Human Suffering During Wartime:

A StoryMap of Violations of International Law During the Russo-Ukrainian War

by

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To my wife, Kaitlyn, who encouraged me throughout my master's program, and patiently endured long weekends and late nights spent working throughout this thesis.
This achievement would not have been possible without you.

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Abbreviations

AAAS	American Association for the Advancement of Science
ABT	American Battlefield Trust
ACLED	Armed Conflict Location and Event Eata
AGOL	ArcGIS Online
AP	Associated Press
BBC	British Broadcasting Corporation
CIA	Central Intelligence Agency
DIL	Digital Investigations Lab
DOD	United States Department of Defense
GIS	Geographic information system
HDX	Humanitarian Data Exchange
HOT	Humanitarian OpenStreetMap Team
HRW	Human Rights Watch
ICC	International Criminal Court
IHL	International Humanitarian Law
ISW	Institute of the Study of War
OSM	OpenStreetMap
OIM	Open Infrastructure Map
UN	United Nations

Abstract

The Russo-Ukrainian War began with the large-scale invasion of Ukraine by Russian forces in the early morning of February 24, 2022. As the war continues, there have been widespread reports of violations of international humanitarian law with civilian populations being heavily impacted by this war. This thesis aims to inform readers about human suffering during the war in Ukraine and the use of spatial visualizations to convey events that contravene international humanitarian law. The three violations researched within this thesis include war crimes, crimes against humanity, and genocide. The study areas for these three sections are the city of Mariupol, the town of Bucha, and the Russian-occupied regions of Ukraine. The data is from publicly available datasets, authoritative news sources, the United Nations, the country of Ukraine, and Armed Conflict Location and Event Data. This thesis displays the occurrence of human tragedies such as civilian fatalities, explosions/remote strikes, battles, strategic developments, violence against civilians, targeting of medical facilities, targeting of educational facilities, occurrences of sexual violence, abducted persons, and damage to civilian infrastructure. The completed work of this thesis is published in an Esri StoryMap to articulate the history of the conflict and visually display the spatial data within a series of Dashboards. Further practices of researching and visualizing human atrocities affecting civilian populations, such as spatial journalism, need to be expanded within the realm of spatial sciences. Organizations seeking to relieve civilian populations' suffering during wartime must adopt and expand upon these practices. The preliminary results of this methodology successfully presented the occurrence of human suffering in a StoryMap via the thesis definition of the violation of international humanitarian law.

Chapter 1 Introduction

Suffering caused by the hands of others has plagued human existence for thousands of years. In the modern era of technology spatially tracking these human atrocities has become necessary for identifying, analyzing, and appropriately reacting to different occurrences of human suffering. The international community needs to further develop its methods within the spatial sciences in the identification of the breaking of international law during wartime. The Russo-Ukrainian War escalated with the large-scale invasion of Ukraine by Russian forces in the early morning of February 24, 2022, after months of militarized buildup on the Ukrainian and Russian border. As of this writing, it is estimated that nearly 500,000 Ukrainian civilians and troops have been killed or wounded during the conflict (Cooper and Helene 2023). In addition to the loss of life and violent crimes, there have been numerous intelligence sources stating Russian strikes on non-military targets such as Ukrainian civilian infrastructure, places of worship, educational facilities, and hospitals. This thesis uses spatial dashboards to depict current data and figures of multiple violations of international humanitarian law during the Russo-Ukrainian war such as war crimes, crimes against humanity and genocide.

1.1 Background

On February 24, 2022, Russia launched a full-scale invasion of Ukraine from multiple fronts to topple the Western-aligned government. Russia's so-called "special military operation" endured bombardments that targeted Ukrainian cities while Russian troops entered Ukraine from Russia, Belarus, and the Black Sea (Eichensehr 2022). Throughout the war, the Ukrainian civilian population has suffered horrific attacks, loss of life, and damage to critical infrastructure (Levy and Leaning 2022). These attacks have caused the displacement of more than 7.1 million

people and directly led to the largest humanitarian crisis in Europe since the Second World War (Levy and Leaning 2022).

The historical relationship between Russia and Ukraine dates more than a thousand years ago to when Kyiv was the center of Kyivan Rus the first Slavic state (Conant 2023). The grand prince of Kyiv Volodymyr the Great accepted the Orthodox Christian faith in 988 A.D. (Conant 2023). This moment in history is what current Russian Leader Vladimir Putin declares as when the Russians and Ukrainians became one people (Conant 2023). Although the Russian narrative is that of unity and collaboration, Russia has subjected Ukraine to decades of abuse and occupation.

In 1793 Ukraine was annexed by the Russian Empire and endured a policy known as Russification where it was forbidden to use and study the Ukrainian language, and Ukrainians were forced to convert to Russian Orthodox (Conant 2023). In the early 1900s, slightly over a hundred years later, Ukraine suffered one of its darkest periods. Following the Communist Revolution of Russia in 1917, Ukraine fought a devastating civil war before being absorbed into the Soviet Union. While Ukraine was a member of the Soviet Union, it was one of the most powerful and populated republics within the Union. (Masters 2023). In addition to having a large population, Ukraine was the Soviet Union's major hub of agricultural production, defense industrial production, and military facilities like the Black Sea Fleet (Masters 2023). Although Ukraine was a major contributor to the Soviet Union's power, Soviet Dictator Joseph Stalin orchestrated a national famine in the 1930s that resulted in the starvation and deaths of millions of Ukrainians (Conant 2023). Following this famine, the Soviet Union relocated thousands of Russians to repopulate the eastern region of Ukraine with Russian influence (Conant 2023). This settlement of Russians in Eastern Ukraine created a divide in culture that can still be seen today.

After the Soviet Union's collapse in 1991, Ukraine became an independent state but the transition to Western democracy proved to be challenging. National pride was not as present in eastern Ukrainians as it was in Ukrainians in the West. While Western Ukrainians were embracing the governmental shift toward democracy and Western culture many Ukrainians in the East longed for the stability and culture of the Soviet Union (Conant 2023). This divide between the eastern and the western parts of Ukraine can be seen in the results of the presidential elections in 2004 and 2010. This political alignment proved to come to a head in the Russian military operations in Ukraine in 2014.

In February 2014 unidentified men began occupying key facilities and checkpoints in the Crimean Peninsula (Pifer 2020). These professional-looking soldiers were dubbed "Little Green Men" by the Ukrainian public as they did not bear a country's flag. After these troops secured the entire Crimean Peninsula, the Russian Federation claimed that these were Russian troops (Pifer 2020). Following this claim the Russians conducted a rigged referendum for citizens to vote to return Crimea to Russian control (Pifer 2020). This illegal referendum passed in March 2014 and led to the illegal annexation of Ukrainian Crimea to Russia. Following this annexation, Russian-backed separatists began operating in Eastern Ukraine's Donbas region which resulted in the declarations of the Russian-backed People's Republics of Luhansk and Donetsk (Conant 2023). The tension caused by these events existed from the militarized buildup of Russian forces on the Ukrainian border in 2021 and 2022 to the full-scale invasion of Ukraine in February 2022.

1.2 International Humanitarian Law

International humanitarian law in the form it is accepted today was established following the horrors the world endured during the Second World War. The Geneva Convention of 1949 sought to protect victims of war. Additional rules were added to the Geneva Convention in 1977

with aid from the International Committee of The Red Cross. International humanitarian law establishes rules that focus on limiting the effects of armed conflicts for humanitarian reasons (UN 2024a). These laws protect individuals who are no longer considered to be participating in the conflict and forbid means and methods of warfare. People these laws seek to protect include humanitarian effects for civilian populations, sick or injured combatants, and prisoners of war (UN 2024a). These laws establish a standard agreement between states' militarized interactions.

1.2.1 War Crimes

War crimes establish a framework for the laws by which armed conflicts are conducted. The Geneva Conventions in 1949 following the mass death and destruction of the Second World War sought to establish rules to protect people who were not or no longer acting in the armed conflict (UN 2024b). Article 8 of the Rome Statute classifies War Crimes as a deliberate attack committed as a component of a scheme or policy on a large-scale employment of such crimes (UN 2024b). To classify as war crimes these crimes must take place in the circumstances of armed conflict (UN 2024b). Examples of war crimes as established by the UN are intentionally directing attacks against civilian populations or individuals, intentionally directing attacks toward civilian objects and infrastructure, intentionally targeting humanitarian efforts, intentionally conducting attacks with the knowledge that such an attack causes loss of life or injure civilians, and attacking or bombarding buildings dedicated to religion, education, art, science, monuments, or hospitals (UN 2024b).

1.2.2 Crimes Against Humanity

It is unknown the exact origin of the use of the phrase crimes against humanity. Some State that crimes against humanity were first seen in scholarly writings referring to atrocities associated with European colonialism (UN 2024c). Others have pointed to the 1915 declaration

by France, Great Britain, and Russia to end the killing of Armenians by the Ottoman Empire as the origin of the word concerning international crimes (UN 2024c). To prevent crimes against humanity has become an established standard of International Law. Article 7 of the Rome Statute of ICC states that Crimes Against Humanity occurs when a violent act is knowingly carried out in connection to a widespread or systemic attack that targets a civilian population (UN 2024c). Examples of crimes against humanity as established by the UN are murder, extermination, enslavement, deportation or forcible transfer of populations, imprisonment, torture, rape, enforced prostitution, forced pregnancy, enforced disappearance of persons, the crime of apartheid, or other inhumane acts (UN 2024c).

1.2.3 Genocide

The word genocide was first used by a Polish lawyer in his 1944 book discussing the Nazi occupation of Europe. The word consists of a combination of the Greek word for "race" or "tribe" and the Latin word for "killing" (UN 2024d). This word was created to discuss the systemic killing of the Jewish people by the Nazi party as well as historical instances to eradicate a specific group of people (UN 2024d). genocide was later recognized as a crime under international Law in 1946 by the United Nations. Article II of the Geneva Convention and Article 6 of the Rome Statute of ICC states that genocide occurs when any of the following acts are committed with intent to destroy, in whole or in part, a national, ethnical, racial, or religious group (UN 2024d). Examples of genocide, as established by the UN, are forcibly transferring children of a group to another group, targeted killings of members of a group, causing serious physical or mental harm to members of a group, deliberately inflicting on a group situation of life to cause physical elimination of part of the whole of the group, imposing situations to prevent births within the group (UN 2024d).

1.2.4 Violations of International Humanitarian Law in Ukraine

Since the full-scale invasion of Ukraine, there have been mass reports of violations of international humanitarian law (IHL) committed by Russia. The Russian military has committed acts that fall within the jurisdiction of war crimes, crimes against humanity, and genocide. The human suffering of civilians is mounting as the result of Russia's lack of respect for basic human rights and principles of humanitarian law (UN OHCHR 2024a). As of the writing of this thesis, The Office of the United Nations High Commissioner for Human Rights (OHCHR) estimates that 11,520 civilians have died, 23,640 civilians have been injured, and 6.6 million refugees from Ukraine have been registered globally (UN OHCHR 2024b). Widespread violence and destruction have been recorded throughout the Russo-Ukrainian War with over 140 states calling for the end of Russian aggression.

1.3 Study Area

The study area for this research is the country and specific cities of Ukraine. Figure 1 shows an aerial map of the oblast and country boundaries of Ukraine with a drop shadow effect to make the study area more visible.

Figure 1. Study Area – Ukraine

According to the United States Central Intelligence Agency (CIA), the country of Ukraine is approximately 603,550 sq km with 579,330 sq km of land and 24,220 sq km of water (CIA 2024). Ukraine's territory is located in Eastern Europe with bordering countries of Russia to the east Poland, Romania, and Moldova to the west, and the Black Sea and the Sea of Azov to the south. As of the writing of this section, approximately 43,133 sq km, or roughly 7.1% of Ukraine's territory, is Russian-occupied (CIA 2024). The work within this thesis focuses on the town of Bucha, the City of Mariupol, and areas in which Russian forces have occupied Ukraine. These three locations were chosen to aid in depicting the occurrence of human suffering in the three areas of focus war crimes, crimes against humanity, and genocide.

1.3.1 War Crimes Study Area

To research the occurrences of war crimes during the Russo-Ukrainian War this thesis focuses on the Port City of Mariupol in the Donetsk Oblast Russia's military operations in Ukraine have drawn criticism from many countries calling for a cease-fire to prevent further tragedies such as the war crimes that occurred during the Siege of Mariupol. The Siege of Mariupol occurred from February 24, 2022 - May 20, 2022, in the Port City of Mariupol, Donetsk Oblast (Farge 2024). During the two months, three weeks, and five-day Russian assaults Ukrainian civilians suffered through heavy bombardments that targeted infrastructure such as residential apartments, hospitals, education facilities, religious establishments, and electricity & water infrastructure (Sabbagh 2024). Figure 2 depicts the major streets, buildings, and city boundaries of the City of Mariupol in Ukraine.

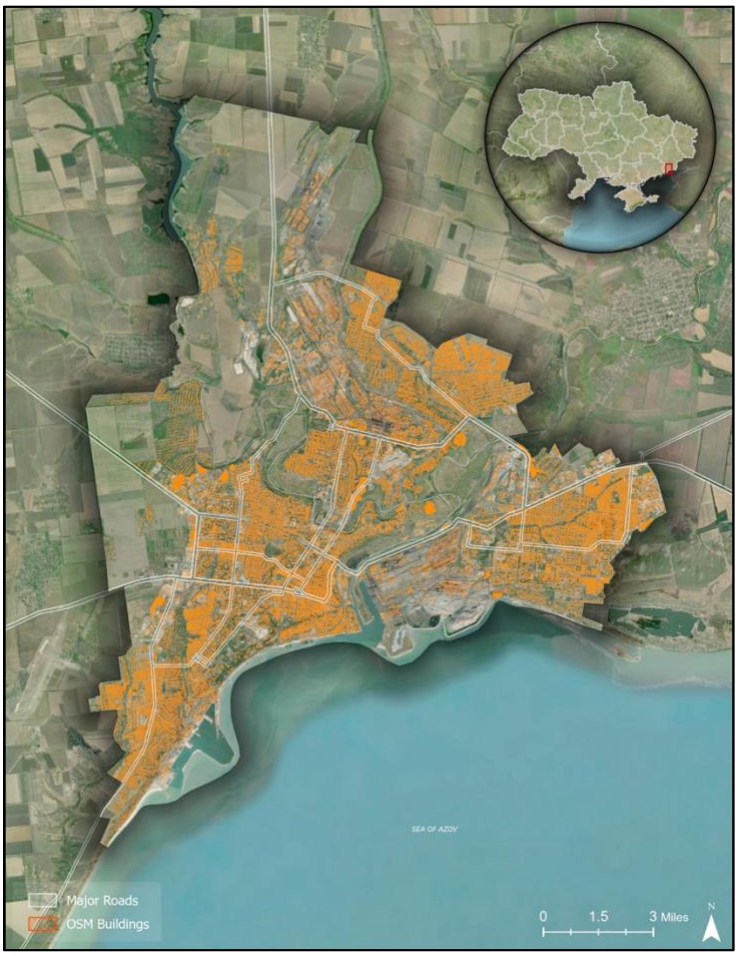

Figure 2. Mariupol Study Area

1.3.2 Crimes Against Humanity Study Area

To research the occurrences of crimes against humanity during the Russo-Ukrainian War this thesis focuses on the Town of Bucha in the Kyiv Oblast. Russia has justified its invasion by claiming to bring freedom to the Ukrainian people. However, violent and horrific crimes committed by Russian troops are present in towns occupied by Russian forces. The Ukrainian city of Bucha was occupied by Russian forces from February 27, 2022, to March 31, 2022 (Zhukova 2024). Throughout the occupation of the city, Russian forces carried out mass executions, interrogations/tortures, and rapes of Ukrainian civilians. After the withdrawal of Russian troops on March 31, 2022, the crimes that Ukrainian civilians experienced were

uncovered (Shuster 2022). Ukrainian bodies were found strewn through the streets and makeshift dungeons with bound hands (Shuster 2022). This reveal prompted international outrage and an investigation from the United Nations. Figure 3 depicts the road system, buildings, and boundary of Bucha in Ukraine.

Figure 3. Bucha Study Area

1.3.3 Genocide Study Area

To research the occurrences of genocide during the Russo-Ukrainian War this thesis focuses on the territory wherein Russian forces have abducted civilians, notably of Ukrainian children. Since the start of the Russo-Ukrainian War, around 20,000 children have reportedly been taken (Revill 2024). These children are being taken and relocated to Russian foster homes, technical schools, military training facilities, and re-education camps to turn them into Russian

citizens (Holligan 2024). Children who have been returned to Ukraine have exhibited serious harm to their mental well-being. Figure 4 depicts the oblast boundaries, country boundaries, and the furthest territorial gain made by Russian troops during the Russo-Ukrainian War.

Figure 4. Territory Height of Russian Military Study Area

1.4 Project Overview

The objective of this thesis is to develop a StoryMap depicting three violations of international law such as war crimes, crimes against humanity, and genocide that were committed by Russia during their invasion of Ukraine. Spatial data will be prepared and uploaded to ArcGIS Online using ArcGIS Pro. Non-spatial data will be prepared using Microsoft Excel and uploaded directly into ArcGIS Online. The interactive dashboards and StoryMap will be developed using the ArcGIS Online platform. The final product of this thesis will be a publicly available StoryMap discussing and depicting human suffering via violations of international law.

