternates. If our invitation was refused, we sent an invitation to the next highest ranking alternate. We plotted out the locations of each teacher on a map of Massachusetts to ensure that we had a fair distribution.

### **3.2.2 Orientation**

We had several goals that we set out to achieve during our PicturePost Teacher Orientation. We wanted to inform the teachers about the MVH project so that they would be able to have a clearer understanding of what was being asked of them. We also asked them to install their PicturePosts as soon as they could, so that we could clarify any installation problems that may arise and include that in our guide. We were also requiring them to give us feedback on the manuals and the educator’s guide, as well as any other ideas that they had for additional activities.

We held a three hour orientation meeting in the Museum of Science's Hodgkinson Room. The teachers were given their PicturePost at the orientation. We gave a detailed presentation explaining the concepts behind the Measuring Vegetation Health project, the analysis software available, and how PicturePosts can be used for educational purposes. We gave them a tour of the MVH website to familiarize them with how to navigate those pages.

We developed and administered a questionnaire, included in Appendix G. The questionnaire asked them to answer some basic questions, such as what classes they teach as well as how much class time they could devote to this project. We also included some thought questions, such as what ideas they had for activities or what problems they could foresee in completing this project with students. We intended to use the questionnaire as a tool not only to get some individual feedback from the teachers, but to also aid their brainstorming to initiate our discussion, which we started when they were done filling out their questionnaire. This allowed the teachers to ask specific questions and bounce ideas off of each other and the MVH team.

We gave each board member a folder containing the installation and software manuals, what we had done on the educator's guide, which included a few sample activities, the questionnaire, a filter, and a CD containing all of the materials, sample pictures, and a few software programs. Before the orientation ended, we asked them to look over the materials that we gave them and provide feedback before they got their stipend.

### **3.2.3 Continued Feedback**

After orientation, we had some occasional, brief contact with the board through email when we hit a roadblock or found that we needed further clarification of something that was said. We received feedback and comments on all of the materials that we had provided. With these thoughts in mind we performed our final revisions, making additional contact as needed. The idea, of course, was to create a program that could be distributed and stand on its own, so all questions or concerns were of great importance to us and were addressed to the best of our ability in the final product.

### **3.3 Resource Construction**

By combining the information gathered by our PicturePost- and advisory board-related methods (Section 3.1 and 3.2), as well as our background research into existing materials (Section 2.3.1), we constructed an educator's guide.

The goal of the educator's guide was not only to give lessons and activities that a teacher can use, but to also include background information on the MVH project as a whole. We needed to first familiarize the educators with the concepts and tools of the project before they could pass that knowledge on to their students. We decided to include both the installation and software manuals in the Guide to aid teachers in the technical aspects of the project. With the technical background covered, we used the input we received from the teachers on our advisory board, as well as information gleaned from the website, to design engaging hands-on activities for children. In creating these activity guides we referred to past guides developed by the Museum, as discussed in our Background. These gave us an idea of expected formatting, detail of content, and overall function of these types of resources.

As mentioned earlier, after developing this initial draft of the educator's guide, we submitted it to our advisory board during the orientation for additional input. With the second round of suggestions and requests for clarification we were able to increase its breadth and effectiveness. This method of development allowed us to produce several drafts, which improved the quality of the guide.



## **4 Findings**

In this chapter we will identify the gaps discovered in the PicturePost program's documentation and how we decided to resolve them. Second we summarize our workings with the advisory board, including an analysis of their input. Finally, we present the educational resources we developed as the primary goal of this project: increasing the educational utility of the Measuring Vegetation Health and PicturePost projects.

### ***4.1 Gaps in PicturePost Documentation***

While working with the PicturePosts, we came across five primary gaps in the documentation of the program, other than the lack of an educator's guide. In this section we describe these identified gaps and the ways in which we addressed them during the development of new PicturePost documentation. They include standards for collecting sky image data, criteria for choosing PicturePost locations, instructions for implementing the new plastic lumber PicturePosts, instructions for using the PicturePost analysis software, and finally, more informative visuals for the MVH website.

During our initial data collection we were unable to locate any information about how to capture the sky image. The image of the sky from the post offers a large amount of information that none of the other eight pictures from the post can provide. Images up to this point have no reference as to how the sky image is oriented. We decided that during the sky shot, the bottom of the camera should be oriented along the north face of the PicturePost. This reference will keep the images standardized and useful for comparison. With a minor adjustment to the camera settings, short movies could even be taken from the PicturePost sky shot to track cloud movement.

As we progressed deeper into the PicturePost process and prepared to install a new PicturePost, we discovered the MVH website did not provide much information as to choosing the location of a Post. Location choice can be the most important part of the PicturePost station and more information on the topic was necessary. After continuing discussion with John Pickle on his choices for the current post locations, we developed a list of criteria and suggestions to enable the user to establish the post in an area that will

maximize their observations and results. We defined two main considerations, each with separate criteria.

- **Educational Merit**

- **Provide a look at different aspects of the ecosystem:** The location should access a variety of both plant and animal species to observe their interaction.
- **Have at least one easily identifiable landmark:** Such as a large tree or bush, having a predominant plant to observe allows users to pick one plant and observe how that one plant is changing along with the rest of the ecosystem.
- **Ability to observe different layers of the ecosystem:** Observation of the different layers (herbaceous, shrub, and canopy) provides comparison between different plant species and how they green up or green down in relation to each other.
- **Sky image:** Provide a clear image of the tree canopy to observe green up and green down cycles or clear image of the sky for meteorological observations.

- **Outside influences**

- **Vandalism:** Although this is yet to be a serious issue for the project, it is best to use caution and choose a location with minimal risk for vandalism.
- **Extreme weathering:** Areas with tendency to have severe erosion or flooding (i.e. Steep hillsides). Any area in which the integrity of the post can be compromised and eventually dislodged is not a good location choice.

Another gap we identified while beginning to install new Posts was the lack of information pertaining to the new plastic lumber PicturePosts. No update on how to work with the new product was available either on the MVH website or from the manufacturer. The new product is constructed of plastic lumber and information on how to build or maintain wooden PicturePosts is no longer applicable. We have created an instruction manual for installing the new PicturePosts, including information on location choice, installation instructions, taking pictures, and contributing them to the PicturePost database. This manual is described in greater detail in Section 4.3.2. The manual we developed is also intended to fill the gap presented by the lack of any ‘getting started’ manual being shipped with the newly ordered Posts.

We also found that the PicturePost program was missing a manual describing how to use the various pieces of image analysis software developed by John Pickle. He has continued to create both new software titles, such as an automatic photo renaming program, as well as new versions of previous software, all of which are available on the MVH website. As we assembled the educator’s guide, we decided information on how to use the software related to PicturePosts should be highlighted, making it easier for students and teachers to become familiar with the software.

The last main issue we found involved out of date or unclear visuals on the MVH website. The website itself will soon be taken over and redesigned by the Museum of Science; however, we felt some of the visual aids needed to be updated and improved. We have redesigned some of the main visuals related to the MVH project concepts to better incorporate the main goals of the project. For example, Figure 9 shows the previous visual representing the three primary aspects of Measuring Vegetation Health as well as our updated version of the same image, which we feel better communicates the relation between the three branches of the program. New images and visuals were also created for the “science of light” section to better understand the mixing of colors and understanding of pixels.

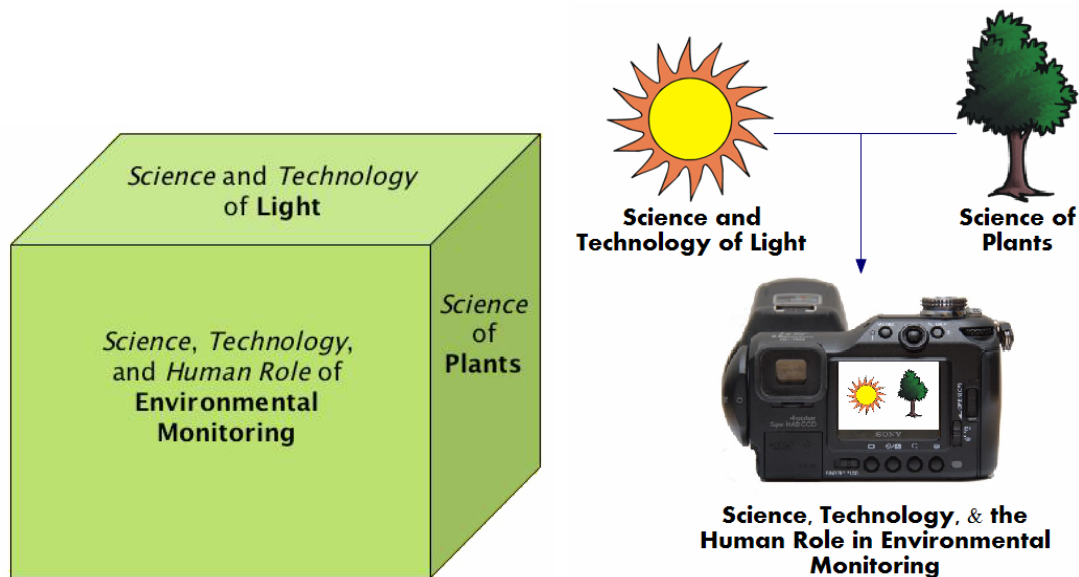


Figure 9: MVH Website Visuals, Before (left) and After (right)

## 4.2 Interactions with Advisory Board

The educators in the advisory board provided us with important input and feedback throughout the resource construction process. Our interactions with the advisory board consisted of four phases, each with its own results: the actual formation of the board, the preparation of an orientation meeting for the members, the board's initial impressions of the program, and their revisions and suggestions for the educator's guide.

### 4.2.1 Advisory Board Formation

During the process of gathering teachers for the advisory board, we created a key resource for the Museum and the MVH project moving forward: a database of thirty-eight volunteer teachers, the reasons they are interested in an environmental project, and their locations throughout the state (see Appendix F for partial entries for the members of our advisory board). We selected a board of ten teachers, from nine different organizations, who taught at two distinct grade levels as can be seen in Figure 10. The geographic distribution of the teachers spread across Massachusetts and included one member from Rhode Island, as seen in Figure 11.

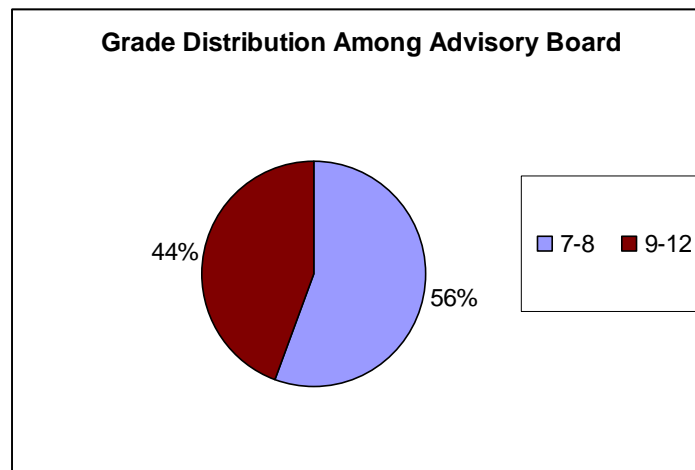


Figure 10: Grade Distribution of the Advisory Board



**Figure 11: Geographic Distribution of the Advisory Board**

This distribution is important since every member of the board received a PicturePost. This means that there are going to be nine more posts across the state (and one in Rhode Island), which will greatly add to the scientific value of the picture database. This will allow anyone who is analyzing the photographs from the smugmug website to view and compare the vegetation from different parts of the state.

This teacher database is important to the MVH project, since it is a listing of teachers who are interested in the program. Therefore, these teachers would most likely be willing to participate – and indeed are participating – in a pilot study of the educator’s guide and any other materials that may be developed in the future. This group of contacts will be helpful for the Museum as they develop the project in the future.

#### **4.2.2 Preparation for Orientation**

The primary document prepared for orientation was a prototype of the educator’s guide itself. This initial draft was developed through research on the MVH site, reference to previous Museum of Science educator’s guides, and our own team brainstorming. The MVH website’s focus on the science of plants, the science of light, and digital image technology guided the focus of our lessons, as well as providing material for the guide’s background “getting started” information. The past guides we reviewed gave us an idea of what is required in such an introduction section, how guides can be organized overall, and interesting formatting examples for the lesson sheets and worksheets themselves.

More specifically, the review encouraged us to add a “Using This Guide” section to our resource, describing its focus and applications. The prototype educator’s guide included the following chapters:

- **Introduction:** background summary of the MVH and PicturePost programs, goal of guide, and necessary materials for the lessons
- **Indoor Unit:** three example lessons and a worksheet, intended to be completed indoors as preparation for the PicturePost activities
  - The first lesson introduced the primary digital colors, and how to determine what colors objects around the classroom are made up of.
  - The second lesson involved an investigation into photosynthesis, leaf color, and plant health.
  - The third lesson teaches about pixels and how a digital image is constructed.
- **Outdoor Unit:** two example lessons describing ways of involving children with the PicturePost program
  - The first lesson connects everything learned in the previous unit about photosynthesis and how pixels measure colors, and explains how to use a PicturePost to determine the health of vegetation in the local area.
  - The second lesson takes the concept of measuring vegetation health and encourages educators to apply it to measuring changes in health over time.
- **Software Manual:** step by step instructions for using software mentioned in the lessons
- **PicturePost Manual:** step by step instructions for installing the PicturePost, taking pictures, and uploading pictures

This prototype educator’s guide gave the advisory board members a starting point for making use of the Posts with their classes as well as allowing them to give us feedback on and new ideas for the guide’s organization and lessons.

### 4.2.3 Initial Impressions of MVH

In meeting with the advisory board during the PicturePost orientation, we received an overwhelming response to the prospect of incorporating the PicturePost project into the classroom. The board developed lots of different ideas as to how PicturePosts can be incorporated into the classroom, used for extracurricular activities, as well as by local park programs. They suggested the program was applicable to the subject areas shown in Table 3. While many board members reiterated applications to general and environmental science and measuring vegetation health, others had intriguing ideas concerning topics such as weather and geography. We considered such rapid expansion to applications beyond the basic MVH program very promising for the potential utility of PicturePosts.

**Table 3: Concepts Related to PicturePosts Identified by Advisory Board**

<b>Concepts or Courses</b>	<b>Number of responses</b>
general science	7
environmental science	4
biology	3
light	3
digital imagery	2
water	2
weather	2
art	1
geography	1
math	1

The questionnaire we distributed during orientation sparked lots of feedback as to the best way to use PicturePosts and the surrounding technologies. Table 4 summarizes the educators' suggestions for activities PicturePosts could help them perform with their students. As expected, the board believed strongly that the project ties to all aspects of general science as well as art and technology topics. We received advice suggesting we

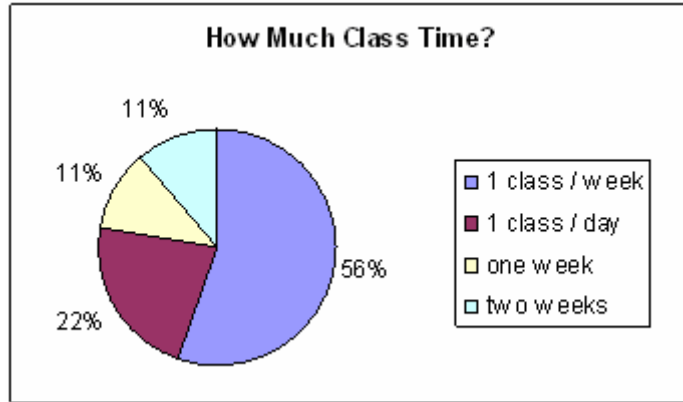
relate PicturePost to topics such as mapping, GPS/orienteering, observing plant/water changes, meteorology, comparing locations and drawing conclusions, and observing plant species. The results nearly speak for themselves: the board concluded that PicturePosts, along with the MVH project, provide a “toolkit” for creating better ways to teach several different concepts as well as being a great way to connect the concepts to each other.

**Table 4: Potential PicturePost Activities Identified by Advisory Board**

<b>Potential Activities</b>	<b>Number of Responses</b>
observing greening / plant changes	8
comparing two locations	6
Project	3
identifying clouds	2
identifying plant species	2
Mapping	2
observing animal species	2
observing water changes	2
using filters	2
gps / orienteering	1

Another question we posed the board was how much class time they thought they could devote to activities involving PicturePosts. This gave us insight not only into their time constraints, but also how much they valued what PicturePosts have to offer. Most thought they would find connections to parts of the project about once a week. We were surprised to see such a high level of support and commitment to the project in such early stages.





**Figure 12: Class Time Available for PicturePost Activities Identified by Advisory Board**

We also asked the board if they could identify any extracurricular school clubs that might be interested in PicturePosts. This provided us with one measure of interest and likelihood of continued use, but also possible additional applications outside the classroom for the program itself. Some of these suggested applications are shown in Table 5.

**Table 5: Potential Club Interest Identified by Advisory Board**

Related Clubs in School	Number of Responses
science	3
technology	3
environmental	2
none	2
photography	2
adventure club	1
physics	1

Along with all of the positive response we also received valuable feedback on what the board members thought were potential barriers facing the PicturePost program as it's moved into schools. One of the board members commented: "The main challenge is the availability of a quality digital camera." Not all schools have the technology resources that the PicturePost program suggests. Other issues included "filtering through

the large amount of material available” and “incorporating activities in a crowded curriculum - time factors” which can be seen in Table 6 below. Overall, however, it is important to note how few responses identified potential barriers.

