

WCAG 2.0 Success Criterion 1.1.1 Compliance:  
Using Accessibility Checkers to Find Empty Alt Attributes in University Home-pages

by

Michael Robert Sabbia

A Thesis Presented in Partial Fulfillment  
of the Requirements for the Degree  
Master of Science

Approved October 2018 by the  
Graduate Supervisory Committee:

Barry Maid, Co-Chair  
Eva Brumberger, Co-Chair  
Andrew Mara

ARIZONA STATE UNIVERSITY

December 2018

## ABSTRACT

With 285-million blind and visually impaired worldwide, and 25.5 million in the United States, federally funded universities should be at the forefront when designing accessible websites for the blind community. Fifty percent of the university homepages discussed in my thesis failed accessibility checker tests because alternative text was not provided in the alt-attribute for numerous images, making them inaccessible to blind users. The images which failed included logos, photographs of people, and images with text. Understanding image content and context in relation to the webpage is important for writing alternative text that is useful, yet writers interpret and define the content and context of images differently or not at all. Not all universities follow legal guidelines of using alternative text for online images nor implements best practices of analyzing images prior to describing them within the context of the webpage. When an image used in a webpage is designed only to be seen by sighted users and not to be seen by screen reader software, then that image is not comparably accessible to a blind user, as Section 508 mandates.

## TABLE OF CONTENTS

	Page
LIST OF TABLES .....	v
LIST OF FIGURES .....	vi
INTRODUCTION .....	1
LITERATURE REVIEW .....	3
WCAG 2.0 Basics .....	5
Alternative Text.....	6
Screen Readers .....	8
Images .....	10
Accessibility Checkers .....	13
Automatic Alternative Text.....	15
Access-First Design.....	16
Image Analysis Before Alternative Text.....	17
METHODOLOGY .....	19
Collection of Data .....	20
Research Question.....	21
Hypothesis.....	21
Rationale.....	21

	Page
Sampling University Homepages.....	22
University Web Standards Pages .....	23
Sampling WCAG Guidelines .....	27
Sampling Accessibility Checkers.....	29
W3C Filters .....	32
Accessibility Checkers Matching W3C Filters: .....	33
Accessibility Checker Inclusion and Exclusion Criteria.....	34
Final List of Accessibility Checkers Included .....	35
Accessibility Checker Procedures.....	35
AChecker.....	35
Cynthia Says .....	36
Nu Html Checker .....	37
RESULTS .....	38
AChecker.....	38
Cynthia Says.....	44
Nu Html Checker .....	46
Arizona State University .....	48
Auburn University.....	49
Illinois Institute of Technology.....	49

	Page
Metropolitan State University .....	50
Michigan Technological University .....	51
Montana Tech.....	51
North Carolina State University .....	51
Oregon State University .....	52
Texas Tech University .....	53
University of Washington (Seattle).....	53
DISCUSSION .....	54
AChecker Usability .....	54
Cynthia Says Usability .....	56
Nu Html Checker Usability.....	57
Foaf Images/Slides .....	57
Implications.....	67
CONCLUSION.....	68
Further Research to Consider .....	70
REFERENCES .....	73

## LIST OF TABLES

Table	Page
1. Does the university have a web-standards page?.....	22
2. W3C Filters Chosen.....	33
3. AChecker Known Problems Category.....	38
4. AChecker Likely Problems Category.....	39
5. AChecker Potential Problems Category.....	39
6. AChecker Known, Likely, and Potential Combined.....	41
7. AChecker-Lines of Code Regarding Alt-text Issues.....	43
8. Results for Cynthia Says.....	44
9. Cynthia Says-Lines of Code Regarding Alt-text Issues.....	45
10. Results for Nu Html Checker.....	46
11. Nu Html-Lines of Code Regarding Alt-text Issues.....	47
12. Patterns: Lines of Code with Empty Alt-Attributes.....	48
13. Did a Web-Standards Page Help Results?.....	70

## LIST OF FIGURES

Figure	Page
1. A Complex Image of Line Graphs.....	12
2. W3C Filters.....	32
3. AChecker Homepage.....	35
4. Cynthia Says Homepage.....	36
5. Nu Html Checker Homepage.....	37
6. A Female student holding a graduation cap with the word "HIRED!" on it. ....	57
7. ASU Homepage showing a female student holding a graduation cap with the word "HIRED!" on it. ....	58
8. Illinois Institute of Technology Homepage: Number 1 in Intellectual Property Law. ....	60
9. Illinois Institute of Technology Homepage Clip. ....	61
10. Nine People Standing-Metropolitan State University.....	62
11. Metropolitan State University Homepage Content Mentioning Nine Students ...	63
12. American Flag at North Carolina State University.....	64
13. North Carolina State University Homepage Content.....	65
14. University of Washington, Image from Line 10.....	66
15. University of Washington Image from Line 10: Did You Know? .....	67

## INTRODUCTION

My interest in accessibility stems from attending Web design courses at Arizona State University where I first learned about the alt-attribute in HTML, and during a grant writing course where I wrote a proposal for funding a music braille project at a non-profit shelter for blind students in Vietnam. The amount of research about accessibility that I concluded during my courses helped me to become aware of the many problems blind people face online, which ultimately led to writing my thesis about compliance with Web Content Accessibility Guideline 2.0 (WCAG 2.0) Success Criterion 1.1.1 Level A. In addition, I discuss using accessibility checkers to find empty alt-attributes in university homepages, and how those accessibility checkers performed in finding empty alt-attributes.

In January 2018, Web Content Accessibility Guidelines 2.0 (WCAG 2.0) was incorporated into Section 508 of the Rehabilitation Act of 1973 and are legal recommendations for making online information accessible to people with disabilities. Under WCAG 2.0, public universities are required to make their website images accessible to blind audiences by following WCAG 2.0 Success Criterion 1.1.1 Level A recommendations for providing alternative text in the image alt-attribute. WCAG 2.0 Success Criterion 1.1.1 Level A explains that non-text content, i.e., an image, requires a textual alternative. An exception exists for decorative images though; decorative images should only have an empty alt-attribute—meaning the image is free of any description and should serve no other function in a webpage other than being for decorative or visual formatting purposes, otherwise it would not be considered a decorative image and should have an alternative text description in the alt-attribute which describes the image.



Decorative images with empty alt-attributes will conditionally pass accessibility checker tests, depending on the accessibility checker used, because screen reader software is designed to overlook images with empty alt-attributes; the negative side is that any image with an empty alt-attribute may also conditionally pass an accessibility checker test. Blind users will not know that an image exists, whether it's decorative or not, if it has an empty alt-attribute. Since any image with an empty alt-attribute might pass an accessibility checker test, it's possible that those images can be defined simply as being decorative in nature, when in fact the image may contain useful content to a blind user. Images with empty alt-attributes is what I was testing for in my thesis, because they are so subjective in nature and I can argue that they could or should have an alternative text description in the alt-attribute. On the other hand, if no alt-attribute is provided for an image, screen reader software will read aloud the image link and title on the computer speakers and may be confusing to a blind user, because there is no alternative text description for the image. As a best practice, an image with no alt-attribute should be placed in CSS, otherwise it will fail an accessibility checker test if it is located within the HTML.

The problem I researched in my thesis is also a problem in the field of accessibility testing—depending on the accessibility checker used, university homepages may receive a conditional pass during an accessibility test when images containing useful information for blind users have empty alt-attributes. This defeats the purpose of making websites accessible in the first place and goes against the legal aspects of Section 508 and WCAG 2.0; therefore, it is necessary to continue researching issues regarding empty alt-attributes. I conducted accessibility checker tests on ten university homepages using three

accessibility checkers against WCAG 2.0 Success Criterion 1.1.1 Level A, the most current legal guideline available regarding alternative text for images. When I first began testing, my focus was on whether the homepages simply passed the accessibility checker criteria based on WCAG 2.0 Success Criterion 1.1.1 Level A guidelines; this approach was broad and gave too many results, though I recorded them all nevertheless. Hence, I refined my focus to only use accessibility checkers to discover empty alt-attributes in university homepage images, and how the accessibility checkers performed in finding empty alt attributes.

## **LITERATURE REVIEW**

The National Health Interview Survey (NHIS) estimates that 25.5 million adult Americans are visually impaired (American Foundation for the Blind, 2018). According to the World Health Organization (WHO), the number of visually impaired worldwide is estimated at 285-million (39-million blind and 246-million with low vision)—low vision is defined as a combination of moderate visual impairment and severe visual impairment, whereas low vision combined with blindness makes up the totality of visually impaired. There are 4-levels of visual function: (1) normal vision, (2) moderate visual impairment, (3) severe visual impairment, and (4) blindness (WHO, 2017).

### **Legal Requirements**

Legal requirements for accessibility date back as far as 1973, with the Rehabilitation Act, where its Section 504 prohibits discrimination of handicapped people within programs and services which receive federal funding—this includes colleges and universities which receive federal assistance (U. S. Equal Employment Opportunity

Commission, 1973). In 1990, the Americans with Disabilities Act (ADA) was put into place which also prohibits discrimination based on disability, and further guarantees that people with disabilities have equal opportunities to government assisted services and programs as everyone else (U. S. Department of Justice, 1990). In 1991 the World Wide Web ushered in a new era of communication in which accessibility eventually needed to be better defined. As was necessary to improve accessibility to the Web, Section 508 of the Rehabilitation Act of 1973 was amended in 1998 to require federally assisted programs and services to make their electronic and information technology (EIT) accessible to people with disabilities. (GSA, 1998). Under Section 508, agencies must give disabled employees and members of the public access to information that is comparable to access which is available to others without disabilities.

As of March 21, 2017, the United States Access Board revised and updated Section 508 standards to incorporate the Web Content Accessibility Guidelines (WCAG) 2.0 Level A, AA, and AAA Success Criterion and Conformance Requirements to websites. Compliance with the new standards was not required until January 18, 2018 (U. S. Access Board, 2017; U.S. Architectural and Transportation Barriers Compliance Board, 2017). The newly incorporated WCAG 2.0 guidelines are more descriptive and defined in accessibility requirements, supposedly making it easier for authors to define Web accessibility issues. WCAG are international in scope and have been agreed upon by participating nations. The Web Accessibility Initiative (WAI) of the World Wide Web Consortium (W3C) publishes WCAG 2.0 guidelines. WAI updates techniques for, and understanding of, WCAG 2.0 (W3C, 2017b). The W3C is an international body of member organizations and the public, working together to develop standards for the Web.

According to W3C, textual alternatives must be provided for all images, and must serve the equivalent purpose of the content of the image (W3C, 2017a).

Since Section 508 and WCAG 2.0 guidelines were put into place, government websites have increased dramatically in accessibility, but accessibility for most other websites has decreased overall for the blind and visually impaired. New advances in web technologies, such as text, script, Flash, videos, images, and other web-based objects have made it increasingly difficult for all involved to make their online information completely accessible. Accessibility of online information is supposed to be about the ability for disabled users to use a website by navigating its text, documents, and images, but ninety percent of websites are still inaccessible to disabled users. Hence, it was much easier for visually impaired individuals to navigate the Internet twenty-five years ago, when most websites were comprised mostly of text, compared to modern websites. Therefore, it is important to use alternative text in online documents and websites, so screen readers can understand and read aloud the alternative text to the blind or visually impaired user; this gives the user a sense of what is being shown on screen (Al-Badi, Ali, & Al-Balushi, 2012; Hanson & Richards, 2013).

### **WCAG 2.0 Basics**

WCAG 2.0 Success Criterion 1.1.1 is the minimum level of conformance required by the federal government for agencies, programs, and universities which receive federal funding are required to follow. The recommendations are as follows: images require an alt attribute so that screen reader technology can identify the image to the blind user. If the image is pure decoration, used only for visual formatting, it should have an empty alt-attribute, as to avoid meaningless descriptions unrelated to the context of the webpage. If

the image provides visual content related to the context of the website or, more specifically, to the context of the surrounding text or caption, it requires an alternative text equivalence in the alt attribute. Images that are surrounded by textual content or captions which fully describe the image in detail require an empty alt attribute; however, I want to add that a reference to the image caption or surrounding text, such as “Refer to caption” or “Refer to text” is a good practice to not only let the blind user know that an image exists on the webpage, but to avoid redundant image descriptions previously described. If non-text content is a control, accepts user input, is time-based media, a test or exercise, a CAPTCHA, or primarily intended to create a specific sensory experience, then text alternatives should provide a description of the content and its purpose. (W3C, 2017a).

### **Alternative Text**

Writing alternative text is one of the most technical and subjective fields to be in; it is tedious, time consuming, and costly. People describe images differently, and organizations involved with writing alternative text often have their own goals and objectives. For example: writing alternative text for images can take a lot of time and content editors to complete a large website or online book project, so time and cost may be a factor. An alternative text job might require 3-content editors who get paid by the hour to complete a large alternative text project for the publisher McGraw Hill. The project is due in 2-weeks; it is an online book titled Corporate Management and is intended for blind, university level Canadian students. The book was converted from HTML to a Word document consisting of 1000 pages of text with over 650 images. The content editors must quickly research Canadian Corporate Management and maintain

conciseness with Canadian English spelling prior to writing alternative text. The document is proofed, edited, proofed again, and finalized all within a two-week period at 40 hours per week for each Content Editor. As you can see, writing alternative text can be quite tedious, time consuming, and costly. The next time logging in to your university website, try turning off the images to fully experience the existence, or lack, of alternative text (Pemberton, 2003).

Alternative text describes information presented in online images and assists blind readers who use screen reader technology in understanding image content, and it helps define context of an image on a web page. Without some form of alternative text, blind people navigating a website with screen reader software will not be aware of an image. An alt-attribute is not alternative text, rather, it is where alternative text can and should be written. The text-content surrounding an image on a webpage, including captions and figures, can also be considered a form of alternative text. The best location for alternative text is within the alt-attribute, though, as it is the easiest and fastest way for screen readers to locate and describe images to blind users. The alt attribute is located in the HTML, and is simply alt="" with no spaces, and the image description goes inside the quotes. For example: alt="A large tree" would be read aloud by screen readers to the blind as "a large tree", but only if text is provided within the two quotation marks. For example: ``. The `img src (tree.jpg)` is the address to the image location and is not meant to describe the image, but the alt attribute (`alt=""`) does. The alt attribute describes the `tree.jpg` image as being a large tree with the sun in the background. The terms "alternative text", "textual alternatives", or "textual equivalencies" may be used throughout alternative text related

literature; nevertheless, they mean the exact same thing—all images need to have some sort of alternative text, so they are accessible to users who require screen reader technology assistance.

