David Biggs

Reading Conflict Landscapes

Aerial Imagery, Ground-Truthing, and Intervisuality in Vietnam

No places on Earth have been as bombed, defoliated, and bulldozed as the former battlefields and bases of Vietnam. In the hills surrounding Hue, where I have studied for over fifteen years, "reading nature" requires attention not just to plants, soils, water, and structures but also to munitions, base operations, concrete ruins, and chemicals. Studying conflict landscapes requires careful attention to subterranean realms in the soil and with local communities. More than fifty years since the end of the Vietnam War, researchers still tread lightly (on the soil and in communities) in research on war legacies. Earth's modern war zones are fraught like this, and they pose practical and ethical challenges for anyone who wants to scrape the surface. Wars also generate a lot of historic materials, especially aerial images and geographically tagged data, and once declassified, these sources offer less invasive means for studying the environmental past. The increasing availability of historic aerial images and the increasing ease of use of geographic information systems (GIS) means that environmental historians and others can assemble new visual means for seeing into the wartime past; however, working with images still requires "ground-truthing," comparing visual information with on-the-ground observation and local sources. Comparing

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images, considering their production and transformations into digital formats, also requires an intervisual method, one that considers images relationally, evolving from one medium to another and from one human viewer to another.

This essay draws on a GIS-based study of two satellite-based images and one digitized preconflict map, plus field research drawn from years of study in central Vietnam, to outline an intervisual method for using aerial imagery in conflict zones with considerations of technical and ethical issues in this work. It begins mid-war in 1969 with a US spy satellite photograph to introduce major features in an area, and then turns to a 2002 commercial satellite multiband image of the same area to produce intervisual comparisons. It then uses the two images in an intervisual analysis combined with ground-truthing to consider how such studies open up new questions in the history of conflict landscapes. The essay ends with a digitized 1909 topographic map as a means to explore deeper, premodern factors that shaped military activities in the area.

Before we enter the lab space, several callouts are in order. First, let me foreground the hyperlinks and QR codes in the published images that link to full-resolution, full-color versions, some enabled with sliders that allow real-time intervisual analysis.[1] Second, a brief note about the history and exponential growth of aerial imagery is due. Once a novel visual perspective tied to the wonders of flight, aerial imagery has become an essential component of everyday life through navigation apps and a major component of geospatial intelligence, or "geoint," in the clandestine, militarized world of surveillance.[2] The advent of cameras in the late 1800s launched this enterprise as hobbyists and militaries alike put cameras on balloons, kites, pigeons, and planes to survey cities, rural landscapes, and battlefields. In World War I, aviators with plane-mounted cameras snapped thousands of images, and the formation of military photo reconnaissance units in turn produced a new sort of imagery archives.[3] The Cold War took cameras into space, and the digital revolution added electronic scanners. Since then, an ever-growing array of vehicles now collect digital data about the Earth's surface using photographic, electronic, radar, microwave, sonic, and laser sensors. The recent explosion of imagery and declassification has attracted historians who have begun to examine histories of aerial imagery and unpack the politics of its use.[4] Some have also built historical GIS applications and explored technical challenges in assessing images that require familiarity with imaging technologies, metadata, and GIS or remote sensing software needed for working with multiband images.[5] Finally, while most historians are relatively new to these areas of research, we must tip our hats to archaeologists who created aerial archaeology as a vibrant subfield that took off in the post–World War I years as it became possible to request aerial photographs.[6]

This excerpt of a CORONA spy satellite photograph (Fig. 1), taken over central Vietnam in the midday on March 20, 1969, offers a good visual starting point to the lab and the conflict zone. A KH-4A "keyhole" camera aboard a Discoverer satellite traveled in an elliptical,

