Landscapes from Above:

A layered framework of ecology and infrastructure at regional and municipal airports in Minnesota

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This thesis was possible because of the community that surrounds me.

To my father, who sparked my own passion for aviation and appreciation for the skies—thank you for showing me the beauty of flight. To my mother, who taught me the importance of writing and the power it can have—thank you for your words, as they have inspired mine. To my sister, who radicalized me to become an advocate for the environment—thank you for your advocacy and care for the land. To my brother, who continues to be my forever role model—thank you for being the kind of person I am trying to become.

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abstract

Regional and municipal airports across the United States occupy vast expanses of land, often maintained by land-use practices that, while meeting infrastructural needs, contribute to the fragmentation and degradation of surrounding ecosystems, leading to ecologically sterile and isolated spaces. Currently, airports are almost always an exclusive land use that precludes overlapping or shared use, maintenance regimes tend to be intensive and destructive of native ecologies, and chemical and fuel use often leave polluted land and water runoff. While these approaches to land use have served infrastructural aims, they have been damaging to surrounding ecological systems. In recent decades, scholars have examined airports as a form of landscape typology. Predominantly focused on large international airports, this existing scholarship has overlooked opportunities at smaller airports for design interventions. Focused on Minnesota specifically, this thesis examines how regional and municipal airports can become more dynamic spaces through design interventions that balance existing infrastructural use with proposed ecological value. To investigate the existing conditions at airports and their surrounding landscapes, I used principles and methods from landscape ecology scholarship that focus on identifying patterns and connections between sites. I further developed a mixed methods approach to develop design intervention proposals that incorporated policy review, key informant interviews, spatial analysis, fieldwork, and design as research methods. Results showed that when regional and municipal airports are organized by ecological adjacency and the frequency of use is considered, there is ample opportunity for design interventions that then can be applied across numerous sites. These design principles, which consider both existing infrastructure and a future of higher ecological diversity, may be implemented in the form of grading strategies, green infrastructure, wildlife corridors, or planting areas. The opportunity for a reprioritization of ecology within airport landscapes advances existing scholarship while offering design strategies to reevaluate and shift airport configurations towards greater infrastructural and ecological balance.

introduction

Regional and municipal airports play a vital role in aviation infrastructure, bridging the gap between regional and international systems. These airports are frequently responding to aviation demands of an area, but rarely responding to other aspects of site context and its surrounding environments. Airports and their landscapes are characterized by their distinctive vastness, as this type of large, open, and flat landscape is rarely seen in other designed contexts. The ecological health of these sites is extremely poor, with incredibly low biodiversity and previous development that has historically fragmented the land (Waldheim et al. 2017, 28). This use of land is not only ecologically sterile, but disruptive as well, demanding of resources and maintenance to achieve the infertile, frequently mown, grass blanket aesthetic that is seen at the majority of airports. For almost a century, this configuration has been the precedent set by airport planners and designers. However, opportunities exist to reframe the ways in which we design and include these spaces in ecology, landscape architecture, and urban design.

By approaching the analysis of airport landscapes through a lens of landscape ecology, this project asks: how can regional and municipal airports become more dynamic spaces through design interventions that balance existing infrastructural use with proposed ecological value? This question works to intertwine the strictly regulated infrastructure of airports with future ecological interventions, including those that may arise from reduced flight use, as well as potential decommissioning. This project investigates the patterns of ecological adjacencies surrounding regional and municipal airports in Minnesota to propose contextually appropriate and responsive design interventions that seek to bridge the existing gap between grey and green infrastructure in airport landscapes and their history of development. This thesis argues that these design interventions, when categorized by adjacency and frequency of use, are general enough in nature that they can be applied across numerous airport sites with similar ecological and traffic conditions.

Currently, the United States has more than 4,000 regional and municipal airports and they are, on average, approximately 400 acres, meaning approximately one and a half million acres of land are currently occupied by these categories of airports. These airports are not only ecological dead zones, they are also economically depressed and suffering from underfunding, but are strictly regulated. It is estimated that from 2023-2027, U.S. airport infrastructure needs are as high as $151 billion ("Terminally Challenged: Addressing the Infrastructure Funding Shortfall of America's Airports," n.d.). It is extremely unlikely that these needs will be met, due to strict eligibility requirements and underfunding of many federal grant programs, including the Airport Improvement Program (AIP), which is what many airports depend on for their funding. In Minnesota specifically, the infrastructure needs of the current 144 airports is estimated to be $4 billion from 2023-2027. However, the current airport debt within the state sits at $1.5 billion and this number will continue to rise due to many airports not being eligible for funding and upgrades using federal funding (Airports Council International, n.d.).

The concerning prognosis of an uncertain future for many airports illustrates a need for urgency in considering not only the current management of these airports, but also their bleak ecological and economic futures. If funding continues to remain scarce and regulations do not allow for adaptation, there is a real possibility of the decommissioning of these airports. In this scenario, they must be prepared to integrate with surrounding environments and land uses. Urban theorist Charles Waldheim argues that the abandonment and decommissioning of these airports is a "pervasive phenomenon" and will only accelerate in coming years (Waldheim et al. 2017, 1). The reprioritization of ecology

is necessary in the current conditions of airports, but it is also crucial to think about the possibility of uncertain use in the future and how these landscapes can not only give back to the surrounding ecologies, but welcomes them back into these infrastructural spaces where possible.

The idea of airports as landscape has been studied previously by many scholars, including landscape architects, geographers, artists, and more. Walheim has played an important role in the recent scholarship on this topic, as he has written multiple publications on airports and helped organize, alongside landscape historian Sonja Dümpelmann, a conference in 2014 at the Harvard Graduate School of Design focusing on airports as landscape typologies. Waldheim argues in "Airport Landscape" that commercial flying, although continuously damaging the environment and emitting carbon, will continue current operations so we must find ways to offset these impacts. In response, he discusses using "airport as landscape" as a medium in which to understand the ecological and economic complexity of these unique environments (Waldheim 2016, 124).

In the last few decades, ecology has expanded its applicability beyond the natural sciences to extend into social sciences, humanities, and design. From its development as a modern science during the twentieth century, and increasingly developing into a "multidisciplinary intellectual framework," numerous disciplines, including landscape architecture, are now recognizing the importance of ecology in their studies and research (Waldheim 2016, 181). The use of the word "ecology" in this project aims to take a progressive stance on airport landscapes and the potential they hold. This approach is supported by landscape urbanist Laura Cipriani and her use of the word "ecological" in her phrasing of "ecological airport landscapes" (2016, 145). She explains that the word "ecological" suggests not present conditions, because airports are rarely described using this adjective, but rather the potential for a future of airport landscapes that can consider ecological conditions alongside infrastructural development. Cipriani further suggests framing the challenges facing airports through an ecological lens to better understand how to address the interrelated issues of including climate change, strict regulation, and widespread urban development (Cipriani 2016, 145).

Because of the importance of ecological consideration in airport landscapes, the scholarship of landscape ecology helps bring together the approaches of both landscape architecture and ecology in this project. Landscape ecologists Richard T.T. Forman and Michel Godron describe this subdiscipline as the "spatial patterns and interactions between ecosystems within a given landscape" (1986, 28). Landscape ecology frequently uses maps or spatial diagrams to explain the relationship between habitat and infrastructure, and the use of these methods similarly focuses on adjacencies, ecological fragmentation, and landscape pattern recognition.

When viewed through a lens of landscape ecology, the characteristics of regional and municipal airports suggest consistency in their geographical location, landscape treatment, maintenance regimes, surrounding ecosystems, and contaminating toxins. Because of these similarities in regulation, landscape conditions, and weak ecological health, I developed this thesis through a categorical approach that can provide a series of strategies to be applied across airports that share ecological and aviatic qualities. Guided by the principles of landscape ecology, this framework approach structures my proposals for design strategies that focus on habitat connectivity, soil and water health, vegetation diversity, and recreational use.

Approaching landscape analysis, I work to illustrate and investigate the middle ground between airport infrastructure and landscape ecology in order to demonstrate the ways in which these spaces have been developed and the repercussions they have had on local ecologies. With this information, I propose a set of design

interventions to act on existing patterns and uniformities across regional and municipal airport landscapes in order to begin mitigation and remediation efforts for more vibrant ecologies in airport landscapes.

The scales used in this project are unique when compared to previous research and analysis that has been done regarding airport landscapes. Numerous precedents and case studies focus on larger airports, such as international airports or military bases (Dümpelmann and Waldheim 2016, 21–34, 120–55; Waldheim 2016, 140–59; 2006, 124–29; Favargiotti 2018, 90–100); however, the scale of regional and municipal airports has been overlooked. Despite their omission from many studies and design proposals to date, the ecological health of these airports is still in dire need of redesign and modification in order to better coexist with surrounding ecosystems and environments (Waldheim 2016). The intensity and scale of possible interventions vary greatly in size, required construction, and economic demands, so these regional and municipal airports are valuable sites on which to propose ecological interventions. Considering the similarities between these sites through a lens of landscape ecology further allows me to consider typological proposals or a framework that could be applied at numerous scales and on similar sites.

Throughout this project, each of the sections explores and responds to the research questions posed in my project. Beginning with a literature review, I categorize and analyze relevant literature that relate to landscape architecture, aviation, or the intersection of the two topics. Because many of the lessons about airport landscape redesign have been learned through designed and built work, in addition to traditional scholarship, I further analyze precedent projects of either currently operating or decommissioned airports that have been redesigned for ecological or social uses. Although these precedents often differ in scale or approach, they are crucial in developing an understanding of existing research and design work within airport sites. Following the literature and precedent review, I explain the research methodology, outlining the five methods I used to conduct primary research. I then thematically categorize the data gathered through the various methods, summarizing both the findings and implications of how these findings informed my design proposals. Finally, I summarize the research I conducted to form concise conclusions, which provide answers and resolutions to the research questions I initially posed. These conclusions explain how my research examined existing scholarship and also the contributions it has made to the emerging intersection of landscape architecture and aviation.

literature review

This literature review summarizes the current knowledge and understanding of airports as landscape to better situate aviatic sites as credible locations for future intervention. To better understand and synthesize these ideas, this review is organized in five sections: airports as landscapes, ecological interventions at airports, regulation and guidelines, landscape ecology, and a precedent analysis. The scale of regional and municipal airports has not yet been researched in relation to their ecological productivity (or, lack thereof) and potential. However, approaching the topic from an infrastructural, ecological, and design perspective begins to position regional and municipal airports as valuable sites with exciting potential to be transformed through landscape interventions.

airports as landscapes

In the past few decades, the question of how to define and categorize airports has been one that has preoccupied landscape scholars. Waldheim argues that although airport buildings are an architectural matter and the boundaries and site of an airport are one of urban planning, the land within the borders of these airports has often gone without definition. To some, defining the airport as a landscape may be a misrepresentation, but to accurately define the airport site in its entirety requires an interpretation beyond architecture and urban planning, which introduces the idea of looking at the airport as a landscape (Dümpelmann and Waldheim 2016, 14). This understanding of landscape urbanism further extends into ongoing discourse regarding the ideas of ecological urbanism, which is concerned with analyzing urban spaces through an ecological approach in order to better connect the urban development to adjacent ecologies (Waldheim 2016, 13).

Beyond spatial discourse about how to define airports, these spaces have been described as cultural blind spots. Although airports are critical infrastructures within aviation systems, they often lack cultural context, which contributes to further confusion about their role in societal systems (Augé 2008). In reaction to this complication, Waldheim argues that the emergence in the mid 20th century of air travel and the ability to see in the aerial view has led to increased importance of the cultural construction of landscape because of a recognition of landscapes that historically had not been previously understood as such (Waldheim 2016, 147-148).

The aerial representation of landscapes has advanced our understanding of the cultural relevance of airports, while further contributing insights on the geographical and ecological importance of these spaces. In the last century, the idea of landscapes has shifted its focus from pictorial representation to one of aerial representation (Waldheim 2016, 140). This relatively new way of seeing the earth has not only been used to inspire designers, but also has been seen as a new way to plan, shape, and organize landscapes. The aerial view holds power in its ability to condition how we see, interpret, and act within environments. Whether imagery or renderings, the aerial view acts as a powerful tool in representing landscape (Corner and Hirsch 2014, 26).

The use of aerial representation has also proved to be powerful in its ability to represent and explain ecologies and infrastructures. The aerial view is argued to be one of the most effective ways to represent the "interrelational ecology of the earth" and provide this information in a way that is easily understood and able to be manipulated. With ongoing advancements of geographical information systems (GIS), the aerial view has become not only synoptical, but sophisticated as well. Corner argues that this perspective has impacted the development and implementation of ecological policies and practices because the view from above allows us to see systems in their entirety (Corner and MacLean 1996, 15). Additionally, Corner argues for the importance of landscapes being

seen as a fluid, dynamic, and changing medium, rather than a "scenic and spatial phenomenon," which will continue because of the growth of GIS in the discipline (Corner and MacLean 1996, 21). Understanding landscapes as flexible spaces that are a part of a larger system works towards including perspectives such as ones of ecology in the context of defining airports as landscapes. The scholarly approaches to airport landscapes shaped how I analyzed airport spaces, as I considered these spaces systematically by looking at both infrastructure and ecology, mainly in the aerial view.

ecological approaches to airport infrastructure

There is an emerging perspective that considers aviatic ecology as simply a condition of the airport landscape typologies, rather than a barrier. The majority of current airport design and planning is dictated by airport operations, including the development of airport buildings, potential for future expansion, or general aircraft operations. Because of the singular importance placed on the functionality of these spaces, they are frequently devoid of all previous environmental processes, whether these processes be hydrological, biological, or ecological. This eradication of ecology has historically been a contributor to the ongoing isolation and alienation of these landscapes from larger ecological systems. Historically, these sterile and bleak landscapes began to emerge at airport sites following an increase of wildlife (mainly bird) strikes in the early 1960s, further disrupting and homogenizing the ecologies of airports (Dümpelmann and Waldheim 2016, 108–12). These policy shifts initiated a battle against situated ecologies that persists today, with the Federal Aviation Administration (FAA) still reluctant to adopt strategies that include "softer" biological methods of reacting to and designing with existing habitats and environments, contributing further to the ecological obstacles that airport design faces (Corner and MacLean 1996, 56–59).

Ecological destruction and isolation are common across many infrastructural forms beyond airports. The development of infrastructure fragments existing ecosystems and landscapes, altering the natural dynamics of environments by causing inflexible boundaries. The purpose of infrastructure, generally, is to facilitate the flow of people and goods. However, in relation to the natural world, these systems often interrupt and slow ecological processes and flows. To respond to these negative impacts on ecologies, urban geographer Maan Barua has proposed considering infrastructure as a medium for non-human life, along with thinking of non-human life as infrastructure. Although abstract, these ways of thinking introduce attitudes about infrastructural ecology that respond to ecological concerns (Barua 2021, 1473-1475). My project acknowledges the existing infrastructure of airports sites and proposes ecological considerations that blur the boundaries between infrastructure and ecology, as Baura has proposed in his work.

regulation and guidelines

The ecological implications and concerns of climate change at airports have been at the forefront of numerous airport development related discussions in past years. It is estimated that aviation accounts for 2.5% of all global greenhouse gas emissions, although this number fails to account for airport construction and operation. Not only do these spaces contribute to emissions, but they also cause water and noise pollution and drastic interruptions on surrounding ecologies (Greer, Rakas, and Horvath 2020). This environmental destruction catalyzes discussions of the existing impact of airports in relation to nearby and intersecting ecologies. Despite continued research on these themes, policies are seldom changed or implemented. This failure to develop sufficient policy and regulation is due

mostly to a lag of policy that continues today and affects the ways in which airports center their attention and, concurrently, their funding. These barriers all lead to a larger question of how to reinforce the institutional capacity for creating and implementing radical climate adaptation policies at airports (Lindbergh et al. 2022). This question, as well as others, can be answered through extensive policy review in order to find patterns of and opportunities for ecological approaches and actions.

In response to existing regulation and the lack of policy implementation, The Green Airport Design Evaluation (GrADE) was developed to answer questions about how to effectively describe methods for designers to consider ecology and impacts on the natural environment within airport sites. GrADE outlines environmental considerations, such as water management, noise abatement, habitat destruction, and wildlife safety, among many others (Ferrulli 2016). These components of airport environments, although incredibly dependent on adjacency and geographical context, are effective ways to consider the feasibility and adaptation of airports.

landscape ecology

The term landscape ecology was pioneered by German geographer Carl Troll in 1939, and is defined as emphasizing the "interaction between spatial pattern and ecological process" (Turner, Gardner, and O'Neill 2001, 2). Landscape ecology frequently focuses on the aerial view of the landscape, with the geographer's spatial perspective and the ecologist's functional one (Turner, Gardner, and O'Neill 2001, 4). Troll defined the term landscape ecology with consideration to both the vertical (within a spatial unit) and horizontal (between spatial units) relationships. He contended that previous ecology scholarship had focused on the vertical relationships, but what made landscape ecology unique were the horizontal patterns (Forman and Godron 1986, 7). The aerial view is used to understand these patterns and frequently the land is characterized by landscape elements, which make up the structure of the landscape. In addition to structure, Forman and Godron define landscape ecology as focusing on the function and change of landscapes (Forman and Godron 1986, 11). These three characteristics of landscape (structure, function, change) help us to better understand not only what exists on the site, but how it has been altered or changed over time, whether by natural or human forces.

Landscape ecology posits that there are three structural elements that are present in all landscapes: patches, corridors, and a background matrix (Forman and Godron 1986, 23). How these elements look and are defined vary greatly from landscape to landscape, but they provide an organized approach to categorizing and analyzing landscapes. Because of the commonalities in airport landscapes, a similar configuration of patches, corridors, and matrices can be seen across airport sites. The structure of the landscape plays a critical role in defining both its ecological function and change over time and also can show the human impact of the site on adjacent landscapes (Forman and Godron 1986, 204). As has been described throughout this project, humans frequently create high contrast landscapes at airports with the intense development of infrastructure (Forman and Godron 1986, 216). Because of the categorical approach I took to this project, I decided to use these ideas from landscape ecology and apply them to organizing airport landscapes through ecological adjacencies. While this approach is more thematic in nature, it brings in landscape ecology theory because of the similarities in how these ecologies emerge and exist within the state of Minnesota. The decision to use thematic categories also ensures that the results I produced could be applicable at airport sites across the state.

The idea of contrasting landscapes, oftentimes leading to fragmentation, is closely related to the

scholarship of road ecology. Landscape and road ecology have been used in tandem in recent years because of their usefulness in analyzing habitat and ecosystem fragmentation (Saunders, Hobbs, and Margules 1991, 26). Although a majority of this research is centered around road infrastructure, the same ideas and analysis can be applied to airport infrastructure. Intense infrastructure development at airports commonly attracts generalist species, such as Canada geese or white-tailed deer, because of its creation of a high edge-to-area ratio (DeVault, Blackwell, and Belant 2013, 121); (Pfeiffer, Kougher, and DeVault 2018, 39–43). Much of the existing work regarding ecology within airport environments is focused on researching the concerns of safety related to bird strikes at airports, so the concept of road ecology and fragmentation is of utmost importance throughout this project. Analyzing airport landscapes through a landscape ecology perspective allows for a more efficient approach to understanding how the surrounding landscapes of airports impact the human and non-human life that rely on these spaces.

precedent analysis

Landscape planning, which is heavily influenced by both landscape ecology and aerial photography, has been and continues to be used in studies regarding ecological restoration at airports. Playing a crucial role in the development of this methodology was landscape planner Ian McHarg with his 1969 book, Design with Nature, which illustrated the "plight" of cities and land use that had developed in the post-industrialist decades (McHarg 1992, 19–30). To McHarg, designing with nature meant "fitting" together existing land uses with appropriate locations in a way that would minimize human impact but still fulfill human needs and desires (Dümpelmann 2014, 224). His development of this "ecological approach" was highlighted in the 1969 publication of Master Planning the Aviation Environment in his chapter entitled "Ecological Planning for Evolutionary Success" (Cerchione et al. 1970). McHarg's work and research has influenced airport designers and planners who have recently begun to focus on an environmental approach to the construction, maintenance, or decommissioning of airports. Whether active or decommissioned, examining current and past work on airport landscapes shows the feasibility and possibility of spaces that are driven by ecological considerations.

For over a century, landscape architects and planners have begun to think about the possibility of airports integrating into cities' public open space because of their expansiveness and centrality in urban areas. When commercial airline travel began to gain popularity in the United States, designers perceived airports using the words "open spaces," "green gaps," and "refreshing lungs" that had the prospect to become public recreational spaces (Dümpelmann 2014, 27). However, after Flight 375 in October 1960, in which 62 people died as a result of a bird-induced plane crash, regulations and forms for airports quickly became more ecologically-sterile, less catered to environmental considerations, and set the precedent for contemporary airport landscapes (Dümpelmann 2014, 1). In the past few decades, designers have started to think creatively within the regulatory constraints, leading to numerous projects centered around airport landscape design. The precedents I analyze in this review vary in their history of development, types of designs implemented, level of use, prediction of the future of the site, and geographic location. I chose these projects with these differences in mind to provide a comprehensive overview of past and current projects regarding airport landscapes.

One of the most well-known designs of an ecological restoration project at an active airport is West 8's design of Schiphol Airport in Amsterdam (see figure 1). Proposed in 1992 and completed just three years later, the focus of the proposal was the planting of 25,000 native birch trees (*Betula pubescens*)(see figure 2) that over time

figure 1: West 8's proposed plan for the terminal area at Schiphol Airport in Amsterdam

would become "more or less densely wooded areas" (Dümpelmann 2014, 70). This species of tree was chosen because of its low maintenance requirements, high resistance to the soil's high salt and water content, and its resistance to birds, which are considered to be the highest wildlife threat to airports. In addition to the tree plantings, the design features daffodils near frequented buildings that add color to the landscape in the springtime, clover that was to improve the soil in the early years after completion, and beehives located within the wooded areas that allowed for the propagation of the clover until their inevitable succession by grass species. West 8's categorized approach to the landscape also contributed to the design's success. The airport was designed based on three separate areas: the central space containing the runways and taxiways, the core of the airport near main buildings, and the surrounding areas of the expansion area that saw less activity (Dümpelmann 2014, 70–72). This project, which not only created an airport identity, was successful due to its aesthetic considerations in combination with pragmatic ones, with attention to human experience, existing noise and land pollution, land use, and native ecologies.