### **Screen Readers**

Screen readers, such as JAWS and COBRA, read aloud the alternative text description of an image so people who are blind or visually impaired will get a better understanding of the image content. The output of screen readers is usually in a male or female computerized voice, and can be listened through the computer monitor, audio speakers, or a headset. Some screen readers also provide braille output. The alternative text description that gets read by a screen reader can either be the text surrounding an image, including captions, tables, figures, or within the image alt-attribute. When there is a description in the alt-attribute, a screen reader will only read that description of the image, but not the image url address, letting the blind user know that an image exists and what information it contains. However, when there is an image with an empty alt-attribute, screen readers will overlook that image and not inform the blind user that an image is present; it's just the way screen readers are designed, because sometimes Web-developers sometimes create invisible images with empty alt-attributes for formatting purposes, so they use empty alt-attributes on purpose so they won't be read by a screen reader. With no alt-attribute, images in websites would be void of meaning to the blind user, as only the image url address will be read by a screen reader, causing confusion. The only way that a blind person would know that an image exists then, if no alt-attribute description was available, would be by listening to the screen reader communicating the text surrounding the image; however, text is not always available surrounding an image

that accurately describes the image. Furthermore, screen readers help the blind and visually impaired user navigate websites using the TAB and other function keys to determine web content organization., the layout and organization of heading elements as well as alternative text in images, tables, icons, company logos, and other web-based objects. The blind and visually impaired user can then hear how the webpage is organized and understand image content within the context of the webpage. To make tables fully accessible to screen readers, the table must not have any merged cells. Merging table cells is a common practice of formatting for style; however, screen readers read from left-to-right, not top-to-bottom as many tables are designed as such. The output from a screen reader trying to read a table with merged cells, or from a table that is designed to be read from top to bottom, will not be comprehensible to the blind or visually impaired person listening. The content writer must not consider formatting for style when writing alternative text for tables; instead, the content writer must consider formatting for accessibility as the essential outcome. Designing accessible tables for screen readers is a difficult and tedious task and can become very confusing when doing so. An accessible table can easily become several pages long, with numerous columns and rows. When designing an accessible table, sometimes the text within table rows and columns becomes unreadable to a sighted person, because horizontal text will become vertical text, spanning several pages, while making it impossible to read without making it 2pt or 3pt font and zooming in to the appropriate percentage level in order to simply read the text. Nevertheless, screen readers have no problem reading huge tables that are not readable by sighted users, just so long as the table is designed from left to right, and without headings above each column.



## Images

Images can be simple or complex. Simple images would be a logo on a university homepage or a photograph of the university and its students. Complex images are actual photographs, or snip-it captures, of financial spreadsheet tables, line graphs with points and legends, bar charts with different colors and data, mathematical equations including Greek symbols, and even cartoon images. Some images are subjective, and some are absolute. Subjective images can be described in different ways by different people depending on what content they see; however, describing image context based on personal opinion should be avoided when writing alternative text. Absolute images would be mathematical in nature, meaning that numbers and equations should not be changed when writing alternative text. Mathematical images are absolute; they must be specific in language, description, and may require short and long descriptions because of their complexity. Signs, such as minus, plus, divided-by, multiplied-by, greater-than-or-equal-to, and Greek symbols such as Delta, Phi, and Zeta must be typed out accordingly so that screen readers can understand the language. Fractions and parentheses also need to be written out accordingly. Since screen readers read from left to right, the equation  $(1+5)/6 = 1$ , for example, would have a short alternative text description written exactly as “start-fraction, left-parenthesis, one plus five, right-parenthesis over six, end-fraction equals one.” According to Splendiani & Ribera (2016), most alternative text provided for complex images often falls short of accessible descriptions. Complex images are often “semantically dense and rich” with technical information. Although my study focuses solely on the homepages of universities that offer Technical Communication degrees, there are many other disciplines offered by universities such as science, technology,

engineering, and mathematics (STEM), where accessibility for websites and online information is required for the blind and visually impaired. Too often alternative text or HTML alt attributes are either missing completely or implemented in such a way as to be inaccessible in academic STEM publications, research journals, and digitized academic libraries. Furthermore, mainstream publishing habits often do not include the implementation of comprehensive, accessible content development practices.

Normally one would not find highly complex images such as line graphs, bar charts, flowcharts, equations, and even Greek symbols in university homepages. Rather, these types of images would be found within an online book in a university course website. Nevertheless, these types of images appear within academic websites and require alternative text, so I wanted to provide a unique example of a complex image, in Figure 1 on the following page, with a very large alternative text description. Short descriptions should only be 30 words or less, whereas long descriptions can be any length. The long description that I provided is very long and burdensome to read, but this is the only way to fully describe what is in the image, plus it gives an idea of what blind people have to listen to and decipher. Each short and long description would be read by a screen reader to a blind user; however, the blind user would have the choice of listening to the long description if he or she wanted to. Note that acronyms such as ATC, MR, and MC in the following line graph must be spelled out with a space between each letter, so that each letter is stated by a screen reader; otherwise, a screen reader would attempt to say the abbreviation as a single, mumbled word—this goes for any type of acronym, such as BMW, USA, DOJ, etc.

Figure 1 below shows an image of two, complex line graphs followed by a short and very long description which I wrote as a Content Editor.

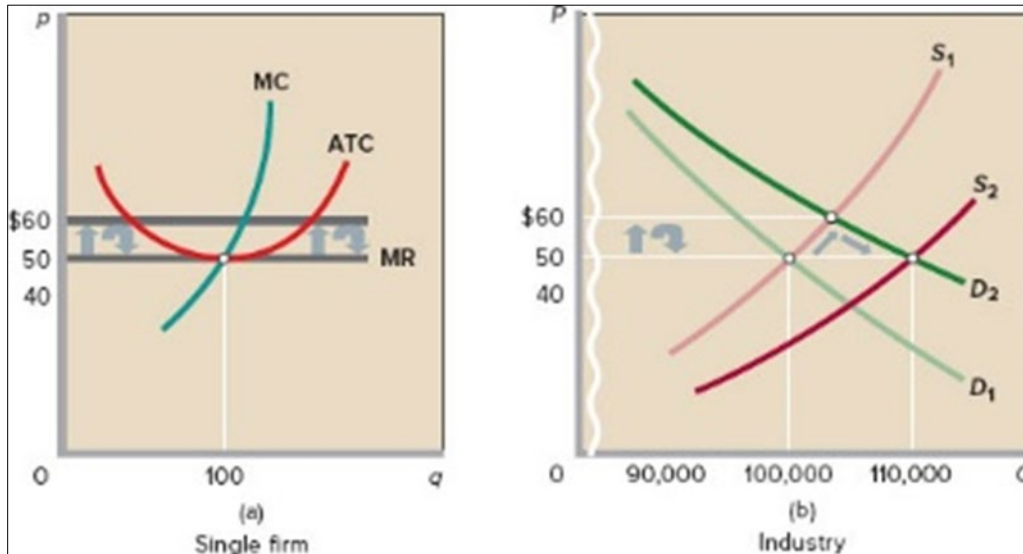


Figure 1. A Complex Image of Line Graphs.

**Short Description:** Two, line Graphs.

**Long Description:** The first line graph is titled (a) Single firm: The x-axis is labeled  $q$ . An increment is marked 100, two fifths across. A line extends up from the increment. The y-axis is labeled  $p$ . Increments are marked: 40, a third up; 50, halfway up; and \$60, just above halfway. A line, labeled  $MR$ , extends right from increment 50; another line extends right from increment \$60. Arrows point up from 50 to \$60. Curved arrows point down from \$60 to 50. A point is plotted at: (100, 50). Two curves are plotted: The first curve, labeled  $ATC$ , starts in the left upper middle, curves down to the right, passes through point (100, 50), curves back up to the right, and ends in the right upper middle. The second curve, labeled  $MC$ , starts in the left lower middle, curves up to the right, passes through point (100, 50), and ends in the upper middle.

The second line graph is titled (b) Industry: The x-axis is labeled upper Q. Increments are marked: 90,000, a third across; 100,000, halfway across; and 110,000, three quarters across. Lines extend up from increments 100,000 and 110,000. The y-axis is labeled upper P. A squiggly vertical line runs up alongside the y-axis. Increments are marked: 40, a third up; 50, halfway up; and \$60, just above halfway. Lines extend right from increments 50 and \$60. An arrow points up from 50 to \$60. A curved arrow points down from \$60 to 50. An arrow points up to upper D subscript 2. An arrow points down to the increment 50 line. Three points are plotted; all data are approximate: The first point is (100,000, 50). The second point is (110,000, 50). The third point is (104,000, \$60). Four curves are plotted: The first curve, labeled upper S subscript 1, starts in the lower left, curves to the right, passes through the first and second points, and ends in the upper right. The second curve, labeled upper S subscript 2, starts in the lower left, passes through the third point, and ends in the right middle. The third curve, labeled upper D subscript 1, starts in the upper left, curves down to the right, passes through the first point, and ends in the lower right. The fourth curve, labeled upper D subscript 2, starts in the upper left, curves down to the right, passes through the second and third points, and ends in the middle right. —End long description.

### **Accessibility Checkers**

Checking for alternative text errors can be accomplished with the use of accessibility checking software to verify website code against specific guidelines, standards, or laws. Accessibility checking software, commonly referred to as accessibility checkers, automatically checks for many kinds of issues related to website or webpage accessibility problems. Accessibility checkers are designed to check HTML code for

accessibility issues that might cause problems for people who have a number of types of disabilities, such as visual impairments, hearing impairments, and even cognitive impairments. Several accessibility checkers are downloadable and may require purchasing the software and creating a user account. On the other hand, some accessibility checkers are available online and free to use. One of the accessibility checkers I worked with, AChecker, had multiple guidelines and Levels to choose from for designing an accessibility test, but most only provided WCAG 2.0. The following is a list of all the different guidelines I found within the accessibility checkers:

- WCAG 1.0 (All Levels)
- WCAG 2.0 (All Levels)
- BITV 1.0 (Level 2)
- Section 508, and the
- Stanca Act.

Some accessibility checkers allow the user to obtain results based on how the test was manually set up, such as getting results by guideline or by line number; however, not all accessibility checkers have all of these multiple options to choose from. Not all accessibility checkers are suited for checking for text within images, although some attempted and did find actual text inside images, as in a picture of a person holding a graduation cap with the word “HIRED!” written on it, and gave results stating that there could be text in the image that is not defined in the alt-attribute. In every instance, though, checking for image content always required a manual check to make sure of its context within the webpage.

## **Automatic Alternative Text**

Bigham (2007) states that the content of images on the web is a vital component for the blind to understand websites, yet the paucity of alternative text for images remains a problem. Bigham's research, completed at the University of Washington's Department of Computer Science and Engineering, is based on the removal of the human barrier to writing alternative text in place of an automated system that would "automatically produce and insert alternative text for web images". Bigham explains that too often decorative images or images that relay no meaning to the context of the webpage content are given alternative text that is not helpful, when in fact that type of image requires an empty alt attribute according to WCAG guidelines. For example: imagine a website about Corporate Management in Canada and one of its webpages has an image of someone snow-skiing down a mountain—trying to describe someone skiing in alternative text, when the content is not about skiing, is not very helpful to a blind user, unless the writer is implying that Corporate Management is all downhill. This is the subjective aspect of alternative text, which is controversial to say the least. Bigham's (2007) research concluded that approximately 40% of the images he worked with had important information which needed to be conveyed, but alternative text was not manually provided. The automated system Bigham refers to is named WebInSight, a system that automatically inserts alternative text for web images. The system is highly conservative because the software cannot yet judge which alternative text description is appropriate, as there could be many definitions for a single image. WebInSight was able to produce accurate alternative text for web images that were used as links, such as logos or main images of web pages, but the software was dependent on whether the author provided a

name for the link and if the name was appropriate. For example: if the link was named logo, based on an image file name also named logo, then an appropriate alternative text could be provided by the system. But the reliance on the human aspect was not an appropriate strategy because the automated system could easily provide useless alternative text based on the authors poorly written file name, such as img123.jpg. Bigham (2007) concluded that it is possible to automate quality alternative text, but it will never be as accurate as a “trained human”.

### **Access-First Design**

Slatin (2001) explains that designing academic websites in a more relevant and productive way for people with disabilities will lead to better experiences for those without disabilities; on the contrary, the opposite approach does not lead to better experiences for those with disabilities. When designing accessible websites, the goal is to not only introduce informative content and material, but it is also to encourage participation—and participation is attributed to accessible, semantic websites. Slatin relies on WCAG 1.0, an earlier guideline of that time for web developers designing accessible websites, and not yet enforceable by law under Section 508. The project Slatin discussed in his research and started was a web-based project from 2000-2001, named Texas 2000 Living Museum (TX2K). TX2K was made for both teachers and students to act as builders of the website, discussing exhibits about their communities; over 30 schools participated. The interesting detail about this project is that four alternative views of the site were designed for different audiences (e.g., Guest, Student, Teacher, and ITAL staff) with different levels of access. The site was filled with more graphics than previous years, with a commitment towards accessibility for people with disabilities. The goal was

to produce an “Access-first design” concept prior to building the website, so that people with disabilities could participate and experience a website equal to that of everyone else. For example: navigation, contextual equivalence for images and audio, and orientation information were requirements to focus on first. Page titles with links were matched in the ALT attributes as well—this was a very semantic design concept for this time and holds true to this day. A concern was that alternative text should at a minimum identify the non-text item and give access to its function, but WCAG did not specify the length of alternative text. Furthermore, JAWS screen reader had problems with alternative text exceeding 150 characters at that time. The access-first design principle was to organize alternative text first and then place images, rather than placing images first in the web page and then writing alternative text. This did two things; it helped people who were blind to not be confused by images with links while they were understanding page orientation, and second, it made it somewhat of an equal alternative to viewing the page as a sighted person, where the sighted person is also not affected or confused by images with links. The conclusion to Slatin’s project is somewhat obscure and subjective, although Microsoft did support the access-first concept. On one-hand, some would argue that it would just be better to design a “text-only” separate webpage for blind people, because it is too expensive to maintain multiple websites for all audiences. On the other hand, being separate is not being equivalent, as Section 508 implies.