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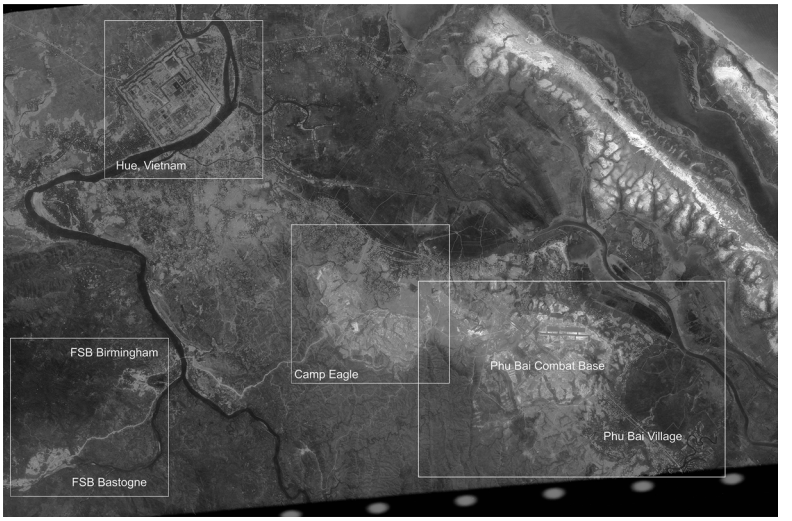


Figure 1. Excerpt of CORONA frame DS1050-1006DF129 with annotations.

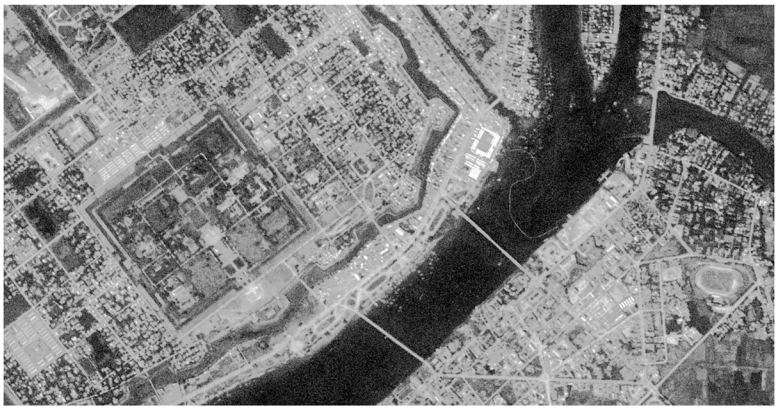
circumpolar orbit between 100 and 150 kilometers above the Earth at 7 kilometers per second. DS1050-1006DF129 was snapped along with thousands of other images during a twenty-two-orbit mission lasting several days. It was called a "keyhole" image because each image was a long and narrow rectangle covering 130 by 30 kilometers of the Earth's surface. CORONA satellites carried two cameras fore and aft to construct stereo images, but on this mission, as with many others, one of the cameras failed or the film was lost on reentry. These early satellites contained film cameras, and the unexposed rolls traveled back to Earth in heat-shielded capsules called "buckets" outfitted with small thrusters and parachutes. US Navy planes with trolling devices grabbed them in midair, and the film then traveled to developing facilities in California before images were sent to Washington. Each CORONA mission cost several million dollars to assemble and launch; they (like their Soviet counterparts) were history's most expensive disposable cameras. Finally, even if the rockets and cameras worked perfectly, meteorologists could not predict the weather; so getting a cloud-free shot like DS1050-1006DF129 was nearly impossible.[7]

Visually, this excerpt of a keyhole image shows an iconic stretch of the central Vietnamese coast at Hue, the former imperial capital. Of the white boxes I've added to indicate major features, the one in the upper left details the imperial city, surrounded by citadel walls and a moat. Two others describe sprawling American military encampments, the Phu Bai Combat Base and airfield, home to US Army and Marines units, and Camp Eagle, the site of the 101st Airborne Division's major encampment and headquarters after the Tet Offensive. The Perfume River runs from south to north on the left side of the image, and a snaking whitish line runs west from the American bases across the river to two FSBs, or fire support bases, on the far left in another square. This

road continued on another thirty kilometers into the Central Highlands, where some of the war's most ferocious battles and heaviest bombing took place. Images like this are especially valuable for researchers today as they show locations and features of former military areas that have long since been built over or forgotten.

A zoomed-in excerpt (Fig. 2) shows the high resolution of the CORONA photographs where ground features were visible at about 1.5-meter resolution, a mark *commercial* space images did not exceed until the 1990s. It shows buildings and walls, the royal palace as a darkish square (left center), and some white rectangles (lower right) near the river. These rectangles were the highly reflective tin roofs of temporary shelters near the point where US Marines fought their way across the river in February 1968 during the Battle of Hue.