**Table 6: Potential Barriers to Use of PicturePosts Identified by Advisory Board**

<b>Potential Barriers</b>	<b>Number of Responses</b>
computer	2
time	2
amount of information	1
digital camera	1
getting to site	1
software	1

#### **4.2.4 Guide and Manual Feedback**

In the weeks following the orientation meeting we received additional feedback from all ten members of the advisory board regarding their PicturePost installation experiences, new lesson ideas, and suggested revisions to our educator’s guide. These user opinions greatly assisted us in identifying unclear or lacking areas in our material, as well as providing us with thoughts on new content.

Some of the comments brought to light practical gaps in our own documentation. We had included in the manual an informational sheet intended to be mounted on the Posts, previously designed by the Museum’s MVH team. Unfortunately it was a little too wide for the new thinner plastic Posts, making it more likely to get knocked off. One teacher helpfully suggested using a Dremel saw to etch the ‘north’ indicator into the top of the Post. Another teacher had difficulty with the photo renaming process, as the instructions were spread across two pages in the manual. These seemingly small changes can mean a lot for usability, which is a prime concern when hoping a group will adopt a program.

The educators were very appreciative of our inclusion of lesson suggestions in the educator’s guide. Most found installing the Post, learning the software, and taking initial

pictures fairly time consuming, and were glad to not have to develop initial lesson ideas. One teacher even planned to have her AP Environmental Science students design a year-long project involving the photos from PicturePosts, adding “I would also like them to design some activities in photo analysis using the software for my freshmen.” Overall, the format and focus of the educator’s guide seemed very well embraced. As another teacher proclaimed, “I really think I can use PicturePost as an overall theme or tying [the] knot with all of my units.” We made sure to add encouragement for teachers to get excited and come up with their own applications.

### ***4.3 Development of Educational Resources***

Our experiences with PicturePosts and the advisory board greatly assisted us in achieving our goal of creating educational resources for the MVH project. We designed two types of resources: the educator’s guide and manuals covering PicturePost installation and software use. None of these resources existed in comprehensive form and should now be available to benefit educators as well as purchasers of PicturePosts and even visitors to the MVH website.

#### **4.3.1 Educator’s Guide**

The primary focus of our documentation development was placed on creating an educator’s guide that would inform teachers about the MVH and PicturePost programs and ease integration into their curricula. The guide was created in two phases: the prototype of the guide, described in Section 4.2.2, and the final draft. The final draft was created using the new ideas and feedback obtained during the orientation meeting (Section 4.2.3) as well as subsequent feedback from the board (Section 4.2.4). It is included in Appendix H.

Moving from the prototype to the final draft, the basic structure of the guide went through minimal changes. In an attempt to clear up some early confusion about where to find materials and what the software does, we split the prototype’s introductory section into two chapters: a basic Introduction about the program and guide itself, and some Getting Started information. This new Getting Started chapter first describes suggested materials and then the purpose of the three utilized software programs. One teacher

expressed her desire to use PicturePosts to evaluate whether her students “can correctly record data using appropriate language and units in an organized way.” We added a section to the Getting Started chapter describing the program’s relation to the Scientific Method, and suggesting it be applied throughout. The PicturePost project, involving data collection, analysis, and drawing of conclusions is a clear application of the Scientific Method. Highlighting this connection not only insures that students are getting the most out of their collected data, but provides yet another tie-in to school curriculums that we had previously not thought of stressing.

The members of the board expressed appreciation for the format of the lessons included in the guide. Providing step-by-step directions and building up to broad lesson extensions gave educators the guidance to start using PicturePosts while allowing them to mold the program to their individual needs. The final lesson structure, originally adapted through our research of past Museum guides, follows:

- **Objective:** a short statement describing the intention of the lesson
- **Getting Started:** required introductory and background material pertaining to the lesson
- **Procedure:** steps for engaging students in the material
- **Thought Questions:** example questions to evaluate deeper comprehension of the material
- **Extensions:** opportunities for applying more advanced MVH concepts to the lesson for varying amounts of time and skill levels

As described in Section 4.2.2, the prototype guide contained five suggested lessons for indoor and outdoor applications. These lessons were very well received, so we moved forward with constructing more specialized lessons involving some of the unique PicturePosts applications proposed by the board. We created a new chapter for these new lessons entitled More Applications. Four new lessons were included:

- **Discovering Erosion:** Investigating erosion by constructing mounds of different materials and monitoring their size over time
- **Water World:** Monitoring the growth and shrinkage of vernal pools

- **Changes in Elevation:** Investigating the effect of mountain elevation on plant health and green-up
- **Weed Invasion:** Monitoring the spread of rapidly-reproducing vegetation

All of these alternative lesson ideas are excellent and varied applications of the PicturePost program. Even though some are dependant on specific features in the Post's surroundings, they should serve to spark ideas in educators, which is the main purpose of the guide.

### 4.3.2 Manuals

In addition to an educator's guide, we created manuals for setting up PicturePosts and using the MVH software, solving the problem of outdated or missing information as well as providing a guide that could be included with all new PicturePost orders. We decided that two separate manuals were in order: one for PicturePosts and one for the software programs. Each was also included as an appendix to the educator's guide (see Appendix G).

The PicturePost manual was intended to be a guide to installing and using PicturePosts. It consists of three main sections: installing the post, taking pictures from the post, and uploading the photos:

- **Installing the Post:** Includes information about how to choose the location, how to find true north, how to determine the latitude and longitude of the post, and how to physically install the plastic lumber posts. This section is crucial since the scientific value of the data collected from a post degrades if these steps are not completed properly. For example, the true north step is very important since the post needs to be oriented properly. If the post does not have a side that points to true north, then any cloud data that is collected from sky shots will be skewed.
- **Taking Pictures:** Gives the proper order of taking pictures. It has been updated with the information about how to take a sky shot.
- **Uploading the Photos:** Explains the process of renaming and uploading pictures. This section is necessary since the smugmug website is very confusing to most users.

The other manual, the software manual, is also extremely important to the MVH project. It explains the basic functions of three software programs: Pixel View, Color Picture, and MVH Image. These programs can help make image analysis easier, more accurate, and more thorough than visual observation. The manual provides step-by-step tutorials describing how to use the software to learn about pixels and see the percentages of red, blue, and green present in any area of a digital image. The analysis of data is as important as its collection, and this manual therefore greatly increases the value of the PicturePosts.

## **5 Conclusions and Recommendations**

As we examined our findings, we drew conclusions based on the information we collected about each aspect of our project. These conclusions led us to recommendations that we believe will, if applied, change the future of the Measuring Vegetation Health project for the better.

### ***5.1 Concluding Remarks***

The process of installing PicturePosts, taking and uploading pictures, and using the analysis software helped us gain a deeper understanding of the PicturePost project. During the data collection at the four existing posts we were able to analyze the process for its educational potential and to identify any gaps in the process. Our weekly data collection trips provided us with our own set of image data to compare against itself as well as serve as additional data in the PicturePost database.

Although other partners in the MVH project used the filters to determine plant stresses, this technology had never been tested with the PicturePosts. We applied this filtering technology to PicturePosts and basic digital images. After taking the initial nine images without a filter, an additional nine images can be taken with the filter applied. Although weather conditions prevented us from conducting any significant analysis of our photographs, an addition was made to the naming protocol for pictures uploaded to the photo database indicating that the picture was taken with a filter. In addition to filtering the PicturePost images, basic filtered images of leaves or other plant material can be taken in the classroom and still analyze plant stress. However, since the local foliage had not budded during our project, we were not able to fully test this technology.

During the image data uploading we did, a few issues emerged. The current smugmug website that supports the PicturePost image database does not allow for adequate organization. Images are currently sorted by state and post location, but when there is more than one post at a location, those pictures are grouped together. This makes navigating the smugmug site extremely difficult. Additionally, the user is directed away from the MVH website to the third party smugmug server which makes it difficult for the user to find their way back to the MVH website.

The MVH website itself served as one of our primary references while creating our educator's guide and manuals. It includes a wealth of information on nearly every topic we addressed in the educational resources we developed. However, the MVH website as a whole has been an impediment for us. A first impression of the website does not suggest the professionalism that should be attributed to the incredible potential the project has to offer. The organization of the website has become our primary concern, as it is very difficult to navigate between pages or find information quickly. After using the website intensively for the past four months, we still will find a page we have never seen before and still have trouble finding information easily. As the advisory board unanimously concluded, their main concern was effectively using all that the MVH project has to offer. This is a daunting task with such a cumbersome resource and will affect the success of the project. A modernized and reorganized website is crucial for it serve as a useful educational resource.

Resulting from our creation of the advisory board, we were able to gather their ideas for activities. We revised the Guide to accommodate their comments on time constraints and level of detail. However, since the board members received their posts relatively late in our project, they did not have time to truly familiarize themselves with the posts and the MVH project. The ideas that they initially presented were important additions to the MVH project. The new perspective of these educators allowed us to see how PicturePosts could be used outside of the "plant world". For example, we never thought of using the posts to monitor erosion. They are likely to have more innovative ideas as they continue to use and acquaint themselves with the capabilities of the posts. Most of this valuable educational feedback will be reported to Brian Rogan at the Museum well after our project has been completed.

We have successfully completed an educator's guide for the PicturePost program, increasing its utility as an educational resource. Our PicturePost manual has been sent to EPS Plastic Lumber for inclusion with new PicturePosts. With the installation of the PicturePosts given to the board members, the project has spread throughout the state. These are only the first steps; we feel that the project has potential on the national stage. As PicturePosts begin to spread across the country, the educational value of the project increases substantially. Having access to photos from around the country all in the same



format allows educators and students alike to compare different ecosystems. Since the United States has varying climates, the seasons present differently in different states. The board suggested that comparing sites would be an interesting addition to the project – something that will become more realistic as the posts become widespread.

## ***5.2 Recommendations for the Future of PicturePosts***

In the process of achieving our project goal, and based on the above conclusions, we have made a number of observations concerning aspects of PicturePosts that we consider prime candidates for further development and progress. Following are our recommendations for the Museum of Science as well as the entire MVH association:

- **Continue to work with the advisory board.** The teachers have not had much time to integrate their ideas into their teachings. Following up during and after lessons have been run would be most beneficial. Additionally, new ideas may arise once teachers have formed a base of multiple years' worth of measurements.
- **Post the manuals and the educator's guide on the MVH website.** We believe the PicturePost program should be given a prominent link from the MVH homepage. We would recommend the guide be posted within that PicturePost specific page. This will allow people to see the educational merit of the project, hopefully sparking more teacher interest or simply allowing people to use the materials at home. PicturePosts should also be mentioned or even linked with the section of the website entitled "For Educators".
- **Expand and update the educator's guide and manuals.** As more feedback is received, the guide and manuals will only improve if revised. This will also allow some of the areas that we were not able to cover, such as cloud and weather studies, to be adequately researched and added to the Guide.

- **Continue integration of filters with PicturePosts.** The MVH photo database will soon accommodate pictures taken with the green-light filters. Before our input, light filtering was primarily done with the ForestWatch project and had not yet been tied into PicturePost. If the MVH team continues encouraging the use of filters in an educational environment, deeper, more straightforward analysis by students will be enabled.
- **Develop a search mechanism for the image database.** With the addition of keywords to the pictures and a search option, people will be able to make comparisons between pictures of similar environments from different sites around the country. For example, if a teacher wanted to observe the differences between an evergreen in Massachusetts and an evergreen in North Carolina, a search option would allow him or her to locate two such photographs.
- **Integrate a new PicturePost database into the MVH website.** Without the restrictions of a third party website (the current smugmug database), an MVH database will allow benefits such as deeper levels of organization for areas with multiple Posts, easier archiving, and better navigation. With the assistance of partner institutions such as the University of New Hampshire and Indiana State, such a resource could be cheaply developed and integrated.
- **Improve the organization of the MVH website.** The Museum of Science is currently investigating possible ways to reorganize the website or rebuild it from the ground up. We suggest this be accomplished as soon as possible, especially with additional educators becoming involved as PicturePosts spread.
- **Continue to actively spread the use of PicturePosts to other states.** We've distributed PicturePosts throughout Massachusetts, but the educational and scientific value of the program will only increase with their spread across the country. This could be done with an expansion of orientation program we

implemented in Massachusetts, gathering and introducing educators to the potential of PicturePosts.

PicturePosts are currently poised to become the premier avenue for hands-on environmental education in the state. We have developed clear, thorough manuals and educator's guides for the program, distributed the first wave of Posts to schools throughout the state, and the mass production of the new, low-maintenance, plastic lumber Posts is just beginning. We believe that with effective marketing and the continued close involvement of educators, PicturePosts could easily find application country- and even world-wide, simultaneously increasing the value of the program as a method of monitoring the spread of environmental change.

By introducing students to the availability and importance of Citizen Science investigations, as well as instilling in them local connections to the environment, the effort towards monitoring vegetation health will not be in vain. Helping students become interested in scientific and environmental processes ensures future development in all fields, but also the continued protection of the planet. If our green canaries ever come calling, we can all have hope that there may be scientists capable of answering.

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## Appendix A: The Boston Museum of Science

The Boston Museum of Science is one of the most visited institutions in all of Boston (“Support MOS”, 2007). In 1830, the foundation for the Museum of Science was established by six men through the creation of the Boston Society of Natural History (“History of the Museum”, 2007). The museum has developed into a world-class collection of exhibits and information that educates over 1.6 million visitors per year (“Support MOS”, 2007). Now displaying over 400 exhibits, the museum is at the forefront of research and invention in New England.

The Boston Museum of Science has a unique mission statement, which is given by the President of the Museum:

We have also expanded our role as a partner in education, serving teachers, parents, and students as a community resource. Dynamic new exhibits foster lifelong curiosity in science and technology and support what children are learning in school. Our Educator Resource Center offers models and materials to help teachers integrate engineering and technology into their science curricula. And expanded outreach efforts — such as Traveling Programs, Courses, the Computer Clubhouse, and numerous other initiatives — encourage a love of science and technology in all our regional communities.

We continue as a leader in encouraging girls to pursue the sciences. Our many educational programs and more than 550 interactive exhibits invite girls as well as boys to touch, test, take apart. And every day, our new research initiatives explore ways to motivate young women.

The Museum of Science has an extraordinary story to tell: new interactive exhibits; leadership in technological literacy; attention to pioneering discoveries in biomedical and life sciences. We invite you to visit. Discover how this dynamic national institution has inspired people and changed lives since 1830. It might even change yours (“President’s Welcome”, 2007).

*Ioannis N. Miaoulis, Museum director and president*

The Boston Museum of Science is a nonprofit organization (“Support MOS”, 2007). It thrives on donations received from businesses, charities, and individuals. The Museum itself is divided into three wings: the blue wing, the red wing, and the green

wing (“Museum of Science”, 2007). These wings have many, diverse exhibits including the Theater of Electricity, the Human Body Connection, Mathematica, the Charles Hayden Planetarium, the Mugar Omni Theater, and various traveling exhibits. Some past traveling exhibits have included “Star Wars: Where Science Meets Imagination” and the popular “Gunther von Hagens’ Body Worlds 2” (“Exhibit Archive”, 2007). The exhibits are intended to inform, entertain, and stimulate the visitors. The Museum intends to leave their visitors with a sense of how science affects their every day lives and how they can get involved.

To accomplish this task, the Museum utilizes volunteers, full and part time staff, and interns to inform the public and perform the necessary research to keep the Museum up to date on modern technologies. Each project that the Museum devotes time to has various personnel assigned to that venture (“Museum of Science Team”, 2006). For example, the Measuring Vegetation Health project has had numerous staff and interns, such as Brian Rogan and John Pickle, from the museum working on it presently, or who have worked on it in the past.

The Museum of Science has a plethora of resources that could aid in the MVH project. The Measuring Vegetation Health initiative makes use of funding the Museum received from NASA (“Collaborations”, 2007). In terms of other resources, the Boston Museum of Science is able to contribute their vast stores of scientific equipment, information, and expertise regarding the environment and world around us.

The Museum of Science in Boston is not the only organization committed to the success of this project. Six other organizations are part of the collaboration (“Collaborations”, 2007). These include:

- Lawrence Hall of Science, University of California, Berkeley
- Forest Watch, University of New Hampshire
- EOS-WEBSTER, University of New Hampshire
- Remote Sensing and GIS Laboratory, Indiana State University
- Blue Hill Observatory, Milton, MA
- College of Education and Human Development, University of Southern Maine (“Measuring Vegetation Health Partners”, 2006)



All parties are ready contributors, with the University of New Hampshire and Indiana State in particular integrating the program into their Forest Watch and Remote Sensing curricula and Lawrence Hill including it in their Global Systems Science curriculum for high schools (“Science@NASA”, 2007).

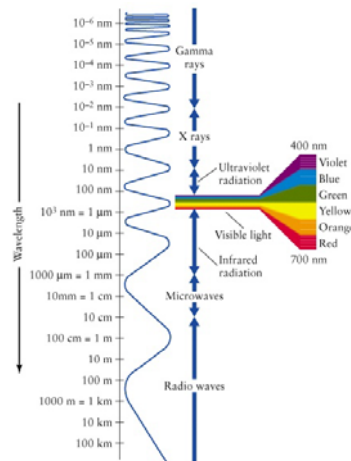
As one of the premier science museums in the country, the Boston Museum of Science is an ideal organization with which to cooperate for a project like Measuring Vegetation Health. As they say, their very existence revolves around creating activities that “inform,” “educate” and “encourage curiosity, questioning and exploration,” which is certainly this project’s goal (“About the Museum”, 2007). MVH aims to have its participants learn how their environment affects their daily lives (“MVH Home”, 2006). One of the ultimate goals of the project is to have citizens become active in their local government to protect the environment. The Museum of Science has made it very clear that “active citizenship” is also their goal (“About the Museum”, 2007). The Museum also caters to educators with many special programs and even some suggestions for in-class activities (“Educators”, 2007). This falls right in line with another of MVH’s goals. The project is intended to be used as a way for middle through high school students to be able to study the environment (“MVH Home”, 2006). The Boston Museum of Science seems to be the best partner with which the MVH project team could possibly work.