### **Image Analysis Before Alternative Text**

Because images are so subjective and dependent on the context of the webpage, there are no legalized standards set in stone for how to describe them with alternative text; however, there are some best practices out there, such as Tang’s (2012) image



analysis guidelines, which she discusses in her dissertation. Tang (2012) states that alternative text is often avoided altogether by web developers and the like because it is misunderstood or used in such a way to be uninformative or inaccurate—the reasoning behind this may be because WCAG provides no guidelines on how to write it. WCAG only provides guidelines stating that alternative text is required for all images, which includes a variety of image categories—this is the same issue for both WCAG 1.0 and 2.0 versions. Tang discusses the use of accessibility checkers and how it is quite easy for developers to simply add an empty alt attribute for an image and it will be given a pass by the software; however, this does not improve accessibility for the blind or visually impaired. She discusses decorative images and how they are not required to have alternative text written for them, but that they only require an empty alt attribute with the two quotation marks inside. Tang would organize the images into who, what, where, and when categories to understand if alternative text was required. The idea of writing alternative text for decorative images is subjective; it depends on the context of the image and the webpage. Decorative images might even add to the mood or feeling of a webpage to a sighted user, and this needs to be carefully examined. Although decorative images are not required to have alternative text, an argument can be made that they should. Rather than focusing on possible reasons as to why or why not authors write alternative text for images, Tang designed an elaborate procedure for comprehensively analyzing the information within web-based images and using that data to write more descriptive and useable alternative text. The procedure is written below:

- Step 1. Identify the purpose that the image served within the document.
- Step 2. Identify the image components within the image.

- Step 3. Identify the image (or image component) content.
- Step 4. Elaborate on the image (or image component) content.
- Step 5. Organize the identified information into text alternatives.
- Step 6. Evaluate the resulting text alternatives.

The idea is that with a better understanding of image content and context, alternative text could be comprehended by and communicated to all audiences. Four studies were concluded based on Tang's procedure, which helped to establish whether it was a useful strategy to identify image data at a holistic level. The results revealed that Tang's procedure was more effective in pinpointing important information within images and writing more usable alternative text than without the procedure. Furthermore, Tang's study showed that different authors could use her procedure for a variety of image genres. The procedure was published in the International Standards Organization (ISO) as ISO/IEC TS 20071-11:2012(en): Information technology — User interface component accessibility — Part 11: Guidance for alternative text for images.

## **METHODOLOGY**

Most of my studies at ASU were Technical Communication courses, yet several were Web Design courses used to fulfill degree requirements. Technical Communication and Web Design are strong skills to have in such fields as Content Editing, Technical Writing, Documentation, and many others. These fields in Technical Communication have a strong relationship to the term "accessibility" because their job functions may consist of analyzing content for proper HTML and CSS, converting file types to different, multiple file types, writing descriptive alternative text for non-textual digital content, and documenting the processes. Because of my interest in Technical Communication and

accessibility, I chose to test university sites which offer degrees in Technical Communication.

### **Collection of Data**

University homepages were never static and frequently changed without notice, which means images and alternative text changed as well. With the understanding that changes to homepages could happen at any time, the collection of data had to be completed one homepage at a time. Accessibility checker results, source code, images, and screenshots were recorded in one sitting. Webpage data were formatted as a .pdf file, and images were saved as image .jpeg or .png files. Furthermore, each accessibility checker used in this study required a different procedure for testing homepages and is described in the Accessibility Checker Procedures section.

All data were collected through my PC: an Alienware X51R2 with Windows 10 Home operating system that was firewalled and secured by Norton Security. Accessibility testing took place on my PC, using Microsoft's Internet Explorer 1 Web Browser. For accessibility testing, I used the following three accessibility checkers: AChecker®, Cynthia Says™, and Nu Html Checker. University homepages were tested from the following ten universities that offer Technical Communication degrees: (1) Arizona State University, (2) Auburn University, (3) Illinois Institute of Technology, (4) Metropolitan State University, (5) Michigan Technological University, (6) Montana Tech, (7) North Carolina State University, (8) Oregon State University, (9) Texas Tech University, and (10) University of Washington.

### **Research Question**

The research question was “are the 2017 university homepages compliant with WCAG 2.0 guidelines specifically regarding empty alt-attributes?”

### **Hypothesis**

Universities which provide an accessible Web-Standards page having policies and/or guidelines pertaining to WCAG 2.0 will have homepages with higher levels of accessible images and alternative text than those institutions without a Web-Standards page. My reasoning for this assumption is explained below.

### **Rationale**

My hypothesis was tested by investigating the existence of university support provided through a Web-Standards page on the university website, which included policies and/or guidelines pertaining to WCAG 2.0 Guideline 1.1.1 Non-text Content, including image categories and alternative text best practices. It was my assumption that a university which took the effort to create a Web-standards page would indeed have a more accessible website, let alone the home-page. A Web-standards page is used by Web-authors, developers, content writers, etc. to format their content, including heading levels, colors, images, alt-text, placement of logos, text size and font, and other HTML related things. A Web-standards page also lets the public know that the university follows accessibility guidelines. In Table 1 on the following page, I identified whether each university supplied a web-standards page or a minimum, a partial/incomplete web-standards page within the universities’ websites.

**Table 1.** Does the university have a web-standards page?

<u>University</u>	<u>Yes</u>	<u>No</u>	<u>Partial</u>
Arizona State University	X		
Auburn University		X	
Illinois Institute of Technology		X	
Metropolitan State University		X	
Michigan Technological University		X	
Montana Tech			X
North Carolina State University	X		
Oregon State University			X
Texas Tech University		X	
University of Washington	X		

### **Sampling University Homepages**

Ten university homepages were chosen for alternative text testing. The universities are based in the United States and each offer master’s degrees in Technical Communication. Each university homepage contains at least one standard, functional, decorative, or advanced image to qualify for alternative text testing. I checked to see if each university provided an accessible Web-standards page on their website by typing in a forward slash (/) without the parentheses followed by the term “accessibility” without the quotes immediately following the homepage URL in the address bar and pressing the ENTER key, or by typing in “accessibility” without the quotes in the homepage search function. Notes were taken of the ease of access to each university Web-standards page and how well these standards correlate with WCAG 2.0 guidelines pertaining to alternative text and images.

## University Web Standards Pages

Arizona State University: (<https://www.asu.edu/>) To access ASU's Web-standards page, the user is required to have a My ASU account; it is not accessible to non-students. ASU's Web-standards page basically models WCAG 2.0 Guideline 1.1.1 Non-text Content. ASU provides six-guidelines for using images:

- All images must have an ALT attribute.
- Equivalent alternate text for images can be located in the content itself, a caption or an ALT attribute.
- For linked images, the ALT attribute should describe both the content of the image and the function of the link.
- For decorative images, the ALT attribute should be left blank.
- When CSS background images convey information, provide alternate text.
- Images that contain text should be avoided. ("Web Standards", 2017)

Auburn University (Auburn, Alabama) <http://www.auburn.edu/>. Auburn University's Web standard page is accessible to the public and provides best practices for describing images:

- Every image should hav [sic] an alt attribute, even if it is null (alt="")
- Do not use phrases like "image of ....., picture of ....., graphic of ....., etc." Screen reading technology tells the user it is a graphic. For example. "Samford Hall Tower" should be used to describe a picture instead of picture of "Samford Hall Tower".
- Be clear and brief. There is no steadfast rule, but generally image descriptions should be less than a hundred characters.

- Do not use CSS to display images unless they are purely decorative. The Alt attribute cannot be added to CSS images.” (Key Principles of Web Accessibility, 2017).

Metropolitan State University (Saint Paul, MN): <http://www.metrostate.edu/>. Metropolitan State University provides an incomplete “Web Accessibility page” with no guidelines listed. They only provide the following information and a phone number to call to get more information: Web Accessibility: In an effort to ensure access to Web-based and other electronic resources and services, the Federal and State of Minnesota governments have enacted an assortment of laws that require government Web sites to be accessible to persons with disabilities. Accessible web pages are constructed to be useable by anyone, even if they are using assistive technology to access the web page. Examples of assistive technology are screen readers, screen magnifiers, voice recognition software, alternative keyboards, and braille displays. For more complete information please visit Minnesota State's accessibility web site. In order to comply with Federal and State requirements all web pages on the Metropolitan State web site must be developed with accessibility in mind. To assist web developers in this task we have provided a checklist for use. Level 1 is the minimum compliance and covers the basic areas which must covered. We are planning additional levels in the future that will cover more areas. If you have any questions, please contact the webmaster. Information contained in these documents is available in alternative formats to individuals with disabilities upon request. (Web Accessibility, 2017a).

Illinois Institute of Technology (Chicago, IL): <http://web.iit.edu/>. IIT does not have a Web-standards page or any page related to accessibility, alternative text, or images (Illinois Institute of Technology, 2017).

Michigan Technological University (Houghton, MI): <http://www.mtu.edu/>.

Michigan Tech provides an Accessible Technology page with no guidelines listed. They state that: “Michigan Tech is in the process of developing a comprehensive policy and guidelines regarding the accessibility of information and technology. Michigan Tech addresses web accessibility and usability together as websites are developed as guidelines, approaches, and end goals overlap significantly. Standards and best practices continually change, making this an ongoing effort.” (Accessible Technology. 2017).

Montana Tech (Butte, MT): <http://www.mtech.edu/>. Montana Tech provides an incomplete Web Accessibility page that is accessible, stating “We are currently in the process of rebuilding mtech.edu and making the new website accessible is a top priority.” A web accessibility plan of action list is provided:

- Meet WCAG 2.0 AA standards
- Utilize HTML5 and accessible tags.
- All headers will be labeled and in the appropriate order.
- Migrate as many PDF files into HTML pages as possible.
- Develop a strategy and templates to make PDFs accessible.
- Train faculty and staff to use our templates to make accessible PDFs.
- All web forms will be accessible.
- All images will have alt tags” (Web Accessibility, 2017b).

North Carolina State University (Raleigh, NC): <https://www.ncsu.edu/>. NC State University provides an accessible “Alternative Text” page which gives examples of how to administer alternative text with images. For their eight-guidelines, green check marks



are used to associate with best practices, whereas red X-marks are used to associate with non-compliance:

- ✓ Alternative text stored in the alt attribute
- ✓ An empty string stored in the alt attribute
- ✓ A contextual description
- ✓ A linked image with appropriate alt text
- ✓ A button image with appropriate alt text
- ✗ An image missing the alt attribute
- ✗ An important image with an empty alt attribute
- ✗ An alt attribute on a decorative image (Alternative Text, 2017)

Oregon State University (Corvallis, OR): <http://oregonstate.edu/>. Oregon State University provides an “Accessibility” page titled “Alternative Text for Images.” They reference WCAG 2.0 guideline 1.1.1 Non-text Content, and provide examples for the following types of images:

- Standard Images
- Images with Text
- Linked Images
- Decorative Images
- Complex Images
- Drupal CMS related images and alternative text” (Alternative Text for Images, 2017).

Texas Tech University (Lubbock, TX): <https://www.ttu.edu/>. Texas Tech University provides an incomplete “Online Accessibility” page with no guidelines. They

provide definitions of online accessibility based on certain lawsuits and regulations in the past years. And, if the user needs help creating accessible websites, they can contact IT Help Central. They also show a video by David Berman stating that “This is the decade we shift towards accessibility. This is the decade we do better business, we do better civilization, by all learning how to create a more accessible Web.” To learn more about accessible websites, you need to buy David Berman’s book “Do Good Design (Pearson, 2013)” (Online Accessibility, 2017).

University of Washington (Seattle, WA): <http://www.washington.edu/>. University of Washington provides an “Accessible Images” page. The page defines accessible images as “If web pages include images, the content of those images is, by default, inaccessible to people who are unable to see the images. Whether and how to address this issue depends on the purpose of the image within the context of the web page.” They define simple images as being designed to communicate information to the user and needs a short alternative description. They define complex images as containing lots of detail that needs a short title or summary in the alternative text description. And they define decorative images as images that should be placed into the CSS, not in the HTML” (Accessible Images, 2017).

### **Sampling WCAG Guidelines**

Prior to WCAG 2.0, WCAG 1.0 was in place as the standard guidelines for Web accessibility, but it was not implemented by the U.S. Government. To understand the differences between WCAG 1.0 and 2.0, I included this section to note any changes to be aware of when using accessibility checkers to test university homepages. Two questions needed to be answered to understand which accessibility checkers to use for this study

and which WCAG accessibility guidelines and conformance levels alternative text is associated to: (1) which WCAG 1.0 priority and checkpoint correlate with alternative text for images, and (2) which WCAG 2.0 guideline and level correlate with alternative text for images?

WCAG 1.0 is organized around guidelines that have checkpoints, which are priority 1, 2, or 3. The basis for determining conformance to the WCAG 1.0 are the checkpoints. The conformance levels for WCAG 1.0 are defined as follows: for a conformance level of A, all Priority 1 checkpoints are satisfied; for a conformance level of AA, all Priority 1 and 2 checkpoints are satisfied; and for a Conformance Level of AAA, all Priority 1, 2, and 3 checkpoints are satisfied. The checkpoints for WCAG 1.0 are defined as follows: a priority 1 checkpoint means that a Web content developer must satisfy this checkpoint, otherwise one or more groups, including the blind and visually impaired, will find it impossible to access information in the document. Satisfying the priority 1 checkpoint is a basic requirement for some groups to be able to use Web documents; a priority 2 checkpoint means that a Web content developer should satisfy this checkpoint. Otherwise, one or more groups will find it difficult to access information in the document. Satisfying this checkpoint will remove significant barriers to accessing Web documents; and a priority 3 checkpoint means that a Web content developer may address this checkpoint. Otherwise, one or more groups will find it somewhat difficult to access information in the document. Satisfying this checkpoint will improve access to Web documents (W3C, 2009). To answer to my first question then, according to the W3C, alternative text for images is a Priority 1, Conformance Level A, and falls under

WCAG 1.0 Checkpoint 1.1— “Provide a text equivalent for every non-text element...” (W3C, 1999).