That's a general interpretive introduction to an image, but art historians and others are quick to note that how one reads an image rests on not only their understanding of what is in it but also how they learned to read it. How do we know what we know? History teachers often begin with this question, and it's also where intervisuality and ground-truthing come in. How do images, especially aerial photographs, get embedded into ways of knowing and intervisual discourse? Without annotations or guidance, what and how does one see in the CORONA image? A general recognition of rivers, cities, and other features might be conditioned by years of exposure to maps and similar images in textbooks or news media or on apps. Military photo interpreters receive specialized training to recognize things like missile silos or bunkers, but they still test these interpretations by ground-truthing—comparing what the image shows with what eyewitnesses or other ground-based observers report. Ground-truthing can even explain things invisible or blank on an image. For example, in Vietnam, American observers were often confused by People's Army and Viet Cong units that fought hard to hold seemingly "worthless" barren hilltops. There were no visible elements to suggest a strategic advantage. However, postwar research showed that some were sites of resistance and martyrdom in earlier



QR code for Figure 2

Figure 2. Excerpt of CORONA frame DS1050-1006DF129.

wars. They were symbolically important. American writer J. B. Jackson calls these intangible features the "vernacular landscape," and they can be discovered only by ground-truthing techniques such as oral histories and textual research in local sources.[8] By adding oral histories and different means of community engagement required to see vernacular landscapes, I should add that my definition of ground-truthing here is far more expansive than that used by photo interpreters.

Intervisual methods engage with ground-truthing, but they also address images as things that, especially in the digital realm, are physically and semantically in flux. Observers may understand an aerial image differently depending on what they already know from technical or vernacular sources, but an image, especially an aerial image, is itself transforming as it moves from points of original "capture"—film negatives or raw data—to prints, aggregated data, scans, and georectified layers in a GIS. Visual theorist Nicholas Mirzoeff introduced the term "intervisuality" to describe this phenomenon. He writes, "Life in the pixel zone is necessarily ambivalent, creating what might be called 'intervisuality.'"[9] For those working with aerial images in GIS, preserving metadata on transformations is essential. What might at first seem like a relatively straightforward enterprise, reading an image or comparing it with another image of the same place at a different time, can quickly snowball into multiple interpretations and derivative images. There are also dozens of operations that a GIS can perform to isolate particular elements and generate new images. It is in this highly intervisual "pixel zone" where historians can compare a set of aerial images (and scanned maps) and begin to generate new questions and interpretations. The second aerial image in this lab, a 2002 satellite image (Fig. 3), is a perfect example of a highly modified derivative image.[10]

It shows the Phu Bai area of the conflict zone, focusing on the American bases in the center and a high hill to the west. It is not a photograph

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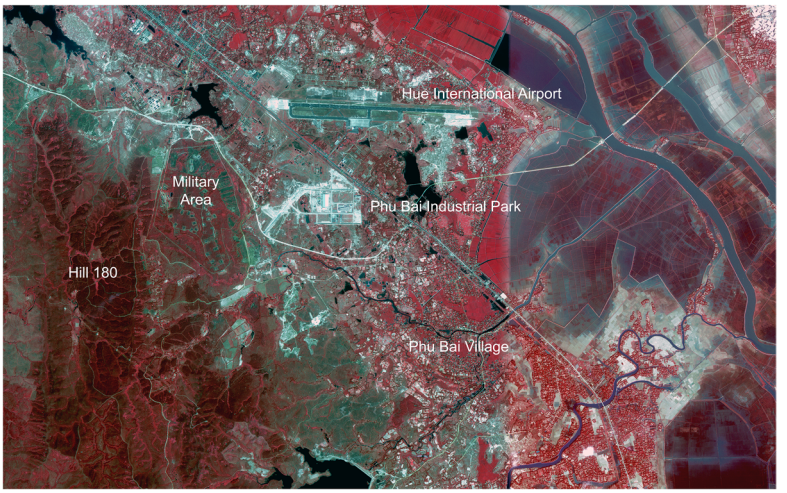
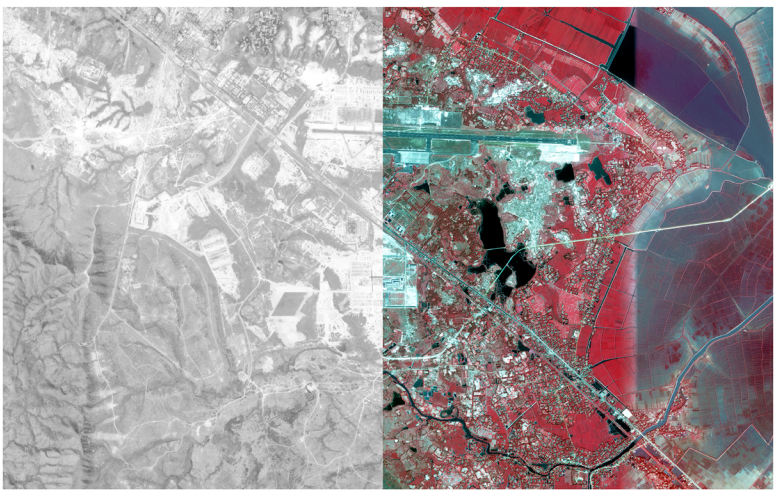