The decommissioning of airports, although sometimes considered radical, are also a central focus within the dialogue surrounding airports that may be economically depressed and struggling from underutilization. Architect Sara Favargiotti contends that "the combination of centrality, emptiness,

figure 2: hundreds of thousands of trees planted both in nearby business parks and the airport's periphery

environmental contamination, and economic capability makes airfields exceptional case studies from a landscape perspective" (Favargiotti 2018, 91). Favargiotti defines four intervention typologies, varying in deconstruction and renovation. Some airports may be completely renovated and deconstructed, as in the case of the Stapleton Redevelopment in Denver, Colorado, which in the 1990s became a large-scale real estate operation and now is zoned for commercial and residential use (see figure 3), also with nearly a third of the previous airport's site dedicated as public park space (Favargiotti 2018, 92).

figure 3: Stapleton Redevelopment in Denver, Colorado

Other decommissioning projects, such as Lleida-Alguaire Airport in Catalonia, may design the airport to be on "hold" for many years with attempted renewal projects being implemented. In the case of Lleida-Alguaire Airport, a land transformation occurred with existing infrastructure in place, with local farmers using the land to graze their sheep (see figure 4) during the nighttime cessation of flight activity (Favargiotti 2018, 99). The other two typologies focused on in Favargiotti's analysis include partial conversions of the airfield during the decommissioning process.

Downsview Park in Toronto, Ontario, is located on the site of a decommissioned airfield, which ceased operations in the 1990s and has been converted into a public recreation space through integrating the airfield into the surrounding community and topography (see figure 5). The design combines both space for public use, as well as wildlife conservation and protection of natural systems (see figure 6). The site, albeit mostly flat, holds great topographical importance, as it is located on a divide

figure 4: sheep grazing during nighttime cessation of activity at Lleida-Alguaire Airport in Catalonia

between two watersheds, so the proposed design also responded to this hydrological consideration. The competition to redesign this airport space is one of the most significant landscape design competitions in contemporary landscape history, and the study of proposals that were included in the design process can be illuminating to future landscape design ideas. The proposal for this site by Bernard Tschumi Architects was titled "The Digital and the Coyote" and focuses on the recent ideas that everything is "urban," even when you

figure 5: aviation-themed playground at Downsview Park in Toronto, Canada

figure 6: open public park space at Downsview Park in Toronto, Canada

are in the "wilderness" (Dümpelmann and Waldheim 2016, 159). Another finalist project was proposed by James Corner and Stan Allen which successfully showed the potential of an airport for a landscape park. Focusing on phased design and successional plantings, animal habitats, and hydrological conditions, Waldheim has argued that this proposal had a "complex interweaving of natural ecologies with the social, cultural, and infrastructural layers of the contemporary city" (Waldheim 2016, 153). Although never materialized, Corner and Allen's proposal for this site successfully brought the framework of landscape urbanism to an airport site, setting a precedent for many projects that would come later.

Another well-known decommissioned airport site is the previous Tempelhof Airport in Berlin, Germany, which ceased operations in 2008. It has since been converted into the largest public open space in the city, visited by over 2,000,000 people every year. The site has had minimal intervention on the land, both because of the site not requiring soil remediation and also because of the desire to preserve the majority of the heritage of the landscape. Despite having contaminated soils, it was determined that this would not affect the air quality, therefore the site was not considered a potential hazard to visitors. Because of this decision, and the integrity of the site's infrastructure being maintained, the park was able to open to the public just two years after ceasing operations and opening up for proposals of the land. From open fields to urban gardening to recreational use, Tempelhofer Feld now sees activity and use throughout the year (see figure 7), proving its success as an urban design project.

Maurice Rose Airfield near Frankfurt, Germany has been decommissioned and converted into a public park with a focus on natural processes and balancing the past infrastructural use with ecological renewal and restoration. Due to financial constraints, the runway and other infrastructural elements could not be

figure 7: Tempelhofer Feld on previous site of Tempelhof Airport in Berlin, Germany

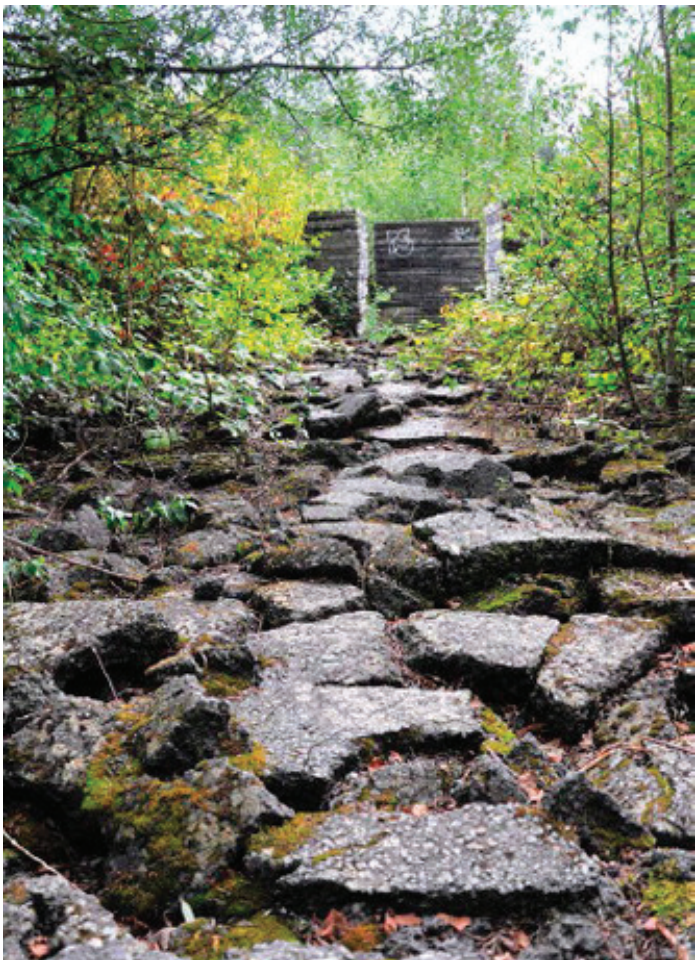


figure 8: existing infratstructure and ecological renewal blend together at Maurice Rose Airfield

figure 9: opportunities for public recreation at the previous site of Maurice Rose Airfield

demolished, and they still exist today as "physical traces of [the airport's] former self and of the presence of its previous life and former activity" (Favargiotti 2018, 94). The park represents a progressive reinterpretation of what an airfield may become, with the concrete and asphalt being incorporated into the form of an urban park (see figure 8). Another focus of this project was the intervention of hydrological and biological processes. Engineers and designers leading the project placed importance on cut and fill operations in order to recover streams and ponds in nearby wetlands, restore wildlife habitat, and implement an extensive and sustainable water system that would work over time to create new, more natural topography on the site (Favargiotti 2018, 95). Throughout the construction of this park, infrastructure and nature were layered together and created a harmonious balance between the remnants of the past and possibilities of the future for human and non-human use of the landscape (see figure 9).

LCLA Office, based in Oslo and directed by scholar and architect Luis Callejas, has also proposed a few projects on airfield sites and looks at these spaces through an architectural and landscape architectural perspective. Their proposal for an airport park in Caracas, Venezuela (see figure 10) was submitted for a competition titled, "Concurso La Carlota" and transforms the air base into a metropolitan park ("CARACAS / Airport Park," n.d.). LCLA's design of a three kilometer airport park in Quito, Ecuador won them second place in the "Lake park international competition to transform Mariscal Sucre airport in a metropolitan park" ("QUITO / 3km Airport Park," n.d.). This design features a flooding of the existing runway in order to restore a wetland ecosystem and to create an active hydrologic park (see figures 11-13). The urban park features six different zones to support different phases of remediation, as well as other programming to support both human and non-human use of the site.

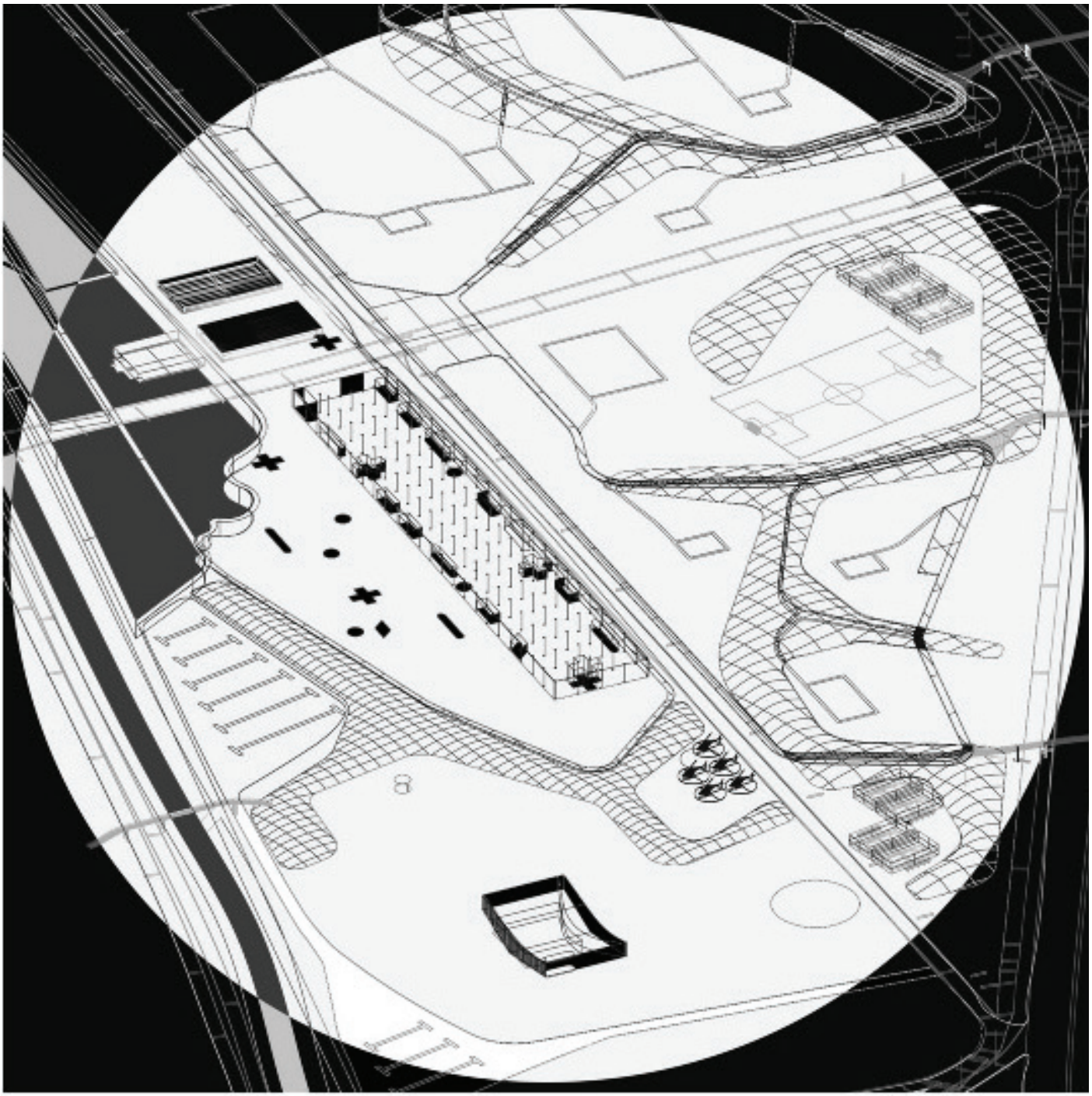


figure 10: diagram for LCLA Office's proposal for an airport park in Caracas, Venezuela

figure 11: plan proposal for Quito's "3km airport park" by LCLA Office

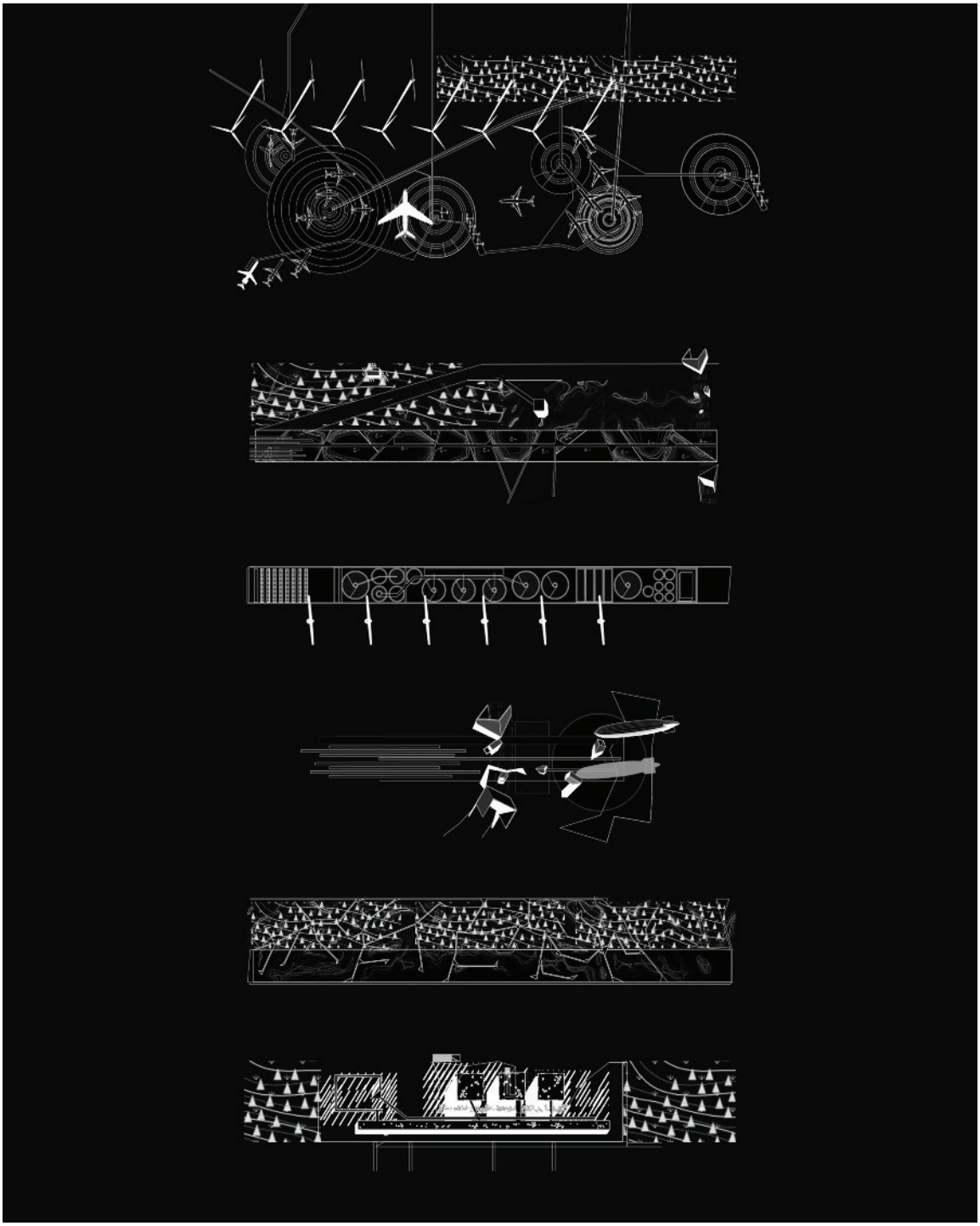


figure 12: diagrams for LCLA Office's proposal for a hydrological metropolitan airport park in Quito, Ecuador

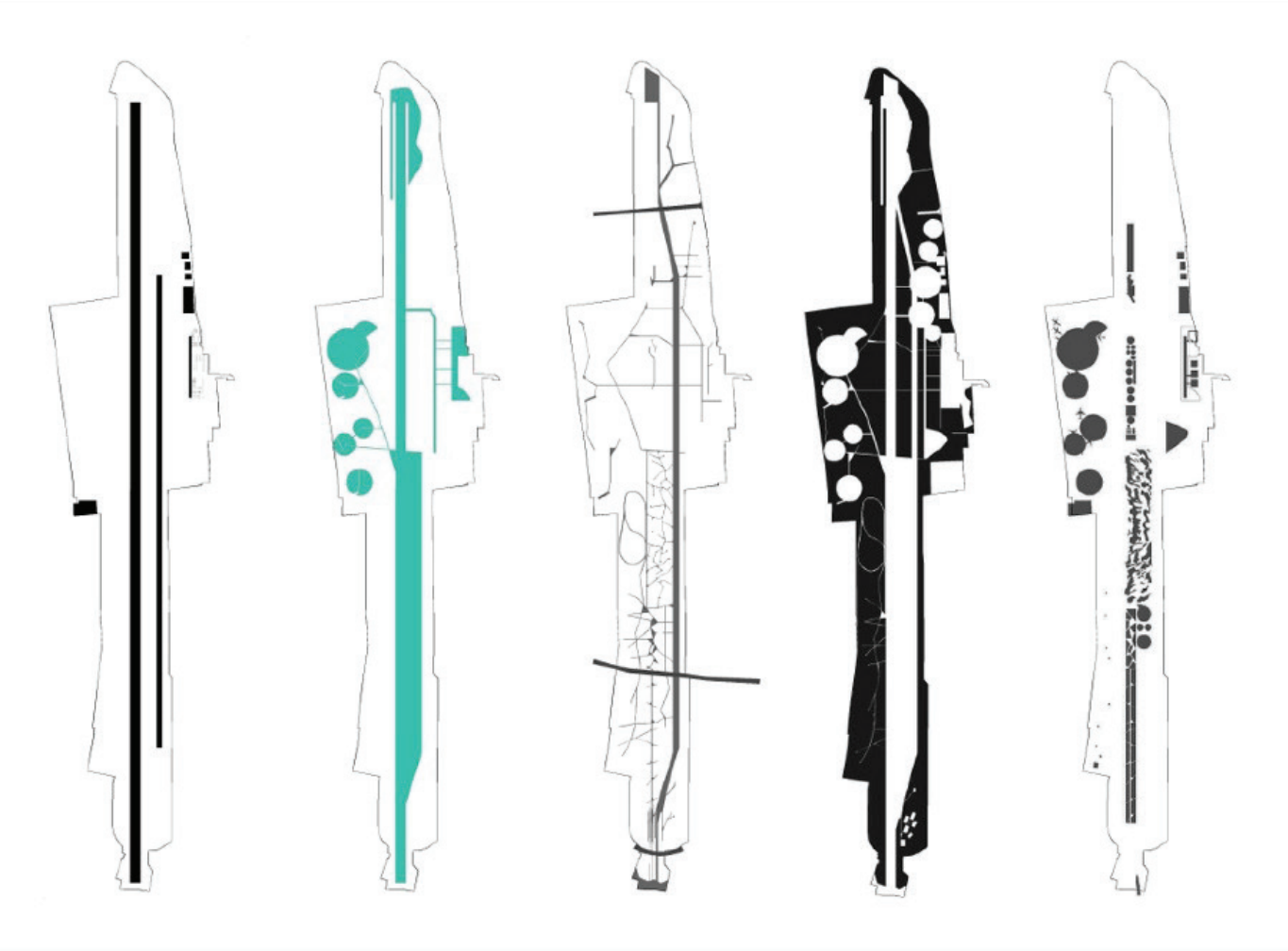
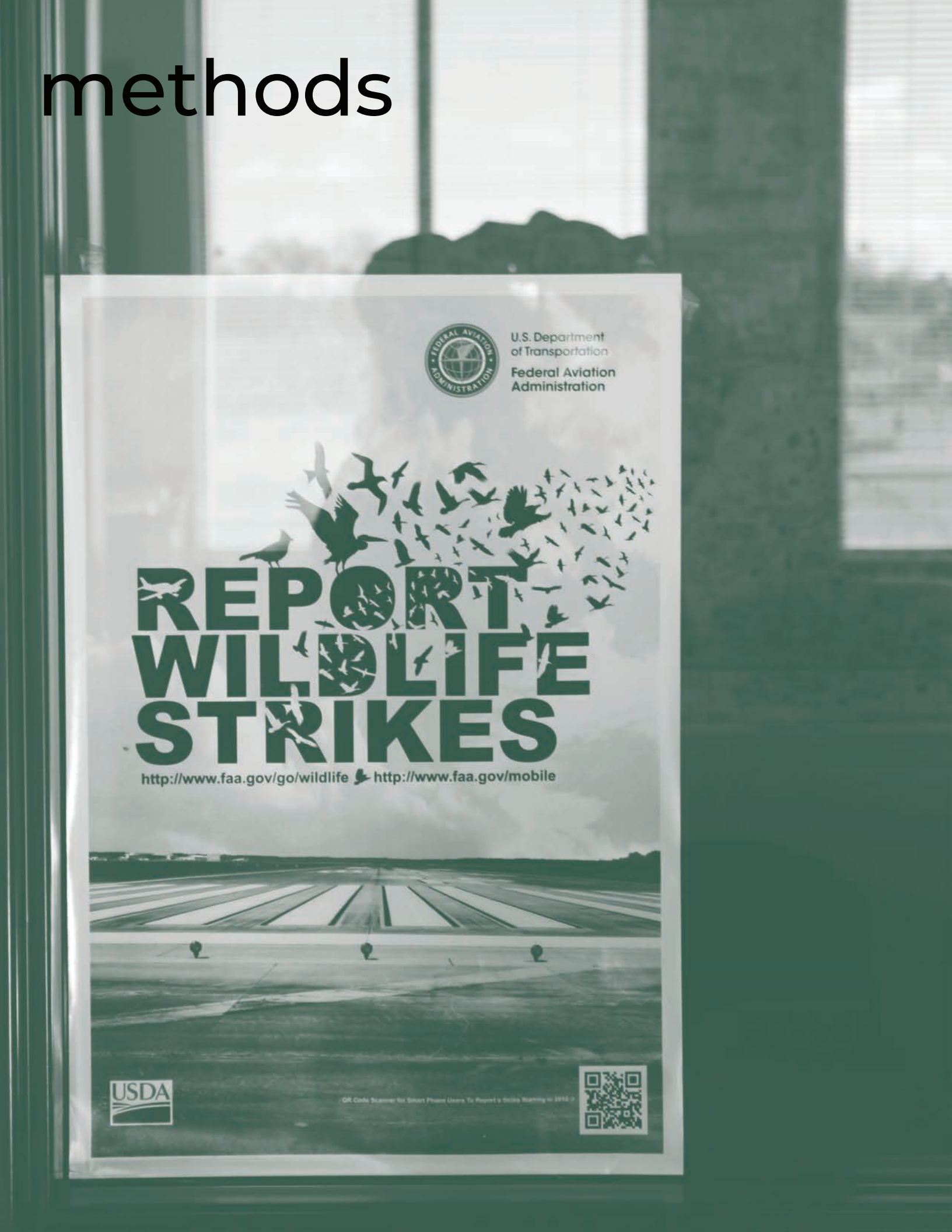


figure 13: layer diagrams drawn by LCLA Office showing different site activation and programming at the proposed airport park in Quito, Ecuador

methods


U.S. Department of Transportation
Federal Aviation Administration
REPORT WILDLIFE STRIKES
http://www.faa.gov/go/wildlife
http://www.faa.gov/mobile
USDA

To investigate how regional and municipal airports can become more dynamic spaces through design interventions, I advanced a mixed methods approach. To investigate existing conditions, I specifically used policy review, key informant interviews, spatial analysis, and fieldwork. Considering the data I gathered, I used design as research as my final method to propose design interventions. These methods helped me better understand maintenance practices and regulations to determine potential barriers that could impede the redesign of airports into sites of increased ecological diversity. As someone with a private pilot's license (PPL), I understand the importance and excitement of general aviation and made sure to incorporate this perspective throughout my project, specifically in my methods. Using my knowledge as both a designer and a pilot allowed me to develop a methodology to this project that is both realistic and holistic in the approach to proposing design interventions within the airport site.

policy review

To ground this project within the parameters of current federal, state, and municipal regulations, I reviewed relevant policy documents in order to determine the relationships between stakeholders in airport design (see figure 14) and also to examine existing regulation.