On the other hand, WCAG 2.0 is organized around four design principles of Web accessibility: Perceivable, Operable, Understandable, and Robust. Each principle has guidelines, and each guideline has testable success Criterion at level A, AA, or AAA. The basis for determining conformance to the WCAG 2.0 are the success Criterion. In regard to WCAG 2.0 conformance levels, one of the following levels of conformance is met in full: for a level A conformance (the minimum level of conformance), the Web page satisfies all the Level A Success Criterion, or a conforming alternate version is provided; for a level AA conformance, the Web page satisfies all the Level A and Level AA Success Criterion, or a Level AA conforming alternate version is provided; and for a level AAA conformance, the Web page satisfies all the level A, level AA and level AAA Success Criterion, or a level AAA conforming alternate version is provided (W3C, 2009). To answer my second question then, according to the W3C, Alternative text for images falls under WCAG 2.0 Guideline 1.1.1 Non-text Content, Conformance Level A— “All non-text content that is presented to the user has a text alternative that serves the equivalent purpose...” (W3C, 2008).

### **Sampling Accessibility Checkers**

To understand which accessibility checkers to use for this study, two questions needed to be answered to help define which WCAG accessibility guidelines and conformance levels alternative text is associated to:

1. Which WCAG 1.0 priority and checkpoint correlate with alternative text for images?

- a. Answer: According to the W3C, Alternative text for images is a Priority 1, Conformance Level A, and falls under WCAG 1.0 Checkpoint 1.1— “Provide a text equivalent for every non-text element...” (W3C, 1999).
2. Which WCAG 2.0 guideline and level correlate with alternative text for images?
    - a. Answer: According to the W3C, Alternative text for images falls under WCAG 2.0 Guideline 1.1.1 Non-text Content, Conformance Level A— “All non-text content that is presented to the user has a text alternative that serves the equivalent purpose...” (W3C, 2008).

Alternative text, then, falls under WCAG 1.0 and WCAG 2.0 guidelines with Level A conformance, so the sampling of accessibility checkers was contingent on whether those WCAG guidelines to check against were provided in the accessibility software as user options. Not all accessibility checkers provide both WCAG 1.0 and WCAG 2.0 guidelines though. Most accessibility checkers only have WCAG 2.0 guidelines and conformance levels, while others may have both WCAG 1.0 and WCAG 2.0 guidelines and conformance levels, and some include accessibility guidelines or laws set by different countries. Since most accessibility checkers that met the requirements for this study only had the option of the WCAG 2.0 guideline with A, AA, and AAA conformance Levels, it was determined that only accessibility checkers based on WCAG 2.0 guidelines with a Level A conformance would be used for this study because alternative text is associated with only a Level A conformance.

Accessibility checkers were located by conducting an Internet search using the Internet Explorer 11 browser. Any accessibility checkers that required downloading, purchasing, or creating an account in order to use the software were criteria for exclusion;

I figured most people and organizations would not want to purchase accessibility software when they could get similar results online for free, without having to divulge lots of personal and financial information. Nu Html Checker and Cynthia Says™ were both found in the Internet search and are discussed in the Accessibility Checker Inclusion and Exclusion Criteria section of my thesis. Furthermore, five other accessibility checkers were found and sampled by using the Web Accessibility Evaluation Tools List provided by W3C Web Accessibility Initiative (WAI). This tools list provides information and links to numerous types of accessibility checkers based on the type of filters the user checks. Seven categories of filters are provided in W3C's Tools List to choose from, depending on the type of accessibility study desired. Included in W3C's filters are ten guidelines to check against (e.g., WCAG 2.0, WCAG 1.0, Section 508), twenty-five different world languages, six types of tools (e.g., authoring tool plugin, Browser plugin, online tool), twenty different technologies (e.g., CSS, HTML, PDF), four "assists by" technologies which determine how results are displayed, three technologies that "automatically check" single, group, and restricted webpages, and six types of software licenses (e.g., commercial, free, open source) (W3C, 2016).

Unfortunately, the Web Accessibility Evaluation Tools List provided by WAI was a little counterproductive, as it gave me a list of accessibility checkers that were not very useful. Nevertheless, I was able to weed-out a few of the accessibility checkers that were not user-friendly or were not what I asked for in my filter selection. I provided an example in Figure 2 on the following page that shows all of the filters available to use with the Web Accessibility Evaluation Tools List provided by WAI. I also provided a list of the filters I chose in Table 2 of my thesis.

## W3C Filters



**Figure 2.** W3C Filters.

Figure 2 to the left shows a list of the W3C filters available that can help a user find accessibility checkers that identify alternative text issues in a single web page. Notice that there are many different legal guidelines a user can choose from, including international guidelines from different countries. The only guideline that I really needed for my research was the WCAG 2.0 filter. However, I also included several other filters, so I could try to find the best accessibility checker specific to my research needs. It would have been useful, though, if there were a tool specifically made for image results. For my research, accessibility checkers needed to provide specific lines of code in its results section where an alternative text issue was present; results that provided images were highly useful. Accessibility checkers which required downloading, purchasing, or creating an

account to simply use the software were criteria for exclusion. I did not want to have to download software I was not familiar with for security reasons. Furthermore, many companies often try to use free software instead of having to pay for it. Why pay for an accessibility checker when you can get the same function and results from a user friendly one that cost nothing? After the appropriate filters were checked, a list of accessibility checkers based on the filters the user defined automatically appears in the results section.

On the following page, Table 2 shows all of the filters that were available when I used the Web Accessibility Evaluation Tools List, provided by WAI. For each filter

group, there are a number of tools available to choose from, such as languages, guidelines, and Licenses. I listed the filters that I chose from the number of tools in the filters chosen column.

**Table 2.** W3C Filters Chosen

<b>Filter Group</b>	<b># of tools</b>	<b>Filters Chosen</b>
Guidelines	74 tools	WCAG 2.0
Languages	68 tools	English
Type of Tool	37 tools	Online tool
Technology	6 tools	HTML
Assists by	5 tools	Generating reports of evaluation results
Automatically checks	22 tools	Single web pages
License	6 tools	Free Software

**Accessibility Checkers Matching W3C Filters:**

The following list shows the results from all of the filters I chose from the Web Accessibility Evaluation Tools List, provided by WAI. The Web Accessibility Evaluation Tools List found five accessibility checkers recommended for what I needed, based on the filters that I chose. Unfortunately, only one accessibility checker was useful to me for a variety of reasons.

- Accessible Email by Measuremail
- AChecker® by Inclusive Design Research Centre
- Asqatasun by Asqatasun.org
- Mauve by Human Interfaces in Information Systems Laboratory - ISTI-CNR
- Wave by WebAIM



## **Accessibility Checker Inclusion and Exclusion Criteria**

The following list provides the reasoning as to why all of these accessibility checkers were either useful to my study or not. The list includes all of the accessibility checkers that I found on the Internet, as well as the results from using the Web Accessibility Evaluation Tools List, provided by WAI. AChecker, Cynthia Says, and Nu Html Checker were useful to my research, as they were the most usable to me.

- Accessible Email by Measuremail was excluded from this study because it is designed specifically for email marketing.
- AChecker® was included in this study because it provides images and source code in its results, providing easy verification and analysis.
- Asqatasun was excluded from this study because it requires downloading.
- Mauve by Human Interfaces in Information Systems Laboratory - ISTI-CNR was not useful to this study because its results produced highlighted red-errors or yellow-warnings that were located on incorrect lines of code that were completely different than the original source code from the university homepages.
- Wave did not provide results specific to HTML lines of code, and all results related to images and alternative text issues were unusable because the software did not highlight the specific image that had a problem; therefore, WAVE was excluded in this study.
- Nu Html Checker was included in this study because it provides images along with specific lines of code where alternative text issues exist.
- Cynthia Says™ does not provide images in its results but does provide specific lines of code where non-compliance failures exist. Cynthia Says™ was included in this

study because image results from other accessibility checkers could still be used to verify with the specific line of code in the results from Cynthia Says™.

### Final List of Accessibility Checkers Included

The following list shows the accessibility checkers that I chose to use for my research and testing.

- AChecker®: <https://achecker.ca/checker/index.php>
- Cynthia Says™: <http://www.cynthiasays.com/>
- Nu Html Checker: <https://validator.w3.org/nu/>

### Accessibility Checker Procedures

In this section, I provide images of the three-accessibility checkers that were used for my research. The images show the filters that I used for each accessibility checker to perform the tests and get the results. As you can see, each accessibility checker is unique.

#### AChecker

Figure 3 is an image of AChecker’s homepage. AChecker® provides several

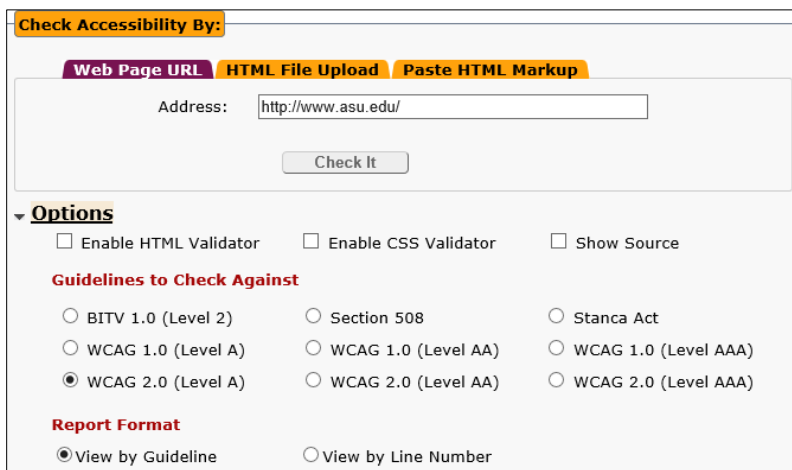
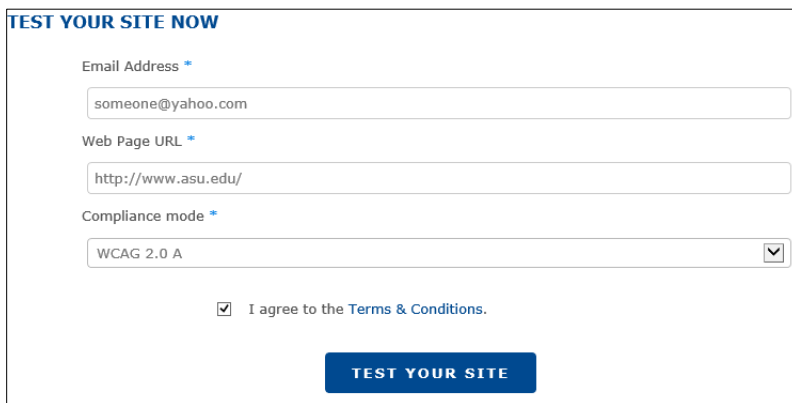


Figure 3. AChecker Homepage

options for validating HTML, CSS code, accessibility guidelines to check against, and two options to format report results. Submitting code for testing can be accomplished by either

pasting the URL address of the webpage, uploading an HTML file, or by copying the source code of a webpage and pasting it into the text box. The only other accessibility checker used for this study that has options to upload HTML files or paste source code is Nu Html Checker; therefore, using the URL address was the best method to use for each accessibility checker. Since alternative text is a Level A conformance, and it was previously determined to only check against WCAG 2.0 guidelines, WCAG 2.0 (Level A) was chosen. Checking the Show Source box was necessary to have a copy of the source code, so I could save the code from the original date and time of testing. Choosing the View by Guideline box for the report format keeps all accessibility issues organized by WCAG 2.0 Level A guidelines, whereas viewing results by line number requires scrolling through the results of each line of code to locate alternative text issues with an image.

### Cynthia Says



The screenshot shows a web form titled "TEST YOUR SITE NOW". It contains three input fields: "Email Address \*" with the value "someone@yahoo.com", "Web Page URL \*" with the value "http://www.asu.edu/", and "Compliance mode \*" with a dropdown menu set to "WCAG 2.0 A". Below the fields is a checkbox labeled "I agree to the Terms & Conditions." which is checked. At the bottom of the form is a blue button labeled "TEST YOUR SITE".

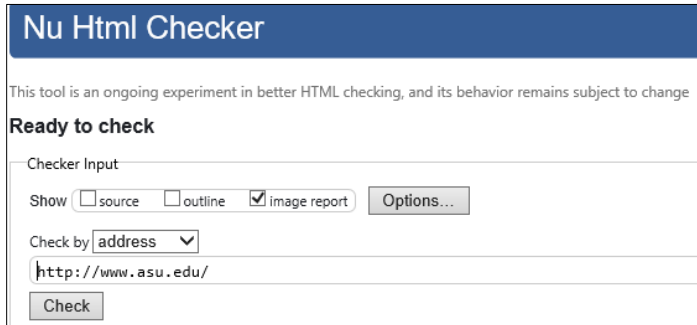
**Figure 4.** Cynthia Says Homepage

Figure 4 is an image of Cynthia Says' homepage. Cynthia Says requires an email address for each webpage that is tested; it is a bit of a burden having to type it

in for each webpage URL, but this is the only personal information required. Pasting the URL address is the only option available for submitting webpage code for testing. The software provides only WCAG 2.0 Level A, AA, and AAA compliance modes to check

against and no options from the start page for how a user wishes to view results. The user must agree to the terms and conditions prior to testing the webpage. Results come slower than all other accessibility checkers.

## Nu Html Checker



**Figure 5.** Nu Html Checker Homepage.

Figure 5 is an image of Nu Html Checker’s homepage. Nu Html Checker checks for proper HTML instead of specific WCAG 2.0 guidelines.

However, this software provides an image report pertaining to alternative text issues that states results which fall in line with WCAG 2.0 guidelines. Since alternative text and images are the priority for this study, “image report” must be checked to get any results associated with those issues. Like AChecker, Nu Html Checker provides three options to submit code for testing, by either pasting a URL address, uploading an HTML file, or by pasting the source code from the web page. I wanted to have a copy of the source code from the specific date of testing, so checking Source was necessary so I could look back at the original code at that specific date and time.