Figure 3. Excerpt of study area from two stitched IKONOS frames showing pan-sharpened 4-3-2 bands.

like the CORONA image but a "false color" image produced from a combination of three recorded bands of light—near-infrared (band 4), red (band 3), and green (band 2)—plus a fourth panchromatic band used to sharpen the image resolution. Denser vegetation absorbs more near-infrared light and appears darker red. Things that are blue to human eyes appear purple or black, while bare surfaces without vegetation appear white or gray. Lighter red areas describe thin vegetation such as grass or bamboo. The darkest reds to the left of the image describe Hill 180, a once-bare mountain replanted with pines after the war. Darker purples on the right of the image are rice fields inundated with water. This digital image is also not just one shot on one day but a "stitching" of two separate satellite shots using the same "false color 4-3-2" bands of light. A vertical line in the center right shows an abrupt shift in color from bright red on the left to purple on the right. This reflects pre- and postharvest of rice paddy from the left frame (January) to the right frame (March).

As with the CORONA photograph, figure 3 can be analyzed in technological and intervisual terms; however, by bringing both images into the same coordinate space in a GIS, it is possible to engage in an additional, comparative analysis that can be generative in that this sort of intervisual comparison brings new questions about conflict landscapes in the war and postwar eras. In the GIS (and on my website via QR code), figure 4 is rendered with a slider to allow the viewer to move between the two images, to consider how specific land features have changed (or not).

Comparing the two images from 1969 and 2002 and ground-truthing them with texts, oral accounts, and site visits, what storylines emerge? First, what is clear in the center of the image is that the old base geometry of roads and lots persisted. The airfield continues as Hue International Airport, and the old Phu Bai base in 2000 was converted into Phu Bai Industrial Park. This conversion story parallels a global history of



QR code for Figure 4

Figure 4. The 1969 and 2002 images, georeferenced and orthorectified.

BRAC, or Base Realignment and Closure, in the post–Cold War era. In ecological terms, very little changed in the base and airfield areas. The industrial park, in ecological terms, continued to operate like a military base, but in reverse. Raw materials came into factories, and finished goods exited them. Daily activity produced toxic substances and exposures, and the industrial zone required masses of laborers working together in tight quarters.

In the least developed areas, like Hill 180, a comparison of the two images suggests significant vegetation recovery (Fig. 5). Upon my first time seeing this in the image and before I visited the hill, I wondered whether this might be a sign of natural forest recovery. However, on subsequent trips to the area and following inquiries with local foresters, I soon learned this was not natural forest regrowth but an industrial tree plantation.

Private owners bid for wood lots here and planted them in fast-growing pulp and paper trees like Sumatran pine (*Pinus merkusii*). They periodically clear-cut parcels once the trees reach the desired size. The area at the eastern base of the hill experienced little change in vegetation because of its persistence as a firing range still operated by local military units. I unwittingly discovered this during one motorcycle tour when I drove through an open gate into an active military camp. I met confused guards, quickly retreated, and quickly realized that many old base areas continue to operate as bases under new "owners." Ground-truthing is essential to navigating active boundaries in former military zones; it requires sustained coordination with local authorities. As I developed my research during extended stays, building up my ground-based knowledge, the questions I asked of the images began to shift too. I began to focus on how new constructions like postwar reservoirs not only marked evidence of postwar economic change but in some cases also hid controversial sites from the war period. Through