1.4.1 Data Overview

The data used within this thesis is centered around violations of international law related to war crimes, crimes against humanity, and genocide during the Russo-Ukrainian War. Data focuses on three locations from the beginning of the war to the time of writing this paper. The data used within this thesis articulates a specific type of violation of international humanitarian law. The statistics that are used come directly from investigative sources or governmental statements. Datasets consist of geospatial locations, atrocities count, actors, event types, fatality counts, and several population breakdowns from the different locations. Additional data sets are geographic boundaries of Ukraine such as oblast boundaries and city geographies. Specific information on individual datasets is provided in the following sections.

1.5 Structure of Thesis

This Thesis includes a literature review, methodology, results, and discussion sections. Chapter 2 provides a literature review on the importance of researching human rights violations during wartime, other spatial investigations, and methods of spatially displaying this data. Chapter 3 describes the data, and the methods employed to complete this thesis. Chapter 4 presents the results of the StoryMap and Dashboards created by completing the methods described in this thesis. Chapter 5 discusses challenges and how future works can improve upon the methodology.

Chapter 2 Related Work

This chapter examines how researchers attempt to understand and track human sufferings, produce spatial datasets for humanitarian purposes, and what insights spatial visualizations provide. Additionally, this chapter displays the current practices and challenges that exist within responsively using spatial science for event tracking.

2.1 The Significance of Identifying and Alleviating Human Suffering

Armed conflicts and wars cultivate death and grief for people who endure and experience them. International humanitarian law (IHL) seeks to establish the rules of what can and cannot be done by fighting forces during wartime (International Committee of The Red Cross 2024). These laws were instated to minimize human suffering and protect civilian populations and prisoners of war (Amnesty International 2024). The primary agreement between nations was the 1949 Geneva Conventions which were established following the large-scale global conflict of World War 2 (Amnesty International 2024). These rules of war state that combatant forces should not deliberately target civilian populations. Militarized actors should minimize harm to civilian structures such as residential buildings, educational institutions, and hospitals. IHL states that crimes against humanity such as murder, extermination, forced movement/deportation, torture, rape, and other forms of sexual violence during military operations (Amnesty International 2024).

Tracking violations of IHL such as war crimes, crimes against humanity, and genocide is significant in the prosecution of war criminals. Diligent documentation of war crimes that occur around the world leads to future prosecution of the assailants who oppress human rights (Horne 2023). Human rights do not disappear during armed conflicts and the suffering that civilian

populations experience must be documented to aid in the prevention of future agony and the successful prosecution of the perpetrators (Horne 2023).

(ICC is governed by the international treaty called the Rome Statute and is one of the authoritative courts that investigates and tries individuals who have been charged with the harshest of crimes that are recognized by the international community (ICC 2024). These crimes that the ICC investigates are war crimes, genocide, crimes against humanity, and the crime of aggression. The ICC does not replace national courts but is meant to complement them by having a broader ability to admit evidence (Jonathan and Harris 2018). The crimes that the ICC has jurisdiction over are by their nature challenging to understand in both their inhumanity and their complexity (Jonathan and Harris 2018). These types of crimes are difficult to document as they can involve many actors who can enact human rights violations across large territories and international boundaries. These investigations can take years and span over multiple locations to be able to compile an abundant amount of proof to ensure a successful prosecution.

Since the mid-1800s, there have been two main lines of thought about human suffering in wartime (Witt 2012). The first manner of viewing human suffering in wartime is that the occurrence of suffering is inherently evil for humanity. The second perception of suffering sees it as an inevitable occurrence and requires viewers to understand why suffering exists. The combination of these two lines of thought shows there is value in alleviating the impact that war and armed conflict on civilian populations by providing medical care and recognizing that their loss is not undocumented (Rosa and Grant 2022).

This line of thinking aims to mitigate and alleviate the effects of suffering people in wartime as a goal of external characters (Witt 2012). This stance is taken by the founder of the

Red Cross who sees any suffering of civilian populations during wartime as something that should be prevented.

2.2 Spatial Investigations Related to Human Rights Violations

Spatial datasets provide a major societal opportunity for advancing and understanding human rights violations. A significant portion of large datasets being created today has a spatial component where locations are geographically situated (Venkatachalam 2023). The importance of expanding abundant datasets for data analysis revolves around giving spatial sciences abundant data points to study topics from several perspectives. Extensive datasets give decision-makers various perspectives to break down real-world situations to enhance storytelling capabilities. Spatial datasets of this caliber have been used in connection to save everyday consumers time and money in their routing to and from retail locations (Lee and Kang 2015). Having legible and abundant datasets and visualizations with spatial components enables Human Rights researchers with the ability to dissect and interpret the space in which violations are occurring.

Human Rights Watch (HRW) is an organization that investigates and reports on human rights violations across the globe. HRW has utilized Geospatial data and visualizes to inform and expand upon their reports (Human Rights Watch 2023). The HRW's Digital Investigation Lab (DIL) is responsible for making an ethical and accountable use of spatial data and modern technologies to research human rights violations. DIL employs open-sourced spatial data collection to conduct research geospatial analysis to document violations. DIL uses satellite imagery to track the changes in locations over time, create 3D renders of buildings and locations where violations occur, and data mining situations of arrest rates or deportations to draw patterns.

The American Association for the Advancement of Science (AAAS) provides a comprehensive assessment of the use of geospatial technologies in the research of human rights violations. The AAAS's Scientific Responsibility, Human Rights, and Law Program (SRHRL) is one of the world's largest multidisciplinary organizations that address legal, ethical, and human rights violations. The SRHRL conducts investigations into the effectiveness of differing applications of science and engineering. Through their research, they determined that geospatial technologies provide enormous potential in human rights violation documentation. By using geospatial technologies analysts can generate data sets related to events in a study area that is inaccessible to ground-based investigators due to security, legal, or logistical reasons (Jonathan and Harris 2018). By mapping human rights violations researchers can assess the distribution of events to determine if a pattern exists.

The AAAS within their assessment determined several limitations when using geospatial data from sources such as governments, global organizations, private corporations, and non-governmental organizations. These limitations are caused by the coverage or resolution, governmental restrictions, ethical considerations, authenticity, and cost. Limitations vary based on where the source of the data is coming from. While the ICC is investigating crimes the discussion of evidence authenticity is often discussed. This was illustrated in the alleged war crimes recorded in Sri Lanka where the perpetrators did not dispute the video evidence authenticity but in hand claimed that the video was staged. In addition to data, the ICC tries to obtain witness testimony to work with digital evidence (Jonathan and Harris 2018).

Location data is a strong aspect of digital journalism regarding how stories are created, written, and understood. An emerging aspect of digital journalism is how it allows audiences or users to interact with the story (Peters 2014). Narratives within spatial journalism can provide

this interactivity while aiding readers in personalizing the story and situation being examined (Peters 2014). Spatial journalism is created using data and information with a spatial capacity connected to a social meaning through space, place, or location (Weiss 2014). This data is often delivered in several aspects, from text, websites, videos, multimedia, and graphics (Weiss 2014). This data should have the capability to be consumed by the general public in several forms, such as digital, mobile, and physical (Weiss 2014). The ability to communicate a location or social landscape is important to aid readers in understanding the significance of an event.

2.3 Spatial Data Storage, Dashboards, and Storytelling

Spatial data can be incredibly powerful and informative but without a way to prepare, display, and provide context the data may fall flat. The software company Esri has created several tools and resources that empower users to make impactful deliverables that provide spatial context.

2.3.1 Esri ArcGIS Online

ArcGIS Online (AGOL) is Esri's secure and private infrastructure for cloud-based mapping and data storage solutions (Esri 2024). AGOL allows users to develop interactive web-based applications that can display geospatial insights. AGOL provides users with a single platform where users can work with spatial data, make maps, analyze data, share results, and collaborate with others (Esri 2024). AGOL is used to house the spatial data and to create web maps that can be read and added to Esri applications to expand upon the geospatial data. Figure 5 depicts the AGOL content interface where data is stored within folders.

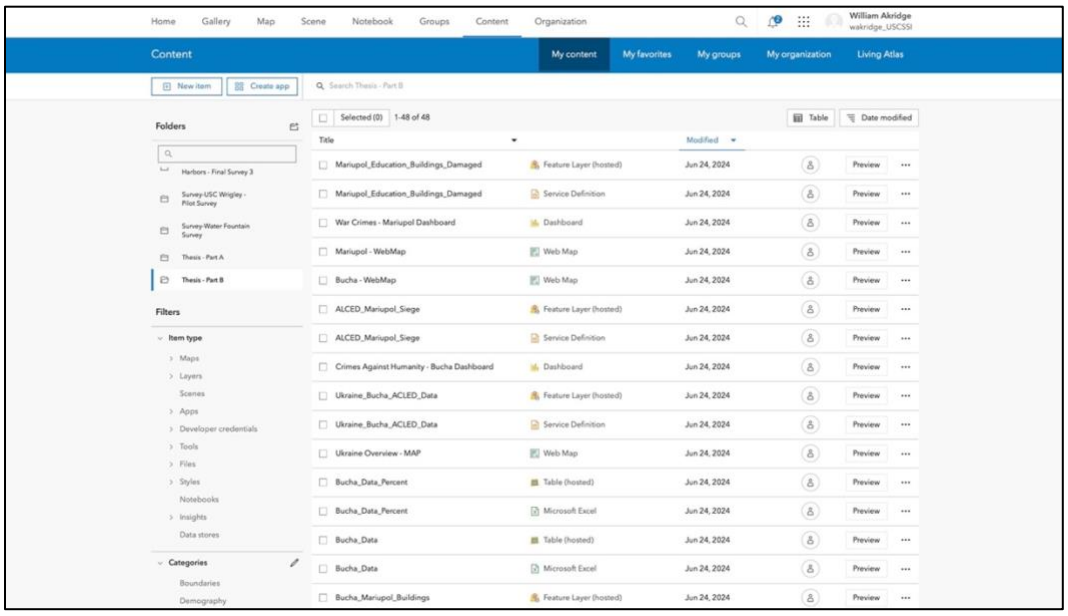

Figure 5. AGOL Folder and Data Used

2.3.2 Esri Dashboards

Esri's Dashboards provide users with the ability to display several pieces of spatial data analytics on a single interactive page (Esri 2024). Dashboards are graphically designed web-based applications that display visualizations that work together on a single screen. Dashboards present the capability to display spatial data in a map view with several data visualization methods such as bar graphs, pie charts, and total sums of values. Dashboards offer a holistic view of spatial data by providing major insights at a glance (Esri 2024).

Dashboards have been powerful tools in displaying and articulating the many characteristics found within datasets. The implementation of a good Dashboard design can allow users to combine several data sources into a single visualization that elaborates on data trends (Orlovskyi and Kopp 2020). This incorporation of data allows for the expansion and understanding of complex and unique data sets. An important characteristic of Dashboards for spatial data is to show how multi-dimensional data can be (Lyer 2012). The importance of displaying multi-dimensional spatial data is that the data can be incredibly deep with numerous

variables that cannot be articulated in a single visualization. Dashboards allow users to expand and display the multi-faceted data to elaborate on complex data points.

Spatial Dashboards were used by the Australian government to monitor how locations of wildfires in South Whales have changed over time. Figure 6 and Figure 7 depict the Esri Dashboard created by the Australian Government to display historic bushfire data. This research sought to display the spatio-temporal changes in hotspot analysis of bushfires over southern Australia. The importance of creating dashboards to display the results is to allow public access for users to explore the data and directly interact with several different results (Michael and Shirowzhan 2021). The importance of the Dashboard is to allow users to also interact and understand the story that is being articulated. To further articulate the motives, methods, and results of the research the Australian government produced an Esri StoryMap.

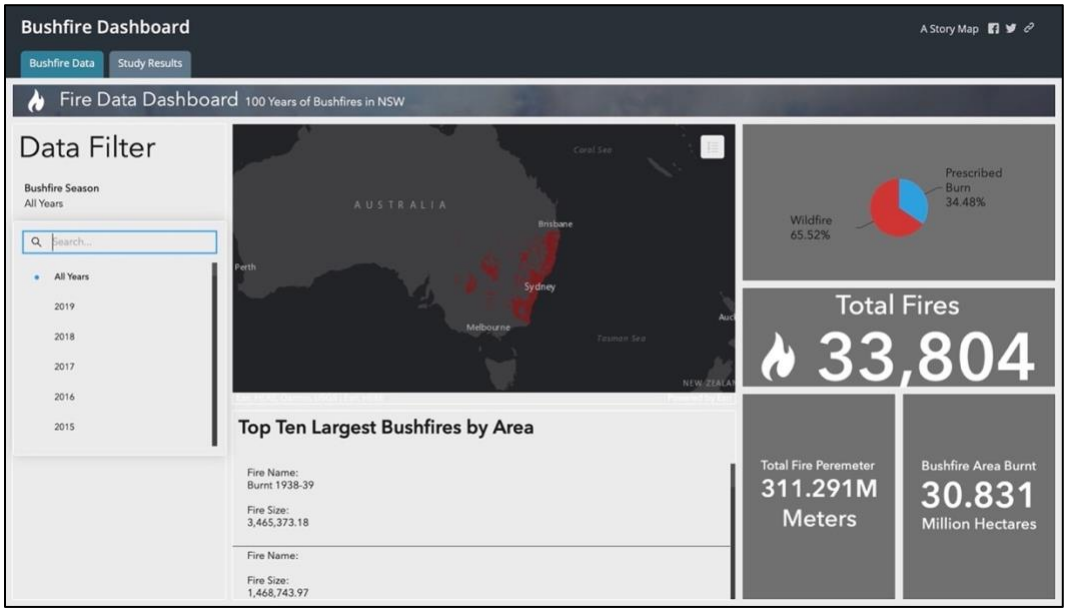

Figure 6. Fire Data Dashboard - Bushfire Data

Figure 7. Fire Data Dashboard – Hot Spot Analysis Results

2.3.3 Esri StoryMaps

Esri produces ArcGIS StoryMaps which are web-based applications that infuse maps, multiple forms of media, and text to create an informative story (Haynes 2023). Esri's ArcGIS StoryMap provides developers with a platform to inform audiences with spatial data via digital storytelling. This platform allows for the combination of written text, spatial data, embedded content, and data articulation to inform audiences of a situation. Figure 8 depicts part of the Esri design page for cover and font options for StoryMaps.

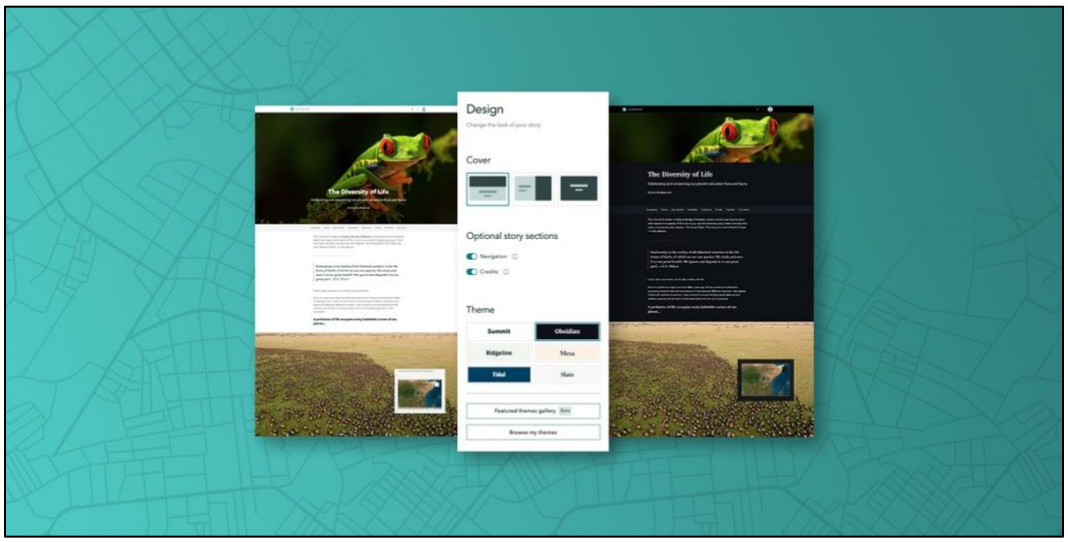

Figure 8. StoryMap Design Page

2.4 Spatial Applications of War and Human Tragedies

The American Battlefield Trust (ABT) created a spatially related StoryMap that displays descriptions, locations, and outcomes of battles of the American Civil War and the American Revolutionary War. These one-page StoryMap allows users to search for specific battles, read detailed descriptions, see pictures of battles, and explore the spatial-temporal distribution of when battles occurred. This StoryMap provides an easy to interpret map that displays locations with the symbology depicting who won the battles and the size of the point showing how historically significant the battle was. The left hand panel lists battles depicting the name, dates of the battles, outcomes, state, picture, and description of the battle. Upon clicking on a specific battle, the map pans to the location and expand the description of the battle. At the bottom of the description, there is an external link to the ABT website where even more details of the battle can be found such as how it ended, in context, before the battle, during the battle, aftermath, and questions to consider of how this battle affected the overall war. Figure 9 depicts the Battles of the American Civil War StoryMap zoomed into the State of Virginia.