## RESULTS

### AChecker

Tables 3, 4 and 5 below, and on the following page, show AChecker's Known, Likely, and Potential results. From left-to-right: university homepage, number of known problems, number of alt text problems, and percentage of Alt text known problems from the number of known problems rounded to the nearest hundredth. For example, in Table 3 AChecker found zero known problems and zero Alt text known problems in Arizona State University's homepage, resulting in 0% Alt text problems. However, AChecker found seven known problems and one Alt Text known problems with Montana Tech's homepage, resulting in 14% Alt text problems.

**Table 3.** AChecker Known Problems Category

<u>University Homepage</u>	<u>Known</u>	<u>Alt Text Known</u>	<u>%</u>
Arizona State University	0	0	0%
Auburn University	3	0	0%
Illinois Institute of Technology	7	7	100%
Metropolitan State University	2	2	100%
Michigan Technological University	0	0	0%
Montana Tech	7	1	14%
North Carolina State University	1	1	100%
Oregon State University	0	0	0%
Texas Tech University	1	0	0%
University of Washington	3	0	0%

*Note:* Known problems have been identified positively as accessibility barriers and must be manually modified to comply with WCAG 2.0 guidelines.

**Table 4.** AChecker Likely Problems Category

<u>University Homepage</u>	<u>Likely</u>	<u>Alt Text Likely</u>	<u>%</u>
Arizona State University	0	0	0%
Auburn University	5	1	20%
Illinois Institute of Technology	0	0	0%
Metropolitan State University	0	0	0%
Michigan Technological University	0	0	0%
Montana Tech	1	1	100%
North Carolina State University	0	0	0%
Oregon State University	0	0	0%
Texas Tech University	0	0	0%
University of Washington	1	1	100%

*Note:* Likely problems have been identified as probable barriers and require a human to decide if modifying the source code in the homepage will fix these problems.

**Table 5.** AChecker Potential Problems Category

<u>University Homepage</u>	<u>Potential</u>	<u>Alt Text Potential</u>	<u>%</u>
Arizona State University	380	33	9%
Auburn University	539	86	16%
Illinois Institute of Technology	518	20	4%
Metropolitan State University	220	17	8%
Michigan Technological University	321	21	7%
Montana Tech	324	66	20%
North Carolina State University	389	30	8%
Oregon State University	169	19	11%
Texas Tech University	414	3	1%
University of Washington	339	18	5%

*Note:* Potential problems are problems that AChecker cannot specifically identify and require a human to decide modifying the source code in the homepage will fix these problems.

AChecker places alternative text issues that it finds into categories called Checks and gives them a numbered label. There were several Checks found within the homepages and AChecker defined each Check with a brief description. These Checks are not an exhaustive list of possible checks; there are other Checks that may occur depending on what types of issues AChecker finds in any type of webpage. The Checks discovered in the university homepages are defined by AChecker below:

- Check 1: Image element missing alt attribute.
- Check 7: Image used as anchor is missing valid Alt text.
- Check 3: Image Alt text may be too long.
- Check 8: Image element may require a long description.
- Check 11: Image may contain text that is not in Alt text.
- Check 16: Alt text is not empty, and image may be decorative.
- Check 59: Image used for input element may have Alt text that does not identify the purpose or function of the image.
- Check 178: Alt text does not convey the same information as the image.
- Check 193: Form submit button image may contain text that is not in Alt text.

In Table 6 on the following page, all combined known, likely, and potential categories of alternative text issues found by AChecker were counted and totaled for each university homepage. By totaling the results, it is possible to understand where some of the major issues are occurring regarding alternative text. However, since AChecker did not specify precisely where empty alt attributes were located by assigning a numbered Check with a description that states, “empty alt attribute,” the results were not as useful as they could have been. In the end, I had to manually analyze each image anyway.

Furthermore, results in Table 6 suggest that the two largest issues found are Check 11: image may contain text that is not in Alt text—with a total of 102 issues between all university homepages; and Check 8: image element may require a long description—with a total of 97 issues between the ten homepages. Each university showed problems in these two areas. These two issues alone (check 11 and check 8) total 199-images that supposedly either contain text or require a long description. However, these results are completely inaccurate, because 56 of these 199-images (approximately 28%) are void of alternative text descriptions in the first place; AChecker does not specify this in its results.

**Table 6.** AChecker Known, Likely, and Potential Combined

University Homepage	Check 1	Check 7	Check 3	Check 8	Check 11	Check 16	Check 59	Check 178	Check 193
Arizona State University				11	11	1		10	
Auburn University			1	27	27	27		5	
Illinois Institute of Technology		7		9	9	2			
Metropolitan State University	1	1		6	7	1		3	
Michigan Technological University				7	7	7			
Montana Tech	1		1	16	20	20	1	8	1
North Carolina State University		1		9	9	11		1	
Oregon State University				6	6	6		1	
Texas Tech University				1	1	1			
University of Washington			1	5	5	3		5	
TOTAL	2	9	3	97	102	79	1	33	1



In Table 7 on the following page, lines of code were recorded in place of alternative text related issues. For example, if there were 11 instances of Check 8 in Arizona State University's home page, as is shown in Table 6 above, I found the 11 different lines of HTML code related to that specific Check 8 issue regarding alternative text. The data shows several instances where the same lines of code were placed in multiple categories, such as line 400 at ASU, making it difficult to determine the specific problem without having to manually review each line of code and each image. Each line of code had to be manually observed and analyzed for empty alt-attributes, and each image had to be observed and analyzed for content and context in relation to webpage content and context. Notice how Auburn University shows numerous images with alt-text issues with the same line numbers in multiple categories. Although these images in Auburn's homepage may require some research to find out if long descriptions are needed, if text is in an image, or if they may be decorative or not, none of them contained empty alt attributes. Furthermore, there are several instances where the same line number was used multiple times within the same Check. For example, Michigan Technological University's homepage was found to have three images in line 18 and four images in line 56. The same pattern can be seen in University of Washington's homepage, where five images can be located within line 10. For those images which were located in the same lines of code, it was difficult to determine why the images were coded like this, and it was also difficult to diagnose whether the images were duplicates or if they were unique in any way. Lastly, there are only three universities that were found to have anchor images with missing valid alternative text. Unfortunately, there was no Check listed for empty alt attributes, which would have made it much easier to manually analyze results.

**Table 7. AChecker-Lines of Code Regarding Alt-text Issues**

University	Check	HTML line of code
Arizona State University	Check 8	100, 351, 374, 400, 424, 447, 470, 493, 516, 539, 738
	Check 11	100, 351, 374, 400, 424, 447, 470, 493, 516, 539, 738
	Check 16	100
	Check 178	351, 374, 400, 424, 447, 470, 493, 516, 539, 738
Auburn University	Check 3	646
	Check 8	213, 214, 244, 566, 606, 646, 686, 719, 725, 731, 742, 748, 754, 832, 867, 902, 1007, 1018, 1029, 1049, 1194, 1197, 1200, 1203, 1206, 1209, 1253
	Check 11	213, 214, 244, 566, 606, 646, 686, 719, 725, 731, 742, 748, 754, 832, 867, 902, 1007, 1018, 1029, 1049, 1194, 1197, 1200, 1203, 1206, 1209, 1253
	Check 16	213, 214, 244, 566, 606, 646, 686, 719, 725, 731, 742, 748, 754, 832, 867, 902, 1007, 1018, 1029, 1049, 1194, 1197, 1200, 1203, 1206, 1209, 1253
Illinois Institute of Technology	Check 7	154, 167, 180, 193, 206, 219, 355
	Check 8	154, 167, 180, 193, 206, 219, 312, 355, 1520
	Check 11	154, 167, 180, 193, 206, 219, 312, 355, 1520
	Check 16	312, 1520
Metropolitan State University	Check 1	879
	Check 7	353
	Check 8	231, 262, 353, 385, 417, 917
	Check 11	147, 231, 262, 353, 385, 417, 917
	Check 16	147
Michigan Technological University	Check 8	18, 18, 18, 56, 56, 56, 56
	Check 11	18, 18, 18, 56, 56, 56, 56
	Check 16	18, 18, 18, 56, 56, 56, 56
Montana Tech	Check 1	138
	Check 3	57
	Check 8	50, 55, 56, 57, 58, 132, 133, 134, 135, 212, 212, 212, 212, 212, 212, 212
	Check 11	50, 55, 56, 57, 58, 61, 66, 72, 77, 132, 133, 134, 135, 212, 212, 212, 212, 212, 212, 212
	Check 16	50, 55, 56, 57, 58, 61, 66, 72, 77, 132, 133, 134, 135, 212, 212, 212, 212, 212, 212, 212
	Check 59	171
	Check 178	61, 66, 72, 77, 132, 133, 134, 135
North Carolina State University	Check 7	476
	Check 8	296, 470, 473, 476, 479, 482, 485, 488, 491
	Check 11	296, 470, 473, 476, 479, 482, 485, 488, 491
	Check 16	390, 401, 412, 470, 473, 479, 482, 485, 488, 491, 603
	Check 59	296
Oregon State University	Check 8	39, 177, 224, 234, 244, 285
	Check 11	39, 177, 224, 234, 244, 285
	Check 16	39, 177, 224, 234, 244, 285
	Check 178	178
Texas Tech University	Check 8	79
	Check 11	79
	Check 16	79
University of Washington	Check 3	10
	Check 8	10, 10, 10, 10, 10
	Check 11	10, 10, 10, 10, 10
	Check 16	10, 10, 10
	Check 178	10, 10, 10, 10, 10

## Cynthia Says

Table 8 shows the results for Cynthia Says. Issues found were simply given a brief description of what the problem was. I counted each occurrence for each university homepage and totaled the numbers.

**Table 8.** Results for Cynthia Says

University Homepage	Non-decorative IMG element contains empty ALT attribute.	Image with non-descriptive alt text found.	IMG element inside anchor with no text has empty ALT attribute.	IMG element contains no ALT attribute.	IMG element has long ALT text (> 100 chars).	Anchor element does not have alternative text which describes purpose of the link.
Arizona State University	10					
Auburn University		3				
Illinois Institute of Technology		1	7			
Metropolitan State University	5		1	1		
Michigan Technological University						2
Montana Tech				1	1	
North Carolina State University	2		1			
Oregon State University						
Texas Tech University						
University of Washington	2				1	
<b>TOTAL</b>	<b>19</b>	<b>4</b>	<b>9</b>	<b>2</b>	<b>2</b>	<b>2</b>

Table 9 is a mirror image of Table 8, only that lines of code were recorded in place of the number of alternative text related issues. The data shows almost no cases where the same lines of code were placed in different categories, with the exception of University of Washington’s code in line 10. Cynthia Says did a nice job of finding empty alt-attributes by providing all of the lines of code, which made it pretty easy to work with, but did not supply image results.

**Table 9.** Cynthia Says-Lines of Code Regarding Alt-text Issues

University Homepage	Non-decorative IMG element contains empty ALT attribute.	Image with non-descriptive alt text found.	IMG element inside anchor with no text has empty ALT attribute.	IMG element contains no ALT attribute.	IMG element has long ALT text (> 100 chars).	Anchor element does not have alternative text which describes purpose of the link.
Arizona State University	351, 374, 400, 424, 447, 470, 493, 516, 539, 738					
Auburn University		566, 686, 832				
Illinois Institute of Technology		312	154, 167, 180, 193, 206, 219, 355			
Metropolitan State University	231, 262, 385, 417, 917		353	879		
Michigan Technological University						18, 18
Montana Tech				138	57	
North Carolina State University	296, 552		476			
Oregon State University						
Texas Tech University						
University of Washington	10, 10				10	

## Nu Html Checker

Table 10 shows the results for Nu HTML. Four defined categories were provided by Nu HTML which made it easy to determine which image had an empty alt attribute. For some reason, Nu HTML provided no data for Auburn State University, but did for all others. Although not much data was provided by NU HTML, it was still useful for my tests because it at least provided data regarding images with or without alternative text, and I was able to use the data to corroborate, if not validate, my results from the other two accessibility checkers simply by verifying the images were indeed the same.

**Table 10.** Results for Nu Html Checker

University Homepage	Empty textual alternative—Omitted from non-graphical presentation	Images with textual alternative	No textual alternative available, image linked	No textual alternative available, not linked
Arizona State University	10	2		
Auburn University	Data Unavailable	Data Unavailable	Data Unavailable	Data Unavailable
Illinois Institute of Technology	7	2		
Metropolitan State University	6	1		1
Michigan Technological University		7		
Montana Tech		20	1	
North Carolina State University	3	11		
Oregon State University		6		
Texas Tech University		1		
University of Washington	2	3		
TOTAL	18	53	1	1

Table 11 below is a mirror image of Table 10, only that lines of code were recorded in place of the number of alternative text issues. The data shows two cases where code line 10 was placed in more than one category. After analyzing the issue, it was found that five images were located within the source code of line 10 in the University of Washington’s homepage, but only two had empty alt attributes.

**Table 11.** Nu Html-Lines of Code Regarding Alt-text Issues

University Homepage	Empty textual alternative— Omitted from non-graphical presentation	Images with textual alternative	No textual alternative available, image linked	No textual alternative available, not linked
Arizona State University	351, 374, 400, 424, 447, 470, 493, 516, 539, 738	100, 992		
Auburn University	Data Unavailable	Data Unavailable	Data Unavailable	Data Unavailable
Illinois Institute of Technology	154, 167, 180, 193, 206, 219, 355	312, 1520		
Metropolitan State University	231, 262, 353, 385, 417, 917	147		879
Michigan Technological University		18, 18, 18, 56, 56, 56, 56		
Montana Tech		50, 55, 56, 57, 58, 61, 66, 72, 77, 132, 133, 134, 135, 212, 212, 212, 212, 212, 212	138	
North Carolina State University	296, 476, 552	390, 401, 412, 470, 473, 479, 482, 485, 488, 491, 603		
Oregon State University		39, 177, 224, 234, 244, 285		
Texas Tech University		79		
University of Washington	10, 10	10, 10, 10		

Table 12 shows all lines of code from each homepage where images have empty alt attributes. As it appears, five homepages failed the tests because they have images with empty alt attributes and the other five homepages pass. Results are consistent across all three accessibility checker results.