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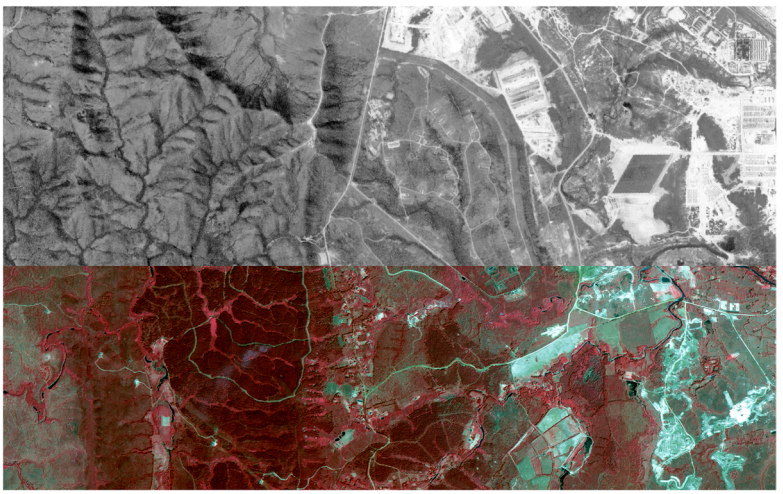

Figure 5. Vegetation on Hill 180 and adjacent military area in 1969 and 2002.

local partners, I learned of a major toxic cleanup in one area now hidden from view by a reservoir.

Khe Loi Reservoir (Fig. 6) was constructed by postwar settlers some years after the war's end. The 2002 image shows the earthen dam (bottom center) with downstream farms, while the 1969 image shows a few dirt roads, bare hills, and winding lines of creeks. While visiting Hue in 2007, I learned that when workers drained and cleaned the reservoir in 1999, they discovered a buried cache of CS (2-chlorobenzalmalononitrile), a riot-control agent (tear gas) used as a tactical chemical by US forces who dropped barrels of it in "smoke drops" from helicopters, especially over underground bunkers where the gas asphyxiated troops who struggled to reach the surface. Local partners reported that workers cleaning out the reservoir punctured some containers and, upon inhaling the powdered concentrate, received severe burns in the throat and lungs.[11] The province government, together with Vietnam's Ministry of Defense, coordinated a military forensics cleanup.

I later learned from colleagues that post-2000 concerns about buried waste sites (see Fig. 7) helped persuade provincial officials to accept my initial proposals to gather historic imagery and share it with local partners. Phu Bai Combat Base contained one of the largest explosive ordnance depots (EODs) in Vietnam, and either as part of the base transfer to the Republic of Vietnam in 1972 or during its abandonment in 1975, surplus materials were buried at various sites.[12]

Especially in conflict zones, community engagement is a vital part of ground-truthing and the sharing of research findings. Through interacting with community groups over years of study, I learned not just that Phu Bai was scarred by the Vietnam War but that the same base areas had been sites of industrial and military occupation dating back to the 1400s. In 1471, when the Le dynasty troops defeated Champa, the first military settlers came to the Phu Bai region to establish local strongholds. The *O Chau Chronicle* (1555) detailed the establishment of a barracks at Phu Bai, which became a district seat. The village was a

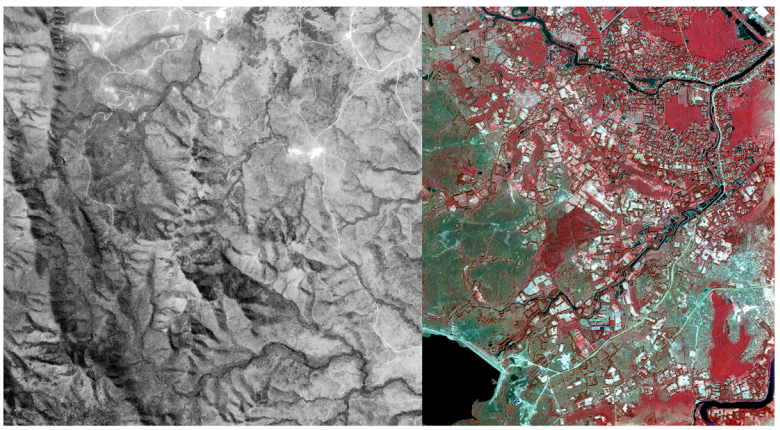

Figure 6. Hills and watersheds in 1969 (*left*) and 2002 (*right*) at Khe Loi Reservoir, site of a hazardous waste cleanup in 2001.