## Appendix B: Physical Science of Light and Plants

The MVH program relies on concepts from two major areas of physical science: the science of light and the science of plants. This appendix will explain some of the relevant details of each.

### B.1 Light

In its simplest terms, light is electromagnetic radiation that is visible by the human eye. All light is measured in wavelengths. When considering the wavelengths associated with light, a very wide spectrum of radiation occurs (“Light”, 2007). Different wavelengths of light produce different types of light other than visible light, such as ultraviolet and infrared light. Ultraviolet light occurs when the wavelength of the energy is too short for human detection and, conversely, infrared light has wavelengths too long. Continuing to broaden the spectrum, several other types of light are found at different wavelengths, all with different possible applications. The rainbow colored region in Figure 13 corresponds to the visible light spectrum and each color respectively. Also figured are the approximate wavelengths for several other types of non-visible light



**Figure 13: Light with Corresponding Wavelengths. Courtesy of NASA Science Atmospheric Data Center**

Applications of light outside the visible spectrum are found in everyday life, from portable FM radios, to microwave ovens and medical X-Ray equipment. Most applications of visible light today are integrated with some type of photography. Within the visible light spectrum, small changes in wavelengths cause the light to produce colors.

Starting on the low end of the visible light spectrum (around 400 nm) violet light begins to appear. As the wavelength increases visible colors slowly change to blue, green, yellow, orange and finally red respectively. The high end of the visible light spectrum cuts out at around 700 nm and becomes infrared light.

## B.2 Plants

Found in the chloroplasts of green plants, chlorophyll is a photoreceptor; meaning it collects light for photosynthesis. There are actually two main types of chlorophyll, named *a* and *b*. These two types are very similar as they are both based off of the same main molecular chain. Only their sub-chains, which branch off of the main chain, differ (in *a* it is  $-\text{CH}_3$ , in *b* it is  $\text{CHO}$ ). Both types of chlorophyll are very effective photoreceptors due to their internal network of alternating single and double bonds, and the ability of the molecule's orbitals to delocalize, stabilizing the structure. Such delocalized orbitals have increased light absorption bands in the visible regions of the spectrum, creating an ideal location to allow the plant to absorb the energy from sunlight (May, retrieved 2007).

These chlorophyll are ultimately what causes plants to appear green. When the plant is absorbing sunlight for photosynthesis, the process in which green plants transform light energy into chemical energy, ("photosynthesis", 2007) the chlorophyll reflects light with a wavelength of around 510 nm. This wavelength directly correlates to a pure green, which is how the plant gets its color (Billingsley, 1984). The lack of absorption between 500 nm and 600 nm is clearly visible in Figure 14.

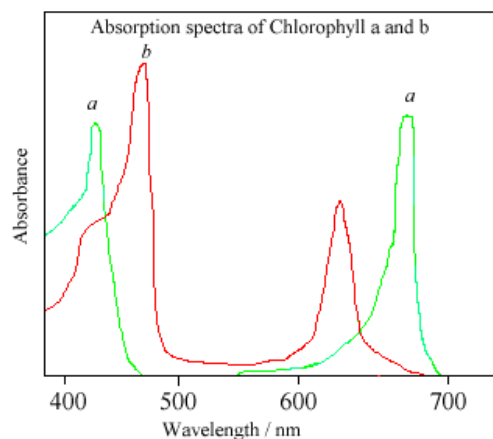


Figure 14: Chlorophyll a and b Absorbance Courtesy of the University of Bristol

## Appendix C: Gantt Chart

During our seven weeks in Boston, Massachusetts we used a Gantt Chart to organize our time. In the chart below, the blue bars identify tasks related to our PicturePost workings, the red bars scattered represent our advisory board plans, and the green bars make up the time devoted to the actual lesson plan development.

Task	week 1		week 2		week 3		week 4		week 5		week 6		week 7							
	S	M	T	W	R	F	S	S	M	T	W	R	F	S	S	M	T	W	R	F
Determine post locations	■		■		■															
Install PicturePosts												■								
Collect data from posts	■			■		■		■		■		■								
Learn analysis techniques		■		■																
Create advertisement for teachers	■																			
Contact advisory board		■		■		■		■		■		■								
Prepare for Orientation			■		■		■													
Advisory Orientation									■											
Submit lesson plan for review									■											
Board feedback due										■										
Research lesson plans				■		■		■												
Extract information/programs from MVH website					■		■		■		■									
Assemble lesson plan				■		■		■												
Revise lesson plan									■		■		■							

## **Appendix D: Weekly PicturePost Data**

Once every week over the course of our seven weeks in Boston, Massachusetts, we traveled out to Menotomy Rocks Part in Arlington, MA and Fresh Pond in Cambridge, MA to collect data from the existing PicturePosts. There were two Posts at each location for the first five weeks, but for the sixth and seventh weeks we also collected data from the two new Posts we installed in Menotomy Rocks Park. The following five pages contain proof sheets for all of the photos taken. Each row represents a different week, and each column displays a different direction on the Post.

Fresh Pond, Post 1



Fresh Pond, Post 2



# Menotomy Rocks Park, Post 1





# Menotomy Rocks Park, Post 2



Menotomy Rocks Park, Post 3



Menotomy Rocks Park, Post 4



## **Appendix E: Advisory Board Ad**

We developed the following advertisement as our initial request for interested educators to serve on our advisory board. It was distributed to the Massachusetts Area Science Teachers (MAST) website, as well as sent via email to area science teachers through the University of Massachusetts. We received 38 responses.



Museum of Science™

# Classroom Opportunity for Science Teachers

An innovative approach to  
Environmental Education!

What are PicturePosts?

- Environmental monitoring tools developed by the Measuring Vegetation Health team at the Boston Museum of Science
- Allows the user to take a series of pictures at the same location to track the changes in the local ecosystem
- Educational tool that teaches about photosynthesis, how light creates color, and plant health



The Museum of Science wants to bring this new tool to classrooms as a creative and exciting way for students to learn about the environment. We are looking for teacher input and feedback!

Educators interested serving as advisors to this process can earn a **complimentary PicturePost station** and **\$100 stipend!** Please respond to [mvh-d07@wpi.edu](mailto:mvh-d07@wpi.edu).



For more information on PicturePosts  
and Measuring Vegetation Health visit  
<http://mvh.sr.unh.edu/index.htm>



## Appendix F: Advisory Board Contacts

Below is a table of the ten educators that made up our Advisory Board during this project. This was submitted to the Museum of Science along with a similar list of all 38 teachers that responded to our original ad including the full text of their responses. This database will greatly assist the MVH team as they continue to expand the PicturePost program to more schools or look for feedback on new developments.

Rob Banks	Audubon Society of RI Environmental Education Center 1401 Hope St, Bristol, RI 02809	rbanks@asri.org
Ellen Brenneman	Kennedy Middle School 165 Mill St, Natick, MA 01760	Ellen_Brenneman@natick.k12.ma.us
Lisa Camp	River Valley Charter School 2 Perry Way, Newburyport, MA 01950	campsitelm@yahoo.com
Christina Connolly	Algonquin Regional High School 79 Bartlett St, Northboro, MA 01532	CConnolly@nsboro.k12.ma.us
Timothy Herrmann	Hoosac Valley High School 125 Savoy Road, Cheshire, MA 01225	savoyboy@hotmail.com
Margaux Parino	Assabet Valley Collaborative Alternative High School 85 Sawin Street, Marlborough, MA. 01752	margauxme@yahoo.com
Rebecca Schwer	River Valley Charter School 2 Perry Way, Newburyport, MA 01950	rebeccaschwer@gmail.com
Stephanie Selznick	Dr. Joseph Coakley Middle School 1315 Washington St, Norwood, MA. 02062	stephanie@super8records.com
Stephen Sousa	Andover High School 80 Shawsheen Road, Andover, MA 01810	SSousa@aps1.net
Christine Welk	Sullivan Middle School 140 Apricot St, Worcester, MA 01603	eriecn@yahoo.com

## **Appendix G: Orientation Materials**

Included in this Appendix are both the agenda and questionnaire developed for our orientation meeting with the advisory board. They may also prove useful as future groups of educators are introduced to the program.



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## Measuring Vegetation Health with PicturePosts Orientation Itinerary

9:00	Arrival and Introductions (name tags, refreshments)
9:10	MVH Background and PicturePost Presentation
9:45	Website Tour
9:50	Break
10:00	Questionnaire
10:20	Open Discussion
11:00	Overview of Installation Manual
11:15	Software Demonstration
11:30	Post Pickup and Departure



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## Measuring Vegetation Health with PicturePosts Questionnaire

Name: \_\_\_\_\_ Grade Level: \_\_\_\_\_

1. How much classroom time would you be able to devote to activities involving PicturePosts?
2. Where do you think PicturePosts fit into your current curriculum?
3. What extracurricular clubs or other enrichment groups in your area/school do you foresee having interest in PicturePosts?
4. What types of activities, lessons, or other materials do you foresee using with your PicturePost?



5. What challenges do you see with integrating PicturePosts into your teachings? Would you prefer step by step instructions for activities, or just a general overview of what could be done and taught during an activity?
6. What ideas do you have for specific activities that we could include in a teacher's guide? (Be sure to indicate suggested age level.)
7. Besides the analysis software, how do you plan on working with the topics brought up by PicturePosts in the classroom?
8. Is there anything in particular you would like to learn more about the MVH project?

## **Appendix H: Educator's Guide**

Included in this Appendix is the educator's guide we developed for the Museum of Science. Included in the guide as appendices are the PicturePost and software manuals we also developed. The PicturePost manual was also created as a separate document to be included with all new orders of PicturePosts (this separate document is not provided, but all of the material is in the PicturePost Setup appendix of the guide).

# Measuring Vegetation Health with PicturePosts

## Educator's Guide



Authors:

**Russell Kernan**

**Jeff Madden**

**Cara Messier**

Museum Contact:

**Brian E. Rogan**

*Program Manager,*

*Earth and Space Science Education*

*Educator Resource Development*

Tel: 617-589-4252

E-mail: [brogan@mos.org](mailto:brogan@mos.org)

Presented by:



Museum of Science™



# Table of Contents

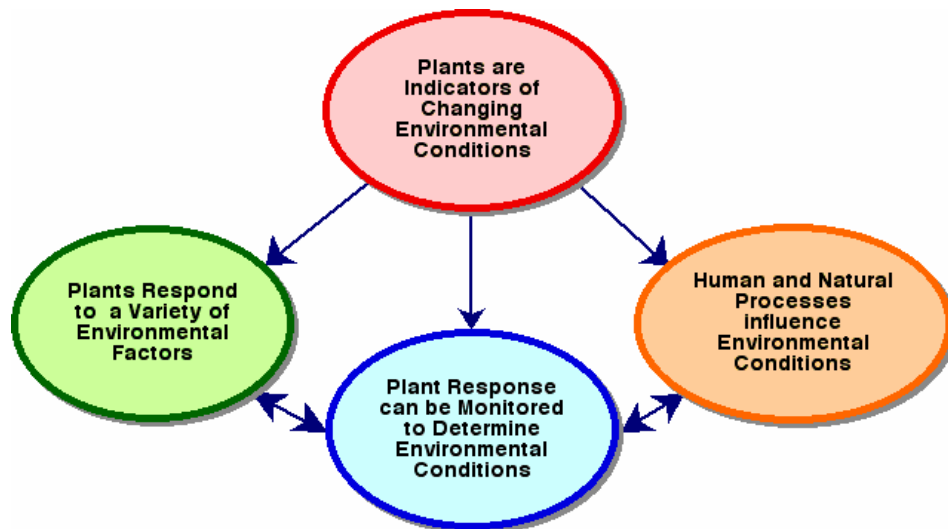
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<b>I</b>	<b>Introduction</b>	<b>3</b>
	<i>1.1 Measuring Vegetation Health with PicturePosts</i>	3
	<i>1.2 Using This Guide</i>	5
<b>II</b>	<b>Getting Started</b>	<b>7</b>
	<i>II.1 Materials</i>	7
	<i>II.2 Software</i>	8
	<i>II.3 The Scientific Method</i>	10
<b>1</b>	<b>Classroom Exploration Unit</b>	<b>14</b>
	<i>1.1 Colors in the Classroom</i>	15
	<i>1.2 The Leaf Spectrum</i>	17
	<i>1.3 What is a Pixel?</i>	19
<b>2</b>	<b>Outdoor Exploration Unit</b>	<b>22</b>
	<i>2.1 Your Current Conditions</i>	23
	<i>2.2 Change Over Time</i>	25
<b>3</b>	<b>More Applications</b>	<b>27</b>
	<i>3.1 Discovering Erosion</i>	28
	<i>3.2 Water World</i>	30
	<i>3.3 Changes in Elevation</i>	32
	<i>3.4 Weed Invasion!</i>	34
	Appendix A: PicturePost Setup	36
	Appendix B: Software Guides	49

This Educator’s guide is designed to help educators integrate an exciting new tool for learning about the environment into their classrooms: PicturePosts. PicturePosts are a part of the Measuring Vegetation Health program, led by the Museum of Science, Boston. This guide provides lessons, activities, and ideas that will supply students with the hands-on experiences necessary to generate a sincere interest in the world around them while learning that science is a process in which everyone can take part.

## Measuring Vegetation Health with PicturePosts I.1

Plants are like “green canaries” – if they die, then other organisms will likely follow. By measuring the health of plants, we are measuring the environmental conditions that affect all nearby organisms, including humans. Modern technologies let us monitor plant health using the proportions of light reflected from leaves. Combining this data with our understanding and observations of plant behavior and physiology helps us to quickly assess the quality of the local environment. Measuring Vegetation Health brings together biology, physics, chemistry, technology, art, engineering, and math in a project that predominantly supports field studies in middle to high school and self-guided education in environmental science



## *What is a PicturePost?*

### *I.1.1*

PicturePosts are the latest addition to the Measuring Vegetation Health program. Pictures of the same location provide a wealth of information and data to monitor changing environmental conditions. The United States Geological Survey (USGS) has research projects devoted to “repeat photography,” such as documenting Mojave Desert Ghost Towns and Mining Sites. Woods Hole Research Center has taken this a step further by accumulating aerial photographs over the same area. The Museum of Science, Boston, as part of their “Citizen Science” initiative of bringing technology to everyday people, created PicturePosts to make the process of repeat photography more accessible.

Setting up the camera to take photographs of the same location can be time consuming, and it is not practical to leave the camera in the field, waiting to take the next photograph. The Measuring Vegetation Health project team worked with several local park groups in the Boston area to create a stable platform in which people use their digital cameras to take repeat photographs of not just one scene, but the complete 360 degree landscape in less than a minute. We have also created a free website for people to upload their pictures for others to view. This is our PicturePost system.

## *Using Filters for Objective Image Analysis*

### *I.1.2*

We have recently developed a new addition to this system in the form of light filters. Plant leaves absorb primarily red and blue light to make food (photosynthesis), reflecting the green light – making the leaves appear green! Plant leaves that are stressed due to drought, flooding, ozone, excessive foot traffic, salt spray, acid rain, nutrient deficiencies, disease, pests, etc., are not as productive photosynthesizers, so they reflect more red and blue light. Using a filter that blocks out (absorbs) the green light, healthy plants will appear dark and stressed plant leaves will be noticeably lighter in color. Such filters can either be physically mounted on a camera, or applied digitally with software provided by the MVH project.

Keep in mind these filters do not tell you why the plant is stressed; they just make it easier see stressed parts of plants. You need to look for clues to find the cause of the plant stress. Plants respond to their environment in a variety of wonderfully dynamic

ways – although often on a time scale that most of us don't notice or with a subtlety our senses can't detect. Technologies such as PicturePosts and light filters allow anyone to monitor plant changes using the proportions of light reflected from leaves, which, when combined with our understanding of plant behavior, helps us to quickly and objectively assess the quality of the local environment. If we find that the environment is not healthy, then we must find the causes and whether they are a result of natural or human-influenced processes.

## **Using This Guide**

## **I.2**

The information in this guide is intended to be used either as a stand-alone unit on Measuring Vegetation Health or to simply provide engaging activities that expand on other topic areas. PicturePosts and the related image data can easily be incorporated into existing units on:

- Photosynthesis
- Plant Sciences
- Ecosystem Interaction
- Environmental Monitoring
- Pollution
- Weather and meteorology
- Light
- Photography
- Experimentation

Additionally, the activities in this guide are largely focused on expanding the practice of “inquiry-based” or “discovery” learning in the classroom. These educational philosophies have been rapidly gaining in popularity, and for good reason. The traditional process of experimentation in grade schools uses strongly controlled, packaged activities with straightforward and often expected results. The answer is known by the instructor ahead of time, and students are led to “the answer.” Some would argue that this method does not truly emphasize the scientific process of drawing conclusions based on facts, as students are rarely tasked or trusted to make conclusions on their own.

PicturePosts are different since they do not necessarily represent controlled experiments, meaning there is no need for a ‘control’ group or ‘proper’ result for the

program to be effective. The plants may be affected in ways that are unexpected, and teachers must only help the students reach decisions about the observed reality based on that. Answers are not 'right' or 'wrong' and must often be imaginative. These inquiry-based or discovery learning techniques more effectively engage students in critical thinking and may help spark a lasting interest in experimentation and science.