**Table 12.** Patterns: Lines of Code with Empty Alt-Attributes

University Homepage	AChecker	Cynthia Says	New Html
Arizona State University	351, 374, 400, 424, 447, 470, 493, 516, 539, 738	351, 374, 400, 424, 447, 470, 493, 516, 539, 738	351, 374, 400, 424, 447, 470, 493, 516, 539, 738
Auburn University	None	None	None
Illinois Institute of Technology	154, 167, 180, 193, 206, 219, 355	154, 167, 180, 193, 206, 219, 355	154, 167, 180, 193, 206, 219, 355
Metropolitan State University	231, 262, 353, 385, 417, 917	231, 262, 353, 385, 417, 917	231, 262, 353, 385, 417, 917
Michigan Technological University	None	None	None
Montana Tech	None	None	None
North Carolina State University	296, 476, (552 shows in code but not results)	296, 476, 552	296, 476, 552
Oregon State University	None	None	None
Texas Tech University	None	None	None
University of Washington	10, 10	10, 10	10, 10

### **Arizona State University**

All three-accessibility checkers found the images in lines 351, 374, 400, 424, 447, 470, 493, 516, 539, and 738 from Arizona State University’s homepage to be void of alternative text. These images received a pass from AChecker’s known and likely problems but were found as potential problems needing manual review. However, Cynthia Says and Nu Html Checker did not pass these images. All ten images containing

an empty alt attribute (alt =“”) in the source code were “foaf” images and used as a slideshow in the homepage.

### **Auburn University**

Results from all three-accessibility checkers show that all images in Auburn’s homepage have alternative text descriptions. This is a good sign for Auburn and shows that WCAG 2.0 guidelines are being met in this aspect. Other issues regarding the content of the alt-text descriptions could be problematic though. These issues require manual analysis of each image and its content in relation to the context of the homepage. For example, AChecker states that the image in line 686 may require a long description, Cynthia Says fails line 686, stating that an image with non-descriptive alt text was found, but Nu Html Checker failed to find this issue in line 686. The alt description for line 686 is: `img alt="An image of a man looking at a laptop."` The main issue with this description is that stating that an image is an image is redundant. When a screen reader, such as JAWS, reads the alternative text description, it will repeat, image of an image of a man looking at a laptop. W3C guidelines suggest avoiding stating an image is an image, or a logo is a logo in the alt text description to avoid redundancy. It would be better to simply say, “a man looking at a laptop.”

### **Illinois Institute of Technology**

The images from lines 154, 167, 180, 193, 206, 219, and 355 failed AChecker’s known problems category because they are all “foaf” images without alternative text descriptions. These foaf images are being used as a slide show in the same manner as Arizona State University’s “foaf” images are; however, they did not receive a conditional pass from AChecker like Arizona State University’s “foaf” images did. The question here



is, since all “foaf” images have empty alternative text and are being used as a slideshow, why did AChecker fail them for Auburn’s homepage but not for Arizona State University’s homepage? Cynthia Says failed the same seven foaf images, stating that when using the image element, specify a short text alternative with the alt attribute, or alt text. Nu Html Checker also failed the same seven foaf images, stating that a review of the textual alternatives for each image is necessary to make sure that they make sense considering the purpose of the image in the context of the page, and that phrases like “image of” are avoided to reduce screen reader redundancy.

### **Metropolitan State University**

Images from lines 231, 262, 353, 385, 417, and 917 were all found to be void of alternative text descriptions; they all had empty alt-attributes. Again, these images needed to be manually reviewed for content in relation to the context of the homepage to determine whether alternative text was needed in the first place. AChecker placed these images, as well as most of the other university homepage images, in its “Potential Problems” category, and required much more analysis to determine if the images had empty alt-attributes. Cynthia Says failed these images, stating that non-decorative IMG elements contain empty alt-attributes. Nu HTML also failed these images, stating that due to the empty alt-attributes, these images will be omitted from graphical presentation—meaning that these images will not be understood by someone using a screen reader. On a side-note, all three-accessibility checkers found that the image from line 879 was void of an alt-attribute, therefore failing the WCAG 2.0 requirement that all non-text content requires an alternative text attribute.

## **Michigan Technological University**

All three-accessibility checkers found no issues regarding missing alt-attributes or alternative text descriptions for any images within the homepage for MTU. However, all three-accessibility checkers found potential issues regarding several logo images and their alternative text descriptions in line 18 of the source code. The logos are linked, meaning that the purpose of the logos is to guide the user to another page within the website when clicking on them. The purpose of the links is not described within the alternative text and fails WCAG 2.0 guidelines.

## **Montana Tech**

Montana Tech had zero issues related to images with empty alternative text, according to all three-accessibility checkers. However, all three-accessibility checkers found that the image located in line 138 of the source code was missing an alt attribute, failing the WCAG 2.0 guidelines. AChecker failed the image in line 138 as a known problem and to repair it requires adding an alt attribute to the image element. Cynthia Says also failed the image because it contains no alt attribute. Nu HTML went a step further by failing the image because it had no textual alternative as well as it being a linked image.

## **North Carolina State University**

This was an interesting find. North Carolina State University's homepage had three images void of alt-attributes; however, AChecker only found two in its results, but did show the empty alt-attribute in the source code, whereas Cynthia Says and Nu HTML Checker found all three in their initial results. AChecker found that the images in line 296 and 476 were used as an anchor, missing valid alternative text, and were identified as a

known problem. The image in line 552, which had an empty alt-attribute, was only found within the source code results in AChecker; AChecker failed to record the image as having an empty alt-attribute. I had to manually search for line 552 to see if the image was really missing an alternative text description. Fortunately, AChecker provided all the source code in its results, so all I had to do was search for line 552 in AChecker's results to see if the alt attribute was empty or not, which it was. This was the only case where an empty alt attribute was missed from the initial results from all three-accessibility checkers. Cynthia Says found empty alt attributes in lines 296, 476, and 552 and failed them all. Nu Html Checker found the same three images to be void of any textual alternative as well and failed them as well, stating that they would be omitted from non-graphical presentation when used by screen reader technology; in other words, the visually impaired user would never understand the content or context of these images because no alternative text description was provided.

### **Oregon State University**

All three-accessibility checkers found no issues with empty alt-attributes in Oregon State University's homepage. AChecker found images requiring long descriptions, images containing text not in Alt-text, decorative images with Alt-text that was not-required, and Alt-text that didn't describe the same information as the image. In all these cases, manual analysis of each image is necessary to define the relevancy of Alt-text or not. Cynthia Says found no issues related to Alt-text. Nu HTML found no issues related to Alt-text other than explaining that any image with Alt-text should be manually reviewed for its purpose in relation to the context of the homepage, and that redundant phrases such as "Image of..." are avoided.

### **Texas Tech University**

All three-accessibility checkers found no issues with empty alt-attributes in Texas Tech University's homepage. AChecker found image elements which may require long descriptions, images which may contain text that was not available in the Alt-text description, and possible decorative-only images with Alt-text that was not required based on WCAG 2.0 guidelines. In all these cases, manual analysis of each image is necessary to define the relevancy of having an Alt-text description or not. Cynthia Says found no issues related to Alt-text. Nu HTML found no issues related to Alt-text other than explaining that any image with Alt-text should be manually reviewed for its purpose in relation to the context of the homepage, and that redundant phrases such as "Image of..." are avoided.

### **University of Washington (Seattle)**

AChecker found two issues related to empty alt-attributes in line 10, but the same two-images in line 10 failed Cynthia Says as being non-decorative image elements containing empty alt-attributes, and both failed Nu HTML as being empty textual alternatives which will be omitted from non-graphical presentation. In other words, when using screen reader technology, the visually impaired user would never understand the content or context of these images in relation to the homepage or why they are even there in the first place.

## DISCUSSION

This thesis is a comparative analysis of AChecker, Cynthia Says, and Nu Html Checker accessibility checkers to determine which is more useful for testing university homepages against WCAG 2.0 Success Criterion 1.1.1, using accessibility checkers to find empty alt-attributes in university homepages, and how those accessibility checkers performed in finding empty alt-attributes. Based on results obtained from AChecker, Cynthia Says, and Nu Html Checker, Arizona State University, Illinois Institute of Technology, Metropolitan State University, North Carolina State University, and University of Washington—five out of the ten universities I tested—have issues pertaining to empty alt-attributes for numerous images. Of the three-accessibility checkers used to help find empty alt-attributes, Nu Html Checker was my first choice for the most usable software, followed by Cynthia Says, and AChecker. Furthermore, I provided a few image examples that had empty alt-attributes in this section and discuss some of the reasons as to why they failed the accessibility tests.

### **AChecker Usability**

AChecker was the most comprehensive accessibility checker regarding the number of guidelines a user can test against; however, its results were problematic, as it did not specifically identify and organize empty alt-attributes into a category. During my tests, almost every university homepage received a conditional pass from AChecker. This was basically a green light to not manually check for empty alt-attributes, but an incorrect assumption though, because most of the results were not placed in AChecker's "Known Problems" category. AChecker was not useful in automatically finding empty alt-attributes, because almost all of the results were lumped into its "Potential Problems"

category, making it difficult to count each instance of an empty alt-attribute. Furthermore, many of the images with empty alt-attributes were not specifically defined as “empty alt-attribute”; instead, they were defined as having different problems unrelated to empty alt-attributes. This was a big problem and resulted in a time-consuming task of confirming whether each image in each line of code for all AChecker’s known, likely, or potential results from all ten homepages had an empty alt-attribute or not. AChecker’s known, likely, and potential category results contained a wide variety of alternative text issues as well as a many other accessibility issues unrelated to alternative text found within the homepages. Because AChecker lumps all the different issues together, manual confirmation is needed for all results from each AChecker category, so it is up to the user to count the specific results they want. In fact, AChecker seemed to have lumped almost all accessibility problems in its Potential Problems category because it could not specifically identify them, so I had to review hundreds of potential problems to confirm any empty alt-attributes. This was a huge drawback for such a comprehensive piece of software. Nevertheless, AChecker was able to find all the images with empty alt-attributes that the other accessibility checkers found, so in that respect, it was consistent. Plus, AChecker supplied the lines of code along with the image in its results, which made it easy to confirm.

Each university homepage contains cases of the same lines of code placed in different AChecker categories, and many of these images were void of alternative text descriptions which were not specified in the results. For example, line 351 for Arizona State University was placed in three categories: Check 8: img element may require a long description, Check 11: Image may contain text that is not in Alt text, and Check 178: Alt

text does not convey the same information as the image; however, line 351 is completely void of alternative text which makes the Check 8, Check 11, and Check 178 results from AChecker irrelevant. Another example is that Line 231 from Metropolitan State University was also placed in Check 8, Check, 11, and Check 178 categories; however, line 231 is also void of alternative text. What matters here to me is not the specific category that a line of code was placed in; rather, the most significant finding is that most of these images and their lines of code in AChecker's results were void of alternative text descriptions but not stated as such. After analyzing the images in all three AChecker categories, a total of 28 images were found out of 130 alternative text issues to be void of alternative text within five university homepages, which is approximately a 21.5% inaccuracy rate—close to the overall inaccuracy rate of 28%.

### **Cynthia Says Usability**

Cynthia Says was not as comprehensive as AChecker regarding the different guidelines a user can test for; however, it did a decent job of finding empty alt-attributes and was very accurate. Cynthia Says found all cases of empty alt-attributes, which was very useful, but did not supply the images that went along with the empty alt-attribute. Without the assistance of another accessibility checker that supplied image results, Cynthia Says would not have been useful though, because there was no way to know what image belonged to a specific line of code in the results. The nice thing was that Cynthia Says at least gave all the Html line numbers where the empty alt-attributes were located, which made it very easy to match the line number with an image from either AChecker's or Nu Html Checker's results. Cynthia Says was my second choice for usability.

## Nu Html Checker Usability

Nu Html Checker only tests for proper HTML, so it could not be compared with the other accessibility checkers regarding which guidelines to check against. However, this accessibility checker worked the best for locating empty alt-attributes, as well as supplying the images in question in the results. Images were easy to identify and required almost no manual analysis compared to the other accessibility checkers. Nu Html Checker was my first choice for the most usable software to find empty alt-attributes.

## Foaf Images/Slides

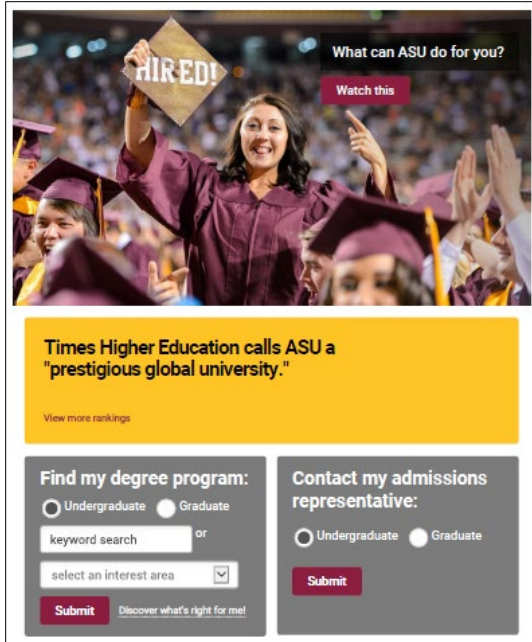
Foaf images consistently failed the accessibility tests because they always had empty alt-attributes. These images were used in slide-show presentations on university homepages and automatically change images, like a slideshow, when the user clicks on the university homepage for the first time. At least two universities used “foaf” images in their slideshow. Some of the images with empty alt-attributes are logos, but most of the images would not be considered decorative images. Decorative images are only required to have an empty alt-attribute based WCAG 2.0 guidelines. However, these Foaf images fail because they should have some alternative text description.



**Figure 6.** A Female student holding a graduation cap with the word "HIRED!" on it.

Figure 6 to the left is an example of a foaf image taken from Arizona State Universities homepage at the time of testing. The image is void of alternative text in the source code's alt attribute.