In order to gain a contextual understanding of regional and municipal airports in Minnesota, I began with the reviewing of airport master plans. In this review, I was specifically interested in the environmental overview section that these documents typically include. These portions of the master plan discuss water and air quality, noise considerations, land and resource adjacencies, and compatible land use, and I analyzed them to understand what environmental themes are frequently raised within this type of policy document.

I then analyzed policies and publications at the state and federal levels, seeking out regulatory publications about airport land use, environmental considerations, and wildlife concerns. Through this analysis, I found that the two most relevant types of policy document at the federal level were Advisory Circulars (ACs) and Federal Aviation Regulation (FAR) Parts, both published by the FAA. ACs are documents that inform the aviation public of non-regulatory material. I analyzed the most recent ACs pertaining to hazardous wildlife activity and attractants at airports, as well as the recommendations put forth by the FAA. Additionally, FAR Parts outline all existing regulations that airports and airmen have to follow.

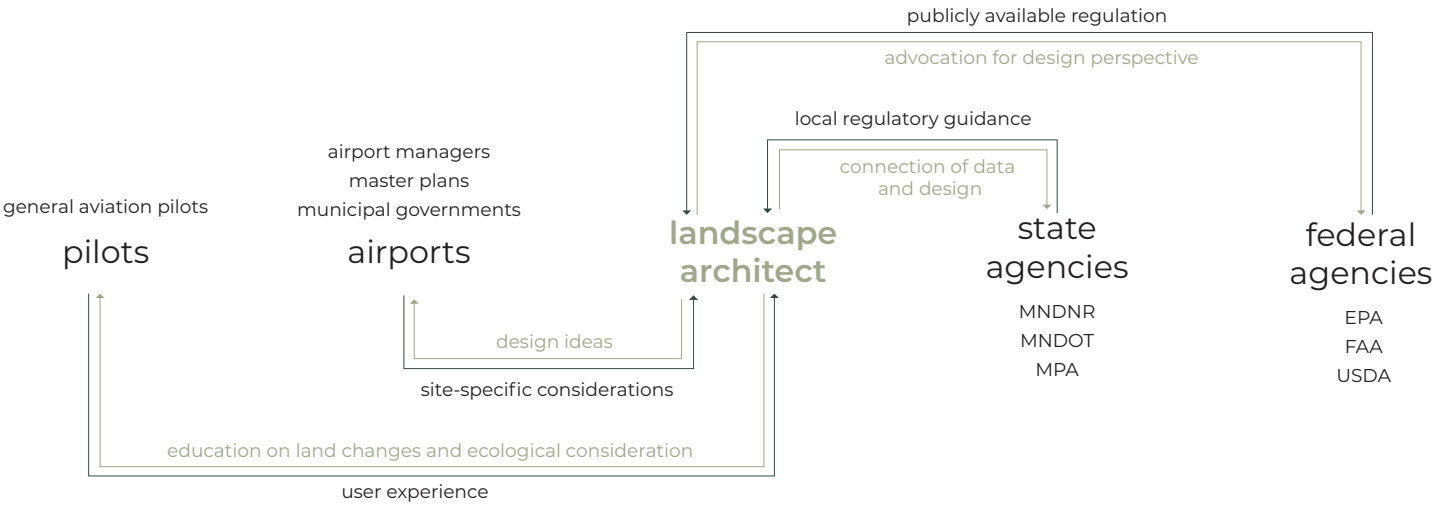


figure 14: relationships between policy, designers, airport managers, and users (pilots)

This policy review of FAA documents and regulations offered insight into the generalized policy that regional and municipal airport managers often consider in daily operations.

key informant interviews

Key informant interviews were crucial to understand the ways that airports are currently maintained and the perceived barriers to changing maintenance regimes on airport sites. Because of my focus on the maintenance of regional and municipal airports, I chose airport managers as key informant interview participants because of their unique insight and experience. Landscape architecture scholars M. Elen Deming and Simon Swaffield suggest in *Landscape Architectural Research* that interview participants can be chosen by "purpose," which in this case was their profession and the role they held. Deming and Swaffield go on to argue that sampling participants in this way is relevant when the question is "related to some aspect of practice or a particular landscape or place" (2011, 154). As the question of airport land maintenance and use is foundationally concerned with questions of practice at specific types of sites, I found this method of sampling to be the most appropriate.

I then relied on snowball sampling to expand the connections I was making and allow participants to recommend other airport managers to interview. Through snowball sampling, I was also connected with an aviation planner who I then interviewed, which gave me important insight on the development and land use at airports. All of the airport managers I interviewed had direct experience with land maintenance practices at airports and were able to share information about specific practices that impact the airport they manage. I conducted these interviews to evaluate current practices and norms at airports to better understand the constraints my designs would need to acknowledge and respond to. The interviews also helped to analyze the involvement that airport managers have with airport operations and maintenance practices to better understand the decisions being made and what regulations or people dictate these decisions.

The interviews I conducted were semi-structured, which meant that they were guided by questions but also left space open for dialogue and unscripted follow-up questions. The prepared questions I had for participants related to current operations, relevant regulations that the airport follows, budget considerations and constraints, challenges within airport maintenance, stormwater management, and wildlife interference. This approach not only allowed for a more productive conversation, but also encouraged lines of questioning and considerations that I had not considered previously. After each recorded interview, I transcribed the conversation and coded the interviewee responses to better understand emergent trends across interviews. This coding initially used the main themes of each prepared question, and I used a secondary coding round to capture any emergent themes that I hadn't predicted.

spatial analysis

To better understand airport landscape sites and their adjacencies and to identify potential sites to test proposals for redesign, I used spatial analysis methodologies. I mapped airports and analyzed spatial data specifically using ArcGIS Pro, a landscape industry-standard geospatial platform. I began analyzing these spaces by first collecting GIS data from the Minnesota Geospatial Information Office, which included municipal and regional airport locations, as well as land use and ownership data. I used a buffer analysis on the airport sites to understand how airports impact and are impacted by their ecological contexts. Buffer analysis is a type of spatial analysis commonly used in proximity studies within GIS. This type of analysis examines the relationship, distance, and any other connections between the center object (in

this case, airports) and other objects within a specified distance (Zhou et al. 2018, 2487). Because of FAA recommendations on "hazardous wildlife attractants," which suggest that "many types of vegetation, habitats and land use practices can provide an attractant to animals that pose a risk to aviation safety" (Federal Aviation Administration 2020), specifically within a 5,000 foot radius of an airport. I subsequently analyzed a 5,000 foot buffer around regional and municipal airport sites across the state of Minnesota to quantify the land use within buffer spaces, which allowed me to contextualize the significance of the project at the scale of the state, understand high-level emergent patterns, and inform site selection for my design interventions. I then calculated the percentages of different ecological adjacencies across all airport sites within Minnesota, and then focused this analysis more specifically on the four different airports I used as case study sites for my design as research explorations.

fieldwork

Before moving into the design phase of this project, conducting fieldwork research provided me with an in-depth understanding of not just airports in general, but specific sites within Minnesota. In order to understand the landscapes in their entirety, experiencing and analyzing them allows us to understand our place in the world and the impacts that we as humans have had on the landscape (Oles and Horrigan 2025, 57). Maps and spatial analysis can provide important information to begin understanding landscapes, but their static nature neglects the more dynamic elements of the ecosystems - weather, water, movement of plants and animals, etc. It is our job as designers to fully understand the natural processes and makeup of the land we are studying (Oles and Horrigan 2025, 160). For this reason, experiencing the site in person and, if possible, from multiple viewpoints, is ideal to understand the entirety of the landscape system.

McHarg insisted that only the view from an airplane could accurately depict the "human land-use pattern and humankind's impact on the earth" (Dümpelmann 2014, 223). His use of mapping, aerial photography, and flight led to a more holistic approach to landscape, one that now considered both human experience and impact, just as landscape ecology does (Forman and Godron 1986, 19). Considering this approach to the study of airport landscapes, I chose to visit them to conduct fieldwork via both air and land-based approaches. Flying a Cessna 150, I visited three airports in Minnesota in varying seasons to experience the landscapes from above. While in flight, I focused on observing airport layouts and adjacencies, as well as comparing these observations to what I had previously studied through GIS mapping and spatial analysis. Depending on the wind direction, I observed how changing wind patterns could also impact not only aircraft flight, but also animal behavior and potential conflicts between the two. Although my flights only took place in VFR (see "list of acronyms") conditions, visiting these sites through this method allowed me to observe how changing or extreme weather conditions may impact airport operations and ecological systems. As a pilot, using flight as a type of fieldwork method also gave me the perspective of someone who may be impacted by a redesigned and altered airport landscape. Beyond safety concerns that may arise because of an ecologically-centered airport design, assuring that pilots are able to have a similar, if not improved, experience at these airports in order to ensure I am acknowledging as many perspectives and experiences as possible.

In addition to visiting airport sites aerially, I also visited five different municipal airports in central Minnesota on the ground and took photographs to better understand the small-scale ecological conditions and patterns seen within these landscapes. Focusing on runway adjacencies, the outskirts of the airport property, as well as

existing ecological concerns or opportunities, I gathered data through photography, which I later categorized thematically to see how these conditions and patterns emerge across numerous sites. Using this method of photography is a way to understand the site through a different, more rooted perspective ("Photography As A Research." 2020) that ultimately helped inform my designs for each airport site. I took photos of vegetation on the sites, evidence of past cut and fill operations, existing stormwater management strategies, different types of infrastructure, and more to holistically understand the connections between observations I made aerially and the ones I made on the ground.

design as research

After I researched existing conditions and regulations, I synthesized all of this information to be used into a strategy for design as research. Specifically using projective design, this approach to research creates new, generalizable knowledge through its "purposes, protocols, and outcomes" (Deming and Swaffield 2011, 205–9). My project achieves these three elements through the reason or purpose behind my project, the protocols developed during the research, and the outcomes produced through this method of design as research. In order for this method to qualify as research, many scholars argue that it must have a "clear research question, a theoretical framework and appropriate methods" (Brink 2017, 56–59). Because my research has all of these required elements, incorporating design into my methods helped produce valid and visual answers to the issues I have identified. Throughout this process, I used an iterative design process that was guided by my research findings.

Using the four adjacencies I used to categorize airports (forest, field, wetland, open water), as well as three different scenarios of use (current/high use, low use, decommissioned), I created renders for four different scenarios at each airport: the landscape without a design intervention (to show examples of what these landscapes look like currently), an intervention if the airport was to continue its current levels of use and traffic, an intervention in a scenario in which the airport has declined in use and traffic but still operates as an airport, and a decommissioned site in which flight activities have ceased. This research does not propose that every airport should enter a phased design approach that ends in decommissioning, but rather shows the possibility of design in different future scenarios, where the economic or aviatic stability of an airport may have changed. Using results I found from policy review, interviews, spatial analysis, and fieldwork, I worked to create feasible design solutions for each of these unique adjacencies.

results

In this results section, I present the findings from research across methods, as discussed above. The data I found focused on analyzing current maintenance practices at airports, existing challenges in airport management, important regulations and guidelines that govern the airport environment, and any opportunities that exist at these sites. Generally, the results showed that although each airport is unique in current maintenance, environmental conditions, and challenges, there are numerous patterns–both spatial and bureaucratic–between airports, meaning that possible opportunities and interventions can be relevant across sites. Different adjacencies will noticeably have different regulatory and environmental needs, as was validated through interviews, further supporting the framework approach I took throughout the design process of this project. The results from this project provide further insight into both analyzing prevailing practices at airports and the challenges that come along with them, as well as considering how future design interventions can fit into mandatory regulatory and financial constraints.

policy review

By reviewing different types and levels of policy, I was able to identify rules, regulations, and potential challenges that govern the current operations at regional and municipal airports wtihin the state of Minnesota. I was also able to examine the patterns and relationships that exist between different levels of polocy, which uncovered the bureaucratic processes of all the policy being spoken of in conversations at airports. While there is a large amount of policy governing these airport landscapes, I still found plenty of opportunities for design interventions through analyzing where design might fit into and align with these policies.

aircraft noise. Although still short in comparison to some

policy review

airport master plans

My policy review began at the level of individual airports by analyzing different airports' master plans. I found large discrepancies between municipal and regional airports, and also found that the level of depth of environmental considerations also depended on the engineering firm that drafted the plan, as some were more comprehensive than others. At the municipal level, I found in one master plan nearly 300 pages in length, that only four pages were used to discuss environmental considerations, and much of this was to discuss hypothetical projects or development in the future rather than focusing on improvements that could be made now. This airport, albeit being located directly adjacent to wetlands and a lake, had a one page environmental overview that had three categories: land use; fish, wildlife, plant communities, and sensitive ecological resources; and water resources. The information provided was extremely brief and failed to include crucial existing environmental conditions that could be taken into consideration by airport management. The environmental considerations section, while longer in length and detail, discussed only future development and the anticipated actions taken to minimize environmental impact.

In comparison to this master plan, I reviewed the plan of a regional airport only 30 miles away, meaning that the environmental conditions and considerations would have some overlap. Throughout this 20 page document, the following topics were discussed: air quality; compatible land use; cultural resources; department transportation section 4(f) lands; farmlands; biotic resources; water resources and floodplains; water quality; wetlands; and aircraft noise. Although still short in comparison to some of the 200-page environmental overviews written for various international airports around Minnesota, this plan was much more comprehensive in the information provided. The summary for this overview reads, "[The airport] is host, neighbor, benefactor, and beneficiary to environmental resources. Airport operations and development can and do occur in balance with the environmental resources on and surrounding the Airport. Airport improvements will require environmental processes and documentation prior to implementation. Consideration and coordination with agencies and regulation prior to Airport development activities will allow [the airport] to continue to be a good steward of the environment." However, similar to the municipal airport master plan, there is seldom discussion of current actions that can be taken to improve ecological or hydrological conditions. The omission of potential actions that airports could take was a theme that I found throughout many master and environmental plans. Although these plans are considering future development and implications, current issues such as habitat fragmentation or species displacement, both frequent consequences of airport development, are continuously overlooked.

state regulation

While federal regulation seemed of higher influence for airport sites, I first reviewed state regulation to provide context for some of the topics and requirements that were discussed in interviews. I first focused on reviewing a publication by the MPCA titled, "Guidance on the Industrial Stormwater Permit for the Air Transportation Sector (Sector S)" to more thoroughly understand the regulations that larger airports were under, as these are producing the most pollution concern. This document discussed a Stormwater Pollution Prevention Plan (SWPPP) and the requirements of what this plan means. Airports that are under requirement to have a SWPPP are generally only airports with scheduled commercial service. These airports both have inspection and monitoring requirements, ensuring that the airport is managing stormwater and its pollutants as it is directed. All of these requirements are measured quantitatively through water or soil samples. I also found that there are different

requirements for airports that conduct deicing activities and those that do not. Numerous interview participants mentioned that although they do not use deicing fluid at their airport, they knew it was one of the biggest pollutant concerns. Although only one of my interview participants fell into the category of needing intensive stormwater control and regulation, I found it helpful to clarify the depth at which the MPCA analyzes the environmental health of these airports.

Although the next document I reviewed was published by a federal agency (FAA), it was titled "Requests by State Wildlife Agencies to Facilitate and Encourage Habitat for State-Listed Threatened and Endangered Species and Species of Special Concern on Airports," and describes procedures and responses all proposed by a state agency. These responses to the state wildlife agency requests are listed as being separate from federal guidance. The document lists background information and a discussion on the topic of wildlife interference at airports, as well as five different recommendations for responding to state requests, as well as continuing to follow federal guidelines. While the document is quite brief, it shows an important intersection between federal and state regulation and how this is responded to by each.

federal regulation

At the federal level, I first reviewed a publication titled "Wildlife at Airports" published by the USDA for a Wildlife Damage Management Technical Series. This document discussed how to monitor wildlife strikes, how to manage them, and other information and resources about legal considerations and general airport assistance ("Wildlife at Airports" 2017). Within a section specifically describing what wildlife attractants are and the different types, the document discusses the different needs of animals–food, water, and cover–and how providing these, usually unintentionally, can attract wildlife to airports. Providing airport managers and planners with these types of resources is crucial to keeping them informed about how their specific airport may benefit from some kind of intervention. In the "Management Methods" section, the policy proposes methods of habitat modification, fencing, translocation, visual deterrents, auditory and tactile repellents, chemical repellents, population control, and avian radar. Within these recommendations, the document repeats required federal regulation, which can help support airport managers who have limited direct contact with the FAA ("Wildlife at Airports" 2017). Throughout this document, numerous types of environments, habitats, and adjacencies are considered, which means that airport managers could find what information could be applicable in their situation and focus on those methods or mitigation strategies.

All other policies I reviewed at the federal level were published by the FAA, and I started by looking at an Advisory Circular titled "Airport Design," which gives a general overview of the requirements and suggestions of both new airport construction and proposed improvement projects ("AC 150/5300-13A, Airport Design" 2012). Although the majority of the document writes about types of airport infrastructure (runways, taxiways, lighting, aprons, navigation aids, etc.) and their location or structural requirements, one of the purposes of the document listed is to "comply with federal environmental standards," which specifically are the categories listed in NEPA, as I heard about in interviews ("AC 150/5300-13A, Airport Design" 2012). There is no specific section in this document for environmental considerations, but rather these standards and compliances are embedded within the document when applicable to each infrastructural element. The document also lists the roles of federal, state, and local agencies and describes the responsibilities of each.