Questions? Please contact:

**Brian E. Rogan**

*Program Manager,*

*Earth and Space Science Education Educator Resource Development*

Tel: 617-589-4252

E-mail: [brogan@mos.org](mailto:brogan@mos.org)



This chapter covers some of the items, software, and ideas associated with the PicturePost program. While few of these components are strictly necessary, familiarity with them will allow the educator to make the most out of the included lesson ideas. Additionally, being aware of the tools developed may spark original ideas among users.

## Materials

## II.1

Throughout this guide we will make reference to three crucial items related to the program. Below are descriptions of each and how you can get them for yourself.

### *PicturePosts*

### *II.1.1*

PicturePosts can be ordered from EPS Plastic Lumber. They are made from recycled plastic that will remain maintenance free for 50 years. The Post and 8-way “RAPcap” post topper (required) can also be ordered separately. This allows the cap to be mounted on a tripod, creating a portable version of a PicturePost, if necessary. A PicturePost with RAPcap is \$45, while a RAPcap alone is \$25. It is important to find out the area’s frost depth, and order a post long enough to be installed past it, ensuring stability over multiple winters. See Appendix A for setup instructions.

To order:

[https://omega.mc.net/epsplasticlumber.com/orderform\\_recap.php](https://omega.mc.net/epsplasticlumber.com/orderform_recap.php)

### *MVH Filters*

### *II.1.2*

Filters are not strictly necessary to make use of a PicturePost, but as described in I.1.2, help provide more visual and easier to understand results. Theater lighting “gels,” or transparencies, can serve as inexpensive light filters and are available at most art and theater stores. Large sheets (20 in x 24 in) are typically available for \$6-7 each, and nearly 200 filter flags and monoculars or 90 paper frame glasses can be made from one

sheet. Referred to inclusively as the “MVH Filter” in this guide, the following brands and colors are recommended:

Medium Purple Filter by Rosco (#049)

<http://www.rosco.com/us/filters/roscolux.asp>

Mauve Filter by Lee (#126)

<http://www.leefilters.com/LPFD.asp?PageID=179>

Orchid Filter by Gam (#995)

<http://www.gamonline.com/>

Sour Grape Filter by Apollo (AP3250)

[http://www.internetapollo.com/products/productline.aspx?pl\\_id=8](http://www.internetapollo.com/products/productline.aspx?pl_id=8)

Additionally, instructions for creating flags, monoculars, and cardboard frame glasses can be found on the MVH website; just click on “Useful Tools,” and then “Plant Stress Detection Filters,” or go to the following URL:

[http://mvh.sr.unh.edu/mvhtools/psd\\_filters.htm](http://mvh.sr.unh.edu/mvhtools/psd_filters.htm)

### *Digital Cameras or Existing Image Data*

### *II.1.3*

The use of digital cameras is an integral part of the PicturePost system and associated analysis tools. Any digital camera will work. In case a camera is not available, pictures taken by all PicturePosts users are stored online at the following site:

<http://picturepost.smugmug.com/>

The photos from the various locations and posts listed on the site could be used to perform some activities, however we caution that in order to fully appreciate the program and help your students form a local connection to their environment, collection of original data with a digital camera is strongly recommended.

## **Software**

## **II.2**

The MVH project has developed around twenty programs related for manipulating, processing, and analyzing images. Three of these are directly applicable to PicturePosts and are referenced throughout this guide: PixelView, ColorPicture, and

MVHimage. The capabilities of these programs will be briefly described in this section, and tutorials for their use are provided in Appendix B. All of the programs are free and available at the following address:

<http://mvh.sr.unh.edu/software/software.htm>

### *PixelView*

#### *II.2.1*

PixelView allows the user to study the effects of changing the size of pixels for any digital picture – called pixilation. Digital images are broken up into millions of tiny squares, called pixels, which average the colors in that area of the photograph. As fewer pixels are used, the picture becomes much less clear, as large portions of the image are being averaged into a single block of color. PixelView will help beginners understand the way pixels make up an image, by allowing the number of pixels used in the representation be varied on the fly.

### *ColorPicture*

#### *II.2.2*

ColorPicture allows the user to separate the red, green, and blue color components of any digital picture. This can assist in some basic experimentation with the information contained in a digital image. It is basically a simplified version of the next piece of software called MVHimage.

### *MVHimage*

#### *II.2.3*

MVHimage is the ‘analysis suite’ associated with the PicturePost program. It allows users access to more advanced tools for analyzing the spatial and color information within any digital image. The color makeup of single pixels, lines, or any area of the photo can be determined through a simple point-and-click interface. For example, single leaves can be selected, displaying the amount of red and blue light detected from each. It even supports the export of color, length, and area measurements directly to a tab-delimited text file which may be used by any graphing spreadsheet program, such as Excel, for further analysis of results.

## **The Scientific Method**

## **II.3**

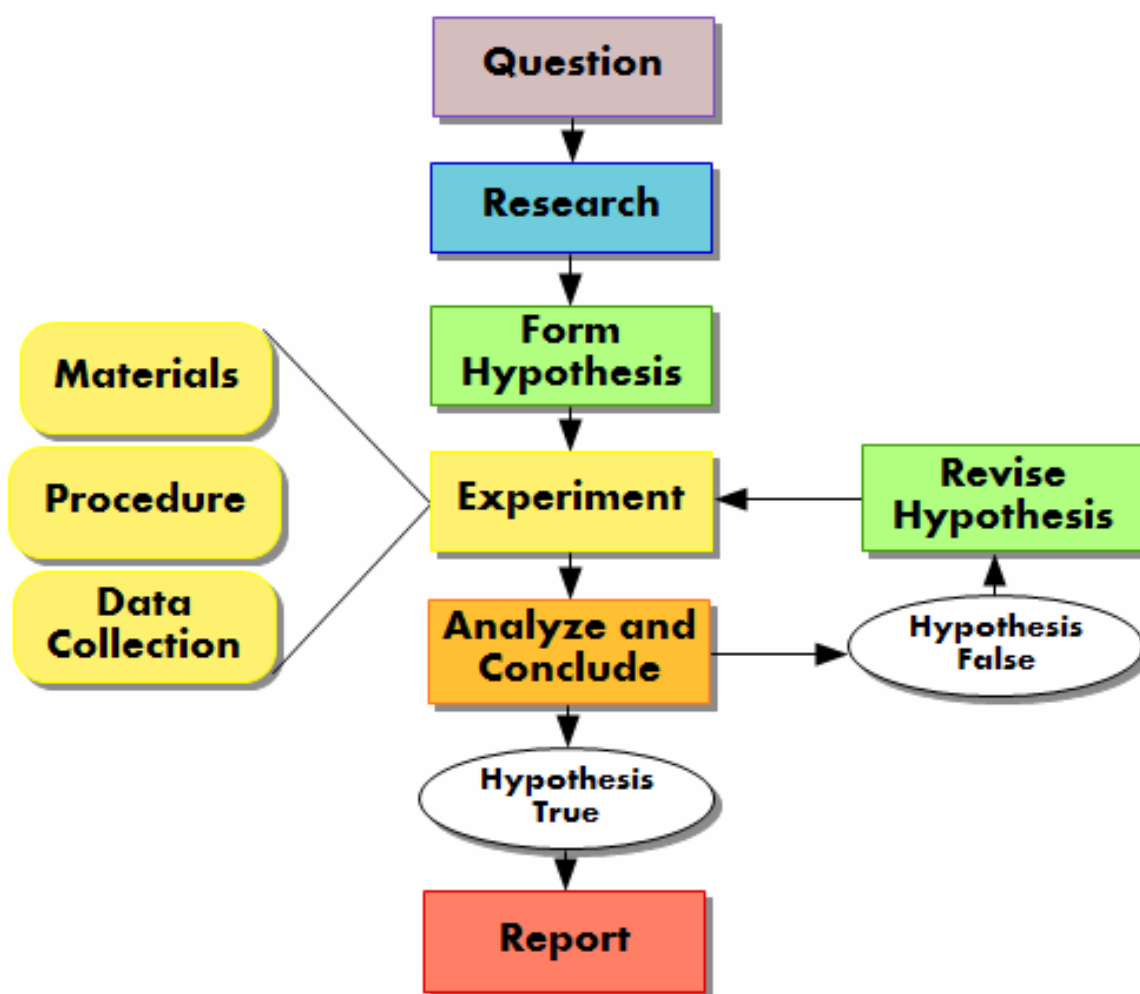
The following three pages contain a quick-start guide to the Scientific Method, which can be easily applied to the PicturePost program. Observing and analyzing nature provides students with the kind of thought-provoking, open-ended experiments that are most effective in sparking scientific interest. Any number of original experiments can be imagined by simple application the Scientific Method to PicturePosts.

# What is the Scientific Method?

Objective: Learn about the Scientific Method and how to conduct experiments

## Getting Started

The Scientific Method is the process that scientists use to create and conduct experiments. The development of the modern Scientific Method is attributed to Francis Bacon during the Scientific Revolution. The process of experimentation is as follows:



## What to do

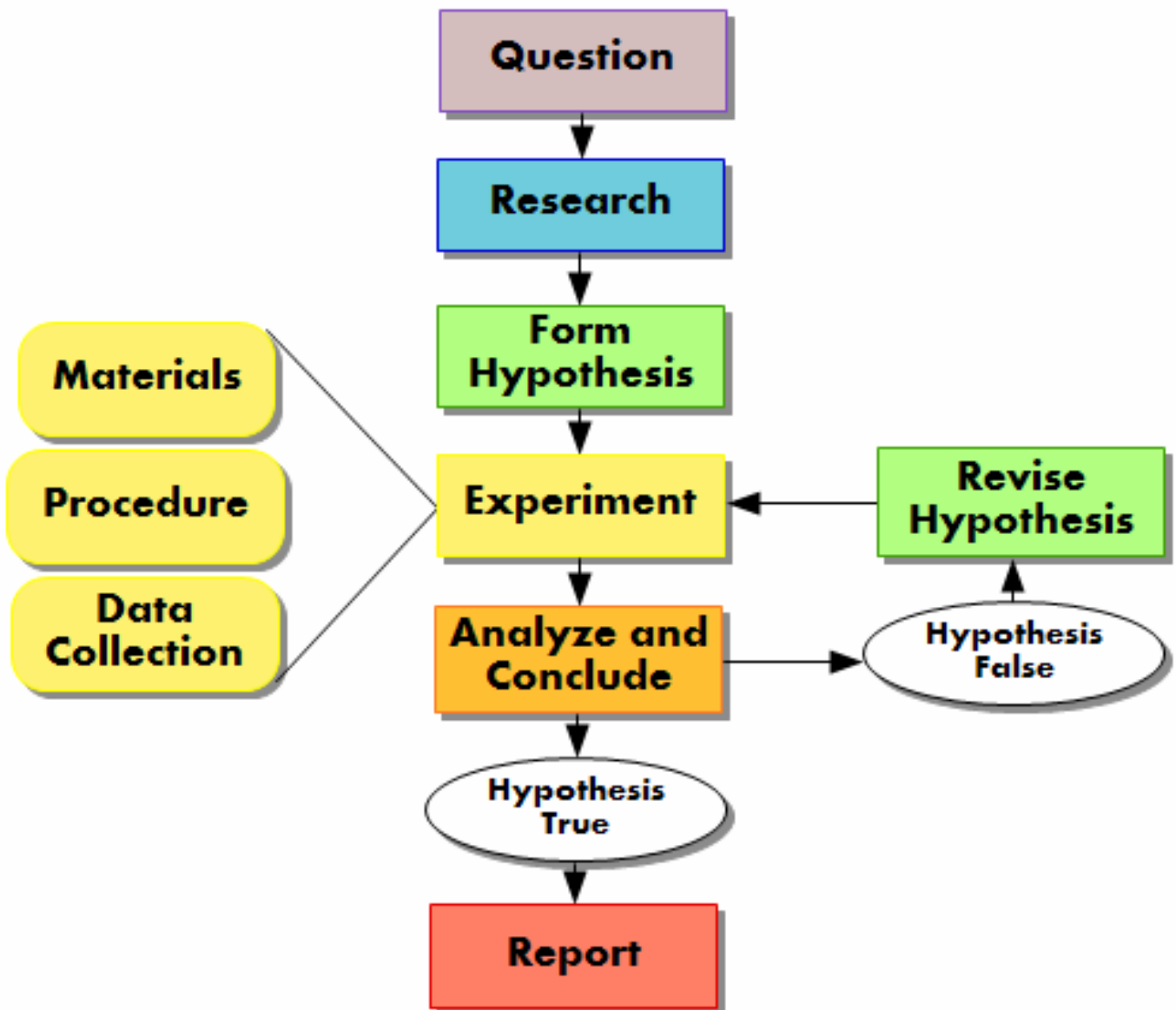
1. Encourage your students to keep a laboratory notebook. In the notebook they can write down their thoughts and feelings along with the experiment records.

2. Review the methods flow chart with your students (image available on the next page so that you can print it out and give them a copy to keep).
3. Each separate block should be a separate section in a laboratory writeup. The three yellow sections that branch off the experiment block are the additional steps involved in experiments. Materials should include a list of materials and equipment used. Procedure should include the steps taken to set up equipment, collect, and analyze the data. Data Collection should include the actual data as well as any observations.
4. The analysis and conclusion section is usually extremely difficult for students to complete on their own. Most students do not have the capability to objectively look at information and draw conclusions. To aid their efforts, we suggest helping them form matrices to break down the information. By breaking down information and examining possible outcomes, the students can have an unbiased way to view the information. For example, a student hypothesizes that a particular leaf will deteriorate from one picture to the next. But the data shows that in the first picture the leaf has 76% green and the next picture has 74% green. Their matrix might look like this:

Data	Date	% change	Meanings	Hypothesis?
76% green	4/13	$(74-76)/76*100=-2.63\%$	Leaf got healthier	false
74% green	5/13	Very small negative change	Leaf got sicker	true
			Can't tell (not enough information)	

5. This method helps students see past biases and make meaningful conclusions. It can also help them understand the differences between analysis and conclusions.
6. Depending on the age level, you may want to encourage your students to write up their own procedure. Obviously, this is the best method for high school age students. With younger students, your focus should be on the process as a whole and helping them write these sections is advisable.

# What is the Scientific Method?



The first unit of this guide describes some indoor activities that can be completed to introduce students to concepts related to the Measuring Vegetation Health and PicturePost programs. Exploring light, color, photography, and computer software will help get the most out of later outdoor activities. Learning the process of photosynthesis will allow students to understand the significance of later measurements.

The activities described here are intended to create an engaging classroom experience. The following lesson suggestions are presented:

<u>Lesson</u>	<u>Page</u>
Colors in the Classroom	15
The Leaf Spectrum	17
What is a Pixel?	19



# Colors in the Classroom

**Objective:** Investigate the colors that make up objects around the classroom

## What You Need

- Objects of various colors, patterns
- Digital camera
- MVHimage software (see software, p. 40)

## Getting Started

Digital cameras take pictures by breaking up an image into millions of tiny squares, called pixels, and using sensors to measure the amount of red, green, and blue light in each square. Describe this process to students. *(For more information, visit: [http://mvh.sr.unh.edu/mvhinvestigations/digital\\_investigations.htm](http://mvh.sr.unh.edu/mvhinvestigations/digital_investigations.htm))*

## Experiment

1. Take pictures, or let students take pictures of objects around the classroom, or their homes.
2. Ask students to record their hypotheses about what primary colors (red, blue, green) make up parts of the image. What color will be strongest overall?
3. Load images onto a computer and open them in MVHimage. Select key portions of the image and compare the color intensities to the predicted colors.
4. Select the entire image to discover which color was strongest overall.

## Conclusions

The typical digital camera uses between 2 million and 6 million pixels to create an image, each one measuring the intensity of the three primary colors. That's a lot of information! This is why scientists are finding pictures of the environment so useful. For example, there is a lot that can be determined about the health of a plant by knowing the exact amounts of color reflected by each leaf.

Thought Questions: Which colors would be recorded in a picture of a white sheet of paper? A black chalkboard?

## Extensions

Here are some variations on the Colors in the Classroom activity that may be useful.

- Illustrating with PixelView (see software, p. 36)

PixelView allows you to reduce the number of pixels used to represent an image, basically averaging the colors in portions of the image and turning them into one larger pixel. Import a photo into this program and slowly decrease the number of pixels to 2x2 for a good illustration of the dominant color in the image.

- Introducing the MVH Filter (see p.6)

In addition to the original activity, pictures could also be taken of the same objects through the MVH Filter. This will filter out the majority of green light (making green portions appear black, and white portions appear purple), which can be seen by observation or measured with MVHimage. These filters are useful when photographing plants, as the more green (healthy) a plant is, the darker black it appears through the filter. Similar filtering results can also be attained with ColorPicture (see software, p.38).

- Using the MVH Filter without a camera

The filter will have the same effect on images observed by the naked eye. Simply view the various images through the filter, and notice how the green information has seemingly been removed.

# The Leaf Spectrum

**Objective:** Investigate the relation of color to plant health

## What You Need

- Leaves of various color and health

## Getting Started



Plant leaves absorb primarily red and blue light to make food in the process of photosynthesis. Green light is reflected, which is what makes leaves appear green! Plant leaves that are stressed are not as productive during photosynthesis, so they reflect more red and blue light, changing the color of the leaves.

In fact, plants are sometimes referred to as “green canaries” – if they die, other organisms will likely follow. By measuring the health of plants, we are measuring the environmental conditions that affect all nearby organisms, including humans. Leaves serve an important role in environmental monitoring. Modern technologies let us monitor plant health using the proportions of light reflected from leaves. Combining this data with our understanding and observations of plant behavior and physiology helps us to quickly assess the quality of the local environment.