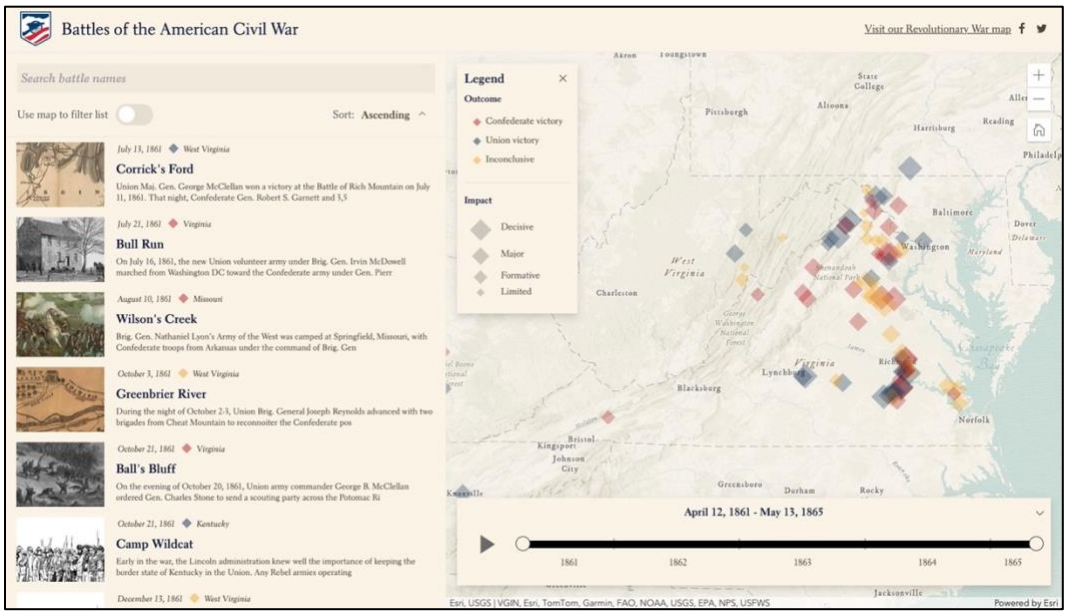

Figure 9. Battles of The American Civil War StoryMap

Cooper Thomas, a member of Esri's StoryMap team created a StoryMap titled Bombing Missions of the Vietnam War which is a visual record of the largest aerial bombardment in human history. The StoryMap begins with setting the stage for the events discussed such as dates for the war, total tons of munitions dropped, and the study area discussed. The StoryMap also provides a detailed description of the United States Department of Defense (DOD) data and where it was collected. The StoryMap provides users with a comprehensive understanding of what types of planes were used during the Vietnam War, the number of missions, where concentrations of bombings occurred, and what nations and military branches operated throughout the country.

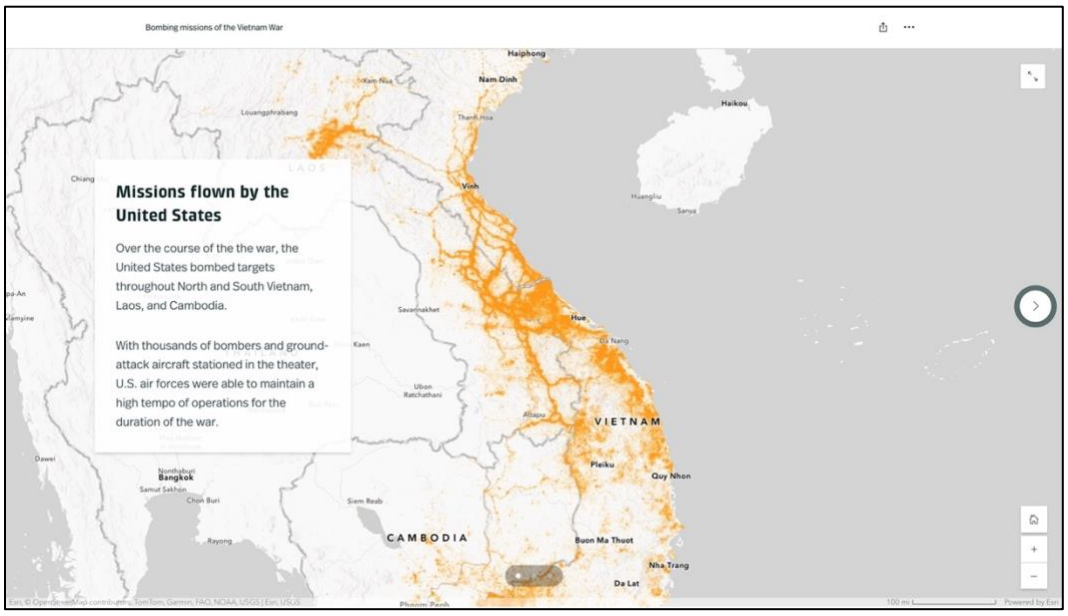

Figure 10. Bombing Missions of the Vietnam War - flown by the United States

Cooper Thomas, a member of Esri's StoryMap team created a StoryMap titled Mapping Russia's War on Ukraine which is a live map of territorial control to provide an up-to-date overview of the situation on the ground. This StoryMap begins by establishing the Russian invasion has been the largest and most destructive conflict in Europe since the Second World War and how the Ukrainian people successfully repelled Russian forces in the West to Russia reallocating their forces to the East. The StoryMap is updated daily to display the territory controlled by Russia in Red and the reclaimed territory by Ukraine in Blue. The StoryMap explains that the data itself is from the Institute of the Study of War (ISW) which is a Washington DC based think tank. The StoryMap consists of seven sections and maps displaying different aspects of the data collected by the ISW such as the big picture, Russian controlled territory before February 24, 2022, Occupied Ukrainian territory, recent Russian advances, recent Ukrainian counteroffensives, partisan actions behind the front lines, and putting the pieces together. Figure 11 depicts all the different pieces of ISW data in the Putting the Pieces Together section in the Mapping Russia's War on Ukraine StoryMap.

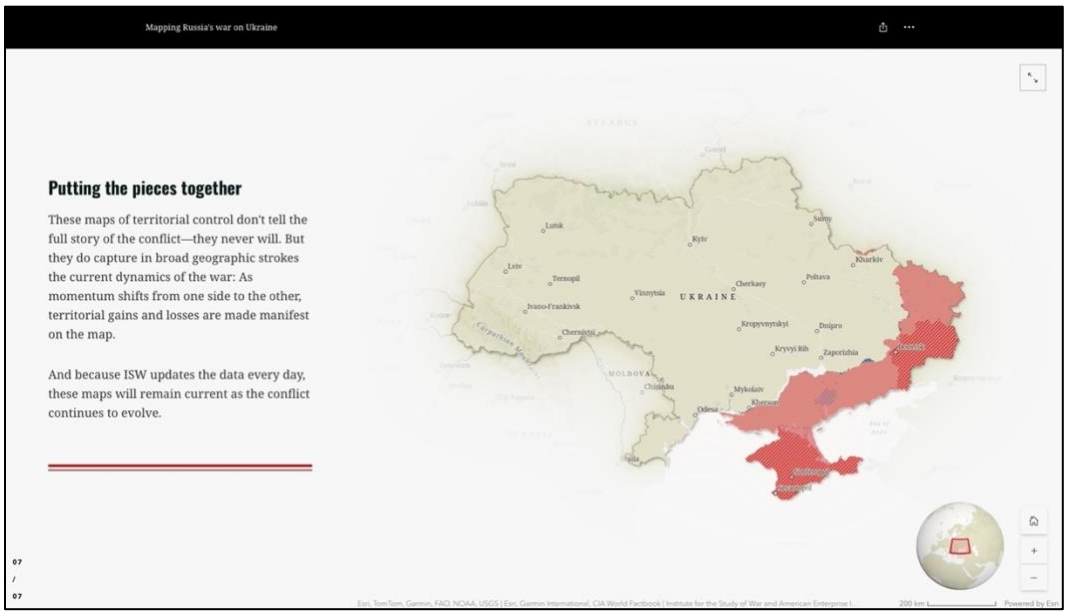

Figure 11. Putting the Pieces Together Section of Mapping Russia's War on Ukraine

Chapter 3 Methods

This Chapter discusses the data and methods required for the completion of this thesis. The data which is discussed is spatially related to the people and land that was been affected by the war in Ukraine. This Chapter provides a detailed description of the data and process used in depicting the occurrence of war crimes, crimes against humanity, and genocide in the Russ-Ukrainian War.

3.1 Methods Overview

The workflow to complete this case thesis requires the preparation and visualization of spatially related data on violations of International Law. The identification of spatial data requires research of sources of events connected to the three violations. Data preparation entails preparing the identified data in a spatial format which can be rendered to inform users. The visualization of this data is depicted in an Esri StoryMap with several Dashboards to give users the ability to understand and explore the three violations of international law. Figure 12 depicts a diagram of the workflow to complete this thesis.

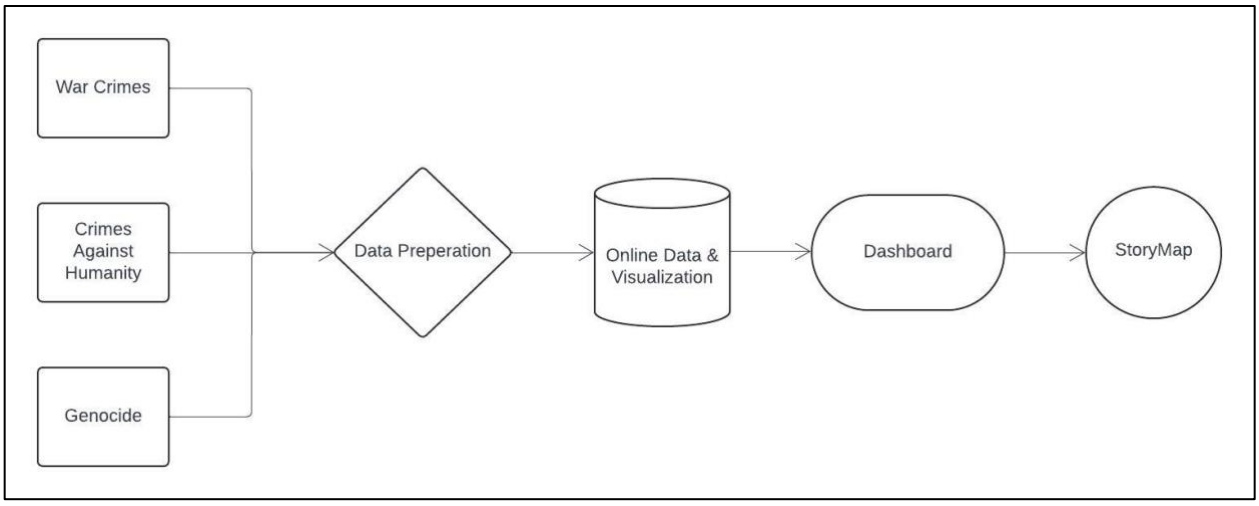

Figure 12. Workflow Diagram

3.2 War Crimes – Mariupol

This section describes the data and methodology for the development of the Dashboard and StoryMap section on war crimes committed during the Siege of Mariupol. A combination of spatial and non-spatial data was used. The first subsection enumerates the data used, the second explains the steps taken in ArcGIS Pro and/or Microsoft Excel to prepare the data prior to publication online, the third section describes the work done in AGOL to effectively map the data, and the fourth section explains the steps to produce a AGOL Dashboard with the data and the creation of a section on the topic in the final StoryMap.

3.2.1 Data for War Crimes – Mariupol

This section enumerates the data used on war crimes committed in Mariupol, including the source of each data set, how each was acquired, and a description of the data as acquired. An appendix itemizes these data sets.

3.2.1.1 Mariupol city boundary

The boundary polygon was downloaded from HDX and initially depicted every level of administrative boundary. This layer was used to display the City of Mariupol to aid in visualizing the geographic Study Area. This GeoJson titled “Subnational Administrative Boundaries” contains boundaries for Country (ADM0), Oblasts (ADM1), Raions (ADM2), and Hromadas (ADM3). GeoBoundaries produced the data for their global database of political administrative boundaries. This database is an open license and contains standardized boundaries such as states and counties for every country in the world (HDX 2024a). Figure 13 depicts the city outline polygon of the City of Mariupol, Ukraine.

Figure 13. Mariupol Boundary

3.2.1.2 Mariupol city building footprints

The building footprint polygons were downloaded from HDX as a polygon shapefile and was imported into ArcGIS Pro. OpenStreetMap's (OSM) building footprint polygons were used to aid in visualizing the geographic setting of the city of Mariupol. OSM has roughly 6.8 million records of building footprints within Ukraine (HDX 2024b). The data set was produced by volunteer contributors within the Humanitarian OpenStreetMap Team (HOT). This makes data quality a topic with the completeness of the dataset, accuracy of the data, and how up to date the data is. This makes the data accurate and trustworthy to the extent that volunteers correctly geofenced the buildings in an area. OSM includes an AI-mapping estimated 25% of all buildings

in Ukraine (HDX 2024b). Most of the residential buildings in Mariupol have been mapped but a portion of industrial buildings appear to have been missing. The average age of the data within the dataset is roughly three years (HDX 2024b). The Data within this thesis was downloaded from HDX in the July 2024 update. Figure 14 depicts the OSM building polygons within the City of Mariupol, Ukraine.

Figure 14. Mariupol OSM Building Footprints

3.2.1.3 Mariupol City Damaged Hospitals

This thesis utilizes OSM hospital campus outline polygons to aid in visualizing the geographic setting of the city of Mariupol. The building footprint polygons were downloaded from HDX as a polygon shapefile and were imported into ArcGIS Pro. This OSM feature displays healthcare

locations with classifications such as doctors, dentists, clinics, hospitals, and pharmacies (HDX 2024c). The data of medical campus boundaries appeared accurate when cross referencing other datasets. The outline data within this thesis was downloaded from HDX in the July 2024 update. The damaged classification comes from the damage assessment completed by HRW. Figure 15 depicts the OSM building polygons that are classified as healthcare facilities and damaged by HRW within the City of Mariupol, Ukraine.

Figure 15. Mariupol OSM Damaged Hospital Building Footprints

3.2.1.4 Mariupol City Damaged Education

This thesis utilizes OSM's education building outline polygons to aid in visualizing the geographic setting of the city of Mariupol. The damaged education building footprint polygons were downloaded from HDX as a polygon shapefile and were imported into ArcGIS Pro. This specific OSM feature displays education locations in Mariupol with Kindergarten, school, college, and university classifications (HDX 2024d). The data on education campus boundaries appeared accurate when cross referencing other datasets for education facilities. The outline data within this thesis was downloaded from HDX in the July 2024 update. The damaged classification comes from the damage assessment completed by HRW. Figure 16 depicts the OSM building polygons that are classified as education facilities and damaged by HRW within the City of Mariupol, Ukraine.

Figure 16. Mariupol OSM Damaged Education Building Footprints

3.2.1.5 Mariupol City Power Lines

This thesis utilizes Open Infrastructure Map (OIM) Power Lines to aid in visualizing the electric infrastructure of the city of Mariupol. Downloading this data directly from their webpage produces a TileJson file. OIM is sourced from OSM's database to display the world's infrastructure system (Open Infrastructure Map 2024a). With this data being collected by volunteers it makes the data accurate to the extent that volunteers correctly geofenced the infrastructure. OSM has identified and mapped 1,102 power plants and roughly 81,944 miles of power lines (Open Infrastructure Map 2024b). The mapped electric infrastructure in Ukraine OSM displays roughly sums to 51,391 Megawatts of power (Open Infrastructure Map 2024b).

OIM provides users with the ability to view and download the world's infrastructure data within an extent that is not a direct feature in OSM (Open Infrastructure Map 2024a). Figure 17 depicts the OIM Power Lines within the City of Mariupol, Ukraine.

Figure 17. Mariupol City Power Lines

3.2.1.6 Mariupol City Power Stations

This thesis utilizes Open Infrastructure Map (OIM) Power Stations to aid in visualizing the locations of the power station infrastructure of the city of Mariupol. With this data being collected by volunteers through OSM it makes the data accurate to the extent that volunteers correctly geofenced the infrastructure. OSM has identified and mapped 1,102 power plants and roughly 81,944 miles of power lines (Open Infrastructure Map 2024b). The mapped electric

infrastructure in Ukraine OSM displays roughly sums to 51,391 Megawatts of power (Open Infrastructure Map 2024b). OIM provides users with the ability to view and download the world's infrastructure data which is not a direct feature in OSM (Open Infrastructure Map 2024a). Figure 18 depicts the OIM Power Stations points within the City of Mariupol, Ukraine. .