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center for the production of pig iron via large-scale mining and smelting operations in the hills.[13] The same ground that US soldiers camped on in 1969 had likely been occupied by many generations of soldiers before them over several centuries. Research in the province library turned up a study of iron and blacksmithing villages by local historian Bùi Thị Tân, who detailed how Phu Bai's guilds supplied the southern Vietnamese government in Hue with much of the metal for swords and muskets.[14]

Like archaeologists, I and my colleagues used imagery to look backward in time into the premodern past. Textual accounts confirmed that Phu Bai had been a military zone since the 1500s, but there were no maps or other spatial documents detailing specifically where the village's mines, kilns, or waste slag were located. Perhaps the airfield, constructed on elevated mounds of "wasteland" in 1926, was located on part of the ancient industrial space. Mining stopped in the region after the eruption of a civil war in 1772 that lasted for thirty years. Severely depleted forests and rising imports of cheaper metal goods from China limited modern efforts to restart the industry. Local sources colloquially referred to an area west of Phu Bai Village and near the military area as a "rust area" (*vùng phèn*), and village histories pointed to Quách Mountain (Hill 180) as the source for iron ore, so the mountain's base was most likely the candidate for historical smelting.[15] This possible correlation between modern and premodern waste sites added an unusual twist to the well-known storyline of American war legacies in Vietnam. A series of visits to this area turned up ferrous-red soils indicating the presence of iron.

I was unable to find pre-1945 imagery, so instead I scanned and georeferenced a 1909 topographic map to study areas of bare land in the vicinity of the Phu Bai EOD and airfield. Additional consultation with Vietnamese cadastral surveys from the early nineteenth century confirmed that the *vùng phèn* was considered "wasteland" (*đất bỏ hoang*) as early as 1825.[16]

QR code for Figure 7

Figure 7. The base of Hill 180 facing the military area, February 6, 2014. Iron-rich soils are evident in the foreground, and a low hill planted in *Acacia augustifolia* (lower elevation) and *Pinus merkusii* (ridgeline) rises in the background.

An intervisual comparison of the 1909 map and the 2002 image (Fig. 8) helped to confirm theories about the EOD area being situated on a former iron slag site, but it also suggested other environmental trends over the longer *durée*. A comparison of village hedgerows, field dikes, and levees in the village and estuary areas (right side of the image) showed almost no change over a one-hundred-year gap, and this was despite military base construction and frequent eruptions of violence from the colonial conquest in 1884 to the Vietnam War's end in 1975. These highly plastic, earthen, and plant-based structures required constant maintenance. This persistence of their geometry suggests stubborn resilience in the face of disruptions. Village life and the local agroecology persevered. The same geometry continues today.

A visual comparison on the left side of the image showed an unusual rise that today lies under the runway at Hue International Airport. Perhaps this rise of land was not some ancient dune but a leveled-out mound of alum and iron slag from several centuries of smelting activity? Perhaps the inability of farmers to farm these soils also explained why the site was selected as an airstrip and decades later as a military base? I was unable to answer these questions with colleagues at the time, and because parts of this area are highly secured, we have yet to conduct soil tests to confirm the theory.

Nevertheless, this intervisual approach underscores the highly generative effects that come from bringing aerial images into a sort of dialogue with ground-sourced and vernacular knowledge. This brief lab tour demonstrates the potential for aerial imagery through the use of GIS-based intervisual inquiry and ground-truthing to better understand the environmental history of conflict zones. An ethical and provocative intervisual method integrates ground-truthing and community-engaged research that may in turn lead to new questions and

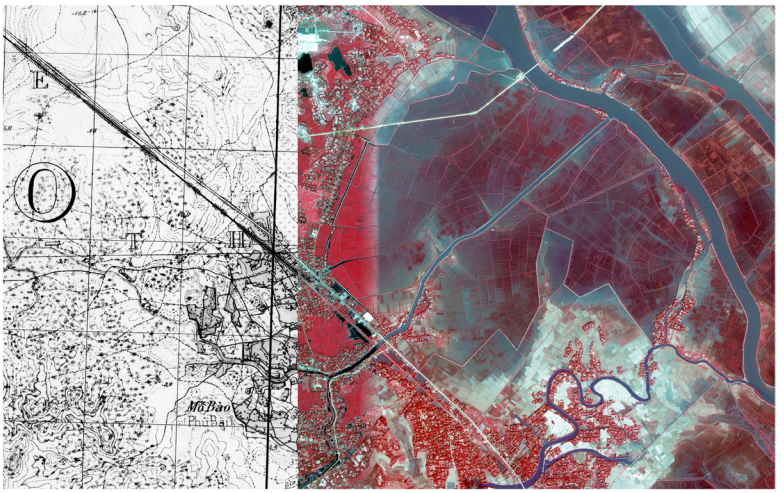

Figure 8. Airfield area and Phu Bai Village in 1909 and 2002.