## Experiment

1. Ask students to collect leaves that are different colors: dead leaves on the ground, healthy-looking leaves on trees, and everything in between. Different children could be asked to find leaves in different states, to keep numbers manageable.
2. In class, have the students order leaves from most to least healthy. Have them explain their reasoning behind the order.
3. Discuss what might have been happening to the various leaves. See if the students can create a rough storyline for a leaf out of the series.

## Conclusions

Observing the light reflected by a leaf can reveal the plant's relative health, but it does not reveal what is causing the good or bad health effects. Some common stressors include drought, flooding, ozone, excessive foot traffic, salt spray, acid rain, nutrient deficiencies, disease, pests, or even just changing seasons. It is up to the observer to identify the source of any changes in the environment.

Thought Questions: Why do leaves change color in the fall? How might this information be useful to scientists evaluating a forest?

## Extensions

Here are some variations on The Leaf Spectrum activity that may be useful.

- Using MVHimage (see software, p. 40)

Take photos of a leaf series and open the photos in MVHimage. Select different leaves and compare the amounts of red, blue, and green in them objectively.

- Using the MVH Filter (see p.6)

Repeat the above extension, but take pictures through the MVH Filter. Notice how healthier leaves appear darker than the leaves that are reflecting higher amounts of red and blue light. Similar filtering results can also be attained with ColorPicture (see software, p.38).

- Using the MVH Filter without a camera

Simply view the leaf series through an MVH Filter. Healthier leaves will appear darker than the leaves that are reflecting higher amounts of red and blue light.

# What is a Pixel?

**Objective:** Investigate the basic concepts of pixels and digital images

## What You Need

- Pictures taken with a digital camera
- PixelView software (see software, p. 36)

## Getting Started

Digital cameras take pictures by breaking up an image into millions of tiny squares, called pixels, and using sensors to measure the amount of red, green, and blue light in each square. The data is then saved to recreate the picture. Describe this process to students.

## Experiment

1. Load four pictures (renamed as Picture 1, Picture 2, etc.) into a new folder that will be easy to find. Make sure you test these pictures yourself to ensure that they will be adequate for this activity.
2. Open PixelView and load one of the photos. The photo should appear as a 2x2 pixel block to begin.
3. Have students guess what the image is when it is 2x2. How about when it is 4x4 or 8x8 (etc.)? How many pixels do you need before you are able to tell what the image really is?
4. Repeat this process until each student has seen each picture.

## Conclusions

The typical digital camera uses between 2 million and 6 million pixels to create an image, each one averaging the intensity of the three primary colors. That's a lot of information! Imagine the detail stored in an image that size.

Thought Questions: How does the computer pick which colors to show when the image is only 2x2 pixels? How many pixels do you think most digital cameras use?

## Extensions

Here are some variations on the What is a Pixel? activity that may be useful.

- Reversing the lesson with PixelView (see software, p. 36)

PixelView allows you to reduce the number of pixels used to represent an image, basically averaging the colors in portions of the image and turning them into one larger pixel. Import a photo into this program and slowly decrease the number of pixels to 2x2 for a good illustration of the dominant color in the image.

# Let's Investigate: What is a Pixel?



Name: \_\_\_\_\_

Date: \_\_\_\_\_

Picture Number: \_\_\_\_\_

What do you think it is?

2x2	4x4	8x8	16x16	32x32

64x64	128x128	256x256	512x512

The second unit of this guide describes some basic outdoor activities developed for use with your PicturePost as part of the Measuring Vegetation Health program. Students will receive hands-on experience with determining the health of plants while learning about how they work and their role in the environment. Perhaps most importantly, students will become familiar with part of their surroundings, creating a local connection from which further interest can grow.

The activities described here are intended to serve as an engaging way to introduce students to the possibilities of Citizen Science and allow them to draw their own conclusions. The following lesson suggestions are presented:

<u>Lesson</u>	<u>Page</u>
Your Current Conditions	23
Changes Over Time	25



# **Your Current Conditions**

**Objective:** Investigate the current state of your local environment

## **What You Need**

- Installed PicturePost
- Digital camera
- MVHimage software (see software, p. 40)

## **Getting Started**

A common assumption is that one has to be a botanist in order to evaluate the health of a group of trees from only a picture. However, the Measuring Vegetation Health project has identified a straightforward way of determining the relative health of plants from digital photographs. Plants absorb red and blue light during the process of photosynthesis, reflecting the green light we see. As plants become stressed, photosynthesis slows and less of the red and blue light is absorbed, and is instead reflected. Digital cameras use red, blue, and green sensors to create a picture, and by measuring the amount of red and blue light present in a photo of a plant, you can achieve a relative measurement of its health.

## **Experiment**

1. Take a set of pictures using your camera and PicturePost.
2. Load the images onto a computer and open them in MVHimage.
3. Select leaf-heavy areas of the photo and compare the amounts of red, blue, and green to other areas.
4. Determine which areas are most and least healthy.

## Conclusions

Measuring the amount of various colors reflected by plants is a very quick, objective way of determining their health. Imagine taking a picture of a forest from a plane overhead – the entire area could be easily analyzed. Plants don't move, so their health is a strong indicator of the environmental quality of the surrounding area. The MVH project refers to them as "green canaries," serving as our first warning of developing problems.

Thought Questions: What kinds of stressors could be affecting the plants in your area? If you return to the scene can you identify any? What would you see if you took pictures of leaves in the fall? Why?

## Extensions

Here are some variations on the Your Current Conditions activity that may be useful.

- Using MVH Filters (see p.6)

In addition to the original activity, pictures could also be taken of the same objects through the MVH Filter. This will filter out the majority of green light (making green portions appear black, and white portions appear purple), which can be seen by observation or measured with MVHimage. These filters are useful when photographing plants, as the more green (healthy) a plant is, the darker black it appears through the filter. In this way, the same analysis can be done regarding the plant health, but in a much more visual way. Similar filtering results can also be attained with ColorPicture (see software, p.38).

- Adopt a tree, branch, or leaf

Many teachers find it easier to get their students started with environmental monitoring by having them each adopt a tree, branch, or leaf to focus on in their pictures and studies. These pictures can be taken without a PicturePost; or in addition to the PicturePost to get more detail on a plant of interest. Simply follow the recommended lesson, but have students take close-up pictures of single trees, branches, or leaves for analysis. Make sure to keep records of or somehow mark (perhaps with string) the object chosen so it can be found again in the future.

# Change Over Time

**Objective:** Investigate the changes taking place in your environment

## What You Need

- Installed PicturePost
- Digital camera
- MVHimage software (see software, p. 40)

## Getting Started

The PicturePost program provides a quick, easy way to evaluate the health of an area; however its true strength lies in monitoring development and change. By taking pictures using your PicturePost on a regular basis, changes in the area can be traced over time.

## Experiment

1. Take a set of pictures using your camera and PicturePost.
2. Take additional sets of pictures at regular time intervals (every week, month, year, etc)
3. View the progression of photos, and then load them into MVHimage and perform a health analysis on each (see “Your Current Conditions” activity)
4. Identify trends and possible causes for any changes.

## Conclusions

Tracking the developments in a nearby environment over a period of time can help create students’ local connection with nature, needed to foster long-lasting interest in the environment. The PicturePost program assists in both the capturing of time-series photos, as well as the simple analysis of the data captured in the photos.

Thought Questions: What trends did you identify in your local environment? What are possible causes of these changes? If the changes were negative, what could be done to correct them? If they changes were positive, what could be done to further encourage them?

## Extensions

Here are some variations on the Change Over Time activity that may be useful.

- Using MVH Filters (see p.6)

In addition to the original activity, pictures could also be taken of the same objects through the MVH Filter. This will filter out the majority of green light (making green portions appear black, and white portions appear purple), which can be seen by observation or measured with MVHimage. These filters are useful when photographing plants, as the more green (healthy) a plant is, the darker black it appears through the filter. In this way, the same analysis can be done regarding the plant health, but in a much more visual way. Similar filtering results can also be attained with ColorPicture (see software, p.38).

- Adopt a tree

Many teachers find it easier to get their students started with environmental monitoring by having them each adopt a tree, branch, or leaf to focus on in their pictures and studies. These pictures can be taken without a PicturePost; or in addition to the PicturePost to get more detail on a plant of interest. Simply follow the recommended lesson, but have students take close-up pictures of single trees, branches, or leaves for analysis. Make sure to keep records of or somehow mark (perhaps with string) the object chosen so it can be found again in the future.

The PicturePost team has worked under the advisory of ten teachers throughout Massachusetts and Rhode Island to create this guide. This chapter includes some additional applications of the PicturePost program brainstormed through this cooperation. Some of the suggestions may rely on very specific environmental features that may not be available everywhere, however hopefully they will prove interesting and perhaps spark even more ideas!

We have created the following lesson suggestions:

<u>Lesson</u>	<u>Page</u>
Discovering Erosion	28
Water World	30
Changes in Elevation	32
Weed Invasion!	34

# Discovering Erosion

**Objective:** Investigate and experiment with the basic concepts of erosion

## What You Need

- Installed PicturePost
- 3 foot+ mound of dirt
- Digital Camera

## Getting Started

Erosion is the process of changing the natural features of the Earth with wind, ice, or water. Erosion is responsible for many natural wonders and disasters. It causes mud slides that wipe out entire towns, or creates the astounding beauty of the Grand Canyon. Erosion is a force to be reckoned with, especially as the world faces the rising levels of the oceans.

## Experiment

1. This experiment would be best performed in the fall or the spring, when rain is more likely to occur (snow would distort results). Build a large (3 foot or so) mound of dirt in clear view of one side of your PicturePost (meaning that you can see the entire mound in a single picture taken from the post).
2. Teach students the basic concepts of erosion, explaining that wind, ice, and rain can be responsible. Perhaps include a case study or research project on erosion. Ideas include the Grand Canyon or various mud slides or land slides.
3. Monitor the changes in your mound as weathering takes effect. Take pictures as often as possible, but at least once a week. Allow the students to view the pictures and note their observations in a lab notebook. Determine what is causing the erosion, or lack thereof.

## Conclusions

Erosion has shaped the natural world as we know it, and it's still occurring. Engineers work to prevent natural disasters caused by erosion, but as the climate change phenomenon continues, much more will need to be done.

Thought Question: What kinds of human activities would speed the process of erosion? What could be done to prevent erosion?

## Extensions

Here are some variations on the Discovering Erosion activity that may be useful.

- Comparing Materials

The speed of erosion is not only affected by the cause of erosion; it is also affected by the material that is being exposed. Consider building multiple mounds of different materials (dirt, sand, pebbles, sawdust, etc). Since a PicturePost provides 8 different views, build up to 8 mounds in these separate views. The fact that the mounds are so close together ensures that they are experiencing similar weather (same relative amounts of rain, wind, etc). Compare the variations between the mounds, as different materials will erode differently.

# Water World

**Objective:** Discover how vernal pools are affected by water levels

## What You Need

- Installed PicturePost
- Vernal pool, or other water source (in view of post)
- MVHimage software (see software, p. 40)

## Getting Started

A vernal pool is a natural waterhole that fills with or empties water based on the water table of the area. It may flood an entire area in one season and be completely dried up in another. These pools tend to be a well-spring of life during the wet seasons. To find out more information, please visit <http://www.vernalpool.org>.

## Experiment

1. Although this experiment works best with vernal pools, many streams, rivers, lakes, and other water sources experience changes in water levels.
2. Teach students the basic concepts of water tables and vernal pools. This is a helpful lesson to tie into the study of the water cycle and animal adaptation.
3. Use your PicturePost to take pictures of the pool. Make sure that there is a permanent structure near the pool (such as a tree or fence post). Measure and record the height of the object (or the height of a specified section of that object). Take pictures as often as possible, but at least once a week. Load the pictures onto a computer and organize them by date.
4. Using MVH Image, load a photograph. When the “Select a Method of Scale Calibration” box pops up, select “Scale Present in Image”. Draw a line along the permanent structure that you measured. Then enter the height of the object and the unit of measurement (eg. feet or meters) in their relative spaces. Select the analysis tool called line tool and draw a line from the base of the permanent structure to the water’s edge. The program should tell you how long that line is in the lower right hand corner.
5. Doing this for every picture will allow you to analyze the changes in the water level for the pool. Your students should create a chart keeping track of these changes. Just remember that if the line gets longer, the water level has dropped and if the line gets shorter, the water level as risen.



## Conclusions

The concept of water levels is very important to the future of our world. As the ocean levels rise, coastal flooding will be a problem with which the next generation will need to cope. Understanding the differences between flooding due to water tables and flooding due to climate change will help our future scientists.

Thought Question: Why do the changing seasons affect the water levels in vernal pools? What else could cause the water levels to rise or fall?

## Extensions

Here are some variations on the Water World activity that may be useful.

- Identifying Species

Vernal pools are the home to many species, plant and animal. Try identifying the various species that are living in and around your pool. Pictures will also help you track their life cycles.

- Finding Plant Stresses

PicturePosts were developed to monitor plant stresses. By using either the MVH filters or computer programs, changes in plant health can be seen. The unhealthy plants will appear either lighter under the filters, or will have a higher percentage of red and blue on the computer programs. Please note: these analysis tools are not intended to compare plants to each other, but to compare a plant to a previous picture of the same plant. This is because all species of plants are different shades of green, so comparing two plants will not provide accurate results. Also, the lighting at the time of the pictures will also affect the data, so try to take the pictures at the same time of day under similar weather conditions. Another way to see damage to a plant is to compare different leaves from the same plant.

# Changes in Elevation

**Objective:** Investigate the effect of elevation on plant health and green-up

## What You Need

- Installed PicturePost
- Mountain or large hill in view
- Digital Camera

## Getting Started

Elevation refers to the height of an area of land. Differences in elevation can change many factors in the environment, such as temperature, air thickness, wind speed, storm strength, sunlight, and others. If there is a large change in elevation visible in your area, such as a distant hill or mountain, a PicturePost can help monitor how these changes effect vegetation.

## Experiment

1. Take photos from the PicturePost with the hill or mountain visible in the background.
2. If possible, viewing the effect of elevation on spring green-up may be most striking. Start taking pictures in late winter before the trees start to grow buds and continue the series until all the leaves bloom.
3. Allow the students to view and analyze the pictures and note their observations in a lab notebook. What changes can you see that might be elevation related?

## Conclusions

The planet is full of elevation changes, but vegetation thrives in even the most precarious of changes. Still, changes in air, rain, and sunlight can have a noticeable effect on when plants bloom, and how healthy they are overall.

Thought Question: Did plants bloom earlier at the bottom or the top of the hill? What other differences did you notice between different elevations?

## Extensions

Here are some variations on the Changes in Elevation activity that may be useful.

- Tree Height

Using MVHimage, have students measure the height (whether in pictures or calibrated feet) of trees at different elevations. Compare various samplings. Does elevation have an effect on how tall trees will grow?

# **Weed Invasion!**

**Objective:** Monitor the spread of fast-growing vegetation, such as weeds

## **What You Need**

- Installed PicturePost
- Field being potentially overrun by a certain type of plant
- Digital Camera

## **Getting Started**

There are many different kinds of weeds: dandelions, crabgrass, Japanese Knotweed, and others. Once they begin to appear in a field it often doesn't take long until they are everywhere! PicturePosts can help keep track of their progress as they spread across the lawn.

## **Experiment**

1. Take photos from a PicturePost with a good view of the "threatened" field. This may be a good use of the PicturePost cap mounted on a tripod, as it can be taken to the center of any nearby field.
2. Continue taking pictures daily, weekly, or however you feel appropriate depending on the progress of the invasion.
3. Allow the students to view and analyze the pictures and note their observations in a lab notebook. How quickly are the weeds spreading?

## **Conclusions**

Weeds seem to grow and reproduce in nearly any sort of conditions. It can only be a matter of weeks between the first dandelion of the year and a field covered in yellow. It can be astonishing how quickly they manage to reproduce.

Thought Question: How long do you think it will take until the weeds cover the entire field? If you are monitoring dandelions, how long does it take for them to turn to seed? How many seeds do you think all the dandelions in the field could produce?

## Extensions

Here are some variations on the Weed Invasion! activity that may be useful.

- Bugs and Disease

Often a much more serious problem for vegetation, bug infestations and vegetation diseases can harm or even devastate entire areas. Using a PicturePost, track the spread of evidence and damage caused by bugs or diseases in the local environment. Using MVHimage or the MVH Filters, monitor the health of all the vegetation in the area. Is there anything that can be done to help?

This section of the guide describes the process of setting up your new PicturePost. There are two, equally important parts of setup: picking a location and installing the post.

<u>Steps</u>	<u>Page</u>
PicturePost Installation	37
Taking Pictures	41
Uploading Pictures	43

## PicturePost Installation

A.1

### Materials Needed

- EPS PicturePost
- Shovel or Post Digger
- Compass
- Level
- Electric Drill
- 4 Wood Screws (for plastic lumber if available)



### Step 1: Finding a Location

Choice of location when installing a PicturePost is extremely important as it will directly influence the type and quality of data collected from the area. Every area introduces a different ecosystem with different monitoring opportunities, and you may have a very specific monitoring goal or focus in mind, which is great. However there are a few general recommendations to take into consideration that will help guarantee the success of your program.