Figure 18. Mariupol City Power Stations

3.2.1.7 Mariupol City Power Towers

This thesis utilizes Open Infrastructure Map's (OIM) Power Towers to aid in visualizing the locations of power Towers along the Power Lines infrastructure of the city of Mariupol. With this data being collected by volunteers through OSM it makes the data accurate to the extent that volunteers correctly geofenced the infrastructure. OSM has identified and mapped 1,102 power

plants and roughly 81,944 miles of power lines (Open Infrastructure Map 2024b). The mapped electric infrastructure in Ukraine OSM displays roughly sums to 51,391 Megawatts of power (Open Infrastructure Map 2024b). OIM provides users with the ability to view and download the world's infrastructure data which is not a direct feature in OSM (Open Infrastructure Map 2024a). Figure 19 depicts the OIM Power Tower points within the City of Mariupol, Ukraine.

Figure 19. Mariupol City Power Towers

3.2.1.8 Mariupol City Key Water Network

This thesis utilizes (OIM) Key Water Network lines to aid in visualizing the locations of the major water infrastructure of the city of Mariupol. Downloading this data directly from their webpage produces a TileJson file. The data contains a single key water network line that

transports water to the city is an underground water pipeline. The data does not provide a robust water system infrastructure of water pipes from the filtration facilities to civilian infrastructure. OIM is sourced from OSM's database to display the world's infrastructure system (Open Infrastructure Map 2024a). With this data being collected by volunteers it makes the data accurate to the extent that volunteers correctly geofenced the infrastructure. OIM provides users with the ability to view and download the world's infrastructure data which is not a direct feature in OSM (Open Infrastructure Map 2024a). Figure 20 depicts the OIM Key Water Network within the City of Mariupol, Ukraine.

Figure 20. Mariupol City Key Water Network

3.2.1.9 Mariupol City Key Water Facilities

This thesis utilizes OIM data to display key water network facilities to aid in visualizing the locations of the major water infrastructure of the city of Mariupol. Downloading this data directly from their webpage produces a TileJson file. The data contains two water network facilities that filter water to the city are called The Starokrymska filter stations. The data does not provide a robust water system infrastructure of additional water storage facilities. OIM is sourced from OSM's database to display the world's infrastructure system (Open Infrastructure Map 2024a). With this data being collected by volunteers it makes the data accurate to the extent that volunteers correctly geofenced the infrastructure. OIM provides users with the ability to view and download the world's infrastructure data which is not a direct feature in OSM (Open Infrastructure Map 2024a). The water network facilities that filter water to the city are called The Starokrymska filter stations. Figure 21 depicts the OIM key water facilities within the city.

Figure 21. Mariupol City Key Water Facilities

3.2.2 War Crimes Data Preparation

The war crimes data were prepared using ArcGIS Pro for data that contained a spatial component and Microsoft Excel for data that did not contain a spatial component.

The data that was already in a spatial format was brought into ArcGIS Pro using the add data button where all the required layers were selected and brought into the application. For Microsoft Excel comma-separated values (CSV) that were not in spatial format but contained latitude and longitude which could allow it to be converted into a spatial format was added to the ArcGIS Pro document as a table. Then right clicking the table and converting the table to XY format alters the table to a point feature using the latitude and longitude. Once all the data was

within the ArcGIS Pro document it was necessary to convert all the features to the same coordinate system. Using the Project tool within ArcGIS Pro all features were converted to the WGS 84 Web Mercator coordinate system. Once all features were in the same coordinate system, The data was clipped to the Mariupol Boundary layer to only display data within the study area. Once all the features were within the study area the data was ready to be shared with AGOL.

The non-spatial data that was pulled from news articles were compiled within a single Microsoft Excel document where each data point has its own column.

3.2.3 Data Publishing for War Crimes – Mariupol

Once the data related to war crimes was prepared it was uploaded to AGOL via two methods depending on if the data contains a spatial characteristic.

Spatial data that exits in point, polygon, and line formats were uploaded directly from ArcGIS Pro by right clicking the layer, hovering over Sharing, and then selecting Share as a Web Layer. Within the Share as a Web Layer window sections such as Name, Summary, Tags, Layer Type, Location, and Group Sharing. Every spatial layer is named and summarized according to the data it represents, tagged with "WAKRIDGE", marked as a feature layer, uploaded to the user wakridge_USCSSI's "Thesis – Part B" folder, and marked as shared with the organization. Once all the appropriate fields are filled the button Publish is selected.

Non-spatial data that was prepared within Microsoft Excel was uploaded directly within AGOL by selecting "New Item", then "Your Device", choosing the desired document, and selecting "Upload". The file was then opted to be uploaded and to create a hosted feature layer or table. Next, the user confirms each field is assigned to the correct type i.e. String, Integer, or Data. The location setting for this new feature is selected as "None" which states that this

Microsoft Excel file contains no location data, and the file is uploaded as a table. The following page prompts users to provide sections such as Title, Folder, Tags, and Summary. The new feature table is named and summarized as the table data for war crimes, tagged with "WAKRIDGE", and uploaded to the user wakridge_USCSSI's "Thesis – Part B" Folder. Once all the fields are filled out accordingly blue "Save" button is selected.

3.2.4 War Crimes Layers and Map Preparation in ArcGIS Online

Once the war crimes data is uploaded in AGOL it is time to create a Web Map called "Mariupol – Web Map" which is later connected to the Dashboard. The first step to prepare the war crimes Map within the New Map Viewer is to add all spatial related data by selecting the "Layers" tab and then selecting "Add" to add in spatial data related to war crimes stored within AGOL. To add the data tables the "Tables" tab is selected followed by the "Add Table" button to add tables related to war crimes that are stored within AGOL. Once all the data was added it was time to select how the spatial data would look by selecting the layer and followed by properties to adjust the symbology.

The symbology selected is to aid in the expression the layer brings to the overall map composition. The Mariupol boundary polygon was chosen to have a solid green and blue outline with a high transparency fill so the layers within the study area take prominence. The building polygons have a white stroke and a high transparent white fill to signify the peaceful and neutral standing of civilian infrastructure. The damaged education facilities polygon has a solid red outline and high transparent red fill which is to depict the violence directed toward a crucial civilian infrastructure. Similarly to the education layer, the damaged hospitals layer polygon has a solid orange outline and high transparent orange fill to communicate the violence inflicted on this type of civilian infrastructure. The water infrastructure layers for pipes and filtration systems

are both a light blue color to communicate the commonly used color for water. The water filtration facility is a white background point with a faucet and water symbol to aid in the understanding that civilians lost access to clean drinking water. The power infrastructure layers for substations, power lines, and power towers are all orange to communicate the electric current of this infrastructure. The substations are depicted with a white point and an orange electric symbol to show where civilian power is sourced. The power lines and power towers were both orange with the lines being a solid orange line while the towers being an orange firefly symbology to show electric energy.

After each layer has the appropriate symbology, each layer is configured to only display important information within its pop-up. Lastly, the Basemap is selected by selecting the "Basemap" tab and choosing "Dark Gray Canvas" as the Web Maps basemap. Once all data layers, data tables, symbology selected, layers have been configured, and the basemap has been selected it is time to save the war crimes Web Map by selecting the "Save and Open" tab followed by "Save".

3.2.5 War Crimes Dashboard and StoryMap Development

Once the Web Map is prepared with all the necessary data it is time for the Dashboard by selecting "Create New App" followed by "Dashboards". Next, a window opens where the title, tags, summary, and folder location can be assigned. Once the dashboard was created it was time to add elements by clicking on the circular button with a plus in the upper left corner. Once selecting "Add Element" users are prompted to choose a location to place the desired elements. The design of the war crimes Dashboard consists of eight different types of elements such as a splash screen, map, five indicators, one table, one serial chart, one gauge, one pie chart, and one embedded content in the form of a video. Splash screens are pages that populate before

displaying the product, allowing developers to display important notes to inform audiences of the contents within the dashboard or explain how to use the dashboard. The map is the core of Esri dashboard development and allows developers to embed an Esri Web Map that contains all the spatial datasets and tables. Within Esri Dashboard development, Indicators are cards that show numeric attributes of specific features and summarize statistical value. All indicators within the War Crimes Dashboard use the table as source data and the value types are classified as a feature with the value field being the desired data. The bottom text of the indicator displays the label of the data displayed within the specific indicator. Each indicator has a unique icon that coordinates with the specific data being shown. Tables within Esri's dashboard development page tables present data attributes in rows and columns to allow users to quickly examine values and specific categories. The table within the War Crimes Dashboard is used to depict the list of major events during the siege. The table type is a feature, and the value fields displayed are the dates and the description. Serial charts within Esri dashboards can visualize one or more series of data points along a horizontal axis and vertical axis. The Serial chart within the War Crimes Dashboard depicts the sum of Armed Conflict Location and Event Data (ACLED) sub-event types. The serial chart category was selected as a statistic count and numbers are shown from highest to smallest. Gauges within Esri Dashboards allow developers to display a single metric of a quantitative value from a feature numeric field or summary statistic. The gauge within the War Crimes Dashboard was a half-circle and displayed the percentage of damaged infrastructure. Pie charts within Esri dashboards are circular charts divided into sections for the proportional quality of a feature. The pie chart depicted ACLED data to show the percentages of event types. Esri dashboards allow developers to embed content such as images, videos, or other types of web content. This dashboard displayed a YouTube video where the embedded content link URL was

used to display the city's destruction. Once all the desired elements were added to the dashboard the spatial design was determined by placing the map in the middle and making all the elements and spacing as equal as possible. Figure 22 depicts the Dashboard development process for the war crimes Study Area. Once the Dashboard was fully developed it was time to embed the Dashboard into the StoryMap along with a description of the crimes committed, event, and study area.

Figure 22. War Crimes Dashboard Development

3.3 Crimes Against Humanity – Bucha

This section contains the methodology for the development of the crimes against humanity Dashboard and StoryMap section. This section discusses the spatial and non-spatial data used within the crimes against humanity section and how it was compiled, shared, stored, and displayed within the final Dashboard and StoryMap.

3.3.1 Crimes Against Humanity Data

This section enumerates the data used on crimes against humanity committed by Russian forces during the occupation of Bucha, including the source of each data set, how each was acquired, and a description of the data as acquired. An appendix itemizes these data sets.

3.3.1.1 Bucha city boundary

This thesis utilizes the Bucha town boundary to aid in visually displaying the area that was occupied from February 27, 2022, to March 31, 2022. This polygon was determined by searching for the town of Bucha in Google Maps and then manually geofencing the polygon within ArcGIS Pro. Figure 23 depicts the polygon created by manually creating the feature outline of Bucha, Ukraine.

Figure 23. Bucha Boundary – Google

3.3.1.2 Bucha city bodies identified

This thesis utilizes field reports from The New York Times journalists on the locations of bodies in Bucha to aid in depicting how the town was affected. This data was originally published as a map displaying the location of bodies from the field reports research shortly after the occupation in 2022. This data can be trusted as it was produced by eyewitness experience from New York Times journalists. This data was replicated in Esri's ArcGIS Pro by manually creating a point feature where The New York Times plotted body locations. This dataset does not provide a complete display of where bodies were discovered but it aids in understanding the spatial distribution of crimes. Figure 24 depicts the Points where bodies were identified by New York Times journalists in the town of Bucha, Ukraine.

Figure 24. Bucha Bodied Identified (Source: The New York Times)

3.3.1.3 Bucha city building footprints

The building footprint polygons were downloaded from HDX as a polygon shapefile and was imported into ArcGIS Pro. OpenStreetMap's (OSM) building footprint polygons were used to aid in visualizing the geographic setting of the town of Bucha. OSM has roughly 6.8 million records of building footprints within Ukraine (HDX 2024b). The data set was produced by volunteer contributors within the Humanitarian OpenStreetMap Team (HOT). This makes the data accurate and trustworthy to the extent that volunteers correctly geofenced the buildings in an area. OSM includes an AI-mapping estimated 25% of all buildings in Ukraine HDX 2024b). This percentage of mapped buildings is apparent when looking at the town of Bucha. The completeness of this dataset is questionable as many residential and commercial buildings are

missing from this dataset. The average age of the data within the dataset is roughly three years (HDX 2024b). The Data within this thesis was downloaded from HDX in the July 2024 update. Figure 25 depicts the OSM building polygons in the town of Bucha, Ukraine.

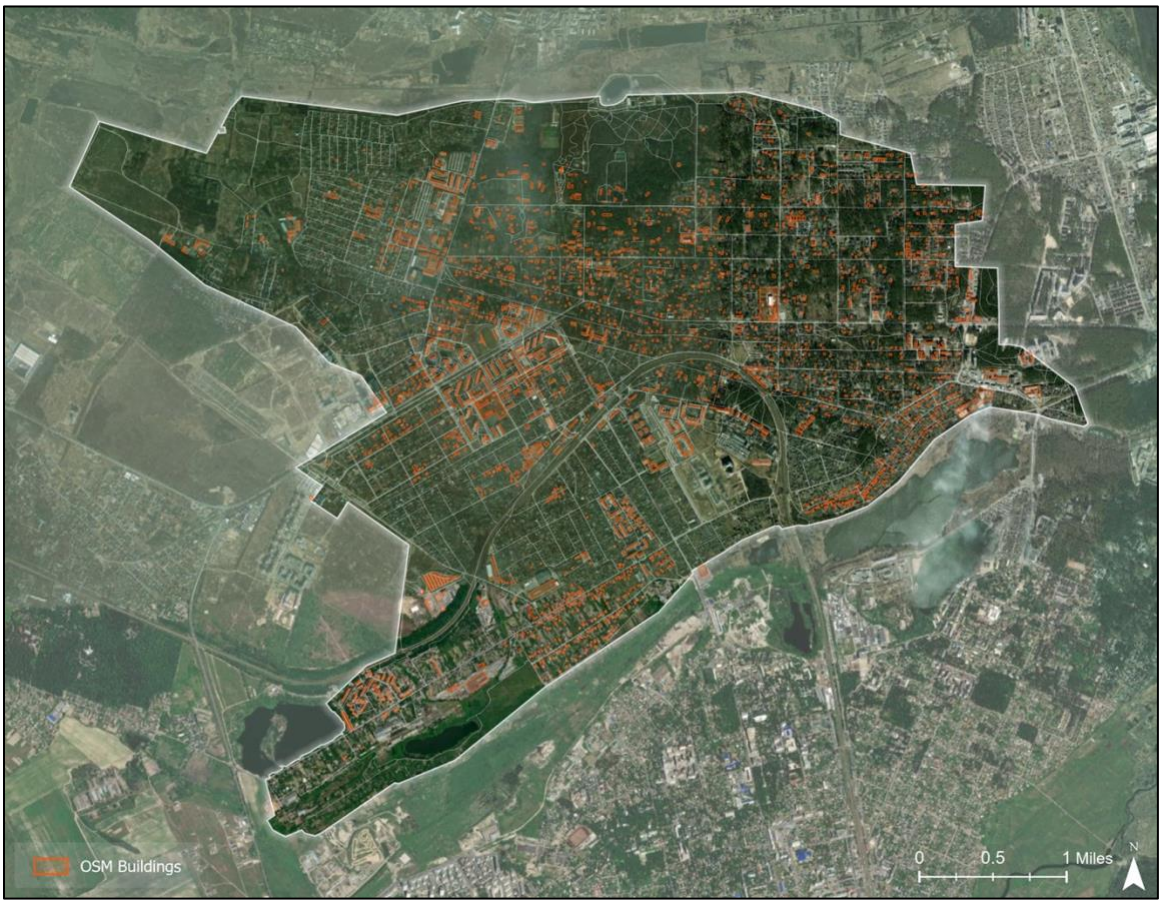

Figure 25. OSM Bucha Building Footprints

3.3.2 Crimes Against Humanity Data Preparation

The crimes against humanity data was prepared using both ArcGIS Pro for data that contained a spatial component and Microsoft Excel for data that did not contain a spatial component.

The data that was already spatially related was brought into ArcGIS Pro using the add data button where all the required layers were selected and brought into the application. For Microsoft Excel comma-separated values (CSV) that were not in spatial format but contained

latitude and longitude which could allow it to be converted into a spatial format was added to the ArcGIS Pro document as a table. Then right clicking the table and converting the table to XY format alters the table to a point feature in WGS 1984 coordinate system using the latitude and longitude. Once all the data was within the ArcGIS Pro document it was necessary to convert all the features to the same coordinate system. Using the Project tool within ArcGIS Pro all features were converted to the WGS 1984 Web Mercator coordinate system. Once all features were in the same coordinate system, The data was clipped to the Bucha boundary layer to only display data within the study area. Once all the features were within the study area the data was ready to be shared with AGOL.

The non-spatial data that was pulled from news articles were compiled within a single Microsoft Excel document where each data point has its own column.

3.3.3 Crimes Against Humanity Data Publishing

Once the data related to crimes against humanity was prepared it was uploaded to AGOL via two methods depending on if the data contains a spatial characteristic.