The other FAA publications I reviewed, either through interviews or my own research, focused specifically on wildlife rather than general environmental considerations. Within an Advisory Circular titled "Hazardous Wildlife Attracts on or near Airports,"

extensive information is provided regarding separation criteria of these attractants, land use practices when attractants are near, procedures for surveys and assessments, and other procedures recommended for airport "operators" (or managers)("AC 150/5200-33C, Hazardous Wildlife Attractants on or near Airports" 2020). Depending on adjacency, these practices and procedures could be applied to numerous airports with adjustments being made for adjacency, airport size, and daily traffic. In addition to potential measures to be taken within the airport site, the publication also described coordination efforts with local governments or agencies to prevent new creation of hazardous wildlife attractants. In addition to this Advisory Circular, I found two CertAlerts that provided additional guidance on wildlife at airports. One was titled "Grasses Attractive to Hazardous Wildlife" ("CertAlert No. 98-05, Grasses Attractive To Hazardous Wildlife" 1998) and the other "Recommended Wildlife Exclusion Fencing" ("CertAlert No. 16-03, Recommended Wildlife Exclusion Fencing" 2016). Although extremely brief (and published at the federal level, with no consideration of different climates and ecosystems), these documents can assist airport managers in better understanding the non-lethal methods they can use to keep their airport operating as safely as possible. I also noted that these CertAlerts are always addressed to "Airport Operators and FAA Airport Certification Safety Inspectors (ASIs)" ("CertAlert No. 98-05, Grasses Attractive To Hazardous Wildlife" 1998), meaning that the airport managers could be using federal guidelines more thoroughly to determine what is best at each airport. The majority of these guidelines and regulations will be acknowledged by agencies outside of the individual airport, but it is important to acknowledge the policy and regulation available to the general public.

key informant interviews

Throughout the interviews I conducted, there were seven key themes that were raised. Five themes I anticipated (see appendix A for interview questions), and they were therefore included in my first round of coding. These included: maintenance practices, budget, regulations, airport development, and wildlife. Through the interviews, I also found conversations emerged on environmental surveying and planning, as well as existing environmental concerns and considerations, so I further coded these themes in a second round. Attention to these themes allowed me to gain an understanding of the past development on the sites, existing practices and conversations, as well as possibilities and opportunities for the future.

key informant interviews

maintenance practices

Across all interviews with airport managers, participants discussed maintenance practices, focusing on the stark differences between summer and winter maintenance operations. As one participant said, "There's two seasons: there's snow and there's getting ready for snow." During the summer months, all participants said the mowing is done weekly, either by themselves or city employees. One participant mentioned that at the airport they manage, which is around 50 acres, the mowing takes approximately 10 hours per week. Although FAA regulation allows for grass up to 6 inches, a participant mentioned that they always try to keep the grass height under six inches. Any other vegetation management, black top patching, or light maintenance also occurs mainly during the summer as well, preparing the airports for the potential heavy snow of the northern Minnesota climate. During the winter, the maintenance is on a less strict routine, as the weather dictates when and how much maintenance needs to occur. Frequently, snow plowing is completed on city roads first, and then at the airport. For many regional and municipal airports, this is the only consistent practice in the wintertime, although one participant mentioned the use of deicing fluid because of the presence of larger jets and commercial airlines. Other than this, participants did not mention any heavy use of chemicals to maintain the land.

budget

Interviewees frequently discussed the airport's budget, as this has a direct impact on how the airport is maintained. The configuration of budgets varied from participant to participant, as some airports receive more state funding than others, and some receive none at all. One participant stated that, as a generalized approximation, small to middle sized airports usually receive an amount close to $150,000 per year from the state. Two participants stated numbers ranging from $55,000 to $70,000 being used for yearly lawn maintenance and anywhere from $40,000 to $140,000 on snow and ice maintenance in the winter. One manager from a regional airport discussed the amounts of 90 percent federal funding, 5 percent state funding, and 5 percent local funding, which could either come from the county or city. A manager at a municipal airport stated that the funding they receive is 90 percent state funds and 10 percent city funds. These percentages usually apply for both routine maintenance and larger projects. However, there are various federal grants available for larger projects, but these always come with grant assurances, as two participants mentioned. These assurances state how someone is to explicitly use the funds, as well as the period of time one has to use the funds. If the money is not used, the airport loses it. Although these budgets are spoken of in an annual timeline, I found that they are roughly calculated whenever an airport undergoes the process of creating a new master plan.

regulations

In addition to budget regulations, airports are under numerous restrictions, from the municipal to the federal level. During the coding process of my key informant interviews, regulation and policy were the topics that was discussed the most, showing its significance to both my project and the daily routines and practices of airport managers and planners. As expected, I found that larger airports, such as regional airports, are under more regulations than smaller airports, such as ones at the municipal level. One participant stated that in a recent environmental assessment, 23 different agencies, both governmental and not, were involved with the process of writing up that document. As may be expected, they mentioned that these agencies are frequently not all in agreement with each other, leading to a strung out bureaucratic process when trying to write up new master plans or project documents. Multiple municipal airport managers mentioned a 5010 inspection that is conducted

by the FAA every three years, which usually is when environmental assessments or surveying is done. The FAA also has a presence when an airport proposes any action, whether a construction or maintenance project. The National Environmental Policy Act of 1969 (NEPA) is crucial in the decision by the FAA, determining whether this act applies to the proposed action. If it does meet anticipated environmental impact or project magnitude requirements, the FAA decides the appropriate level of review. The airport planner I spoke with mentioned four levels of review: a written report, a Categorical Exclusion (CATEX), an Environmental Assessment, and finally an Environmental Impact Statement (EIS). Although EIS documents are infrequent, I spoke with a regional airport manager that discussed the EIS documentation they have gone through, which is an extensive and in-depth process. Throughout this EIS, as well as mentioned by most of other participants, is the importance of finding a solution to the presence of polyfluoroalkyl substances, or PFAS, at airports. Although regulation has since changed, these chemicals were used in firefighting foams in the past, and still have a dangerous presence at airports today. Removing these chemicals is incredibly tedious, but many managers recognize the environmental importance of doing so, as one said, "We need to see how we can actually be mindful of the environment, even through the stuff that we do as humans." In addition to PFAS, another topic of frequent conversation is around deicing fluids and the chemicals found in them. Fortunately, these are seldom used at municipal airports, as many participants stated that they do not use these types of chemicals at the airport they manage.

In addition to federal regulatory presence, I found in almost all of my interviews that the participants talked about a heavy presence of the Environmental Protection Agency (EPA) and Minnesota Pollution Control Agency (MPCA) at airports, which dictates many of the environmental regulations and decisions that occur. Third party engineering firms also work in partnership with these agencies to write regulations and recommendations for airports, including extensive environmental surveying and planning. However, one airport manager felt that this process wastes a lot of the money that airports could be using for environmental projects and improvements, as they said, "I just think we waste so much money on airports needlessly that could go to parts of the environment to really do some good, but it's become a cash cow for the engineering firms to do these things." Numerous participants stated that a large barrier to implementing projects that may help surrounding environments and ecologies is simply the money needed for these projects, as well as the approval by the FAA and other agencies. If the FAA is not 100 percent sure that these projects will succeed, they will deny the request. There are very few precedents of ecologically-centered maintenance projects at airports because of this, which then prevents the projects from being approved still to this day.

airport development

Another topic that participants discussed as a barrier to new projects within an airport site is the discrepancy between the existing airport development (disturbed land) and surrounding land (undisturbed land). While the majority of current environmental regulations that airports are beholden to were written in the past few decades, many airports were built long before they were in place. As a result, regulations about ecological adjacencies have changed, and now the location and geography of some currently operational airports do not comply with current regulatory requirements. For example, one participant mentioned that airports cannot be within 10,000 feet of a landfill, federal wildlife area, or other areas considered "wildlife attractants," but because these regulations have been determined in recent years, many airports around the state were built within this current required buffer distance. Because of this, new projects can be hard to get

approved because of the frequent need to develop on undisturbed land, which is more highly regulated now than in the past.

Although it still includes extensive paperwork, proposing a project on disturbed land is a much shorter process. A participant stated that the airport that they manage had solar panels installed on disturbed land, which was a simple process to get approval. However, another participant discussed the challenge of proposing different grading strategies to help manage stormwater and runoff, but because it was an unprecedented project, as well as it being on undisturbed land, the proposal was declined by the FAA due to the uncertainty of the success of the project, as well as the long term effects. This participant stated, "We had a plan to actually try and stop the runoff into that lake, and the FAA and the local agencies wouldn't approve it because they weren't sure it would work. So instead, we had to buy wetland credits." This topic of the purchasing of wetland credits was another challenge discussed by four participants. At airports near open water or specifically wetlands, if they need to build on land with wetlands, they have to purchase around 150 percent of the acreage they are impacting and dedicate this land to wetland. One participant argued that the money used to purchase this land could be used for a future project at the airport that focuses on improving environmental health, so buying these credits harms not only the budget, but also the potential for future environmental considerations. All of these challenges related to the development of the land and the regulations that have been written since the opening of the airports frequently leads to discourse and a lag in not only creating proposals and project documentation, but also the process of getting these applications approved (or, more frequently, denied).

wildlife

The final topic that appeared in my first round of coding with both the airport managers and the airport planner was the topic of wildlife/bird interference and consideration at airports. All airport managers stated that they have not had any significant or dangerous encounters with wildlife at the airport they manage, but have had instances in which they had to try different strategies to keep pilots safe when landing or departing. The specific topic of birds surfaced in every interview I had, proving its importance in environmental planning of airports. The airport planner I interviewed mentioned that although birds are often spoken of generally, it is important to acknowledge the species that each airport is dealing with, as each species has different requirements for the habitat they tend to occupy. For example, they discussed the fact that some species of birds prefer short grass because they can see predators, and others prefer long grass for nesting and habitat purposes. One airport manager mentioned that Minnesota's Department of Natural Resources (DNR) has been involved with the airport and has suggested different approaches to minimizing habitat loss. For example, the DNR once suggested that to support native butterfly habitat, the airport should use a different type of grass and allow it to grow a bit longer than what was previously being done at the airport. However, the airport manager stated that, "What the DNR wanted us to do would be in direct conflict to what the FAA and the state of Minnesota wanted us to do. So we politely declined to do that." They felt that this change in lawn maintenance would attract birds (specifically Canada geese) to the airport, posing a safety hazard to pilots. Another interview participant mentioned that they have had quite a few geese at the airport, but haven't had much luck in deterring them from the land. They mentioned the attempt to use inflatable coyotes, but just after a few days the geese weren't bothered by them anymore and

returned to the airport. Other than this method, this manager said the airport hasn't tried any other methods yet because of the low success rate, as they stated, "What can you really do to keep them out of there?" The answer, unfortunately for many airport managers, is nothing.

While most preventative wildlife measures haven't had extreme success, another participant described success regarding the mitigation of migratory waterfowl, including geese. Three years ago, the adjacent city to the airport built a railroad bypass, which in turn created a borrow pit that eventually filled with water. The pit was located approximately a mile and a half away from the end of the airport runway, which raised concerns. The airport was worried that the proximity of a water feature would attract migratory waterfowl, but, as the manager stated. "In reality, what it's done is given the geese a better place to park than the airport. And so since that was completed, our goose problems have actually been reduced pretty significantly." In addition to this success at the airport, the same airport manager mentioned that in the past, a few local hunters have brought out their dogs to the airport, which left a scent that repelled geese from the airport. Lastly, they mentioned a permit they have to use lethal methods on birds (75 geese and 150 seagulls per year) if they become an issue. However, they noted not having to use a lethal method now in the past three years (since the borrow pit was created). Lethal methods are, as expected, a highly contentious topic when it comes to wildlife and in this same interview, the manager described that generally, the rural airports don't experience pushback on this method (in fact, some local hunters ask if they can use the airport land to hunt geese) and there is more discourse in urban environments. Although a generalization of the issue, this distinction is important to keep in mind when proposing methods of mitigating wildlife and birds at regional and municipal airports.

Another species of bird frequently discussed in Minnesota airport planning is the bald eagle. Across the state of Minnesota, there is a deep respect for the bald eagle, but they can pose a threat to airports with their nesting and feeding habits. An airport manager who manages an airport right along the Mississippi River stated, "We want to minimize the impact, because it's fun to watch those eagles soar above. They are nasty, nasty birds. We can respect them, but they are very, very messy." This contradictory attitude puts airport managers and planners in a difficult position at times, as it asks the question of whether to prioritize human or non-human health and safety.

In addition to birds, other animals that airport managers discussed as being a past or current issue included deer, jack rabbits, and gophers. These species are typically less of a concern than birds when it comes to safety, but one participant discussed the issues of gophers and their ability to "create havoc," which takes the airport maintenance crew time to repair the destroyed land or fence. Although deer and jack rabbits were mentioned in interviews, no participants described specific or hazardous experiences they have had with reducing the presence of these animals. When I asked each participant about any environmental concerns or issues they have had, almost each participant began by talking about wildlife interference at airports, showing that it is a main concern and consideration of many. However, the mindset was never explained as needing to completely get rid of these animals in whatever way possible. Instead, many explained wanting to deal with wildlife issues in a safe and humane manner. One participant summed this up well by saying, "We in Minnesota, we just have a great group of compassionate men and women that are really trying to be good stewards of the resources that we have, and that includes environmental."

environmental surveying and planning

The first topic that I coded in my second round was regarding the process and importance of environmental surveying and planning at airports. Before the interviews of this project, I was unaware of this process and how it plays a role in environmental decision making at airports, no matter the size. The airport planner I interviewed stated that as a planner within an engineering firm, they are phase one of any airport project or master plan. In this phase, the two things that need to be determined are what the airport needs, and where to locate these needs. When building a master plan, the main considerations are existing facilities, current users, and forecasted users. The airport planner participant also mentioned that the engineering firms that help create these documents also are in contact with numerous other agencies, with an example being the United States Department of Agriculture (specifically a wildlife specialist) conducting wildlife hazard safety visits. These visits span the course of a year, with a specialist spending a few days on the airfield each season to accurately survey the land. An airport manager also discussed this USDA survey but from a budget perspective, saying that the airport had to pay $30,000 for this survey to be done, which is in addition to other finances needed for environmental surveying and planning.

Other than engineering firms being contracted to survey and plan at airports, a few airport managers stated that they don't have a strong involvement with other agencies. Normally, much of the FAA regulation and documentation that is required to be followed is noted by the engineering firm when putting together airport master plans, capital investment plans (CIPs), or other documentation. Because of this, many airport managers, especially those at smaller airports, have infrequent and indirect contact with the FAA. Two participants discussed a yearly inspection done by Minnesota Department of Transportation (MNDOT), usually focused on identifying safety hazards or obstructions. Another state agency that has a frequent presence when it comes to environmental surveying is the Minnesota Pollution Control Agency (MPCA). One participant discussed quarterly stormwater sampling, due to the airport being regional, as well as the proximity to both the Mississippi River and wetlands. They stated, "Whether that's swamps, rivers, lakes, streams, you name it. MPCA really regulates us, so we are required to do storm water sampling at least once every quarter." The surveying and planning processes in both their nature and frequency differ from airport to airport, but they have a presence at all of them and the decisions of these surveys and plans have a strong impact on how the airport land is used and maintained.

existing environmental concerns and considerations

The second topic in my second round of coding was related to existing environmental concerns or considerations. Because of the ecological sterility of airports, I did not know before starting these interviews whether this was just a precedent set at all airports, or if there had been past or current attempts to change the airport landscape. Although not all participants discussed opportunities or a push for a change in landscape, it was clear that environmental considerations are frequently part of airport planning and maintenance discussions. As discussed above, PFAS have recently been at the forefront of many discussions and a few participants mentioned this as being one of the main (and, for a few, the only) recent topics of regulatory state environmental consideration.

One participant mentioned that because the airport they manage has a close proximity to sewage ponds, this has been a concern raised by state agencies, which proposed that either the airport or the sewage ponds need to move, which the participant stated as being unreasonable due to the huge financial burden that would come from either move. Another participant discussed the regulations their airport currently has in place for what

kinds of crops are allowed to grow within a close proximity to the airport, which were negotiated between the airport and local farmers. When I asked about regulations surrounding the use of chemicals at the airport, they said that because they are a small, regional airport, there were not any that they knew of.

One participant mentioned a proposal for a park next to the airport about 20 years ago that was rejected soon after being proposed due to safety concerns. However, they stated that they think it would have been a strong community recreational space and would raise awareness and excitement about the airport. Another participant mentioned a future proposed (and approved) recreational trail that will run alongside the airport. Because the trail is part of a larger trail system and surveyors did not find its construction or use to be a safety threat to the airport, it was approved.

Lastly, a frequently discussed environmental topic was surrounding the protection of water, whether that be rivers, lakes, other bodies, or wetlands. One participant discussed the mitigation of fuel leakage and pollution through recent efforts to put fuel tanks above ground with containment systems, whereas in the past these tanks were below ground. This participant also mentioned PFAS in the discussion of protecting water from pollutants. Another participant largely discussed only environmental concerns relating to water because of the importance and proximity of water to that specific airport. Through minimal deicing fluid (which contains glycol) use, quarterly stormwater sampling, elimination of PFAS systems, and more, the participant acknowledged the importance of pollution control and environmental stewardship when it comes to the state's water resources. This participant also mentioned needing to find a balance between proposing new projects on undisturbed land and needing to minimize the balance of infrastructure development and habitat support. They then discussed different policies and decisions that have gone into wildlife mitigation at the airport, some of which focus more on humans and their safety and others on the health of the non-human habitats and species that live there. The participant summed this up by saying, "It's the balance of human safety versus environment that went into

spatial analysis

The results of the spatial analysis are presented below in two parts. First, I mapped all 144 airports within the state of Minnesota to visualize land cover of airports across the state. I mapped these airports starting on the northern border of the state and moving south in order to best visualize a change in the land use and cover. Second, I analyzed the four case study airports I later used in my design as research method. I calculated percentages of each land cover adjacent to the airports (see appendix B) in order to visualize how these adjacencies would impact the design proposed for each. Covering 273,714 acres across the state, regional and municipal airports airports account for a large area of land mass, so understanding their use is critical. The results of this section not only helped me better understand patterns and site conditions across these airports in Minnesota, but it also assisted me in choosing sites for the design portion of this project.

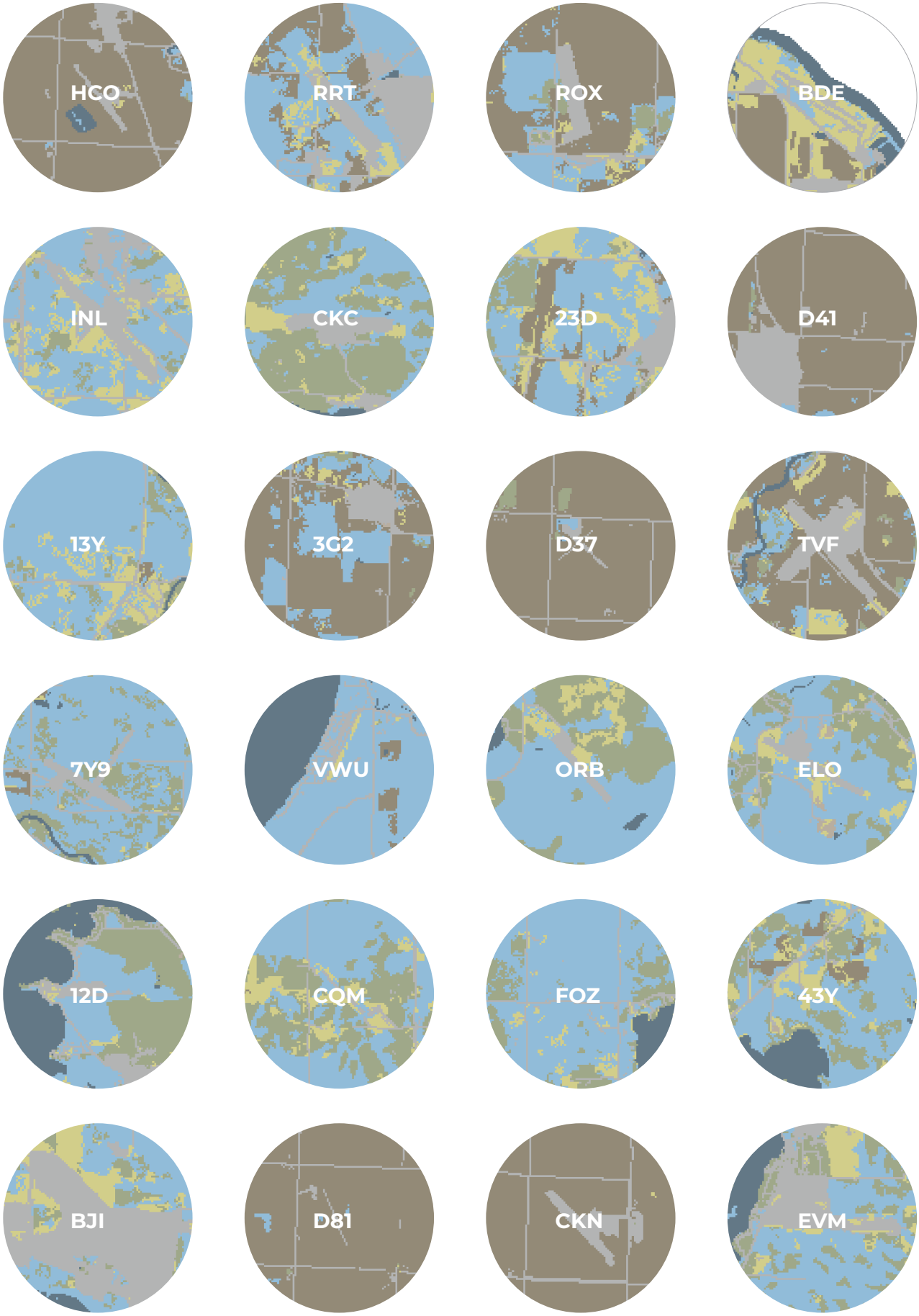


figure 15: land cover data for Hallock Municipal Airport (HCO) through Evelyth-Virginia Airport (EVM)

figure 16: land cover data for Bagley Municipal Airport (7Y4) through Pelican Rapids Airport (47Y)

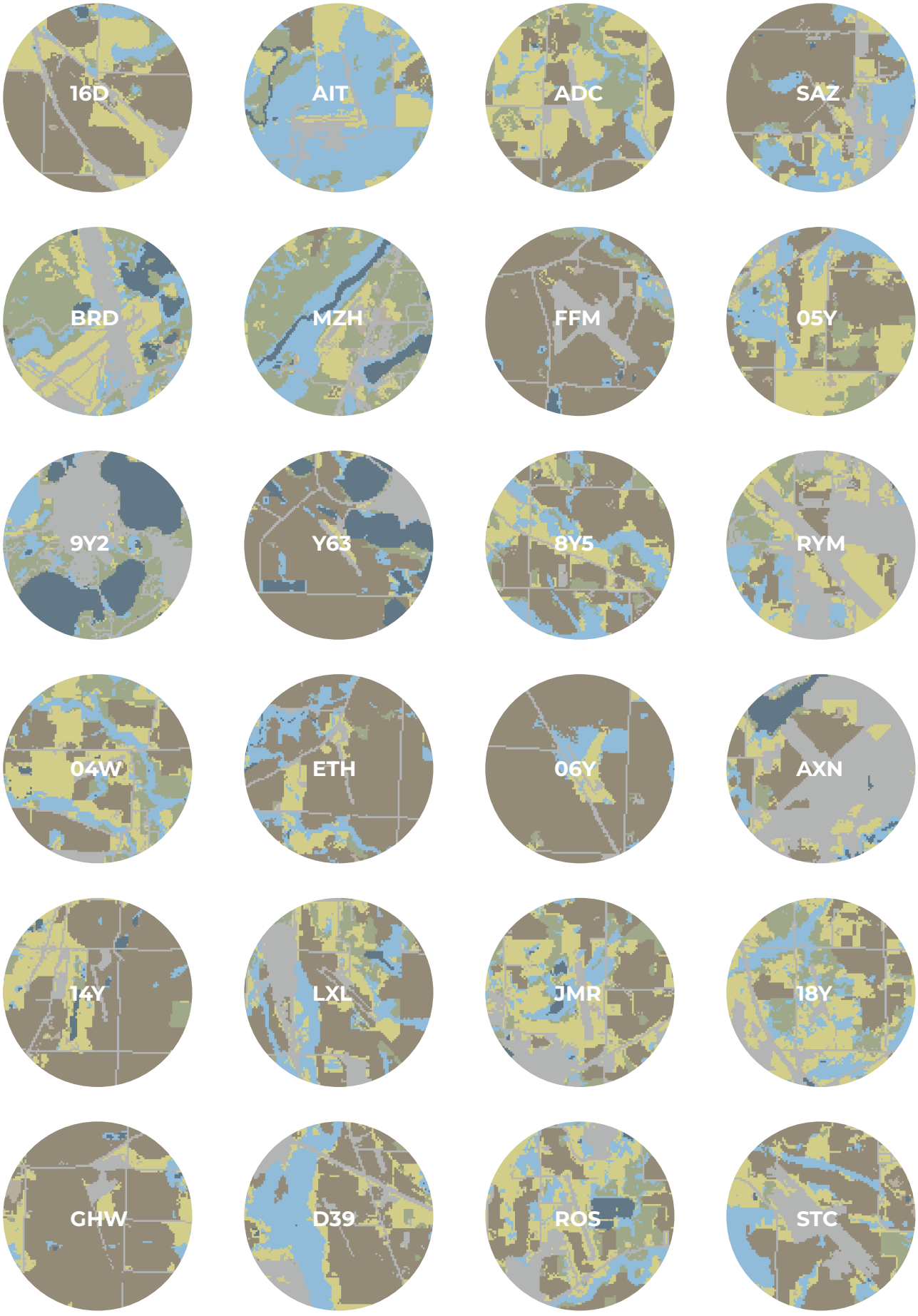


figure 17: land cover data for Perham Municipal Airport (16D) through St. Cloud Regional Airport (STC)