- The post must be in a location that has “sufficient” vegetation surrounding it. The more the better for observation purposes.
- An optimal location should incorporate different environmental features such as hills, rocks, water, and a variety of vegetation so the effects on all can be monitored. Such features can also serve as reference points in comparing data taken from the same location.
- Look for areas that might capture growth in each of the herbaceous (ground-level), shrub (mid-level) and canopy (tree-level) “layers” of the environment. Their growth should be especially striking during spring green-up. They may also be affected by different potential environmental influences.
- PicturePosts should be placed in an area with easy access for the public but not in an area where the post is likely to face vandalism.
- If public, make laminated instructions to post (see next page):
  - Modify to include your post's location.
  - Keep in column format to ensure the size will be adequate.
  - Print and trim down to size.
  - Laminate the instructions to protect it from weather.



# Picture Post #1

## Menotomy Rocks Park

Latitude: 42° 24.637'N

Longitude: 71° 9.899'W

**The project:** We are studying the health of plants and the status of invasive species in this area of Menotomy Rocks Park while having fun watching nature change with the seasons.

**We need digital pictures** to create a time-lapse sequence of photos that will document the growth of plants 360° around this picture post throughout the year, and hopefully years to come.

**You can help** by taking a set of pictures from this post. Here's how:

- 1) Take a digital picture of these instructions to indicate the location of the post. Include your watch in the picture, if possible, since this will be used as an accurate check of the time and date of the photos.
- 2) Place the bottom of the digital camera flat on the disc, with the back against the side of the octagon that faces North and is marked "N." Align the middle of the back of your camera with the edge of the octagon. Point the lens away from the post.
- 3) Use widest angle lens setting and take a picture. Repeat for the other 7 **clockwise** locations on the octagon.
- 4) With the camera pointing skyward and the bottom along the north edge of octagon, take a picture of the sky and/or leaf canopy cover overhead.
- 5) Submit your photos and view others' at

<http://picturepost.smugmug.com>

If you have nothing to write this information down, take a photograph of this card and reread on your computer screen.



### Step 2: Installing the Post

- Dig a hole at least 3 feet deep and wide enough for the 4x4 post. You want 4 feet of the post above ground. This means that, for most areas, the post will need to be 7 feet tall. Currently, EPS, the manufacturer of the posts, only make 6 foot or 8 foot posts. We recommend buying an 8 foot post and cutting it down to size.
- For stability, the bottom of the post must be below Frost Depth. For the Boston, MA area, this is 3 feet. Talk to local builders to see what is recommended in your area.
- You may attach post head to an existing post or secure structure.
- Keep the post vertical (check with a level in all directions), back fill the hole with dirt, stamp dirt until firm and post is stable.



### Step 3: Assembling the Post

- Take GPS reading from the top of the post to find the latitude and longitude. Center and level post head onto post. If you don't have a GPS, or to verify your GPS reading, visit <http://www.mapbuilder.net/>. Type in your location and hit enter. You should see a balloon pop up on your map. Zoom in all the way on your location and click on the "Hybrid" button. Use the mouse to scroll until you can see the exact location of your PicturePost. Type in a caption and click the "add" button (don't worry about the exact location of the balloon). The balloon should stop flashing and the color should tone down. Now you can click on this balloon, drag, and drop it at your post's exact location. Click on your post's balloon (it will highlight) and write down the latitude and longitude displayed.
- Find True North for your location using the information at



<http://www.ngdc.noaa.gov/seg/geomag/jsp/struts/calcDeclination.html> For Boston, MA area in early 2007, magnetic north is 15 degrees west of true north (see photograph of compass on previous page). Notice that the

compass is held so that the white tip of the compass, which points north, points 15 degrees west of north.



- Align the post cap such that the north direction is in the same direction as the true north previously calculated.



- Double check alignments and drill four holes through the post head into the post.
- Secure with the drywall or wood screws.



- Using permanent marker or paint, label the post head with location information and attach the basic instructions.



Now, PHOTOGRAPH AWAY!!

## Taking Pictures

A.2

### Materials Needed

- Digital Camera
- PicturePost

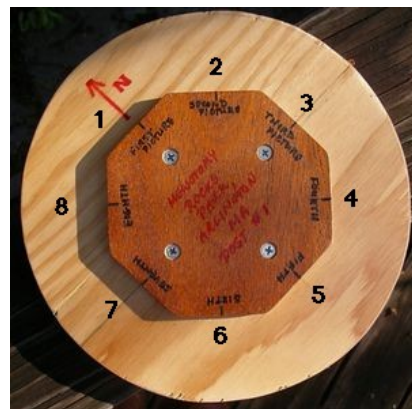
### Step 1: Recording the Date and Time

- To check your camera's date and time settings, take a picture of a watch. If you are taking pictures from more than one post, include the post information in the picture.



### Step 2: Take 8 Photos of the Landscape & 1 of the Sky

- If you have a zoom lens, make sure camera is set to the widest angle lens setting.
- Consistently align feature of camera to a corner or marking on octagon.
- For the first photo, place the back of the camera against the octagon so the camera is facing North.
- Continue taking photos in a clockwise order, as shown below.
- Shoot the last photo with the camera on its back and the lens pointing skyward and the bottom edge of the camera aligned with the north edge of the octagon as shown below.



### How Often To Take Pictures?

- To study the seasonal plant cycles, at least once a day during spring “green up” and during autumn “green down”.
- During the remainder of the year, take pictures once a week.
- Coordinate with a group of photographers during the busy weeks.



## Uploading Pictures

A.3

### Materials Needed

- Computer with Internet Access
- Digital Camera with memory card and appropriate cables to hook up to computer

### Step 1: Saving and Renaming your photos

- Save your pictures to a folder on your computer that you have designated for PicturePost Pictures. It is suggested that you create a different folder per post for every date that you take pictures (include the date in the name of the folder)
- You must rename the files before adding them to the website. Software to assist in the uploading process is available at:

[http://mvh.sr.unh.edu/mvhtools/picturepost\\_intro.htm](http://mvh.sr.unh.edu/mvhtools/picturepost_intro.htm)

Once the images have been uploaded, they CANNOT be renamed. Please double check that the renamed images have the correct file information and follow the rules on the following page.

## **SSPPP#CCYYMMDDHHmmii.jpg**

*Where*

**SS** = State abbreviation

**MA** = Massachusetts

**NC** = North Carolina

**PPP** = 3-Letter Park Name

**MRP** = Menotomy Rocks Park, Arlington, MA

**FPR** = Fresh Pond Reservation, Cambridge, MA

Note: If you install your own PicturePost and would like to share your photos, we will create a folder with its own 3-letter name

**#** = Specific number of post in the park

**CC** = Direction Camera Pointing

**NN** = North

**NE** = Northeast

**EE** = East

**SE** = Southeast

**SS** = South

**SW** = Southwest

**WW** = West

**NW** = Northwest

**SKY** = Camera pointing skyward

**YY** = Year (e.g. 06 = 2006)

**MM** = Month (e.g. 04 = April)

**DD** = Day of the Month

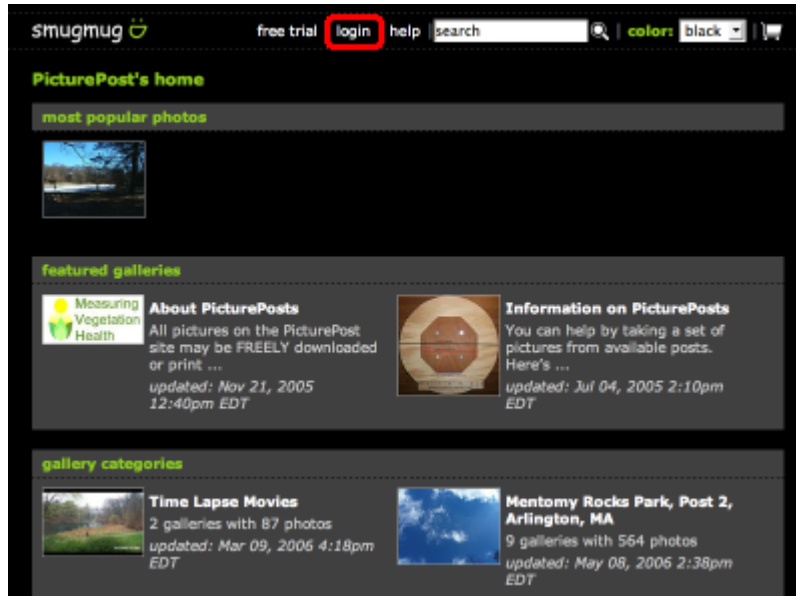
**HH** = Local Hour (24-hour clock; e.g. 15 = 3 PM)

**mm** = Minutes

**ii** = Additional information (e.g. IR = infrared photo)

## Step 2: Logging In

- Go to <http://picturepost.smugmug.com/>
- Click login button and use “picklejohnmr@gmail.com” as the user name and “postguest” as the password:



**to proceed, please log in below**

By logging in, you agree to smugmug's [terms of use](#).

**email:**

**password:**

I'm using a public computer, don't keep me logged in.


Password: postguest

### Step 3: Pick your State

**gallery categories**

	<b>Massachusetts</b> 38 galleries with 3991 photos <i>updated: Jul 10, 2006 8:50am PST</i>		<b>Information</b> 2 galleries with 12 photos <i>updated: Mar 28, 2007 3:42pm PST</i>
	<b>North Carolina</b> 36 galleries with 0 photos <i>updated: Mar 20, 2007 7:35pm PST</i>		

### Step 4: Pick the Park


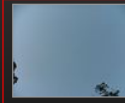

**SmugMug**  [quest photos](#) | [logout](#) | [help](#) |   | [color: black](#)

**tools:**

PicturePost > **Massachusetts**

**Massachusetts sub-categories**

sort sub-categories: [arrange](#)

	<b>Time Lapse Movies</b> 2 galleries with 101 photos. <i>updated: Jul 10, 2006 11:50am EDT</i>		<b>Menotomy Rocks Park, Arlington, MA</b> 18 galleries with 2782 photos. <i>updated: Apr 02, 2007 11:07am EDT</i>
	<b>Fresh Pond Reservation, Cambridge, MA</b> 18 galleries with 1120 photos. <i>updated: Apr 02, 2007 11:28am EDT</i>		



## Step 5: Pick the Direction

tools: [new gallery](#) [control panel](#) [order backup](#) [themes](#)

[PicturePost](#) > [Massachusetts](#) > *Menotomy Rocks Park, Arlington, MA*

**Menotomy Rocks Park, Arlington, MA galleries**

sort galleries: [arrange](#)

**MRP2 Up [edit](#)**  
Pictures taken looking skyward from PicturePost #2 installed near the ...  
[edit](#)  
updated: Apr 02, 2007 11:07am EDT

**MRP2 Northwest [edit](#)**  
Pictures taken looking northwest from PicturePost #2 installed near th ...  
[edit](#)  
updated: Apr 02, 2007 11:05am EDT

**MRP2 West [edit](#)**  
Pictures taken looking west from PicturePost #2 installed near the sou ...  
[edit](#)  
updated: Apr 02, 2007 11:02am EDT

**MRP2 Southwest [edit](#)**  
Pictures taken looking southwest from PicturePost #2 installed near th ...  
[edit](#)  
updated: Apr 02, 2007 11:04am EDT

**MRP2 South [edit](#)**  
Pictures taken looking south from PicturePost #2 installed near the so ...  
[edit](#)

**MRP2 Southeast [edit](#)**  
Pictures taken looking southeast from PicturePost #2 installed near th ...  
[edit](#)

## Step 6: Click "Add Photos"

SmugMug

[guest photos](#) | [logout](#) | [help](#) |  | style: [smugmug](#) |

[map this!](#) | [share photo](#) | [slideshow](#) | [themes](#) | **+ add photos** | [add photos](#)

**MRP2 Northwest [edit](#)**

ictures taken looking northwest from PicturePost #2 installed near the south end of Hills Pond in Menotomy Rocks Park (<http://www.friendsofmenotomy.org/>), Arlington, MA (42 24.622°N 71 9.988°W).

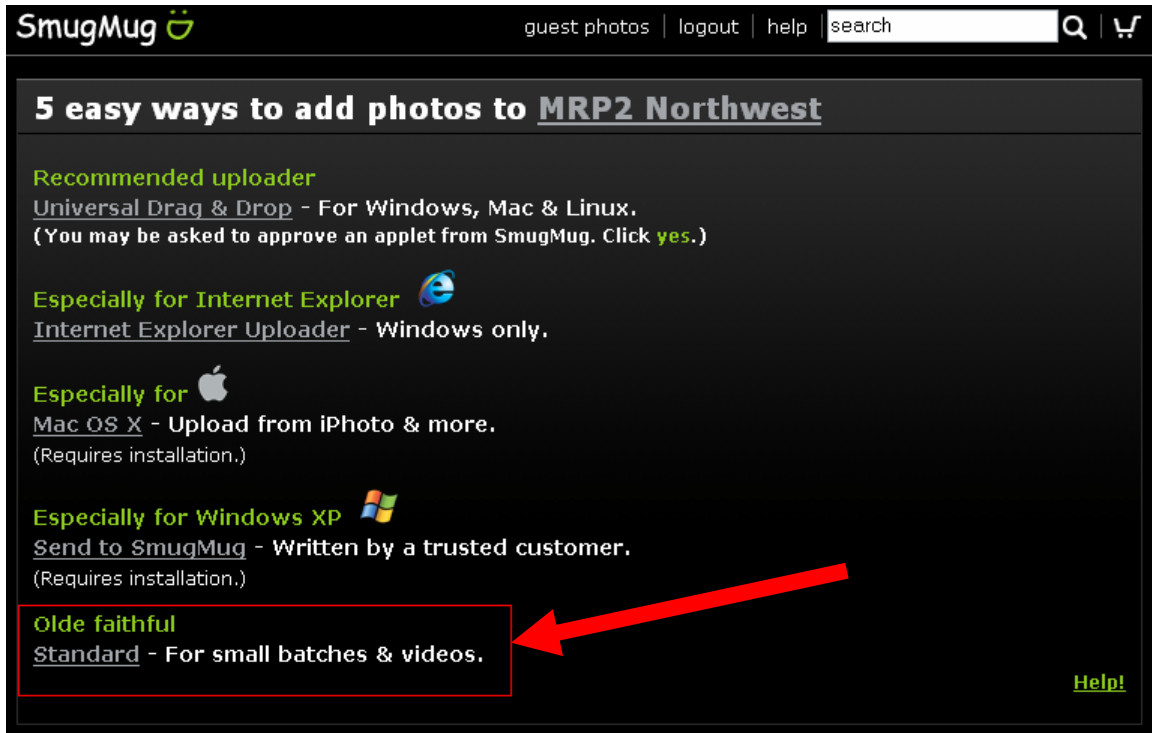
ove cursor over the images to see the filenames.

enames use the following convention: SSPPP#ddYYMMDDhhmm  
here SS is the state, PPP is the park code, # is the post number in that park, dd is the direction the camera was pointing, YY is the year, MM is the month, DD is the date, hh is the hour in that particular time zone, mm is the minute the first picture was taken. For more information, see <http://picturepost.smugmug.com/gallery/635128>. [edit](#)

Page 1 of 11 [Next >](#) >> 1 of 160 [Next >](#) [buy: this photo](#) [multiple photos](#) [view cart](#)

## Step 7: Select Upload Process

“Standard” provides easiest to follow procedure, but it is not automated.



The screenshot shows the SmugMug website interface. At the top, there is a navigation bar with the SmugMug logo, links for "guest photos", "logout", "help", and a search bar. Below the navigation bar, a header reads "5 easy ways to add photos to MRP2 Northwest". The main content area lists five upload methods:

- Recommended uploader**: Universal Drag & Drop - For Windows, Mac & Linux. (You may be asked to approve an applet from SmugMug. Click **yes**.)
- Especially for Internet Explorer** (with Internet Explorer icon): Internet Explorer Uploader - Windows only.
- Especially for** (with Apple logo): Mac OS X - Upload from iPhoto & more. (Requires installation.)
- Especially for Windows XP** (with Windows XP icon): Send to SmugMug - Written by a trusted customer. (Requires installation.)
- Olde faithful** (highlighted with a red box and a red arrow pointing to it): Standard - For small batches & videos.

A "Help!" link is visible in the bottom right corner of the content area.

## Step 8: Browse Your Computer to Find Photos

- Double check location, post number, & direction
- Click “Add Photos”



The screenshot shows the "Add photos to: MRP2 Northwest" interface. It includes a note: "Try a [different uploader](#)." Below this is a "Getcha:" warning: "After hitting 'add photos', it can take a long time to upload. Don't continue to browse the web in this window, or your upload won't finish properly." There is a dropdown menu for "How many photos would you like to upload at once?" set to "1-5". Below this are five rows, each labeled "photo 1:" through "photo 5:", with a text input field and a "Browse..." button. At the bottom, there is an "Add Photos +" button.

\* Repeat Steps 4-7 until all directions are added for that post

Approximately 20 different software programs have been developed as part of the Measuring Vegetation Health program, through collaboration between seven member organizations and universities. The software is very useful for analyzing a wide variety of digital images for many different purposes. This section of the guide details how to use the three MVH software programs used by our suggested lessons: PixelView, ColorPicture, and MVHimage.

The directions in this manual cover the basic aspects of these programs; there is much more that can be done once you become familiar with them. Experiment! Consider this a tutorial on how to get started with the software.