Spatial data that existed in point and polygon formats were uploaded directly from ArcGIS Pro by right clicking the layer, hovering over Sharing, then selecting Share as a Web Layer. Within the Share as a Web Layer window sections were filled out such as Name, Summary, Tags, Layer Type, Location, and Group Sharing. Every spatial layer was named and summarized according to the data it represented, tagged with “WAKRIDGE”, marked a feature layer, uploaded to the user wakridge_USCSSI’s “Thesis – Part B” folder, and marked as shared with the organization. After all the appropriate fields were filled out the button Publish was selected.

Non-spatial data was prepared within Microsoft Excel and then uploaded directly within AGOL by using “New Item”, then “Your Device”, choosing the desired document, and selecting “Upload”. The file was then opted to be uploaded and created a hosted feature layer or table. Next, each field was assigned to the correct type i.e. String, Integer, or Data. The location setting for the new feature was selected as “None” which stated that the Microsoft Excel file contained no location data, and the file was uploaded as a table. The following page prompted the user to provide a Title, Folder, Tags, and Summary. The new feature table was named and summarized as the table data for crimes against humanity, tagged with “WAKRIDGE”, and uploaded to the user wakridge_USCSSI’s “Thesis – Part B” Folder. Once all the fields were filled out accordingly the blue “Save” button was selected.

3.3.4 Crimes Against Humanity Layers and Map Preparation in ArcGIS Online

Once the crimes against humanity data were uploaded in AGOL it was time to create a Web Map “Crimes Against Humanity – Web Map” which was later connected to the Dashboard. The first step was to prepare the crimes against humanity Map within the New Map Viewer to add all spatial related data by selecting the “Layers” tab and then selecting “Add” to add in spatial data related to crimes against humanity stored within AGOL. The data tables were added using the “Tables” tab followed by the “Add Table” button to add tables related to crimes against humanity that are stored within AGOL. Once all the data was added it was time to adjust how the spatial data looked by selecting the layer followed by properties to adjust the symbology.

The symbology selected was to aid in the expression the layer brings to the overall map composition. The town of Bucha boundary polygon was chosen to have a solid green and blue outline with a high transparency fill so the layers within the study area take prominence. The building polygons have a white stroke and a high transparent white fill to signify the peaceful

and neutral standing of civilian infrastructure within the town. The locations where bodies have been spatially mapped were shown as red and orange firefly points to make them as visible as possible while communicating the horrific nature of the actions of the Russian military on the people of Bucha.

After each layer was given the appropriate symbology, each layer was configured to only display important information within its pop-up. Lastly, the Basemap was selected by selecting the "Basemap" tab and choosing "Dark Gray Canvas" as the Web Maps basemap. Once all data layers, data tables, symbology were selected, layers been configured, and the basemap selected it was time to save the crimes against humanity Web Map by selecting the "Save and Open" tab followed by "Save".

3.3.5 Crimes Against Humanity Dashboard and StoryMap Development

Once the Web Map was prepared with all the necessary data it was time to create the Dashboard by selecting "Create New App" followed by "Dashboards". Next, the window opened where the title, tags, summary, and folder location were assigned. Once the dashboard was created it was time to add elements by clicking on the circular button with a plus in the upper left corner. Once selecting "Add Element" a prompt to choose a location to place the desired elements was displayed. The crimes against humanity dashboard design consisted of six elements: seven indicators, two pie charts, one table, one serial chart, one gauge, and the data from the web map. Splash screens were pages that populate before displaying the product, allowing developers to display important notes to inform audiences of the contents within the dashboard or explain how to use the dashboard. The map was the core of Esri dashboard development and allowed developers to embed an Esri Web Map that contain all the spatial datasets and tables. Within Esri Dashboard development, indicators are cards that show numeric

attributes of specific features and summarize statistical value. The indicators within the Crimes Against Humanity Dashboard are connected to the table as the source data and the value types are classified as a feature with the value field being the desired data. The bottom text of the indicator displayed the label of the data displayed within the specific indicator. Each indicator has a unique icon that coordinates with the specific data being shown. Tables within Esri's dashboard development page tables present data attributes in rows and columns to allow users to quickly examine values and specific categories. The table within the Crimes Against Humanity Dashboard was used to depict the list of descriptions of how bodies were found in Bucha. The table type is a feature, and the value fields displayed are descriptions. Serial charts within Esri dashboards can visualize one or more series of data points along a horizontal axis and vertical axis. Gauges within Esri dashboards allow developers to display a single metric of a quantitative value from a feature numeric field or summary statistic. The gauge within the Crimes Against Humanity Dashboard was a half-circle and displayed the percentage of mapped bodies within the map extent. The serial chart within the Crimes Against Humanity Dashboard depicted the sum of ACLED sub-event types. The serial chart category was selected as a statistic count and numbers are shown from highest to smallest. Pie charts within Esri dashboards are circular charts divided into sections for the proportional quality of a feature. One pie chart depicted ACLED data to show the percentages of sub-event types. The second pie chart depicted the percent of natural vs inflicted deaths on bodies discovered. Once all the desired elements were added to the dashboard the spatial design was determined by placing the map in the middle and making all the elements and spacing as equal as possible. Figure 26 depicts an Esri Dashboard being created to depict crimes against humanity in Bucha, Ukraine. Once the crimes against humanity Dashboard was

fully developed it was time to embed the dashboard into the StoryMap along with a description of the crimes committed, events, and study area.

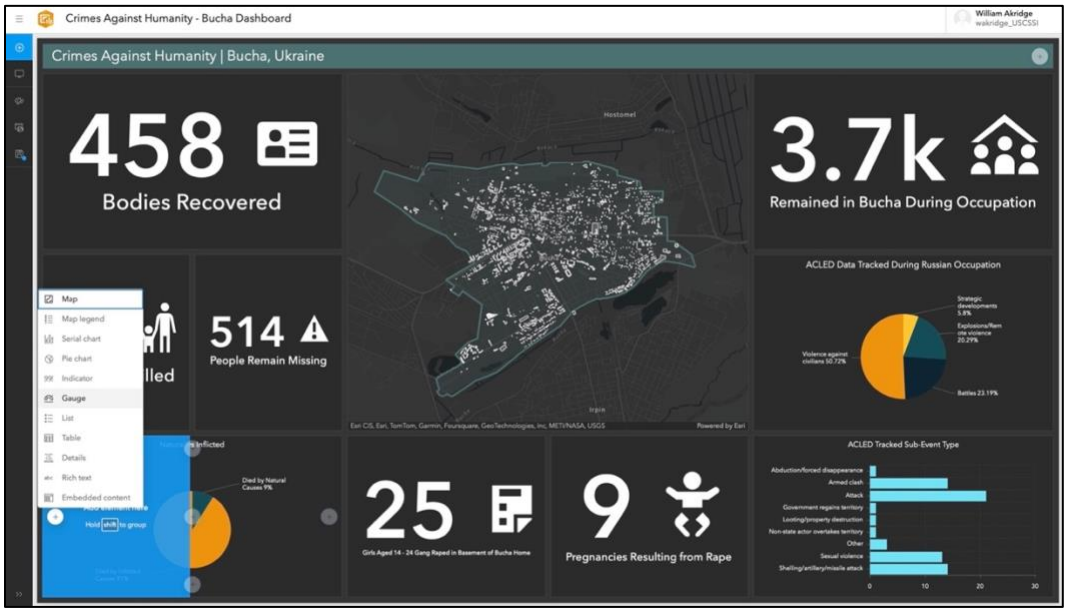

Figure 26. Crimes Against Humanity Dashboard Development

3.4 Genocide – Ukraine

This section contains the methodology for the development of the Genocide Dashboard and StoryMap section. This section discusses the spatial and non-spatial data used within the genocide section and how it was compiled, shared, stored, and displayed within the final Dashboard and StoryMap.

3.4.1 Genocide data

This section enumerates the data used on genocide via the abduction and relocation of Ukrainian children that occurred in Russian controlled territory in Ukraine, including the source of each data set, how each was acquired, and a description of the data as acquired. An appendix itemizes these data sets.

3.4.1.1 Kidmapping

This thesis utilizes locations identified by Kidmapping as locations where children have been and where there are high concentrations of children in Russia, Belarus, and occupied Ukraine and Russia. This data was created using open sources such as news reports, social media, and video sources (Kidmapping 2024). This data was collected by a group of volunteers to provide parents, human rights activists, and volunteers data on possible locations where children are and have been (Kidmapping 2024). This data was originally published on their webpage with an interactive interface. The point data set includes 155 Locations where children were located and 109 Locations where there were high concentrations of Ukrainian children. Figure 27 depicts the Points where Ukrainian children have been identified by Kidmapping.

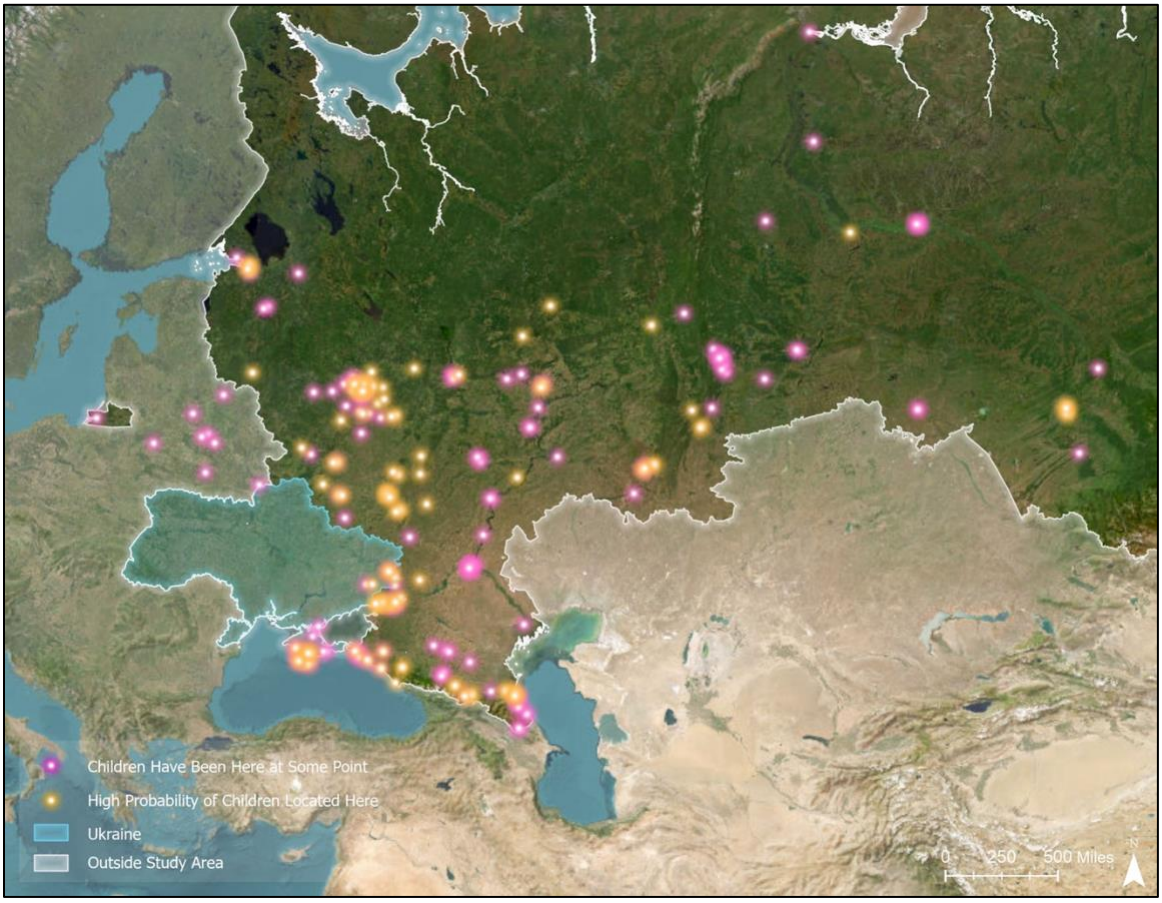

Figure 27. Locations where Ukrainian Children were abducted to – Kidmapping

3.4.1.2 Re-education camps and military facilities for children

This thesis utilizes locations of identified re-education maps and military training facilities in Russia and occupied Ukraine. This data was created by volunteers using open sources and was originally published as a custom Google Maps KML file (Rubryka 2024). The point data set includes 45 children's re-education camps locations and 12 military training facilities. Figure 28 depicts the Points where Re-education camps and military facilities for Ukrainian children have been identified.

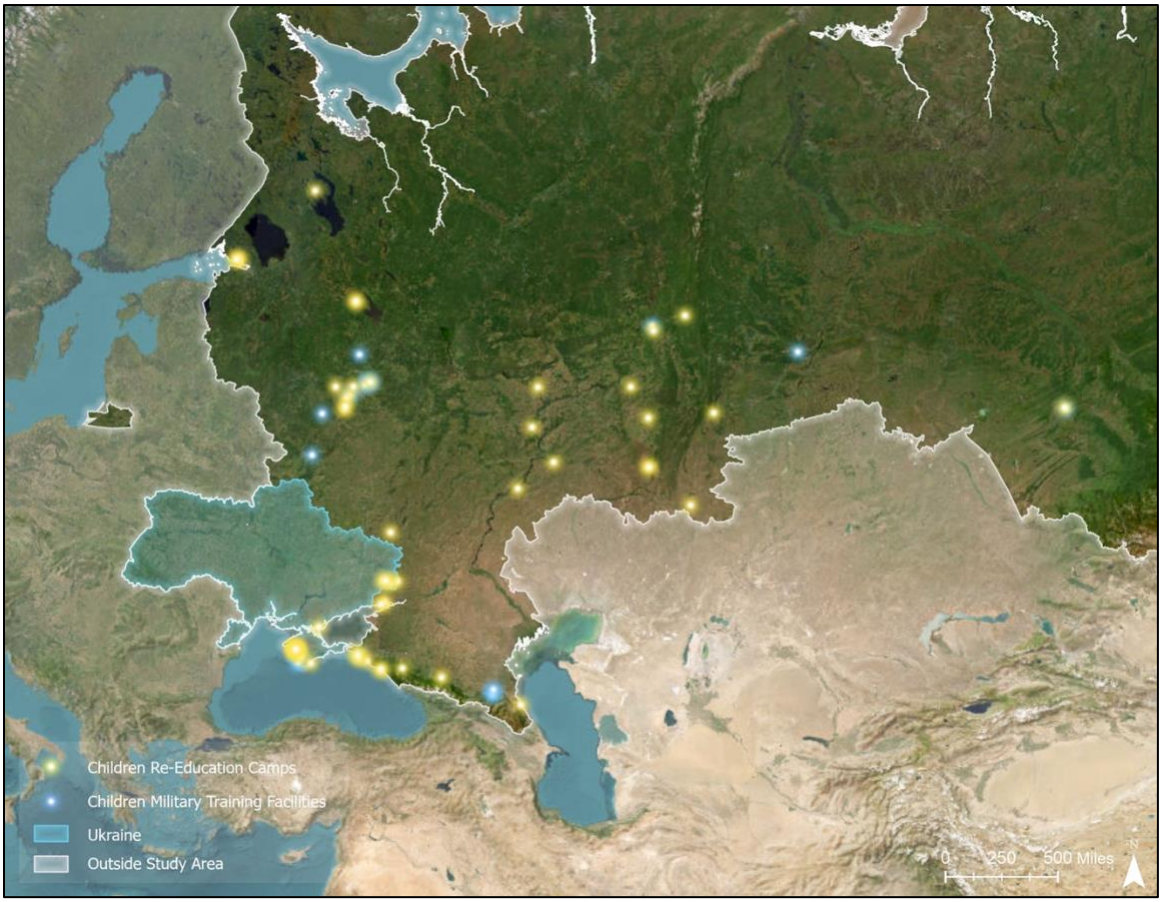

Figure 28. Re-Education Camps and Military Facilities for Children – Rubtyka

3.4.1.3 ACLED abduction event data

This thesis includes ACLED to aid in displaying the visual distribution of abductions of the civilian population by Russian forces in the Russo-Ukrainian War. The ACLED data was downloaded directly from their website as a table with columns for latitude and longitude. ACLED is an independent non-profit organization that collects and analyzes spatial data on violent conflicts globally (ACLED 2024). ACLED's team tracks data such as actors, spatial locations, fatalities, and event types (ACLED 2024). This section of the thesis focuses on the event type related to reported civilian abductions across Ukraine. Figure 29 depicts the distribution of abduction data from the escalation of the Russo-Ukrainian on February 24, 2022.