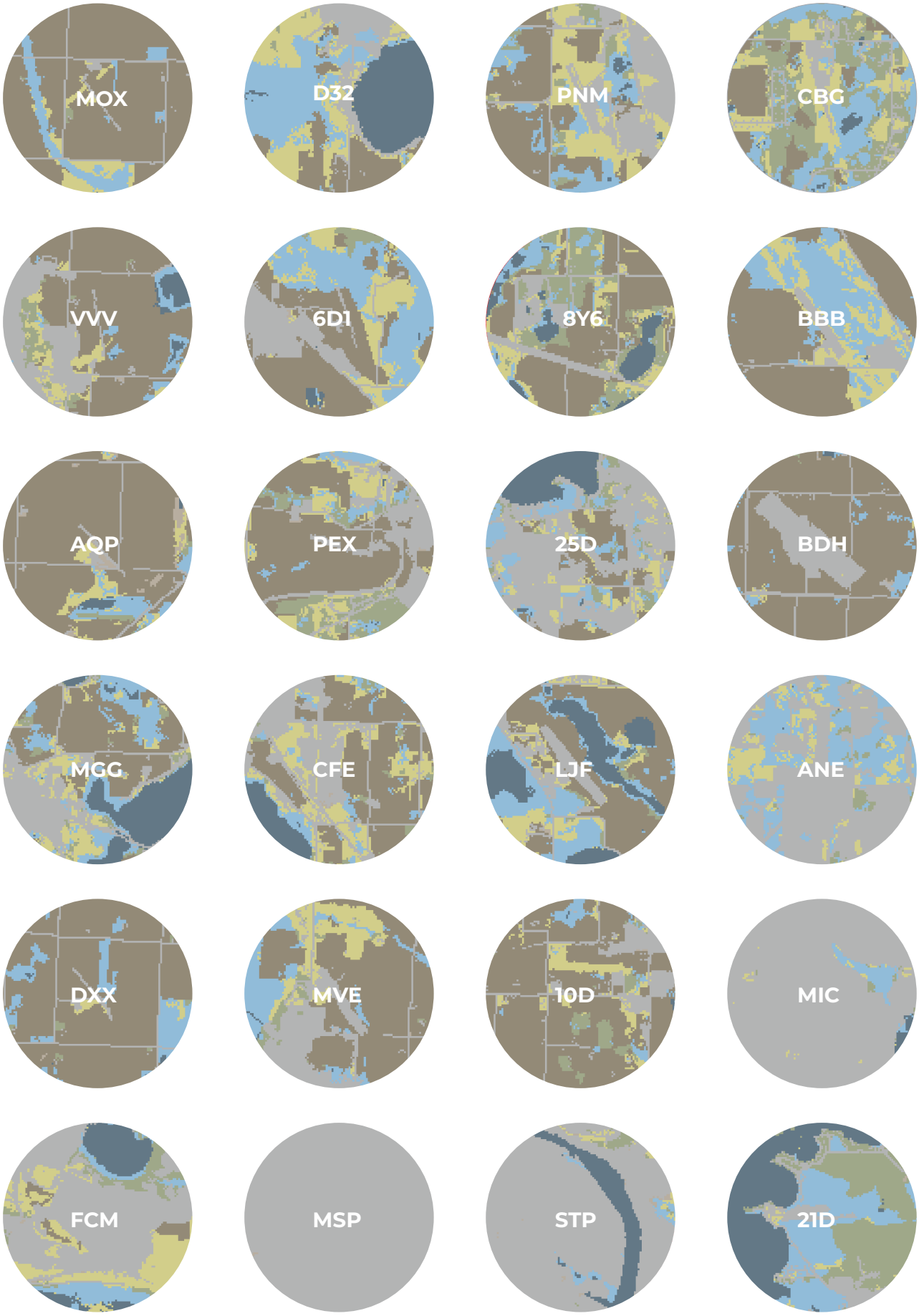


figure 18: land cover data for Morris Municipal Airport (MOX) through Lake Elmo Airport (21D)

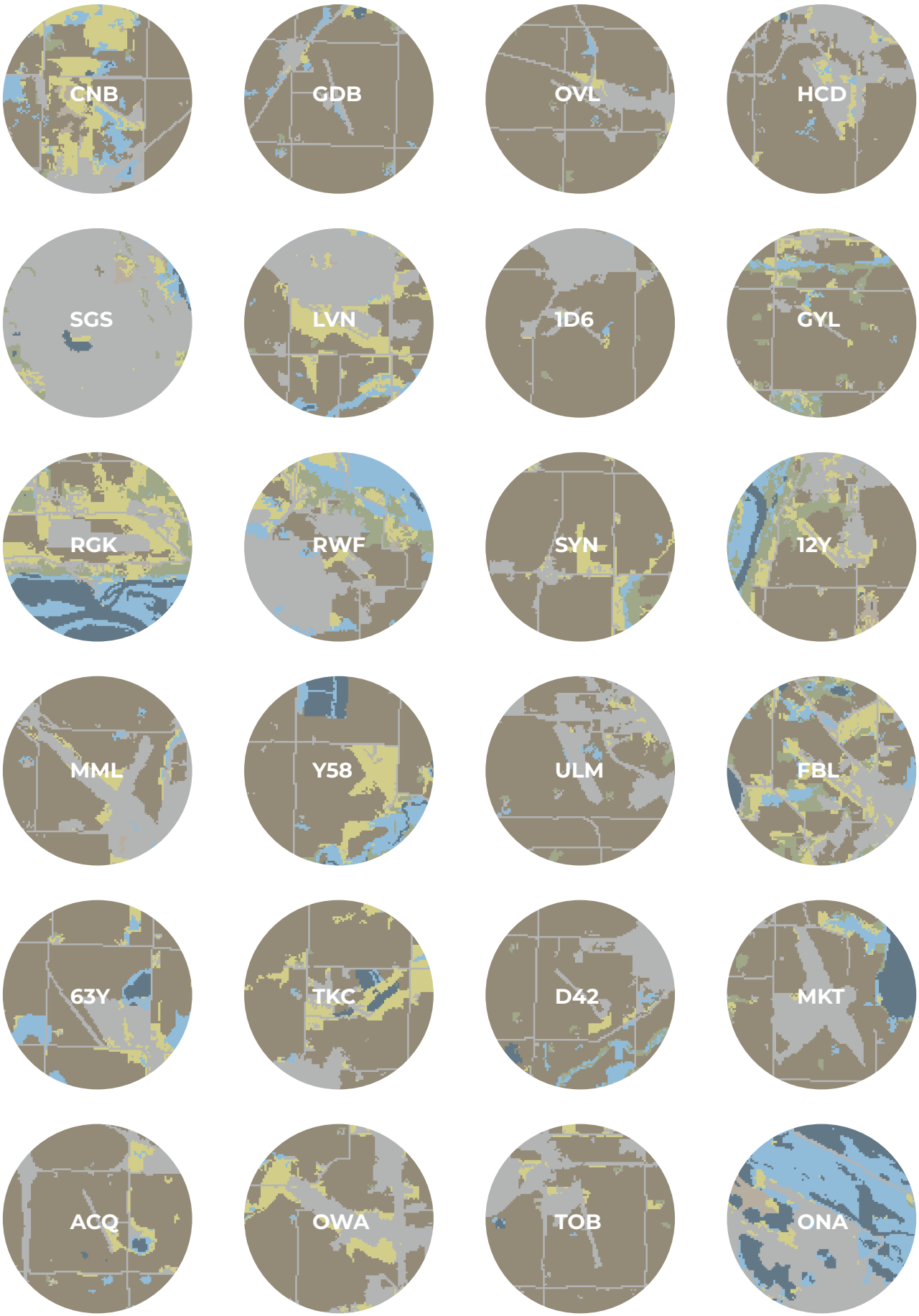


figure 19: land cover data for Canby Municipal Airport (CNB) through Winona Municipal Airport (ONA)

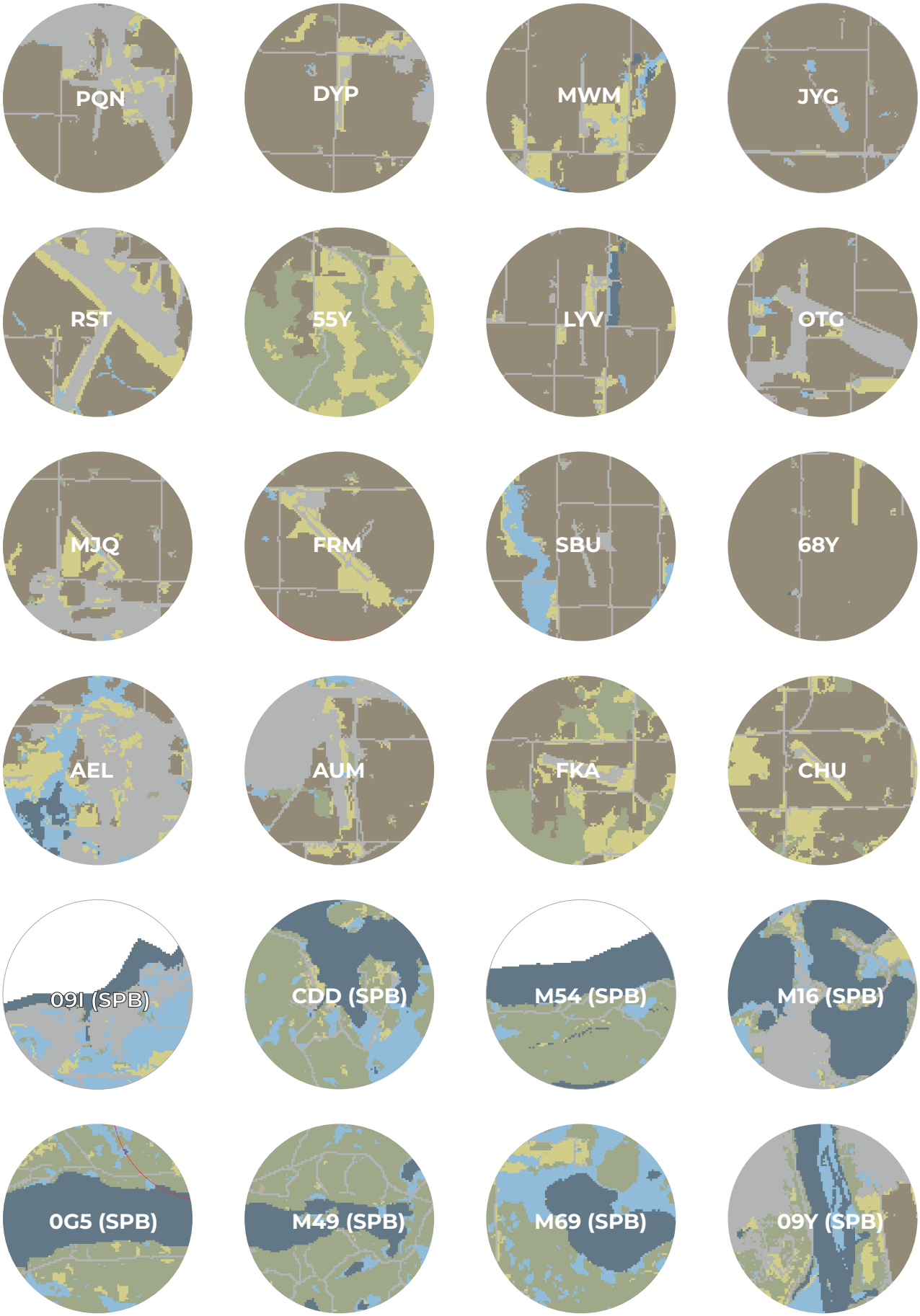
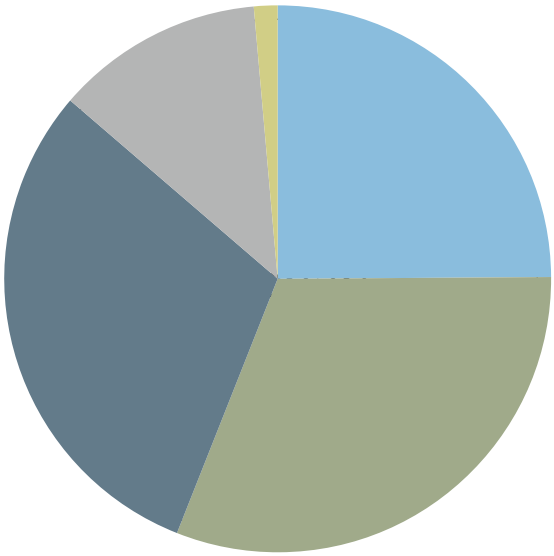


figure 20: land cover data for Pipestone Municipal Airport (PQN) through Wipline Seaplane Base (09Y)

forest adjacency:

Tower Municipal Airport (12D)

city: Tower, Minnesota
coordinates: 47.8181556N, -92.2860667W
elevation: 1,369’



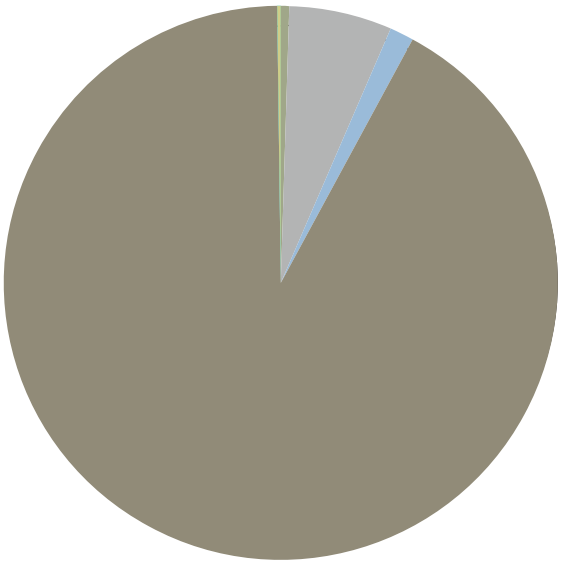
- forest: 31.1%
- open water: 30.3%
- wetland: 24.9%
- developed: 12.3%
- other: 1.4%

figure 21: land cover data for Tower Municipal Airport

field adjacency:

St. James Municipal Airport (JYG)

city: St. James, Minnesota
coordinates: 43.9863539N, -94.5579742W
elevation: 1,067’



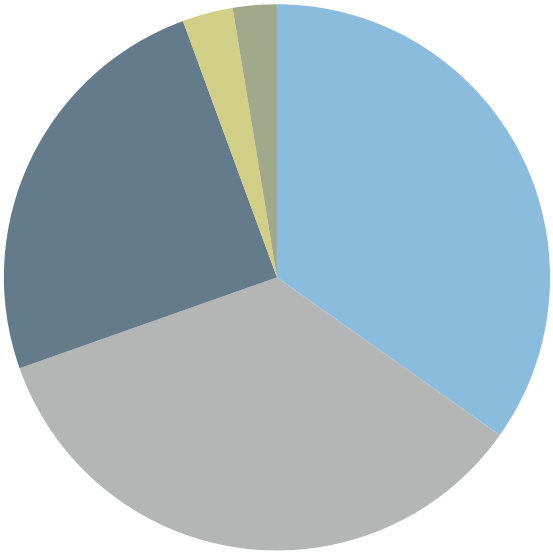
- field: 91.9%
- developed: 6.0%
- wetland: 1.4%
- forest: 0.5%
- other: 0.2%

figure 22: land cover data for St. James Municipal Airport

wetland adjacency:

Winona Municipal Airport (ONA)

city: Winona, Minnesota
coordinates: 44.07722°N, -91.70833°W
elevation: 656’



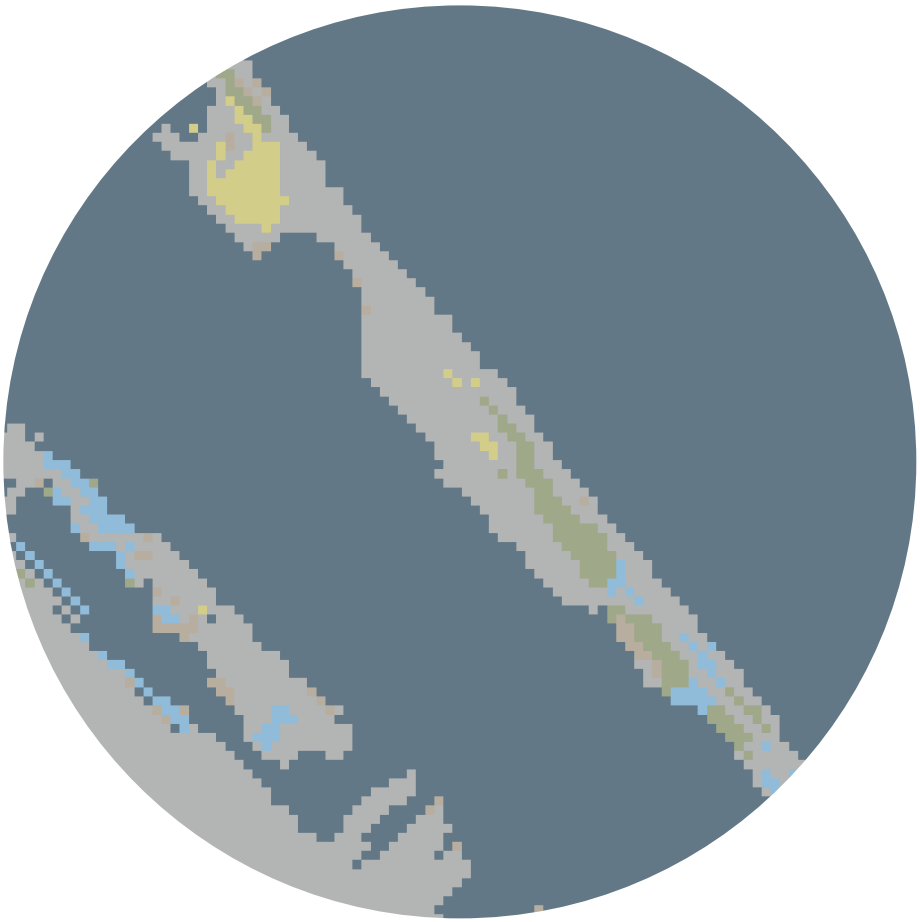
- wetland: 34.8%
- developed: 34.8%
- open water: 24.8%
- herbaceous: 3.0%
- other: 2.6%

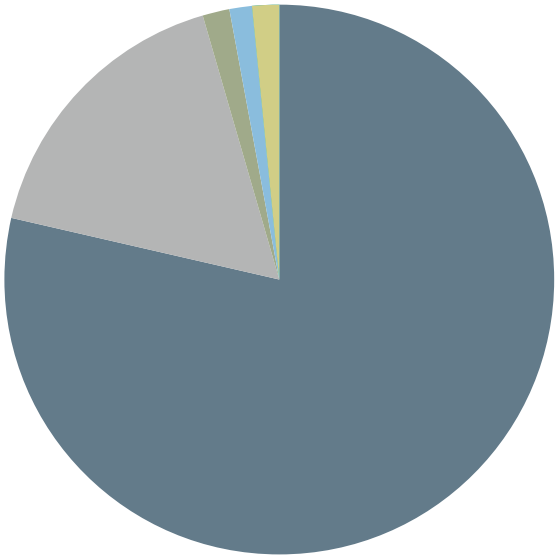
figure 23: land cover data for Winona Municipal Airport

open water adjacency:

Sky Harbor Airport (DYT)

city: Duluth, Minnesota
coordinates: 46.7221225N, -92.0443858W
elevation: 610’