**Figure 7.** ASU Homepage showing a female student holding a graduation cap with the word "HIRED!" on it.

Figure 7 is a partial clip of Arizona State Universities homepage: According to WCAG 2.0, all non-text content requires alternative text. At first, the image of the young lady may or may not seem to require alternative text in the alt attribute because it is hard to determine whether the textual information supplied is part of the image or digitally altered. I could not find any paragraph or heading element in the source code that displayed the exact text from the

image; therefore, the text in the image must be a part of the image. Therefore, this image would technically be considered non-text content, and would technically be required to contain an alt-attribute with an alternative text description. This image is, arguably, subjective and may not supply information related to the context of the homepage, depending on how one views it. Does the image serve a function? Not really. Does the image help the user navigate the homepage? No. Does the homepage talk about the image? Well, the question “What can ASU do for you?” is seen on the homepage, and the graduation cap the young lady is holding says “HIRED!”, so that could mean that students will get hired after graduation, right? But you see, this is the context that is very subjective when attempting to write alternative text for the blind user, and arguably so. Technically, the image might be saying that this young lady was just hired, but from what employer? So, the following question needs to be asked—what is the true function of the

homepage? The objectives of the homepage might be twofold—to let the reader know that if they attend ASU and graduate, then they will get hired later down the road. But is this technically true? Is the reader guaranteed to get a job after graduation? No, they are not. So, the true function of the homepage may only be to get the reader interested enough to click on “Find my degree program:” or “Contact my admissions representative:”. The image may only be used to persuade the reader to get excited about earning a degree at ASU. Because this image is subjective and would require me to possibly insinuate its meaning in alternative text, I may or may not be required to eliminate any mention of the image in my profession of writing alternative text. In fact, some people would strongly argue that this image needs to be mentioned with alternative text. In my profession, I am not allowed to insinuate, guess, suggest, or add to information displayed on the webpage. I am only allowed to write facts. In other words, I would argue that the facts of the image are defined as “In a crowd of graduate students, a young lady holds a graduation cap with the word HIRED written on it”; that would be my alternative text short description, and no long description would be required. Of course, other organizations involved with accessibility might have different methods regarding their alternative text descriptions of images in websites. That’s the great subjectivism of writing alternative text.

Let’s look at another example in Figure 8 on the following page, from Illinois Institute of Technology. Again, I have found another foaf image void of alternative text in the source code. These foaf images are displayed as image slideshows as soon as the user opens the webpage. Each image is displayed for several seconds before changing to a different image. After researching the source code for the exact textual content that the

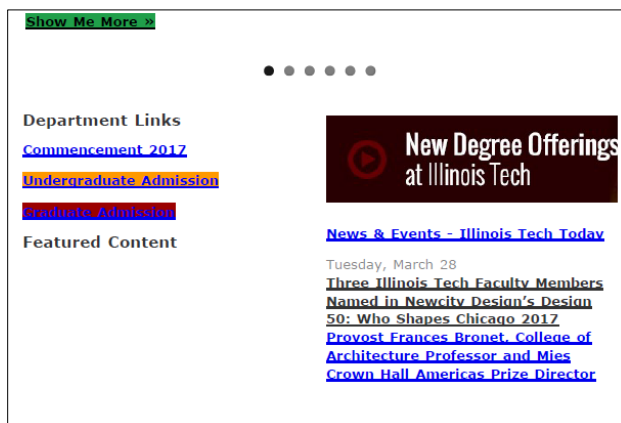
image contains, I have concluded that the text is part of the image and not an actual block of text, such as text within a paragraph <p> or heading <h1> through <h6> element. Therefore, the image would be considered non-text content, which is required to have a textual alternative based on WCAG 2.0 guidelines. The alternative text would be as simple as repeating the text in the image, stating “Law Street. Number one in intellectual property law.” There would be no need to describe the colors or shapes within the image, as they have no specific meaning related to the context of the homepage. Furthermore, one never describes colors in alternative text to the blind unless it is absolutely necessary based on the surrounding context.



**Figure 8.** Illinois Institute of Technology Homepage: Number 1 in Intellectual Property Law.

On the following page, Figure 9 shows a portion of the remainder of Illinois Institute of Technology’s homepage layout. Notice the six circles in the center; each circle represents a foaf image that is to be displayed next in cue. The image in Figure 8 would be directly above this Figure 9 image, changing every several seconds based on the timing set by the web designer. The Figure 8 image does not play a central role in the function of the homepage in Figure 9, but I would argue that it plays a persuasive role

within the context of the homepage. If the image in Figure 8 was considered simply as a decorative image by the web designer or content editor, and to only supply an empty alt attribute, then why is it so important to add the textual information stating that Illinois Institute of Technology is number one in Intellectual Property Law? That information means something to a reader. That textual information in the image is not decorative, but the remainder of the image, its shapes and colors are decorative. There is a saying amongst people and organizations that if the image does not require a textual alternative in the first place, then why add the image in the first place? This kind of leads me to a conclusion that when an organization, or individual, states that they are all inclusive about accessibility for all types of challenged individuals, that this really is not the case in most circumstances. Nevertheless, the several problems I found associated with missing alternative text in Illinois Institute of Technology's' homepage is relatively small in relation to the many other accessibility issues that were found when using AChecker, NuHTML and Cynthia Says; however, this was only the homepage. It takes only a few accessibility problems to make an entire site inaccessible.



**Figure 9.** Illinois Institute of Technology Homepage Clip.

Figure 10 below is one of the images from Metropolitan State University that failed all three-accessibility checkers for having an empty alt text attribute. This image is not a foaf image, but it is a regular image coming from an image source. According to WCAG guidelines, all non-text content requires alternative text unless otherwise used as a decoration of some sort. The image itself doesn't say anything to the reader about who these people are or why they are all standing together, but if the surrounding textual content on the webpage states who these people are in this image, then it is technically feasible to leave the alt attribute empty, although not recommended. If that were the case, then the blind user must read the surrounding content to eventually realize that an image of nine people exists. After careful inspection of the surrounding text, I have determined that a paragraph of text introduces the image, which can be seen in Figure 11 on the following page.



**Figure 10.** Nine People Standing-Metropolitan State University.

In Figure 11 below, notice the text in the first link which describes the image as “Nine named as spring 2017 outstanding students.” This text is referring to the nine-people standing in the image.

[Nine named as spring 2017 outstanding students](#)

[May 11, 9:00 PM](#)

[Nine students were named as Outstanding Students for spring 2017 semester. The students were recognized at Metropolitan State University's 100th commencement exercise, May 1, at Roy Wilkins Auditorium in Saint Paul.](#)

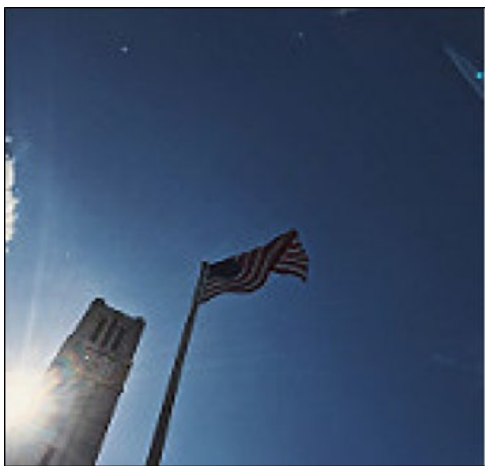
### Recent News

-   
[Metropolitan State University announces Dental Hygiene Dual Enrollment Program](#)

**Figure 11.** Metropolitan State University Homepage Content Mentioning Nine Students

However, this small paragraph, which is linked, is not very descriptive to a blind user because it makes no reference to the image, nor does it make any reference to who the nine people are. Instead, the alt attribute is simply left empty; therefore, the image is inaccessible. Clicking on the link may provide answers to who these people are, but the point is that the image is inaccessible due to the empty alt-attribute. The image must be referenced in the alternative text surrounding the image, or the image must have a descriptive alternative text in its alt attribute, none of which have been done. Designing images to be accessible sometimes takes a little research into the image. A little research would have found the names of the people in the image in Figure 10. A simple, yet

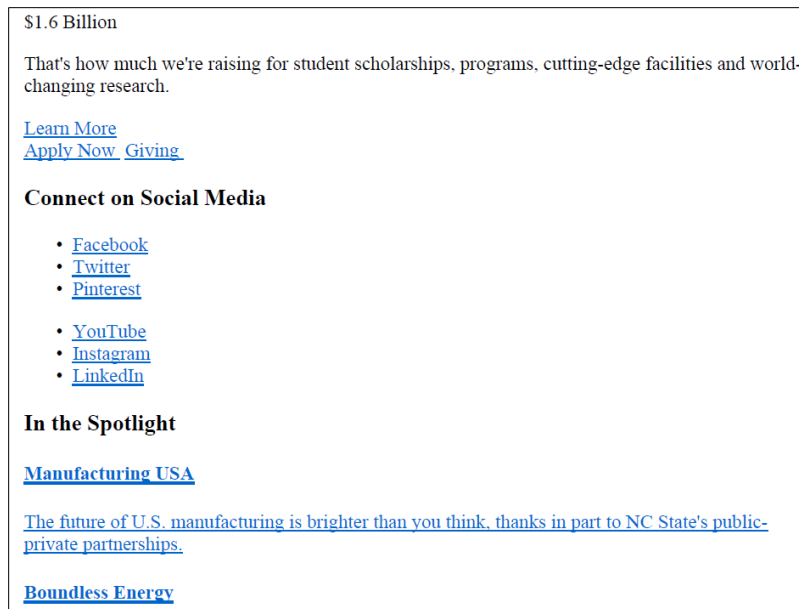
accessible alternative text short description could have been “Nine students standing together, from left to right: Sue, Mike, Betty, Mary, Eve, Dan, Kathy, George, and Sybil” (NOTE: I made up the names). There is no need to mention skin color, what each person is wearing, or attempt to define race, country of origin, or religion; that is beyond the scope of the intended context of the university homepage and is also most likely beyond the knowledge of the author writing alternative text. Furthermore, it’s not a good idea to guess at any of these distinguishing factors. However, if the author wanted to research more into what fields these students are studying, then that would be acceptable, but it would have to be written as a long-description in the source code, or would have to be typed out in the image’s surrounding textual content due to the number of words, such as “Nine students standing together, from left to right: Sue, a Dental Hygiene Master student; Mike, a Mechanical Engineer student; and so forth.” This kind of alternative text, applied with a little research, can be very accessible and rewarding to a blind reader, because he or she will at least have the power to choose to read only the short alternative text description and not the long-description, or both. Now that is accessible.



**Figure 12.** American Flag at North Carolina State University.

Figure 12, to the left, is an image from North Carolina State University’s homepage that is missing alternative text. Figure 12 is obviously a poor-quality photograph, and I wonder why it was even used on the homepage in the first place. Nevertheless, it is an image of an American Flag that has an empty alt attribute. An author must attempt to research the context of the homepage

for the reason an American Flag is presented in an image. At the time of recording this image and the homepage, it seems that North Carolina State University was highlighting manufacturing in the USA, which can be seen in Figure 13, below.



**Figure 13.** North Carolina State University Homepage Content.

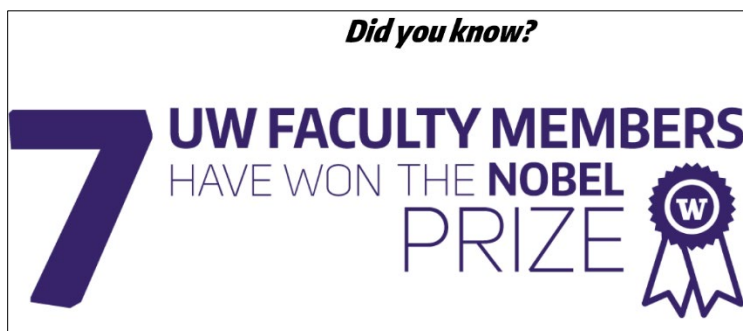
Figure 13 to the left is the content section of North Carolina University's homepage which says anything about the USA. I'm trying to figure out if this is the reason for the American Flag image, but I'm kind of guessing

here. Regardless of what I interpret the image to mean, and given the context of the homepage, I can't be certain. There is no mention of an American Flag in any paragraph's text in the homepage; there is only mention of USA and Manufacturing. My professional opinion is that the American Flag represents Manufacturing in the USA, but since no mention of it has been made in the homepage, I must follow the WCAG guidelines which state that all non-textual content must have an equivalent alternative text. Therefore, since there is no mention as to why the American Flag is present in the image, then the simple and short-description should only be "American Flag." That description would suffice and would pass all accessibility checkers. The reason the image



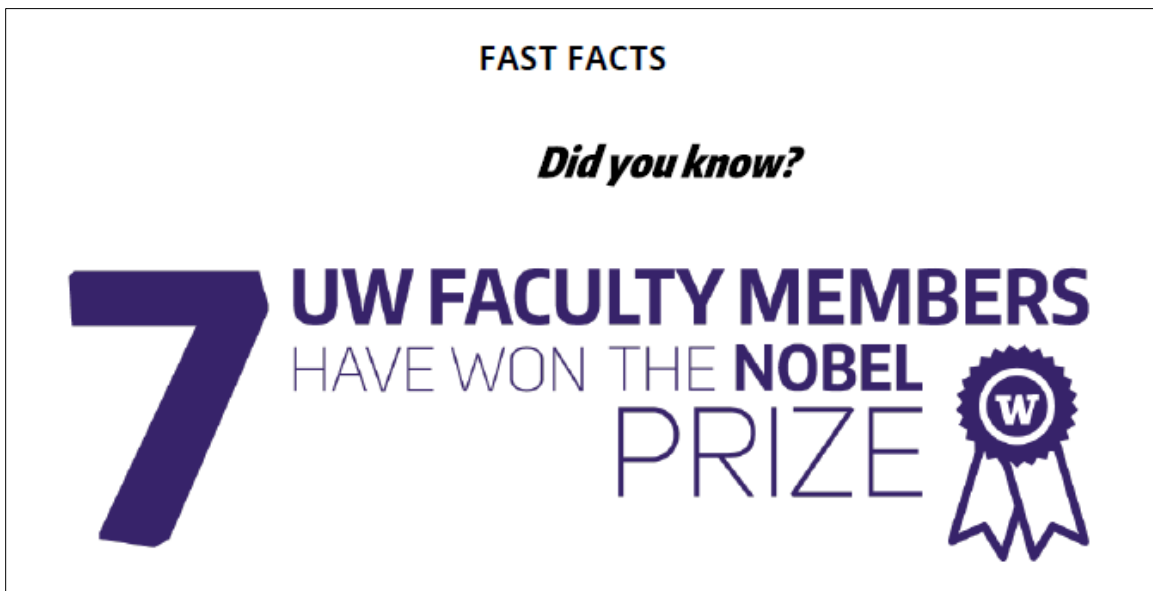
in Figure 12 has an empty alt attribute I do not know; I can only guess that it was an error in editing, because WCAG guidelines are specific in this case.