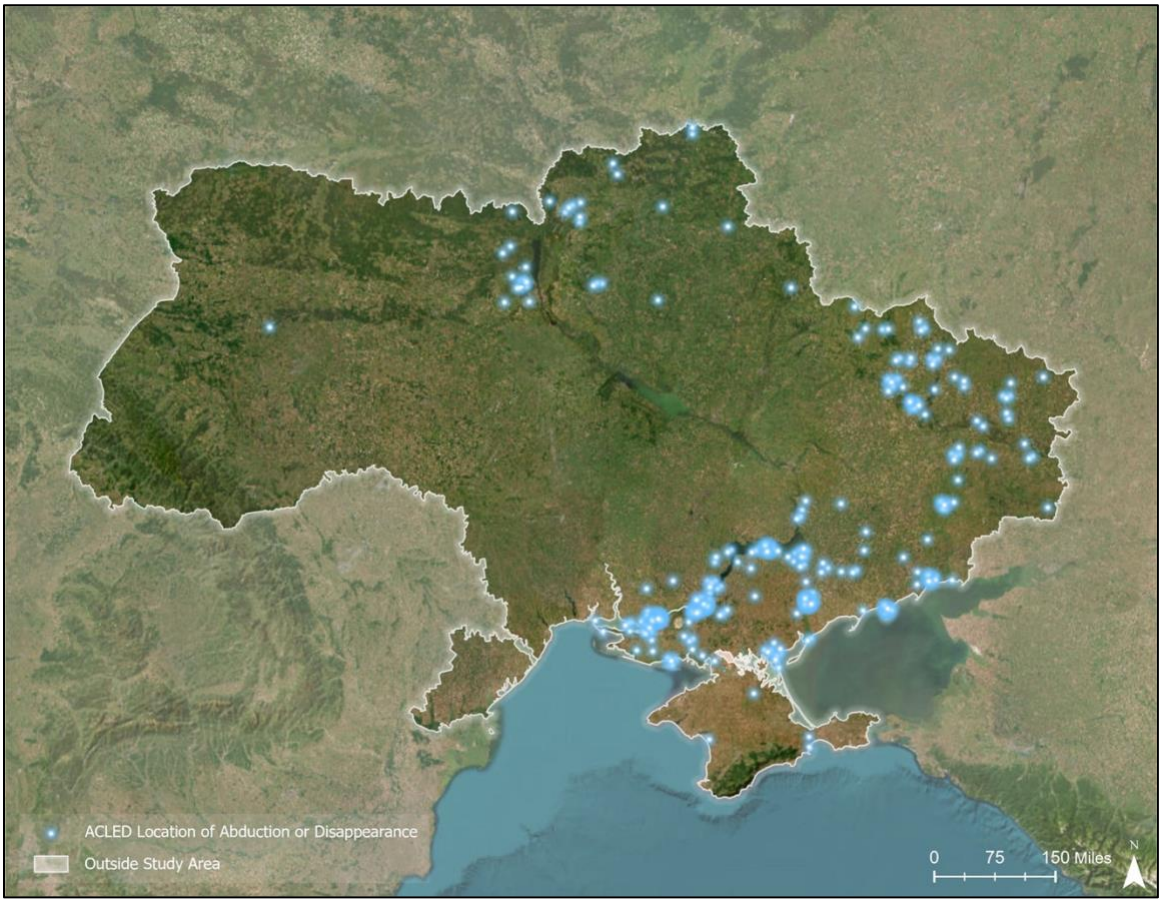

Figure 29. ACLED Civilian Abduction Data

3.4.1.4 Oblast boundaries

The oblast boundary polygon was downloaded from HDX portal as a GeoJson containing Ukraine's 24 oblasts. This thesis depicts the oblast boundaries of Ukraine to provide a spatial reference for viewers while looking at the dashboard. GeoBoundaries produced the data for their global database of political administrative boundaries. This database is an open license and contains standardized boundaries such as states and counties for every country in the world (HDX 2024). In addition to providing spatial context to viewers in the dashboard, it allows users to see the spatial distribution of ACLED abduction and disappearance data points. Figure 30 depicts the oblast boundaries.

Figure 30. Oblast Boundaries – HDX

3.4.2 Genocide Data Preparation

The genocide data was prepared using both ArcGIS Pro for data that contained a spatial component and Microsoft Excel for data that did not contain a spatial component.

The data that was already spatially related was brought into ArcGIS Pro using the add data button where all the required layers were selected and brought into the application. For Microsoft Excel comma-separated values (CSV) that were not in spatial format but contained latitude and longitude which could allow it to be converted into a spatial format was added to the ArcGIS Pro document as a table. Then right clicking the table and converting the table to XY format alters the table to a point feature using the latitude and longitude. Once all the data was within the ArcGIS Pro document it was necessary to convert all the features to the same coordinate system. Using the Project tool within ArcGIS Pro all features were converted to the WGS 84 Web Mercator coordinate system. Once all features are in the same coordinate system, they are ready to be shared with AGOL.

The non-spatial data that was pulled from news articles were compiled within a single Microsoft Excel document where each data point has its own column.

3.4.3 Genocide Data Publishing

Once the data related to genocide was prepared it was uploaded to AGOL via two methods depending on whether the data contained a spatial characteristic.

Spatial data that exits in point and polygon formats are uploaded directly from ArcGIS Pro by right clicking the layer, hovering over Sharing, then selecting Share as a Web Layer. Within the Share as a Web Layer window sections such as Name, Summary, Tags, Layer Type, Location, and Group Sharing. Every spatial layer is named and summarized according to the data it represents, tagged with “WAKRIDGE”, marked as a feature layer, uploaded to the user

wakridge_USCSSI's "Thesis – Part B" folder, and marked as shared with the organization. Once all the appropriate fields are filled the button Publish is selected.

Non-spatial data that was prepared within Microsoft Excel is uploaded directly within AGOL by selecting "New Item", then "Your Device", choosing the desired document, and selecting "Upload". The file is then opted to be uploaded and to create a hosted feature layer or table. Next, the user confirms each field is assigned to the correct type i.e. String, Integer, or Data. The location setting for this new feature is selected as "None" which states that this Microsoft Excel file contains no location data, and the file is uploaded as a table. The following page prompts users to provide sections such as Title, Folder, Tags, and Summary. The new feature table is named and summarized as the table data for genocide, tagged with "WAKRIDGE", and uploaded to the user wakridge_USCSSI's "Thesis – Part B" Folder. Once all the fields are filled out accordingly blue "Save" button is selected.

3.4.4 Genocide Layers and Map Preparation in ArcGIS Online

Once the genocide data was uploaded in AGOL it was time to create a Web Map "Bucha – Web Map" which is later connected to the Dashboard. The first step to prepare the genocide map within the New Map Viewer is to add all spatial-related data by selecting the "Layers" tab and then selecting "Add" to add in spatial data related to genocide stored within AGOL. To add in the data tables the "Tables" tab is selected followed by the "Add Table" button to add in tables related to genocide that are stored within AGOL. Once all the data was added it was time to select how the spatial data would look by selecting the layer and followed by properties to adjust the symbology.

The symbology selected is to aid in the expression the layer brings to the overall map composition. The country of Ukraine boundary polygon was chosen to have a solid white outline

with an empty fill, so the boundary is communicated. The oblast boundaries are the next boundary with a thin slightly transparent outline to communicate the boundaries without competing with the national boundaries. The next layer to aid viewers in understanding the study area is the total height of Russian control which is displayed in transparent red grassland effect to not take away from the point data but provide a visual understanding. The point data is symbolized to communicate the two sides of the data with the ACLED data showing where they were abducted and the kidmapping and open-source datasets showing where children have been taken. The ACLED point data is displayed using a pink firefly to communicate the emotion of sadness and loss. The location of the kidmapping and open-sourced data is symbolized in a cool color. The two kidmapping data points are shown as purple firefly points for where high concentrations of children likely are and as blue firefly points to show where children have been at some point. The open-sourced data is symbolized as green firefly points for re-education facilities and as yellow firefly points for military training facilities. These colors for locations of abducted children are to communicate the hope that by knowing their location they may one day be reunited with their family in Ukraine or other parts of the world.

After each layer has the appropriate symbology, each layer is configured to display important information within its pop-up. Lastly, the Basemap is selected by selecting the "Basemap" tab and choosing "Dark Gray Canvas" as the Web Maps basemap. Once all data layers, data tables, symbology have been selected, layers have been configured, and the basemap has been selected it is time to save the genocide Web Map by selecting the "Save and Open" tab followed by "Save".

3.4.5 Genocide Dashboard and StoryMap Development

Once the Web Map is prepared with all the necessary data it is time for the Dashboard by selecting “Create New App” followed by “Dashboards”. Next, a window opens where the title, tags, summary, and folder location can be assigned. Once the dashboard was created it was time to add elements by clicking on the circular button with a plus in the upper left corner. Once selecting “Add Element” users are prompted to choose a location to place the desired elements. The design of the genocide Dashboard consists of six different elements such as seven indicators, four lists, one table, one pie chart, one bar graph, and the data from the web map. Splash screens are pages that populate before displaying the product, allowing developers to display important notes to inform audiences of the contents within the dashboard or explain how to use the dashboard. The map is the core of Esri dashboard development and allows developers to embed an Esri Web Map that contains all the spatial datasets and tables. Within Esri Dashboard development, Indicators are cards that show numeric attributes of specific features and summarize statistical value. All indicators within the Genocide Dashboard use the table as source data and the value types are classified as a feature with the value field being the desired data. The bottom text of the indicator displays the label of the data displayed within the specific indicator. Each indicator has a unique icon that coordinates with the specific data being shown. Lists are used to show features as rows and the symbology of a specific layer. The lists within the Genocide Dashboard are filtered to only display the specific type of location. This is achieved by having the filter equal to the specific value that is wanted to be shown. Tables within Esri’s dashboard development page tables present data attributes in rows and columns to allow users to quickly examine values and specific categories. The table within the Genocide Dashboard was used to depict the list of locations of ACLED abduction data. The table type is a feature, and the value fields displayed are the oblast, description, and source. Serial charts within Esri dashboards

can visualize one or more series of data points along a horizontal axis and vertical axis. The Serial chart within the Genocide Dashboard depicts the sum of ACLED abductions and disappearances by year. The serial chart category was selected as a statistic count and numbers are shown from lowest to highest year. Pie charts within Esri dashboards are circular charts divided into sections for the proportional quality of a feature. The pie chart depicted ACLED abduction and disappearances by the percent within each oblast seen within the map extent. Figure 31 depicts the development of the genocide Dashboard within Esri's AGOL. Once the genocide Dashboard was completed, the genocide section of the Esri StoryMap was developed providing context to the crimes and the event discussed.

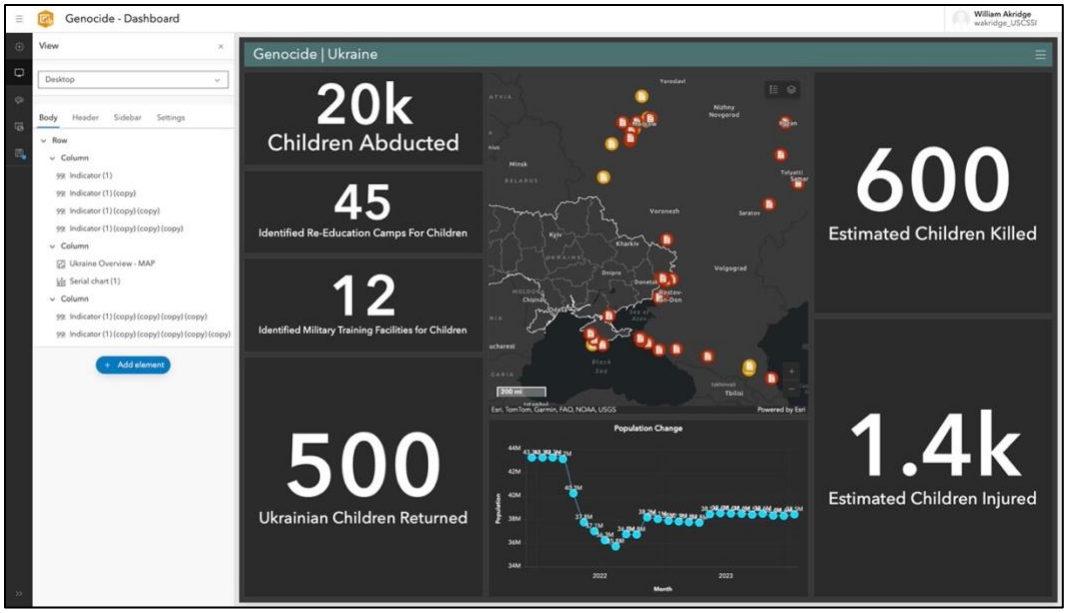

Figure 31. Development of Genocide Dashboard

Chapter 4 Results

This chapter provides an overview of the Human Suffering During Wartime StoryMap. displays the results from running workflow pieces discussed in the methods chapter of this thesis. This methodology successfully produced dashboards and a StoryMap that successfully explains and depicts events where human rights violations occurred in the Russo-Ukrainian War. The link for the StoryMap can be accessed by following the link provided. - StoryMap Link

4.1 Human Suffering During Wartime StoryMap Section

The StoryMap that is developed for this thesis contains multiple sections each diving into the definitions of the violations of human suffering, locations in Ukraine which has experienced this type of human suffering, spatial data, and statistics of researched and created datasets. This allows users time to understand the type of suffering being discussed and the.

Figure 32. Human Suffering During Wartime StoryMap Cover

Human suffering within the constraints of this thesis is defined at the beginning of the StoryMap. This definition prepares readers for the topic before discussing and displaying the data related to war crimes, crimes against humanity, and genocide. This was achieved by having Human Suffering During Wartime sections that define IHL and how it was applicable within the thesis. Figure 33 depicts the header and introduction to the thesis to provide context to readers.

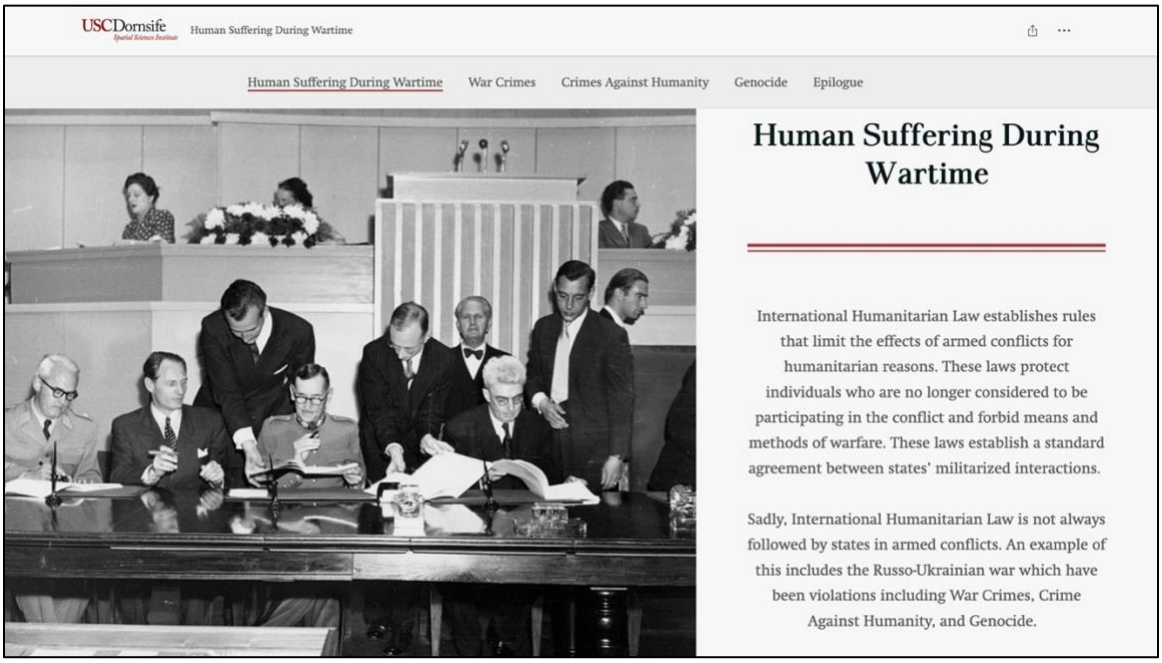

Figure 33. Human Suffering During Wartime Section

4.2 War Crimes StoryMap Section

The war crimes section of the StoryMap contains a section on a written description of war crimes as defined by the United Nations, a description of the Siege of Mariupol in 2022, images of the Siege of Mariupol, and the Dashboard depicting spatial and non-spatial data of the Siege of Mariupol.

4.2.1 War Crimes StoryMap Context

Before displaying the spatial data related to war crimes within the dashboard there is a section that describes war crimes as how they are defined by the UN and how they apply to the

study area chosen. The definition of war crimes is accompanied by a list of six examples of war crimes defined by the UN. Figure 34 depicts the initial view of the war crimes Section of the Human Suffering During Wartime StoryMap.