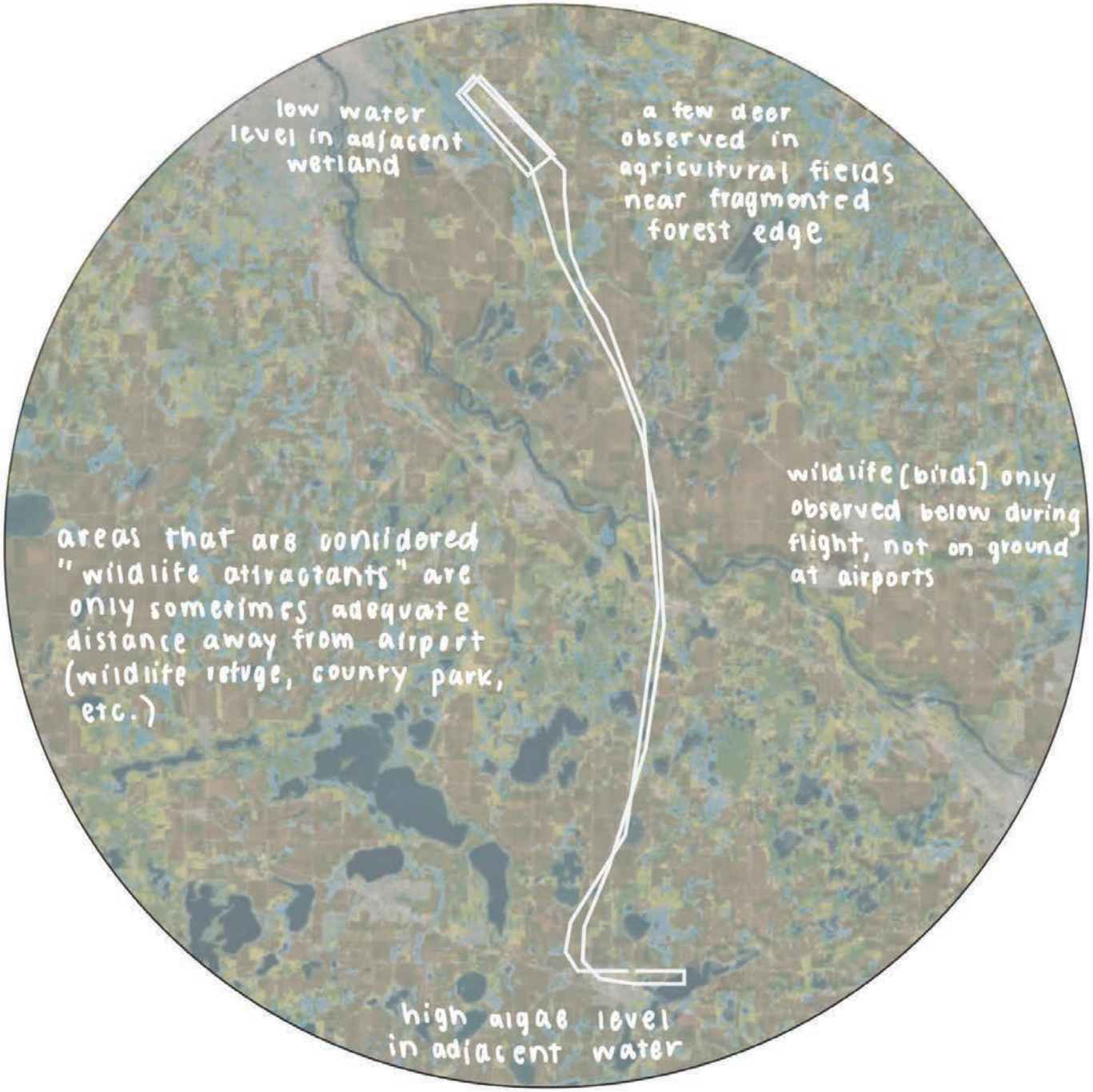


- open water: 78.6%
- developed: 16.9%
- forest: 1.6%
- wetland: 1.3%
- other: 1.6%

figure 24: land cover data for Sky Harbor Airport

fieldwork

By visiting regional and municipal airport sites in central Minnesota, both through flight and on the ground, I was able to develop a comprehensive understanding of these sites and the different conditions that emerge when I looked at the sites using different spatial perspectives. From a plane, I was able to observe site conditions that may not be observed in an aerial map, such as daily or seasonal changes. Experiencing these sites throughout different seasons, as well as through the perspective of a pilot, allowed me to understand the primary user's experience of the site. On the ground, I observed existing landforms and their relationship with the more natural adjacent landscape, existing stormwater management infrastructure, vegetation and possible maintenance practices, as well as the general relationships between infrastructure and ecology within these sites.



day: Monday, August 5, 2024
time: 9:00-11:00
flight route: KMGG - KSTC - KMGG
METAR: KMGG 311355Z AUTO 00000KT 10SM CLR 26/22 A2990 RMK AO2 T02550220

figure 25: flight path map from a flight from Maple Lake Municipal Airport (MGG) to St. Cloud Regional Airport (STC) and back to Maple Lake Municipal

figure 26: bird activity on a municipal airport site (no aircraft present)

figure 27: proof of plant resilience in the in-between spaces of hangars

day: Tuesday, November 26, 2024
time: 11:00 - 13:00
flight route: KMGG - ground work - KMGG
METAR: KMGG 261855Z AUTO 00000KT 10SM CLR M05/M10 A3010 RMK AO2 T10501098

figure 28: flight path map from a flight from Maple Lake Municipal Airport (MGG) to the north to conduct some ground work to observe landscape below

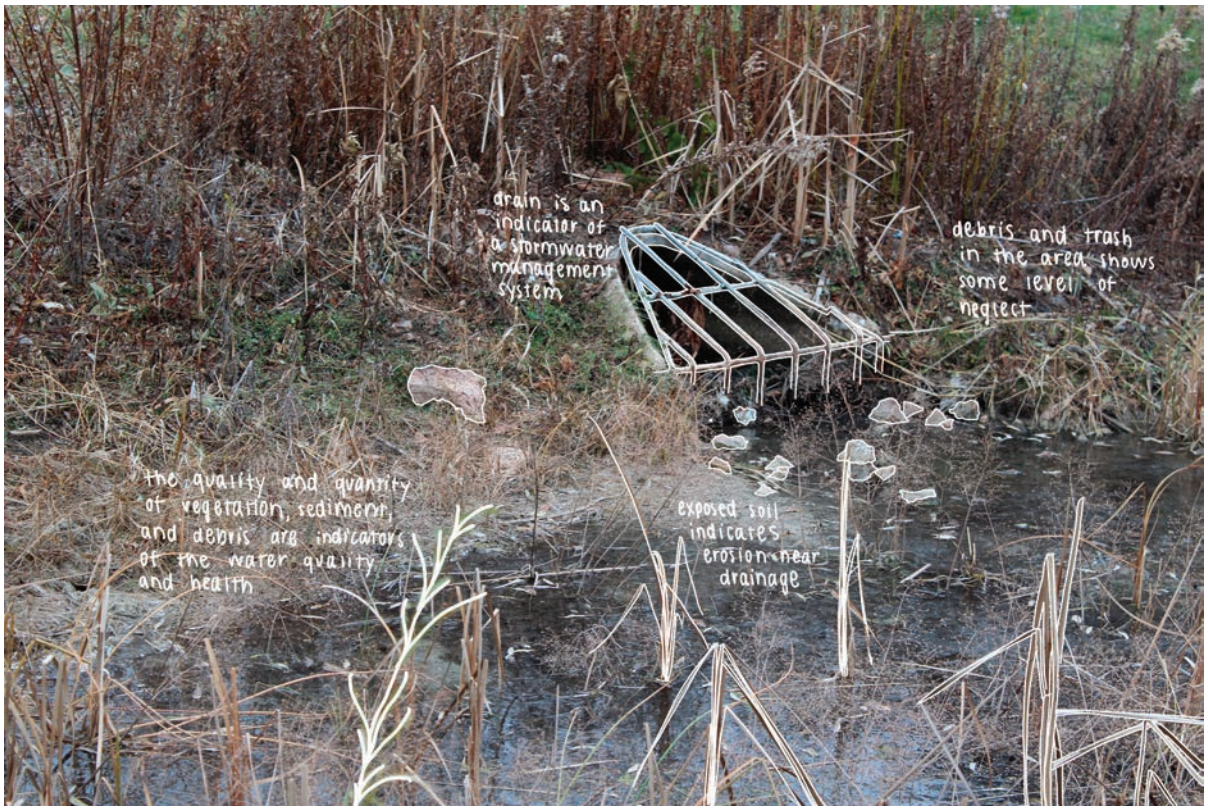
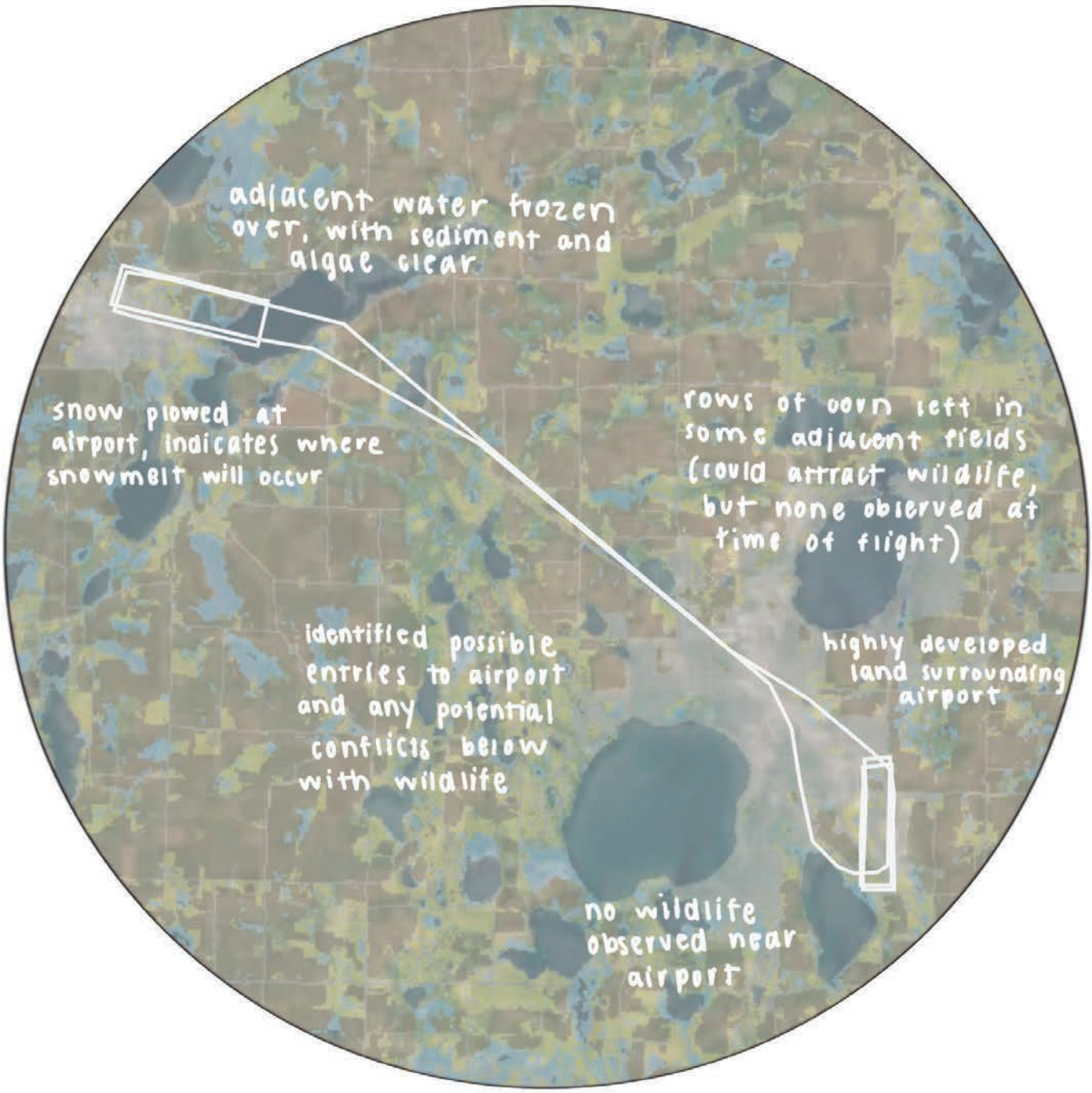


figure 29: a type of drainage systems seen at airports, usually with signs of unproductivity and of being ignored

figure 30: wetlands that were built to account for wetlands that were filled during the airport's development



day: Friday, December 20, 2024
time: 10:00 - 12:00
flight route: KMGG - KCFE - KMGG
METAR: KMGG 201555Z AUTO 34010KT 10SM CLR M12/M17 A3054 RMK AO2 T11221171

figure 31: flight path map from a flight from Maple Lake Municipal Airport (MGG) to Buffalo Municipal Airport (CFE) and back to Maple Lake Municipal

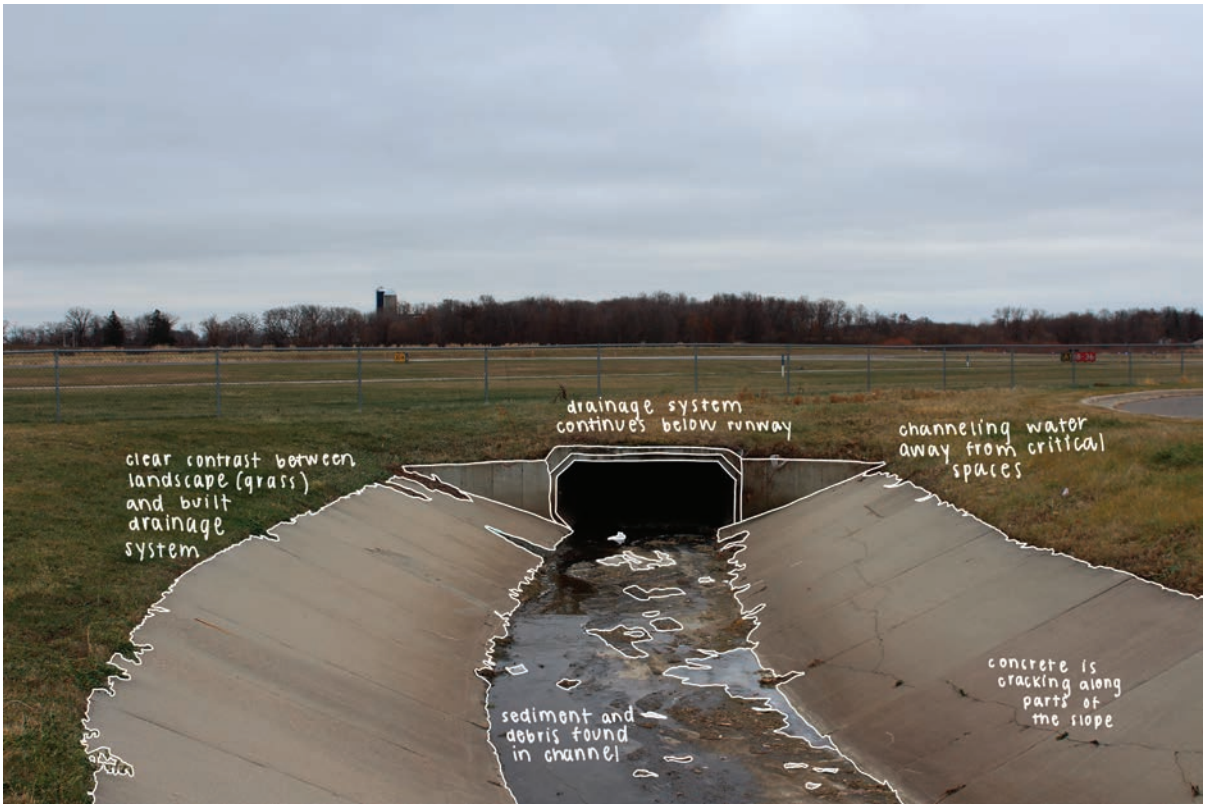


figure 32: stormwater management drain flows beneath the runway

figure 33: water flows into drain from long, linear channel at edge of airport property

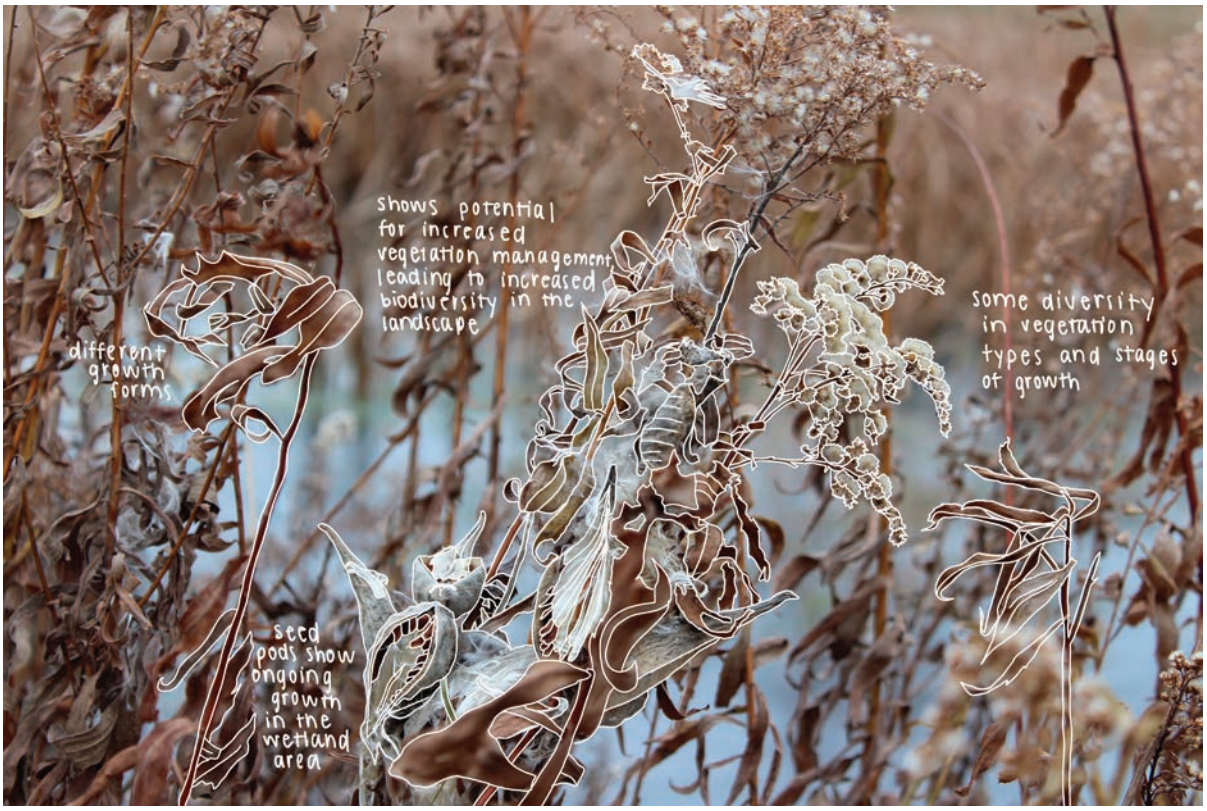


figure 34: plants on edge of wetland show different growth forms and seed pods

figure 36: some different types of plants growing alongside the majority plant, cattails

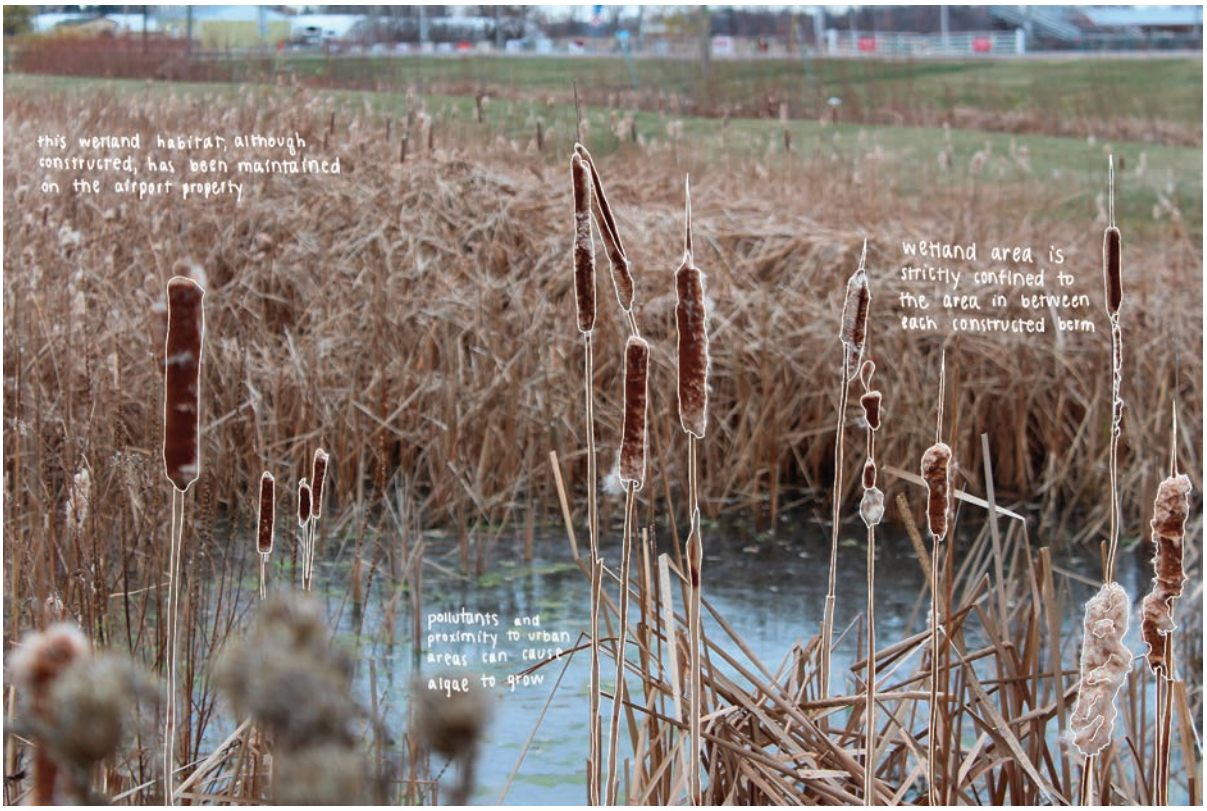


figure 35: typical wetland plants are growing in wetland area with some algae also visible in the water

figure 37: more dense vegetation is growing at the base of a berm and is part of extremely sparse wetland patches

figure 38: engineered berms run alongside runway, some sloping toward the runway and some sloping away from the runway

figure 40: land in airport's periphery also requires high maintenance and is ecologically barren