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research directions. As with any archival source, how we understand it and how we use it—how we know what we know—depends on the strength of collaborations and comparisons.

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1 The full set can be found at https://davidbiggs.net/reading-conflict-landscapes/.
2 For a succinct overview, see the Smithsonian's National Air and Space Museum, "The Beginnings and Basics of Aerial Photography," June 21, 2023, https://airandspace.si.edu/stories/editorial/beginnings-and-basics-aerial-photography.
3 The US National Archives record group 120 consists of about sixteen thousand prints taken by the American Expeditionary Forces. See https://www.archives.gov/research/cartographic/aerial-photography/rg-120-aef-aerial-photography.
4 See, for example, Jeanne Haffner's *The View from Above: The Science of Social Space* (MIT Press, 2013).
5 Environmental historian Richard White co-established Stanford's Spatial History Project in 2007, a major venue for GIS- and imagery-based research to 2022. The site is now archived, and a static version of the site may be found at https://web.stanford.edu/group/spatialhistory/static/publications/pub29.html.
6 In Cambodia and Vietnam, for example, archaeologists in the early 1930s used the first aerial photographs to detect canals and temple complexes. Since the 1990s, they have used space imagery and ground studies to uncover networks of canals and roads at Angkor Wat. See Damian Evans, Christophe Pottier, Roland Fletcher, et al., "A Comprehensive Archaeological Map of the World's Largest Preindustrial Settlement Complex at Angkor, Cambodia," *PNAS* 104, no. 36 (2007): 14277–82.
7 Center for the Study of National Reconnaissance, *The Corona Story* (Center for the Study of National Reconnaissance, 2013), 114, https://www.nro.gov/Portals/65/documents/history/csnr/corona/TheCORONAStory.pdf. For information on CORONA image collections, see EROS Center, "Declassified Satellite Imagery—1," US Geological Survey, July 13, 2018, https://www.usgs.gov/centers/eros/science/usgs-eros-archive-declassified-data-declassified-satellite-imagery-1.
8 John Brinckerhoff Jackson, *Discovering the Vernacular Landscape* (Yale University Press, 1984).
9 Nicholas Mirzoeff, *An Introduction to Visual Culture* (Routledge, 1999), 30.
10 This image was derived from two commercial satellite images shot on March 27, 2002 (left portion), and January 1, 2002 (right portion), and provided through a grant by the GeoEye Foundation.
11 See David Biggs, *Footprints of War: Militarized Landscapes in Vietnam* (University of Washington Press, 2018), 8.
12 Today in Vietnam, Laos, and Cambodia, cleanups of buried chemicals like CS continue, often with bilateral cooperation from the United States. US Army manuals circa 1969 provided detailed recommendations for disposal, recommending burning it in quantities "greater than 25 pounds"; however, here the burials of drummed CS here were likely due to the rushed nature of the US withdrawal in 1972 or the rapid collapse of South Vietnamese defenses in 1975. See US Department of the Army, *Storage, Shipment Handling and Disposal of Chemical Agents and Hazardous Chemicals*, technical manual 3-250 (Department of the Army, 1969), 123.
13 Dương Văn An, *Ô Châu Cận Lục*, trans. Trịnh Khắc Mạnh and Nguyễn Văn Nguyện (Nhà Xuất Bản Khoa Học Xã Hội, 1997), 32.
14 Bùi Thị Tân, *Về hai làng nghề truyền thống: Phú Bài và Hiền Lương* [Regarding two traditional craft villages: Phú Bài and Hiền Lương] (Thuận Hóa, 1999).
15 Bùi Kim Chi, "Phù Bài làng xưa," *Sông Hương*, December 16, 2011, http://tapchisonghuong.com.vn/tin-tuc/p2/c15/n9543/Phu-Bai-lang-xua.html.
16 For a thorough discussion of these sources, see David Biggs, "Clearing, 'Wasting,' and Regreening: An Environmental History of Bare Hills in Central Vietnam," *Journal of Asian Studies* 77, no. 4 (2018): 1037–58.

The American Historical Review, 2026, 131(3), 1075–1085
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