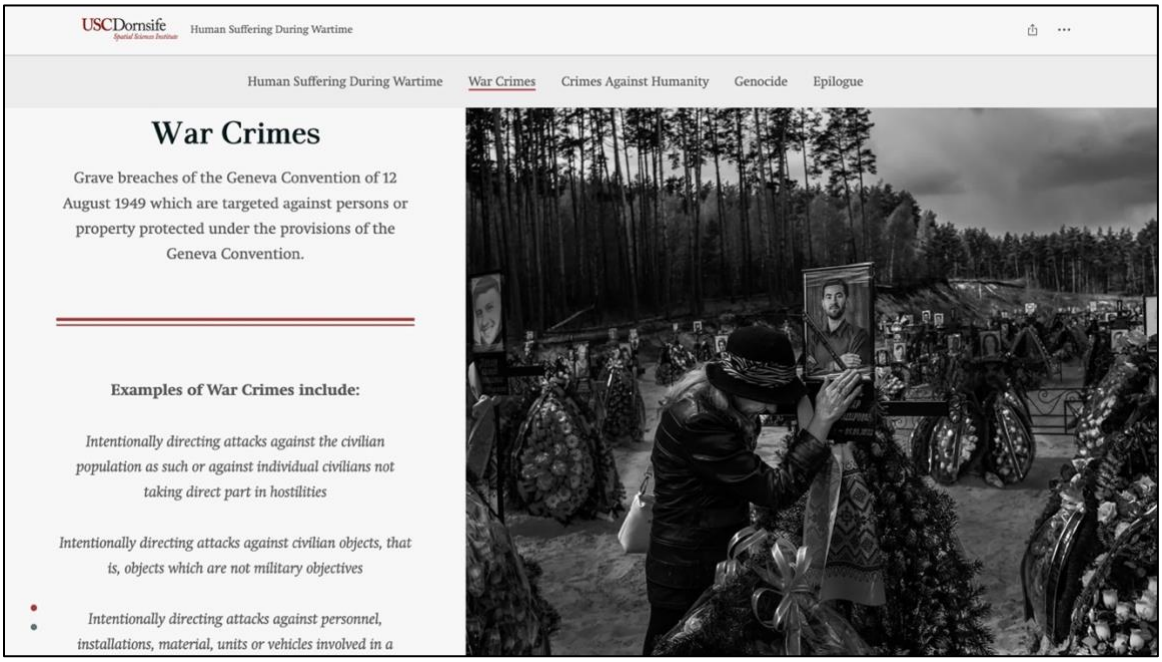

Figure 34. War Crimes Section of StoryMap

4.2.2 War Crimes StoryMap Study Area

After Scrolling past the UN definitions viewers see a description of the Siege of Mariupol to provide informative context of the event and why it's relative to this crime. After scrolling past the historical context, seven images of the Siege of Mariupol are displayed to aid in visually

understanding the spatial data within the dashboard. Figure 35 depicts the initial view of the war crimes Section of the Human Suffering During Wartime StoryMap.

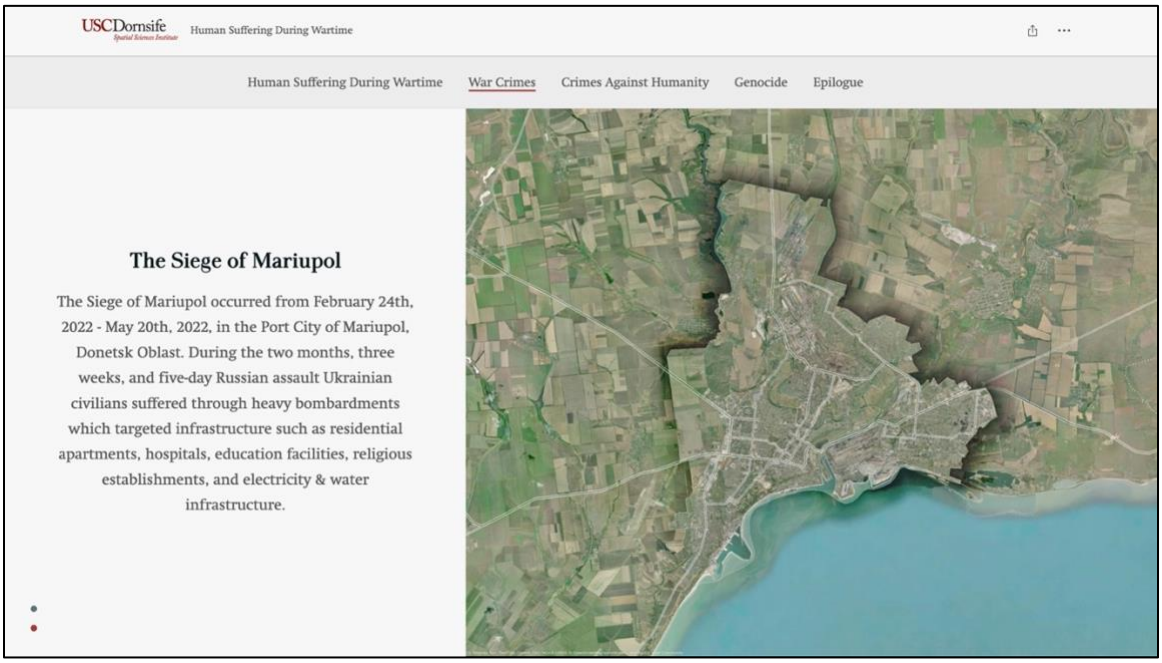

Figure 35. War Crimes Study Area Section of StoryMap

4.2.3 War Crimes StoryMap Dashboard

The war crimes Dashboard focuses on the loss of life and the destructive effect the battle had on civilian infrastructure. The design of the StoryMap allows for the filtration of spatial data based on the desired infrastructure type. The filter for infrastructure type can be found in the upper right-hand corner of the Dashboard users can select options such as water infrastructure, electric infrastructure, damaged education, and damaged medical facilities. The design of the Dashboard places the map in the center and flows from the upper left corner to the bottom right. The dashboards read from the initial population to the events that occurred during the siege to the destruction that happened due to the Russian attacks.

All the elements within the War Crimes Dashboard are connected to the war crimes Web Map and communicate different data points. The table of general stats of the siege of Mariupol is

used within all of the five indicators and the gauge. These indicators and gauges depicted display the total population before the war, death toll estimates, new grave estimates, hospital facilities damaged, education facilities damaged, and the percent of civilian infrastructure reported to have been damaged. The table of key events is depicted within a list feature within the dashboard to display the date and description of the key events that occurred during the siege. The ACLED data is connected to the serial chart and the pie the percent of key events and the number of sub-events that occurred during the siege. All spatial data within the web map such as water infrastructure, electric infrastructure, damaged hospitals, and damaged education facilities can be toggled on and off by using the filter stating select infrastructure type in the upper right corner. Both the Mariupol city and building footprints within the web map are there to provide visual context for viewers. Figure 36 depicts the final war crimes Dashboard that can be found within the final StoryMap.

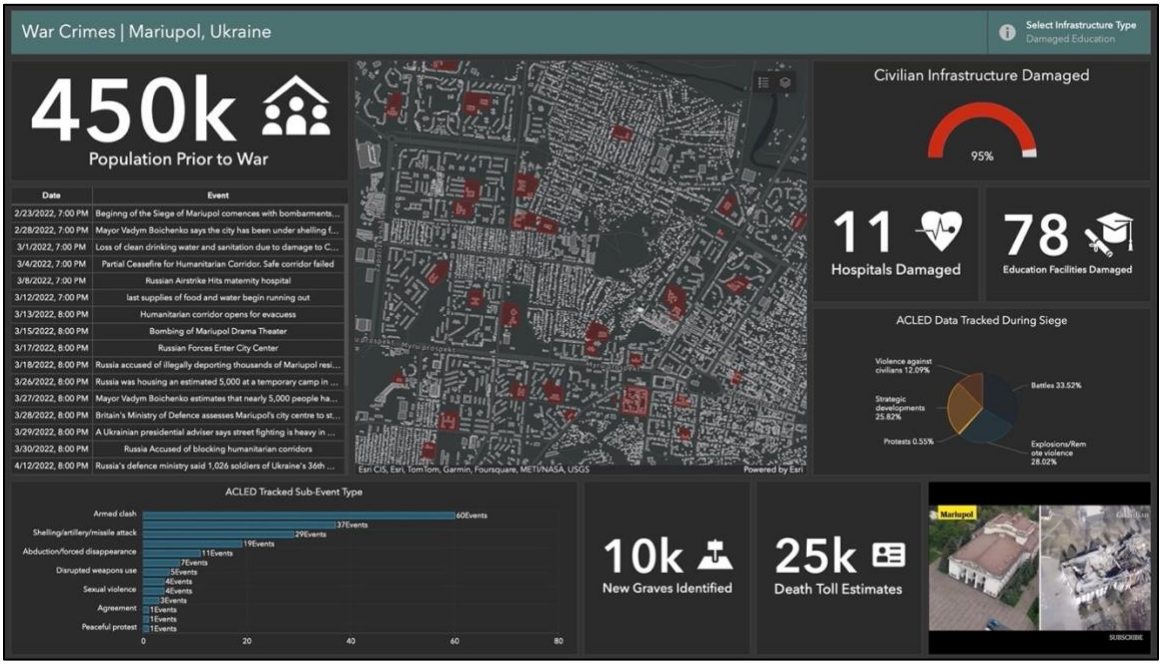

Figure 36. War Crimes Dashboard Final

4.3 Crimes Against Humanity StoryMap Section

The crimes against humanity section of the StoryMap contains a section on a written description of crimes against humanity as defined by the United Nations, a description of the Russian occupation of Bucha in 2022, images of the aftermath of the Bucha Massacre, and the Dashboard depicting spatial and non-spatial data of the Bucha Massacre.

4.3.1 Crimes Against Humanity Context

Before displaying the spatial data related to crimes against humanity within the dashboard there is a section that describes crimes against humanity as how they are defined by the UN and how they apply to the town of Bucha. The definition of crimes against humanity is accompanied by a list of eleven examples of crimes against humanity defined by the UN. Figure 37 depicts the initial view of the Crimes Against Humanity Section of the Human Suffering During Wartime StoryMap.

Figure 37. Crimes Against Humanity Section of StoryMap

4.3.2 Crimes Against StoryMap Study Area

After scrolling past the UN definitions viewers see a description of the Bucha Massacre to provide informative context of the event and why it is relative to this crime. After scrolling past the historical context, six images of the aftermath of the Bucha Massacre are displayed to aid in visually understanding the spatial data within the dashboard. Figure 38 depicts the study area and description of the Bucha Massacre within the Crimes Against Humanity Section of the StoryMap.

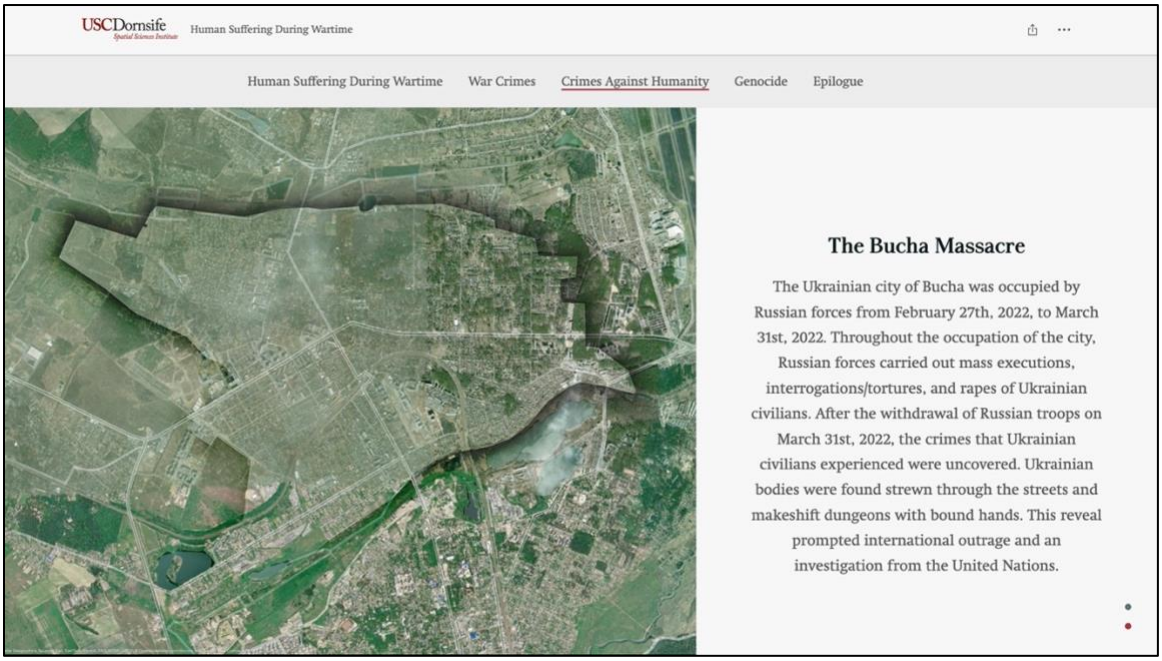

Figure 38. Crimes Against Humanity Study Area Section of StoryMap

4.3.3 Crimes Against Humanity Dashboard

The final spatial dashboard that was created or the Crime Against Humanity Dashboard communicated the graphic events that occurred in Bucha. The dashboard was designed to have the map in the center of the page and for users to start in the top left and continue through the facts displayed in the dashboard. The map contained the Bucha boundary, OSM building footprints, and locations where bodies were discovered. The upper left corner displayed the

number of bodies that were recovered. Next viewers should look at the spatially related locations of where bodies were discovered such as the indicator, percent, and table which update based on the map extent. Below the spatially located body data, there is the percent chart of cause of death. Besides this chart, there are several data points of stats on the number of people who remain missing, the number of children killed, and a single event of sexual violence that occurred. Next, the viewers can see the number of people who remained within the city during the occupation in the upper right followed by the ACLED event data shown in both pie charts and graphs.

All the elements within the Crimes Against Humanity Dashboard are connected to the crimes against humanity Web Map and communicate different data points. The data table that contains general stats of the events that occurred during the occupation was used in six of the seven indicators such as the bodies recovered, people remaining missing, children killed, pregnancies, and the number of people who remained within Bucha during the occupation. The mapped body locations within the map extent communicate to the indicator that displays the number of bodies, the percent of mapped bodies, and the description of the mapped body within the map extent. The cause of death data is used within a pie chart to depict the percent cause of death on bodies recorded whether it be natural or inflicted upon them. The ACLED data that depicts events that occur during the occupation are used to display a pie chart of the percent of events and a bar graph of sub-events. The building and town boundary data is used to provide visual context for viewers. Figure 39 depicts the initial view of the Crimes Against Humanity Dashboard that is within the StoryMap.

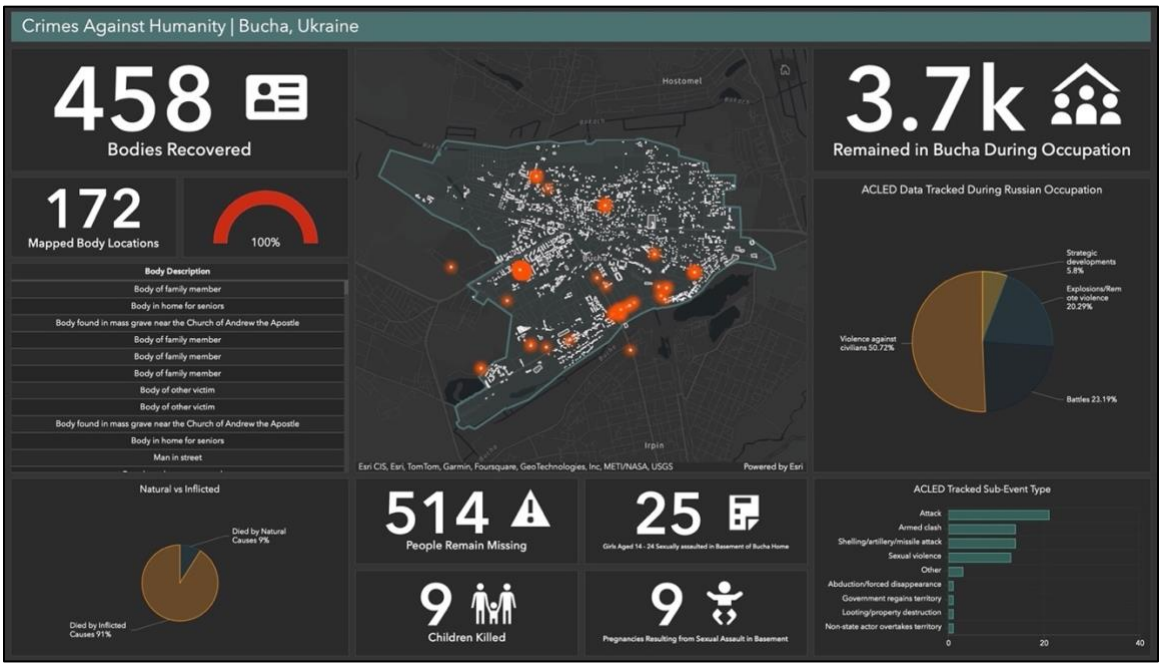

Figure 39. Crimes Against Humanity Dashboard Final

4.4 Genocide StoryMap Section

The genocide section of the StoryMap contains a section on a written description of genocide as defined by the United Nations, a description of Russia's abduction of Ukrainian Children from their initial invasion in 2022 to the present, images of Ukrainian children, and the dashboard depicting spatial and non-spatial data of the abduction and possible locations where Ukrainian children are being housed within Russia.

4.4.1 Genocide Context

Before displaying the spatial data related to crimes against humanity within the dashboard there is a section that describes crimes against humanity as how they are defined by the UN. The definition of crimes against humanity is accompanied by a list of eleven examples of crimes against humanity defined by the UN. Figure 40 depicts the initial view of the Crimes Against Humanity Section of the Human Suffering During Wartime StoryMap.