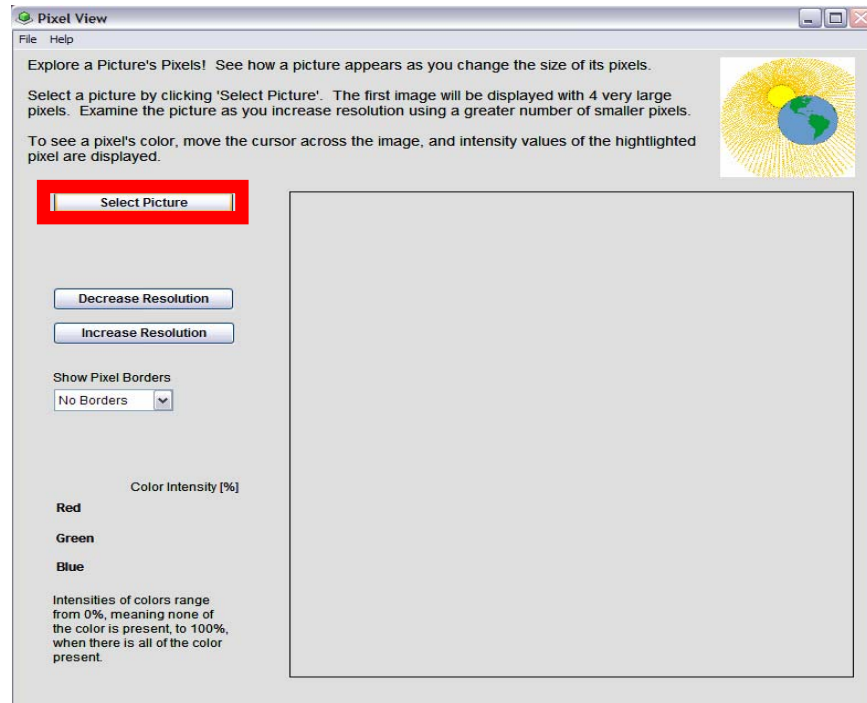
All of the software programs can be downloaded for free from the MVH website:  
<http://mvh.sr.unh.edu/software/software.htm>

<u>Program</u>	<u>Page</u>
PixelView	50
ColorPicture	52
MVHimage	54

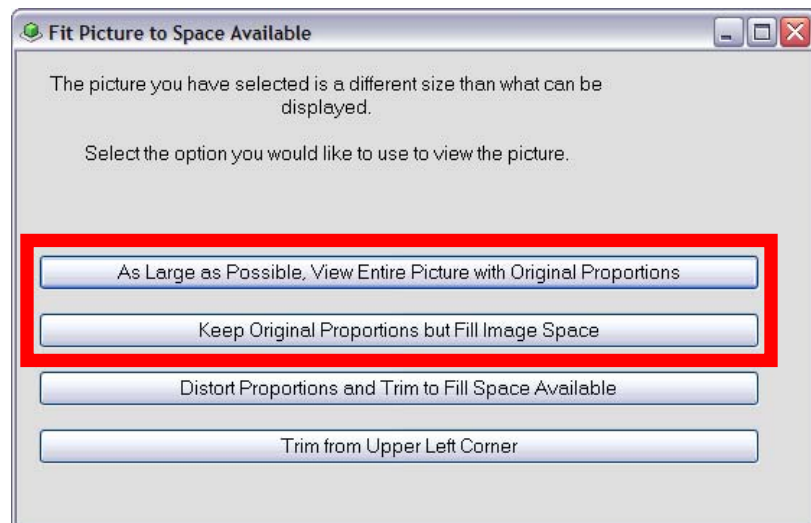
## PixelView

## B.1

1. After opening the program, click on the “Select Picture” button and choose the picture that you would like to view.



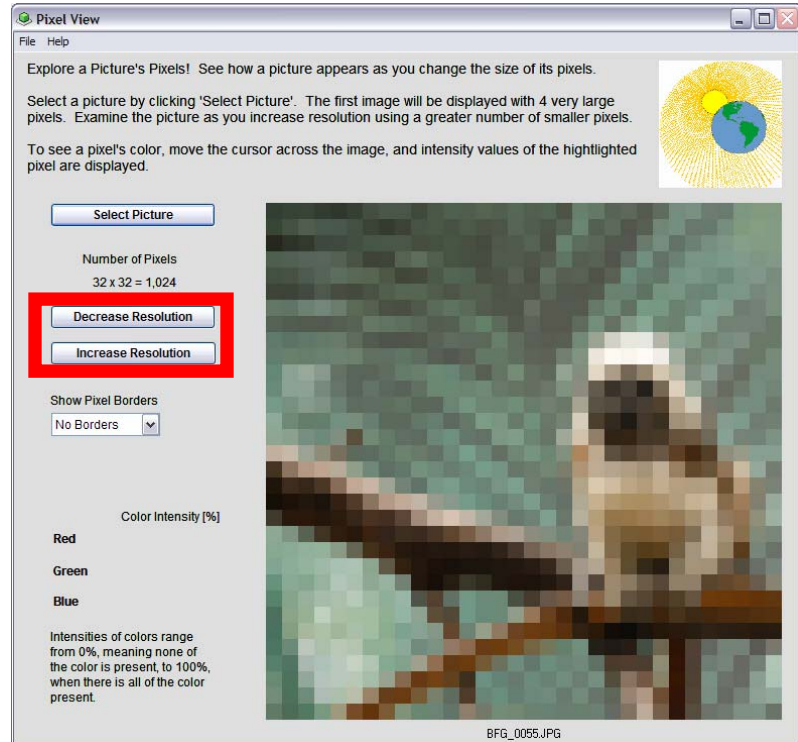
2. After you click the “Open” button, a screen with 4 selections will appear. The recommended choices are either “As Large as Possible, View Entire Picture with Original Proportions”



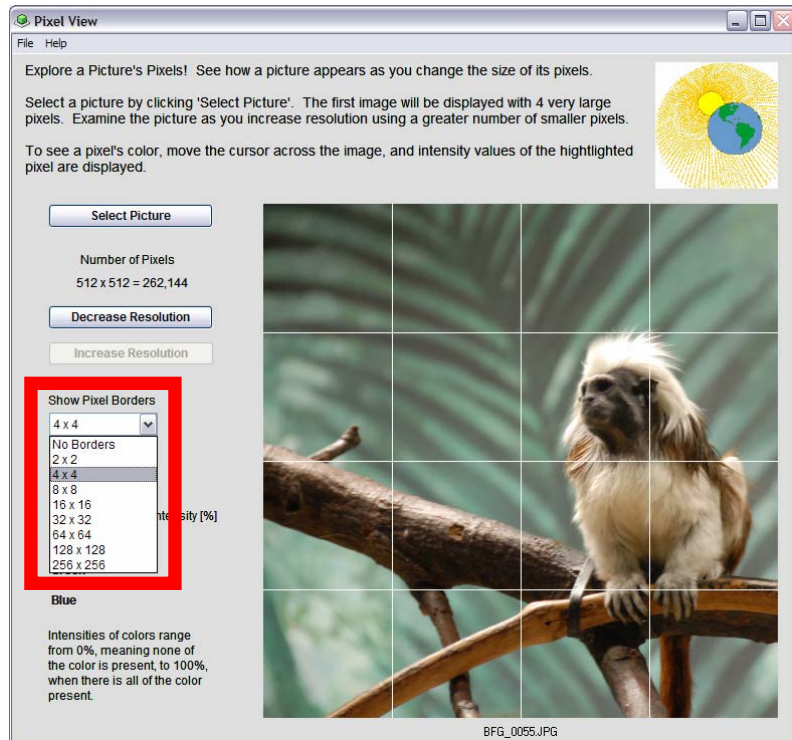
which will show you the entire picture, but may not fill the entire space provided (space not used will appear black) or “Keep Original Proportions but Fill Image Space” which will fill the entire space provided, but may not show you the entire picture.

3. The picture should appear in the outlined box on the right side of the screen as a 2x2 pixelated image.

4. Click either "Increase Resolution" (not available at 512x512) or "Decrease Resolution" (not available at 2x2) to see the photo at different resolution levels. The resolution levels are 2x2, 4x4, 8x8, 16x16, 32x32, 64x64, 128x128, 256x256, 512x512.



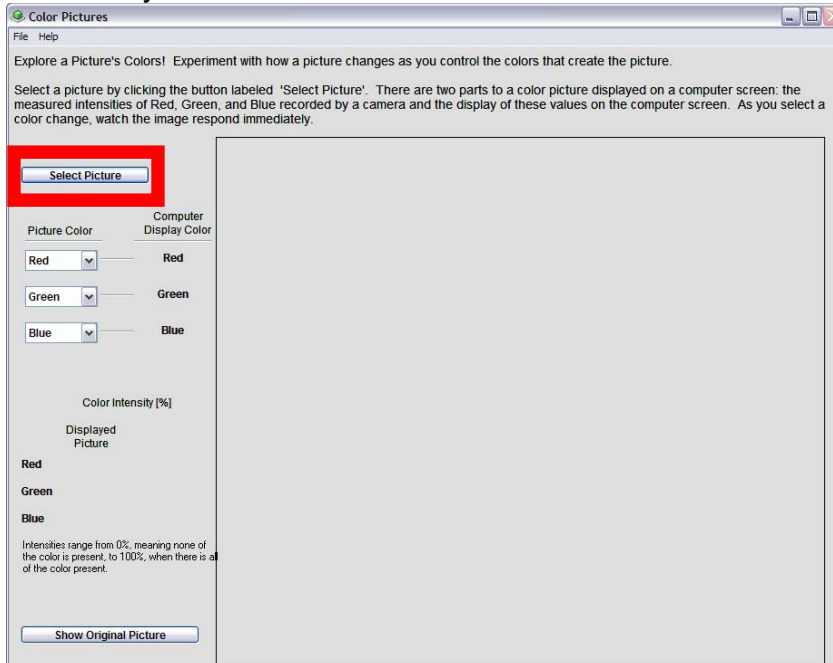
5. To get a better idea of how big the pixels are (especially when you get into the higher numbers), use the drop down box that says "No Borders" and select one of the sizes.



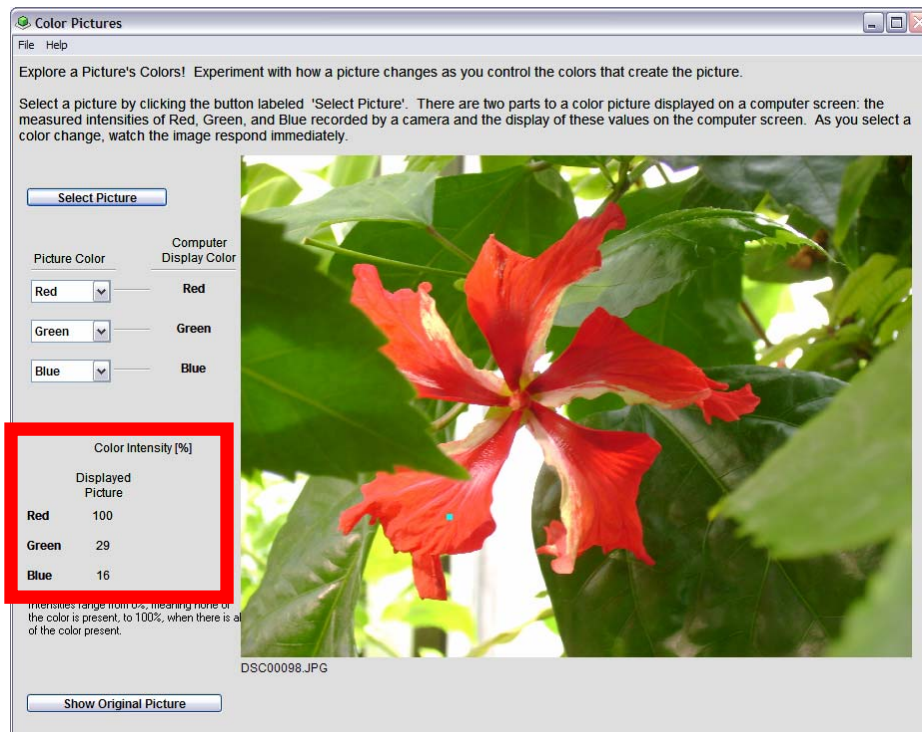
# ColorPicture

# B.2

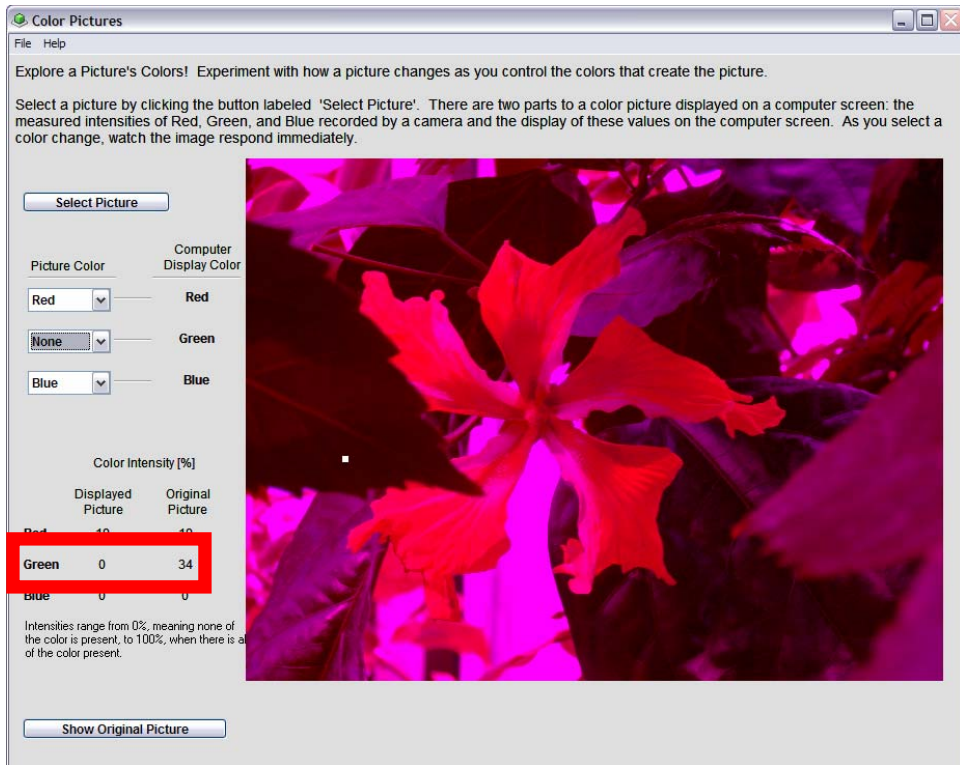
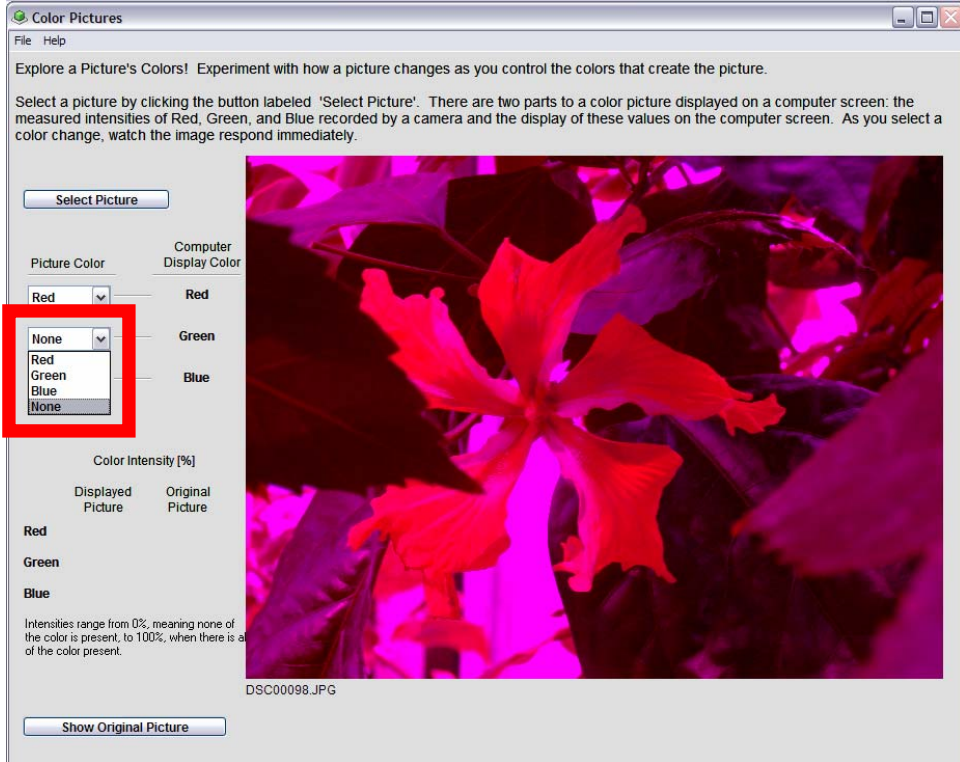
1. After opening the program, click on the “Select Picture” button and choose the picture that you would like to view.