Let's take another look at an image with an empty alt attribute from University of Washington, in Figure 14 below. Figure 14 is from the University of Washington homepage. It's not a photographic image, but a digital image made up of text, maybe from Adobe Photoshop or InDesign. Normally, the alt-attribute is placed at the end of the image src (source), making this image a very difficult one to research and locate in the source code. Here we have an image solely made up of text. And what do the WCAG guidelines tell us? All non-text content must have an alternative textual equivalent, yes indeed. But this image seems to skate around the guidelines does it not? It has text, so it doesn't need an alt attribute description, right? Wrong! Placing text inside a .png image format does not circumvent the requirement for alternative text for non-text content. This image is inaccessible to screen readers; they will not read the text inside an image. Therefore, it is imperative that the content of the image is accessible by way of alternative text, and any surrounding content should be included in the context of the image and the homepage, within the alternative text description.



**Figure 14.** University of Washington, Image from Line 10

Below, Figure 15 shows just a few more facts regarding surrounding textual content on the University of Washington homepage. Illusively, the text “Fast Facts” and “Did you know” is introducing the text within the image; however, the text within the image is not accessible to a blind reader, so this is pointless to have this image void of alternative text. If you can, cover up the image and only read “Fast Facts Did you know” and you will understand how this would be interpreted by a blind reader. A very easy solution would be to add a short description in the alt attribute, stating exactly what the text in the image says, and that’s it; you are done, the image is accessible, and the image will pass an accessibility checker.



**Figure 15.** University of Washington Image from Line 10: Did You Know?

### **Implications**

The implications of my findings could be taken as the glass half full or empty concept, as I can’t really explain if my results are good or bad. Perhaps if previous tests had been done regarding alternative text issues in university websites, a more holistic

picture could have been made. Future research into this issue would help to understand if university websites are becoming more or less accessible. With thousands of universities and colleges in the U.S., it would be very bad in my opinion if half of their websites could not pass the accessibility test.

There were many problems associated with images not having alternative text in the Alt attribute, and there were many issues involving text within images that was not described. Furthermore, several of the images that had empty alt attributes were used as slides in the homages, and some images may be subjective in nature. No matter what the reasons are for not supplying accessible images in any university website, the facts are that the law states that all federally funded universities must make their online information accessible to the all blind, visually impaired, and disabled persons. Organizations such as Target have even been sued and had to settle lawsuits in the millions of dollars for not making their websites fully accessible. It is very possible in this day and age that any university that receives federal assistance and has website accessibility issues is open and fair game to such lawsuits.

## **CONCLUSION**

In conclusion, the answer to the research question, “are the 2017 university homepages compliant with WCAG 2.0 guidelines specifically regarding empty alt-attributes?”, is that half of the university homepages failed the alt-attribute test and the other half, for the most part, fulfilled the WCAG 2.0 Level A requirements regarding alternative text in alt-attributes. The second part of the research question was trying to answer why university homepages were not compliant and, unfortunately, I cannot answer this question decisively. Even after obtaining all my results of empty alt

attributes, I can only make assumptions as to why this issue is present in half of the university homepages tested. After careful consideration, I would assume that time is an issue when designing websites to be accessible. It takes a lot of time to analyze images and describe them with alternative text, and organizations are often in a hurry to produce content on their websites, possibly making it difficult for content writers to manage everything consistently. I do not believe that people who design websites with images are nescient about accessibility guidelines regarding alternative text. If knowledge was an issue, then I would think all images in the university homepages would have been void of alternative text. On the contrary, many images were fully described with alternative text, so the authors are cognizant of the guidelines although some may not be; I'm just guessing here.

My hypothesis was amiss in assuming university homepages would pass the accessorily checker tests if a Web-Standards page was provided in the university website. On the contrary, it appears that whether a web standards page was provided or not made no difference at all based on my results. Some of the web standards pages were very developed, clear and concise yet the homepages failed my tests. On the other hand, some web standards pages were non-existent yet passed my tests. This leads me to believe that no one really uses a web standards page when adding images to webpages. As a Content Editor, I never used a web standards page when writing alternative text for images; instead, I used an internal company style guide. Because of this, I would assume that a web standards page is simply used as a marketing tool to let the public know that the university abides by accessibility guidelines, we care about people with disabilities, and people with disabilities are welcome. Table 13 on the following page shows that having a

Web-Standards page had no effect on the outcome of alternative text issues or empty alt-attributes. Therefore, my hypothesis was incorrect in assuming a homepage would have more accessible images by having a Web-Standards page.

**Table 13.** Did a Web-Standards Page Help Results?

University Homepage	AChecker	Cynthia Says	New Html	Web standards page?
Arizona State University	351, 374, 400, 424, 447, 470, 493, 516, 539, 738	351, 374, 400, 424, 447, 470, 493, 516, 539, 738	351, 374, 400, 424, 447, 470, 493, 516, 539, 738	Yes
Auburn University	None	None	None	No
Illinois Institute of Technology	154, 167, 180, 193, 206, 219, 355	154, 167, 180, 193, 206, 219, 355	154, 167, 180, 193, 206, 219, 355	No
Metropolitan State University	231, 262, 353, 385, 417, 917	231, 262, 353, 385, 417, 917	231, 262, 353, 385, 417, 917	No
Michigan Technological University	None	None	None	No
Montana Tech	None	None	None	Partial
North Carolina State University	296, 476, (552 shows in code but not results)	296, 476, 552	296, 476, 552	Yes
Oregon State University	None	None	None	Partial
Texas Tech University	None	None	None	No
University of Washington	10, 10	10, 10	10, 10	Yes

### Further Research to Consider

If automated alternative text is the future of accessible images, then there should be more research into automated systems that can judge image content and context in relation to webpage content and context; however, there still remains the human aspect of file naming conventions and file types. For example: not all web-based images are simple photographs that can be automatically described accurately; rather, many web-based

images are highly complex snippets of mathematical tables, equations, cartoons, and the like. For now, automated means of image analysis and alternative text description does not seem to be useful in real-world contexts where images, content, and context require manual research. An image of a person skiing down a mountain could very well be automatically-described perfectly, but if the skiing image was placed into an online book titled Corporate management, then it is possible that the image relates to something else, such as the ups and downs of corporate management, subjectively speaking. These kinds of issues more than likely need manual analysis.

Organizations involved with website content use different style guides regarding alternative text, such as what type of image requires alternative text and what specific content from the image needs to be described. Images are very subjective and can be described in various ways depending on what the author sees on screen and in their mind. Therefore, better training in image analysis could be a great way to decipher context in images, where Tang's guidelines for analyzing images and writing alternative text could be used as a go-to training guide.

An argument is established on whether to write alternative text for decorative images or not. WCAG is vague as to what constitutes a decorative image. A logo can be a decorative image, a link, or both; it depends on the context of how it is used in the webpage. An image of a man skiing down a mountain may also be a decorative image or not, depending on the context. WCAG states that decorative images should be placed in CSS or in the HTML with an empty alt attribute as to avoid being seen by screen reader software—to avoid redundancy, but many of those images could be considered as ones that establish different levels of sighted users' experiences and moods based on the image

content, including color. Section 508 clearly states that agencies must give disabled employees and members of the public access to information that is “comparable” to access which is available to others without disabilities. The question that perplexes authors of alternative text is that if the image used in the webpage is designed only to be seen by sighted users and not to be seen by screen reader software, then why use the image in the first place when it is not comparably accessible to a blind user? This subjective use of images goes against Section 508 and WCAG standards.

## REFERENCES

1. Accessible Images. (2017). Retrieved from University of Washington website: <http://www.washington.edu/accessibility/web/images/>
2. Accessible Technology. (2017). Retrieved from Michigan Tech website: <http://www.mtu.edu/equity/access-disability/technology/>
3. Accessible-email.org. (2017). Retrieved June 20, 2018, from <http://www.accessible-email.org/>
4. AChecker. (2017). Web Accessibility Checker. Retrieved from <https://achecker.ca/checker/index.php>
5. Al-Badi, A., Ali, S., & Al-Balushi, T. (2012). Ergonomics of usability/accessibility-ready websites: Tools and guidelines. *Webology*, 9(2), Article 98. Retrieved from <http://www.webology.org/2012/v9n2/a98.html> (Al-Badi, Ali & Al-Balushi, 2012).
6. Alternative Text for Images. (2017). Retrieved from Oregon State University website: <http://oregonstate.edu/accessibility/alttext>
7. Alternative Text. (2017). Retrieved from North Carolina State University website: <https://accessibility.oit.ncsu.edu/it-accessibility-at-nc-state/developers/accessibility-handbook/alternative-text/>
8. American Foundation for the Blind (2018). Statistical Snapshots from the American Foundation for the Blind. Retrieved from <http://www.afb.org/info/blindness-statistics/2>
9. Asqatasun. (2017). Retrieved from <https://asqatasun.org/>
10. Bigham, J. P. (2007). Increasing web accessibility by automatically judging alternative text quality. *Proceedings of the 12th International Conference on Intelligent User Interfaces - IUI 07*, 349-352. doi:10.1145/1216295.1216364
11. Cynthia Says. (2015). Retrieved from <http://www.cynthiasays.com/>
12. GSA/Government-wide Section 508 Accessibility Program. (1998). WCAG 2.0 Conformance. Section508.gov. Retrieved from <https://www.section508.gov/manage/laws-and-policies>
13. Hanson, V., & Richards, J. (2013). Progress on Website Accessibility?. *ACM Transactions On The Web*, 7(1), 1-30. <http://dx.doi.org/10.1145/2435215.2435217> (Hanson & Richards, 2013).
14. Illinois Institute of Technology. (2017). Retrieved from <https://web.iit.edu/>



15. Key Principles of Web Accessibility. (2017). Retrieved from Auburn University website: <https://cws.auburn.edu/Accessibility/cm/webaccessibilityessentials>
16. MAUVE. (2017). Retrieved from <http://mauve.isti.cnr.it/>
17. NuHtml Checker. (2017). Retrieved from <https://validator.w3.org/nu/>
18. Online Accessibility. (2017). Retrieved from Texas Tech University website: <https://www.ttu.edu/accessibility/>
19. Pemberton, S. (2003). The kiss of the spiderbot. *Interactions*, 10(1), 44. doi:10.1145/604575.604594
20. Slatin, J. (2001). The art of ALT: Toward a more accessible Web. *Computers and Composition*, 18(1), 73-81.
21. Splendiani, B., & Ribera, M. (2016). Accessibility of graphics in STEM research articles: Analysis and proposals for improvement. *Journal Of The Association For Information Science & Technology*, 67(6), 1507-1520. doi:10.1002/asi.23464
22. Tang, L. (2012). Producing informative text alternatives for images *ProQuest Dissertations & Theses Global*. (1318655851).
23. U. S. Access Board. (2017). Information and Communication Technology (ICT) Final Standards and Guidelines. Retrieved from <https://www.access-board.gov/guidelines-and-standards/communications-and-it/about-the-ict-refresh/final-rule>
24. U. S. Architectural and Transportation Barriers Compliance Board. (2017). Information and Communication Technology (ICT) Standards and Guidelines. *Federal Register* [2017-00395.] pp. 5790-5841. Retrieved from <https://www.federalregister.gov/documents/2017/01/18/2017-00395/information-and-communication-technology-ict-standards-and-guidelines>
25. U. S. Department of Justice/Civil Rights Division. (1990). Introduction to the ADA. Retrieved from [https://www.ada.gov/ada\\_intro.htm](https://www.ada.gov/ada_intro.htm)
26. U. S. Equal Employment Opportunity Commission. (1973). Rehabilitation Act of 1973. Retrieved from [https://www.eeoc.gov/eeoc/history/ada25th/rehab\\_act-1973.cfm](https://www.eeoc.gov/eeoc/history/ada25th/rehab_act-1973.cfm)
27. W3C. (1999). Web Content Accessibility Guidelines 1.0. Retrieved from <http://www.w3.org/TR/WCAG10/#gl-provide-equivalents>
28. W3C. (2008). Web Content Accessibility Guidelines (WCAG) 2.0. Retrieved from <http://www.w3.org/TR/WCAG20/#text-equiv>
29. W3C. (2009). How WCAG 2.0 Differs from WCAG 1.0. Retrieved from <https://www.w3.org/WAI/WCAG20/from10/diff>

30. W3C. (2016). Web Accessibility Evaluation Tools List. Retrieved from <http://www.w3.org/WAI/ER/tools/>
31. W3C. (2017a). How to Meet WCAG 2.0. W3.org. Retrieved from <http://www.w3.org/WAI/WCAG20/quickref/>
32. W3C. (2017b). Web Accessibility Initiative. Retrieved January 08, 2018, from <https://www.w3.org/WAI/>
33. WAVE. (2017). Wave.webaim.org. Retrieved from <http://wave.webaim.org/>
34. Web Accessibility. (2017). Retrieved from Metropolitan State University website: <http://www.metrostate.edu/site-information/web-accessibility>
35. Web Accessibility. (2017b). Retrieved from Montana Tech website: <https://www.mtech.edu/accessibility/web-accessibility.html>
36. Web Standards. (2017). Retrieved from Arizona State University website: <https://brandguide.asu.edu/web-standards>
37. WHO. (2017). Visual impairment and blindness. Retrieved from <http://www.who.int/mediacentre/factsheets/fs282/en/>