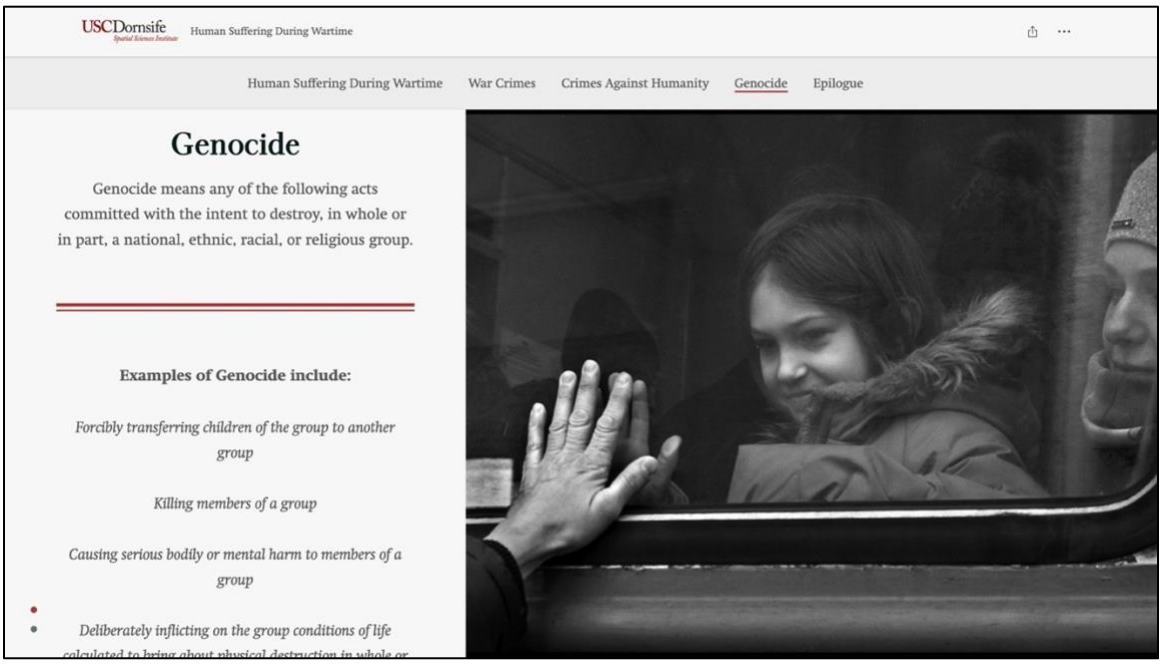

Figure 40. Genocide Section of StoryMap

4.4.2 Genocide StoryMap Study Area

After scrolling past the UN definitions viewers see a description of the abduction and re-locations of Ukrainian children to provide informative context of the event and why it is relative to this crime. After scrolling past the historical context, seven images of Ukrainian children are displayed to aid in visually understanding the spatial data within the dashboard. Figure 41 depicts the study area and description of the situation of abdications and relocations of Ukrainian children within the genocide section of the StoryMap.

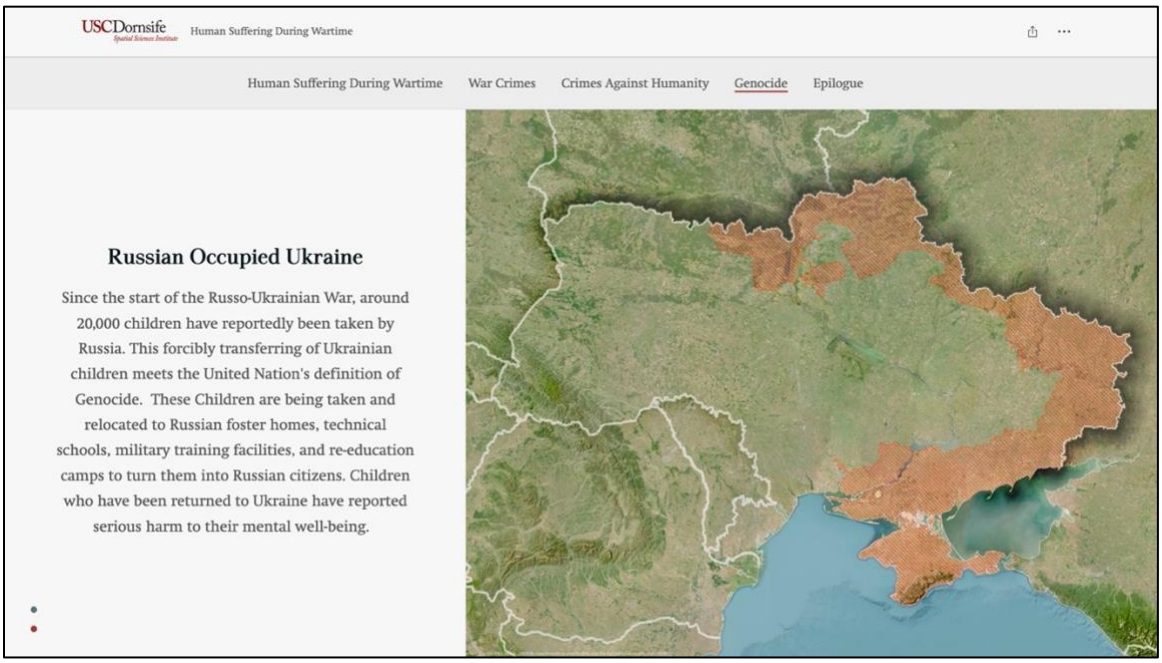

Figure 41. Genocide Study Area Section of StoryMap

4.4.3 Genocide Dashboard

This spatial data display provides end users with an easy-to-interpret final product of genocide via the abduction and relocation of children during the Russo-Ukrainian War. The dashboard has the map with spatial data placed in the middle of the dashboard with the oblast boundaries, Russian troop furthest territorial control, ACLED abduction data, re-education camps, military training facilities, locations where children have been, and locations where children likely are. The data that surrounds the map is separated to display two sides of the abduction and the locations of the children. The left-hand side of the dashboard focused on the number of children abducted, the number of children returned, and where the children and people have been abducted from using the ACLED data as the focus. This side of the dashboard displayed a table of the locations and descriptions of abduction points in both a table and a pie chart. In the middle right below the map, there is a bar graph showing the number of reported abductions that were recorded for each year by ACLED. The right-hand side of the dashboard

displays the locations where Ukrainian children have been relocated with indicators and lists. Both the ACLED data and the location of children datasets are connected to the extent of the map and update stats accordingly.

All the elements within the Genocide Dashboard are connected to the genocide Web Map and communicate different data points. The general table of data related to child abductions is displayed within two indicators showing the estimated number of children abducted and the number of children who have been returned to their families in Ukraine or other parts of the world. The ACLED Data is depicted within the web map and is connected to the indicator of the number of events, the table of the description of events, the pie chart of the oblasts, and the occurrence of abductions or disappearances by year which are all updated based upon the map extent. The Kidmapping data is displayed in the web map and is connected to two indicators and lists of data within the extent showing locations where children have been and locations where children most likely are located. The data displaying locations of children's re-education facilities and military training facilities is displayed within the web map and is connected to two indicators and lists of titles that update based on the map extent. The total Russian territorial gain, oblasts, and country boundaries are included in this web map to provide context to the viewers. Figure 42 depicts the initial view of the genocide Dashboard that is embedded within the StoryMap.

Figure 42. Genocide Dashboard Final

Chapter 5 Discussion

This chapter concludes the thesis with a discussion of the final projects, limitations, challenges, and potential future work.

5.1 Finished Product

The target audience of this work consists of academics and the public, where they can learn about the atrocities that occurred in Ukraine and how spatial journalism can be used as an effective tool for storytelling. The spatial storytelling element of this thesis provided a platform that elaborated on atrocities that occurred during the war in Ukraine. By elaborating on these atrocities, the StoryMap entices viewers to consider how human suffering is not isolated to this event but is occurring in many conflicts around the world. Spatially tracking suffering by documenting violations of international humanitarian law is necessary for humanity to understand the atrocity, seek justice, and memorize those who were lost. Through this understanding, comes the recognition that suffering is not an isolated event but exists wherever human rights violations occur. This thesis achieved the objective of developing a StoryMap with embedded dashboards that depict human suffering during the Russo-Ukrainian War. The StoryMap consists of five sections such as defining human suffering during wartime, war crimes, crimes against humanity, genocide, and epilogue.

5.2 Limitations and Challenges

Creating an application that discusses human atrocities was difficult to produce due to the horrific subject matter. The themes and facts related to this thesis contain some of the worst acts that humans can inflict upon one another. The seriousness of these acts and the topics discussed created pressure to provide the most accurate, informative, and respectful StoryMap possible.

However, the feeling of accurately displaying data related to human atrocities and providing victims with dignity was a challenge.

5.2.1 Data

The main limitation when it came to data is that the Russo-Ukrainian war is still ongoing during the completion of this thesis. This means that counts and data are as accurate as possible as of the completion of this thesis. Accurate counts and datasets are currently being updated as human rights violations within Ukraine are investigated. Data sources are cited within the StoryMap because first-hand accounts vs second-hand accounts can hold significantly different weights. Updated facts and data points will eventually be recorded to display true numbers or numbers that are closer to accurate estimates.

This thesis only used open-source data to compile and produce the applications. Authoritative sources are conducting thorough and classified investigations to be able to produce accurate documentation of the atrocities. These official investigations are guaranteed to have more accurate and complete datasets that are not open to the public. Not having only official data makes the reliability of the data an important topic to discuss.

5.2.2 Human Dignity

Once the data was collected it became an emotional struggle to determine how to appropriately display this data that both accurately spoke to the event and provided respect and dignity to the victims. Word choice and how data was shown was an aspect that took significant congestive thought. Text, indicator icons, images, and the type of data visualization were crucial pieces in the creation of this thesis. It was important to elaborate on the horrors of this war without seemingly glorifying the war itself. It was a conscious decision to not display the bodies of victims of Russia's aggression. It was not taken lightly when depicting data in a way that was

accurate and respectful. Colors needed to be mindful of the subject matter and the data could not be shown seemingly without purpose. All these aspects of depicting human suffering during wartime took longer and were more of a mindful development than initially expected.

5.3 Future Work

Future work on this thesis could entail updating and streamlining data, expanding data, and researching more study areas related to IHL such as war crimes, crimes against humanity, and genocide.

As time goes on more accurate data will be released which should be incorporated in future works. It would be great if future works could incorporate fully authoritative sources from investigative organizations such as national governments or the UN. Streamlined data can be incorporated using GeoJSON so the application is updated without user interaction. These updates could entail correcting valued stats to have more accurate numbers or appending new data to track new and updated locations.

To expand the scope of this thesis and depict human suffering on a larger scale future work should expand the study areas discussed within this thesis. There can be further work to display more violations that are not discussed within this thesis. Future work can go more into depth on examples of violations and tracking every single type of violation. This will ensure that the entire picture of a single study area is being depicted. This could look like having more data sets discussing all the aspects of a single crime.

Once the study areas within this specific thesis have been updated it would be appropriate to expand to more study areas to widen the scope of the thesis. By looking for more study areas where the three IHL violations during the Russo-Ukrainian War. This would entail having multiple locations or events where war crimes have occurred. It would be interesting to have a

single interactive application where users can select locations throughout Ukraine and have as detailed a description and dashboard for that event. This would further expand the goal of this thesis to have a concise and informative location where people can become informed about human suffering during wartime.

Appendix

Mariupol Spatial Data

Building footprints (All)
- Source: HDX
- Data type: Shapefile polygon
- URL: https://data.humdata.org/dataset/hotosm_ukr_buildings

Building footprints (Education)
- Source: HDX
- Data type: Shapefile polygon
- URL: https://data.humdata.org/dataset/hotosm_ukr_education_facilities

Building footprints (Health)
- Source: HDX
- Data type: Shapefile polygon
- URL: https://data.humdata.org/dataset/hotosm_ukr_health_facilities

Campus footprints (Damaged Education)
- Source: Human Rights Watch
- Data type: Shapefile polygon
- URL: https://github.com/HumanRightsWatch/Mariupol-data-2024

Campus footprints (Damaged Health)
- Source: Human Rights Watch
- Data type: Shapefile polygon
- URL: https://github.com/HumanRightsWatch/Mariupol-data-2024

City boundary
- Source: HDX
- Data type: Shapefile GeoJson
- URL: https://data.humdata.org/dataset/geoboundaries-admin-boundaries-for-ukraine

Power (Facilities)
- Source: Open Infrastructure Map
- Data type: GeoJson polygon
- URL: https://openinframap.org/#11.17/47.1358/37.5546/P

Power (Lines)
- Source: Open Infrastructure Map
- Data type: GeoJson line
- URL: https://openinframap.org/#11.17/47.1358/37.5546/P

Power (Towers)
- Source: Open Infrastructure Map
- Data type: GeoJson point
- URL: https://openinframap.org/#11.17/47.1358/37.5546/P

Waterways (Facilities)
- Source: Open Infrastructure Map
- Data type: GeoJson point
- URL: https://openinframap.org/#11.17/47.1358/37.5546/P

Waterways (Pipes)
- Source: Open Infrastructure Map
- Data type: GeoJson line
- URL: https://openinframap.org/#11.17/47.1358/37.5546/P

Mariupol Non-Spatial Data

Death toll estimate
- Source: Human Rights Watch
- Data type: Text
- URL: https://www.hrw.org/feature/russia-ukraine-war-mariupol/counting-the-dead

New graves identified
- Source: AP News
- Data type: Text
- URL: https://apnews.com/article/russia-ukraine-war-erasing-mariupol-methodology-f74b28016b8dea4b82811655f14931f2#:~:text=The%20Associated%20Press%20estimated%20at,the%20earth%20had%20been%20disturbed.

Population before war
- Source: The Economist
- Data type: Text
- URL: https://www.hrw.org/feature/russia-ukraine-war-mariupol/counting-the-dead

Ukraine conflict monitor
- Source: ACLED
- Data type: Table
- URL: https://acleddata.com/ukraine-conflict-monitor/

Ukraine drone footage shows before and after the invasion
- Source: YouTube
- Data type: Video
- URL: https://www.youtube.com/watch?v=kT6pV4rK5Gk

Bucha Spatial Data

Body locations
- Source: The Washington Post
- Data type: Image
- URL: https://x.com/nytimes/status/1513549965792100363

Bodies recovered
- Source: AP News
- Data type: Text
- URL: https://apnews.com/article/russia-ukraine-kyiv-0aced874ccf203a5219ad37c2ed3f636#

Ukraine conflict monitor
- Source: ACLED
- Data type: Table
- URL: https://acleddata.com/ukraine-conflict-monitor/

Bucha Non-Spatial Data

Bodies recovered
- Source: AP News
- Data type: Text
- URL: https://apnews.com/article/russia-ukraine-kyiv-0aced874ccf203a5219ad37c2ed3f636#:~:text=Municipal%20authorities%20say%2058%20bodies,the%2033%2Dday%20Russian%20occupation

Cause of death
- Source: The Washington Post
- Data type: Text
- URL: https://www.washingtonpost.com/world/2022/08/08/ukraine-bucha-bodies/

Children killed
- Source: CNN
- Data type: Text
- URL: https://www.cnn.com/2022/05/03/europe/bucha-ukraine-russia-war-victims-intl-cmd/index.html

Civilians remained in town during the occupation
- Source: TIME
- Data type: Text
- URL: https://time.com/6166681/bucha-massacre-ukraine-dispatch/

People missing
- Source: Euromaiden Press

- Data type: Text
- URL: https://euromaidanpress.com/2024/03/31/ukrainian-police-many-still-missing-bucha-civilian-death-toll-not-final-two-years-on/#:~:text=Ukrainian%20police%20report%20that%20after,of%20Ukrainian%20citizens%20remaining%20unidentified.

Sexual violence (Pregnancies Count)
- Source: BBC
- Data type: Text
- URL: https://www.bbc.com/news/world-europe-61071243

Sexual violence (Victim Count)
- Source: BBC
- Data type: Text
- URL: https://www.bbc.com/news/world-europe-61071243

Ukraine Spatial Data

Kid mapping
- Source: Kidmapping
- Data type: polygon point
- URL: https://mapping.kids/

Oblast boundary
- Source: HDX
- Data type: Shapefile Polygon
- URL: https://data.humdata.org/dataset/cod-ab-ukr

Re-education camps and military facilities for children
- Source: Rubtyka
- Data type: polygon point
- URL: https://rubryka.com/en/2023/03/29/v-ukrayini-stvoryly-mapu-taboriv-kudy-rosiyany-vyvozyat-ukrayinskyh-ditej/

Ukraine conflict monitor
- Source: ACLED
- Data type: Table
- URL: https://acleddata.com/ukraine-conflict-monitor/

Ukraine Non-Spatial Data

Estimated number of abducted children
- Source: BBC
- Data type: Text
- URL: https://www.bbc.com/news/world-europe-68249102

Estimated number of children returned

- Source: BBC
- Data type: Text
- URL: https://www.bbc.com/news/world-europe-68249102

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