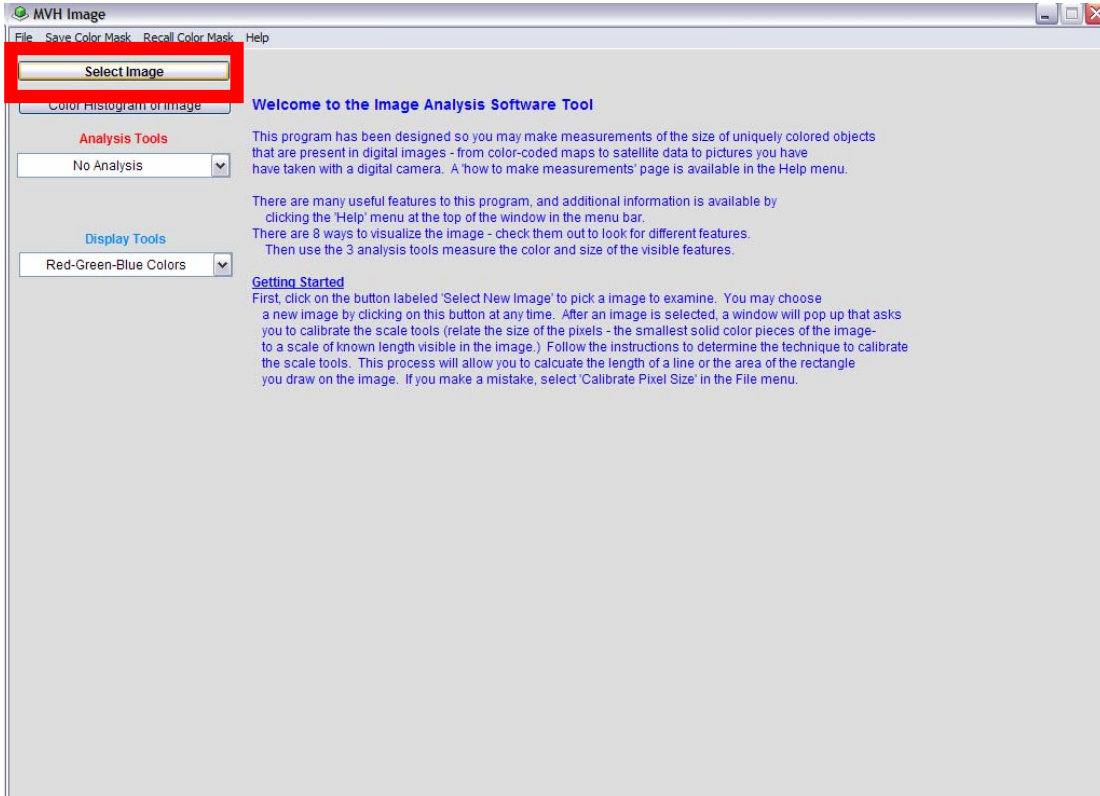
2. A small box should appear at the tip of your arrow (this may take a second). When you move the box around, numbers will appear on the lefthand side of the screen which will tell you the amount of red, green, and blue in that pixel. Keep in mind that a white object will have 100's in each color, where a black object will have 0's in each color.



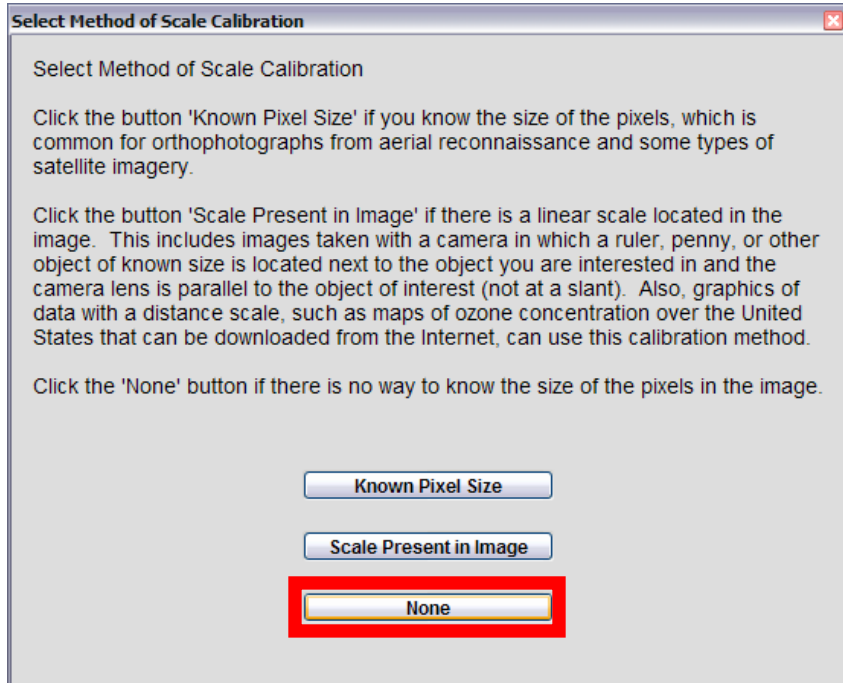
- Color Picture will also allow you to filter out colors. For example to completely take away all of the green light in a picture, click on the drop down box that says "Green" and choose "None". Notice that the level of green intensity now says "0" for any pixel chosen.



1. After opening the program, click on the “Select Image” button and choose the picture that you would like to view.



2. After you click on the “Open” button, a box with three choices will appear. Although knowing the number of pixels and the scale of the picture can be helpful, for most needs the “None” option will suffice.

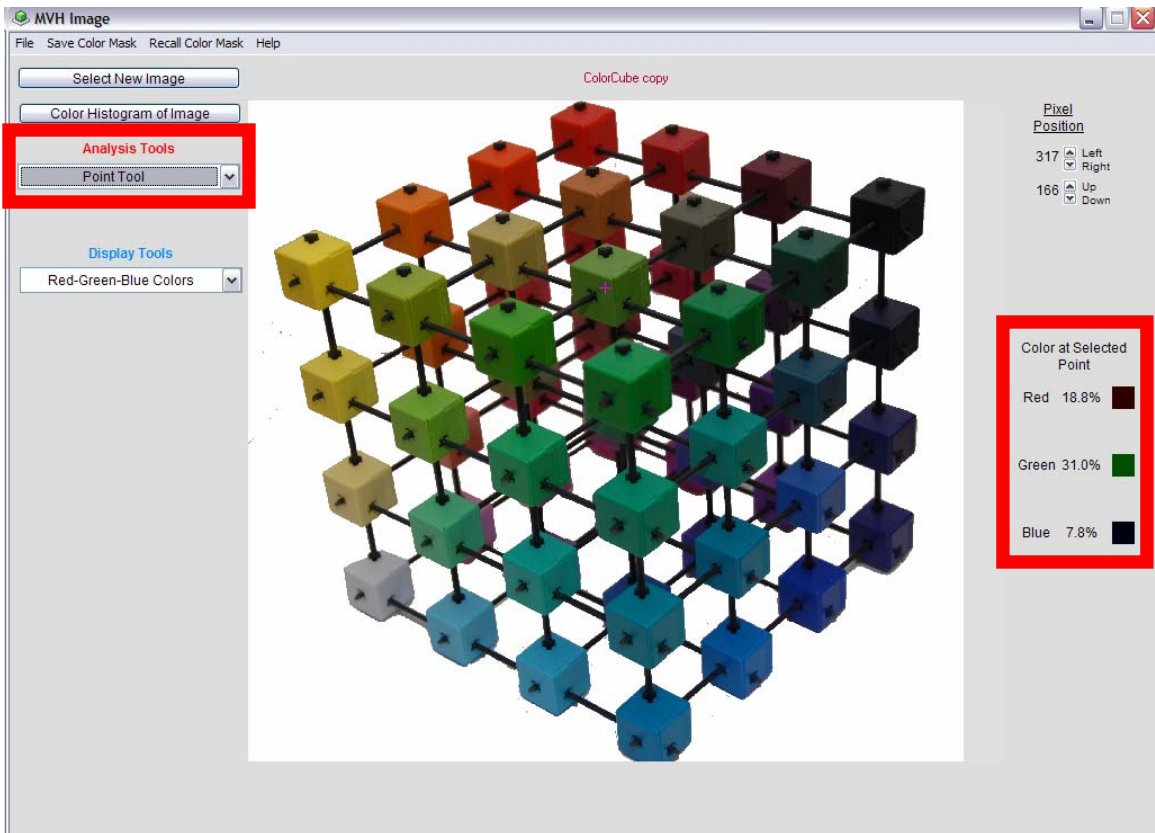
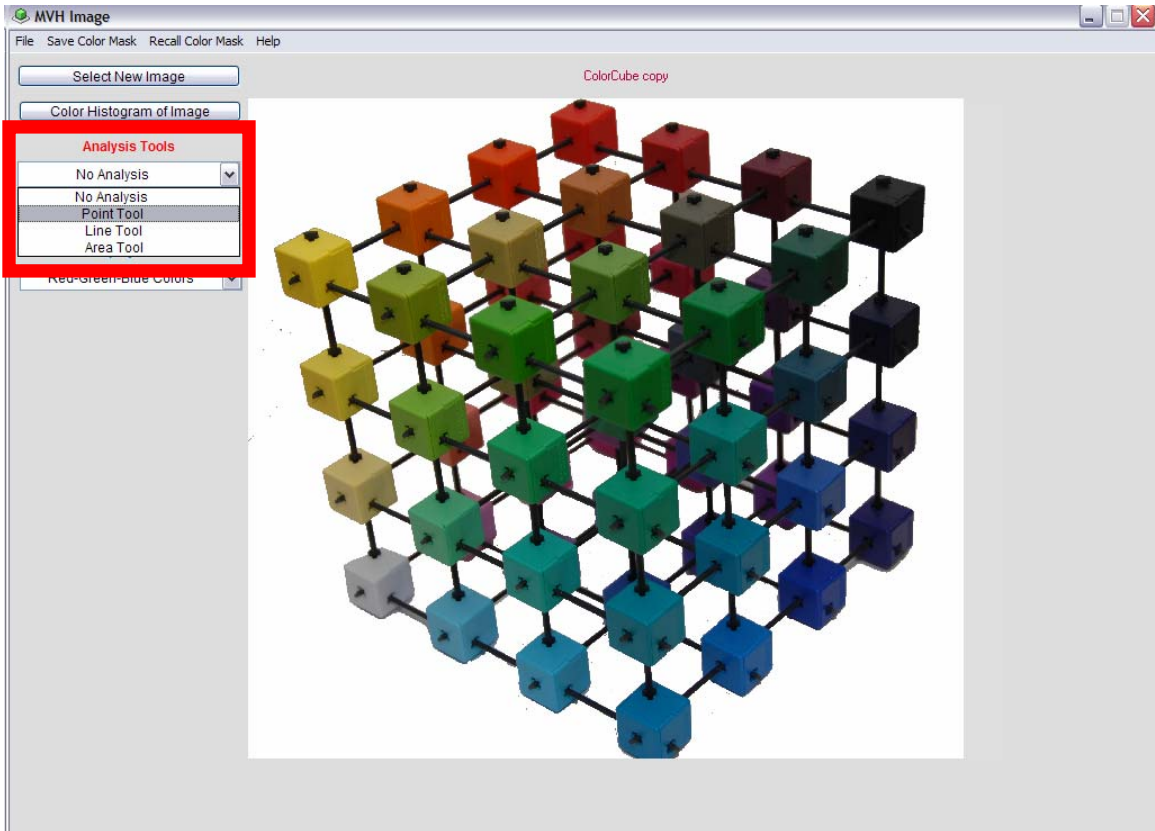


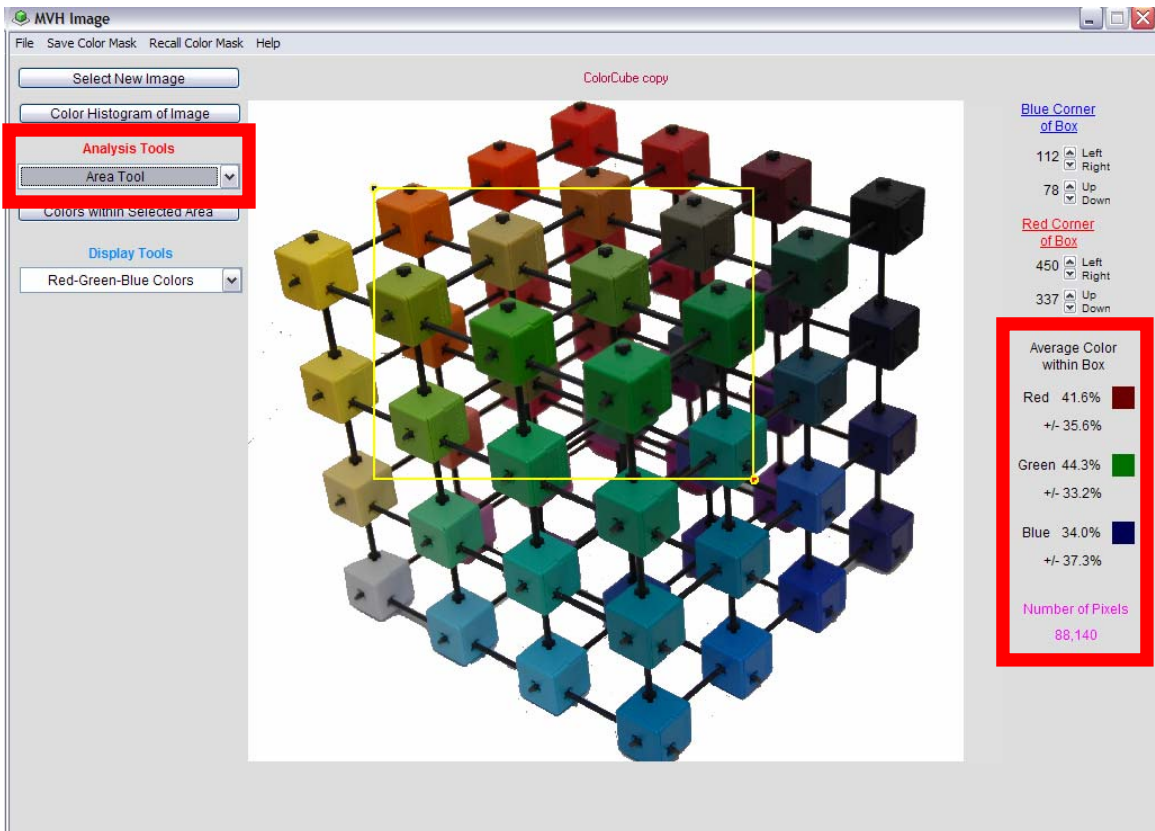
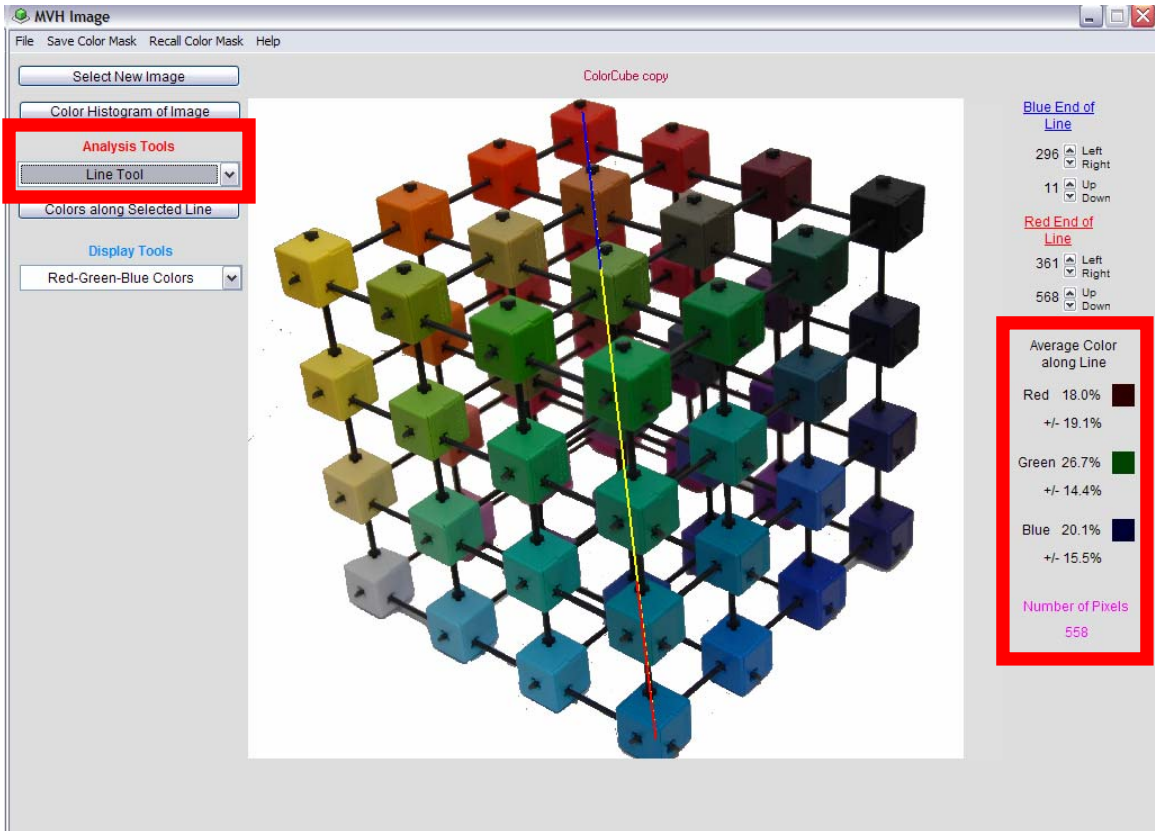


3. MVH Image gives you many analysis options which don't need to be done in any particular order. The first analysis tool provided is the color histogram. This can be seen by clicking the "Color Histogram of Image" button.



4. Under the "Analysis Tools" dropbox there are 4 choices: "No Analysis", "Point Tool", "Line Tool", and "Area Tool". "Point Tool" will give you the intensities of red, blue, and green at any given point (you need to click at the point that you want for the data to appear). With "Line Tool", you draw a line on the image and the color intensities displayed are the averages along that line. In "Area Tool", you draw a box and the average color intensities inside the box are averaged and displayed.





5. MVH image also has a dropdown box which is labeled “Display Tools”. It is normally on “Red-Green-Blue Colors” which means that all of the colors are displayed. There are many choices under this dropbox. You can show the image in each color as shades of gray, with only two of the colors showing (normalized), or even pick what colors you want displayed.