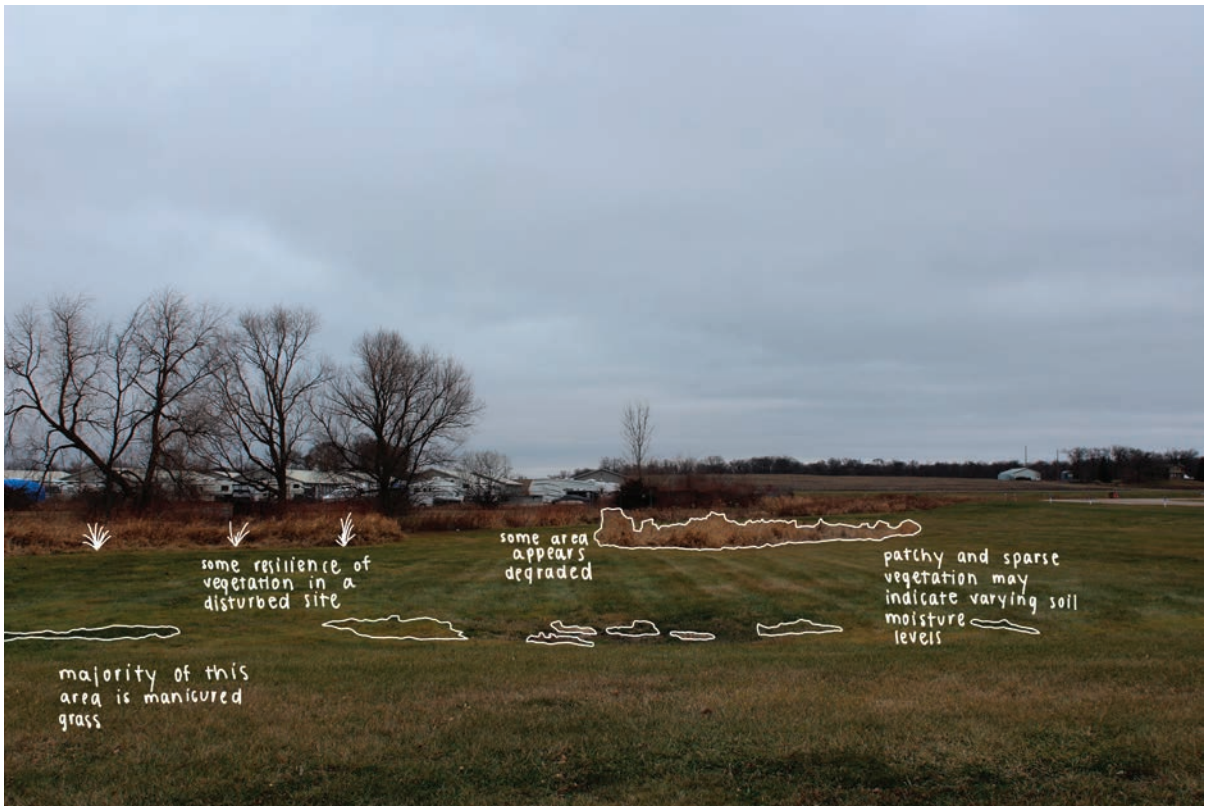


figure 39: sparsely located wetland areas; proof of inefficient drainage

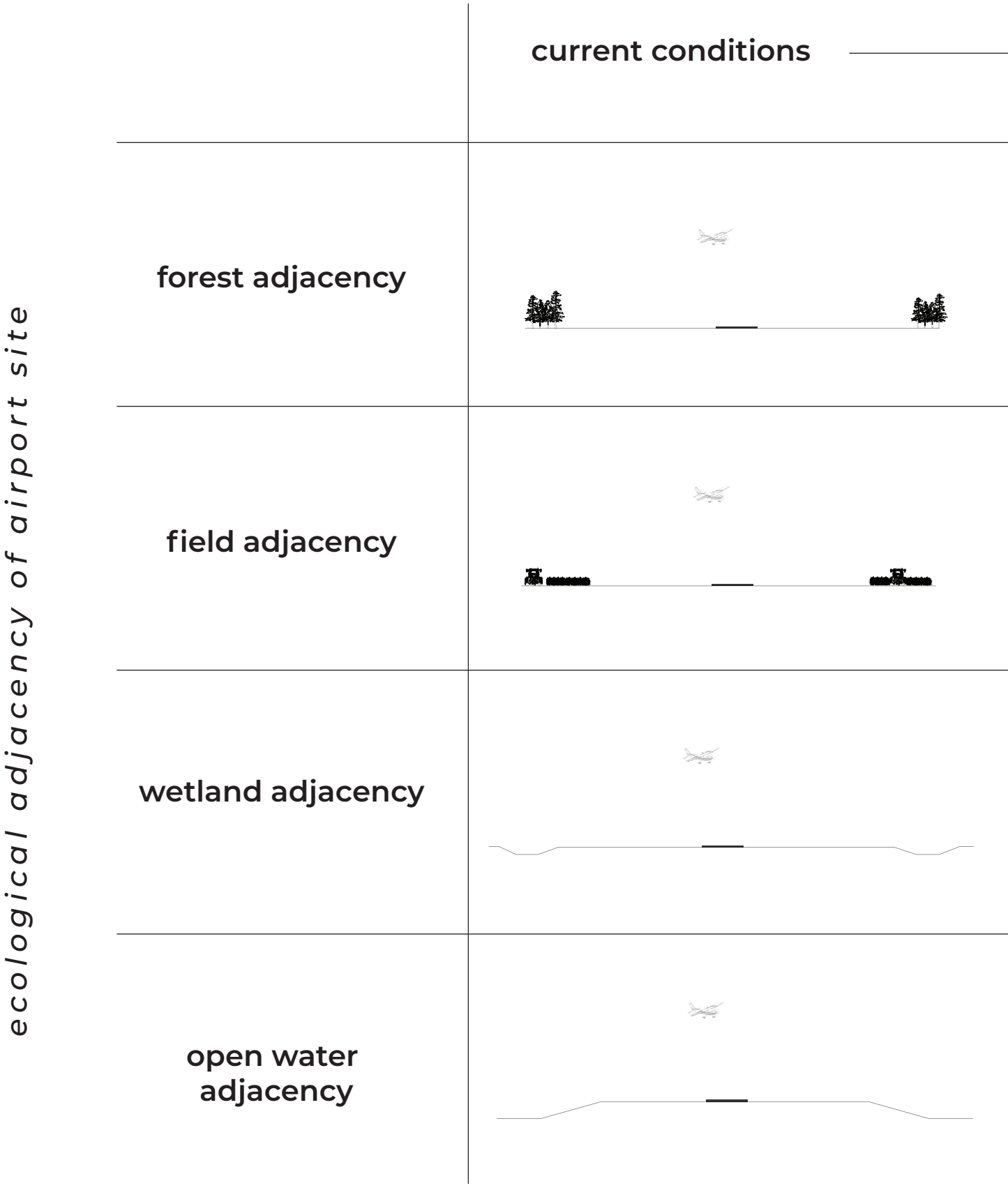
figure 41: past grading strategies contribute to creating ecologically fragmented spaces with no natural elements

design as research

Within the design as research method I used in this project, I first determined the strategies used at each airport adjacency, as well as their phasing throughout different levels of use. The results of this method are first shown below in the categorized matrix that shows the current conditions at each adjacency, as well as the decomissioned scenario. These land use and form changes, shown in section, represent drastic changes within the airport landscape, but the matrix also suggests that the design interventions at airports with high and low use will emerge along this phasing. I then rendered these different scenarios and design interventions with the same categories of adjacencies and levels of use. I found thruough these designs that although each design was proposed with a case study airport in mind, the nature of the interventions proved their ability to be applied to other sites, with small changes being made to site specific context.

matrix used for design as research

figure 42: phasing of the design interventions throughout different levels of use at four categories of airport adjacency

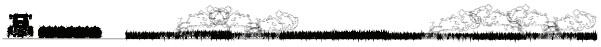


level of use at airport

high use **low use** → **decommissioned**

forest edge moves closer to edge of runway, diverse heights of trees and shrubs are encouraged

maintenance regimes become less intensive, native grass species are planted over time, regenerative practices are seen in decommissioned scenario



cut and fill operations encourage more natural berms and landforms on the site,, vegetation is planted over time to improve ecological, soil, and water health

aquatic plant life is increased to improve health of all aquatic species, vegetated edge on water's edge widens to stabilize soil and improve ecology

forest adjacency, current conditions

ground is bare and not ecologically productive

forest edge is found extremely far from runway

runway development has caused fragmentation

figure 43: forest edge is linear in nature and far from airport edge; forest habitat is fragmented and disrupted by airport development

forest adjacency, low use

evergreen trees support the presence of insects

noctural species are present during cessation of flight activity

smaller wildlife are seen during day in growing forests

figure 45: tree plantings become more dense; species that are not a threat to aircraft are supported

forest adjacency, high use

native species, such as goldenrod, start to emerge

tree roots begin to form a network, increasing soil health

forest edge is sparsely growing towards runway edge

figure 44: sparse tree plantings are seen closer to runway edge; tree roots help stabilize soil and add nutrients

forest adjacency, decommissioned

airport opens for public recreational uses

birds are now supported and encouraged on site

larger wildlife begin to emerge in the dense forests

figure 46: airport is decommissioned into public park, connecting to adjacent trail networks; runway is depaved in some areas to allow for a more natural forest edge

figure 47: phasing of airport with forest adjacency throughout time

low use

decommissioned

field adjacency, current conditions

grass is not native and is high maintenance

deer are attracted to nearby agricultural fields

adjacent land is frequently used for agricultural purposes

figure 48: adjacent agricultural land is heavy in pollutants and chemicals; airport land is high in maintenance requirement

field adjacency, low use

wildlife corridor is planted along airport edge

native grasses are planted to encourage pollinators

groundcovers help stabilize the soil and add diversity

figure 50: grass is encouraged to reach at least six inches before mowing; wildlife corridor planted on airport edge

field adjacency, high use

grass is mown less than once a week

small insects find habitat in grass

pollinator species emerge

figure 49: frequency of mowing and maintenance decreases; longer grasses support pollinator species and other insects

field adjacency, decommissioned

minimal maintenance required

burning encourages new growth

only native grasses are planted

figure 51: airport is decommissioned into native prarie land; only maintenance required is seasonal burning to encourage new growth

current conditions

high use

figure 52: phasing of airport with field adjacency throughout time

low use

decommissioned

wetland adjacency, current conditions

flight activity may be affected by flooding

grading causes high maintenance

airport is heavily impacted by weather events

figure 53: site does not currently have wetlands but rather previous development has filled them

wetland adjacency, low use

great blue lobelia and sedges thrive

new habitat for the blanding's turtle

small insects, including pollinators, emerge

figure 55: high rainfall does not affect airport operations; swale holds water and supports a higher diversity of vegetation and some wildlife

wetland adjacency, high use

variety of grasses are planted

pollinators are supported

marsh milkweed thrives

figure 54: vegetation is planted within swale, stabilizing the soil, adding nutrients, and attracting pollinators

wetland adjacency, decommissioned

human activity on site

birds are supported on site

high diversity of native wetland species

figure 56: airport is converted into a productive wetland with opportunity for public use, such as birdwatching

figure 57: phasing of airport with wetland adjacency throughout time

low use

decommissioned

open water adjacency, current conditions

transition from water to land is abrupt

pilot has minimal engagement with land

extreme weather may disrupt operations

figure 58: current conditions show an abrupt change from land to water, not mimiking natural edge conditions

open water adjacency, low use

plant such as bur reed thrive in water

species like muskrats are benefitted

aquatic species like water celery thrive

figure 60: vegetation along shore widens and becomes denser; intensity of plantings below water is increased

open water adjacency, high use

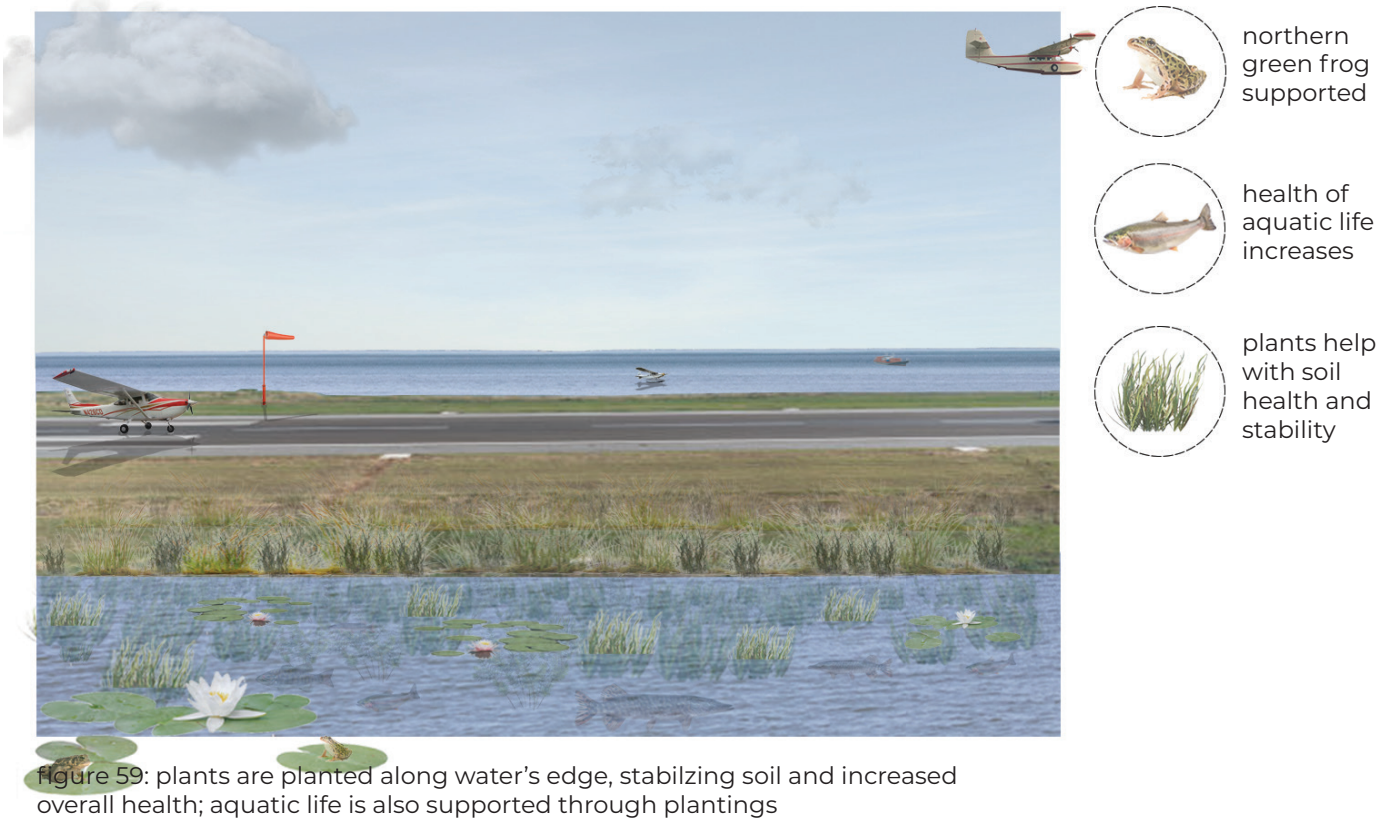


figure 59: plants are planted along water's edge, stabilzing soil and increased overall health; aquatic life is also supported through plantings

open water adjacency, decommissioned

figure 61: airport is decommissioned into public park, consisting of water recreation, recreation on runway, native plantings, and more

current conditions

high use

figure 62: phasing of airport with open water adjacency throughout time

low use

decommissioned

discussion

This project's exploration of the overlooked intersection of aviation and ecology at regional and municipal airports reveals complex connections between the two disciplines that cannot be generalized into one study. However, the results support the argument that there is room for design interventions within these airport landscapes. Additionally, this project's approach to categorize airports by adjacency and level of use was confirmed to be a valid organizational structure, as some level of intervention can be generalized by these two factors. While it is true that each airport has their own unique environmental, economic, and bureaucratic characteristics, and thus one design intervention cannot be proposed across all sites, there are similarities found in both the landscape and airport operations that opens up each airport site to potential design possibilities.

understanding the airport site

In comparison to existing scholarship and policy, this research built on methods and recommendations for balancing human and wildlife safety, as this is a frequent topic within environmentally-centered airport discussion. Because of how often this topic was discussed in interviews, policy, and past projects, I knew it would have to play a key role in my project and would raise concern if I did not acknowledge the potential of safety hazards and wildlife interference within my design interventions. The key informant interview method within this paper was unique when comparing this work to previous research. These interviews were a pivotal method within my project, as the participants not only provided me with valuable knowledge and insight, but they also challenged me to consider the perspective of those who are most involved with the daily happenings at the airport. These interviews also allowed me to dive deeper into questions about ecology and design beyond wildlife concerns, which then created more comprehensive and flexible design interventions.

Approaching the project through a lens of landscape ecology focused the project on organizing and categorizing landscapes through the aerial view and generally using a large scale for analysis. Using flight to conduct fieldwork allowed me to understand these landscapes with the perspective of how they connect to their surroundings, how they are being continuously changed by dynamic elements, and how their edges, whether defined by property ownership or ecology, interact with one another. However, successful landscape architecture design projects acknowledge the small scale characteristics on the ground - the soil, water, plants, animals, and more. While this project lacked an in-depth ecological study of each case study site, using photography in my fieldwork research layered my understanding of airport landscapes by being able to experience and analyze them from the ground. These two methods were unique to other projects I examined in my precedent analysis because of the different spatial perspectives I used to understand these small airports.

opportunity for design interventions

Throughout this project's methodology, I found several opportunities for design intervention because airports landscapes are not always as regulated in their land use and maintenance as we believe them to be. While there is some guiding regulation in place for these sites, there is a need for a future of integrated environmental and ecological policies that work to support sustainable airport sites without compromising aviation safety. Although this kind of integration of environmental considerations into airport design and operations is infrequent, this project showed that such policies and integration are not only needed, but extremely logical and reasonable. Whether through hearing stories from interview participants of attempts to include the environment in the narrative of airport design, reading policy that considers the health of the environment and leaves room for the inclusion of non-human life at airports,

or through designing the landscapes that airports are a part of, this study showed the potential of these sites and the applicability of the designs across other airports with similar adjacencies and air traffic. By proposing these interventions, this study also challenges the current view of airport landscapes as barren land and shows the negative impacts they have had on the site itself and on surrounding environments. This attitude about airports is not generally accepted because of the primary concern of human safety, but through this research I found that airport planners and managers are open to the conversation.

regulatory challenges and limitations

While the design interventions that I proposed within this project are heavily based on research and still follow existing regulation and policy, there is still plenty of work to be done regarding the implementation of interventions such as these. Because of the unprecedented nature of these types of projects, as well as the extensive bureaucratic process involved in proposed airport projects, the truth is that there are still barriers and challenges that would impede the approval and construction of ecologically-centered designs. The future of research regarding the intersection of aviation and ecology must work to not only continue to propose designs, but propose changes within the bureaucratic processes that currently interfere with any efforts to include ecological narratives within airport design. An additional challenge of this project is that there is no clear way to test these designs on actual airport sites without interfering with airport operations, but this challenge further shows the need for the experimentation of designs such as these, which would first require their approval and support from government agencies.

implications of landscape ecology design

Although the work in this project is centered around airports as the sites of study, similar interventions and methodologies can be applied to numerous other landscapes. Analyzing sites for potential overlap using the perspective of landscape ecology can uncover what typologies of sites have similar development history, edge conditions, and interactions with surrounding ecologies and habitats. Because the work of this project mainly focuses on changes to the land, which exists independently of airport operations, the proposed interventions can be considered (and, of course, altered to specific site context) within other landscape typologies, further extending the results of this research to other disciplines of landscape architecture and ecology.

the future of airport design

By initiating the discussion of a change in the relationship between regional and municipal airports and ecological design, this project claims the need for the continuation of similar discussions. As environmental challenges intensify, the need for these conversations to be at the forefront of design is becoming increasingly urgent. By embracing the potential for an overlap of aviation and ecology, airport landscapes could become not only productive in terms of transportation and meeting aviation demands, but in terms of ecological productivity as well. This project demonstrates that regional and municipal airports are uniquely positioned to lead this transformation of airport landscapes due to their approachable scale, patterns of adjacencies, and potential for experimental design interventions.

conclusion

This thesis began with my interest in the intersection of aviation and landscape architecture, which is an under-explored area of design research. Using landscape ecology as a guiding theoretical framework, I organized these airport sites by both adjacency and level of use, which then caused patterns to emerge regarding the possibility of design. By recognizing the opportunity that exists within these landscapes, even with regulatory and budget constraints, I set out with the goal of educating myself on current conditions to ground my research within existing routines and practices. As both a landscape architecture student and a private pilot, I advanced both of these two perspectives to ensure I was considering both the ecological and aviatic aspects of the research questions I posed.

Because of intensive and ecologically destructive maintenance regimes and use of polluting chemicals and fuel, it is crucial to begin thinking about how we can reprioritize the landscapes of airports. My research claims that even though these sites are under strict regulation and maintenance practices, there is ample opportunity for design interventions that balance current infrastructure with proposed adjustments that consider the ecological health of these sites. When these sites are categorized by adjacency and use, interventions for each start to prove applicability between numerous sites. Whether the adjacency be a field, a forest, open water, or wetlands, this research proposes the potential of these sites for a design intervention that responds to their unique ecological concerns.

Currently, airport master plans lack constructive mentions of ecology, which leads to the topic being omitted from discussions around airport planning and maintenance. In order to begin thinking about these design interventions, there first must be an understanding of the need to work towards a reprioritization of airport landscapes that balances existing infrastructure with ecological opportunity. Although shifting recommendations to better incorporate ecology into airport maintenance practices is an important first step, articulating the potential of design to address ecological challenges provides a further strategy for implementing change. The interventions I propose in this project include implementing grading strategies to better direct and retain stormwater, incorporating green infrastructure, rethinking wildlife and human safety through the inclusion of wildlife corridors, and creating planting areas that serve as support to pollinator species and phytoremediation.

Showing the opportunities and benefits of ecologically-driven design interventions at regional and municipal airports expands existing scholarship on the topic of airport landscapes to smaller airports to more clearly advocate for ecological thinking in the design of these spaces. Landscape architects have an incredible opportunity within these spaces to create ecologically diverse and dynamic landscapes that begin to offset the environmental impacts that general aviation continues to have. The potential collaborations between these two disciplines can create airport environments that support their surrounding ecologies with minimal damage to local habitats and ecologies. Regional and municipal airports will continue to service general aviation pilots, like myself, but it is crucial that we begin to think about how to acknowledge and lessen their impact on the environment. Through interdisciplinary design and including as many voices as possible on design decisions, we can develop and design spaces that serve both the human and non-human needs of these spaces. By embracing the need to change the narrative of airport landscapes into one of ecologically-centered design, we can redefine these sites as not only spaces of aviatic enthusiasm, but of environmental stewardship as well, ensuring they continue to support aviation needs but also begin to support the needs of local ecologies, leading us into a future where airports and their surrounding environments can exist as one.

list of acronyms

acronyms

AC (Advisory Circular)

ACI (Airports Council International)

AIP (Airport Improvement Program)

CATEX (Categorical Exclusion)

DNR (Department of Natural Resources)

EIS (Environmental Impact Statement)

EPA (Environmental Protection Agency)

CIP (Capital Investment Plan)

FAA (Federal Aviation Administration)

FAR Parts (Federal Aviation Regulation Parts)

GIS (Geographical Information Systems)

METAR (Meteorological Aerodrome Report)

MNDOT (Minnesota Department of Transportation)

MPCA (Minnesota Pollution Control Agency)

NEPA (National Environmental Policy Act of 1969)

PFAS (polyfluoroalkyl substances)

PPL (private pilot's license)

SWPPP (Stormwater Pollution Prevention Plan)

USDA (United States Department of Agriculture)

VFR (Visual Flight Rules)

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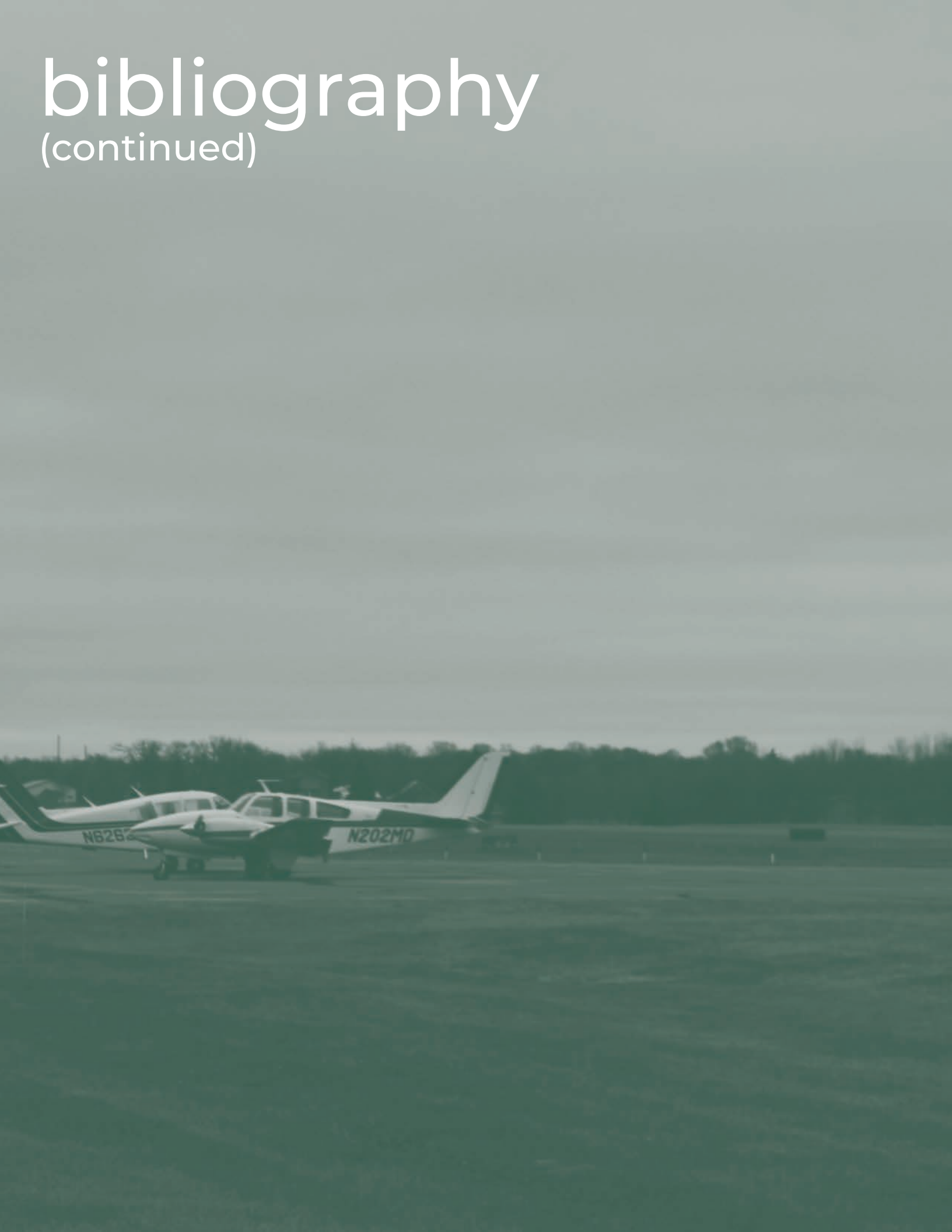

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image sources

Figure 1. West 8's plan for "Landscaping Schiphol Airport" in Amsterdam, NL. (Diagram by West 8, 1992, https://www.west8.com/projects/landscaping-schiphol-airport/).

Figure 2. Planting area on outskirts of Schiphol Airport in Amersterdam, NL, designed by West 8. (Photograph by West 8, 1992, https://www.west8.com/projects/landscaping-schiphol-airport/).

Figure 3. Stapleton Redevelopment in Denver, Colorado. (Photograph by ERO Resources, https://www.eroresources.com/portfolio-item/stapleton-international-airport-redevelopment/).

Figure 4. Sheep grazing during cessation of activity at Lleida-Alguaire Airport in Catalonia. (Photograph in "Renewed landscapes: Obsolete airfields as landscape reserves for adaptive reuse," 2019, https://www.tandfonline.com/doi/figure/10.1080/18626033.2018.1589147?scroll=top&needAccess=true).

Figure 5: Aviation-themed playground at Downsview Park in Toronto, Canada. (Photography by Earthscape, 2017, https://www.earthscapeplay.com/project/downsview-park-toronto-aviation-playground/).

Figure 6: Open public park space at Downsview Park in Toronto, Canada. (Photography by DestinationToronto, https://www.destinationtoronto.com/listing/downsview-park/29828/).

Figure 7: Tempelhofer Feld on previous site of Tempelhof Airport in Berlin, Germany. (Photograph by Dezeen, 2016, https://www.dezeen.com/2016/02/26/berlin-tempelhof-airport-to-become-germanys-largest-refugee-camp/).

Figure 8: Existing infratstructure and ecological renewal blend together at Maurice Rose Airfield. (Photograph in "Renewed landscapes: Obsolete airfields as landscape reserves for adaptive reuse," 2019, https://www.tandfonline.com/doi/figure/10.1080/18626033.2018.1589147?scroll=top&needAccess=true).

Figure 9: Opportunities for public recreation at the previous site of Maurice Rose Airfield. (Photograph in "Renewed landscapes: Obsolete airfields as landscape reserves for adaptive reuse," 2019, https://www.tandfonline.com/doi/figure/10.1080/18626033.2018.1589147?scroll=top&needAccess=true).

Figure 10: Diagram for LCLA Office's proposal for an airport park in Caracas, Venezuela. (Diagram by LCLA Office, https://www.luiscallejas.com/filter/parks/CARACAS-Airport-park).

Figure 11: Plan proposal for Quito's "3km airport park" by LCLA Office. (Drawing by LCLA Office, 2008, https://www.luiscallejas.com/filter/post-airport-landscapes/QUITO-3km-Airport-park).

Figure 12: Diagrams for LCLA Office's proposal for a hydrological metropolitan airport park in Quito, Ecuador. (Drawing by LCLA Office, 2008, https://www.luiscallejas.com/filter/post-airport-landscapes/QUITO-3km-Airport-park).

Figure 13: Different site activation and programming at the proposed airport park in Quito, Ecuador. (Drawing by LCLA Office, 2008, https://www.luiscallejas.com/filter/post-airport-landscapes/QUITO-3km-Airport-park).

appendix

appendix A

interview questions for airport managers:

1. Can you briefly describe current maintenance practices? (lawn maintenance, seasonality changes, equipment used, etc.)
2. What are the municipal, state, or federal regulations that you have to keep in mind when deciding how the land is maintained? (impact of FAA, state/ municipal decisions)
3. How is the budget for maintenance determined, and what influences this?
4. Do the airport's adjacencies affect maintenance practices at all? (filling of wetlands, agricultural land, etc.)
5. How is stormwater managed at the airport?
6. What is the timeline and process for facility upgrades or unscheduled land maintenance?
7. What are some of the biggest challenges you face when it comes to maintenance? (budget, equipment, labor, etc.)
8. What are some chemicals that are used on the land, and what are concerns associated with these? (if any) (aircraft fuel/potential of electrification, PFAs, glycol use)
9. Have there been any projects/land maintenance decisions that are out of the normal maintenance schedule you have seen?
10. What are some considerations of wildlife interference that you have seen used in airport planning and how does it impact the planning? (EIS documents)

interview questions for airport planners:

1. Can you briefly describe current airport environmental surveying/planning procedures?
2. What type of considerations does SEH have to make regarding municipal, state, or federal regulations?
3. What are some of the main things that are considered when analyzing each airport? (stormwater, pollution, adjacencies, wildlife, etc.?
4. What is the timeline for surveys done at airports?
5. What are some of the biggest challenges you face when it comes to working with regional/municipal airports?
6. What are some considerations of wildlife interference that you have seen used in airport planning and how does it impact the planning?

appendix B

spatial analysis land cover calculations

OBJECTID	NLCD_LAI	OBJEC_1	OBJEC_2	OBJEC_3	OBJEC_4	OBJEC_5	OBJEC_6	OBJEC_7
1	Unclassifie	0	0	0	0	0	0	0
2	Open Wate	2443500	4113000	1501200	37800	652500	2569500	0
3	Developed,	2559600	1782900	872100	756900	1598400	1008000	538200
4	Barren Lan	900	900	5400	109800	0	50400	3600
5	Deciduous	1442700	602100	209700	1649700	1363500	2887200	25200
6	Shrub/Scru	192600	280800	181800	530100	685800	314100	692100
7	Cultivated	0	0	4190400	0	0	0	5975100
8	Woody We	433800	376200	35100	3795300	2953800	467100	5400
9	Emergent H	223200	139500	303300	418500	34200	5400	55800

OBJEC_8	OBJEC_9	OBJEC_10	OBJEC_11	OBJEC_12	OBJEC_13	OBJEC_14	OBJEC_15	OBJEC_16
0	0	0	0	0	0	0	0	0
156600	96300	900	26100	108000	372600	503100	90000	0
1685700	1210500	776700	333000	590400	3343500	4173300	410400	2747700
900	14400	0	0	0	18000	23400	207900	0
657900	292500	509400	0	731700	72000	180900	96300	237600
985500	101700	1440000	162900	1299600	1047600	800100	422100	390600
3325500	5221800	3564000	5840100	421200	1280700	1275300	5654700	3739500
82800	43200	314100	80100	2335500	328500	27000	37800	116100
403200	319500	690300	860400	1808100	837000	317700	385200	58500

OBJEC_17	OBJEC_18	OBJEC_19	OBJEC_20	OBJEC_21	OBJEC_22	OBJEC_23	OBJEC_24	OBJEC_25
0	0	2453400	0	0	0	0	0	0
621900	212400	751500	0	135900	918900	2700	125100	389700
1234800	573300	922500	537300	3803400	2586600	675900	683100	413100
7200	100800	7200	1800	900	1800	900	0	2700
1518300	2487600	27000	770400	544500	765900	0	1490400	1046700
1969200	1116000	1503900	805500	936000	623700	1231200	54000	278100
28800	1566000	1328400	5104800	0	0	3518100	98100	0
755100	400500	131400	18000	1594800	1791000	0	4481100	3744000
1161900	840600	173700	62100	285300	607500	1869300	368100	1427400

OBJEC_26	OBJEC_27	OBJEC_28	OBJEC_29	OBJEC_30	OBJEC_31	OBJEC_32	OBJEC_33	OBJEC_34
0	0	0	0	0	0	0	0	0
0	938700	599400	64800	481500	2994300	246600	32400	13500
563400	295200	1670400	1313100	2031300	284400	3432600	715500	707400
9900	0	25200	7200	14400	0	9900	0	6300
9900	3765600	2249100	165600	177300	3255300	2411100	51300	97200
210600	272700	1672200	1049400	1169100	234900	793800	72000	129600
5656500	0	29700	2628900	2935800	0	0	6253200	4518900
609300	1800000	571500	148500	59400	484200	248400	3600	378000
232200	222300	481500	1920600	419400	47700	153900	158400	1448100

OBJEC_35	OBJEC_36	OBJEC_37	OBJEC_38	OBJEC_39	OBJEC_40	OBJEC_41	OBJEC_42	OBJEC_43
0	0	0	0	0	0	0	0	0
144900	17100	0	119700	25200	0	4500	652500	115200
918000	764100	505800	876600	1105200	363600	545400	1014300	1336500
0	0	0	0	151200	4500	8100	0	108000
6300	122400	232200	2221200	78300	8100	676800	1356300	2400300
16200	38700	1255500	1350000	1446300	479700	1241100	764100	1028700
6116400	6241500	5302800	1058400	3820500	6407100	3484800	3005100	0
81900	26100	0	540000	0	0	421200	56700	2056500
15300	85500	0	1123200	666000	38700	915300	449100	252000

OBJEC_44	OBJEC_45	OBJEC_46	OBJEC_47	OBJEC_48	OBJEC_49	OBJEC_50	OBJEC_51	OBJEC_52
0	0	0	0	0	0	0	0	0
0	2106000	0	1790100	1420200	18000	1800	5271300	**5727600**
360900	431100	869400	117900	1791000	1608300	4574700	311400	**1234800**
0	6300	0	0	69300	9900	0	0	51300
2347200	3463200	900	2938500	506700	23400	863100	909000	**115200**
822600	225000	4500	418500	1047600	181800	57600	200700	67500
5400	0	6422400	0	1593000	5440500	0	0	0
3438900	964800	0	1333800	72000	0	1776600	568800	79200
328500	93600	0	696600	795600	14400	18900	35100	13500

spatial analysis land cover calculations, continued

OBJEC_53	OBJEC_54	OBJEC_55	OBJEC_56	OBJEC_57	OBJEC_58	OBJEC_59	OBJEC_60	OBJEC_61
0	0	0	0	0	0	0	0	0
359100	15300	0	900	808200	0	137700	260100	0
1184400	1053900	252900	1972800	251100	964800	328500	1653300	2027700
1800	5400	33300	11700	9900	3600	0	5400	0
1386000	8100	3323700	101700	1463400	58500	2108700	269100	9900
1820700	22500	1666800	85500	856800	73800	640800	438300	744300
128700	6086700	998100	5067000	392400	6140700	0	4320900	4471200
1985400	0	850500	0	3258000	0	3677400	2700	5400
428400	107100	176400	59400	245700	54000	406800	351000	35100

OBJEC_62	OBJEC_63	OBJEC_64	OBJEC_65	OBJEC_66	OBJEC_67	OBJEC_68	OBJEC_69	OBJEC_70
0	0	0	0	0	0	0	0	0
19800	6300	0	443700	132300	57600	15300	206100	2269800
1157400	434700	808200	301500	6480900	1187100	1279800	1363500	900900
0	0	4500	10800	89100	12600	49500	1800	7200
92700	4261500	18900	141300	230400	180900	279000	306900	2211300
1109700	1390500	384300	690300	214200	85500	1210500	553500	91800
3102300	0	6048000	5100300	9900	5458500	3317400	4201200	0
469800	1157400	0	287100	89100	168300	384300	326700	1652400
1344600	45900	35100	320400	55800	137700	766800	339300	162900

OBJEC_71	OBJEC_72	OBJEC_73	OBJEC_74	OBJEC_75	OBJEC_76	OBJEC_77	OBJEC_78	OBJEC_79
0	0	0	0	0	0	0	0	0
191700	0	0	41400	859500	0	20700	1772100	1800
1014300	1580400	440100	1836000	6025500	573300	1125900	1038600	1399500
900	900	0	0	41400	0	6300	1800	0
13500	583200	35100	419400	95400	192600	186300	36900	29700
821700	1636200	17100	1943100	99000	465300	777600	1437300	0
5191200	3386700	6703200	2940300	0	5975100	3598200	1143000	5781600
0	60300	3600	3600	44100	94500	607500	66600	79200
63900	48600	96300	119700	136800	2700	975600	1799100	7200

OBJEC_80	OBJEC_81	OBJEC_82	OBJEC_83	OBJEC_84	OBJEC_85	OBJEC_86	OBJEC_87	OBJEC_88
0	0	0	0	3373200	0	0	0	0
8100	251100	36900	354600	0	0	0	74700	0
1671300	345600	890100	1267200	258300	2286000	499500	1945800	339300
11700	0	9000	900	0	3600	0	4500	0
900900	460800	266400	909900	406800	0	2015100	318600	8100
837000	551700	1593000	1063800	324900	305100	1143000	1452600	1800
3423600	5469300	4104000	780300	2000700	4684500	3640500	2455200	6875100
279000	33300	130500	1621800	95400	0	0	218700	53100
169200	182700	266400	1290600	841500	24300	0	828900	10800

OBJEC_89	OBJEC_90	OBJEC_91	OBJEC_92	OBJEC_93	OBJEC_94	OBJEC_95	OBJEC_96	OBJEC_97
0	0	0	0	0	0	0	0	0
1301400	24300	231300	0	0	258300	0	862200	531900
1350000	2685600	900900	2268000	856800	1307700	328500	3775500	1012500
54900	49500	12600	0	0	5400	0	5400	900
841500	671400	2358000	27900	369000	842400	3762900	327600	85500
1594800	641700	1714500	978300	244800	1960200	1920600	540900	106200
1253700	1943100	161100	3926700	4229100	1852200	1283400	977400	4896000
738000	27900	1626300	0	352800	345600	0	81000	19800
161100	1250100	282600	98100	1242900	723600	0	730800	642600

OBJEC_98	OBJEC_99	OBJEC_10	OBJEC_10	OBJEC_10	OBJEC_10	OBJEC_10	OBJEC_10	OBJEC_10
0	0	0	0	0	0	0	0	0
0	31500	136800	0	15300	3600	0	1800	36900
613800	585900	774000	1564200	519300	399600	2008800	317700	647100
14400	81900	0	5400	51300	9900	0	45900	5400
558000	9900	3651300	32400	840600	36900	753300	2473200	1089000
370800	793800	492300	32400	2322900	350100	1051200	648000	2018700
5489100	5553900	0	5619600	2403900	5946300	0	0	2358900
141300	19800	2106000	0	102600	11700	2398500	2923200	789300
107100	210600	131400	40500	1040400	525600	1087200	881100	353700

spatial analysis land cover calculations, continued

OBJEC_10	OBJEC_10	OBJEC_10	OBJEC_11	OBJEC_11	OBJEC_11	OBJEC_11	OBJEC_11	OBJEC_11
0	0	2834100	0	0	0	0	0	0
17100	0	756900	1523700	0	14400	244800	2168100	1433700
1962900	1965600	1815300	2464200	1603800	849600	1248300	2348100	900900
0	11700	900	9900	10800	0	144000	900	9900
7200	454500	85500	1450800	41400	641700	887400	491400	137700
270000	1174500	217800	491400	495000	1398600	556200	281700	670500
4955400	0	7200	619200	5129100	872100	3690000	0	2842200
9000	2101500	1194300	655200	0	252900	276300	254700	90000
77400	1590300	384300	89100	19800	3271500	241200	1746000	1214100

OBJEC_11	OBJEC_11	OBJEC_11	OBJEC_11	OBJEC_12	OBJEC_12	OBJEC_12	OBJEC_12	OBJEC_12
0	0	0	0	0	0	0	0	0
46800	50400	152100	1100700	168300	23400	13500	639000	1287900
1377000	374400	715500	1236600	587700	424800	252900	1709100	1628100
4500	0	27900	40500	6300	4500	0	0	1800
617400	654300	269100	1611000	11700	56700	12600	191700	225900
1095300	906300	1172700	282600	292500	83700	13500	153900	734400
2928600	48600	4819500	0	6178500	5886900	6565500	4300200	2329200
295200	3634200	8100	2583900	0	5400	21600	23400	127800
936000	1626300	122400	441900	43200	810000	416700	279900	953100

OBJEC_12	OBJEC_12	OBJEC_12	OBJEC_12	OBJEC_12	OBJEC_13	OBJEC_13	OBJEC_13	OBJEC_13
0	0	0	0	0	0	0	0	0
900	58500	17100	11700	2700	82800	823500	0	15300
2084400	1080900	1200600	2753100	4322700	6858900	3919500	7291800	1556100
31500	0	0	5400	0	0	16200	4500	2700
900	169200	1097100	42300	180000	36000	454500	0	188100
248400	223200	2404800	995400	838800	61200	1307700	1800	929700
4833900	0	1331100	3217500	0	0	220500	0	3748500
0	1046700	293400	167400	97200	26100	291600	0	221400
97200	4708800	956700	106200	1854000	232200	255600	0	638100

OBJEC_13	OBJEC_13	OBJEC_13	OBJEC_13	OBJEC_13	OBJEC_13	OBJEC_14	OBJEC_14	OBJEC_14
0	0	0	0	0	0	0	0	0
0	536400	129600	900	0	122400	7200	192600	2700
1241100	985500	1458000	375300	837000	1091700	585900	964800	404100
0	93600	6300	0	5400	0	6300	10800	0
14400	3392100	819000	25200	4192200	7200	1207800	3892500	169200
0	774900	1955700	426600	705600	361800	2528100	580500	0
6017400	107100	2193300	5802300	0	5198400	2343600	11700	6678000
23400	1310400	163800	0	1510200	0	153000	1107000	23400
0	99000	568800	665100	46800	518400	469800	535500	23400

OBJEC_14	OBJEC_14	OBJEC_14	OBJEC_14	OBJEC_14	OBJEC_14	OBJEC_14	OBJEC_15	OBJEC_15
0	0	0	0	0	0	0	0	0
19800	49500	2075400	1525500	2700	46800	19800	57600	**1805400**
1893600	955800	622800	567900	170100	476100	1419300	430200	**2537100**
0	3600	3600	9900	0	25200	10800	7200	211500
18000	9000	3600	4689900	17100	144000	7200	31500	7200
549000	296100	66600	30600	110700	589500	28800	861300	**216900**
1466100	5890500	229500	0	6996600	5012100	5582700	5710500	0
772200	0	3015000	343800	0	18000	25200	0	835200
2573100	92700	1270800	118800	0	986400	205200	202500	1674000

OBJEC_15	OBJEC_153
0	0
14400	3600
1094400	1653300
4500	17100
332100	11700
521100	336600
5055300	5202000
54000	0
223200	73800